J Paleolimnol
DOI 10.1007/s10933-007-9178-y

ORIGINAL PAPER

Rapid 20th century environmental change on northeastern Baffin Island, Arctic Canada inferred from a multi-proxy lacustrine record

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Received: 14 August 2007 / Accepted: 18 November 2007
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Abstract The Arctic has a disproportionately large response to changes in radiative forcing of climate, and arctic lacustrine ecosystems respond sensitively to these changes. The goal of this research is to generate high-resolution climate records for the past two millennia using multiple proxies in order to place 20th and 21st century climate and environmental change into a long-term context. We use a ^{14}C- and ^{210}Pb-dated surface core from Lake CF8 on northeastern Baffin Island, Arctic Canada to generate a high-resolution multiproxy reconstruction of climate and environmental change. Throughout the late Holocene, primary productivity in Lake CF8 was low, but increased almost 20-fold in the past 200 years. Insect (Chironomidae) assemblages also show dramatic changes since 1950 AD, with cold stenothermous chironomid taxa disappearing from the record altogether. These changes in productivity and chironomid assemblages are unprecedented in the past 5,000 years. The dramatic ecological shifts that occurred at Lake CF8 have also been observed elsewhere in the Arctic, and will likely continue at ever-increasing rates as anthropogenic inputs of green house gases continue to cause climate warming and enhanced lacustrine primary production.

Keywords Chironomids · Climate change · Late Holocene · Anthropocene · Arctic · Lake sediments · Paleolimnology

Introduction

Reconstructions of past environmental conditions provide a context for present and future climate change and bolster our understanding of natural climate variability. High latitude regions are exceptionally susceptible to anthropogenic warming due to cryosphere-albedo feedbacks involving changing sea ice, boreal forest, and glacier extents (Overpeck et al. 1997; Smol et al. 2005; Chapin et al. 2005; Smol and Douglas 2007). Changes in the Arctic are of global interest because they have the potential to affect the global climate system, including influencing thermohaline circulation and causing sea level rise (IPCC 2007; Shepherd and Wingham 2007).

The past two millennia encompassed a large range of climate variability with well documented, but not widely quantified, climatic periods (e.g. the Medieval Warm Period (ca. 1100–1200 AD) and the Little Ice Age (ca. 1250–1850 AD); Bradley 2000). The past two millennia experienced natural forcings similar to today (i.e. solar variability, Crowley 2000). High-resolution (i.e. annual to sub-centennial scale) quantitative records of climate during this period provide insight into pre-instrumental climate variability at scales that allow comparison to instrumental records,

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which in the Arctic often extend back only a half-century (Environment Canada 2007). Lake sediments are valuable archives of environmental change because lakes are widespread in the Arctic and their sediments are often continuous and datable (e.g. Wolfe et al. 2004). Furthermore, multiple chemical, physical and biological proxies can be extracted from lake sediments and analyzed to provide highly resolved, reliable indicators of past climate (Pienitz et al. 2004). In addition, several proxies (i.e. chironomids, isotopes, varves and biomarkers) can be used to infer paleo-temperatures.

High-resolution quantitative climate records of the past two millennia are sparse in the Arctic (Jansen et al. 2007). On Baffin Island, there are several millennial-scale quantitative Holocene climate records (e.g. Briner et al. 2006; Francis et al. 2006; Axford 2007) and a few high-resolution quantitative climate records for the late Holocene (Hughen et al. 2000; Moore et al. 2001; Wolfe 2003). This study utilizes sediments from Lake CF8 on northeast Baffin Island to produce a continuous, sub-centennial scale climate record for the past two millennia using chironomids in conjunction with multiple qualitative climate proxies. The resulting record allows us to address whether recent warming trends recorded by instrumental records are within the natural climate variability of the past two millennia.

Setting

Lake CF8 (70°33′ N, 68°57′ W) is situated at 195 m above sea level on the Clyde Foreland, a coastal lowland in the Mid Arctic environment of northeastern Baffin Island (Fig. 1). The lake is 13 km from Baffin Bay and 17 km from the hamlet of Clyde River, which reports a mean annual temperature of −12.8°C, a mean July temperature of 4.4°C and mean annual precipitation of 233 mm year^{-1} (Environment Canada 2007). Lake CF8 is a through-flowing lake with a surface area of 0.3 km^2. The lake basin is 10 m deep and lies in a 1.5 km^2 drainage basin with an ephemeral inflow. Extensive periods of seasonal snow and ice cover characterize Lake CF8, with the ice-free season lasting only 2 or 3 months (between July and September). Lake CF8 is similar in physiography and geology to other lakes near Clyde River and elsewhere on Baffin Island that are characterized by oligotrophic, highly dilute, slightly acidic water (e.g. Wolfe 1996; Miller et al. 1999; Wolfe et al. 2000; Michelutti et al. 2005; Briner et al. 2006).

