Phytoplankton Communities affect Seston Fatty Acids in Vermont's Waters

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Introduction

Background

- Changing lake conditions can alter the patterns of algal growth that occur in lakes, and differences in algal communities can affect food web interactions (Pegra et al. 2012).
- One way to track food web changes is by studying the transfer of fatty acids through an ecosystem (Hiltunen et al. 2015).
- Research on changing phytoplankton communities in fresh water systems has found that differing community compositions can impact the food web, but there are varying hypotheses regarding the type of effect and drivers of community change.

Questions

- Do differences in phytoplankton communities affect the seston fatty acid composition?
- What differences are there between the phytoplankton communities at different sites around the lake and at different points in the growing season?
- What specific correlations exist between phytoplankton community metrics and groups of essential fatty acids, what are the directions of these correlations?

Hypothesis

- Lower percentages of essential fatty acids will be observed when percent cyanobacteria is higher; when percent diatoms are high more essential fatty acids will be present.
- Higher percentages of cyanobacteria will be seen in the more eutrophic lake sites, and diatom percentages will be higher in the less eutrophic lake sites.

Methods

Sampling

- Samples of phytoplankton were taken using a peristaltic pump or Niskin bottle.
- Locations sampled were Missisquoi Bay, the Inland Sea, Malletts Bay, Shelburne Bay and Shelburne Pond (Figure 1).
- Samples were taken in June, August, and October of 2013 and there were three replicates for each sampling event, resulting in a total of 45 samples.
- Each sample was filtered through a 150-micron sieve into a 10L container and mixed to create an integrated water column sample.

Fatty acid extraction and phytoplankton counts

- Fatty acids were extracted from the seston samples, the resulting fatty acid methyl esters were analyzed with gas chromatography-mass spectrometery.
- Phytoplankton were counted and measured for two replicates of each sampling event using the Utermöhl method (Elder and Elbrächter 2010).

Analysis

- Heat mapping and regressions of percent biovolume and fatty acids were used to find important correlations in the data.

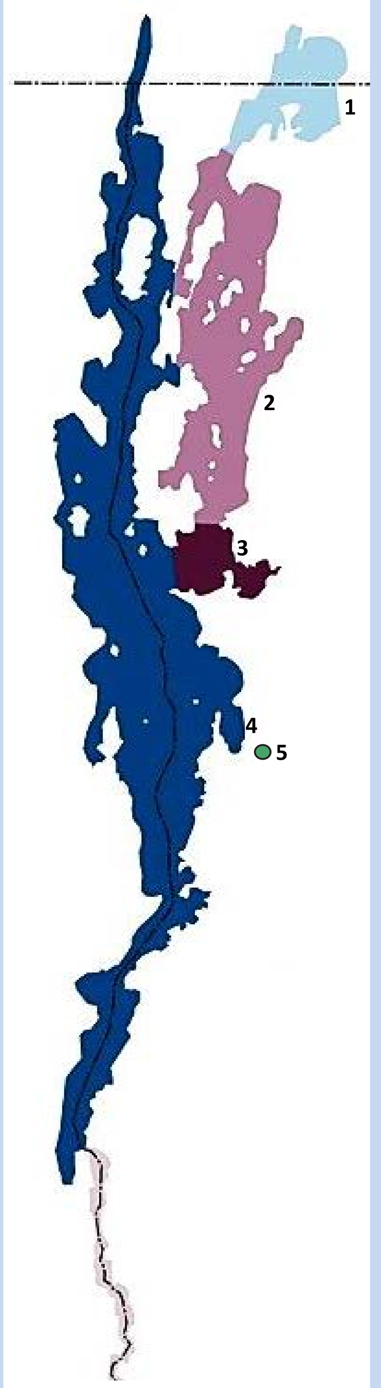

Figure 1: Lake Champlain sampling locations, Missisquoi Bay (1), Inland Sea (2), Malletts Bay (3), the Inland Sea (4) and Shelburne Pond (5). Figure from Lake Champlain Basin Program, www.lcbp.org.

