NWRT Final Report

NWRT Project Number: NWRT-0000000024

Project Title: Baffin and Wager Caribou Health Monitoring

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Summary:

During consultations in January 2019, communities identified their desire for a hunter sample program and concerns over caribou health. The purpose of this project was to establish a hunter-based sample and information collection program that contributes to the monitoring of caribou health on Baffin Island. A similar program was conducted on Baffin Island between 2008 and 2015 but we reduced the number of sample types in an attempt to streamline the process and increase hunter participation. This program was initiated in 2020 with hunters from Pond Inlet only due to restrictions associated with Covid-19. The program was expanded in 2021-2022 to include all communities that harvest caribou from Baffin Island. In addition to collecting samples from Baffin Island the program was again expanded during the 2022-2023 harvest season to include samples from the Wager Bay herd from the communities of Igloolik, Sanirajak and Naujaat.

Similar to previous years, we provided sampling kits to Hunters and Trappers Organizations (HTOs), Government of Nunavut (GN) wildlife officers and directly to hunters that consisted of sampling instructions, datasheets and the required sampling supplies.

The four standard samples were; 1) skin/hair, 2) blood, 3) lower jaw or incisor bar, 4) kidney with the fat attached. In cooperation with the northern contaminants program, a long-term caribou health monitoring program across North America hunters from Igloolik, Sanirajak and Naujaat were invited to collect the 4 main samples for the Wager Bay herd between the communities of Igloolik and Naujaat.

During the 2022-2023 program we received Baffin Island samples from hunters in Iqaluit, Igloolik, Sanirajak, Kimmirut and Pangnirtung. For the Wager bay caribou we only received samples from Sanirajak hunters. Delays at laboratory facilities and government offices occurred due to issues associated with the Covid-19 pandemic and labs are just beginning to catch up now. This has continued to delay availability of results and impacted efficiency within the program. Some additional results are now available and we expect additional results to be received in the near future.

Project Objectives:

The Baffin Island Caribou Health Monitoring Program was designed in partnership with communities and created to assess the overall health, determine presence of disease and parasites, and

increase harvest reporting effectiveness in Nunavut. The program is also designed to engage academia in the continued study and understanding of disease prevalence in barren-ground caribou.

The main research objectives were to;

1) Continue to build on baseline values for health-related parameters.
2) Monitor long-term health and disease to detect future changes.
3) Increase the capacity of community members, including youth, in research.
4) Increase reporting of caribou harvest on Baffin Island.
5) Determine the seasonal age and sex structure of the harvest.
6) Determine the relationship between body condition and herd productivity when compared with parallel demographic studies.

Materials and Methods:

Samples were collected from Baffin Island caribou hunters and some Wager Bay harvesters during the 2022-2023 harvest season on a voluntary basis.

Study area

The study area incorporated the harvesting area for Baffin Island and some of the Wager Bay caribou harvesting area. Communities that harvest caribou from these areas all occur within the study area (Pond Inlet, Arctic Bay, Clyde River, Qikiqtarjuaq, Pangnirtung, Iqaluit, Kimmirut, Kinngait, and Igloolik, Sanirajak and Naujaat) (Figure 1).

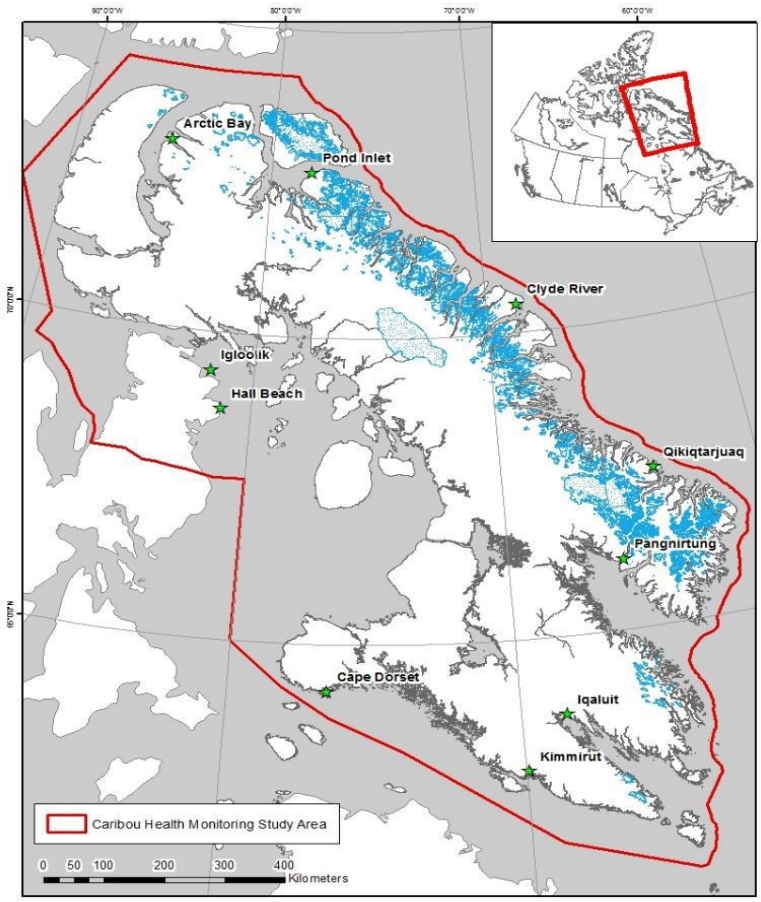

Figure 1 Baffin Island and Wager Bay caribou health monitoring sampling area.

