Diatom-based Paleolimnological Assessment of Long Term Water Quality Trends, near Forrest Island, Lake of the Woods, Ontario

Background

An important requirement for understanding environmental change is determining the “natural” or baseline condition for a given site. This paper aims to examine changes in biological communities preserved in lake sediments due to human activities.

Diatoms are single-celled silica algae of the class Bacillariophyceae that are reliable indicators in paleoclimatic studies for several reasons:

- Well preserved in sediments
- Rapid reproduction rate and rapid response to environmental change
- Narrow environmental optima
- Found in almost all aquatic environments

Diatoms can be used to reconstruct a lake’s environmental history by examining changes in biological communities preserved in lake sediments.

Methods

- 24.5 cm sediment core collected using a Gilson gravity corer and subsampled at 0.5 cm intervals using a Glow enhanced technique.
- Chronology established using 14C dating.
- Minimum of 600 diatom valves enumerated per slide for 34 sediment intervals.
- Data expressed as % relative abundances.
- Cluster analysis (CONISS) used to establish zones of change in diatom profile.
- Changes in water quality over the last 200 years assessed through diatom-inferred model for total phosphorus (DI-TP).
- Sedimentary data and analysis used to track historical trends in primary production.
- Trends in diatom assemblage composition summarized using Principal Components Analysis (PCA).

Results and Discussion

General Diatom Trends

- Distinct diatom changes observed over the last ~250 years (Figure 1A)
- Diatoms indicative of elevated nutrient levels common throughout core
- Earliest intervals (~pre-1900) have the highest abundances of Aulacoseira islandica
- Notable change in diatom assemblages (Zone 1 and Zone 2) over the last 90 years

Recent trends (ca. 1980-present)

- Increase in diatom taxa indicative of lower TP optima
- Cyclotella taxa appear in modest abundances
- Decrease in A. islandica values
- Greatest diatom change occurs at this time in Whitefish Bay (reference site)
- Pronounced increase in Cyclotella taxa and decrease in A. islandica taxa

Comparing diatom trends (Forrest Island) to temperature, lake-ice and Chl a

- Strong positive relationship between PCA axis 1 scores and winter temperatures
- Higher correlation between Chl a and temperature versus chlorophyll (mg/g dry weight)

Conclusions

- DiT trends suggest that the Forrest Island site was naturally somewhat nutrient-rich over the last 250 years, with no pronounced increase in DI-TP in the earlier part of the record (1840-1960) and then variable post-1960
- Diatom assemblage changes and DI-TP are not indicative of recent increases in TP at both the Forrest Island impact site and at the Whitefish Bay reference site
- Strong relationships between diatom trends and temperature and lake-ice records suggest that substantially warmer temperatures and longer ice-free periods (particularly over the last 40 years) have played an important role in diatom changes
- Whitefish Bay, however, showed strong relationships to recent warming and, as expected, diatom changes here were more pronounced
- Primary production (Chl a) increased at impact site
- Highly correlated to recent warming
- Likely tracking algal blooms
- Warmer temperatures together with already elevated TP may exacerbate algal blooms
- Collectively these data suggest that warming over the last few decades has been the main driver of the diatom changes.

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References

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