Contaminants in Yukon Moose and Caribou - 2001

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and
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Executive Summary

This project is part of the ongoing monitoring of contaminants in Yukon wildlife that began in 1992 with a study of the Finlayson caribou herd, continued with a comprehensive look at contaminants in country foods, and is now monitoring temporal and geographical trends using moose and caribou as key species.

Yukon hunters were requested to submit a tooth and kidney, liver and muscle samples from moose and caribou killed during the 2001hunting season. Each hunter submitting samples had their name put into a draw, once for each tissue they submitted. The draw was for a charter flight with Alpine Aviation Ltd. up to a value of $1000. The draw took place on the CBC radio morning show on Dec. 3, and the winner was Reinhart Saure of Whitehorse.

From the 2001 hunt, samples were submitted from 90 moose, 34 caribou and one mule deer. Of these, YTG personnel took samples from the mule deer, two moose and one caribou, (all road killed animals). Samples were taken from one caribou by YTG biologists after a capture mortality. Hunters contributed the remaining samples. Financial restrictions dictated that only caribou kidneys be analyzed under the current program. Remaining kidney, liver and muscle samples were archived in -80°C freezers for possible future analysis. Although results are provided for 26 elements, only six elements of interest are discussed in detail in the report: arsenic, cadmium, copper, lead, mercury, selenium and zinc. Unfortunately, only the Porcupine herd had a sample size greater than two, so the effect of herd on element concentrations could not be tested, and the effects of age and year were only tested using data from the Porcupine herd (including previously collected data).

Arsenic, copper, lead, selenium and zinc concentrations in caribou kidneys from this study are considered normal background levels. There were slight but statistically significant increases in renal lead and zinc with age and in renal selenium with year of collection in the Porcupine herd. In all cases the absolute increase is small and probably of little biological significance.

All mercury concentrations found in this study were low relative to those found in NWT caribou and likely reflect naturally occurring geological sources rather than industrial pollution. Although sample sizes were too low to allow the statistical comparison of mercury levels among caribou herds, the data from this study suggests that some herds (Carcross, Finlayson and Little Rancheria in particular) may have higher mercury concentrations than other herds. Although sample sizes for each herd are low in this year of the study, and conclusions therefore difficult, this pattern is supported by data previously collected under the hunter survey program. There is a small but significant increase in renal mercury with age in the Porcupine caribou. As with lead and zinc, the absolute increase is small and probably of little biological significance. Year of collection was negatively correlated with renal mercury in the Porcupine caribou herd. This may not necessarily indicate an decrease in mercury over time, however, but is more likely an effect of anomalous data from 1991.

Cadmium concentrations in the Porcupine caribou herd are similar to those found in barren-ground caribou from NWT and are not affected by year of collection, indicating their stability over time. Cadmium levels in Yukon woodland caribou tend to be much more variable and dependent on the cadmium found naturally in their local environment. Although sample sizes from particular herds were too low to allow statistical analysis of differences among herds, the data indicate that the Finlayson and Carcross herds tend to have higher cadmium levels than other Yukon herds. Health Canada has recommended limiting consumption of caribou kidneys for individual herds based on previously collected data (the Carcross herd was not considered in this advisory). Age was positively correlated with cadmium in Porcupine caribou. This relationship has been extensively described in the literature and was expected in this study.

Element concentrations in caribou found in this study should be considered background levels. While some Yukon caribou showed higher renal cadmium concentrations than in the same species from other areas, it is likely that this contaminant is entering the food chain from natural mineralizations in the Yukon, and has always been part of this environment. People concerned about the consumption of contaminants from wild game should refer to the health advisory issued by Health Canada.

INTRODUCTION

This project is part of the ongoing monitoring of contaminants in Yukon wildlife that started in 1992 with a study of the Finlayson caribou herd (Gamberg 1993), continued with a comprehensive look at contaminants in country foods (Gamberg 2000a), and is now monitoring temporal and geographical trends using moose and caribou as key species (Gamberg, 1997, 1998, 1999, 2000b, 2001).

METHODS

Collections

Yukon hunters were requested to submit kidney, liver and muscle samples, as well as an incisor, from moose and caribou killed during the 2001hunting season. The program was advertised through posters and newspaper ads. Each hunter that submitted samples had their name put into a draw, once for each tissue they submitted. The draw was for a charter flight on Alpine Aviation of Whitehorse, up to a value of $1000. The draw took place on the CBC radio morning show on Dec. 3, 2001, and the winner was Reinhart Saure of Whitehorse.

Hunters submitted their samples to their local Renewable Resources office where a YBS (Yukon Biological Submission) form was filled out for each submission. Samples were labeled with the YBS number and stored in -20^{o} C freezers until processed.

Each hunter submitting samples was sent a letter thanking them, giving them the age of their animal if they submitted a tooth and telling them what the project was about. A brief background of cadmium in Yukon wildlife was included, as well as the consumption recommendations from Health Canada (Appendices 1 and 2).

