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Assessing the impact of small, Canadian Arctic River flows to the freshwater budget of the Canadian Archipelago
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Assessing the impact of small, Canadian Arctic river flows to the freshwater budget of the Canadian Archipelago (or SCARFs) is a scientific research project funded by the National Science Foundation (USA). The purpose of this project is to collect water samples from seven different rivers and their adjoining estuaries throughout the Canadian Arctic Archipelago (see Fig. 1) in order to determine whether or not their chemical signatures differ from larger North American rivers such as the Mackenzie and Yukon Rivers. Five of the rivers are located within Nunavut, Canada: the Coppermine River (near Kugluktuk), Ellice River (~140 km southeast of Cambridge Bay), Back River (~180 km southeast of Gjoa Haven), Cunningham River (~77 km southeast of Resolute Bay on Somerset Island), and Kangiqtugaapik River (near Clyde River, Baffin Island). Two of the rivers are located within the Northwest Territories, Canada: the Kujjuua River (located approximately 67 km northeast of Ulukhaktok on Victoria Island) and Thomsen River (specifically near the mouth of the river where it empties into Castel Bay, on Banks Island).

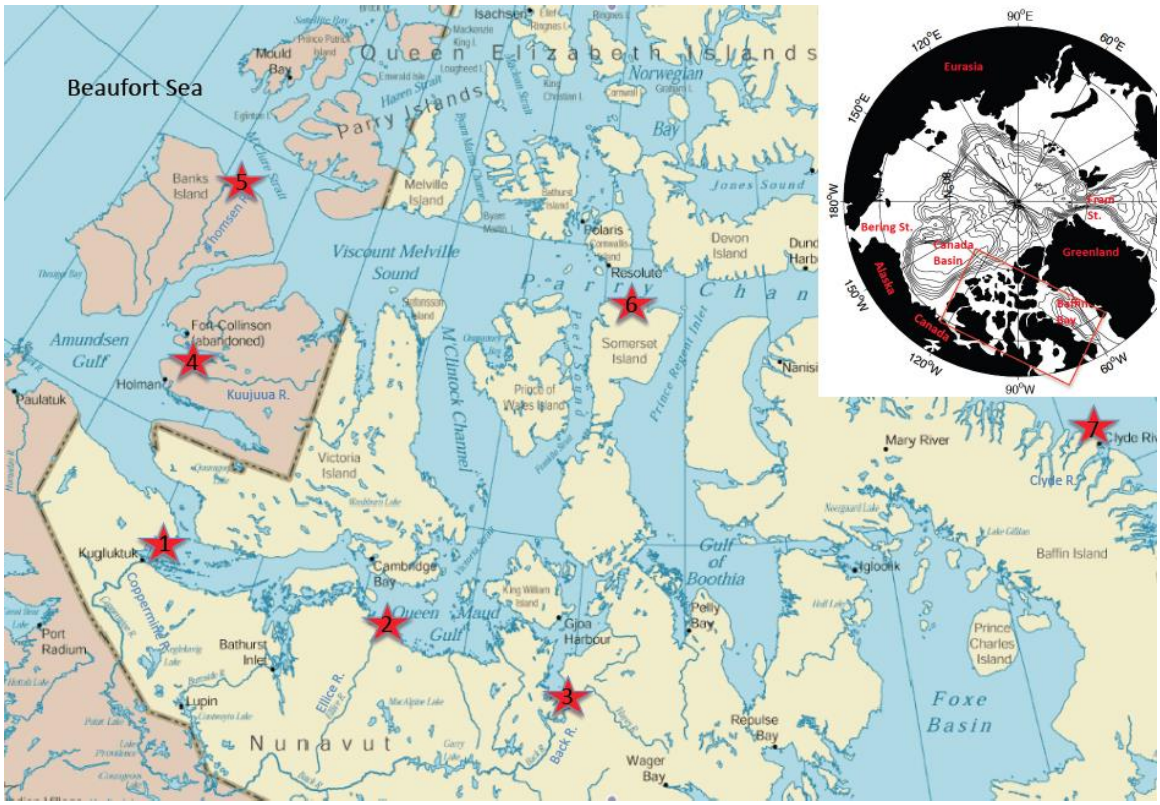

Figure 1. Map of the Canadian Arctic Archipelago. The red stars indicate the mouths of the rivers sampled during this study: (1) Coppermine R., (2) Ellice R., (3) Back R., (4) Kuujuua R. (Victoria Island), (5) Thomsen R. (Banks Island), (6) Cunningham R. (Somerset Island), and (7) Clyde R. (Baffin Island). The Coppermine, Ellice, and Back Rivers are located on the mainland of Nunavut. Inset shows Arctic Ocean with study area highlighted by the red box.

