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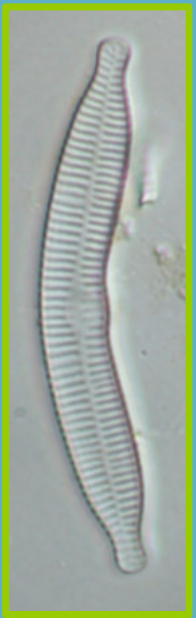
More information: caff.is/freshwater



Exploring patterns of diatom assemblages from circumpolar Arctic lakes & streams

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Daniel Bogan, Robert Brua, Stephane Campeau, Joseph Culp, Kirsten Christoffersen, Árni Einarsson, Jen Lento, Satu-Maaria Karjalainen, Susanne Schneider, Rebecca Shaftel, John P. Smol

The Arctic Biodiversity Congress, 9-11 October 2018, Rovaniemi

Background

The assessment of spatial and temporal trends in Arctic freshwater biota and their physical and biogeochemical habitat in response to a warming climate requires a large-scale harmonized monitoring program. The presented work, performed by the freshwater group of the Circumpolar Biodiversity Monitoring Plan (Arctic Council: Conservation of Arctic Flora and Fauna), is one of the first steps towards such a harmonized monitoring program. Using circum-Arctic diatom assemblage data, specific goals of this study include: 1) establishing current and pre-industrial environmental conditions as reference points to guide future environmental monitoring programs, and 2) understanding the historical context of diatom distributions. Large-scale assessments of diatom distributions in Arctic regions are currently scarce, and detailed taxonomic studies tracking species compositional changes in both lakes and streams have yet to be undertaken. We used contemporary stream and lake data from ongoing monitoring programs, spot data from research projects, as well as surface sediment (modern) diatoms from paleolimnological studies to provide a spatial assessment of species distributions of the circum-Arctic region. Additionally, we analysed a large set of dated and “top-bottom” paleolimnological records to better describe historical background conditions on a circum-Arctic scale.

More information: caff.is/freshwater

More information: caff.is/freshwater

Background

The presented work, performed by the **freshwater** group of the Circumpolar Biodiversity Monitoring Plan (CBMP) (Arctic Council: Conservation of Arctic Flora and Fauna, **CAFF**), is one of the first steps towards a harmonized circumpolar monitoring program.

Goals of this study, aimed at guiding the monitoring plan development:

1) evaluating existing data and identifying gaps in monitoring efforts and scientific knowledge of Arctic freshwaters
2) establishing current and pre-industrial environmental conditions as reference points
3) understanding the historical context of diatom distributions

Fredericton 2011

Circumpolar diatom database

5 different types of diatom data included in our analyses, from monitoring programs & academic research studies:

427 Stream samples (Canada, Finland, Norway, Sweden, USA)

727 Lake surface samples (Canada, Finland, Iceland, Sweden, Russia, USA)

118 Lake shoreline samples (Canada, Sweden) *Modern samples*

116 Top/bottom of sediment cores (Canada, Finland, Russia, USA)

52 Full cores (Canada, Finland, Russia) *Pre-industrial era samples*

- The Circumpolar diatom database is managed centrally by CAFF, and is depending on the CAFF member countries' input of data
- Our study focuses on
  - diatom data expressed as <u>relative abundances</u>
  - <u>dated</u> paleo cores and the last ~ 200 year interval

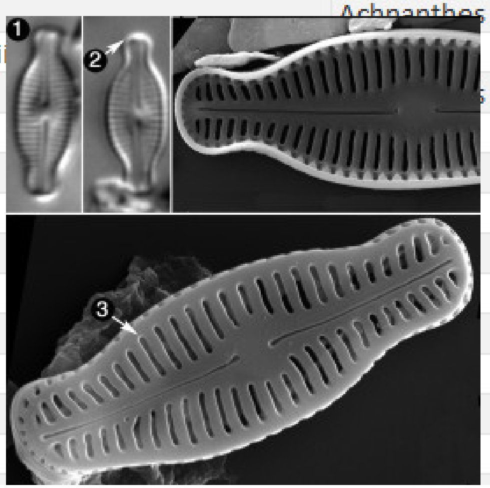
Circumpolar diatom database

Final taxa group: Achnanthes acares/ricula/carissima

NOMENCLATURE_DIATOMS

Class	TaxonName	TaxonNameFi	GenusFinal	Specie
Bacillariophyce	Achnanthes cf. carissima	Achnanthes cf. carissim	Achnanthes	cf. cari
Bacillariophyce	Achnanthes cf. ricula	Achnanthes cf. ricula	Achnanthes	cf. ricu
Bacillariophyce	Achnanthes ricula	Achnanthes ricula	Achnanthes	ricula
Bacillariophyce	Diadesmis sp. 1 (Achnanthes cariss	Achnanthes cf. carissima	Achnanthes	cf. cari
Bacillariophyce	Diadesmis sp. aff. contenta (Navicu	Navicula cf. schmassmannii		cf. schı
Bacillariophyce	Karayevia carissima	Achnanthes carissima		carissi
Bacillariophyce	Navicula cf. schmassmanii	Navicula cf. schmassmanii		schma
Bacillariophyce	Navicula schassmanni	Navicula schmassmannii		schma
Bacillariophyce	Navicula schassmannii	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmasmannii	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmassanni	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmassannii	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmassmanii	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmassmannii	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmassmannii Hustedt	Navicula schmassmannii		schma
Bacillariophyce	Navicula schmassmannii Hustedt 1	Navicula schmassmann		schma
Bacillariophyce	Navicula schmassmanniii	Navicula schmassmann		schma
Bacillariophyce	Navicula schumassmannii	Navicula schmassmann		schma
Bacillariophyce	Naviculadicta schmassmannii	Navicula schmassmann		schma
Bacillariophyce	Achnanthes brevipes	Achnanthes brevipes		brevip
Bacillariophyce	Achnanthes brevipes v. intermedi	Achnanthes brevipes va		brevip
Bacillariophyce	Achnanthes cf. coarctica	Achnanthes coarctata		coarct

Record: 1 of 6148 No Filter Search



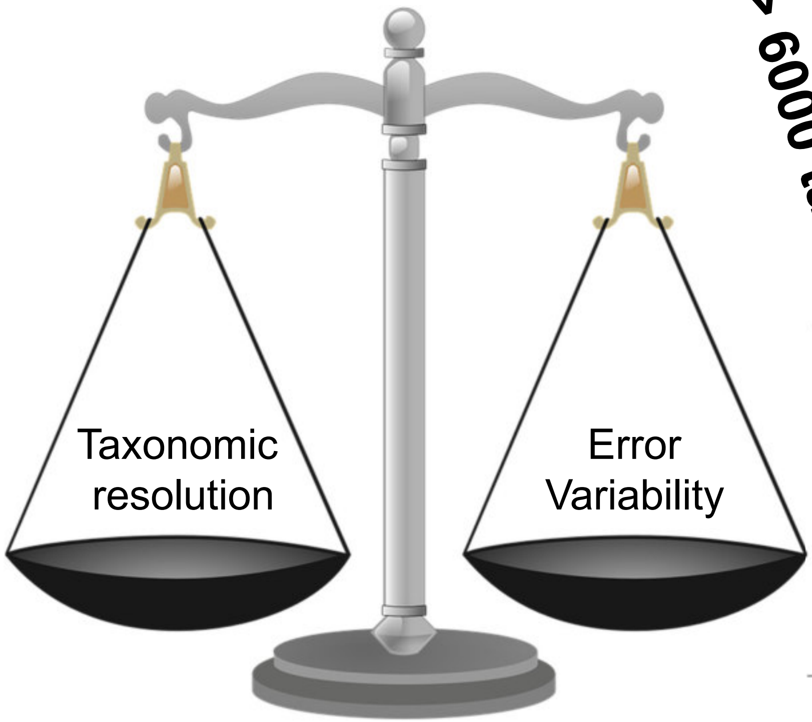
Humidophila schmassmanni
Length: < 9 μm
https://diatoms.org/

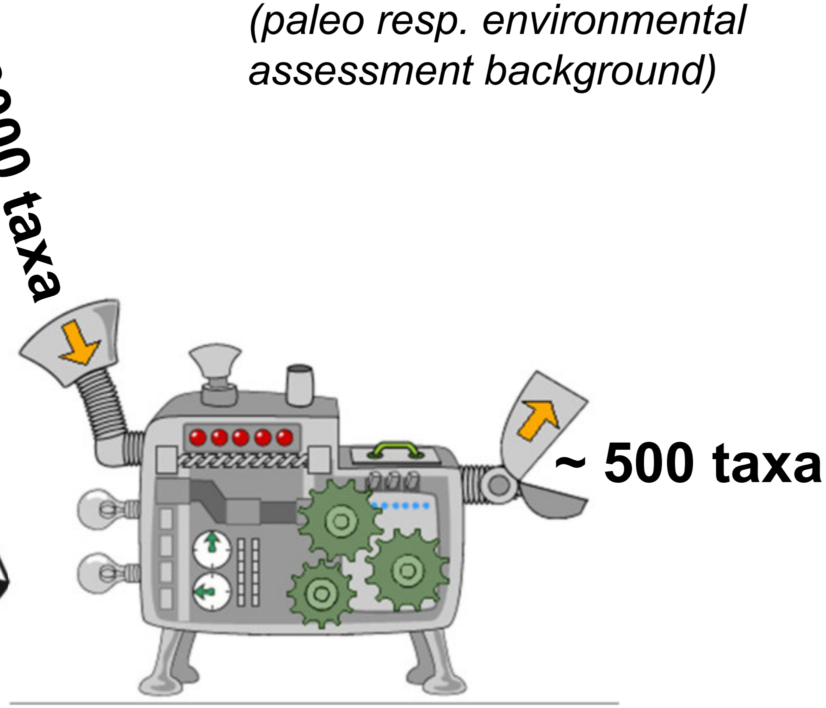
algaeBASE

SLU

Taxonomic harmonization

Practical solutions by a group of diatom experts
(paleo resp. environmental assessment background)





