Project Name: Circum-Arctic perspectives on climate change from Arctic Lakes

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Summary
The absence of long-term climatic and other environmental monitoring data in the Arctic requires that indirect proxy methods be used to reconstruct these missing data sets. Arctic lake sediments have been used to infer past changes and can be used to detect changes in the future. However, records are disparate and the IPY presents a unique opportunity for us to share existing data and to collect new data with the overall aim of gaining a further understanding of recent climate change.

Arctic lakes and ponds only cover a small proportion of the landmass of the Arctic yet they are valued by local people for their fishing resources, for transportation and for water supply. In addition, many aspects of the lakes are interesting to scientists and we are particularly interested in how they reflect the current environmental conditions and how they can be used to assess how these conditions have changed over time.

Arctic lakes are especially sensitive to climate change, as even slight temperature and precipitation shifts may result in amplified limnological and associated ecological responses. Climate affects the lakes through a multitude of mechanisms that directly influence the biology of the aquatic communities. Especially important factors include the presence and duration of ice and snow cover, microhabitat availability, length of growing season and the amount of stratification. The fossil remains of plants and animals preserved in lake and pond sediments can thus be used to show how the biology, and by inference, the climate has changed through time. In the most extreme sites, ice- and snow-cover plays a dominant role in determining species distributions, including substrate availability, whereas the onset and duration of thermal stratification becomes more important in subarctic regions. Climate variables though are not the only forcing factors influencing these aquatic ecosystems; pollution impacts (such as local eutrophication and acidification) and UV changes are also important. In addition, the effects of fishing may be critical in certain systems.

The sediments of Arctic lakes are archives of the past as they can be sampled and analysed to examine changes in, for example, climate, pollution and human activity. Scientists have used a wide variety of techniques to examine such changes. Using evidence from fossilized algae (diatoms and chrysophytes) in lake sediments, researchers from around the Arctic have identified signs of marked environmental changes in a variety of lakes of different depths and type. However, there has been little systematic attempt to synthesise the information, to identify areas of greatest change and to test hypotheses regarding forcing factors.

Preliminary attempts at synthesis are presently underway and we have tried to collate the results of diatoms, chironomids and chrysophye cysts from lakes in Svalbard, Russia (Urals and Kola Peninsula), Canada (Nunavut: Ellesmere Island, NWT: Melville Island, Labrador, Quebec) and Finnish Lapland for a period of the last 200 years. Numerical analyses (Detrended Canonical Correspondence Analysis) have been used to quantify the amount of compositional change that has occurred. We see that areas such as Svalbard, European Russia, Lapland, and Ellesmere Island show more compositional change than lakes on Baffin, N. Quebec and Northern Labrador. Although these changes are neither synchronous nor geographically uniform, the sites located in areas of recent climate warming have shifted directionally to new ecological states characterized by increased diversity and production of siliceous algae (diatoms and chrysophytes), as well as striking changes in species assemblages. Chironomid invertebrate remains have also recorded marked assemblage changes in the few polar paleolimnological studies where these bioindicators have been examined. The remoteness of our sites, as well as the nature of the biological shifts, strongly implies that recent climatic warming is primarily responsible for these ecological changes through prolongation of the summer growing season. However, paleolimnological data are only available from relatively few lakes and ponds and the spatial coverage of sites is still sparse with large gaps in extensive parts of the Arctic (e.g. large parts of Russia and Canada, Greenland and Alaska). These gaps need to be filled by a combination of collating existing data and also new field campaigns.

Our data suggest that the opportunity to monitor truly pristine arctic ecosystems is rapidly disappearing. Changes are dramatic: two to three times greater than changes noted in ‘control lakes’ from temperate regions. Many arctic lakes and ponds are dramatically different ecosystems than those that existed in the early-nineteenth century. Using a weight-of-evidence approach, we hypothesise that recent climatic warming has been an important driver of these large-scale changes.

The proposal thus has a number of aims

- Identify additional sites where palaeolimnological data (diatoms, chironomids, chrysophytes) are already available and collate these data in a database with a GIS interface.
- Core new sites in areas where we have no lake records for recent environmental change.
- Conduct numerical analysis of sediment records to identify rates of change and spatial patterns of change.
- Use palaeolimnological and monitoring data to explore the mechanisms of the unprecedented recent changes. For example, using data from a network of sites across the Arctic to understand the long-term dynamics of AO/NAO.
- Monitor key sites in order to further understand the impacts of climate on aquatic systems. It is essential to link the limnological and biological data with watershed/lake biogeochemical processes and weather/climate changes.
- To involve local stakeholders in monitoring.
- Facilitate data exchange by setting up workshops for taxonomic harmonisation, and the production of floras and faunas.
- Training of young scientists in innovative palaeolimnological and numerical methods.
- Encourage close interaction between palaeolimnologists and other members of the scientific community especially climate and sea-ice modelers, and ice-core scientists.
- Encourage bipolar comparisons with recent palaeolimnological records from Antarctic lakes