Tissue Processing and Analysis

If incisor bars or entire jaws were submitted, an incisor was extracted and cleaned of extraneous tissue. If possible, age was determined from tooth eruption patterns. Otherwise, incisors were aged using the cementum technique. Moose teeth were aged by the author and caribou teeth were aged by a Yukon Government technician.

Kidneys were cleaned of extraneous tissue and the kidney capsule removed. If the kidney was damaged (i.e. sliced or in pieces), or the capsule was torn or missing, the tissue was rinsed with distilled water. Outer portions of each liver and muscle sample were removed leaving ‘clean’ subsamples, which were then archived in polyethylene vials at -80^{o} for possible future analysis of inorganic contaminants. If enough liver tissue was available, a portion was stored in chemically cleaned glass jars and stored at -80^{o} for possible future analysis of organic contaminants. ‘Clean laboratory practices’ were used throughout tissue processing.

Contaminants Analysis

Financial restrictions dictated that only caribou kidneys could be analyzed under the current program. Forty caribou kidneys from the 2001 and the 2000 collections were homogenized, then analyzed for 26 elements by Elemental Research Inc., Vancouver, BC, by the inductively coupled plasma with mass spectroscopy technique (ICP-MS). Certified standard reference materials, blanks and duplicates were used to check laboratory performance as part of standard laboratory quality control practices. All results are presented on a dry weight basis.

Statistical Analysis

All elements were discussed in detail as they related to moose and caribou in the 1996 report (Gamberg, 1997). Most of these elements were at background levels and posed no threat to the animals themselves, or to consumers of the animals. Although data for 26 elements are presented in this report (Table 1), only the following elements of interest were analyzed statistically and will be discussed: arsenic, cadmium, copper, lead, mercury, selenium and zinc.

Because caribou herd has been shown to have a significant effect on some element concentrations

(Gamberg unpubl. data), herd should be considered in this analysis as a potential significant effect on element concentrations. Unfortunately, only the Porcupine herd had a sample size greater than two, so the effect of herd on element concentrations could not be tested, and the effects of age and year were only tested using data from the Porcupine herd. Data for the other caribou herds have been simply summarized and presented (Table 1). To maximize the power of the statistical tests, the effect of age and year were tested on Porcupine caribou data collected through this program since 1991 for all elements except arsenic, lead and selenium. For these elements, different analytical techniques before 1994 resulted in detection limits greater than measured values in later years. Accordingly, only data from 1994-2001 were used in the statistical analysis of these elements.

Where possible, a multiple linear regression was used to test the effect of year and age on element concentrations. When data were not normal, and so precluded this test, Spearman's Rank Correlation was used to test these effects. In all cases the criterion for significant effects was α=0.05.

RESULTS and DISCUSSION

Hunter Response

Samples were submitted from 90 moose, 34 caribou and one mule deer. Of these, YTG personnel took samples from the mule deer two moose and one caribou, which were all road, killed animals. Samples were taken from one caribou by YTG biologists after a capture mortality. Hunters contributed the remaining samples. Teeth were submitted for 83 moose and 27 caribou.

Of the 125 submissions, 77% included liver, 78% included kidney, 62% included muscle, 88% included a tooth, and 46% included all four tissues. 8% of submissions only included teeth.

Tissue Analysis – Quality Assurance

Requested detection limits were met for all 26 elements analyzed by Elemental Research Inc (Appendix 3). Average recovery of three elements fell below the requested 85% minimum in the standard reference materials - calcium (79%), strontium (77%) and tin (66%). Two duplicate samples did not meet the requested maximum difference of 15%, one for aluminum and one for cobalt. In each case two other sets of duplicates did meet the criteria for that element. For all elements combined, the average percent recovery was 93% and the average relative percent difference between duplicates was 8%. This is considered acceptable quality control for this project.

INDIVIDUAL ELEMENTS

Arsenic

There was little variation in renal arsenic measured in this study. Concentrations averaged 0.34 ppm and ranged from 0.21 –0.64 ppm, the highest being found in an individual caribou from the Coal River Herd (Table 1). As these arsenic levels would be considered normal levels for domestic cattle or sheep (Puls 1994), they indicate no cause for concern and should be considered background concentrations.
Arsenic concentrations in Porcupine caribou kidneys were not significantly affected by age or year.

Although **arsenic** is generally considered a non-essential element, it has been identified as an essential trace element for domestic goats (Puls 1994). It can be absorbed by ingestion, inhalation and permeation of skin or mucous membranes and accumulates in the liver, kidney, spleen, muscle, skin and hair. Toxic effects include respiratory cancer, peripheral nervous system disorders and dermatitis (Jaworski 1980). Toxicity depends on the concentration and form, trivalent arsenic (arsenite) being 5 to 10 times more toxic than pentavalent (arsenate). Elemental arsenic is non-toxic. Since the use of arsenic in herbicides, insecticides, fungicides and rodenticides has been largely discontinued, the main sources of arsenic to the environment are mine tailings, smelter waste and natural mineralizations (Jaworski 1980).

