Southampton Island: frontier in a rapidly changing Canadian Arctic ?

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INTRODUCTION

Paleolimnological studies into the recent (ca. last 200 years) history of northern lakes have revealed a striking discrepancy between climatic trends inferred for regions roughly located north and south of the Foxe Basin and Hudson Strait (Pienitz *et al.,* 2004[1]; Smol *et al.,* 2005[2]). While most freshwater ecosystems show signs of pronounced changes associated with global warming in the High Arctic, these changes are not yet detectable in lakes and ponds of northern Québec and Labrador. This remarkable stability at timescales of decades and hundreds of years suggests that northern Québec and Labrador lakes may experience less short-term or delayed climate change relative to other sectors within the Canadian Arctic. However, monitoring of permafrost temperatures now documents warming in the northernmost Ungava Peninsula since about 1995 (Allard *et al.*, unpublished), and climate models imply that these differences in climate change may disappear during the coming decades by which time the freshwater ecosystems surrounding the Foxe Basin region will be subjected to the climate impacts that are well advanced in other regions. They should therefore offer a unique opportunity for monitoring of these changes at high resolution and great detail.

Southampton Island constitutes a key area for understanding the catastrophic collapse of the Laurentide Ice Sheet over Hudson Bay between 8400 and 8000 years BP; however the only available information for this region stems from a preliminary investigation of the Quaternary geology of the island (Bird, 1953[3], 1970[4]). Paleoenvironmental and paleoclimatic data are thus needed to improve our understanding of the climatic variability in northern Hudson Bay and the Foxe Basin, as well as establish a framework for further research into the history, processes and products of deglaciation and relative sea-level changes in this region.

OBJECTIVES

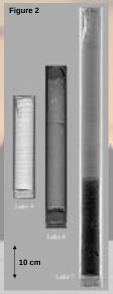
A major objective of this research initiative is to generate paleoclimate proxy data and monitor limnological change in northern Hudson Bay and the Foxe Basin. As part of the Northern Lake Monitoring Network maintained by the Paleolimnology-Paleoecology Laboratory at Centre d'Études Nordiques, specialized equipments (data loggers) have been installed in the water column of selected lake and pond sites that will generate precious baseline data for regions with serious limnological and environmental data gaps. This research provides a unique opportunity to follow and assess the impact of seasonal variability on northern lake ecosystems and their aquatic biota. Such comprehensive limnological surveys with field process studies permit developing robust, quantitative relationships between hydroclimatic and limnological variables and sedimentation processes. They are therefore of tremendous benefits for our paleoenvironmental interpretations in these remote northern regions.

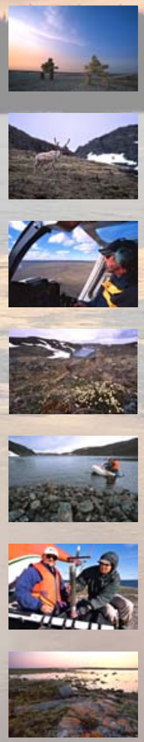
STUDY SITES AND METHODS

Figure 1

In July 2004, a first limnological survey of lake and pond ecosystems has been completed on the eastern part of Southampton Island (*Fig. 1*). A total of 8 sediment cores (max. 1.2 m length) were taken from lakes, some of which revealed finely laminated (varved) sediments (Lake 4) and postglacial marine clays (dark area Lake 7) (*Fig. 2*).

Water and surface sediment samples were shipped to the National Laboratory for Environmental Testing (D. Muir, Environment Canada, Burlington) where they are presently being analysed for chemical composition and contaminants.

Figure 2




Transfer Functions

Based on the limnological conditions and fossil contents of the surface sediment of lakes sampled along different transects, past environmental variables such as pH and mean August air temperature (T°) were respectively inferred using two transfer functions developed for the Baffin Island (Diatoms) and the north-western part of Quebec (Chironomids) (Joynt and Wolfe, 2001[5]; Larocque *et al.*, in press[6]). Other variables such as dissolved organic carbon (Fallu and Pienitz, 1999[7]), water color and alkalinity (Fallu *et al.*, 2002[8]), conductivity, mean summer water temperature and mean annual air temperature (Joynt and Wolfe, 2001[5]) were inferred using the same method.

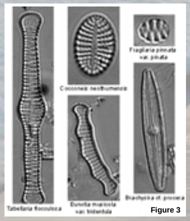


Figure 3

Diatoms analysis (Laperrière and Pienitz)

Diatoms are siliceous algae that are sensitive to changes in environmental conditions and preserve well in lake sediments (*Fig. 3*). They are well represented in the Arctic because of the high number of lakes and ponds and they can be identified to the species level.

Diatom sample preparation followed techniques mentioned in Hay *et al.* (2003)[9]. In Lakes 4 and 7, 35 and 46 samples respectively were analysed with a LEICA DMRX microscope at a magnification of 1000X with oil immersion. A minimum of 500 diatom valves were counted and identified in each sample. Chrysophycean cysts were counted to calculate a percentage between the total number of chrysophytes counted and the total number of diatoms (Smol, 1985[10]).