Methods

In May 2005, a 25-cm-long surface core with an intact sediment–water interface was obtained from the deepest part of Lake CF8 using a 9.5-cm-diameter percussion-piston surface corer. The surface core was sectioned in the field at 0.25 cm increments using an upright extruding device. Each sample bag was weighed before and after freeze-drying for wet and dry bulk density and hydroscopic moisture calculations. Percent loss-on-ignition at 550°C (LOI; e.g. Dean 1974; Heiri et al. 2001) was measured every 0.25–0.5 cm.

Bulk samples from Lake CF8 sediments were analyzed for stable carbon (%C) and nitrogen (%N), isotopes of carbon (δ^{13}C) and nitrogen (δ^{15}N) and

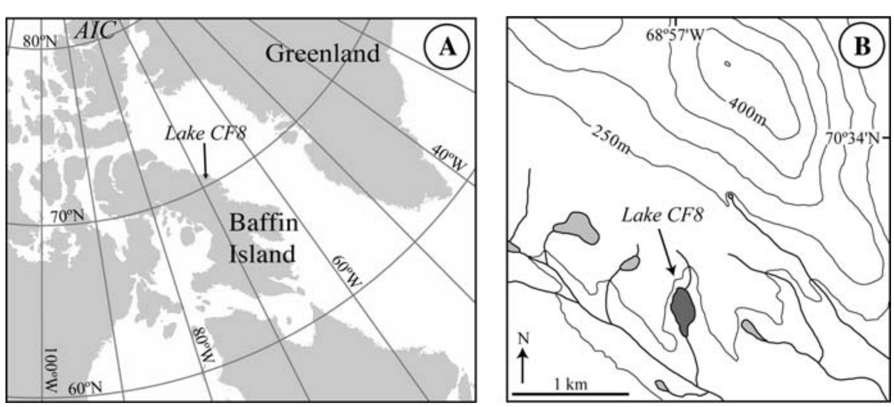

Fig. 1 (**a**) Northeastern North America showing Baffin Island and location of Lake CF8. AIC = Agassiz Ice Cap. (**b**) Lake CF8 and surrounding catchment. Fifty meter contour intervals. Lake CF8 is colored darker than surrounding lakes

biogenic silica (%$BSiO_2$) every 0.25 cm for the top 10 cm and every 0.5 cm thereafter ($n = 70$). For carbon and nitrogen analyses, an aliquot (15–25 mg) of each freeze-dried sample was combusted to CO_2 and N_2 at 1,000°C in an on-line elemental analyzer (PDZEuropa ANCA-GSL) at the UC Davis Stable Isotope Facility. The gases were separated on a Carbosieve G column (Supelco, Bellefonte, PA, USA) before introduction to a continuous flow isotope ratio mass spectrometer (20–20 mass spectrometer, Sercon, Crewe, UK). Standards were analyzed (every 12th sample, $n = 19$) to evaluate the precision throughout the analyses, which was 0.06‰ for $\delta^{13}C$, 0.3% for %C, 0.15‰ for $\delta^{15}N$ and 0.1% for %N, ($\pm 1\sigma$). An aliquot (50–75 mg) of each freeze-dried sample was weighed into a 50 ml centrifuge tube and sent to Northern Arizona University where $BSiO_2$ was analyzed following the methods described by Mortlock and Froelich (1989). A HACH DR/2000 spectrophotometer was used to measure $BSiO_2$ concentration, which was then converted to weight percent SiO_2 of dry sediments. Analytical precision of $BSiO_2$ measurements was approximately 3%. The $BSiO_2$, C and N fluxes were calculated by multiplying concentration by sediment dry density and then dividing by the length of time represented by a sample. Sediment dry density is highly variable between samples, probably due to volumetric differences caused during subsectioning the core in the field. We therefore took a five-point running mean of the dry density to generate values used in sedimentation rate and flux calculations.

Chironomids (non-biting midges, Diptera: Chironomidae) were analyzed every 0.25–2.5 cm ($n = 17$) in the top 12 cm of the sediment core. Sediment samples selected for chironomid analysis were deflocculated with warm 5% KOH for 20 min and rinsed on a 100 µm mesh sieve. Head capsules were manually picked from a Bogorov sorting tray under a 40× power dissecting microscope, then permanently mounted on slides using Euparal. All samples contained at least 50 whole identifiable head capsules. Taxonomic identifications followed Brooks et al. (2007) with reference to Oliver and Roussel (1983) and Wiederholm (1983). The transfer function used to estimate chironomid-inferred summer water and mean July air temperatures is based on a training set of modern samples from 68 sites spanning from the Canadian High Arctic to the northeastern USA, including 31 sites on Baffin Island (Walker et al. 1997; Francis et al. 2006). All taxa found in the subfossil assemblages were also found in this modern training set. The model used for reconstructions is a weighted averaging regression with inverse deshrinking and tolerance down-weighting, and cross-validation by jackknifing (Francis et al. 2006). Temperature inferences are made using the computer software C2 Version 1.4.3 (Juggins 2007). For summer water temperature, the model has an r^2 of 0.88_{jack} and root mean square error of prediction of 2.22°C.