Table 1. Element concentrations in Yukon caribou kidneys (ppm dry weight).

Herd	Carcross			Coal River			Finlayson			Hart River	
Year	1999		2000	2000	2001		1999	2000	2001	2000	
	Mean	SD			Mean	SD				Mean	SD
N	2		1	1	2		1	1	1	2	
Age	7	1			5	1	3		6	4	1
%Moisture	80	0	77	81	80	3	80	79	79	79	1
Aluminum	2.3	0.1	3.2	0.6	1.1	0.3	1.3	0.8	2.7	1.1	<0.1
Antimony	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.32	0.07	0.49	0.22	0.46	0.26	0.27	0.22	0.25	0.25	0.05
Barium	3.33	0.68	2.44	0.76	1.03	0.21	1.53	4.22	2.07	2.01	0.13
Beryllium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	103.2	90.2	244.0	46.2	38.7	0.3	45.7	381.0	113.0	34.0	16.1
Calcium	420	25	419	391	389	23	400	397	366	350	13
Chromium	1.1	0.2	1.5	1.0	1.3	0.3	1.1	1.0	1.1	1.1	0.2
Cobalt	0.19	0.04	1.98	0.37	0.39	0.24	0.19	0.20	0.69	0.36	<0.01
Copper	22.9	1.6	20.4	24.0	25.1	1.9	26.5	21.5	24.0	30.0	1.6
Iron	214	120	349	132	146	8	143	122	182	125	6
Lead	0.32	0.11	0.19	0.33	0.19	<0.01	0.26	0.21	0.11	0.08	0.02
Magnesium	703	89	660	692	707	23	737	697	675	726	23
Manganese	7.61	0.16	7.25	6.37	6.66	1.30	9.25	8.09	8.49	8.71	0.28
Mercury	5.00	2.10	4.10	1.19	1.35	0.07	3.46	4.70	2.86	1.19	0.23
Molybdenum	1.11	0.21	0.63	0.51	0.85	0.34	0.92	0.93	1.20	1.06	0.04
Nickel	<0.05	<0.05	<0.05	<0.05	0.10	<0.05	<0.05	0.08	0.16	0.21	<0.05
Selenium	4.65	<0.1	4.00	4.80	4.15	0.21	5.40	4.80	4.00	5.20	<0.1
Silver	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Strontium	0.67	0.25	0.66	0.45	0.57	0.05	0.48	0.68	0.42	0.62	0.02
Thallium	0.05	0.05	0.04	0.03	0.05	0.01	<0.01	0.02	0.06	<0.01	<0.01
Tin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Vanadium	0.29	<0.05	0.41	0.23	0.34	0.08	0.26	0.23	0.29	0.26	0.07
Zinc	115.3	22.2	137.0	103.0	102.6	6.3	104.0	152.0	121.0	112.0	1.4

Table 1 (cont'd).

Herd	Little Rancheria	Nahanni	Porcupine						Unknown
Year	2001	2001	1997		2000		2001		2000
			Mean	SD	Mean	SD	Mean	SD	
N	1	1	2		7		17		1
Age	2	7	6	2	7	2	4	2	3
%Moisture	78	80	80	3	80	2	79	1	76
Aluminum	1.5	1.1	2.8	0.1	2.0	0.6	2.5	3.4	1.0
Antimony	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	<0.01	<0.01
Arsenic	0.24	0.29	0.44	0.01	0.38	0.12	0.34	0.11	0.25
Barium	1.22	0.82	1.53	0.17	2.66	0.87	2.35	0.71	1.49
Beryllium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	<0.5	<0.5	1.2	0.9	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	10.2	57.9	32.0	6.2	40.4	16.3	33.1	15.0	14.6
Calcium	305	339	400	28	402	46	423	50	375
Chromium	1.0	1.1	1.4	0.2	1.3	0.3	1.3	0.4	0.8
Cobalt	0.12	0.68	0.48	0.13	1.23	0.99	0.88	0.73	0.31
Copper	18.9	25.5	23.6	0.4	23.9	3.5	23.0	2.7	19.6
Iron	215	143	279	74	280	209	223	129	574
Lead	0.12	0.08	0.12	0.05	0.32	0.40	0.16	0.13	0.14
Magnesium	632	767	738	35	714	108	697	53	563
Manganese	5.26	7.94	6.70	0.32	7.16	2.20	7.05	1.79	4.99
Mercury	2.70	1.13	1.46	0.30	1.68	0.77	1.58	0.54	1.89
Molybdenum	0.52	0.67	1.08	0.21	1.22	0.44	1.75	0.66	1.37
Nickel	<0.05	0.06	<0.05	<0.05	0.34	0.52	0.10	0.06	0.06
Selenium	3.50	5.70	4.50	0.42	4.89	0.95	4.50	0.96	4.30
Silver	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Strontium	0.44	0.42	0.32	0.13	0.46	0.08	0.42	0.12	0.47
Thallium	0.02	0.01	0.08	0.05	0.03	0.02	0.03	0.03	0.05
Tin	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Vanadium	0.25	0.28	0.36	<0.05	0.35	0.09	0.34	0.11	0.21
Zinc	91.9	117.0	97.9	3.0	116.4	21.0	119.6	29.1	75.5