Multi-level resolution

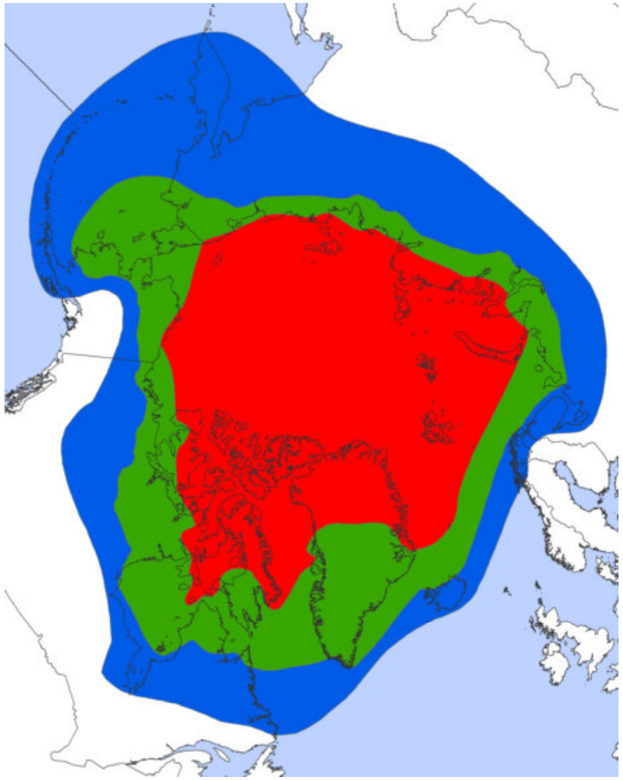
Species
Complexes
Genera

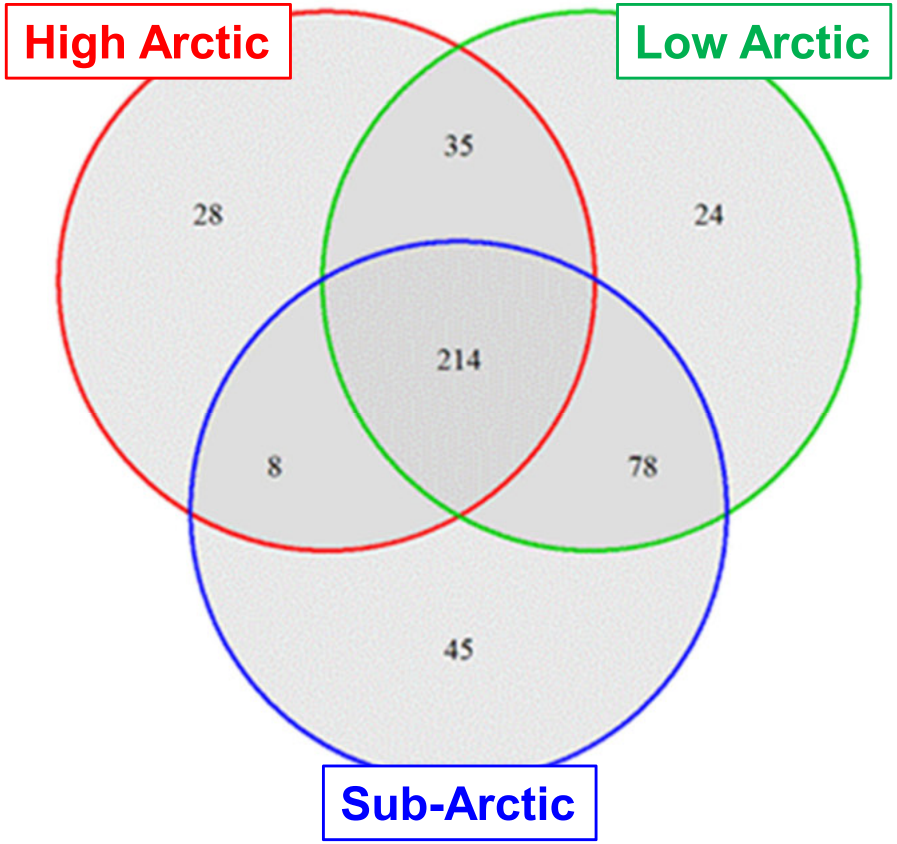
« taxa »

Diatom taxa distribution

Modern samples

Most taxa are common in all Arctic regions (latitude and longitude)



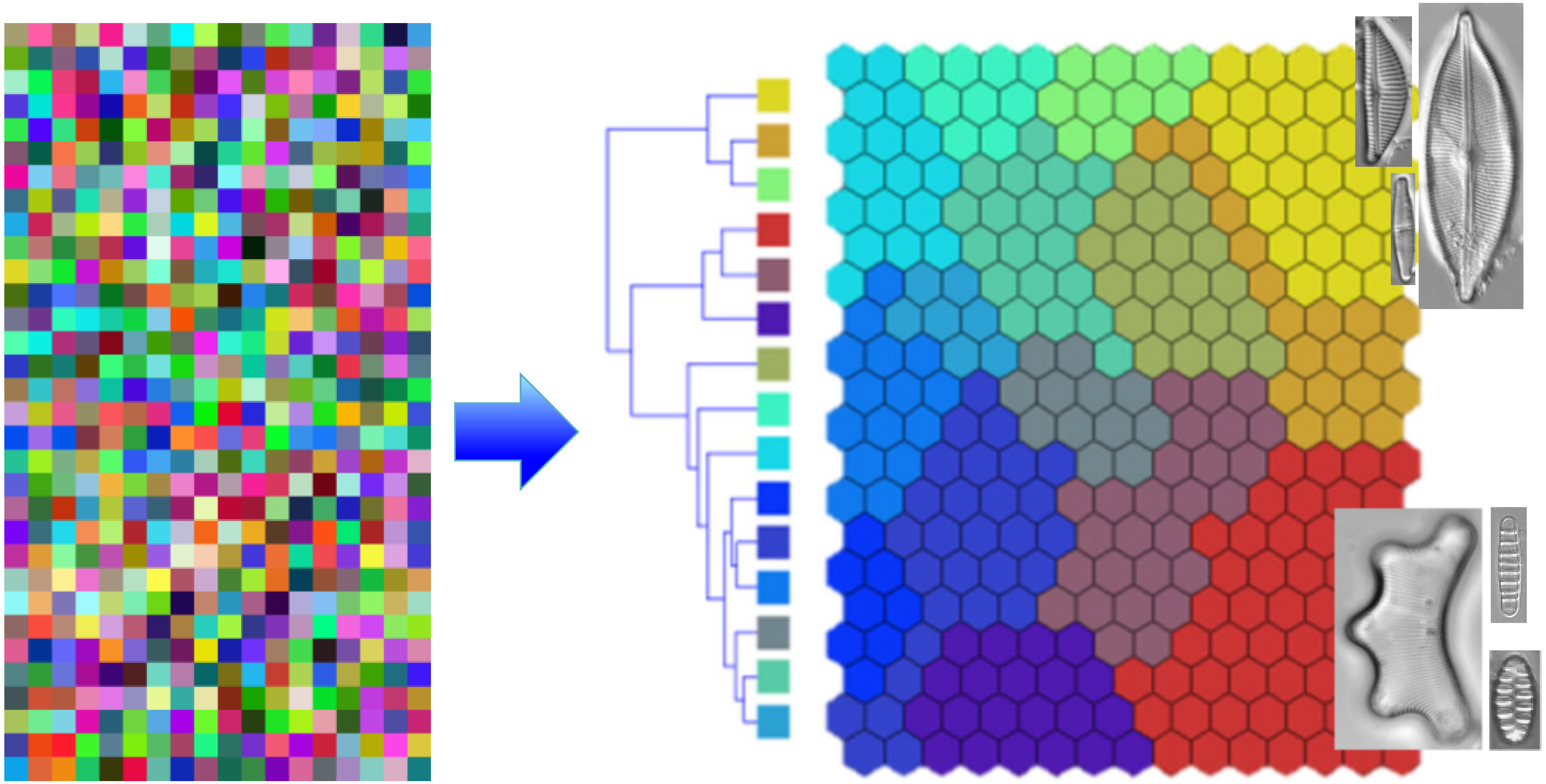


Diatom taxa among Arctic regions
for lake surface sediments

Assemblage composition

Modern samples

"**Biotypes**" created using self-organizing maps (SOM) … clusters in short!