Principal components analysis (PCA) is an ordination technique that reduces multivariate data sets to several derived variables and is useful for visualizing major gradients in the data. PCA was undertaken for five downcore environmental variables (%C, C:N, $BSiO_2$, $\delta^{15}N$ and $\delta^{13}C$). Because %C and %N are highly colinear downcore ($r^2 = 0.88$), %N was excluded from the analysis. PCA was conducted using the statistical software package R v 2.5.1, with data scaled symmetrically.

The core chronology is based on a ^{210}Pb profile and three accelerator mass spectrometry (AMS) ^{14}C measurements on pieces of aquatic moss. Alpha spectroscopy at MyCore Scientific, Inc. was used to determine ^{210}Pb activity, and sediment age was calculated by applying the constant rate of supply (CRS) model to the unsupported ^{210}Pb inventory (Appleby and Oldfield 1978). Aquatic moss samples for ^{14}C dating were picked and washed at the University at Buffalo Paleoclimate Lab, prepared at the INSTAAR Laboratory for AMS Radiocarbon Preparation and Research at the University of Colorado and measured at the W.M. Keck Carbon Cycle AMS Facility at the University of California, Irvine.

Results

An age-depth model was developed using the ^{210}Pb CRS model for the uppermost sediments and two second-order polynomial regressions constrained between (1) the oldest ^{210}Pb age and the youngest ^{14}C age and (2) the three ^{14}C ages (Table 1, Fig. 2). The resulting model shows decreasing sedimentation (dry g cm^{-2}) throughout the past 3,800 years and an increase in sedimentation during the past 200 years (Fig. 2). We focused our analyses on the top 12 cm of sediment, which encompass the past 2,400 years (Fig. 2).

Table 1 Radiocarbon ages from Lake CF8

Midpoint depth (cm)	Material dated	Fraction modern	Radiocarbon age (^{14}C year B.P.)	Calibrated age (cal year B.P. ± 1σ)[a]	δ^{13}C (‰ PDB)	Lab number[b]
5.875	Aquatic moss and insect exoskeletons	0.8881 ± 0.0038	955 ± 35	860 ± 64	−24.6	8269
16.875	Aquatic moss	0.7049 ± 0.0015	2810 ± 20	2910 ± 33	−18.3	8138
25.5	Aquatic moss	0.6518 ± 0.0014	3440 ± 20	3680 ± 39	−9.8	8141

[a] Calibrated according to Stuiver and Reimer (1993) and CALIB 5.0.2

[b] CURL number from the INSTAAR Laboratory for AMS radiocarbon preparation and research

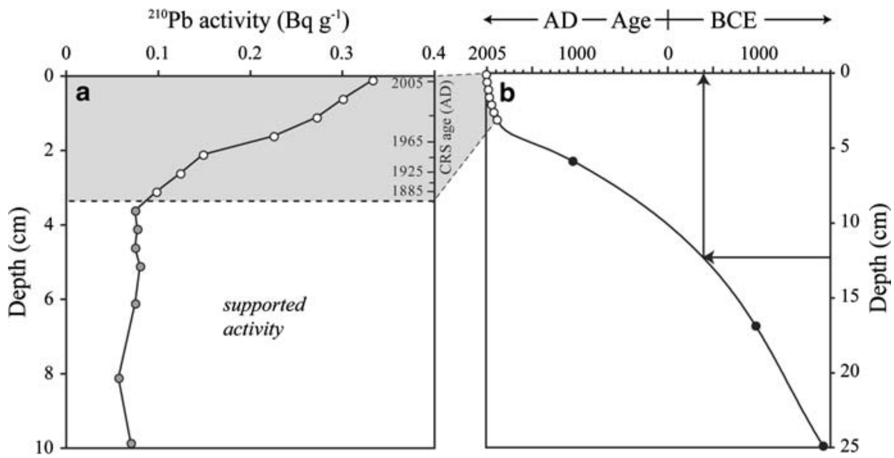

Fig. 2 (**a**) ^{210}Pb data for CF8 core, white circles indicate unsupported ^{210}Pb data entered into a CRS model, gray circles indicate supported ^{210}Pb data. (**b**) Age-depth model for entire core. Black circles represent ^{14}C ages. Arrows indicate maximum depth of sediment (12 cm) and corresponding age (400 BCE) used for this study. Analytical error bars for both ^{210}Pb and ^{14}C are smaller than the data points

The LOI values remained between 12% and 14% from 0 to 1800 AD, with the lowest values around 500 AD (Fig. 3). After 1800 AD, LOI values became more variable and reached 15.5%. The %C and %N, also measures of organic matter content, are similar to the LOI curve (Fig. 3). These two proxies fluctuated dramatically between the last century BCE and the first few centuries AD, and then stabilized after 250 AD. Both proxies increased slowly between 250 and 1800 AD, and then %C increased from <5.00% to 5.75% and %N increased from 0.60% to 0.75% between 1800 and 2005 AD. The C:N ratio decreased slowly from 9.5 to 9.0 since the beginning of the record and dropped to 7.5 during the past two centuries (Fig. 3). Much like %C and %N, %$BSiO_2$ fluctuated between 44% and 60% during the early part of this record, with a noticeable decrease to 33% at 800 AD. After 1800 AD, $BSiO_2$ fluctuated between 28% and 42% (Fig. 3).