Cadmium

Renal cadmium ranged from 10.2 ppm in a Little Rancheria caribou to 381 ppm in a Finlayson caribou (Table 1). Samples from the Finlayson and Carcross caribou were notably higher in cadmium than samples from other herds (Figure 1). It should be noted that the two highest values measured in this study (the Finlayson caribou already mentioned as well as a Carcross caribou which had 244 ppm renal cadmium) came from animals of unknown ages, so they are not included in Figure 1.

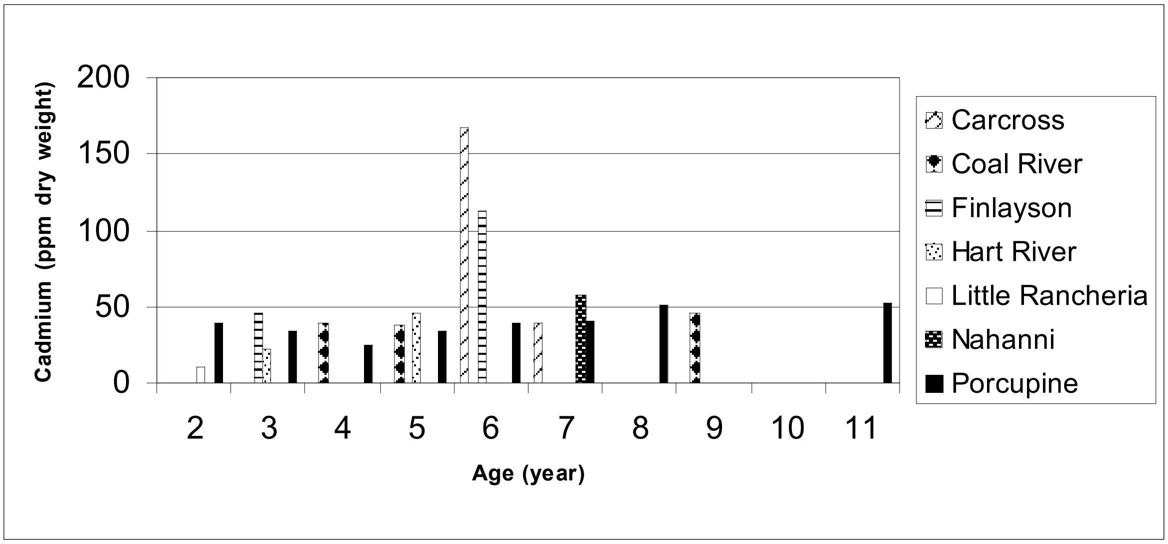

Figure 1. Renal cadmium concentrations in seven Yukon caribou herds. Samples collected in 2000 and 2001.

The barren-ground caribou in this study (Porcupine herd) had concentrations of renal cadmium similar to those found in five barren-ground herds studied in the Northwest Territories (Elkin and Bethke 1995). The woodland caribou (all the other Yukon herds) tend to be much more variable in cadmium levels (Figure 1). This may be attributable to differences in dietary habits between the two subspecies. Barren-ground caribou feed mainly on lichen, which absorb contaminants along with necessary nutrients from the air. Having no root system, lichens do not absorb anything from the soil on which they grow. Arctic lichens are blanketed with low concentrations of cadmium brought to the north by long-range transport via large air masses. In the absence of local point sources of airborne cadmium, this is virtually the only route of cadmium contamination for barren-ground caribou, and it tends to be fairly consistent across the arctic.

Cadmium is a toxic element that accumulates in animals over time (and therefore with age), primarily in the kidneys and liver. Chronic exposure may lead to anemia, enteropathy, renal damage, osteoporosis and osteomalacia. Long-range transport distributes cadmium widely over the environment, and natural mineralizations may serve as point sources. Lichens absorb cadmium directly from the air, eventually passing it on to caribou that feed on the lichen. Plants differ in their ability to absorb cadmium from soil and water, some species accumulating relatively high concentrations if they grow in cadmium-rich soil. Cadmium accumulates in long-lived herbivores, generally not in high enough levels to impair their health. Industrial uses of cadmium include production of cadmium-plated metal, nickel-cadmium batteries, pigments and plastic stabilizers, mining and refining of copper, lead and zinc (Jaworski 1980).