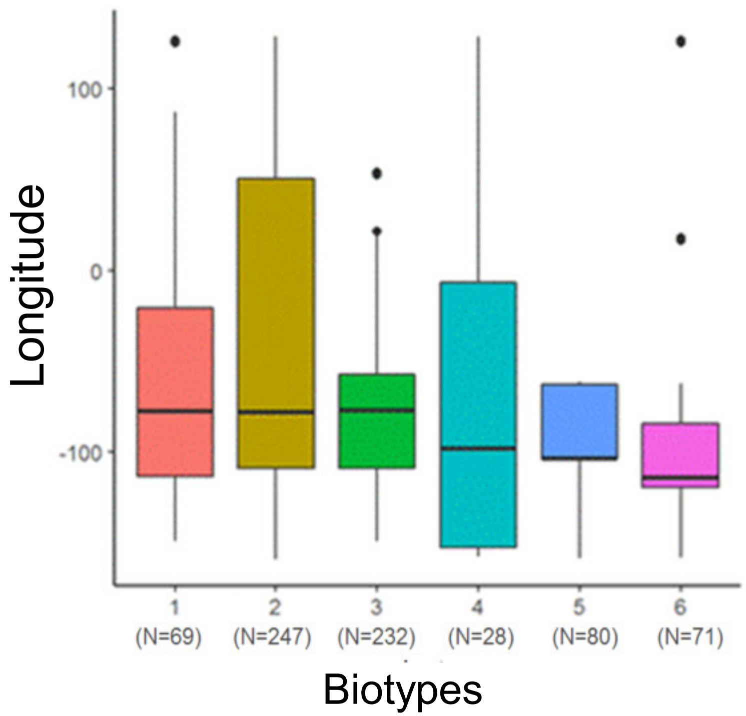


Assemblage composition

Modern samples

Lake surface sediments, n = 727

6 "**Biotypes**"



Modern samples

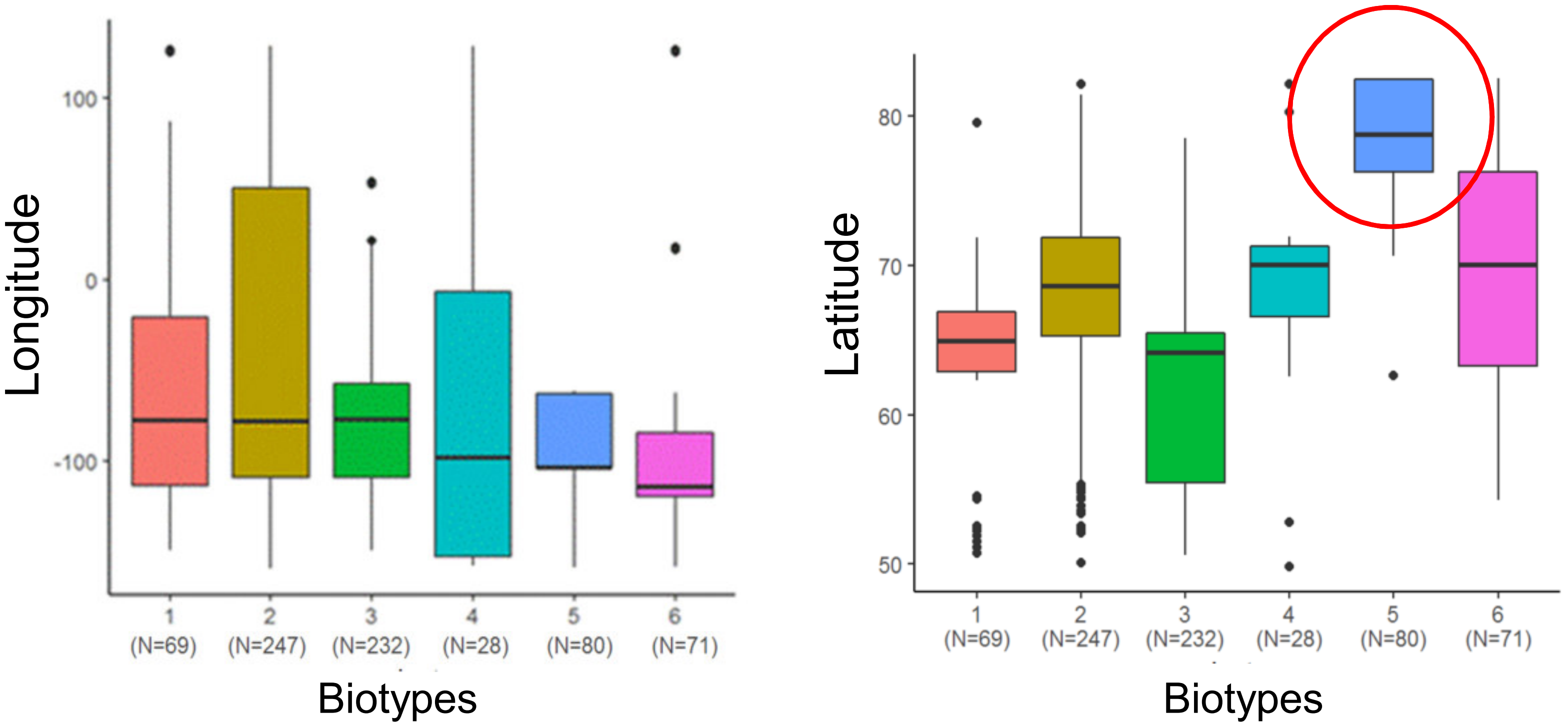
Lake surface sediments

Assemblage composition

Modern samples

Lake surface sediments, n = 727

6 “**Biotypes**”

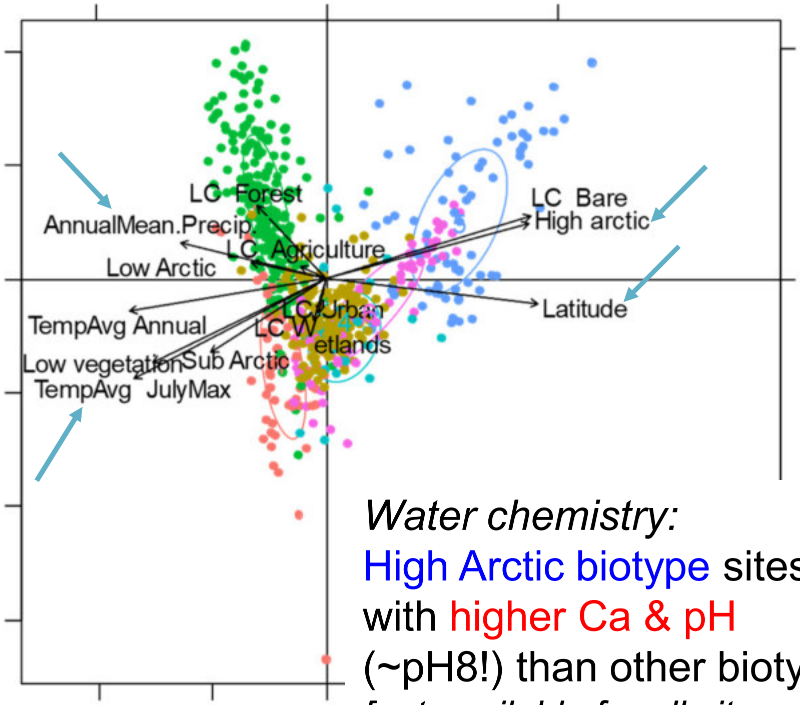


Assemblage composition

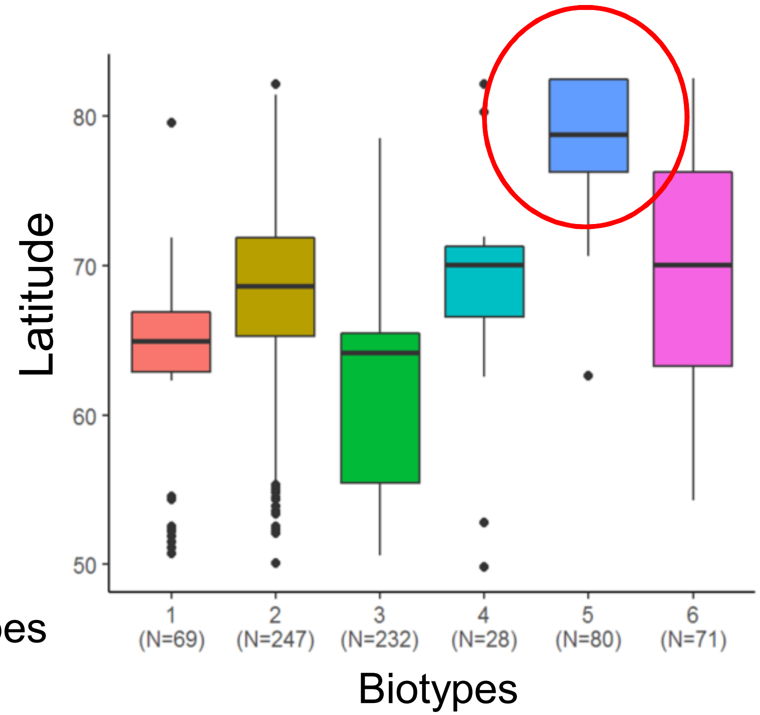
Modern samples

Lake surface sediments, n = 727

Canonical correspondence analysis
Samples color-coded according to biotypes



Water chemistry:
High Arctic biotype sites with higher Ca & pH (~pH8!) than other biotypes
[not available for all sites, n=253]