$BSiO_2$ flux decreased steadily from 4 g m^{-2} year^{-1} to less than 1 g m^{-2} year^{-1} between 400 BCE to 1800 AD, at which time $BSiO_2$ flux increased rapidly to 19 g m^{-2} year^{-1} by 2005 AD, a 20-fold increase in 200 years (Fig. 3). C and N fluxes showed a similar rapid increase in the past 200 years, although they constituted a much smaller portion of the sediment flux in Lake CF8 (maximum C flux was 3 g m^{-2} year^{-1} and maximum N flux was 0.4 g m^{-2} year^{-1}).

The δ^{13}C values remained stable for most of the record, between −26.5‰ and −25.0‰ during the past 2,400 years (Fig. 3). Around 1800 AD, however, δ^{13}C began to increase from −26.0‰ to −25.5‰ in a period of 130 years, a rate more rapid than previously seen in this record. The rate of increase became even greater around 1930 AD, and in the last 75 years, δ^{13}C values increased to an unprecedented −23.5‰. δ^{15}N demonstrates similar variability to δ^{13}C during the past 2,400 years (Fig. 3).

The above results are summarized by extracting the first and second principal components, which provide an objective overview of the major biogeochemical trends occurring in Lake CF8 (Figs. 3, 4).

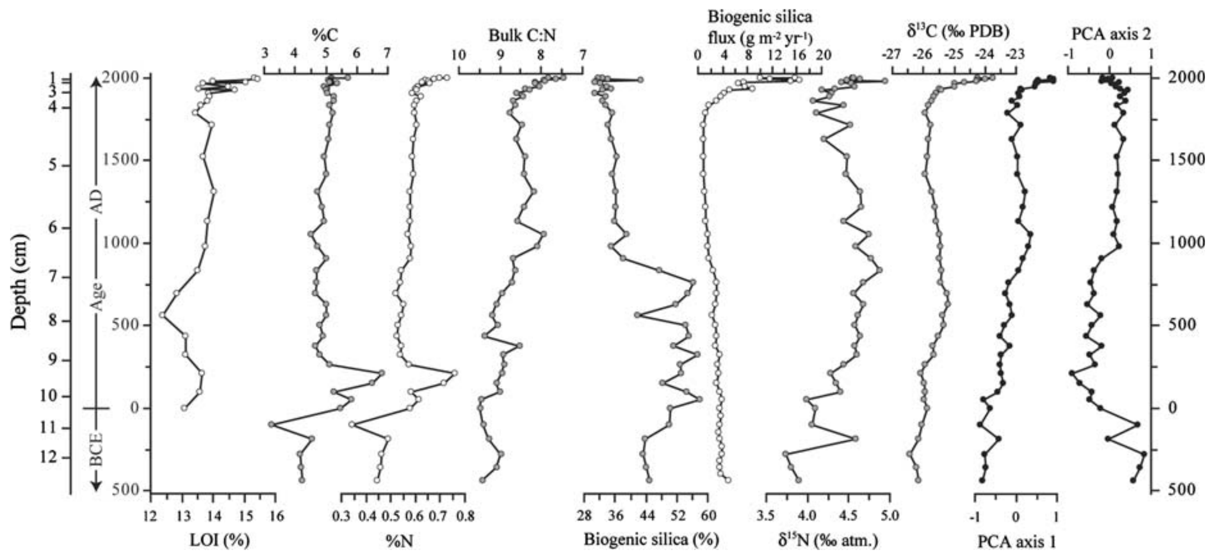

Fig. 3 Biogeochemical parameters of Lake CF8 sediments. Parameters with gray circles (%C, Bulk C:N, $BSiO_2$, $\delta^{15}N$ and $\delta^{13}C$) were included in the PCA, shown in black