Sample collection

Consistent with previous years, hunters were provided sample kits to take with them while hunting which consisted of sampling instructions (in both Inuktitut and English), appropriate pre-labelled sample bags and data sheets. Sample kits included (Table 1) a datasheet to record information about the harvest, (including the hunters name, date of kill, harvest location, sex of animal harvested, and a section to provide notes), and all required labelled bags for individual samples.

Table 1. Sample types and inputs for the 2022/2023 Nunavut caribou health monitoring.

Sample Type	Reason for Sampling
Hair/skin	Genetics, stress, hormones, parasites, minerals
Blood	Disease, genetics
Lower jaw or incisor bar	Age, body condition
Kidney with fat	Body condition, contaminants
Demographic info.	Herd characteristics, general health

Hunters received monetary compensation for the samples of $15 per sample ($60 for a complete kit of 4 samples). The kits were designed so that it would only take a few minutes for harvesters to collect

the required samples. Each sample kit was designed to be used for a single caribou but hunters were able to provide kits from multiple caribou if they harvested more than one.

When caribou were harvested, hunters would collect the samples and information required then provide it to the Government of Nunavut wildlife officer or Hunters and Trappers Organization whne wildlife officers weren't available. Samples were kept frozen and shipped to the Department of Environment regional laboratory in Pond Inlet.

Sample Analysis

Samples were processed in Pond Inlet and sent to the appropriate laboratory for analysis (Table 2). Once analysed the data was provided to the GN and any remaining portions of samples were sent back to the lab in Pond Inlet for archiving purposes. Contaminant analysis was done by ALS' lab in Burlington, Ontario where they were analyzed for a suite of 34 elements. Additional analysis completed by Dr. Susan Kutz at the University of Calgary (Table 2) and some genetic analysis is being conducted by ECCC.

Table 2. Sample types, location and type of analysis.

Sample Type	Testing For	Analysis completed by
Hair/Skin	Genetics, parasites, Essential minerals, cortisol	Dr. Susan Kutz, University of Calgary, ECCC
Blood	Disease, genetics, cortisol levels	Dr. Susan Kutz, University of Calgary
Lower jaw or incisor bar	Age, body condition	GN Internal, Matsons lab
Kidney with fat	Body condition, contaminants	ALS, Mary Gamberg
Demographic info	Herd characteristics, general health	GN Internal

Results:

Caribou hunters provided less than half of the goal of 350 sample kits; one for each caribou harvested, but the numbers provided were an improvement compared to the previous harvest season. Similar to previous years sample collection was sporadic and relied heavily on HTO involvement and conservation officer presence in the community. In communities where there was no wildlife officer present we relied on officers to do relief trips in order collect samples and send them to the lab in Pond Inlet. This further delayed our ability to process and send samples for analysis.

Table 3. Number of samples provided by hunters for the 2022/2023 sampling season.

Sample Type	Number of samples provided
Hair/skin	115
Blood	83
Lower jaw or incisor bar	86
Kidney with fat	91
Demographic info.	350

See attached report (Appendix 1) for results from Kidney analysis from the Northern contaminants program. Harvest from the wager Bay herd occurs in early spring and therefore analysis is still pending. Results will be provided to co-management partners when available. To date we have received preliminary results from University of Calgary and expect a full write-up in winter 2023. We submitted incisors for cementum aging from all samples available (N=165) including previous harvest seasons. Some incisors were damaged and as a result no ages were determined (N=5). Results were categorized into two categories; perfect samples and non-perfect samples (Figure 2). Perfect samples were easily categorized into a single age class (i.e. 4 years old) whereas non-perfect samples were categorized into a range of ages (i.e. 4-6 years old) based on harvest dates and comparison between samples. The oldest age of any caribou harvested was 9 years old (2 male caribou from South Baffin harvest in 2022/23 and one historic sample from Qikiqtarjuaq from 2014 of unknown sex).