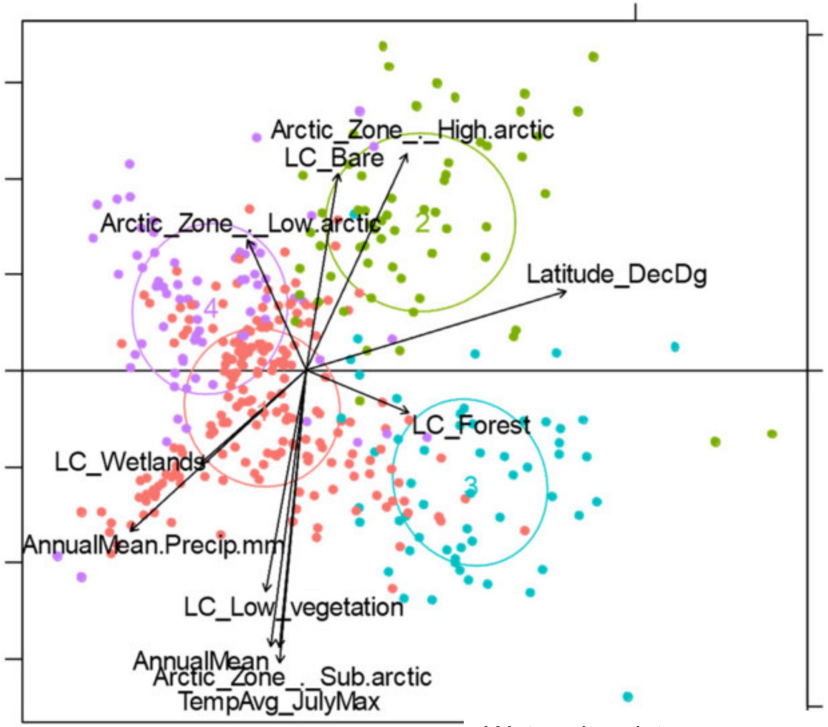


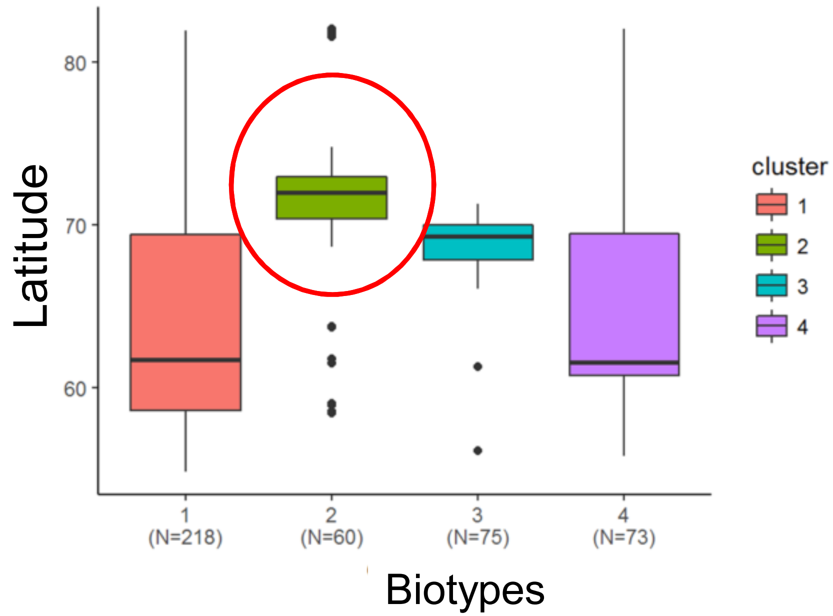
Assemblage composition

Modern samples

Streams, n = 427

4 “**Biotypes**”





Water chemistry:
High Arctic biotype sites with higher Ca & pH (~pH8!) than other biotypes
[not available for all sites, n=174]

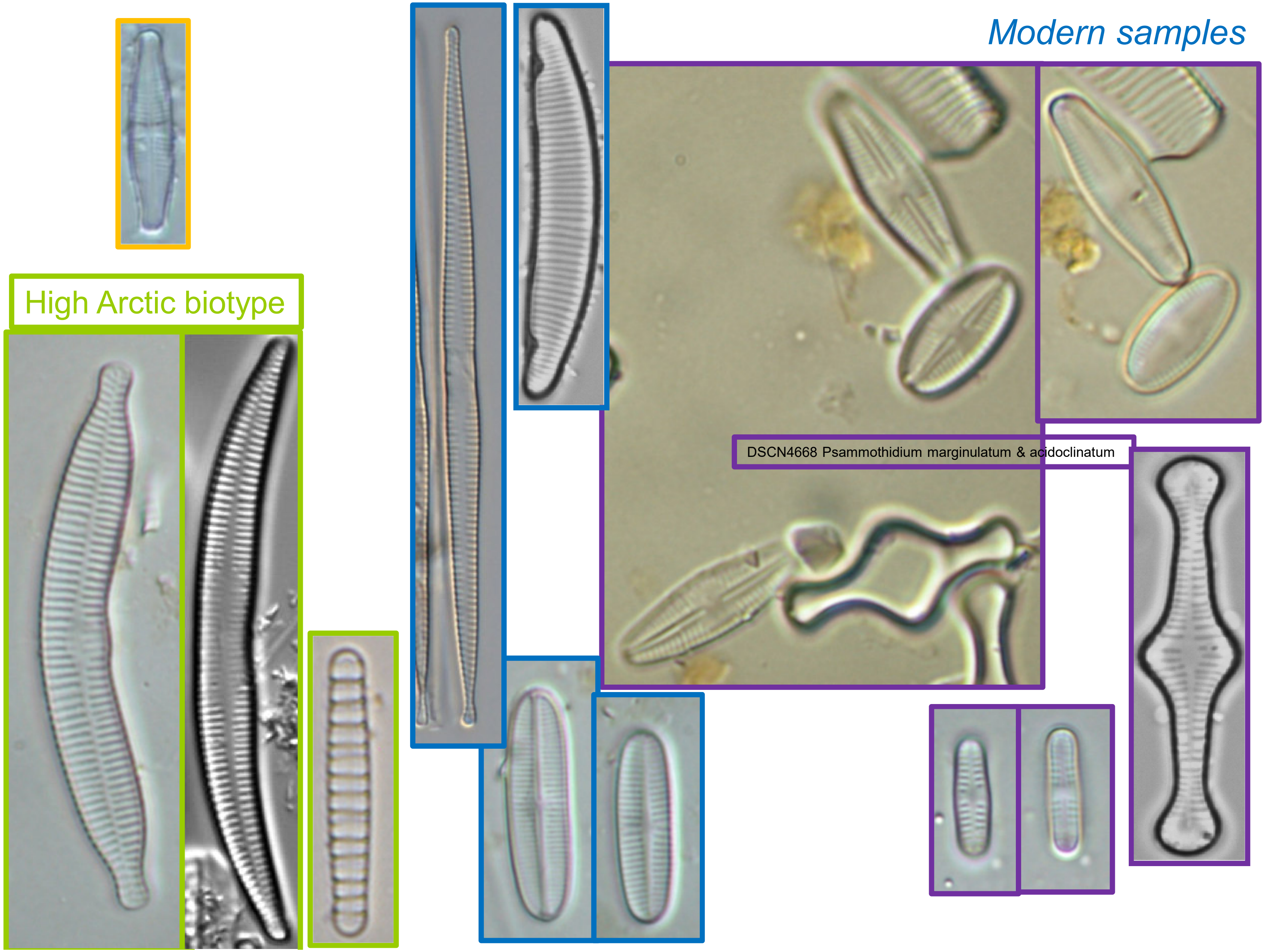
Modern samples

Streams, n=427

rel. abu. [%]	1	2	3	4	sum abun
Achnanthidium minutissimum	0,45	0,19	0,12	0,1	**0,86**
Fragilaria capucina complex	0,09	0,1	0,05	0,18	**0,42**
Tabellaria flocculosa Complex	0,07	0,01	0,03	0,21	**0,32**
Syndedra cyclopum/Hannaea arcus	0,02	0,19	0,05	0,01	**0,27**
Diatoma moniliformis/tenuis	0,02	0,19	0,01	0	**0,22**
Achnanthidium kriegeri	0,03	0	0,01	0,13	**0,17**
Rossithidium pusillum/anastasiae	0,02	0	0,1	0	**0,12**
Nitzschia perminuta Complex	0,02	0,03	0,02	0,04	**0,11**
Fragilaria tenera complex	0,02	0,01	0,08	0	**0,11**
Eunotia.incisa.Complex	0	0	0,02	0	**0,02**
Psammothidium.marginulatum.scoticum.la	0	0	0	0,03	**0,03**