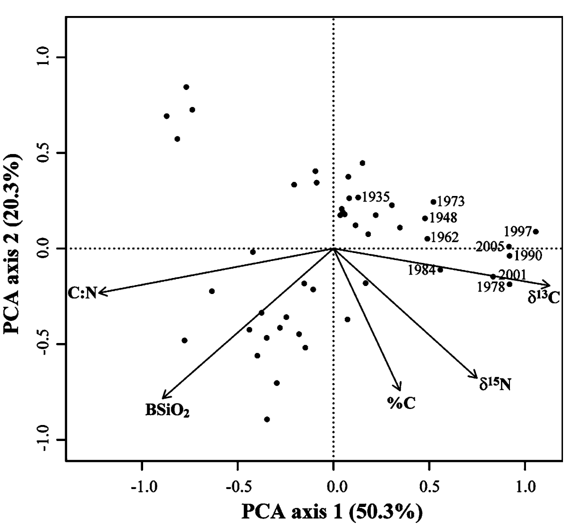

Fig. 4 Biplot of Lake CF8 PCA axes 1 and 2. Vectors of PCA loadings for the five biogeochemical proxies and Lake CF8 sample scores. 20th and 21st century samples labeled

The first PCA axis accounts for 50.3% and the second axis accounts for 20.3% of the variance within the biogeochemical data. The C:N ratio loads negatively and $\delta^{13}C$ loads positively on axis 1 (Fig. 4), which shows an inflection around 1800 AD, when the sample scores rise above background levels at a rate not seen throughout the rest of the record. $BSiO_2$, %C and $\delta^{15}N$ load negatively on axis 2 (Fig. 4), which also shows an inflection around 1800 AD, when the sample scores decrease at a similar rate to the beginning of the record (250 to 0 BCE). When plotted on a biplot, these PCA data show that the 20th century is characterized by different sample scores than the rest of the record (Fig. 4).

The chironomid assemblage was dominated (>50%) by the subtribe Tanytarsini in the early part of this record (400 BCE to 500 AD; Fig. 5). From 500 to 1950 AD taxa with lower temperature optima, including *Heterotrissocladius*, *Abiskomyia* and *Oliveridia*, dominated the record. *Oliveridia* and/or *Pseudodiamesa*, stenothermous taxa with the coldest temperature optima found in these sediments (5.4 ± 2.1 and 6.2 ± 1.6°C, respectively), were present from the beginning of the record to around 1980 AD. These taxa became less abundant beginning around 1950 AD and then both disappeared altogether after 1980 AD. *Abiskomyia* and Tanytarsini, taxa with higher temperature optima than *Oliveridia* and *Pseudodiamesa*, became more abundant since 1980 AD.

Late 20th century chironomid-inferred summer water temperatures exceed temperatures from the past two millennia, including during the so-called Medieval Warm Period (Fig. 5). The surface water temperature reconstructions from 400 BCE to 1950 AD ranged between 5.6 and 6.9°C. From 1970 to 2005 AD there was an increase in chironomid-inferred summer surface water temperature to 7.4°C.