References

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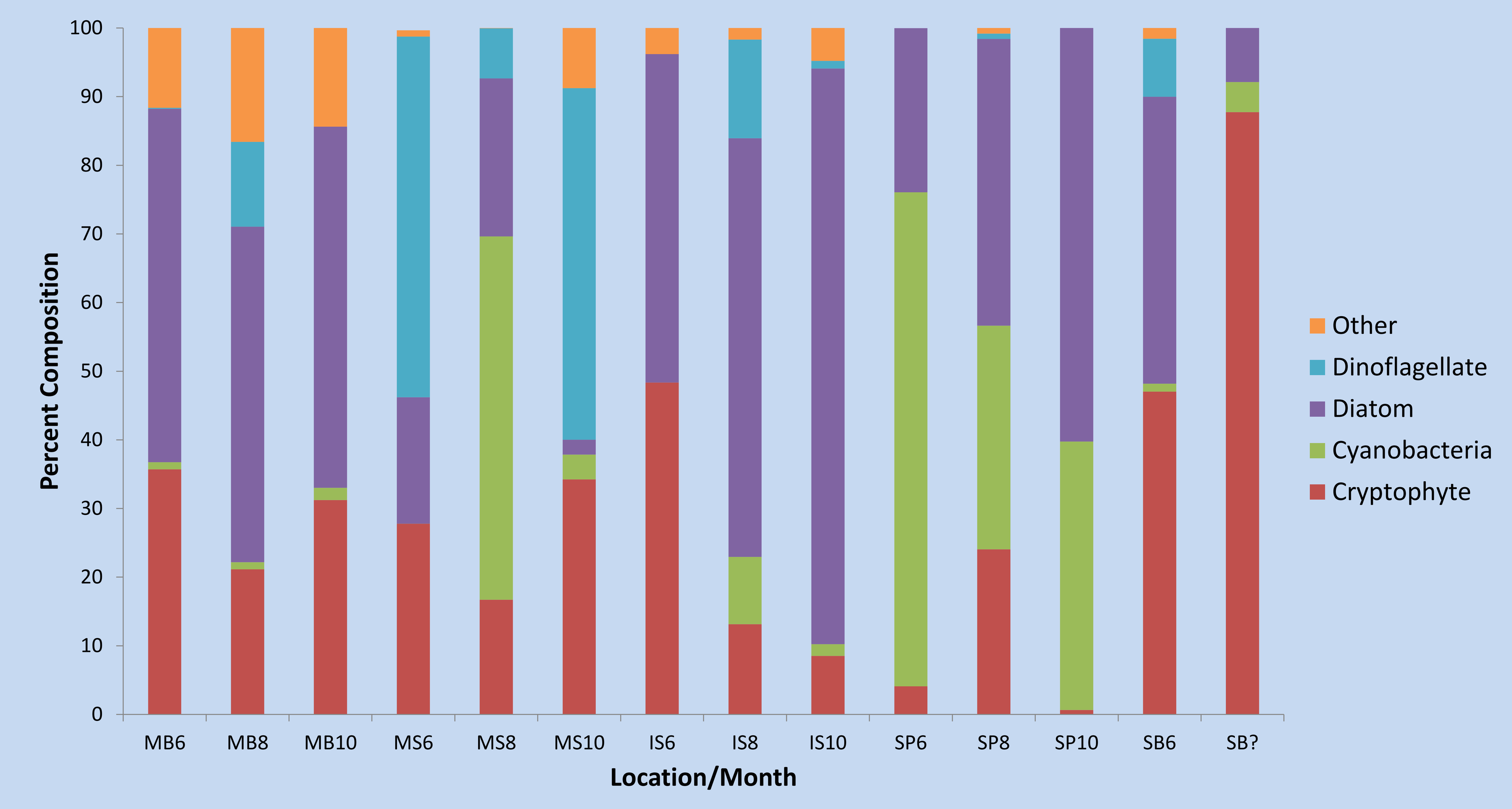


Figure 2: Percent of total phytoplankton biovolume made up by each taxonomic group for each testing event. Numbers in x-axis indicate month and letters indicate location (MB = Malletts Bay, MS = Missisquoi Bay, IS = Inland Sea, SP = Shelburne Pond, SB = Shelburne Bay).

