The Ecological History of Lake Ontario According to Phytoplankton

A compilation of historical phytoplankton research, aiming to determine impacts, remedial successes and future challenges for the lake.

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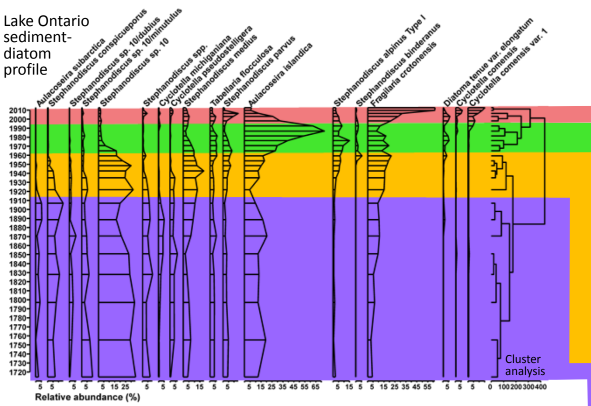
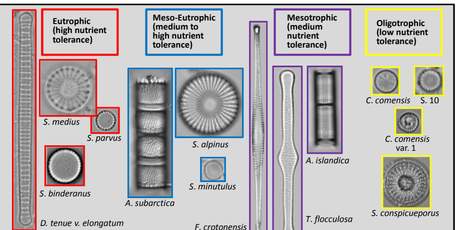


Common Lake Ontario diatoms and their environmental characteristics



We collected sediment cores from Lake Ontario in 2013 for a new long-term paleolimnological analysis (see stratigraphic plot, above).

1. BACKGROUND

Lake Ontario's ecosystem has been impacted by urban sprawl, chemical pollutants, agricultural intensification, land use changes, climate change effects, habitat loss and non-native species. We present a synthesis of long-term information to reconstruct past stressor impacts, remediation and trajectories of current changes. Paleolimnological and long-term monitoring studies, particularly those using **diatoms (above)**, reveal long-term changes, providing a rich understanding of multiple stressor effects on primary production including climate-driven change in lake ecosystems. In this poster we present preliminary analyses from a **sedimentary core analysis (above)** and monitoring data from recent decades. Approximate temporal zones were derived using cluster analysis of the sedimentary assemblages. Primary goals of this investigation are to support management of the lake through a retrospective of stressor impacts.

2. PRE-IMPACT

Prior to large-scale human impacts in the lake and its watershed, diatom microfossils accumulating in Lake Ontario's sediments had a range of nutrient tolerances, inferring that the lake was at least seasonally productive. Overall algal abundance was low and the relative abundance of some species with low nutrient tolerance (oligotrophic *Stephanodiscus* sp. #10 and *S. conspicueporus,* and the eurytopic/mesotrophic *Aulacoseira islandica*) dominated, indicating a prevailing condition of oligotrophy to mesotrophy. During the 1800s gradual eutrophication occurred with early deforestation, agriculture and industry, as indicated by the increase in nutrient tolerant *Fragilaria crotonensis* and several *Stephanodiscus* species.

THIS IS HISTORY, SO START HERE AT THE BOTTOM!

3. EARLY IMPACTS

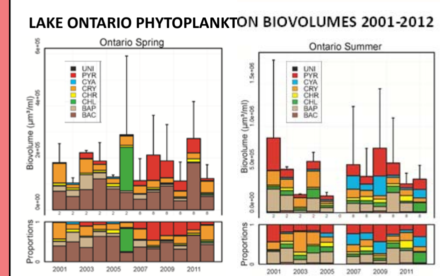
Shoreline towns quickly became urbanized, industrial centers and lake waters experienced increased concentrations of industrial and municipal waste. An increase in phosphorus loading to Lake Ontario beginning in the late 1940s came from phosphate-based detergents, expanding domestic sewering and agriculture. Nutrient-tolerant diatoms such as eutrophic *Stephanodiscus binderanus* and mesotrophic *Fragilaria crotonensis* increased in concord with compounding anthropogenic stressors.

4. MAJOR IMPACTS AND AWARENESS

By the 1960s cultural eutrophication was a major problem. In our sediment core the increase in productivity appeared as an increase in the abundance of *Aulacoseira islandica*. At this time remedial measures intensified, including better sewage treatment and removal of phosphates from detergents. Non-native, filter feeding mussels also invaded the lake in the later years of this period

5. REMEDIATION AND NEW STRESSORS

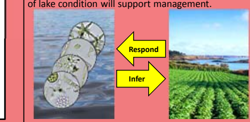
With the onset of nutrient loading reductions and extensive invasion by non-native mussels (late 1980s/early 1990s) algal blooms and eutrophic species decreased. Filter-feeding by mussels reduced water column nutrients and by the late 1990s algal production was significantly reduced. Increases in several species from the genus *Cyclotella*, and a decrease in *Aulacoseira islandica* suggest lower nutrients. These *Cyclotella* species are also well-known indicators of recent, rapid lake warming, and in Lake Ontario there is a clear correlation with recent increases in atmospheric and water temperatures and longer ice-free periods. Open water phytoplankton data collected from 2001 through 2012 by the US EPA's Great Lakes monitoring program (histograms, right) indicate that the phytoplankton are reorganizing. Greater numbers of centric diatoms, particularly eutrophic *Stephanodiscus* and large dinoflagellates dominated during the spring. Eurytopic *Fragilaria crotonensis* comprised more of the summer assemblage relative abundance along with blue-green algae, particularly *Aphanocapsa* sp., which increased in 2012. The numeric dominance of small-celled centric diatoms and blue-green algae may be due to the selective effect of the still-growing mussel population. Clearly this is a complex, multi-stressor ecosystem. Hence, we are currently applying a diatom-based indicator approach that combines modern and paleolimnological data to address issues requiring long-term data for water quality management and remedial decisions.



These histograms reflect basin-wide phytoplankton average biovolume across samples collected from 2001 through 2012 in Lake Ontario. Numbers below each bar indicate the number of samples averaged. Taxon group codes are: BAC = centric diatoms, BAP = pennate diatoms, CHL = chlorophytes (green algae), CHR = chrysophytes, CRY = cryptophytes, CYA = cyanobacteria (blue-green algae), PYR = pyrrophytes (dinoflagellates), and UNI = unidentified and unidentifiable entities.

Water sampling on RV Lake Guardian for modern diatom assemblages and environmental data.

We are calibrating the modern diatom species from the monitoring program to environmental measurements. Species-environmental information will then be applied downcore on fossil diatom data to reconstruct long-term water quality and food web changes. Ultimately, tracing the historical trajectory of lake condition will support management.



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