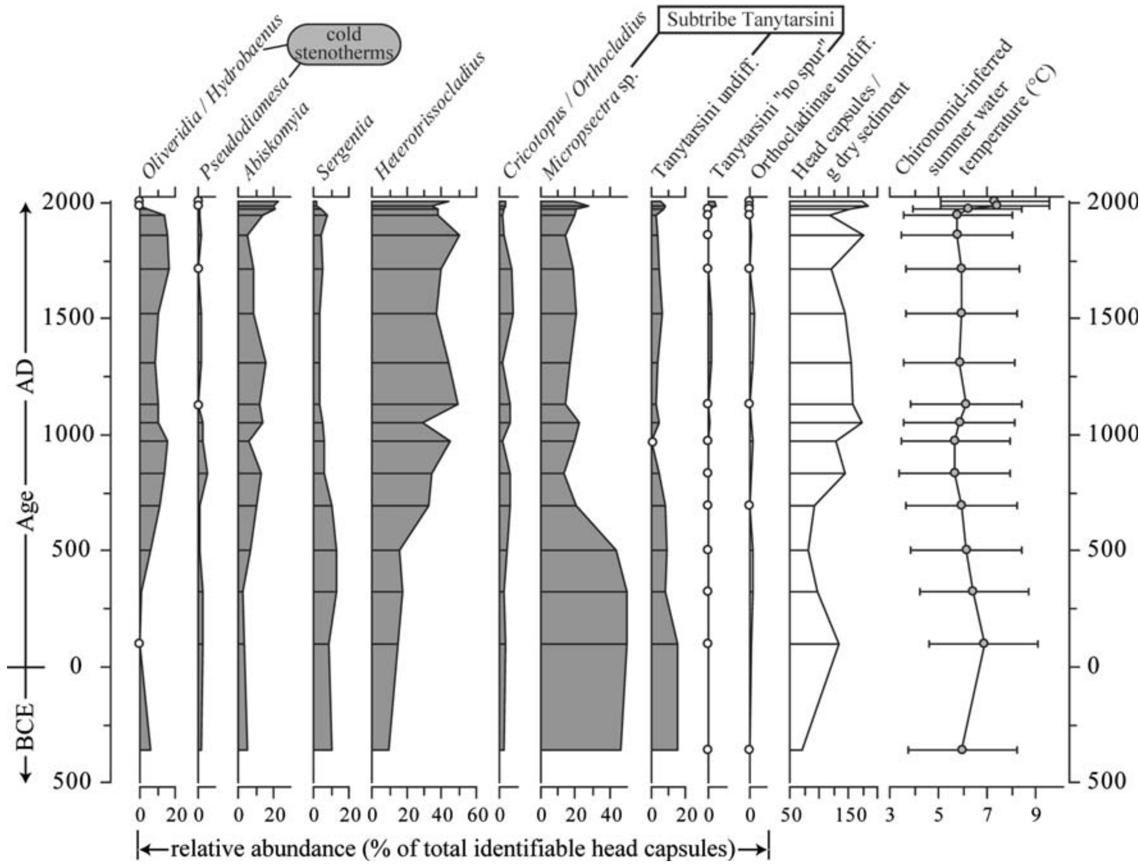

Fig. 5 Relative abundances of select chironomid taxa from Lake CF8 sediments (rare taxa <2% are not shown), head capsule concentrations and chironomid-inferred summer water temperature. Taxa arranged according to their temperature optima, based on Francis et al. (2006), with cold-water taxa on the left. White circles indicate zero values

Discussion

The late Holocene at Lake CF8

The chironomid assemblage shifts suggest that the most recent decades are unique compared to the past 2,400 years with respect to the cold stenothermous taxa. *Oliveridia*, a cold, stenothermous taxon known to occur in very cold, ultraoligotrophic lakes (e.g. Sæther 1976; Brooks and Birks 2004; Hrafnsdóttir 2005; Francis et al. 2006) and *Pseudodiamesa*, also a cold stenotherm (Francis et al. 2006), both decrease in abundance and then disappear from the record simultaneously around 1980 AD, while warmer taxa increase in relative abundance (Fig. 5). Prior to the late 20th century, either one or both of these taxa are present in the entire record, indicating that the environment at Lake CF8 warmed in recent decades above the optimum temperature for the cold stenotherms, a condition not represented in at least the last 2,400 years. Axford (2007) generated a chironomid record from Lake CF8 that spans the entire Holocene. According to their record, the last time when both *Oliveridia* and *Pseudodiamesa* were absent from Lake CF8 was 5,000 years ago, indicating that the recent decades at Lake CF8 are unique in the last 5,000 years with respect to the absence of both cold stenothermous taxa.

Chironomids also provide a quantitative record of summer water temperature at Lake CF8 that shows recent rapid warming, unprecedented in the past 2,400 years (Fig. 5). We recognize that the statistical uncertainty of the chironomid-temperature transfer function presents a challenge for reconstructing low-amplitude temperature changes. Several studies have demonstrated, however, the utility of chironomid analyses for quantifying subtle Holocene temperature variations despite these complications (e.g. Larocque and Hall 2003; Velle et al. 2005; Axford et al. 2008). The chironomid-inferred temperature transfer function of Francis et al. (2006) is effective for the early Holocene on Baffin Island, when temperatures were warmer than today (Kaufman et al. 2004; Axford 2007). The lack of very cold lakes in the training set, however, limits the effective range of the transfer function to summer temperatures greater than about 6°C. The transfer function is therefore less effective for the late Holocene, when temperatures were generally cooler than today (Miller et al. 2005). We infer, based on the results of Francis et al. (2006, p. 112, Fig. 3) that this is especially true for air temperature reconstructions, so we limit this study to surface water temperature. Because of this transfer function limitation, the trends in the chironomid-inferred temperature data presented here are likely accurate, but the absolute values, particularly those around 6°C, may not be. Therefore, these data must be treated with caution until the effective summer temperature range is expanded by incorporating colder training sites into the transfer function. We believe that the prominent warming trend from 1970 to 2005 AD is real, because it results from clear changes in faunal assemblages and because the reconstructed temperatures are within the effective temperature range of the transfer function.

The late 20th century changes in the chironomid assemblage and chironomid-inferred summer water temperature coincide with the most dramatic biogeochemical changes seen in this record. The biogeochemical proxies begin to change, however, around 1800 AD, approximately 150 years prior to the chironomid assemblage changes. The C:N ratio in Lake CF8 likely reflects the relative abundance of terrestrial and aquatic organic matter; aquatic flora have low C:N ratios (~4–10), while terrestrial flora have high C:N ratios (~20; Meyers and Teranes 2001). The decrease in the C:N ratio from 1800 to 2005 AD (Fig. 6) probably indicates an increase in autochthonous relative to allochthonous organic matter, and we therefore infer an increase in aquatic productivity in Lake CF8. The simultaneous increase of $\delta^{13}C$ (Fig. 6) is consistent with enhanced aquatic