Figure 3: Anabaena spp. colonies at Shelburne Pond

Figure 4: Diatom and cyanobacterial colonies at Shelburne Pond

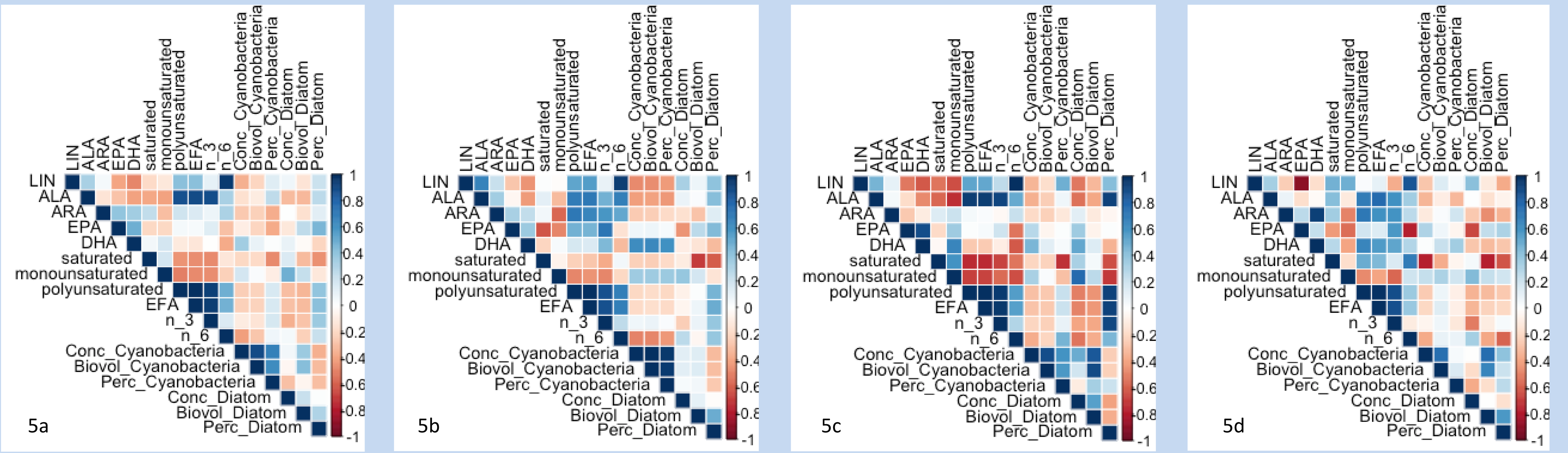
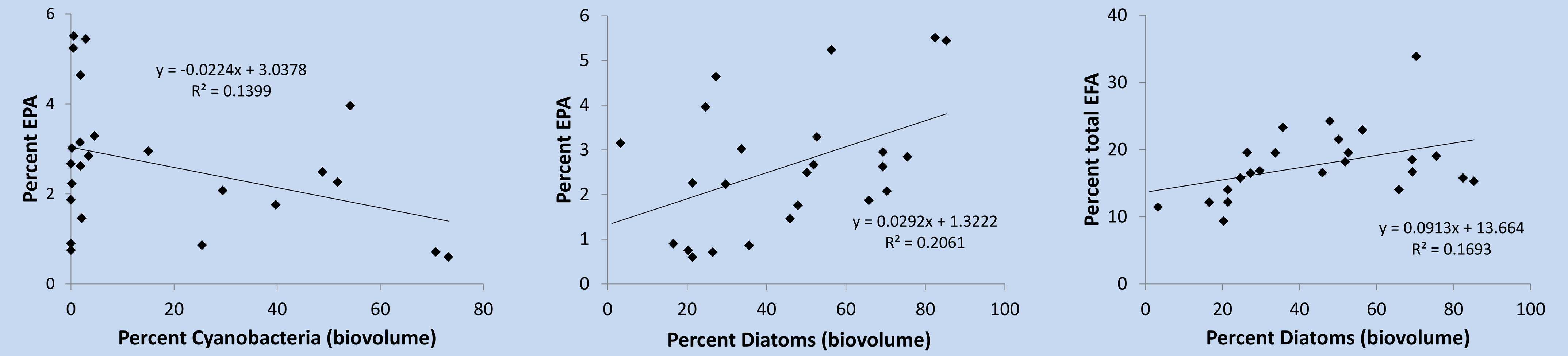


Figure 5: Heat maps show the level of correlation between levels different groups of essential fatty acids and metrics of phytoplankton. Figure 5a uses data from every sampling site, 5b uses just data from the main lake, 5c shows correlations for the more eutrophic sites of Missisquoi Bay and Shelburne Pond, and 5d shows the remaining less eutrophic sites. Red represents a negative correlation and blue represents a positive correlation, the brightness of the color indicates the strength of the correlation.

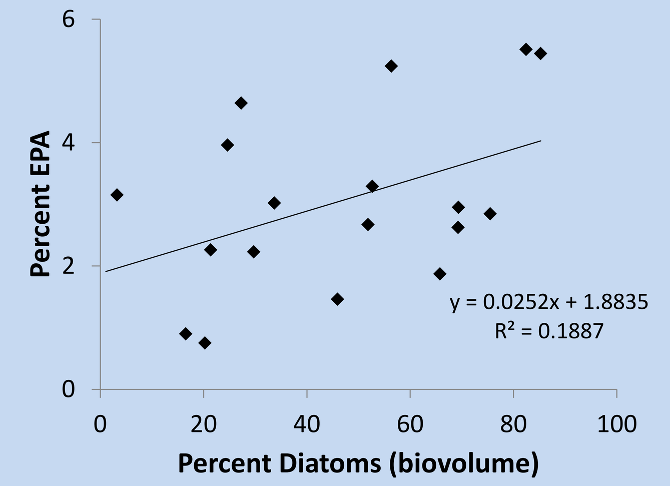


6a: Full data set, percent cyanobacteria versus percent EPA, p-value = 0.072.