1. Permits and community support

A three-year (2014-2016) scientific research license (# 04 008 14N-M) was acquired from the Nunavut Research Institute and an approval without a license (No. 8WLC-CAR1415) was issued from the Nunavut Water Board to collect samples from the specified rivers. As our proposed sampling site on the Ellice River was located within the Queen Maud Gulf Bird Sanctuary, an additional permit (NUN-MBS-14-03) was acquired from the Ahiak Area Comanagement Committee to conduct scientific samplings in the area between June and October of 2014, 2015, and 2016. Finally, reviews by the Nunavut Planning Commission and Nunavut Impact Review Board (NIRB, File No. 13YN042) determined that the proposed project conformed to the North Baffin Regional Land Use Plan and may be processed without review, respectively, after addressing specific comments made by Environment Canada and agreeing to project-specific terms and conditions outlined by the NIRB assessment. Hunters and Trappers Organizations from Kugluktuk, Cambridge Bay, and Gjoa Haven were contacted for guidance, consultation, and support both before and during field work. In addition, representatives from the Illisaqsivik Society (Clyde River) were also contacted for support services as well as help in hiring local residents (Esa Qillaq and Niore Iqaluqjuak) to independently collect water samples from the river on a weekly basis between July and September, 2014. Similarly, field technicians were hired in Kugluktuk (Christian Hikok Kamingoak and Jorgen Anablak) to collect samples from the Coppermine River. Wildlife monitors were also hired from Cambridge Bay (Jorgan Artaok) and Gjoa Haven (Adam Ukuqtunnuak) to watch for polar bears and help keep field operations safe in more remote sampling locations.

A multi-year (2014-2016) scientific research license (No. 15376) was acquired from the Aurora Research Institute. In addition, permissions were granted from the Northwest Territories Water Board to collect river water without a license (water use needs were well below the threshold required for a water license), the Inuvialuit Land Administration to access Inuvialuit Private Lands (ILA Right Number ILA13HN021), and the Environmental Impact Screening Committee. Since the Thomsen River is located within the boundaries of the Aulavik National Park, additional permitting was required from Parks Canada to gain access to this river. After consulting with Research Permit Coordinator Nelson Perry, a Research and Collection Permit (#AUL-2014-16137) was acquired to conduct sampling of the Thomsen River between July 1 and 31, 2014. An Aircraft Landing Permit (registration # 201431) was issued on June 26, 2014 to access the Thomsen River near Castel Bay on July 3, 2014. As specified in the Principle Investigator Responsibilities section of the Research and Collection Permit, the research team, pilot, and co-pilot attended a brief orientation given by John Lucas at the Parks Canada office in Sachs Harbour on July 2, prior to entering the park. Finally, a Bear Monitor Business License and Firearm Permit Application was completed on July 2 at the Sachs Harbour Hunters and Trappers Organization office and faxed to Christopher Hunter at the Parks Canada office in Inuvik for processing. The Hunters and Trappers Organizations from Ulukhaktok and Sachs Harbour were informed about the project details and consulted regarding specific sampling locations and the need for bear

monitors. Two bear monitors were hired from Ulukhaktok (Brian Kudlak and Patrick Akhiatak) and one monitor (Jeff Kuptana) from Sachs Harbour.