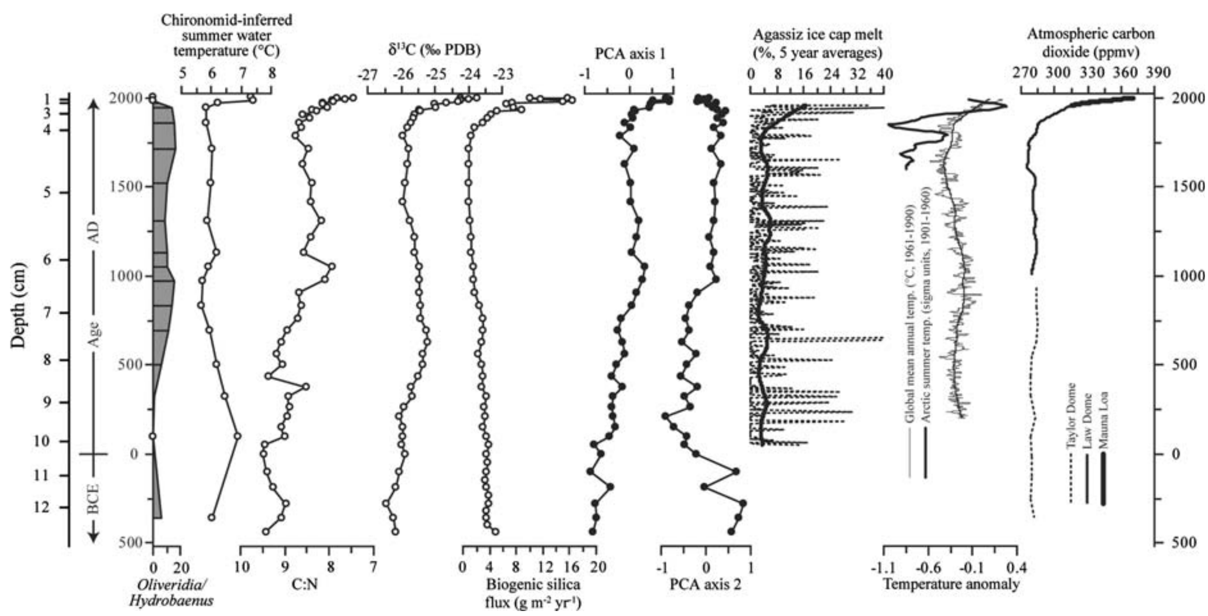

Fig. 6 Lake CF8 proxies and PCA compared to regional and global climate records and atmospheric CO_2 concentration. Abundance of *Oliveridia*, a cold stenothermous taxon, is shown as in Fig. 5. Units of global mean annual and Arctic summer temperature anomalies shown on plot. Agassiz percent melt trendline was fitted with a LOESS smoothing with a span of 0.15. ppmv = parts per million volume. Global mean annual temperature anomalies from Jones and Mann (2004); Arctic summer temperature anomalies from Overpeck et al. (1997); Agassiz data from Fisher et al. (1995) and Fisher and Koerner (1994); Taylor Dome data from Indermühle et al. (1999); Law Dome data from Etheridge et al. (1996); Mauna Loa data from Keeling et al. (1996)

production, because greater photosynthetic drawdown of the dissolved inorganic carbon pool reduces the ability of aquatic flora to fractionate against the heavy isotope (Meyers and Teranes 2001). The enrichment of $\delta^{15}N$ during this time period may also represent an increase in primary productivity, since $\delta^{15}N$ would become isotopically enriched with enhanced utilization of available nitrogen sources (Hodell and Schelske 1998). Other qualitative proxies for organic sedimentation including %LOI, %C and %N show recent rapid changes that are unique in the past 2,400 years (Fig. 3). Percent $BSiO_2$ decreased slightly since 1800 AD, indicating that percent diatom abundance decreased during the past 200 years. When $\%BSiO_2$, %C and %N are converted to dry flux, however, it becomes apparent that the deposition of organic matter has increased rapidly since 1800 AD (Fig. 3). Although flux calculations are a function of the age-depth model (which shows a rapid increase in sedimentation rate around 1800 AD, Fig. 2) and therefore the core chronology, we believe that our interpretations of the flux data are reliable based on two lines of evidence: 1. The ^{210}Pb CRS model dry sedimentation rate continues to increase throughout the 20th century, and 2. The PCA analysis, which summarizes major trends in biogeochemical proxies that are independent of sedimentation rate, not only indicates that the recent changes occurring in Lake CF8 are the most dramatic of the past 2,400 years (Fig. 3), but also demonstrates that the 20th and 21st century became increasingly different compared to previous samples (Fig. 4).

Several independent biogeochemical proxies record an increase in productivity at Lake CF8 beginning around 1800 AD, the rate of which becomes more rapid around 1950 AD. The chironomid assemblage changes lag behind the biogeochemical proxies by approximately 150 years. We hypothesize that a small increase in temperature at Lake CF8 lengthens the relatively short ice-free growing season by a large percentage, and leads to dramatic increases in aquatic productivity (e.g. Michelutti et al. 2005) and thus sediment biogeochemistry. Chironomids may also respond directly to the increase in temperature, or, alternatively, respond to the increase in aquatic productivity and therefore indirectly, and perhaps more slowly, to the temperature change. In either case, small arctic lakes like Lake CF8 would be especially sensitive to climate change (Smol et al. 2005, Smol and Douglas 2007).