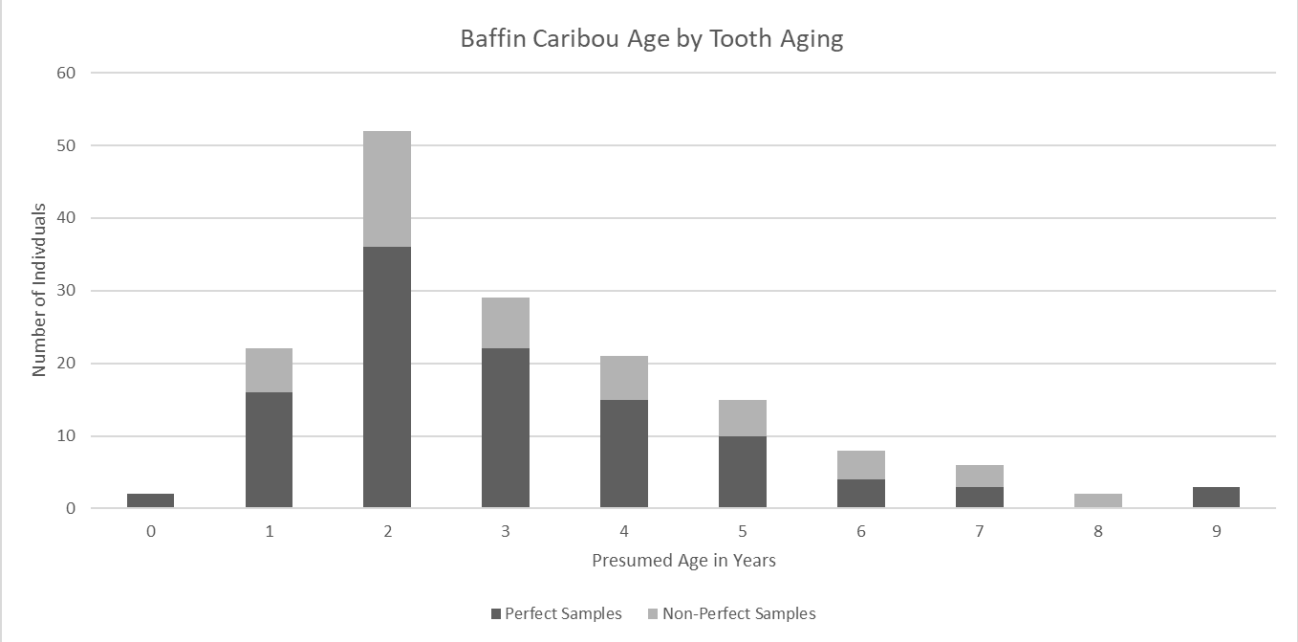

Figure 2 Harvested Baffin Island caribou ages based on incisor submission.

All 38 blood samples submitted to the University of Calgary from the previous harvest season were analysed for Brucella, Toxoplasma, Pestivirus, Herpesvirus and Erysipelothrix. All 38 samples tested were negative for Pestivirus and Brucella. Erysipelothrix (1 positive), Herpes (13 positive) and Toxoplama (1 positive) had very low seroprevalence within the tested samples. Additional analysis of 2022 samples and a final report from the University of Calgary is pending.

Discussion/Management Implications:

Expert interpretation of the results from the blood sample analysis suggests that some of the positive results may be false positives and in all cases Baffin Island caribou show very low seroprevalence when compared to other herds. The negative presence of Brucella and Pestivirus may be a product of low population and low density when compared to other herds. Additional analysis with more samples should provide a better interpretation of the presence of these pathogens and the impacts of regional variation or harvest location. We expect the overall presence of pathogens and disease will increase as the population and density increase. Additional interpretation of false positives and analysis methods will be provided in the final report from the laboratory.

Although we have some additional results to present at this time, we expect to receive final results and final reports from our external partners shortly after the submission deadline for this report. All reports will be provided to co-management partners, including the Nunavut Wildlife Management Board.

The implementation of this program relies heavily on HTOs interest and participate to support the program. We have found that in communities were the HTOs are actively engaged in promoting the program to their hunters we receive many more samples than in communities where HTOs show limited interest. We continue to analyze all samples provided. Long-term management of Baffin caribou relies on the active participation of all co-management partners. Current information gaps exist for Baffin caribou and filling these gaps should be a priority to ensure a quick and successful recovery.

Reporting to communities/resource users:

In person HTO/community consultations take place annually when possible. We continue to provide results to HTOs when available.

References:

None at this time. Additional reports ongoing and will be provided to co-management partners when finalized.

APPENDIX 1

Arctic Caribou Contaminant Monitoring Program

Project Leaders

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Project Team

Mike Suitor, Martin Kienzler, Yukon Government, Dawson, YT; Joe Tetlichi, Porcupine Caribou Management Board, Whitehorse, YT; Erika Tizya, Vuntut Gwitchin Government, Old Crow, YT; Mitch Campbell, Government of Nunavut, Arviat, NU; Arviat Hunters and Trappers Organization, Arviat, NU; John Ringrose, Government of Nunavut, Pond Inlet, NU; Xiaowa Wang and Derek Muir, Environment & Climate Change Canada (ECCC), Burlington, ON; Clive Tesar, Carleton University, Ottawa, ON.

Project Location (s)

- Old Crow, Yukon
- Arviat, Nunavut
- Baffin Island, Nunavut

Abstract/Plain Language Summary

This project studies contaminant levels in caribou in the Canadian Arctic to determine if these populations remain healthy (in terms of contaminant loads), whether these important resources remain safe and healthy food choices for northerners and if contaminant levels are changing over time. In 2022 samples were collected from 23 Porcupine and 23 Qamanirjuaq caribou. Data from 2021 collections have been analysed and reported. Leaf River caribou had higher levels of PFAS than the other caribou collected in 2021, specifically PFOS, although it is unclear why. PFAS concentrations are higher in the Qamanirjuaq caribou than the Porcupine herd and both are declining over time, likely due to national and international controls. Baffin caribou had higher renal mercury levels than the other caribou collected in 2021, likely reflecting regional differences in mercury availability. One caribou from the Leaf River herd had very high levels of hepatic lead and antimony, suggesting contamination by a shattered lead bullet. The use of copper bullets for harvesting caribou would minimize risk from inadvertently consuming microfragments of lead. Results from this project are being communicated through local outreach (lectures and labs at Whitehorse, YT high schools and Yukon University), the annual Wildlife Contaminants Workshop at Arctic College in Iqaluit, and the Northern Caribou website (www.northerncaribou.ca) which hosts all our reports and plain language summaries.