2. Activities

The research team consisted of four members: Matthew Alkire (principle investigator) from the University of Washington, Gregory Lehn (postdoctoral associate) from Northwestern University, John Kelly (middle school teacher) from St. Louis, Missouri, and Robie Macdonald (consultant and co-investigator) from Fisheries & Oceans, Canada. John Kelly was hired to replace Andrew Jacobson (co-principle investigator from Northwestern) since Dr. Jacobson was unable to accompany the research team into the field. Mr. Kelly will utilize his experiences as part of this project to help plan lessons for his students involving river systems and general earth sciences. The research team arrived in Kugluktuk on June 16, 2014. The Twin Otter flight crew from Kenn Borek Air, Ltd. arrived in Kugluktuk on June 23, 2014. The flight crew consisted of pilot James Haffey, co-pilot Douglas Westersund, and engineer Stephen Martyniuk. All necessary scientific equipment was shipped from base laboratories in Seattle (University of Washington) and Chicago (Northwestern) to Kugluktuk and picked up by the research team upon arrival. During the period of field work (June 17-July 9, 2014) the research team and flight crew traveled to various towns and hamlets spread throughout Nunavut (Kugluktuk, Cambridge Bay, Gjoa Haven, Resolute Bay, Clyde River) and the Northwest Territories (Sachs Harbour, Ulukhaktok) and worked from these towns to either sample rivers easily accessible from town (Coppermine and Clyde Rivers) or prepare for flights to more remote locations (Ellice, Back, Kujjuua, Cunningham, and Thomsen Rivers) to conduct sampling operations.

An extendable pole with an attached bottle was used to sample the rivers. Wearing chest waders, Alkire entered the rivers from shore and utilized the pole to collect water from the central channel. Between 4 and 6 liters of water were collected in this manner and the bottles brought back to shore for filtration and subsampling. While on shore, Lehn and Kelly utilized a battery-powered drill specially outfitted to operate a peristaltic pump that pumped water through C-FLEX type tubing from the sample bottles through a filter and into smaller vials. Three of these vials required a small addition of a different chemical (hydrochloric acid, mercuric chloride, or cupric chloride) to preserve the samples. All other vials were simply rinsed with sample before final collection. The vials were carefully labeled and stored for shipment to laboratories in Seattle and Chicago where they will be chemically analyzed to determine the stable oxygen isotope signature, strontium isotopic ratios, total alkalinity, dissolved inorganic and organic carbon content, and concentrations of barium, major cations (e.g., calcium and magnesium), major anions (e.g. chloride and sulfate), and nutrients (e.g., nitrate and phosphate). In addition to river water samples, temperature, pH, and conductivity measurements were made using a portable probe and < 2 kg of mud were collected at each site to determine their mineral content; this helps the research team to determine what sources (rocks, soil, etc.) contribute to the dissolved components measured in the river waters. All samples and equipment were loaded back onto the Twin Otter aircraft prior to departure from each site (nothing was left behind).

Field operations conducted on each river are summarized in the following sections:

2.1 Coppermine River (June 17 – 24, 2014)

After meeting and coordinating with the local Hunters & Trappers Organizations, samples were collected on 17 June from three different positions extending across the river using a small boat powered by an outboard motor. The three positions formed a line crossing the river such that samples were collected near the west and east banks as well as the central channel of the river. These samples should allow the research team to determine whether the chemical signatures in the river vary across its width. Two field technicians (Christian Hikok Kamingoak and Jorgen Anablak) accompanied Alkire and Lehn on a second trip to the Coppermine River to collect a second set of samples on 20 June for training purposes. Alkire and Lehn demonstrated the sample collection and then had the field technicians collect their own set of samples for practice and ask any questions about the procedures. On 23 June, a third set of samples was collected from the Coppermine River by the field technicians while Lehn and Kelly looked on as observers (final phase of training).

2.2 Ellice River (June 24, 2014)

The research team, pilot, co-pilot, and bear monitor (Jorgan Artaok) departed Cambridge Bay airport around 4PM to sample the Ellice River. Mr. Artaok was hired after consulting with the Department of Environment Office in town. Unfortunately, we were unable to meet with members from the local Hunters & Trappers Organization as the resource person was sick during our short stay in Cambridge Bay. The Twin Otter landed on a strip of firm sand with some gravel (67º 58.503'N, 104º 01.061'W) at 5:30PM and the research team walked ~0.5 km to the river. Birds were seen from the plane but no wildlife was encountered on the ground except what looked like a flock of ducks overhead, a couple seagulls, and mosquitos. The landing area was devoid of birds and no signs of nests or nesting parents were encountered during sampling; thus, the sampling operations had minimal impact on the area. Three radios were distributed to Artaok, the pilots (Haffey & Westersund stayed with the plane), and the research team to allow for communication and coordination in case of emergency. While the research team sampled the river, Artaok stood on the bluff above the river bank so he could keep watch on both the pilots and the research team. No bears were sighted. Samples were collected by Alkire wading into the river with the extendable pole and filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. Macdonald took pictures to document the sampling efforts and kept charge of ropes, floats, and first-aid kits in case of accidents. Once work was completed, the team packed up all samples, equipment, and garbage and brought all materials from the river back to the aircraft for loading and departure. The plane arrived back at Cambridge Bay around 8:30PM.

