Ecosystem Health of Arctic Freshwaters

2017 field season report from lake sampling in Cambridge Bay

NRI license # 04 004 17R-M

30.1.2018

Milla Rautio, PhD & Canada Research Chair in Boreal and Polar Aquatic Ecosystems
Université du Québec à Chicoutimi (UQAC)
Phone : (418)5455011 ext. 5084
milla.rautio@uqac.ca

Michael Power, Univ. of Waterloo, m3power@sciborg.uwaterloo.ca
Connie Lovejoy, Université Laval, connie.lovejoy@bio.ulaval.ca
Marlene Evans, Environment Canada, marlene.evans@ec.gc.ca
Joseph Culp, Environment Canada, joseph.culp@ec.gc.ca
Warwick F. Vincent, Université Laval, warwick.vincent@bio.ulaval.ca
Nicolas Derome, Université Laval, nicolas.derome@bio.ulaval.ca
Mathieu Cusson, Université du Québec à Chicoutimi, mathieu.cusson@uqac.ca
Alexander Culley, Université Laval, alexander.culley.1@ulaval.ca

Summary and project aims

Following the lake sampling in greater Greinier Lake watershed in 2014 and 2015 that aimed to fullfill the knowledge gap in Canadian Arctic freshwater monitoring, two new sampling campaigns were carried out in 2018 in Cambridge Bay (Ekaluktutiak): one in summer between 8-16 August, and one in early winter between 30 October and 4 November, 2017. This work continued the research we had initiated with the Canadian High Arctic Research Station (CHARS) and was done under the NSRI license # 04 004 17R-M. The part of the sampling that included fish was done under the DFO licence to Dr. Marlene Evans. The 2017 research also contributed to our Polar Knowledge Canada supported project "Ecosystem Health of Arctic Freshwaters" and to the Circumpolar Biodiversity Monitoring Program (CBMP) that has been created in collaboration with all eight circumpolar countries. Each country aims to follow the same sampling protocol with the aim to provide high quality and comparable information of different environments in the Arctic and their biodiversity.

Nine lakes were sampled to provide a baseline description of the ecological variability of water quality, microbial, phytoplankton and zooplankton biodiversity and production, trophic structure and carbon fluxes (Fig. 1). The primary aim of the 2018 sampling was to identify and quantify fatty acid and mercury (Hg) stocks and fluxes in the freshwater food webs in the lakes near the Ekaluktutiak community. Fatty acids are essential nutrients for animal growth, health and immune system, including humans, and their abundance and composition are considered as indicators of the ecosystem health. While being essential health substances they may also correlate with the abundance of Hg in the food web. The Hg in the aquatic organisms is bioaccumulated in Arctic char and lake trout which contribute substantially to traditional Inuit meals and can be a source of mercury and persistent organic contaminant The results will provide tools for the Ekaluktutiak community to maintain essential ecosystem services (e.g. fishing) in the region.