Key messages

- Levels of most contaminants measured in caribou tissues are not of concern, although kidney mercury and cadmium concentrations may cause some concern for human health depending on the quantity of organs consumed.
- Caribou meat (muscle) does not accumulate high levels of contaminants and is a healthy food choice.
- Copper bullets are recommended for harvesting caribou (and other wildlife) to minimize the potential of ingesting microfragments of lead from a shattered lead bullet.
- This program will continue to monitor the Porcupine and Qamanirjuaq caribou herds annually to maintain confidence in this traditional food and to better understand contaminant (particularly mercury) dynamics within these ecosystems.

Objectives

This project aims to determine levels of and temporal trends in contaminants in Arctic caribou to:

- provide information to Northerners regarding contaminants in this traditional food so that:
    - they can make more informed choices about food consumption. This includes providing information for health assessments and/or advisories as required;
    - wildlife managers can assess possible health effects of contaminants on Arctic caribou populations;
- further understand the fate and effects of contaminant deposition and transport to the Canadian Arctic.

Introduction

Caribou provide an important food resource for Northerners across the Arctic, and the Porcupine and Qamanirjuaq caribou herds have been designated in the NCP blueprint for annual monitoring of mercury, inorganic elements, PBDEs (polybrominated diphenyl ethers) and PFAS (per- and polyfluoroalkyl substances). In addition, the blueprint specifies that one or two other herds will be monitored each year for the same list of contaminants. In 2022/23, we planned to include samples from the Wager Bay herd from Nunavut in collaboration with a Government of Nunavut caribou health monitoring program.

Activities in 2022-23

In the late winter/early spring of 2022, samples were collected opportunistically from 10 Porcupine caribou by local hunters in Old Crow, YT. Samples were collected from an additional 13 caribou in the fall (the usual sampling time). Samples were collected from 23 Qamanirjuaq caribou in the fall of 2022 by local hunters in collaboration with the Government of Nunavut (Mitch Campbell) program. We had planned to sample caribou from the Wager Bay herd in the winter of 2022-23 in collaboration with the Government of Nunavut (John Ringrose), but inclement weather affected hunting over the Christmas holidays, and no samples were obtained. We are hopeful of obtaining samples from this herd during the spring (2023) hunt. Home ranges

of all herds are shown in Figure 1.

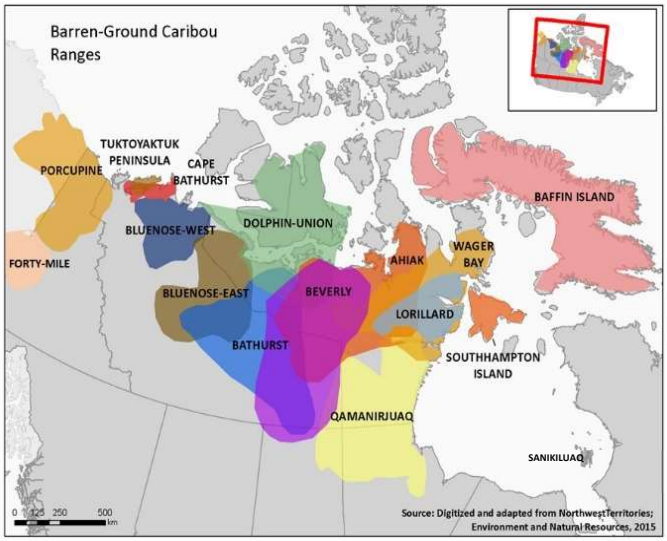

Figure 1. Home ranges of the major barren-ground caribou herds in Canada.

Kidney samples collected in 2022-23 (Qamanirjuaq and Porcupine) are currently being analyzed for elements at ALS, Burlington and livers from 2022-23 (Qamanirjuaq, Porcupine) and 2021-22 (Qamanirjuaq, Porcupine and Leaf River) are being analyzed for PFAS at the Stock Laboratory at Trent University.

Data are presented here for:

- elements in kidneys and livers from the South Baffin and Leaf River herds collected in 2021,
- PFAS in livers from the Qamanirjuaq and Porcupine herds collected in 2019 and 2020,
- PFAS in livers from the Leaf River herd collected in 2013,
- PFAS in fat from the Qamanirjuaq caribou collected in 2020,
- PBDEs in liver from nine herds collected from 2014-2018. These data are presented as a final report as we will discontinue these analyses due to low concentrations of these contaminants.

Kidneys and livers were analyzed at ALS (Burlington) for a suite of 34 elements including mercury. Liver was analyzed for PFAS at the Muir Laboratory at Environment and Climate Change (Burlington) and for PBDEs by a combination of the Muir Laboratory and the Great Lakes Institute of Environmental Research at the University of Windsor. Caribou fat from the Qamanirjuaq caribou herd was analysed for PFAS at the Muir Laboratory at the request of the Arviat Hunters and Trappers Organization. Kidney, liver and muscle samples will be archived at the National Wildlife Research Centre (Environment and Climate Change Canada). Incisors were used to analyze age of the animals using the cementum technique by Angela Milani (Environment Yukon).

Community Engagement

J Brammer travelled to Arviat in September 2022 to meet with hunters, the Hunters and Trappers Organization (HTO), school staff, and the regional biologist to discuss the program and support sample collection from the Qamanirjuaq caribou. The project, with particular emphasis on the sampling component, was discussed on Arviat community radio, Arviaqpaluk 96.5 FM. Harvesters and community members were invited to attend a meeting of the HTO where a summary of the Arctic Caribou Contaminant Monitoring Program was presented, and this year's sampling was discussed. For the rest of the week, J Brammer was available at the HTO office providing sample kits to hunters.