2.3 Back and Hayes Rivers (June 26, 2014)

The research team, pilot, co-pilot, and bear monitor (Adam Ukuqtunnuak) departed Gjoa Haven airport around 1:45PM to sample the Back River. Mr. Ukuqtunnuak was hired after consulting the local Hunters and Trappers Organization prior to our arrival in town. The original intention was to only sample the Back River during this trip; however, it became clear that the separate flows from the Back and

Hayes Rivers met downstream prior to flowing out into Chantrey Inlet. The collection of samples downstream from the point of confluence could result in a mixed sample of the two rivers and sampling upstream would only yield data corresponding to the chemistry of one of the major source waters entering the inlet. Therefore, in order to understand the contribution from both rivers to Chantrey Inlet, samples from the Back and Hayes Rivers needed to be collected.

First, the Twin Otter landed on a sandy beach around 3PM at coordinates 67º 3.916'N, 95º 16.865'W and the research team walked downriver approximately 1.3 km from our landing site to find a spot allowing access to the main part of the channel and thereby ensure samples were reflective of the Back River's chemistry. Ukuqtunnuak accompanied the team at a distance and all parties kept in communication via radio. Samples were collected by Alkire wading into the river with the extendable pole and filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. Macdonald took pictures and again acted as safety officer. After sampling was completed the team walked back to the aircraft and departed at ~6PM to travel to the Hayes River. Approximately 30 minutes later, the Twin Otter landed at coordinates 67º 10.212'N, 95º 10.080'W, a location about 12.6 km away from the Back River sampling site. At this location, the research team traveled only a very short distance from the aircraft down to the river to conduct sampling. Again, samples were collected by Alkire wading into the river with the extendable pole while Macdonald kept safety/rescue equipment ready. Samples were brought back to shore and filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. The plane arrived back at Gjoa Haven around 9PM. Although no wildlife was encountered while on the ground, two wolves and four caribou were seen crossing the river from the air. Flocks of birds were also spotted from the air but were not identified as they were well below the aircraft (cruising altitude ~7500 ft.).

2.4 Kujjuua River (June 29, 2014)

The research team, pilot, co-pilot, and bear monitors (Brian Kudlak and Patrick Akhiatak) departed Ulukhaktok airport around 11AM to sample the Kujjuua River. The monitors were hired with the help of the local Hunters and Trappers Organization during a brief meeting held the previous day to discuss the project, address questions from the HTO council, and seek guidance to help sampling efforts. The plane was landed along a sandy strip near an old hunting cabin at the mouth of the river (71º 16.054'N, 116º 45.878'W) at 12:21PM. The research team, accompanied by Akhiatak (Kudlak stayed with the pilots) hiked about a mile upstream on the north bank to a location (71º 16.232'N, 116º 48.594'W) where the river narrowed and developed strong rapids. Samples were collected by Alkire wading into the river from a position just downstream of the rapids (to ensure good mixing of the river) and deployed the extendable pole to reach the center of the channel while Macdonald acted as safety officer. The collected water was filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. The plane arrived back at Ulukhaktok around 4PM.