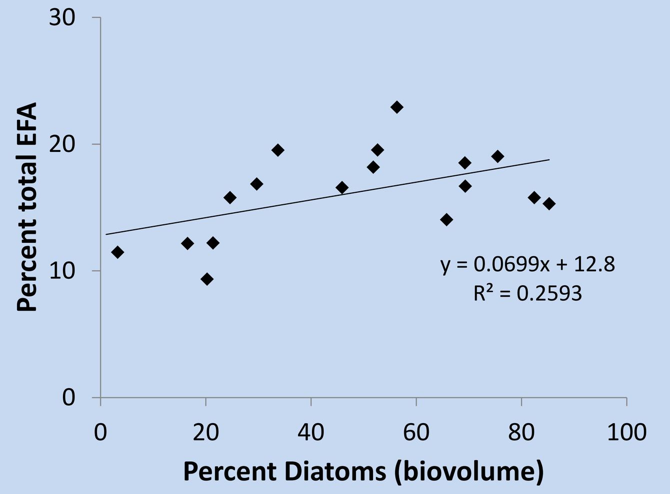
6b: Full data set, percent diatoms versus percent EPA, p-value = 0.026.

6c: Full data set, percent diatoms versus total essential fatty acids, p-value = 0.046

Figure 6: Regressions of the correlation between percent cyanobacteria and percent diatoms versus the percent of some fatty acid groups, including the essential fatty acid EPA as well as total essential fatty acids, for the all the sample sites as well as the Lake Champlain sites.



6d: Lake Champlain data, percent diatoms versus percent EPA, p-value = 0.072



6e: Lake Champlain data, percent diatoms versus total percent essential fatty acids, p-value = 0.037.

Results

Community Composition

- Cyanobacteria levels differed between the sites sampled with the highest percentages of cyanobacteria occurring in Shelburne Bay and Missisquoi Bay (p-value = 0.046, n = 13). Percent of total biovolume made up by diatoms also differed between locations (p-value = 0.024, n = 13) (Figure 2).

Fatty Acid Correlations

- As seen in Figure 6, when all sties were analyzed together percentage diatoms were positively correlated with EPA (p-value = 0.03), EFA (p-value = 0.04), and polyunsatruated fatty acids (p-value = 0.05); percent cyanobacteria was negatively correlated with EPA (p-value = 0.07), and saturated fatty acids (p-value = 0.02).
- When Lake Champlain data was analyzed separately the same trends were seen for diatoms as in the full data set (Figure 6), but correlations between diatoms and LIN (p-value = 0.09) and ALA (p-value = 0.08) were also tending toward significant (Figure 5).
- Regression of the eutrophic sites (Shelburne Pond and Missisquoi Bay) showed slightly different results than the same tests on the less eutrophic sites (Malletts Bay, Shelburne Bay, and the Inland Sea) (Figure 5c, 5d). In both of these groups diatoms were negatively correlated with saturated fatty acids (p-value = 0.02, p-value = 0.03), however in the eutrophic sites diatoms were positively correlated with ALA (p-value < 0.001), EFA (p-value <0.001) , and polyunsaturated fatty acids (p-value < 0.001).

Conclusions

Discussion

- Diatoms appear to be correlated with increasing total essential fatty acids in every division of this analysis, indicating that the diatom community is an important source of nutrition for higher trophic levels, especially in eutrophic systems.
- Cyanobacteria were negatively correlated with some essential fatty acids, which may indicate that cyanobacteria can be a supplemental food source, but does not provide all the necessary nutrition to higher level consumers.

Future Directions

- The next level of analysis would be to determine how changes in the ecosystem translate all the way through the food web.
- Potential study topics are the relationship between the phytoplankton community and ecological conditions, and the effect of phytoplankton community composition on the health of zooplankton and fish.

Error

- It is important to note that sampling was only done three times at each location. More frequent sampling over the course of the summer would help us better understand how phytoplankton and fatty acids vary through the whole growing season.
- The full data set is yet to be analyzed, when this work is completed correlations could change.

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