Discussions were held with LNUK in Tasiujaq regarding the results of the analysis of the Leaf River caribou samples. Plain language summaries were updated in March 2023 and distributed widely. Results from this project were presented to residents of Old Crow, YT, as part of the Research Roundup in January 2023 and at the Canadian High Arctic Research Station in Cambridge Bay, NU to a gathering of Kitikmeot communities (representatives from Taloyoak, Kugaaruk, Gjoa Haven and Cambridge Bay) in March 2023.

Capacity Building and Training

In September 2022 M Gamberg co-led a Wildlife Contaminants Workshop presented to the students of the Environmental Technology Program (ETP) of Arctic College in Iqaluit, providing information on contaminants in the general environment as well as in caribou specifically. This workshop is planned to be offered again in September 2023. J Brammer is a resident of Old Crow, and is on assignment as the Fish and Wildlife Manager of the Vuntut Gwitchin Government. As a result, he interacts with local hunters frequently, particularly in the context of community hunts and in the implementation of the Teechik Land Guardian program. These interactions are excellent opportunities to build local capacity for wildlife, and particularly caribou, tissue sampling for contaminant analysis. For example, the Fall Hunt of the Chief Zzeh Gittlit School included a caribou contaminant sampling module in September 2022. Unfortunately, this module could not be fully implemented as no caribou were harvested during this year's Fall Hunt.

Communications and Outreach

In addition to the Wildlife Contaminants Workshop (see Capacity Building and Training section), outreach activities this fall included two high school classes in Whitehorse, YT and two classes at Yukon University. These each involved a lecture on contaminants in general, and then more specifics on caribou and fish. While the follow-up lab focused on fish, those skills in taking samples for contaminant analysis can easily be transferred to large or small game in the future.

Caribou contaminant-related publications, synopsis reports and plain language summaries are included on the Arctic Caribou website (www.northerncaribou.ca) created by Clive Tesar (Ottawa, ON). Results from this project were included in a presentation at ArcticNet by Adam Morris – Total mercury trends in Arctic biota update (December 2023). An update for the section 'Mercury in Porcupine Caribou' was updated for the Yukon State of the Environment Report (February 2023).

Indigenous Knowledge

This program relies on the Indigenous Knowledge when collecting samples from caribou for analysis and undertakes to collect some samples during community hunts where knowledge can be actively shared between scientists and local elders, adults, and youth. Local hunters use Indigenous knowledge when hunting caribou and submitting samples as well as providing food for their families. Meetings (in-person, phone and virtual) between the PIs and local harvester organizations (e.g. HTOs, Regional Resource Councils) provide an opportunity for the exchange of Indigenous and western knowledge that enhances understanding of contaminants in caribou and facilitates the implementation of this project. Finally, community hunts provide an opportunity for culturally appropriate knowledge sharing with youth and knowledge holders, both scientific and Indigenous, living and working together out on the land collecting samples.

Results and Outputs/Deliverables

Although samples were analyzed for 34 elements, only results for seven elements of concern were statistically analyzed in detail (arsenic [As], cadmium [Cd], copper [Cu], lead [Pb], mercury [Hg], selenium [Se] and zinc [Zn]). These results are presented for kidneys and livers in Tables 1 and 2 respectively. We have no new element results for the Porcupine or Qamanirjuaq caribou.

One individual liver sample had an extremely high level of Pb (422 μg/g dry weight). This was a 10-year-old female from the Leaf River herd, harvested in March 2021. This liver also showed abnormally higher levels of antimony (Sb) (10.7 μg/g dry weight).

Hepatic element concentrations in the Leaf River herd were compared with samples collected in 2013 from that herd. Concentrations of Se were slightly higher in 2021 than in 2013 ($p=0.046$). If the one outlier of Pb in liver was removed from the dataset, then concentrations of Pb in 2021 were lower than in 2013 ($p=0.005$).

Hepatic element concentrations in samples collected in 2021 were compared to each other (Baffin and Leaf River caribou). We did not include other caribou herds in the analysis as we have few comparative hepatic data from other herds and none in recent years. Note that age could not be included in these analyses as the 2021 Baffin caribou had no ages available at the time of data analysis. Cu in Leaf River caribou was higher than in Baffin ($P=0.007$) while the opposite was true for Se ($p=0.0005$). No other elements differed between herds, although Pb was higher in female caribou than in males ($p=0.024$).

Renal element concentrations in the Baffin herd were compared with data from that herd from previous years (1991, 1992, 1993, 1999) but only for Cd (the only data available from those years). Season, sex, and year had no effect on Cd concentrations and age was positively correlated with renal Cd ($p=0.01$).

All renal element concentrations from 2021 were compared by herd (Baffin, Leaf River, Porcupine). Note that age could not be included in these analyses as the 2021 Baffin caribou had no ages available at the time of data analysis. The Porcupine caribou had higher As than the Baffin herd ($p=0.02$) and higher Cd ($p<0.0001$) and lower Pb ($p<0.0001$) than the other two herds. The Leaf River caribou had higher Cu and lower Se and Zn than the other two herds ($p<0.0001$ for all three elements). Baffin caribou had higher Hg than the other two herds ($p=0.0005$).

There are no significant differences among herds in total PBDEs (Figure 3). We were unable to test for temporal trends as our maximum number of years for one herd was four. Overall the most common BDEs were BDE 15, 71, 99, and 83 accounting for 13%, 36%, 14%, and 15% of the total PBDEs respectively.