2.5 Thomsen River (July 3, 2014)

The research team, pilot, co-pilot, and bear monitor (Jeff Kuptana) departed Sachs Harbour airport around 9:45AM to sample the Thomsen River. Kuptana was hired with

the help of the local Hunters and Trappers Organization. The aircraft landed very close to the required landing site, *Thomsen River, where it flows into Castel Bay: 74º 04' 55"N, 119º 46' 00"W,* specified in Aulavik National Park guidelines. The flight altitude heading into the park was 5,000-6,000 ft. until about 7 minutes prior to landing. The plane did not remain at the coordinates specified by Parks Canada due to soft and wet conditions that exacerbated sinking of the aircraft. Due to these unsafe landing conditions, the plane took off immediately after landing and set down again at a location ~1.6 km away at 74º 04.075'N, 119º 47.081'W. Samples were collected near the landing site via Alkire wading into the river with the extendable pole and filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. Again, Macdonald acted as safety officer. No direct encounters with resident wildlife occurred during our trip. However, seagulls (Glaucous Gull), two herds of muskoxen (15-16 individuals in each herd), a flock of Canada geese, two Sand Hill Cranes, fulmars, a "loon", and a Rough Legged Hawk were spotted by the research team and bear monitor. None of the wildlife was disturbed and no bears were sighted. The plane arrived back at Sachs Harbour around 3:45PM.

2.6 Cunningham River (July 5, 2014)

The research team, pilot, and co-pilot departed Resolute Bay airport around 9:40AM to sample the Cunningham River. No bear monitors were hired for the trip. Arctic Watch, a tourist camp set up on the river primarily for beluga watching and other tourist activities, was contacted prior to departure for permission to land using their runway. Coordinating with Arctic Watch, the Twin Otter landed on their airstrip (74º 04' 21"N, 93º 47'W) and the research team walked a short way down to the Cunningham River to collect samples. Samples were collected near the landing site via Alkire wading into the river with the extendable pole and filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. Again, Macdonald acted as safety officer.

2.7 Kangiqtugaapik River (July 9, 2014)

The research team arrived in Clyde River on July 8 and the Kenn Borek crew departed shortly afterward to return to home base in Calgary. The research team met with members of the Ilisaqsivik Society the following day to discuss logistical support and meet the field technicians who would be trained to collect samples from the river over the course of the summer: Esa Qillaq and Niore Iqaluqjuak. During the meeting, the research team was informed that the river close to town was not actually the "Clyde River" but an unnamed river that supplies the town's drinking water and empties into Kangiqtugaapik Inlet. Although no official name was provided, the research team has referred to this river as the Kangiqtugaapik River for simplicity. The research team and the two technicians drove to the proposed sampling site, located next to a bridge over the river. Samples were collected approximately 0.8 km from town and 2.1 km upstream of the river mouth where it empties into the inlet. Samples were collected from the south bank of the river by Alkire wading into the river with the extendable pole and filtered and sub-sampled by Lehn and Kelly using the portable drill-pump and tubing onshore. Macdonald helped to document the sampling exercise and again acted as safety office during sampling operations. Alkire, Lehn, and Kelly explained the sampling procedures

to Qillaq and Iqaluqjuak while they sampled the river. Upon completion, the team moved to the north bank of the river and Alkire and Lehn looked on while Qillaq and Iqaluqjuak collected and filtered samples.

Over the next few days, samples and equipment were packed up and shipped out of Clyde River via First Air. Alkire also gave a brief radio show on the morning of 11 July to inform the community about the project and answer questions. The research team left Clyde River on July 14, 2014 at the end of the project.

3. Preliminary Results

All communities with whom the research team had a chance to speak voiced concerns about low snowfalls and declines in river discharge over the last 3-5 years. In addition, some communities expressed concerns about mining operations conducted within the watersheds of the rivers upon which they rely for drinking water. For example, many residents in Clyde River expressed concerns about the potential for the release of toxins and other pollutants from a DEW line site at nearby Cape Christian. It was clear from these conversations that the local residents were concerned about near-future changes in the quality and availability of drinking water from the local rivers that have supplied clean water for generations. Unfortunately, the chemical analyses conducted as part of this research program do not include contaminants; instead, this project is focused on natural products of erosion and inputs from precipitation and groundwater.

Contaminants such as polychlorinated biphenyls (PCBs) become concentrated in fatty tissues of large aquatic animals (e.g., polar bears, seals and whales) that are exposed through the food web. Therefore, communities are more likely to be exposed to contamination by eating fat-rich tissue from seals and/or polar bears rather than from their drinking water. To determine contaminant exposure, additional chemical monitoring of both drinking water sources and tissue from animals inhabiting these rivers would be required and the research team is willing to provide support for communities interested in submitting an application to organizations such as the Northern Contaminants Program, Environment Canada or Water Survey of Canada to conduct such analyses.