Woodland caribou habitat is much more wooded than the tundra preferred by barren-ground caribou. Woodland caribou are also less migratory, inhabiting a much smaller home range. They feed on lichens, but also have a variety of browse available to them in their wooded habitat. One of the preferred species of browse is willow (*Salix* sp.), which absorbs cadmium very effectively from the soil in which it grows (Crowder 1991). Woodland caribou inhabiting a home range naturally high in cadmium, then, would be exposed to much higher levels of cadmium over their lifetime than barren-ground caribou feeding only on lichen. Conversely, woodland caribou inhabiting an area low in natural cadmium would have far less of this particular contaminant accumulating in their organs.

Although average renal cadmium for all herds measured in this study is well below the critical threshold value (400-800 ppm dry weight) at which renal tubule dysfunction has been shown to occur (Elliot et al. 1992, Kjellstrom 1986), one Finlayson caribou did have renal cadmium (381 ppm) approaching the critical range. This indicates potential for older caribou in some Yukon herds to be at risk of renal dysfunction due to high renal cadmium.

Renal cadmium concentrations positively correlated with age in Porcupine caribou (Figure 1). This relationship has been extensively described in the literature (Crete et al. 1987, 1989, Froslie et al. 1986, Gamberg and Scheuhammer 1994), and has been seen is previous work of this type in the Yukon (Gamberg 1993,1997,1998,1999). It is important to consider age as a factor when comparing cadmium levels among herds or species. Renal cadmium concentrations in Porcupine caribou were not significantly affected by year, indicating a stable situation with respect to cadmium dynamics in that environment.

Health Canada has recommended limiting consumption of caribou kidneys based on previously collected data. Because cadmium levels have not changed over time, the recommendations should still be relevant. They are provided in Appendix 2.

Copper

Renal copper concentrations in caribou from this study were very consistent, averaging 23.5 ppm dry weight, and ranging from 18.2 to 31.1 ppm. They were not affected by age of the caribou in the Porcupine herd. While these levels are somewhat lower than those found in barren-ground caribou in NWT (means ranged from 27.8-49.7 ppm; Elkin and Bethke 1995), they are within the range considered adequate for domestic cattle (Puls 1994). Copper levels in Porcupine caribou kidneys were not significantly affected by year. These concentrations should be considered background levels.

Copper is an essential element. Since it is homeostatically controlled, excess copper is excreted in the urine, and toxicity is rare under normal conditions. Toxic effects may occur, however, and can include dermatitis, anemia, gastric ulcers, renal damage and hemolysis (Aaseth and Norseth 1986). Copper deficiency has been noted in Alaskan moose with faulty hoof keratinization and reduced reproductive rates (Flynn et al. 1977). Industrial uses include production of electrical equipment and alloys, plating, plumbing, heating, and uses in mining and smelting.

Lead

Renal lead concentrations were generally low and usually <0.50 ppm (Table 1). Exceptions to this included two Porcupine caribou with 0.63 and 1.22 ppm lead in their kidneys. When all Porcupine data from 1994 to the present were analyzed, there was a slight, but significant increase in renal lead with age (Figure 2). However, the absolute increase in renal lead from ages 0 (fetus) to 11 is very small and probably of little biological significance. Year did not significantly affect renal lead levels. The concentrations of lead found in this study are similar to those found in NWT barren-ground caribou (means ranged from 0.11 to 0.47 ppm; Elkin and Bethke 1995) and are well within the range considered normal for domestic cattle (Puls 1994). It

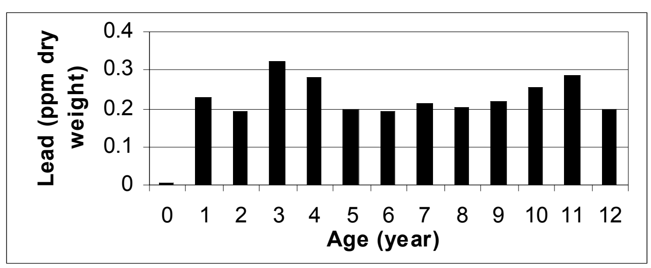

Figure 2. Renal lead concentrations in Porcupine caribou from 1994-2001.

should be noted that even the highest lead concentrations found in this study were well below the threshold level of 80 ppm that is thought to be indicative of lead poisoning (Scheuhammer 1991). Lead concentrations found in this study should generally be considered background levels.

Lead is a toxic element that is stored for the long term in bone tissue, and in the short-term, in liver and kidney. Toxic signs include anemia, anorexia, fatigue and blindness. Common sources of lead include mining, smelting and refining of lead and other ores, burning petroleum fuels containing lead additives, burning coal and oil and use in shotgun pellets. Lead may also be found in paint (even 'lead-free paint may contain up to 1% lead), waste engine oil, lead batteries, putty, roofing tiles, linoleum, solder and golf balls. Some pipe joint or thread compounds (used on drilling sites) can contain up to 40% lead powder (Puls 1994)

Mercury

Renal mercury concentrations varied among herds, ranging from 0.86 ppm in a Porcupine caribou to 6.48 ppm in a Carcross caribou (Table 1). Although sample sizes were too low to allow the statistical comparison of mercury levels among caribou herds, Figure 3 suggests that some herds (Carcross, Finlayson and Little Rancheria in particular) may have higher mercury concentrations than other herds. Although sample sizes for each herd are low in this year of the study, and conclusions therefore difficult, this pattern is supported by data previously collected. These indicate average renal mercury levels of 4.18, 3.36 and 2.48 ppm respectively for the Carcross, Finlayson and Little Rancheria caribou herds (Gamberg 2000b).

