Seasonal Variation in Microbial Community Dynamics and Organic Matter in the Great Lakes

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Introduction

- Winter has been regarded as a period of relative dormancy in limnetic systems[1], characterized by low biological activity.
- Recent work has shown that microbial communities remain active during winter[2], and important biogeochemical processes still occur.
- We present work aimed at understanding the microbial ecology of the Laurentian Great Lakes during winter.

Hypotheses

- Microbial activity will vary across years, lakes, and seasons, with a depressed level of activity in winter, marked by a relative decrease in bacterial production.
- Dissolved organic carbon (DOC) and organic matter will vary across seasons and between lakes.
- Terrestrial inputs of DOM will be higher in spring and summer across lakes, as indicated by a higher specific ultraviolet absorbance at 254 nm (SUVA254).

Methods

- Bacterial production was measured via incubations with tritiated leucine and thymidine.
- Dissolved organic matter (DOM) was characterized using via fluorescence excitation-emission matrix spectroscopy.
- Humification index (HIX) calculated by following equation:

$$HIX = \frac{Area\ under\ eem\ spectra\ 435-480\ nm}{peak\ area\ of\ 300-345\ nm\ +435-480nm}\ at\ excitation\ 254\ nm$$

- Biological index (BIX) calculated by following equation:

$$BIX = \frac{emission\ intensity\ at\ 380\ nm}{emission\ intensity\ at\ 430\ nm}\ at\ excitation\ 310\ nm$$

- SUVA254 calculated by dividing absorbance coefficient at 254 nm by DOC concentration.

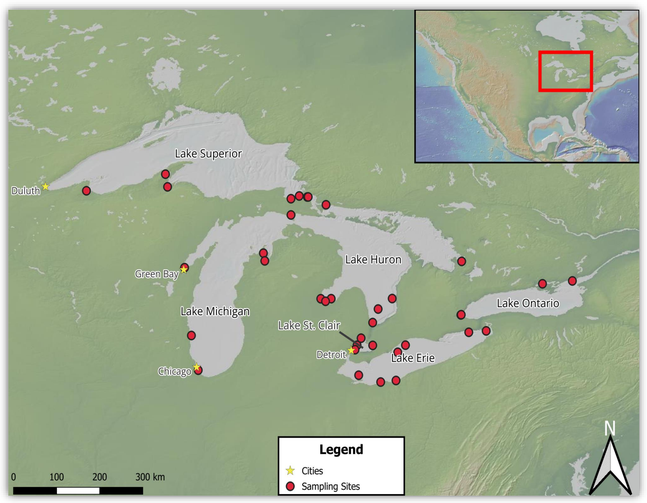

Figure 1. This map shows sites sampled from February 2024 to February 2025. A geographical reference of the Laurentian Great Lakes is shown in the upper right corner.

Dissolved Organic Carbon Concentration

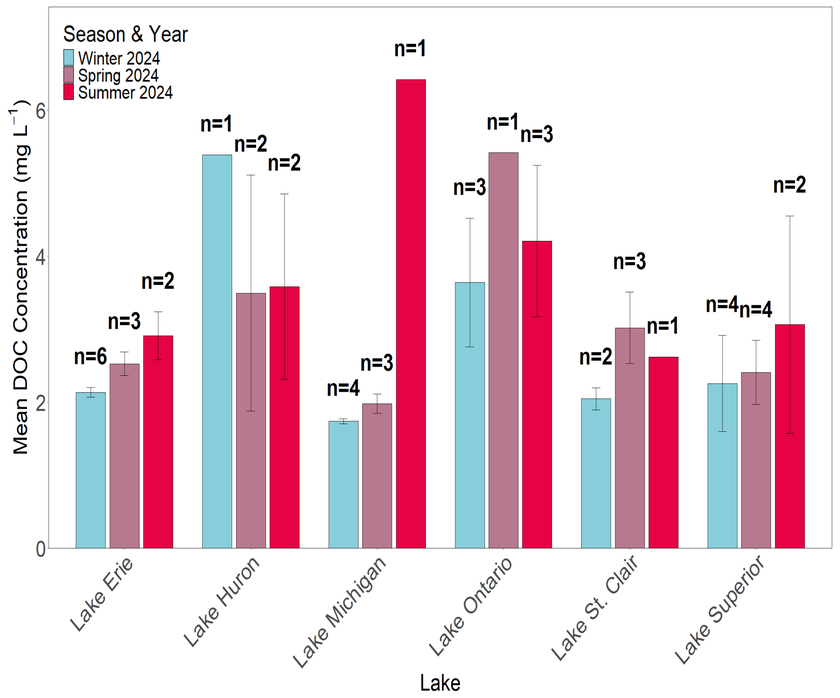

Figure 1. A bar chart showing mean DOC concentration by year and season for each lake. The error bars represent the standard error with the sample size shown above. Data for winter 2025 has not been analyzed yet and therefore not shown.