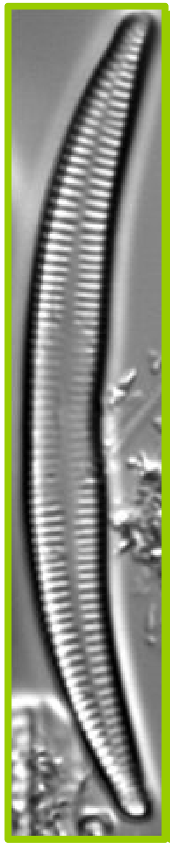
IndVal analysis

1		2		3		4	
Achnanthidium.minutissimum	**0.53**	Diatoma.m	**0.72**	Rossithid	**0.71**	Tabellaria.flocculos	**0.6**
Brachysira.neoexilis	**0.33**	Syndedra.c	**0.56**	Fragilaria	**0.61**	Achnanthidium.krie	**0.59**
Fragilaria.capucina.complex	0.2	Encyonema	**0.43**	Eunotia.in	**0.51**	Psammothidium.ma	**0.51**
Tabellaria.flocculosa.Complex	0.19	Cymbella.ci	**0.35**	Staurosire	**0.49**	Fragilaria.capucina.	**0.41**
Brachysira.brebissonii	**0.17**	Fragilaria.ca	0.23	Eunotia.in	**0.49**	Brachysira.procera	**0.41**
Delicata	**0.17**	Encyonopsi	**0.22**	Gomphor	**0.4**	Eunotia.arcus.muco	**0.38**
Encyonema.silesicacum.minutum.lange.be	0.16	Achnanthid	0.21	Navicula.	**0.33**	Eunotia.Complex	**0.37**
Nitzschia.perminuta.Complex	0.13	Nitzschia.p	**0.21**	Navicula.	**0.32**	Frustulia.rhomboide	**0.37**
Achnanthidium.deflexum.Complex	**0.12**	Nitzschia.p	0.2	Karayevia	**0.32**	Nitzschia.perminuta	**0.29**
Gomphonema.ariostriatum	**0.11**	Nitzschia.in	**0.19**	Psammot	**0.28**	Brachysira	**0.24**
Rossithidium.pusillum.anastasiae	0.11						


Modern samples
High Arctic biotype
DSCN4668 Psammothidium marginulatum & acidoclinatum

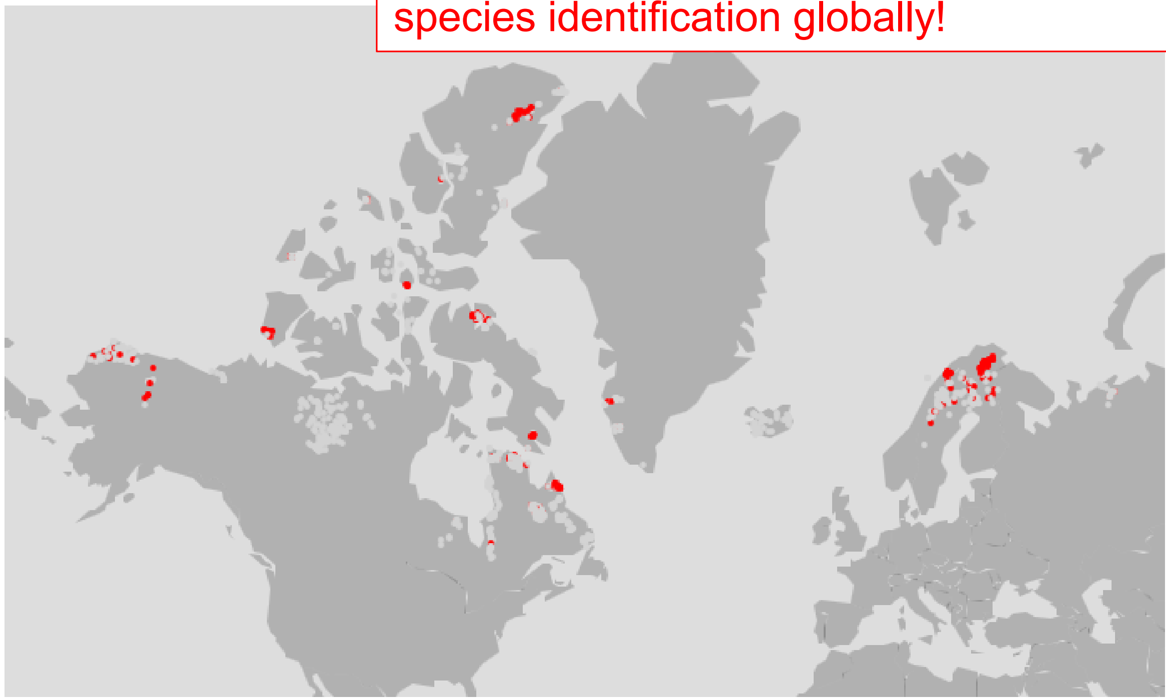
Distribution of complex Synedra cyclopum/Hannaea arcus

Global distribution of single taxa not easy to analyse because of the need to pool species -> we need a more harmonized species identification globally!



Synedra cyclopum Brutschy

Hannaea arcus (Ehrenb.) R.M.Patrick

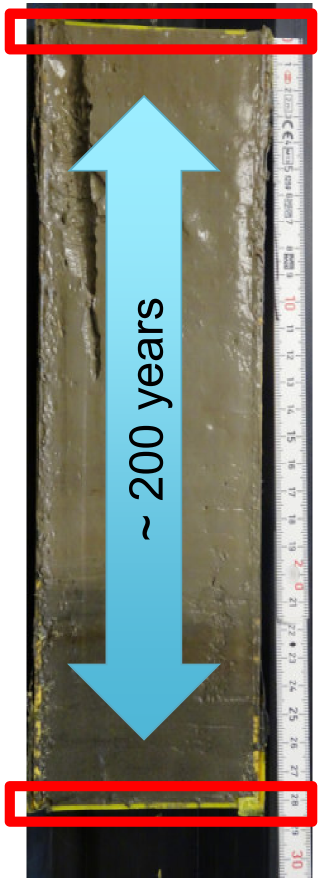


Synedra cyclopum is uncommon and widely dispersed in the plankton of lakes and reservoirs (and in streams below lakes and reservoirs) in the western US. Patrick and Reimer (1966) report that it is often attached to crustacea in cool water. In Europe, Krammer and Lange-Bertalot (1991) report it from lakes of medium electrolyte content, where it lives on copepods.

Hannaea arcus is found in cool flowing water in mountainous regions across the US and Europe. Typical for streams.

Top/Bottom, n = 116

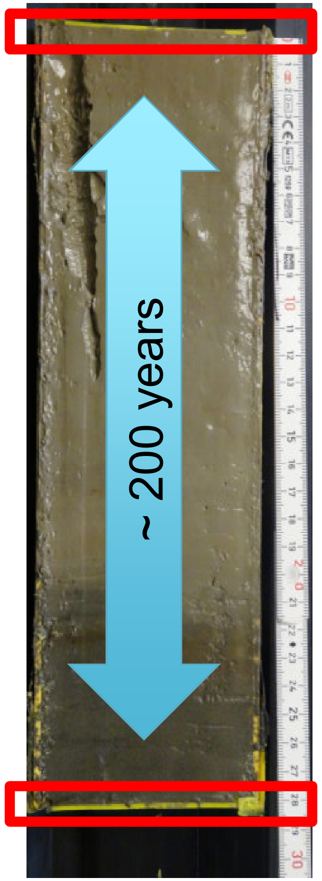
Pre-industrial (~200 years) versus modern sediments