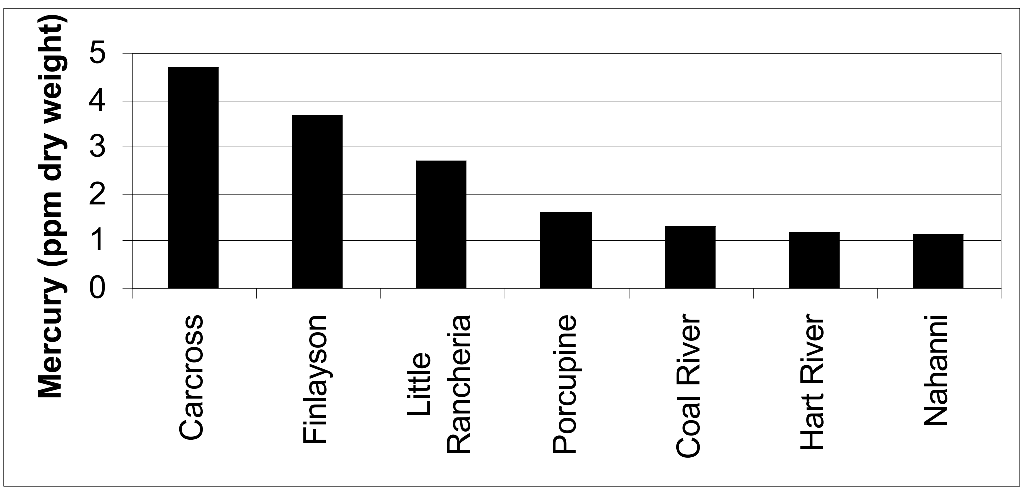

Figure 3. Renal mercury concentrations in seven Yukon caribou herds. Samples collected in 2000 and 2001.

One outlier value of 232 ppm was removed from the Porcupine caribou data set before analyzing the relationships between age and mercury and between year of collection and mercury. Age was positively correlated with renal mercury in the Porcupine caribou, although the absolute increase with age is slight, and not likely to be of biological significance (Figure 4). It should be noted that caribou in the age class '0' were all fetuses. Year was negatively correlated with mercury. However, if the notably higher 1991 data are removed, there is no significant correlation between renal mercury and year. It is unclear why the 1991 data are higher than the ensuing years, but in any case, there does not seem to be a real biological trend over time in renal mercury in the Porcupine caribou.

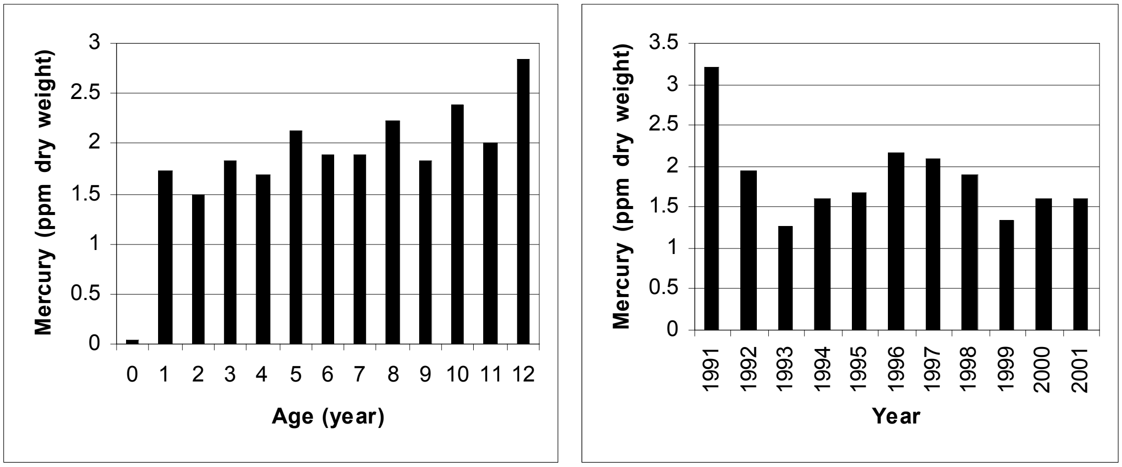

Figure 4. Renal mercury in Porcupine caribou collected from 1991-2001.

All mercury concentrations found in this study were low relative to those found in NWT caribou (2.76-14.14 ppm dry weight; Elkin and Bethke 1995). Even the highest mercury level measured in this study, (6.48 ppm eight or 1.3 ppm wet weight in a Carcross caribou) is far below the threshold level of 30 ppm wet weight cited by Scheuhammer (1991) at which neurological effects might be expected to occur. Braune et al. (1991) suggested that high mercury levels in the Canadian arctic reflect naturally occurring geological sources rather than industrial pollution. Mercury levels found in this study should be considered natural background levels.