3.1 Data

Samples or river water are still being collected by local community members in Kugluktuk and Clyde River and all chemical analyses have not yet been completed on the samples that were collected by the research team during June and July 2014. However, a number of analyses have been completed that allow for a comparison of the chemical composition of the rivers (Table 1). The data that have been compiled cannot show a complete picture of each river's chemistry as concentrations vary with the magnitude of the discharge. For example, over the course of the summer the snowpack is depleted and daily discharge rates decrease with the supply of freshwater. As the water supply decreases, some dissolved solids may become more concentrated whereas others may become less concentrated. Therefore, some of the chemical parameters measured may be expected to increase or decrease between initial sample collection in June and the completion of sampling operations in late September/early October. Nevertheless, some information about the geological composition and weathering climate in the drainage

basins of the various rivers can be gained by studying the data collected close to the time of peak discharge.

Table 1. Summary of measurements completed on samples of river water collected just before or after peak discharge during June-July, 2014. Parameters reported include conductivity (Cond), temperature (Temp), stable oxygen isotopic ratio of water ($\delta^{18}O$), total alkalinity (TA), barium (Ba), dissolved inorganic nitrogen (DIN = nitrate + nitrite + ammonium), phosphate (PO_4), silicic acid ($Si(OH)_4$), and dissolved organic carbon (DOC). The concentrations of DIN, PO_4, and $Si(OH)_4$ are reported in units of micromoles per liter (μM). Barium concentrations are reported in units of nanomolar (nM). DOC concentrations are reported in units of milligrams per liter (mg L^{-1}). Total alkalinities are reported in units of microequivalents per kilogram (μeq kg^{-1}). $\delta^{18}O$ reported in del units (‰) relative to Vienna Standard Mean Ocean Water. Conductivity reported in units of microSiemens per centimeter (μS cm^{-1}).

River	Date	pH	Cond (μS cm^{-1})	Temp (°C)	$\delta^{18}O$ (‰)	TA (μeq kg^{-1})	Ba (nM)	DIN (μM)	PO_4 (μM)	$Si(OH)_4$ (μM)	DOC (mg L^{-1})
Coppermine	6/18/14	6.85	192.8	11.3	-20.82	995	196.3	0.72	0.018	23.28	3.82
Ellice	6/24/14	7.27	132.0	11.0	-20.58	77	-	0.16	0.040	3.15	3.47
Back	6/26/14	7.00	126.5	14.0	-20.01	109	37.6	1.34	0.001	2.63	2.60
Hayes	6/26/14	7.06	29.5	11.4	-21.53	58	5.8	0.10	0.025	2.02	1.53
Kujjuua	6/29/14	7.48	213.0	4.6	-22.24	1003	48.8	0.84	0.000	23.76	2.52
Thomsen	7/3/14	7.49	268.0	11.0	-22.23	1066	117.3	1.56	0.024	22.42	2.34
Cunningham	7/5/14	7.86	288.0	2.8	-25.61	1341	25.3	3.72	0.000	8.29	0.58
Clyde*	7/9/14	7.33	25.3	5.0	-17.88	14	6.8	0.30	0.004	0.68	0.97

*Data reported for Clyde River actually collected from a small stream flowing into the Kangiqtugaapik Inlet

A quick examination of the data summarized in Table 1 indicates that the Ellice, Back, Hayes and Clyde Rivers are characterized by low concentrations of nutrients, barium, and total alkalinity compared to the Coppermine, Kujjuua, and Thomsen Rivers. In contrast, the Cunningham River had high total alkalinity and DIN concentrations but low silicic acid, phosphate, and barium concentrations. A comparison of these rivers versus the six largest Arctic rivers (Mackenzie, Yukon, Lena, Ob, Yenisey, and Kolyma Rivers) indicates generally lower concentrations overall. The lower concentrations in the small Canadian Arctic rivers are likely a consequence of a shorter duration of snowmelt within the drainage basin prior to peak discharge. These shorter timescales minimize weathering and erosion of soils and bedrock, limiting the amount of dissolved materials in the river water. However, total alkalinities measured in the Coppermine, Cunningham, Kujuua, and Thomsen Rivers were similar to measurements collected from Siberian rivers, suggesting some impact from erosion and mineral weathering of carbonate rocks within the drainages basins of these rivers. Continued chemical analyses of collected samples will yield more information about these rivers and their drainage basins.