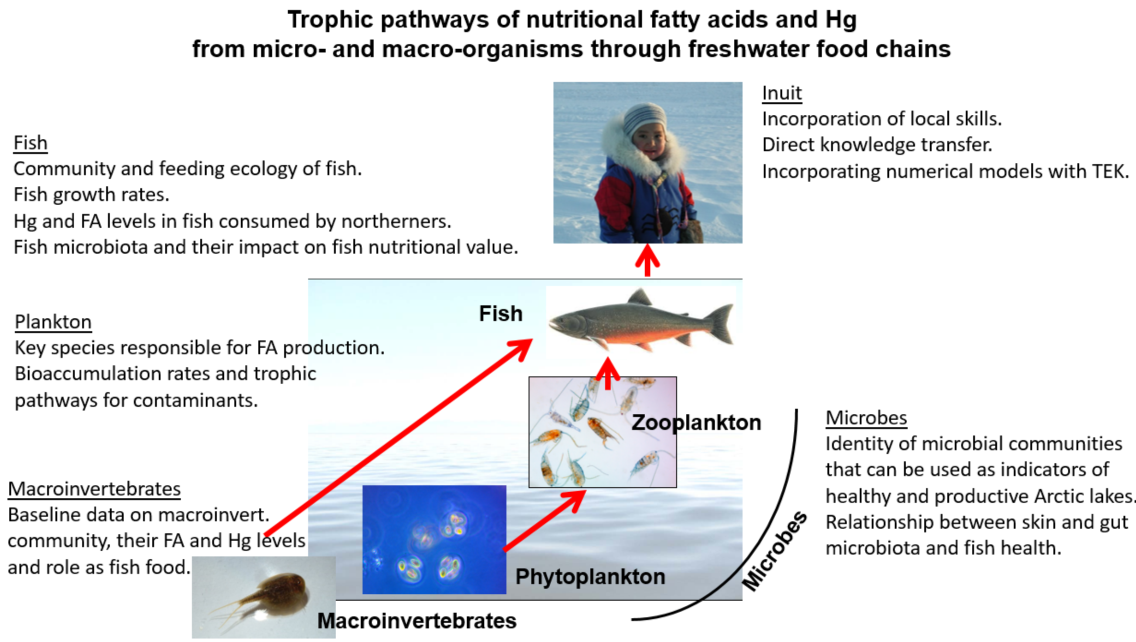


Fig. 1. Schematic presentation of the freshwater organisms that have been sampled in the project and how they contribute to the aquatic food web and transferring nutritional fatty acids and mercury to human consumption.

The sample analyses are taking place in the Laboratory of Aquatic Sciences (LASA) of UQAC, in Environment Canada (Saskatoon), University of Waterloo and Université Laval.

Sampling

The summer sampling in August focused on Greiner Lake (Fig. 3), which is known to be the most productive lake for fishing in Ekaluktutiak. Samples were also collected from four lakes in the experimental and reference area (ERA lakes) and in the Ferguson and Spawning lakes (Fig. 5). The limnological sampling and profiling we carried out in Ferguson Lake is the first ever done for this lake. Earlier research in this lake has exclusively concentrated in fish ecology. The winter sampling in October-November included 6 lakes. They were sampled for water column variables (see blow) and for ice algae and other constituents in the ice. (Fig. 2).

In each lake, profiles of temperature, conductivity and oxygen were made. Water samples were collected for nutrients (Table 1), including total phosphorus and nitrogen but also a large range of elements (fluor, chlorine, bromine, sulfate, nitrites, nitrates, aluminium, calcium, iron, potassium, magnesium, manganese, sodium, sulfur, silicium, strontium, zinc). This will permit to have a baseline for these elements that is inexistent for the Arctic Region of Cambridge Bay. Water was further analysed for the concentration and composition of dissolved organic matter (DOM) to be able to estimate the origin of carbon resources for the lake production. Bacteria, phytoplankton and zooplankton were sampled for abundance and identity. Stable isotope analyses (^{13}C and ^{2}H) were carried out on zooplankton and macro-invertebrates, and their potential food sources (phytoplankton, benthic algae, terrestrial plants, soil, bird feces). Fatty acid and mercusry analyses were been carried out for the same food web components. Finally, food web production was measured for the first time in an Arctic freshwater environment. We calculated primary production (Fig. 3) from phytoplankton and benthic algae as well as secondary productivity with zooplankton production (Fig. 4) in seven lakes. Bacteria production was estimated as well.