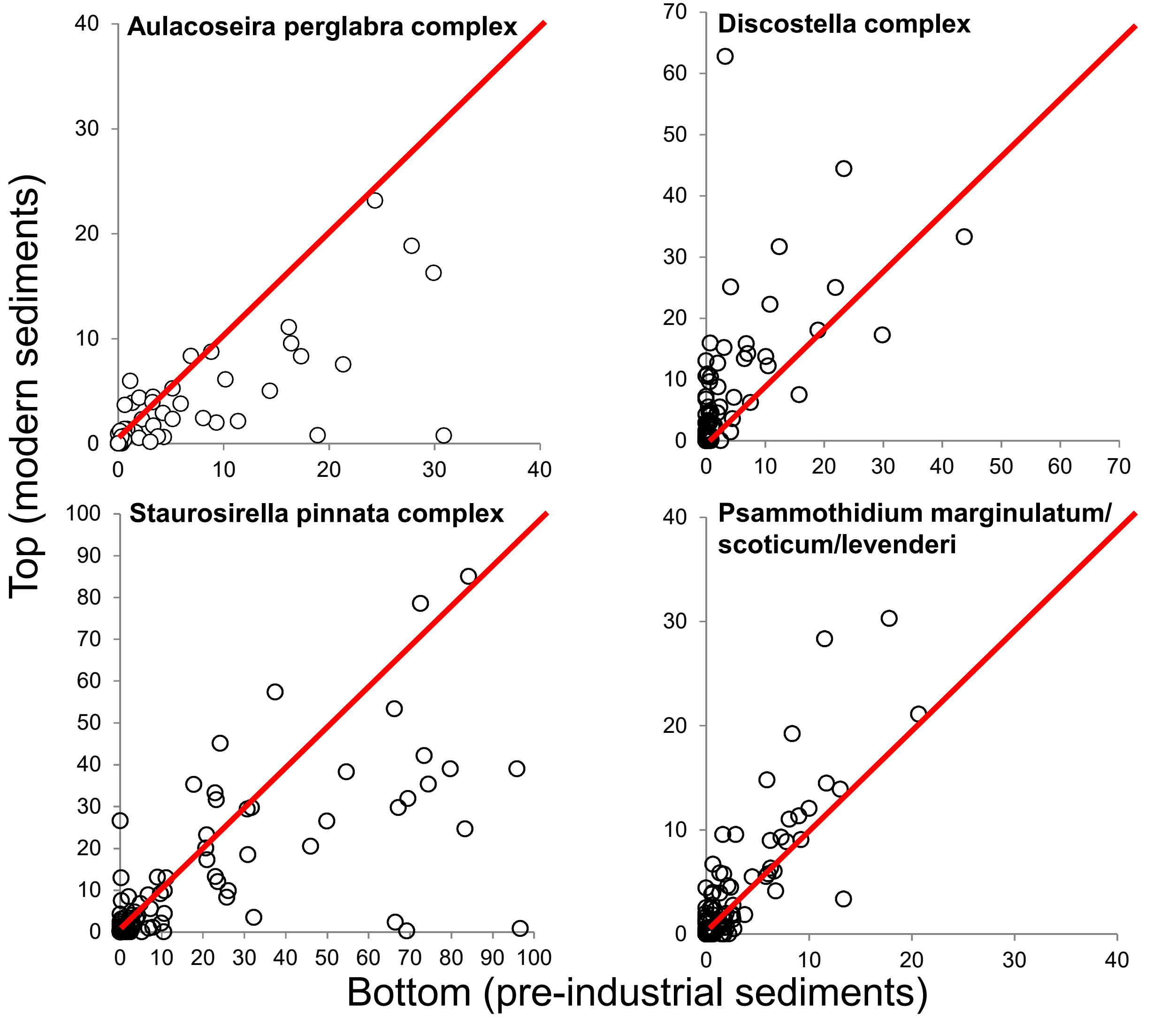
https://www.bas.ac.uk/project/identification-of-glacial-time-sources-for-antarctic-deep-and-bottom-water-masses/

Top/Bottom, n = 116

Pre-industrial (~200 years)
versus modern sediments

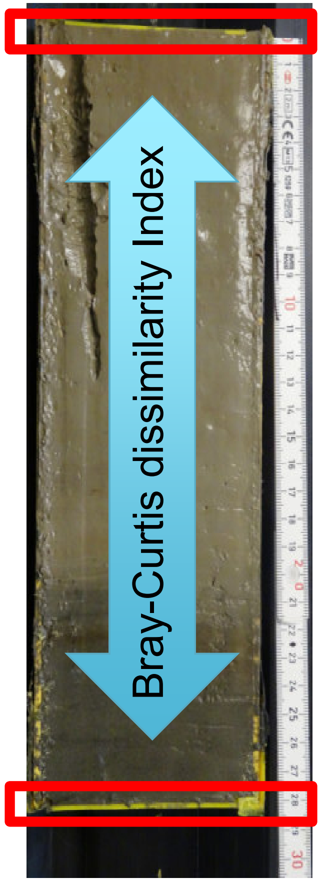


https://www.bas.ac.uk/project/identification-of-glacial-time-sources-for-antarctic-deep-and-bottom-water-masses/



Top/Bottom, n = 116

Pre-industrial (~200 years) versus modern sediments



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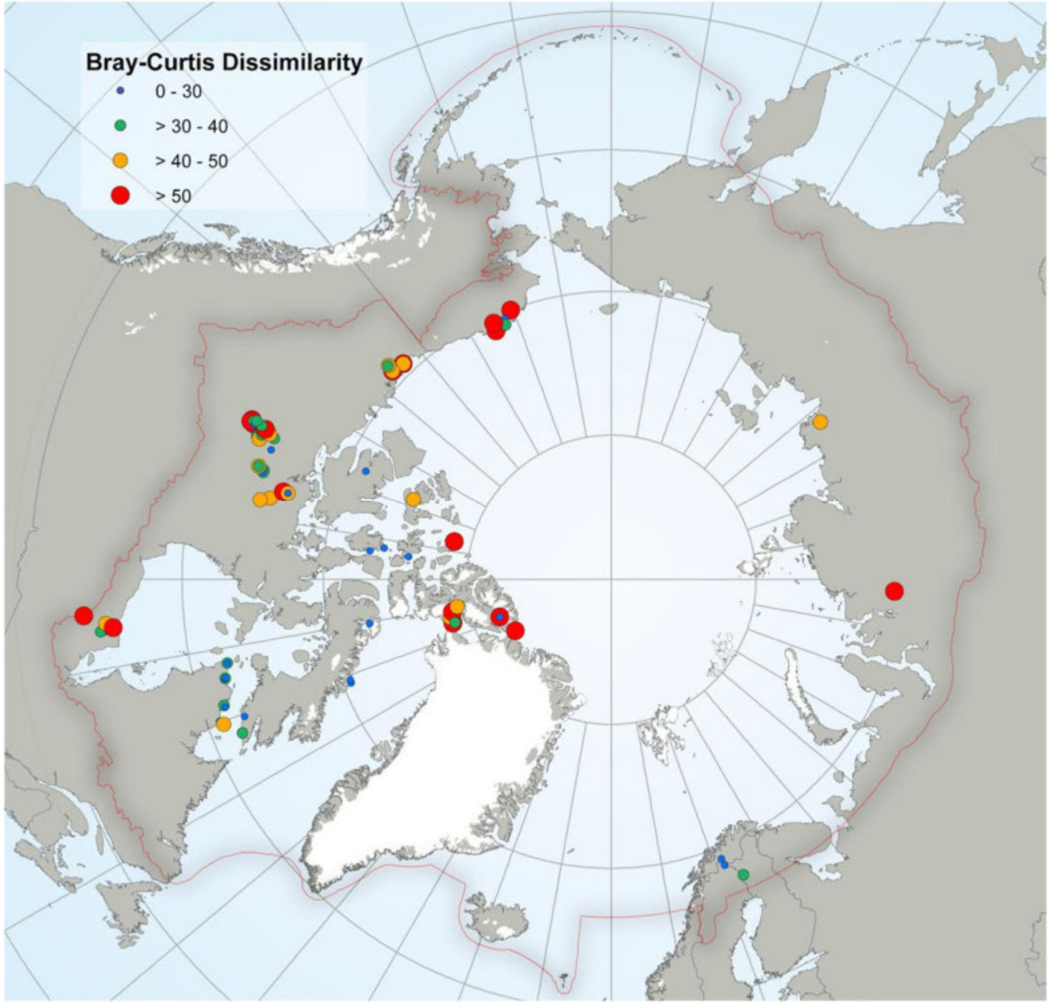
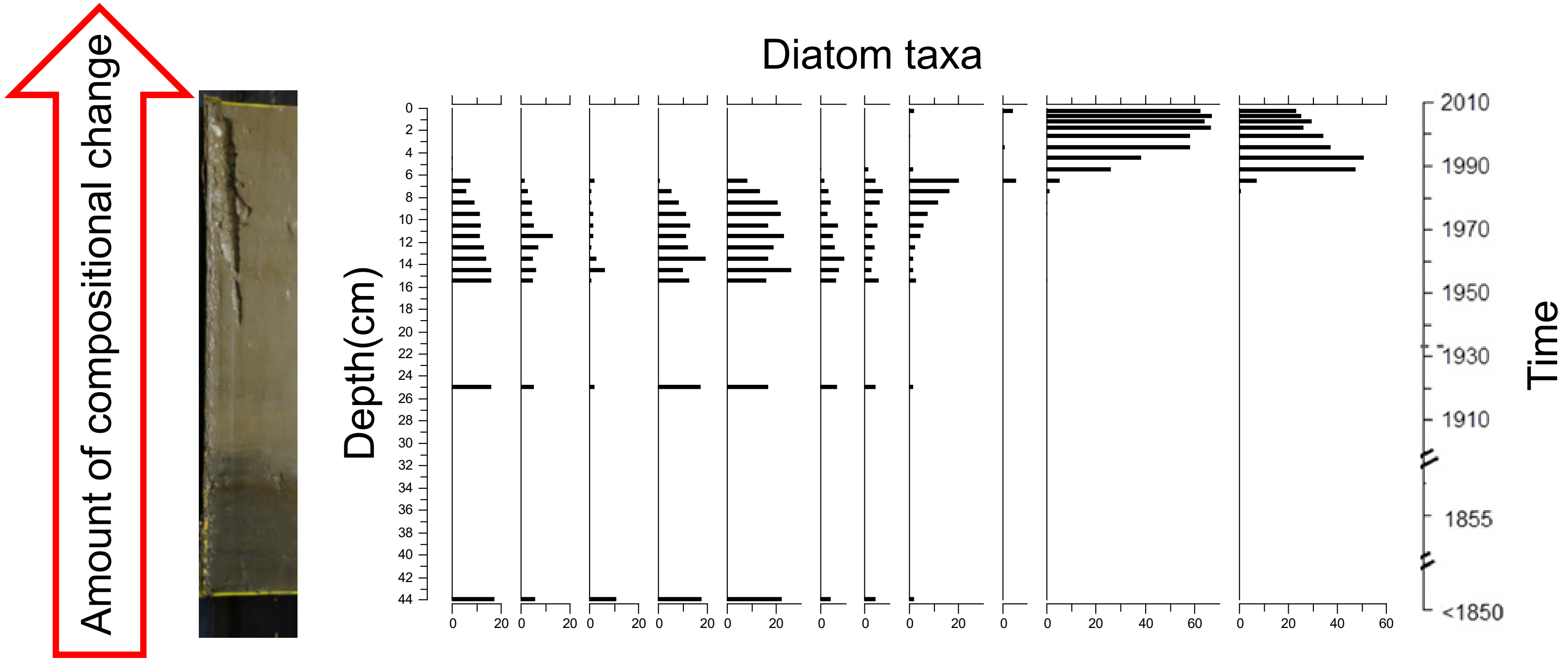