The late Holocene in the Baffin Bay region

In addition to this chironomid record, studies focusing on aquatic productivity and diatom assemblages elsewhere on Baffin Island have demonstrated that the 19th and 20th centuries are unique in the context of previous centuries (Wolfe 2003; Michelutti et al. 2005). These studies showed that aquatic productivity and diatom-inferred temperature have been increasing since 1850 AD. Changes in Baffin Island lakes are coincident with widespread regime shifts observed in lake ecosystems throughout the Arctic (Smol et al. 2005).

Recent environmental change has also been recorded by abiotic proxies. A paleotemperature record derived from varved sediments from a lake on southern Baffin Island shows that the 20th century warmed at unprecedented rates to the highest temperatures in the past 500 years (Hughen et al. 2000). An additional paleotemperature record derived from varved sediments in southeastern Baffin Island also shows considerable warming in the 20th century (Moore et al. 2001).

Changes in the biogeochemical properties of Lake CF8 sediment that began around 1800 AD ($\delta^{13}C$, C:N, $BSiO_2$ and C flux) coincide with increased Agassiz ice cap melt and rising Arctic temperatures inferred from 29 high-resolution paleotemperature records (Fig. 6; Fisher and Koerner 1994; Fisher et al. 1995; Overpeck et al. 1997). The chironomid taxa and inferred temperature changes, as well as changes in the lake sediment biogeochemistry, that have occurred during the last 30 years at Lake CF8 coincide with global, regional and local (Clyde River) temperature increases (Fig. 6; Overpeck et al. 1997; Jones and Mann 2004; Environment Canada 2007). These recent changes, unprecedented in at least the past 2,400 years and probably in the past 5,000 years, are likely driven by atmospheric carbon dioxide concentrations, which increased dramatically since the mid-1800s due to anthropogenic greenhouse gas emissions (Fig. 6; Etheridge et al. 1996; Keeling et al. 1996; Indermühle et al. 1999; IPCC 2007).

Based upon these correlations, climate appears to be a major driver of recent biogeochemical and ecological changes at Lake CF8, but this does not preclude other influences on the Lake CF8 ecosystem. Wolfe et al. (2006) found evidence for enhanced anthropogenic atmospheric nitrogen deposition contributing to ecosystem change in two lakes on the Clyde Foreland. It may be that a combination of climate and atmospheric deposition of pollutants is affecting the Lake CF8 ecosystem, resulting in complex and dramatic ecological responses, including a rapid increase in primary productivity and extirpation of cold stenothermous chironomid taxa.

Conclusions

This multiproxy paleolimnological record provides a high-resolution reconstruction of late Holocene climate and environmental change on northeastern Baffin Island. The late Holocene at Lake CF8 was characterized by low levels of primary productivity and the presence of cold stenothermous chironomid taxa. Dramatic shifts in the lake's ecology began in the early 19th century, when primary productivity began to increase rapidly. These changes became even more rapid in the mid-20th century, at which time chironomid assemblages also began to change, with cold stenothermous taxa becoming less abundant. By 2005 AD, primary productivity had increased dramatically from 1800 AD levels and the cold stenothermous chironomid taxa such as *Oliveridia* and *Pseudodiamesa* had been extirpated from Lake CF8. Chironomid-inferred surface water temperatures indicate that summers are warmer now than during the previous 5,000 years, including the so-called "Medieval Warm Period." The ecological shifts observed at Lake CF8 are likely driven by climate warming, which may be exacerbated by the effects of atmospheric deposition of anthropogenic pollutants onto the landscape around Lake CF8. Similar changes have been observed at lakes throughout the Arctic and are likely to continue at ever-increasing rates as anthropogenic modification of the atmosphere continues to increase.

Acknowledgements We thank Neal Michelutti for assistance in the field, Jamesee Qillaq and other Inuit of Clyde River for logistical support, Gifford Miller for advice and assistance in developing the coring system, Donna Francis for the use of her modern training set data as well as help with chironomid identification, Jocelyn Turnbull for the preparation of materials for radiocarbon dating, David Harris for the stable isotope analyses, Jack Cornett and Janice Lardner for the ^{210}Pb analyses, Darrell Kaufman and Caleb Schiff for biogenic silica analyses and Jason Szymanski for assistance in the UB Paleoclimate Lab. We appreciate the licensing and logistical support provided by the Nunavut Research Institute and the National Science Foundation (VECO Polar Resources). This manuscript was made stronger by the helpful advice of two anonymous reviewers. This research is a contribution to the ongoing NSF-ARCSS 2 kyr Synthesis Project, NSF Grant ARC-0455024.

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