Chironomids and Sedimentological Analysis (Rolland, Larocque and Francus)

Chironomids (*Fig. 4*) are non biting midges that spend their larval cycle on the surface of lake sediments (*Fig. 5*). Once or more a year, they accomplish reproduction using an aerial life adult stage (Fig 4) that lives only for a couple of hours and that is very sensitive to air temperature. This environmental driving force is very important as numerous of chironomid species have a very broad thermal range. Changes in the chironomid species along a sediment core will then described a change in the air temperature.

Chironomid head capsules were picked from the sediment and fixed in Hydromatrix mounting medium on a microscope slide. Standard taxonomic procedures were used for identification.

Sedimentological analysis will include X-ray, microfluorescence-X, structure (lamination) and texture (grain size and orientation using image analysis) of sediment to reconstruct past hydrological variations such as precipitation.

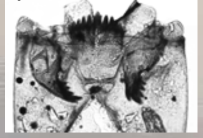
Figure 4



Figure 5

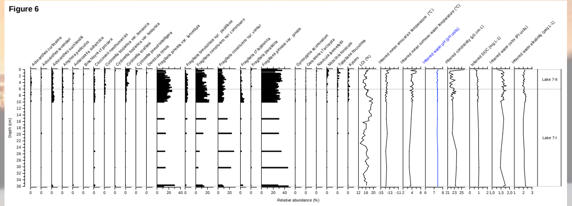
PRELIMINARY RESULTS

The core sediment samples have been analysed for sediment characteristics (particle-size analysis, organic matter content, etc.) and their microfossil (diatoms, chironomids) records.

The diatom assemblages found in Lake 7 (*Fig. 6*) were more representative of pH-circumneutral conditions and oligotrophic waters. The measured pH value in July 2004 was 7 (*in blue*). The dominant species were *Fragilaria pinnata* and other *Fragilaria* spp. which are representative of glacial environments.

Diatom assemblages in Lake 4 (*Fig. 7*) are dominated by acidophilic species commonly found in cold and alpine regions. The pH value in the lake varied between 5 and 6 in July 2004 (*in blue*). The diatom assemblages were dominated by the species *Achnanthes kriegeri*, *Aulacoseira subarctica* and *Tabellaria flocculosa*.

The assemblages of both Lakes 4 and 7 did not show any signs of major changes in the study region.

Figure 6


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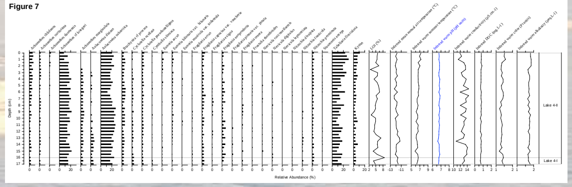
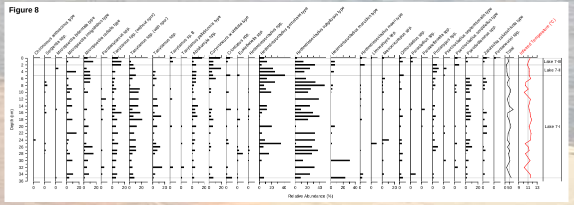
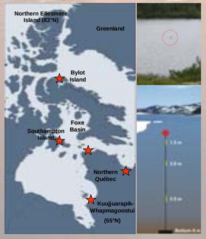


Figure 8


Chironomid assemblages in lake 7 (*Fig. 8*), are dominated by Orthocladinae, a sub-family that is typically encountered in dry and cold tundra environments. Inferred August air temperature (*in red*) show slight variations but these remain within the limit of the model error (i.e. RMSEP = 1,17°C, r_{jack} = 0,82).

Therefore, Chironomids do not show any signs of recent increases in the air temperature within the study region.



Temperature data loggers were installed in the central part of Lake 6 (Tasialuk) located 0.5 hours (helicopter time) east of Coral Harbour and that will be retrieved on a yearly basis over the next ten years. Data logger retrieval in July 2005 was accompanied by water column sampling and profiling (e.g., for observations of changes in thermal structure, pH, oxygenation, specific conductance, etc.).

Actual temperature profiles (*Fig. 9*) do not show any stratification during the ice free period (correlation for June to September between epilimnion and hypolimnion $r^2 = 0.9636$ $p < 0.0001$).

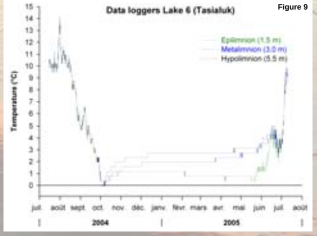


Figure 9

Acknowledgements and References

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[1] Developments in Paleoenvironmental Research (DPER) Series, vol. 8, Springer-Verlag, Dordrecht/Berlin/Heidelberg/ New York, 562 pp. ISBN 1-4020-2125-9. [2] Proceedings of the National Academy of Sciences 102: 4397-4402. [3] Southampton Island. Mem 1. Geog. Br. Can. [4] .[5] Can. J. Fish. Aquat. Sci.58(6): 1222-1243. [6] Can. J. Fish. Aquat. Sci.63(x). [7] Écoscience, 6(4): 603-620. [8] Can. J. Fish. Aquat. Sci.59(2): 329-349. [9] Marine Micropaleontology 48: 291-320. [10] Hydrobiologia 123: 199-208.