A comparison of the stable oxygen isotope signature of the river water ($\delta^{18}O$) indicates significant variability among the rivers as the Coppermine, Ellice, Back, and Hayes Rivers, had slightly more positive (less negative) signatures than the Kujjuua, Thomsen, and Cunningham Rivers but the signature of the Clyde River water (-17.88‰) was the most positive observed during the study. The differences in the $\delta^{18}O$ signatures measured in these rivers can be explained by a number of factors. Different sources of water (snowmelt, groundwater, and/or glacial meltwater), extent of evaporation, and conditions (altitude, latitude, and temperature) during the precipitation all contribute to

the $\delta^{18}O$ of the river waters. The most likely factor responsible for the $\delta^{18}O$ variations observed among the rivers is likely the locations of the drainage basins. The Coppermine, Ellice, Back, and Hayes Rivers all drain more extensive areas of the mainland compared to the Kujjuua, Thomsen, Cunningham, and Clyde Rivers that drain smaller basins located on islands (see Fig. 1). The mainland rivers also derive water from precipitation falling at lower latitudes ($\delta^{18}O$ signatures are generally more negative in precipitation falling at higher latitudes and elevations and colder temperatures). The lower value measured from the Cunningham River could indicate a much lower temperature during precipitation of snow or a contribution from another water source (e.g., glacial meltwater) compared to the Kujjuua and Thomsen Rivers that are located at similar latitudes. The relatively high $\delta^{18}O$ signatures of the Clyde River is most likely the result of its heavy snowfall compared to the other regions, a consequence of its close proximity to Baffin Bay (a source of marine evaporation providing moisture for snow).

Since the rivers were all sampled soon after the maximum discharge of the spring freshet, the data are likely to be the lowest (most negative) $\delta^{18}O$ values observed during the spring and summer months. These values are expected to increase during the summer as the rates of evaporation increase and the snow pack providing the majority of the river discharge decreases. The samples collected by local community members in Kugluktuk and Clyde River will help to better understand the seasonal variations in the $\delta^{18}O$ signatures of these two rivers. These data will be reported online after it becomes available.

3.2 Website

This report as well as all data collected as part of this project is freely available on the website: www.canadianriversproject.org.

The data presented in this report has already been uploaded to the website. As chemical analyses are ongoing, the data sets will be regularly updated as more results are obtained. In addition to the data, tutorials explaining the use of these chemical parameters to learn about the Arctic and subarctic seas have also been made available. More tutorials are planned and will be uploaded to the website as the project progresses.

4. Acknowledgments

We would like to acknowledge the help and support provided by the Hunters and Trappers Organizations of Kugluktuk, Cambridge Bay, Gjoa Haven, Ulukhaktok, Sachs Harbour, and Clyde River. We would also like to especially thank Barbara Adjun, Shane Sather, Victoria Akhiatak, Gil Olifie, Betty Haogak, Jakob Gearheard, Shari Gearheard, Nelson Perry, Christopher Hunter, Cassandra Elliot, and John Lucas for their efforts in helping to plan and support field work. Without their efforts, this work would not have been possible. We also thank Thomas Quinn and Faustine Bernadac for their outstanding logistical support and safety planning prior to field operations. We would also like to thank Christian Hikok Kamingoak, Jorgen Anablak, Esa Qillaq and Niore Iqaluqjuak for their hard work extending the timeseries of the Coppermine and Kangiqtugaapik Rivers over the course of the summer. We also thank Jorgan Artaok, Adam Ukuqtunnuak, Jeff Kuptana, Brian Kudlak and Patrick Akhiatak for their help acting as wildlife monitors during field work operations. Finally, we thank Wally Dobchuk, James Haffey, Douglas

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5. Questions/comments

If there are any questions, concerns, or comments regarding this report or work related to the research project please do not hesitate to contact me via e-mail (malkire@apl.washington.edu) or phone (206-897-1623).

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