Title: Arctic Caribou and Moose Contaminant Monitoring Program

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Abstract
The objective of this project is to determine contaminant levels in caribou in the Canadian Arctic to determine if the animal populations remain healthy (in terms of contaminant loads), whether these important resources remain safe and healthy food choices for northerners and to see if contaminant levels are changing over time. In 2010/11 collections of the Porcupine and Qamanirjuaq herds were unsuccessful. A new sampling strategy is being devised for the future. Results from the previous year's collections were analyzed. Arsenic, lead and selenium were lower in the 2010 Tay herd collection (males) as compared with the 1993 collection (females) while mercury and zinc were higher. These differences may be due differences between years or between genders. Magnesium concentrations found in the Tay caribou are higher than seen in other caribou herds. Arsenic and lead are decreasing slightly over time in male fall-collected Porcupine caribou, while zinc is increasing. Neither cadmium nor mercury are increasing or decreasing significantly over time in Porcupine caribou. While cadmium and zinc increase with the age of both genders of caribou, mercury increases with age in female caribou but decreases with age in males. This is likely due to the greater relative intake of food, and hence mercury, by female caribou. Contaminants of concern in the Porcupine caribou are generally stable over time, although the increase in zinc should continue to be monitored. Levels of most elements measured in both the Porcupine and Tay caribou herds were not of concern toxicologically, although renal mercury and cadmium concentrations may cause some concern for human health depending on the quantity of organs consumed. Yukon Health has advised restricting intake of kidney and liver from Yukon caribou, the recommended maximum varying depending on herd. The health advisory confirms that heavy metals are very low in the meat (muscle) from caribou and this remains a healthy food choice.

Key Messages

- Levels of most elements 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.
- Zinc appears to be increasing in the Porcupine caribou and although is not of concern toxicologically at this time, should continue to be monitored.
- Over the long term, mercury in the Porcupine caribou is stable, but does undergo a cycle. More research is required to determine causes of the cycle and mercury dynamics within the caribou food chain.

Objectives
To determine levels of and temporal trends in contaminants in Arctic caribou in order to:

- Provide information to Northerners regarding contaminants in these traditional foods, so that:
  - They may be better able to make 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 have been designated in the NCP blueprint as key species for monitoring contaminants in the terrestrial Arctic ecosystem. Two barren-ground caribou herds, one from the eastern (Porcupine) and one from the western (Qamanirjuaq) Arctic, have been designated for annual sampling.

Activities in 2010-2011
No samples were collected from the Porcupine caribou herd during this sampling year. A combination of changes to hunting regulations (reducing the licensed harvest from two caribou to one bull per licensed hunter), changes in the

migration of the caribou (few crossed the only accessible highway this year) and cold temperatures during the hunting season resulted in this unfortunate lack of samples. Since there was such a lack of licensed hunter effort this year, an attempt was made to engage First Nations hunters from Old Crow and Aklavik (NWT) to provide samples, but since these were very much last minute and few caribou were available, these attempts were unsuccessful.

No samples were collected from the Qamanirjuaq caribou herd either this year, due to an unfortunate misunderstanding with the local biologist. Once this misunderstanding was discovered, an attempt was made to conduct a spring collection of samples, but since there were no caribou in the area at that time, this was unsuccessful.

Analyses of samples from the fall 2009 collection of the Porcupine caribou and the spring 2010 collection of the Tay caribou have been completed and data are presented. Analysis of samples from the fall 2009 collection of the Qamanirjuaq caribou are waiting upon receiving collection data for these animals (as some of the samples submitted may actually be from 2008). Although kidneys were analyzed for 31 elements, only results for 7 elements of concern were analyzed in detail (arsenic, cadmium, copper, lead, mercury, selenium and zinc). Methylmercury concentrations in caribou muscle tissue are also available and are presented.