Table 1. Element concentration (µg/g dry weight) in livers from Baffin Island and Leaf River caribou collected in 2021.

Herd	Baffin			Leaf River					
Season	Fall						Spring		
Sex	Female	Male		Female		Male		Female	
N	1	24		3		7		2	
	Mean	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age				5		4		6.5	
% Moisture	70.9	68.3		70.3		70.8		78.9	
As	0.08	0.03	± 0.02	0.02	± 0.01	0.02	± 0.02	0.04	± 0.01
Cd	9.7	16.7	± 23.6	3.1	± 1.6	3.0	± 1.5	49.5	± 52.8
Cu	24	61	± 74	141	± 67	200	± 55	20	± 0.10
Pb	0.28	0.38	± 0.22	0.45	± 0.08	0.48	± 0.44	211	± 298
Hg	1.85	2.63	± 2.23	0.57	± 0.41	1.32	± 1.20	4.92	± 0.11
Se	4.65	3.88	± 1.81	2.36	± 0.24	2.57	± 1.14	4.94	± 0.37
Zn	104	103	± 18	87	± 5	89	± 19	104	± 9

Table 2. Element concentration (µg/g dry weight) in kidneys from Baffin Island and Leaf River caribou collected in 2021.

Herd	Baffin				Leaf River					
Season	Fall							Spring		
Sex	Female		Male		Female		Male		Female	
N	3		25		3		7		3	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age					5		4		6.5	
% Moisture	79.6		79.2		79.5		80.0		79.0	
As	0.02 ±	0.02	0.03 ±	0.02	0.03 ±	0.01	0.03 ±	0.01	0.04 ±	0.01
Cd	20.4 ±	8.0	16.4 ±	10.9	2.0 ±	0.3	2.2 ±	1.0	3.7 ±	2.1
Cu	29 ±	3	30 ±	19	111 ±	27	125 ±	44	256 ±	66
Pb	0.34 ±	0.25	0.32 ±	0.15	0.37 ±	0.10	0.44 ±	0.20	0.89 ±	0.50
Hg	2.56 ±	1.61	3.34 ±	2.57	0.63 ±	0.40	0.68 ±	0.62	3.29 ±	2.21
Se	5.18 ±	1.71	4.45 ±	1.69	2.27 ±	0.33	1.61 ±	0.43	3.67 ±	0.91
Zn	129 ±	19	107 ±	14	83 ±	3	90 ±	13	105 ±	58

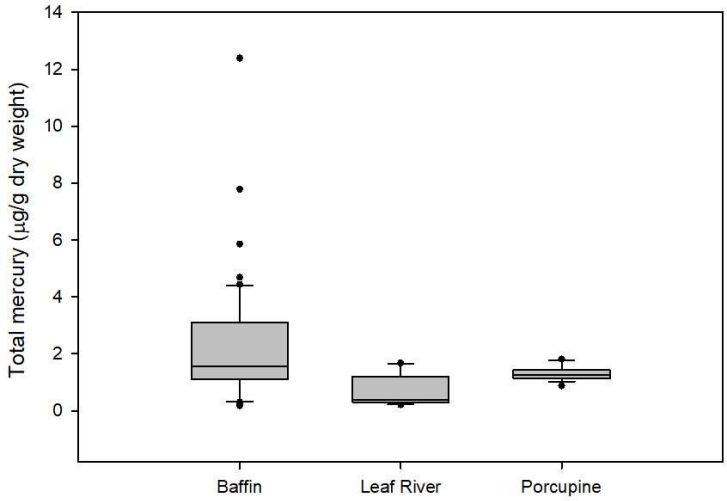

Figure 2. Total mercury in kidneys from three caribou herds collected in 2021.

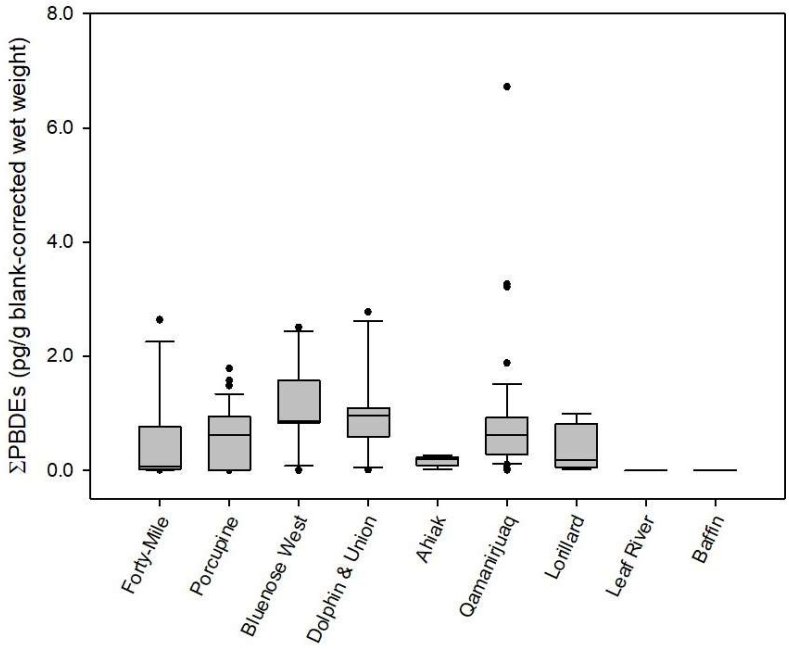

Figure 3. ΣPBDEs in caribou herds from the Canadian Arctic.