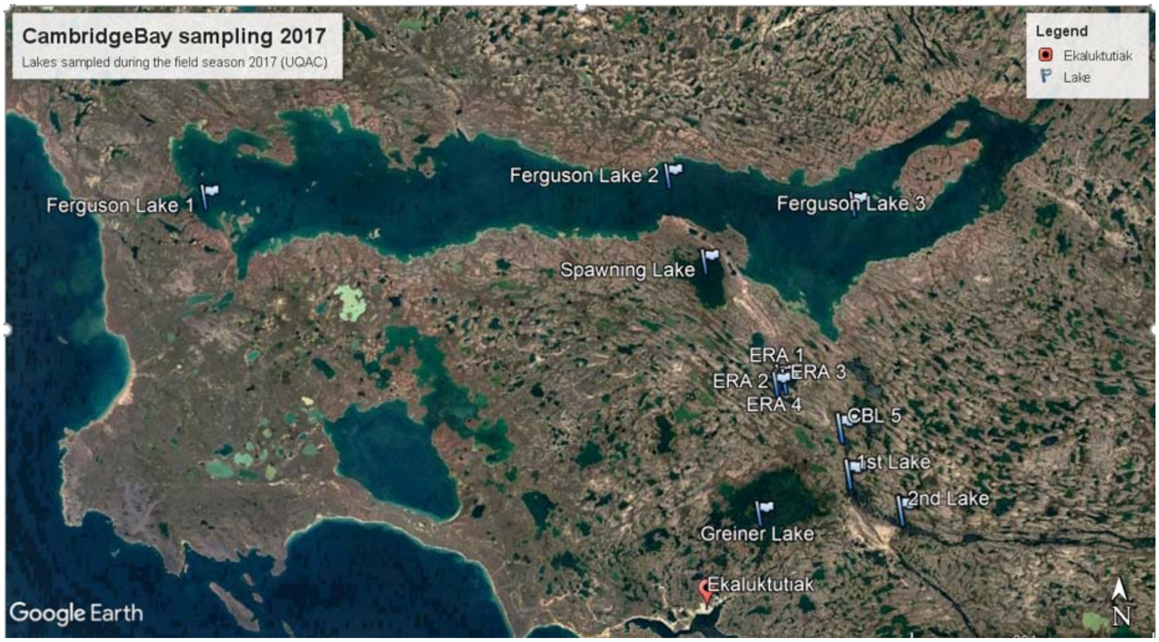


Fig. 2 Sampling sites in the 9 lakes that were sampled in August and/or in October-November in 2017 to collect limnological and ice data.
7-15 August, 2017: 7 lakes (Greiner, ERA 1, ERA 2, ERA 3, ERA 4, Ferguson Lake 3 locations, Spawning Lake
29 Oct – 5 Nov, 2017: 6 lakes (Greiner, ERA 1, ERA 4, First Lake, Second Lake, CBL 5)

As part of the winter sampling an automated logger was installed in Greiner Lake. The logger is a complete submerged monitoring system for long-term water quality monitoring. It is designed to sample water column physical (temperature, oxygen, pressure), chemical (conductivity, dissolved organic carbon) and optical (light) properties over extended periods of time, including under ice conditions in winter (battery life 900 days). These data will serve as continuous baseline information for understanding the metabolic and structural dynamics of Greiner Lake.

The samples and analyses were largely based on recommendations outlined in the Arctic Freshwater Biodiversity Monitoring Plan for circumpolar Arctic freshwater biodiversity assessment to be carried out for all Arctic countries in five year intervals. Each analysis has been pointed out as a key variable indicating the environmental status of a given water body according to the Table1 below.

Analysis	Justification as important Focal Ecosystem Component (FEC)
Bacteria	Pelagic bacteria as important as indicators of change or stressor effects, related to processes such as metabolism and decomposition.
Phytoplankton	High importance because they are the base of the food web, sensitive to change, diagnostic of certain types of change, metrics have been developed to identify stressor effects, low variance within a system; some long term monitoring data available.
Benthic algae	High importance because they are the base of the food web, sensitive to change; data availability generally low, samples sporadic spatially, chl-a used as a measure of periphyton production; high feasibility due to high ease of sampling and low cost, potential for archival analysis
Macroinvertebrates	High importance because of high species richness, reflect local conditions, important to food web, sensitive to change.
Zooplankton	Food for higher trophic levels, important consumers and secondary producers in the food web; community structure reflects environmental changes; easy to sample and fairly easy to identify; some long term monitoring data available.
Lipids and their fatty acids/energy flow	Important for community function and biodiversity, useful to detect changes within and among systems, useful for assessment of targeted species to identify energy flow (benthic vs. pelagic); few data exist.
Seston dry weight, Dissolved organic carbon	High importance because indicators of overall productivity of the system, strong relationship with biodiversity; high feasibility of sampling due to ease of sample collection and low cost; data are spatially and temporally extensive

Table 1. Biotic and biochemical focal ecosystem components (FECs) for arctic lake ecosystems, as identified in Arctic Freshwater Biodiversity Monitoring Plan.