Sediment cores, n = 52

Pre-industrial (~200 years)
Full cores



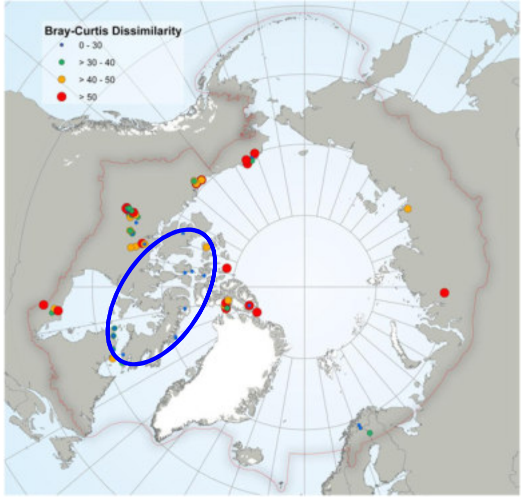
Detrended canonical correspondence analysis (DCCA) to estimate diatom compositional turnover as beta-diversity, scaled in SD units (Smol et al., 2005; PNAS)

Sediment cores, n = 52

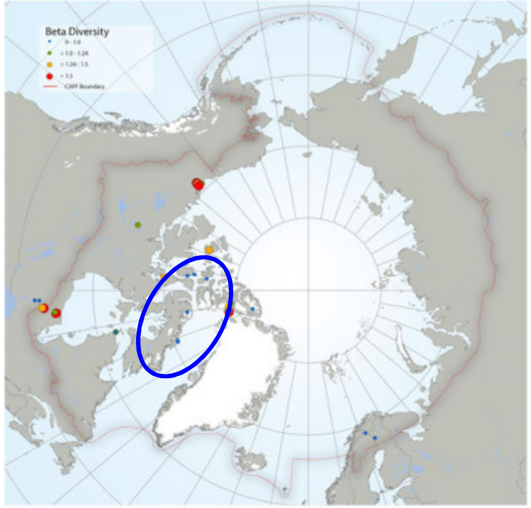
Pre-industrial (~200 years)
Full cores

Pre-industrial (~200 years)

Top/Bottom



Full cores



- Eastern Canada* least turnover, i.e. maybe least affected by global change
- (!) Results quite general, because community turnover is depending on lake characteristics (depth, area, morphology, etc.)) and core age
  (both pooled in this study)

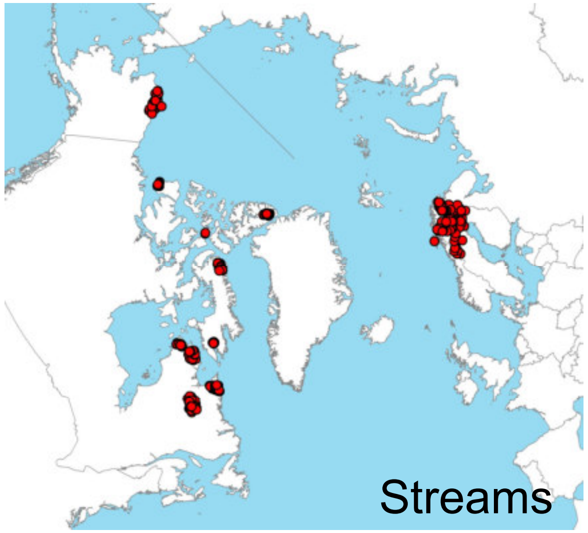
*and Finland

General conclusions

- *Modern samples:*
  - gradual shifts of taxa across the Arctic
  - still typical community compositions found
  - a **High Arctic** biotype found for both lakes & streams
  - driving factors were: low temp., low precipitation, sparse vegetation, bedrock (high Ca & pH), lake depth, substrate (sand)
- *Pre-industrial era samples:* Changes in lake diatom assemblages least in Eastern Canada (and Finland)

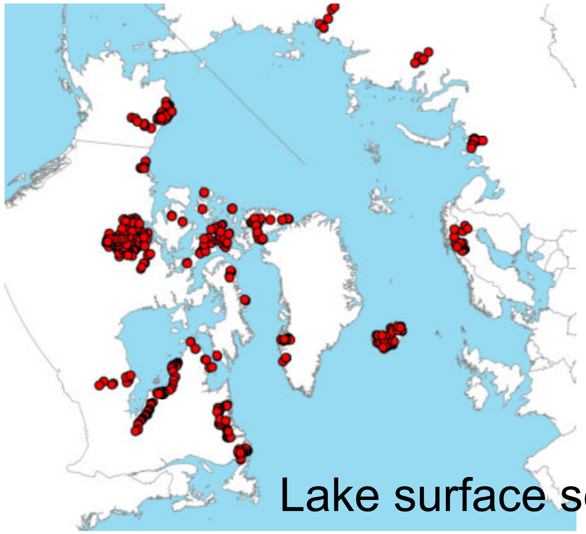
  Causes for change found in other studies:
  - High Arctic: shorter ice cover -> changes in thermal stratification and light penetration
  - Sub-Arctic: changes in the terrestrial vegetation, increase of humic substances (color) and nutrients

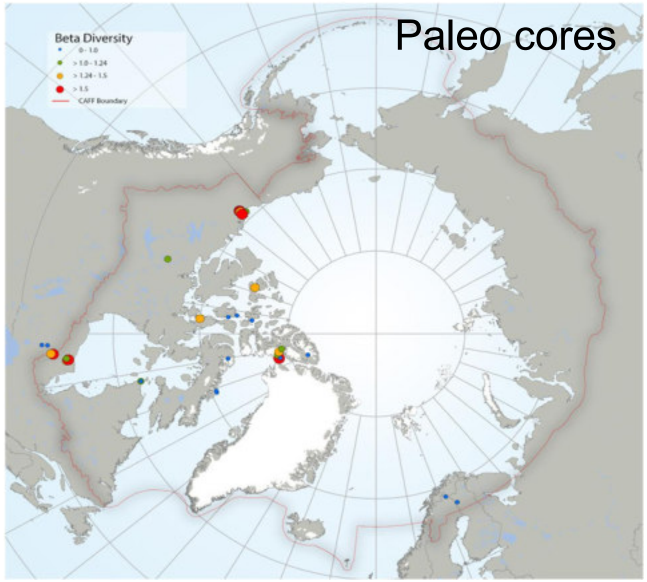
General conclusions



- Clear lack of stream sampling
  Important baseline for future assessment!

- Most paleo cores from Canada, need more from other countries





General conclusions

- Only Finland and Sweden have established long-term diatom-based monitoring programs (streams only)
- Many research based data available (especially lakes), but those sites not included in a routine follow-up
- Low agreement on diatom species identification -> problems when using data from different countries/ laboratories
  - Need for circumpolar diatom harmonization/identification activities
  - In the future: metabarcoding

More information: caff.is/freshwater

Thank you

More information: caff.is/freshwater

Points over global mean richness in red.