Notes: Ahiak (2016), Bluenose West (2014), Dolphin & Union (2015), Forty-Mile (2017-18), Lorillard (2018), Porcupine (2015-17) and Qamanirjuaq (2015-18) included BDE 7, 10, 8+11, 12+13, 15, 30, 32, 17+25, 28+33, 35, 37, 47, 49, 66, 75, 77, 79, 85, 99, 100, 116, 118, 119, 126+155, 153, 154, 138+166, 181, 183, 190, 194, 195, 196, 201, 202, 197+204, 198+199+200+203, 205, 207, 208, 209.

Qamanirjuaq (2020) included BDE 7, 10, 8+11, 12+13, 15, 30, 32, 17+25, 28+33, 35, 37, 47, 49, 51, 66, 71, 75, 77, 83, 85, 99, 100, 105, 116, 118, 119/120, 126, 126+155, 128, 140, 153, 154, 155, 156, 138+166, 181, 183, 184, 190, 191, 196, 197, 203, 207, 208, 209.

Baffin (2021), Leaf River (2021) and Porcupine (2021) included BDE 7, 15, 17, 28, 47, 49, 66, 71, 77, 85, 99, 100, 119, 126, 138, 153, 154, 183, 184, 191, 196, 197, 206, 207, 209.

Fat tissue from the Qamanirjuaq caribou had significantly lower concentrations of all measured PFAS than liver from the same herd ($p<0.0001$). Concentrations of perfluorocarboxylic acids (PFCAs) and perfluorosulfonic acids (PFSAs) were higher in the Leaf River caribou liver (from the 2013 collection) as compared to the Porcupine and Qamanirjuaq caribou ($p<0.0001$ for all) (Figure 4). PFCAs and PFSAs are declining over time in both the Porcupine and Qamanirjuaq herds ($p<0.0001$) and concentrations of both are higher in the Qamanirjuaq herd ($p<0.0001$) (Figure 5).

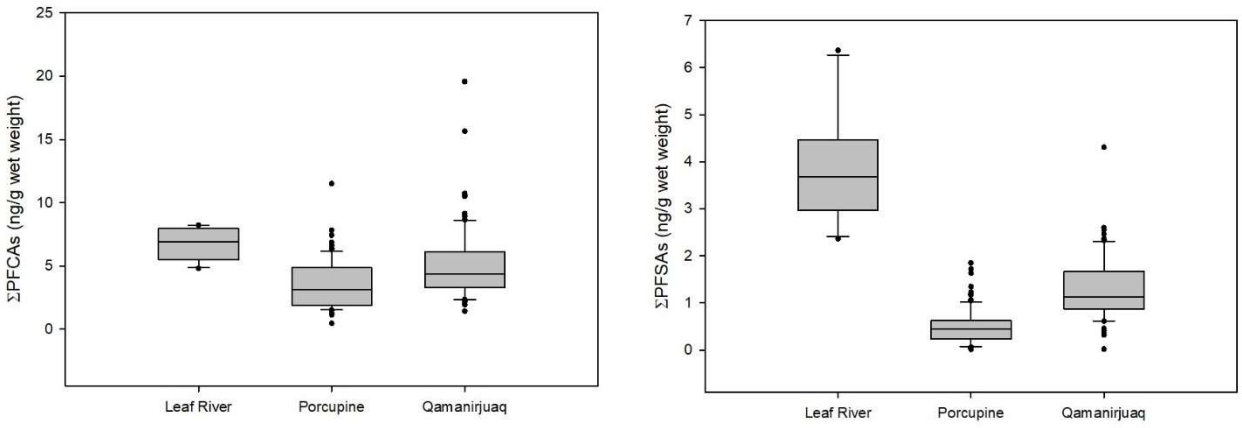

Figure 4. ΣPFCAs (C8-C14) and ΣPFSAs (C6-C12) in caribou liver.

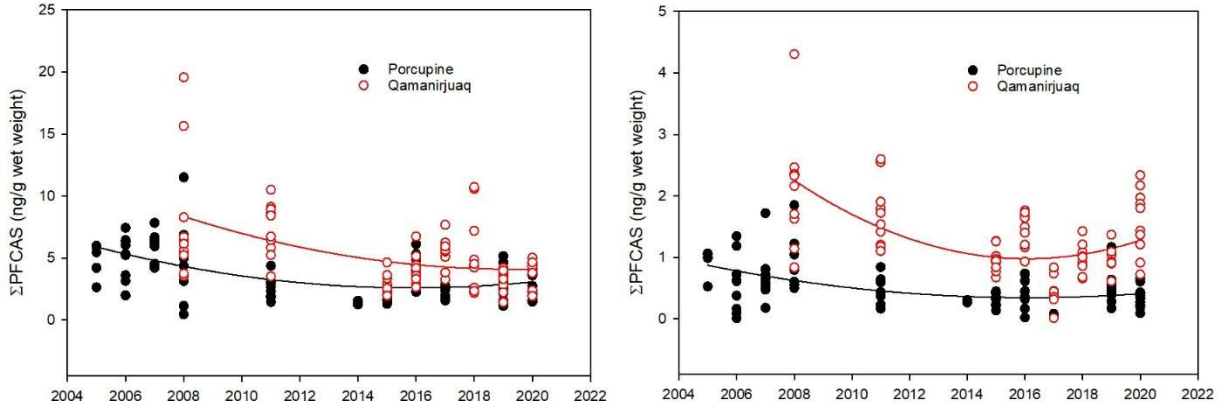

Figure 5. ΣPFCAs (C8-C14) and ΣPFSAs (C6-C12) in Porcupine and Qamanirjuaq caribou liver over time.