Mercury is a toxic element that accumulates in brain and kidney tissue, affects neurological functions and may cause gastrointestinal disturbance, reduction of food intake, poor growth, renal damage or death. Prenatal exposure may lead to cerebral palsy (Berlin, 1986). Inorganic mercury may be transformed to methylmercury (a more toxic form of mercury) by natural microbial action in lakes. This process may be promoted by excess sulphides from atmospheric deposition or nutrification of lakes. Aquatic life is generally more sensitive to methylmercury than terrestrial species. Environmental sources of mercury include mining, milling and smelting of mercury-containing ores, chlor-alkali plants, coal-burning plants, municipal wastewater treatment plants, pulp and paper mills and fungicides. Natural mercury occurs as volcanic gases, natural mineralizations and evaporation from oceans (World Health Organization, 1989).

<u>**Selenium**</u>

Renal selenium in caribou in this study ranged from 3.1 to 6.9 ppm, both animals from the Porcupine herd. The average concentration of 4.6 ppm falls in the 'high' range for domestic cattle (Puls 1994). Year of collection was positively correlated with renal selenium (Figure 5), although the significance level was not high ($r = 0.13; p = 0.04$). The absolute change in selenium over time is small and probably not of biological significance to the caribou. These selenium concentrations should be considered background levels.

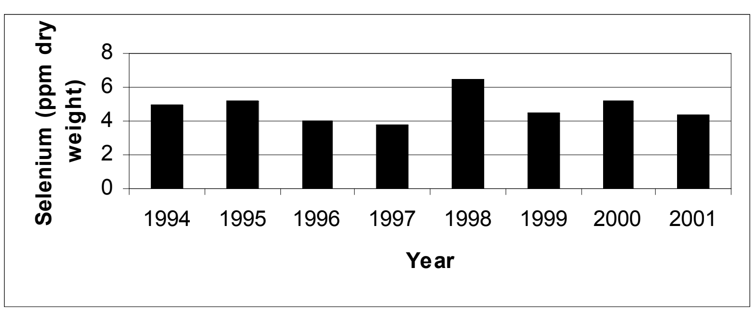

Figure 5. Renal selenium in Porcupine caribou collected from 1991-2001.

Selenium is an essential element, which interacts with vitamin E to ensure optimum functioning of the immune and reproductive systems. Because some geographical areas are naturally low in selenium, deficiencies are possible, causing white muscle disease, reduced growth and reproductive rates, and reduced immune response. Signs of toxicity may include emaciation, lameness, cracked or deformed hooves and loss of hair. It has been thought that excess selenium also caused ‘blind staggers’, but this may be due to other compounds in the selenium-accumulating plants (*Astralagus* sp.) responsible for this disease (Puls 1994). Industrial uses of selenium include electronics, photography, glass production, fungicides, insecticides and pigments in plastics, paints, enamels, inks and rubber.

Zinc

Renal zinc in caribou from this study ranged from 75.5- 181.0 ppm and averaged 155.1 ppm. These concentrations are similar to those found in caribou from NWT (96.75 - 120.86 ppm dry wt; Elkin and Bethke 1995). Age was positively related to zinc (Figure 6), a relationship that was also seen in Yukon moose (Gamberg 2001). The absolute change in zinc levels with age is slight and even the highest levels found in 12- year-old caribou fall within the range considered ‘adequate to high’ for domestic cattle (Puls 1994). Concentrations of zinc found in this study should be considered normal background levels.

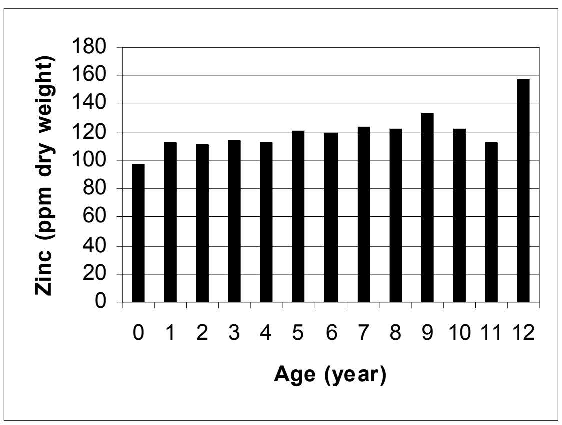

Figure 6. Renal zinc in Porcupine caribou collected from 1991-2001.

Zinc is an essential, homeostatically controlled element, and is an important component of many proteins and enzymes. Zinc deficiency may result in reduced conception rate, reduced feed intake and growth rate, and thickening and shortening of bones. Toxic effects include anemia, poor bone mineralization, arthritis, general osteochondrosis and lameness (Sileo and Beyer 1985). Zinc is released into the environment through mining, smelting and residential and industrial effluents and is used industrially in electroplating, the combustion of fossil fuels, petroleum by-products and solid wastes.