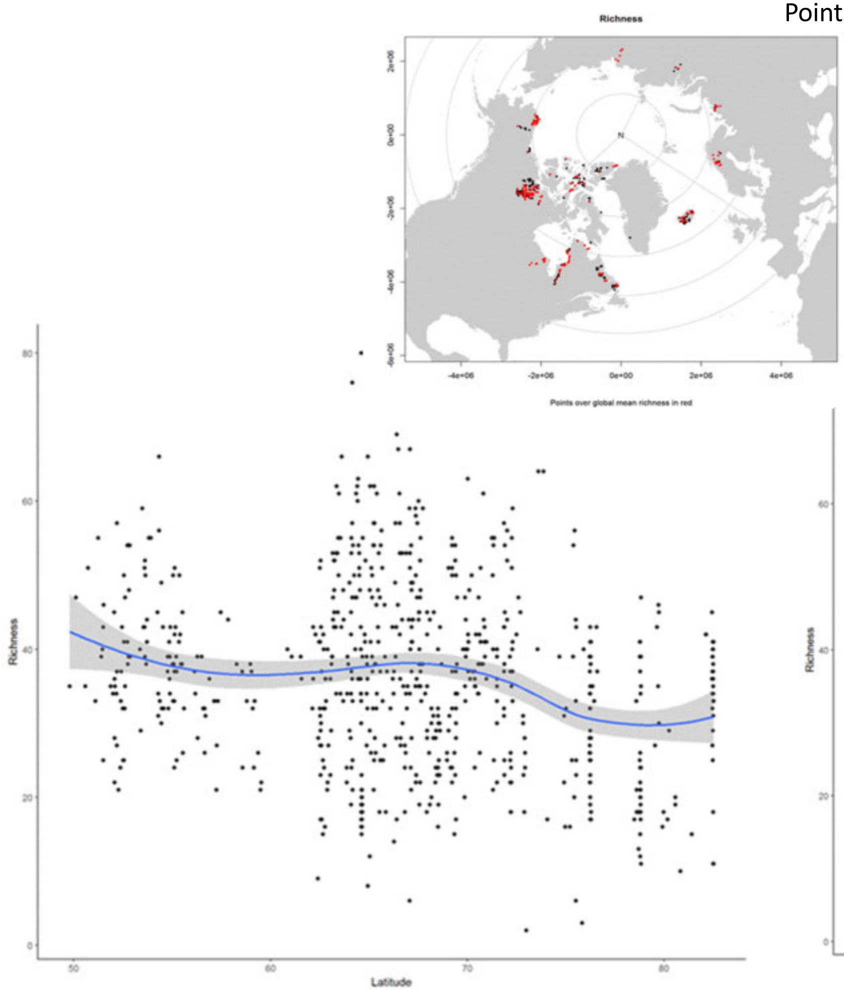


Fig 2b Local species richness of diatom communities in Arctic lakes vs. latitude.

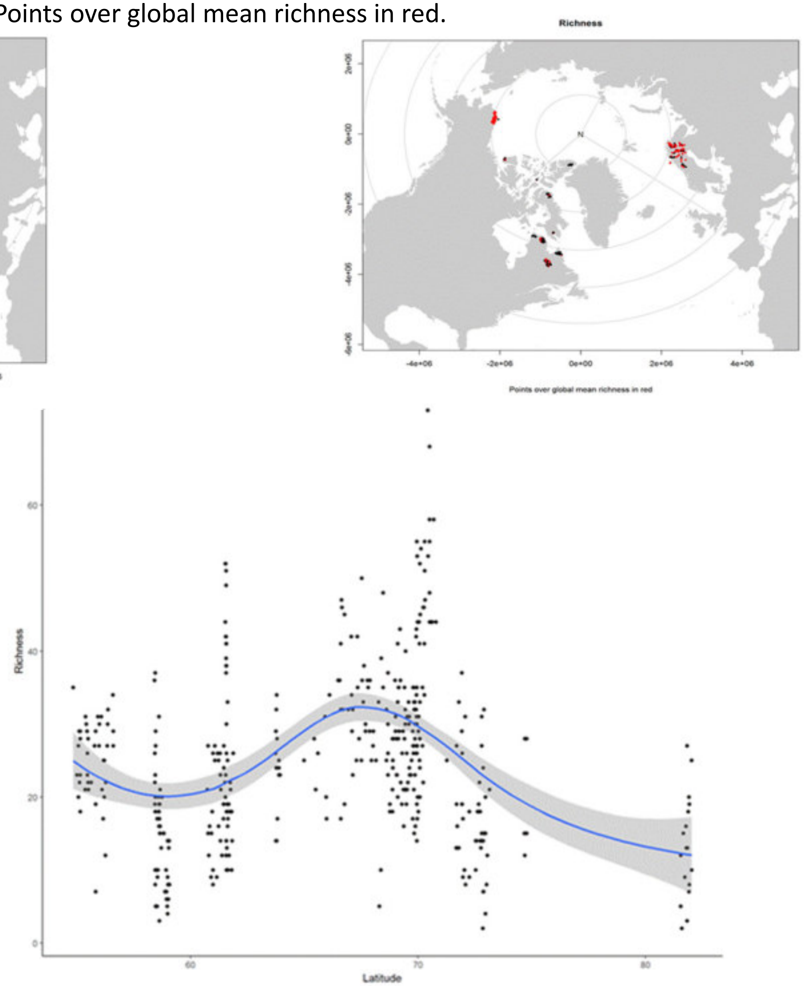


Fig 3b Local species richness of diatom communities in Arctic streams vs. latitude.

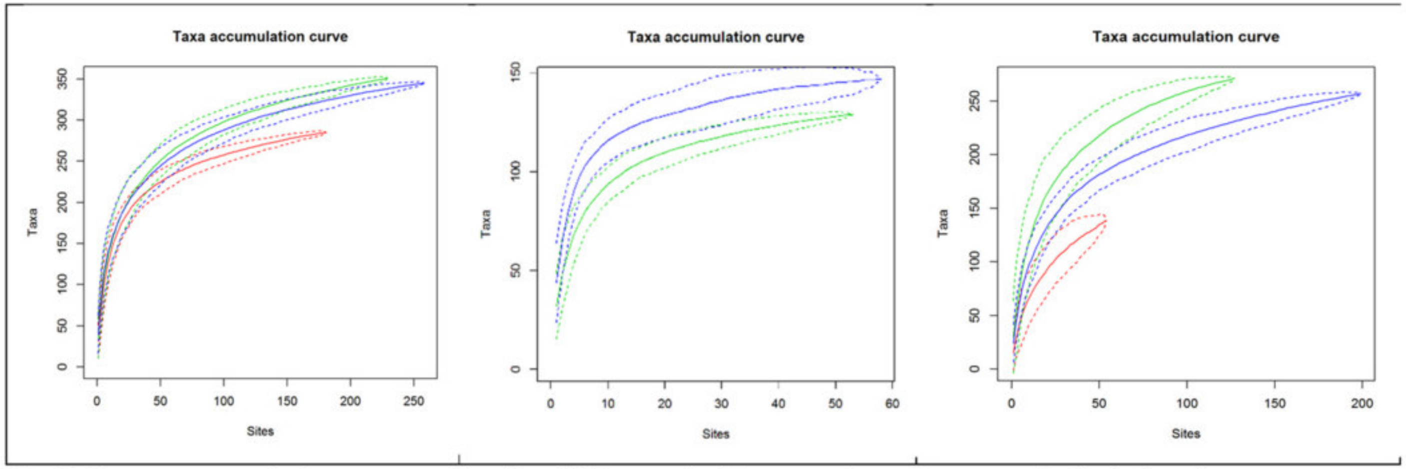


Fig 4. Taxa accumulation curves for the different habitats and arctic zones. Left: Lakes (top sediments), Middle: Lakes (scrapes). Right: Streams. Red: High arctic zone, green: low arctic, blue: sub-arctic.

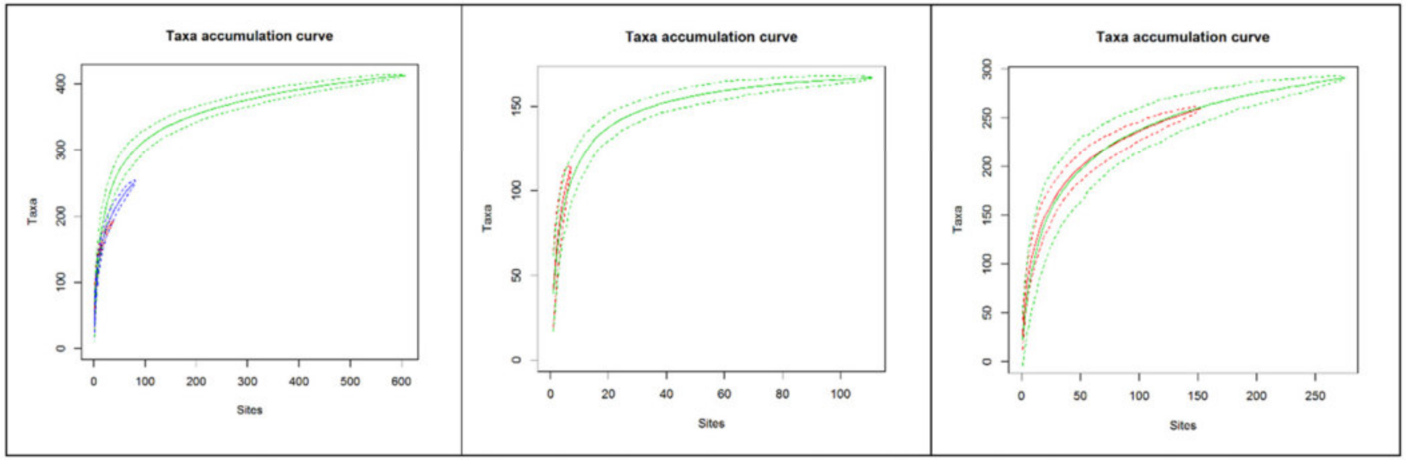


Fig 5. Taxa accumulation curves. Left: Lakes (top sediments), Middle: Lakes (scrapes). Right: Streams. Green: America, red: Europe, blue: Asia.