Although the intent of this project was to compare element concentrations in the Tay caribou herd from 1993 and 2010, it is difficult since all the animals sampled in 1993 were female and all those sampled in 2010 were male. Therefore, differences could be a result of changes over time or due to differences between the genders. Nonetheless, a comparison between the two collections was made and some interpretation of the data was attempted. It should be noted that differences between years do not necessarily indicate an increase or decrease in a particular element over time, since some elements tend to be cyclic in nature (eg. mercury). Temporal trends were assessed for Porcupine caribou using a general linear model. In all statistical analyses, age was tested as a cofactor, and where necessary data were log-transformed to achieve normality. If normality was not achieved by this transformation, non-parametric tests were used to analyze the data.

vii) Capacity Building and Training:
This year provided few opportunities for capacity building and training, since the project was limited to collections from the two caribou herds that were both unsuccessful. However, results of past years of this project were presented to several classes at Yukon College involved in the Renewable Resource program, and the project leader served as a mentor to a Directed Studies student at Yukon College who conducted an associated project on mercury in caribou forage.

viii) Traditional Knowledge:
This program relies on the traditional knowledge of both Aboriginal and non-Aboriginal people when collecting samples from caribou for analysis. In all cases local hunters use traditional knowledge when hunting caribou and ultimately submitting samples as well as providing food for their families. In Arviat, all samples are collected from the Qamanirjuaq herd by one local hunter who uses traditional knowledge on a daily basis, as well as when hunting for food for his community and providing samples for this project.

ix) Communications:
The program was advertised in the fall of 2010 in newspapers and through posters. Several lectures were presented at Yukon College (including the Renewable Resource Program) discussing the results of this program. A radio interview (CBC) was given about results of the program in February 2011.

Results of this project are communicated to the YCC and NAC by this report and will be presented at the NCP symposium anticipated for the fall of 2011. The project coordinator is available throughout the year to answer specific questions or address relevant issues from any of the participating groups or Regional Contaminants Committees as they arise. All data will be incorporated into the existing database for Canadian Arctic moose and caribou contaminants, currently maintained by INAC, Whitehorse. Plain language summaries, brochures and/or posters focussing on individual herds/populations will be prepared and circulated to stakeholder groups in cooperation with each Regional Contaminants Committee. Special presentations may be made as the results dictate, or upon request, in cooperation with the Regional Contaminants Committees. Results of this (and other NCP projects) will be presented at the 2011 International Mercury Conference in Halifax, in July, 2011.

Yukon: The project coordinator is a member of the Yukon Contaminants Committee (YCC), and provides updates on this project at each meeting of the YCC. Each hunter submitting samples to the program is sent a letter informing them about the Hunter Survey Program and the results to date. This form of communication has been in place for the duration of this project in the Yukon (16 years) and is supported by the YCC. The project leader normally arranges at least one radio interview regarding the program, (and often newspaper articles as well), and is available to attend public meetings or health fairs upon request, or to give presentations to local groups (high school or college classes, Yukon Science Institute, Government biologists) to discuss the program and the current status of contaminants in wildlife in the Yukon. Data collected through this program were included in the most recent updates of the CACAR and AMAP reports. Data from this program were also provided to a local consulting group that were assessing contaminant levels in wildlife in a mining area in the Yukon, to provide context for their survey data. A public meeting is planned for Ross River, in cooperation with Yukon Environment and the Ross River Dena Council to present results and answer questions about the program. Informational materials for the meeting will be developed in cooperation with Yukon Environment and the Ross River Dena Council.

Nunavut: Participating Government of Nunavut biologist (Mitch Campbell) includes project results in their ongoing communications with local communities and HTOs. This involves regularly scheduled community meetings, meetings with specific groups and newsletters. An article on contaminants in the Qamanirjuaq caribou herd was included in the fall 2009 issue of Wildlife Tracks, a publication of the Government of Nunavut. The NAC has requested that brochures be produced summarizing the contaminant work done on the Qamanirjuaq and Dolphin and Union caribou herds. Drafts of the brochures were sent to local biologists for comment and input.

Nunatsiavut: At their request, an article was submitted to the Government of Nunatsiavut (Mary Denniston) summarizing the results of research on contaminants in the George River caribou herd, for inclusion in the Government Newsletter.

General: Although the data gathered through this program is the technical property of NCP, the data is being made available to participating researchers and communities for public information purposes. Publication of the data in scientific journals is the responsibility of the project leader. All researchers participating in this program have agreed to abide by the Northern Contaminants Program Data and Sample Accessibility Agreement.

Results and Discussion

Although cadmium concentrations in the Tay caribou (Table 1) are higher than would be considered normal for domestic cattle, concentrations did not differ between the two years of collection and previous research has concluded that high levels of cadmium occur naturally in this geographical area and are not caused by anthropogenic sources (Braune et al. 1994).