Fig. 3. Greiner Lake in August 2017.

Fig. 3 Primary production measurements in Greiner Lake, incubation of water under different light intensities.

Fig. 4 Secondary production measurements, water is filtrated and incubated in the lake.

Fig. 5 Preparing for sampling in Spawning Lake.

Lake	Date	COD (mg C/L)	TN_{diss} (mg N/L)	F (mg/L)	Cl (mg/L)	Br (mg/L)	SO4 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	PO4 (mg/L)	TP (µg P/L)	TN (mg N/L)	SRP (µg P/L)	Al (mg/L)	Ca (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)
Greiner Lake	08-Aug-17	3.7	0.25	0.040	36.3	0.093	6.8	0.066	0.044	< 0.06	< 5	0.298	n.d.	0.019	17.4	0.0623	0.987	13.7	0.00086	14.6
ERA1	10-Aug-17	6.7	0.43	0.062	160	0.582	10.5	0.105	0.024	< 0.06	< 5	0.56	n.d.	0.028	34	0.0907	2.47	31	0.00085	80.1
ERA2	10-Aug-17	15.2	0.94	0.052	103	0.177	19.1	0.104	0.045	< 0.06	8	1.40	n.d.	0.024	31.3	0.038	1.7	33.3	0.00166	46.8
ERA3	10-Aug-17	7.0	0.48	0.085	136	0.379	20.4	0.176	0.051	< 0.06	< 5	0.57	n.d.	0.029	32.6	0.032	2	28.7	0.00086	59.6
ERA4	10-Aug-17	5.9	0.35	0.057	72	0.179	10.9	0.090	0.030	< 0.06	< 5	0.425	n.d.	0.022	30.6	0.125	1.44	25	0.00112	31.7
Ferguson Lake 0m	13-Aug-17	2.2	0.15	0.047	16.4	0.048	4.49	0.074	0.027	< 0.06	< 5	0.137	n.d.	0.021	20.2	0.0129	0.866	13	0.00015	7.91
Ferguson Lake 20m	13-Aug-17	2.1	0.16	0.051	16.8	0.048	4.52	0.075	0.033	< 0.06	< 5	0.179	n.d.	0.021	20	0.0583	0.93	12.9	0.00038	7.93
Ferguson Lake 10m	13-Aug-17	2.1	0.17	0.043	15.5	0.046	4.30	0.078	0.020	< 0.06	< 5	0.168	n.d.	0.026	19.5	0.004	0.84	12.4	0.00022	7.72
Spawning Lake	13-Aug-17	3.2	0.23	0.043	31.5	0.076	4.05	0.079	0.063	< 0.06	< 5	0.271	n.d.	0.024	21.3	0.0652	1.03	15.6	0.00093	13.2

Table 1. Some of the carbon (COD; dissloved organic carbon), nutrient and elemnetal data for the Cambridge Bay lakes.

Results

While detailed results will be available only after the completion of laboratory analyses, the project was already consulted and discussed with the Ekaluktutiak community in several face-to-face meetings, including the two day Freshwater Bioblitz that the researchers organized with CHARS and the community in August (Fig. 6). Preliminary results of the fatty acid transfer in the lake food web and pelagic microbial diversity were also presented at Arctic Change 2017 conference in Quebec City in December 2017.

Grosbois Guillaume, Power Michael, Rautio Milla. Understanding food webs in Arctic lakes: Production and transfer of essential fatty acids from plankton to fish.

Potvin Marianne, Rautio Milla, Wagner Johann, Lovejoy Connie. A first glimse at the pelagic microbial diversity in the Kitikmeot (Cambridge Bay) region, Nunavut.