CONCLUSIONS

Element concentrations in caribou found in this study should be considered background levels. Some Yukon caribou showed higher renal cadmium concentrations than in the same species from other areas. It is likely that this contaminant is entering the food chain from natural mineralizations in the Yukon, and has always been part of this environment. People concerned about the consumption of contaminants from wild game should refer to the health advisory issued by Health Canada (Appendix 2).

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Appendix 1. Cadmium in Yukon Wildlife

Ongoing research on contaminants in wild foods has shown that, for the most part, mammals, birds and plants in the Yukon are free from contamination. However, some animals do have high levels of cadmium in their livers and kidneys.

Cadmium is a toxic heavy metal that is found in abundance in natural ecosystems in the Yukon. Our unique geology that makes mining so profitable here, also means that certain metals work their way into some ecosystems. Cadmium is one of those troublesome metals. The cadmium works its way into the soil, and then into plants through the roots. Animals eating those plants will then absorb the cadmium.

Once it is in the body, the liver and kidney work at removing the cadmium. They are effective to a degree, but if the animal (or person) takes in more cadmium than these organs can get rid of, it will accumulate in the liver and kidney over the lifetime of the animal. For this reason, older animals (or people) tend to have higher levels of cadmium than younger ones. If cadmium levels reach a threshold level in the kidney, there is potential for kidney dysfunction.

The World Health Organization (WHO) has determined the level of cadmium intake that is considered safe for humans. Health Canada has used this level, along with concentrations found in Yukon wildlife, to recommend limiting consumption of kidneys and livers of certain animals. For some, the limit is quite high - 485 snowshoe hare kidneys per person per year, and 382 Mountain Goat kidneys. For caribou the recommendation varies among herds, but ranges from 7-32 kidneys/person/year, and 4-16 livers/person /year. The recommended limit for moose liver and kidney is one of each per person per year. It should be noted that cadmium does not accumulate in the meat or the muscle tissue of any animal, and Health Canada has not recommended limiting consumption of meat from any species.

While health advisories of this sort are relatively new to the Yukon, advisories against eating livers and kidneys of certain species have been issued in other provinces of Canada. Manitoba has a health advisory for moose and elk, Ontario for moose and deer, Quebec for moose and caribou and Newfoundlanders have been advised that the consumption of moose liver or kidney would probably result in their exceeding the WHO standard intake limits for cadmium for that week of consumption. Most of these advisories do not recommend limiting consumption, but advise avoiding consumption completely. Health officials in the Yukon have attempted to be sensitive to the culture and desires of Yukoners, and gone through the extra step of determining what a safe level of consumption would be.

The federal Northern Contaminants Program is conducting an ongoing program to monitor contaminant levels in Yukon moose and caribou. The conclusion after seven years of the program is that cadmium, the major contaminant of concern, is stable and levels do not appear to be changing.

Anyone with further concerns or questions about levels of contamination in Yukon wildlife should contact Yukon Health and Social Services, or their local Renewable Resources Office.

Updated December 2001

Appendix 2. Health Advisory

ANIMAL	Maximum # of Kidneys per year Recommended for Consumption	Maximum # of Livers per year Recommended for Consumption
Caribou		
Bonnet Plume	32	16
Nahanni	28	13
Porcupine	25	12
Forty-mile	20	12
Wolf Lake	15	8
Finlayson	8	5
Tay	7	4
Moose	1	1
Sheep	178	No limit
Goat	382	26
Beaver	15	46
Porcupine	13	17
Snowshoe Hare	485	No limit

There are no limitations on the amount of muscle (meat) that can be consumed from any animal

For further information please call Health and Social Services at 667-5302

Appendix 3. Quality control data for laboratory analysis: element concentrations (ppm) in preparation blanks, recoveries for standard reference materials and relative differences between duplicate samples. % Differences and recoveries were calculated only when element concentrations were greater than 10 times the detection limit.

	Preparation Blanks (Detection Limit for samples)	% Recovery Standard Reference Materials	Relative Percent Difference between Duplicates
Aluminum	0.1	90	16
Antimony	0.01		
Arsenic	0.01	99	10
Barium	0.01		3
Beryllium	0.01		
Boron	0.5		
Cadmium	0.01	91	4
Calcium	1	79	3
Chromium	0.2		
Cobalt	0.01	102	51
Copper	0.05	102	1
Iron	0.5	99	4
Lead	0.01	101	3
Magnesium	0.1	93	3
Manganese	0.01	95	4
Mercury	0.05	101	5
Molybdenum	0.01		4
Nickel	0.05	111	
Selenium	0.1	105	6
Silver	0.05		
Strontium	0.01	77	5
Thallium	0.01		
Tin	0.01	66	
Uranium	0.005		
Vanadium	0.05		
Zinc	0.1	86	2
Average		93	8