Discussion and Conclusions

Element concentrations in caribou kidneys were as expected and similar to other caribou herds monitored under this program. The higher concentration in females as compared to males, particularly for the toxic elements (As, Cd, Pb, Hg) has been seen in the past in caribou (Gamberg et al. 2020) and in other species (mink; Gamberg et al. 2005a) and is likely a reflection of the higher food intake to body weight ratio in the smaller females. The increase in cadmium with age, has also been seen in the past in caribou (Gamberg et al. 2020) and other species (moose; Gamberg et al. 2005b).

The high levels of Pb and Sb that were found in one Leaf River caribou, is suggestive of contamination from a shattered lead bullet, rather than of broad lead contamination of the environment or even a local point source of contamination. Sb is a metal that is used to form an alloy with lead to make bullets harder and less prone to damage within the gun barrel. Some fragments of bullets in harvested animals can be very small and not easily detected and may pose potential health risks if consumed (Knott et al. 2010). Copper bullets provide a toxicologically safer option for harvesting wildlife.

In the Leaf River herd, hepatic concentrations of Pb were lower in 2021 as compared to 2013, likely reflecting the effectiveness of pollution controls both nationally and internationally. While there is no clear understanding of why Se concentrations were higher in this herd in 2021 than in 2013, it is not of concern, as levels do not reach concentrations considered to be toxic for cattle (Puls 1994), and Se can actually be beneficial in ameliorating the toxic effects of mercury. Generally, this herd had higher levels of copper than other herds. This could be a benefit in terms of reproductive resiliency, as the fetus will use Cu resources at the expense of the dam and some northern ungulate populations may have limited Cu availability, possibly even limiting reproduction (Gamberg et al. 2016). The Leaf River caribou had generally low levels of toxic elements including As, Pb and Hg.

Baffin caribou had higher levels of renal Hg than the other two herds (Figure 2) but there were no differences in hepatic concentrations among herds. In the absence of any known Hg sources on Baffin Island, this could reflect regional differences in Hg availability. Notably, levels of renal Hg in the Qamanirjuaq caribou are higher than those found in the Baffin herd (average of 5.31µg/g dry weight in 2020). Other toxic elements, including As and Pb were generally low in the Baffin Island herd.

Since we started measuring them, PBDE concentrations have been consistently low with respect to potential toxicity to caribou or those consuming caribou. Because the levels are so low and the analysis is quite expensive, we have made the decision to discontinue these analyses.

PFAS concentrations in the three caribou herds are low and declining over time in the Porcupine and Qamanirjuaq caribou herds, likely due to national and international controls on use and emissions of these chemicals. The higher ΣPFSAs in the Leaf River herd is driven by higher concentrations of perfluorooctane sulfonate (PFOS) (3.85 ng/g wet weight as opposed to 0.42 and 1.15 ng/g wet weight in the Porcupine and Qamanirjuaq herds respectively). Health Canada does not currently have a guideline for the consumption of PFOS in food. However, the

Sanikiluaq reindeer have almost twice this level of PFOS in their liver (6.07 ng/g wet weight) and Health Canada's advice (2020) to consumers of those reindeer was to limit consumption to seven entire livers per person per year, assuming that each liver weighs about 1 kg (just over 2 pounds). The source of high PFOS in these caribou is not clear, but may reflect regional variation in atmospheric deposition.

Overall, contaminants continue to be low in caribou from the Canadian Arctic and caribou remain a health food choice for Northerners. Continuing to monitor caribou for elements, particularly mercury, and for PFAS will ensure that we are aware if that situation should change. Copper bullets are recommended for harvesting caribou (and other wildlife) to minimize the potential of ingesting microfragments of lead from a shattered lead bullet.

Expected Project Completion Date

This program is ongoing.

Associated websites

www.northerncaribou.ca

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References

Gamberg M, Pratte I, Brammer J, Cuyler C, Elkin B, Gurney K, Kutz S, Larter NC, Muir D, Wang X, Provencher JF. 2020. Renal trace elements in barren-ground caribou subpopulations: Temporal trends and differing effects of sex, age and season. Sci Total Environ 724:138305. https://doi.org/10.1016/j.scitotenv.2020.138305.

Gamberg M, Cuyler C, Wang, X. 2016. Contaminants in two West Greenland caribou populations. Sci Total Environ 554-555:329-336.

Gamberg M, Boila G, Stern G, Roach P. Cadmium, mercury and selenium concentrations in mink (*Mustela vison*) from Yukon, Canada. Sci Total Environ 2005a: 351/352:523-529.

Gamberg M, Palmer M, Roach P. Temporal and geographic trends in element concentrations in moose from Yukon, Canada. Sci Total Environ 2005b: 351/352: 530-538.

Knott, J., Gilbert, J., Hoccom, D.G., Green, R.E. 2010. Implications for wildlife and humans of dietary exposure to lead from fragments of lead rifle bullets in deer shot in the UK. Sci Total Environ 409:95-99.

Puls, R. 1994. Minerals in Animal Nutrition. Sherpa International, Clearbrook, BC, Canada. 356 pp.