Significant differences between years of collection in renal levels of arsenic, lead, mercury, selenium and zinc (Table 1) may be due to gender differences or differences between years. For the most part these elements are not thought to be at toxic or deficient concentrations. However, magnesium concentrations found in the Tay caribou from 2010 (renal concentration average = 935 $\mu g \cdot g^{-1}$ dry weight) would be considered 'excessive' for domestic cattle (Puls 1994). It is unknown whether this applies to wild caribou. In general woodland caribou tend to have higher levels of magnesium than barren-ground caribou and caribou from the western Arctic tend to have higher levels of this element than those from the eastern Arctic (Gamberg, unpublished data). Although magnesium toxicity is possible, it is an essential element that is homeostatically controlled within the body and magnesium toxicity in natural environments is rare.

Renal concentrations of mercury in the Tay caribou were higher than those found in the Porcupine caribou, but similar to those found for several barren-ground herds in NWT (Figure 1). Most mercury data exists for fall-collected caribou, and in those cases females usually have higher concentrations of mercury than males. However, the limited data that exists for spring-collected animals often shows higher concentrations of mercury in males than females. This is likely due to parturition, since some of the mercury from the mother is transferred to the fetus and even more is eliminated from the body during milk production. So females would likely experience a drop in their mercury concentrations while pregnant and nursing (spring) whereas males would not.

The difference in mercury concentrations between the two sampling times for the Tay caribou could also represent a change between the two years (1993 and 2010). It is important to note that even if this is the case it does not necessarily mean that mercury concentrations are rising in this caribou herd. Research on the Porcupine caribou herd indicates that mercury in that herd cycles over time and selecting just two points within any cycle to determine a trend could yield erroneous results. Further annual sampling of the Tay herd would be required to determine whether mercury levels are increasing, decreasing or stable over time.

Table 1. Renal element concentrations (Mean ± Standard deviation) in Tay caribou $\mu g \cdot g^{-1}$dry weight). * indicates a significant difference between the two collections.

	1993 Females			2010 Males		
N	20			7		
Arsenic*	0.07	±	0.06	0.02	±	0.01
Cadmium	118.0	±	91.3	183.5	±	78.3
Copper	22.4	±	2.0	24.1	±	1.6
Lead*	1.47	±	0.64	0.06	±	0.06
Mercury*	3.26	±	0.87	4.23	±	0.95
Selenium*	7.62	±	1.05	5.96	±	0.75
Zinc*	126.2	±	16.6	163.8	±	20.2

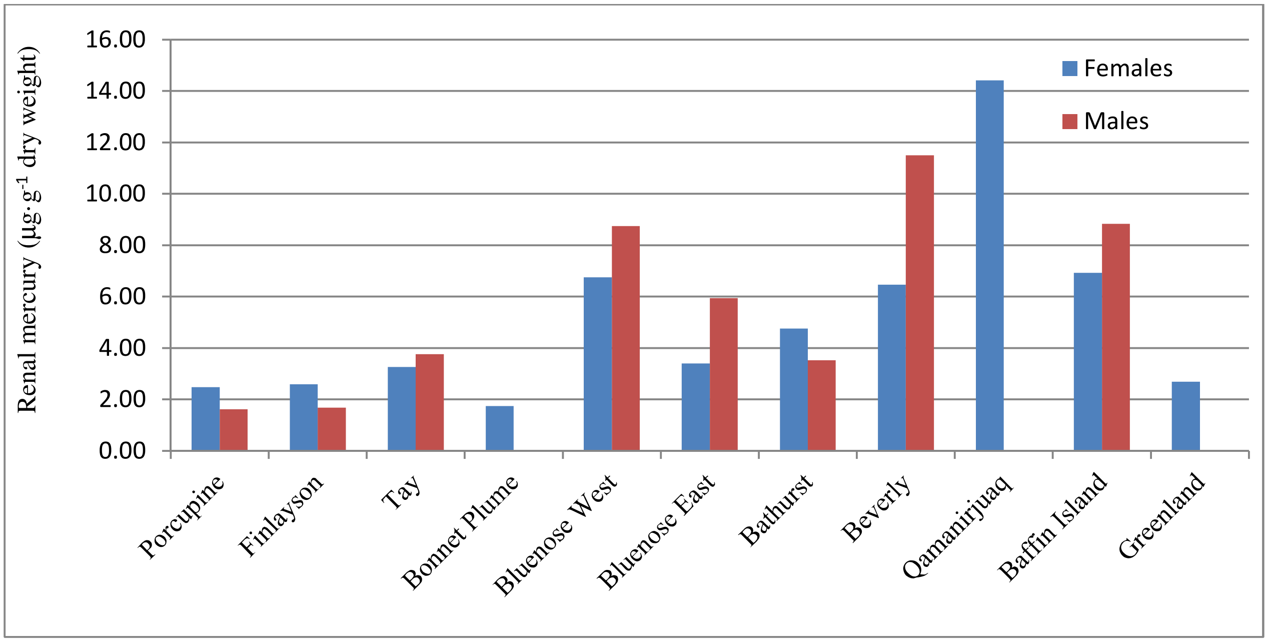

Figure 1. Comparative data for renal mercury in spring-collected caribou. Data from Gamberg (unpublished data) and MacDonald et al. (2002)