An interview about the project was done with Radio Canada (in French).
http://ici.radio-canada.ca/premiere/emissions/l-heure-de-pointe/episodes/387809/audio-fil-du-vendredi-18-aout-2017/3

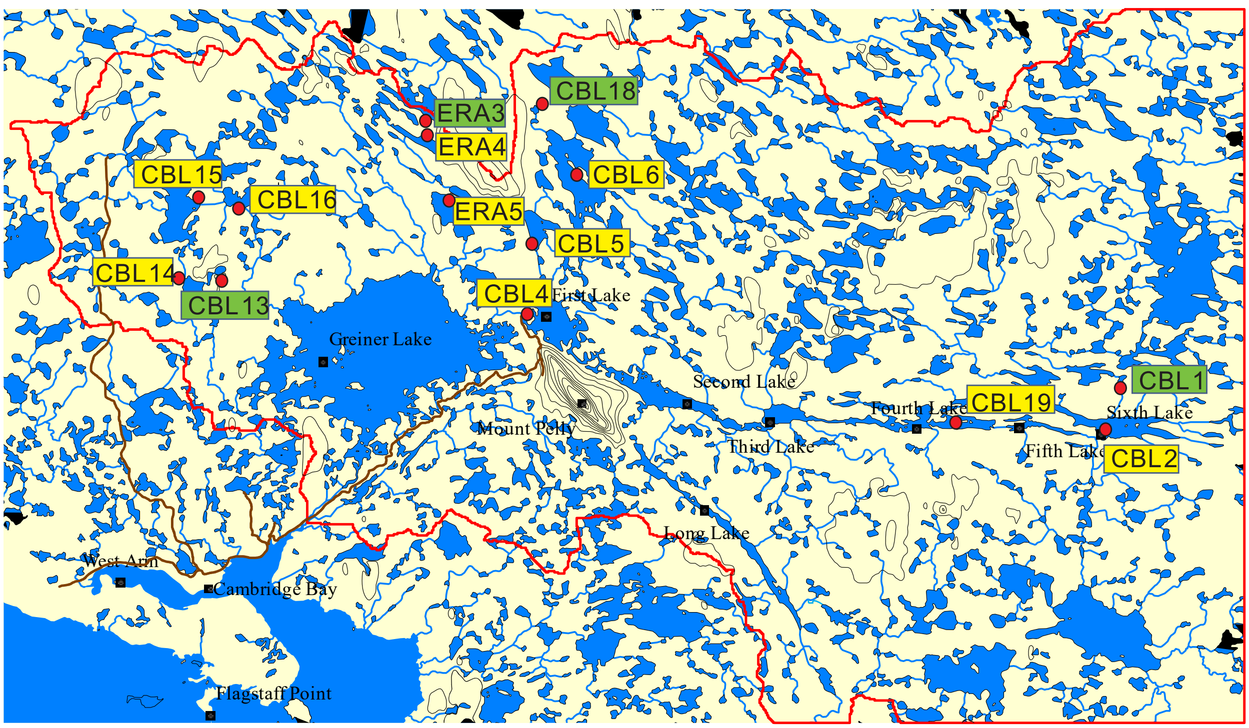
Fig. 6. Bioblitz where Drs. Rautio, Power and Grosbois exchanged with the Ekaluktutiak community about freshwaters and aquatic organisms

Sampling plan for 2018

The lake monitoring in 2018 will build on the work by our team that has been carried out in the Cambridge Bay vicinity since 2014. In 2018, the sampling will be carried out in winter/spring and in summer.

Winter-spring 2018:
Samples will be collected for ice algae and other microorganisms in the ice, to estimate how lake ice acts as a storage of nutrients and carbon, and an inoculum of organisms, which contribute to the production in arctic lakes. This sampling will be carried out in April-May 2018 when the ice has its maximum thickness.

Summer 2018:
Samples will be collected for bacteria, phytoplankton, zooplankton and phytobenthos that govern the overall production of Arctic lakes and that are likely most immediately responsive to environmental change. This sampling will be carried out in conjunction with the lake ice sampling in spring 2018, and during the open water period in July-August 2018. 16 lakes will be sampled. Planned locations are shown in the attached map.



Map showing the lakes to be sampled in 2018, including Greiner Lake and 15 smaller lakes in its watershed. Lakes labelled in green are headwater lakes to the four lake chains that will be sampled.