DOM Quality in Laurentian Great Lakes

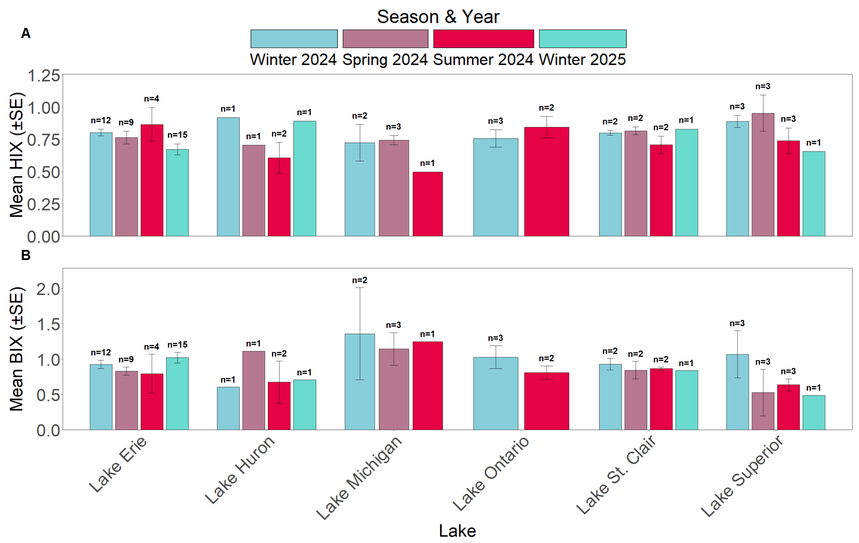

Figure 2. Bar charts showing average HIX (A) and BIX (B) values by year and season for each lake. The error bars represent the standard error of the mean with sample size shown above each bar. Higher HIX values indicate extent of humification, and higher BIX values indicate autotrophic productivity[3].

Terrestrial DOM Inputs

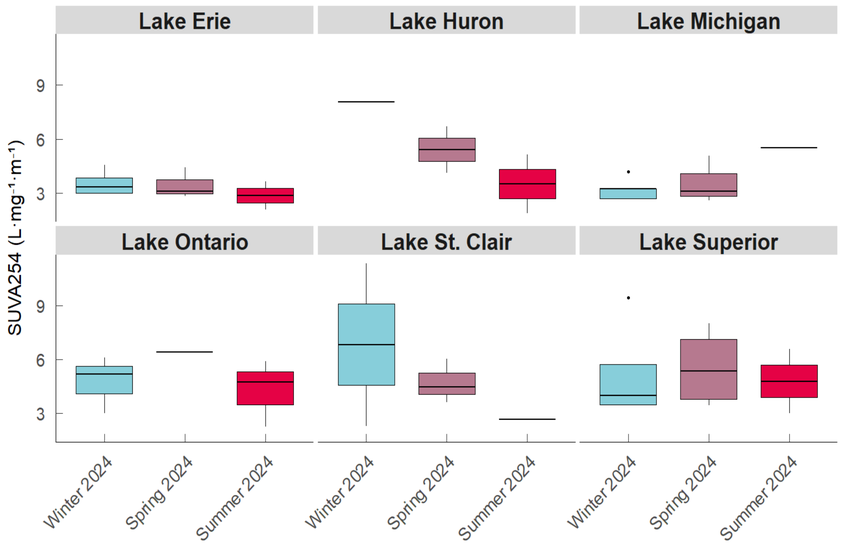

Figure 3. Box plots showing SUVA254, grouped by season and year for each lake. Higher SUVA254 values indicate tannin-like aromatic DOM, indicating terrestrial origin. Winter 2025 SUVA254 is currently being analyzed and therefore not shown.

Seasonal and Annual Bacterial Production

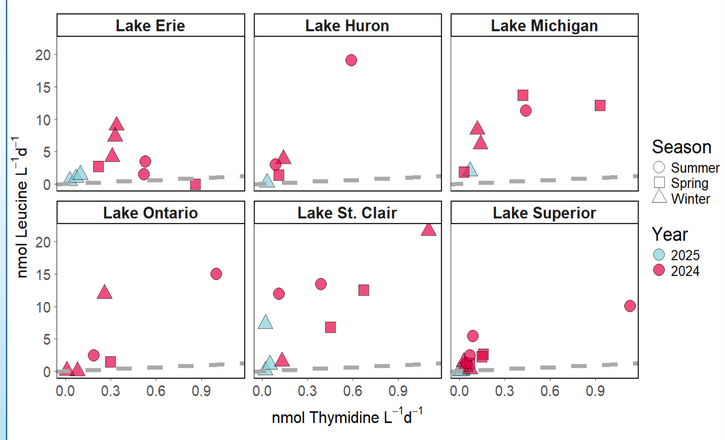

Figure 4. A series of scatter plots showing the relationship between leucine and thymidine uptake for each lake. Season and year are denoted by shape and color, respectively. Greater uptake of leucine relative to thymidine suggests bacterial maintenance over bacterial growth. The dotted grey line shows a 1:1 relationship.

Conclusions

- Lake Huron DOC concentrations were unusually high in winter, however the sample size is small. Summer DOC was consistently the highest across lakes (Figure 1).
- BIX values were more variable between lakes and seasons, indicating differences in autotrophic productivity linked to season and lake (Figure 2).
- HIX remained relatively stable year-round, with each lake displaying unique shifts in HIX, and summer often having the lowest values (Figure 2).
- In most lakes, winter had a higher SUVA254 value (Figure 3).
- Winter 2025 bacterial production was lowest across lakes. Summer and spring bacterial production were the highest, with a distinct shift to bacterial growth (Figure 4).

Future Directions

- Develop a model that includes biological, chemical, and physical parameters to predict microbial activity.
- Incorporate winter 2025 data into analyses.
- Use robust statistical tests like Kruskal-Wallis t-test to analyze difference of means (due to small sample sizes) to test if DOC concentration is different across seasons.

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