Table 2. Renal element concentrations (Mean ± Standard deviation) in male fall-collected Porcupine caribou μg·g^{-1}dry weight).

Year	N	Age	Arsenic*			Cadmium			Copper			Lead*			Mercury			Selenium			Zinc+		
1997	14	4.1	0.42	±	0.32	23.2	±	12.1	21.2	±	2.1	0.17	±	0.11	1.47	±	0.32	3.8	±	0.6	93.4	±	11.8
1998	14	4.7	0.19	±	0.05	26.9	±	21.0	25.6	±	3.7	0.25	±	0.28	1.76	±	0.72	5.2	±	1.2	108.4	±	16.6
1999	11	4.7	0.08	±	0.04	36.0	±	25.9	23.5	±	6.4	0.18	±	0.09	1.23	±	0.63	4.6	±	0.8	113.5	±	16.3
2000	8	4.8	0.30	±	0.11	37.4	±	17.6	25.1	±	4.3	0.25	±	0.39	1.23	±	0.18	4.9	±	1.0	121.6	±	21.5
2001	12	5.1	0.36	±	0.12	29.8	±	11.9	22.5	±	2.6	0.17	±	0.15	1.74	±	0.78	4.4	±	1.1	115.8	±	27.2
2002	9	5.6	0.18	±	0.04	26.8	±	8.4	25.1	±	3.4	0.13	±	0.05	1.39	±	0.27	5.4	±	0.6	123.3	±	14.1
2003	23	5.8	0.25	±	0.06	37.5	±	18.1	25.4	±	3.4	0.16	±	0.18	1.19	±	0.25	6.1	±	0.7	121.6	±	15.4
2004	16	4.9	0.05	±	0.01	24.2	±	13.8	22.8	±	3.0	0.14	±	0.04	1.62	±	0.59	4.2	±	0.6	121.0	±	15.9
2005	14	3.5	0.05	±	0.04	23.1	±	14.8	23.1	±	2.4	0.15	±	0.04	1.81	±	0.33	4.5	±	0.6	121.9	±	18.0
2006	9	5.1	0.07	±	0.02	41.6	±	23.7	24.9	±	3.0	0.10	±	0.02	2.18	±	0.51	5.1	±	0.6	130.6	±	14.5
2007	12	4.7	0.04	±	0.01	28.3	±	12.2	24.5	±	4.6	0.12	±	0.08	1.58	±	0.45	4.4	±	0.7	120.0	±	27.5
2008	20	6.1	0.03	±	0.02	27.3	±	16.8	32.8	±	28.5	0.18	±	0.38	1.34	±	0.60	4.3	±	0.5	138.4	±	33.7
2009	20	6.3	0.05	±	0.04	38.1	±	17.0	24.5	±	5.3	0.10	±	0.06	0.94	±	0.39	4.7	±	0.7	138.0	±	40.0

*indicates a statistically significant decrease over time ($p<0.05$)

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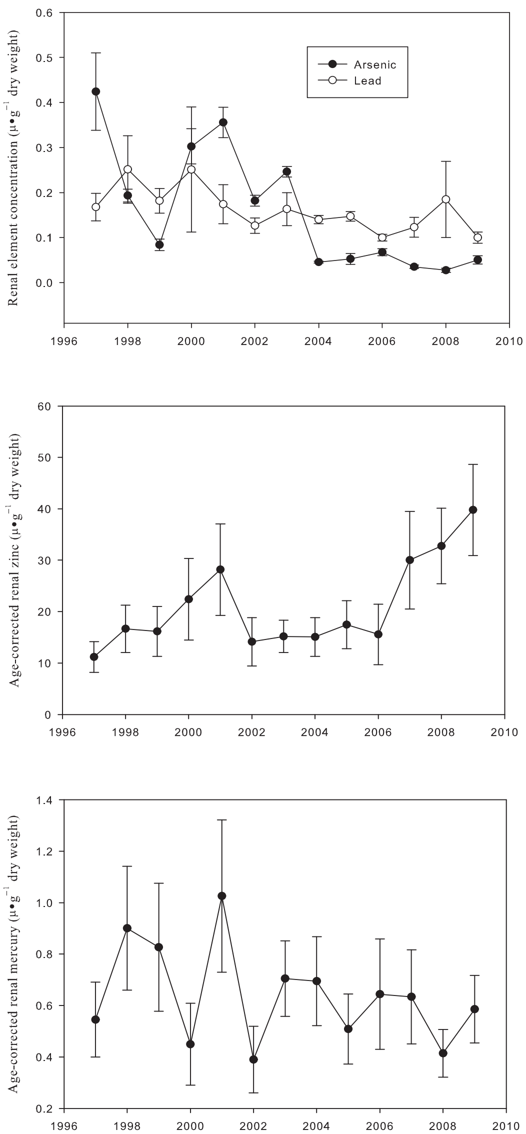

Figure 2. Renal element concentrations in male fall-collected Porcupine caribou from 1997-2009.

While there is a significant negative correlation between year of collection and both renal arsenic and lead concentrations in male, fall-collected Porcupine caribou (Figure 2), the absolute decline is small and particularly in the case of arsenic, may reflect an increased ability for the laboratory detection of smaller amounts of the element rather than an actual decline in the caribou over time.

Zinc is positively correlated with age and is increasing in these caribou over time. It is not clear why this increase is occurring, but Figure 2 shows that while concentrations were low from 2002-06, levels since then have continued to increase. It is not likely that this increase is of concern toxicologically at this point. Zinc is an essential and homeostatically controlled element and is unlikely to occur at toxic levels in a natural environment. Even the highest levels seen in these caribou do not approach levels that are thought to be toxic for domestic cattle (Puls 1994). Nevertheless, continuing to monitor zinc in the herd would be prudent.

Neither cadmium nor mercury are increasing or decreasing significantly over time. Figure 2 shows age-corrected data for renal mercury over time and demonstrates high variability for any given year. While cadmium and zinc increase with the age of both genders of caribou, mercury increases with age in female caribou but decreases with age in male caribou (Figure 3). It is of note that both genders start life with approximately the same concentrations of mercury, then over time male caribou experience a net loss while females experience a net gain, even though females have the additional mercury elimination routes of the fetus and lactation. This is likely due to the greater relative intake of mercury by female caribou. Their smaller body size requires almost as much food (and hence mercury) intake as the larger males, so concentrations are inherently higher (Gamberg 2009). Over time, females apparently ingest more that they can eliminate resulting in increasing concentrations with age, whereas the opposite occurs in males.

Contaminants of concern in the Porcupine caribou are generally stable over time, although the increase in zinc should continue to be monitored. Levels of most elements measured in both the Porcupine and Tay caribou herds were not of concern toxicologically, although renal mercury and cadmium concentrations may cause some concern for human health depending on the quantity of organs consumed. Yukon Health has advised restricting intake of kidney and liver from Yukon caribou, the recommended maximum varying depending on herd (e.g. a maximum of 7 kidneys/year from the Tay herd or 32 Porcupine caribou kidneys/year). The health advisory confirms that heavy metals are very low in the meat (muscle) from caribou and this remains a healthy food choice.

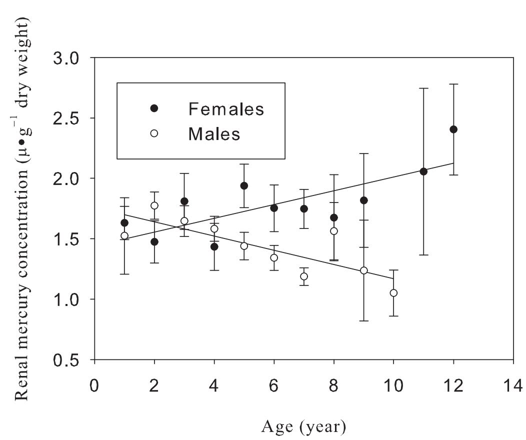

Figure 3. Renal mercury concentrations in Porcupine caribou.

NCP Performance Indicators
Number of northerners engaged in this project: 5
Number of meetings/workshops held in the north: 2
Number of students involved in this project: 1
Number of citable publications: 1 anticipated (in addition to NCP synopsis report)

Expected Project Completion Date: This program is ongoing.

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