PETROLEUM SOCIETY
CANADIAN INSTITUTE OF MINING, METALLURGY & PETROLEUM

PAPER 2007-092

CANADIAN INTERNATIONAL PETROLEUM CONFERENCE

Oil and Gas Development and the Potential for Contamination of Moose (Alces alces) in Northeast BC

C. MAUNDRELL
Adlard Environmental Ltd

N. Roe

This paper is to be presented at the Petroleum Society's 8th Canadian International Petroleum Conference (58th Annual Technical Meeting), Calgary, Alberta, Canada, June 12 – 14, 2007. Discussion of this paper is invited and may be presented at the meeting if filed in writing with the technical program chairman prior to the conclusion of the meeting. This paper and any discussion filed will be considered for publication in Petroleum Society journals.

Abstract

We analyzed moose tissue samples for extractable petroleum hydrocarbons (EPH), heavy metals and polycyclic hydrocarbons (PAH) and compared levels of concentration in tissues between two areas with noticeably different levels of oil and gas activity. Our treatment are (extensive oil and gas activity) had 135 oil and gas wells in a 2100km^2 area in 2003 and the control area (2900 km^2) had no active oil and gas wells in 2003. EPH analysis showed the treatment area had significantly higher levels of C32, C33, C37 and C38 than the control area. Significantly higher levels of heavy metal concentrations, in 14 of 28 heavy metals tested were found in tissues sampled from the treatment area. No significant difference in PAH were found between the study areas. This study suggests that oil and gas activity may have negative impacts on the health of moose in Northeast BC. In order to quantify this impact further work needs to be undertaken that will monitor moose activities as they relate to landscape feature availability to determine the use and impact of oil and gas facilities on the health of moose in Northeast BC.

Introduction

First Nations of Northern Canada today remain reliant on their traditional sources of food for meat, berries, and fish. Much of the meat protein that is consumed by First Nations is obtained by hunting and trapping in traditional areas. First Nations people of the Northwest Territories have relied on moose (*Alces alces*) as a traditional food source for thousands of years (Anonymous 2003a), as many First Nations people have, including the communities of Northeast British Columbia. Moose meat is the most sought after meat by the West Moberly and Saulteau First Nations of Northeast British Columbia.

First Nations of Northern Canada today remain reliant on their traditional sources of food for meat, berries, and fish. Much of the meat protein that is consumed by First Nations is obtained by hunting and trapping in traditional areas. First Nations people of the Northwest Territories have relied on moose (*Alces alces*) as a traditional food source for thousands of years (Anonymous 2003a), as many First Nations people have, including the communities of Northeast British Columbia.

Moose meat is the most sought after meat by the West Moberly and Saulteau First Nations of Northeast British Columbia.

As the level of oil and gas exploration and development activity in north-eastern British Columbia has increased, concerns regarding the consumption of contaminated meat have increased. Oil and gas activity releases contaminants in the form of heavy metals, polycyclic aromatic hydrocarbons (PAH), extractable petroleum hydrocarbons (EPH) and volatile by-products of oil and gas to the water, soil and air during production, processing, storage and distribution (Health Canada 2004). These contaminants may become bio-magnified or may bio-accumulate in the environment through predation and consumption of plants and animals. Contamination of wild game from industrial activity has been documented in the past (D'Have *et al.* 2005; Morrissey *et al.* 2005; Smithwick *et al.* 2005). Indian and Northern Affairs Canada issued a fact sheet in 2003 (Anonymous 2003a) that suggested contaminants in moose (cadmium) resulted from naturally occurring cadmium up-take during plant growth, and that these plants, when consumed by moose, will transfer this contaminant to tissues and organs. Cadmium is only one metal that may contaminate large mammals such as moose. Heavy metals occur naturally, and can enter aquatic ecosystems by anthropogenic activities such as mining, burning, deforestation, agriculture and urban activity (Morrissey *et al.* 2005). Consumption by wildlife of heavy metals that enter surface and subsurface aquatic ecosystems occurs when the metals are transferred to animals either directly by consumption of water, or indirectly through the uptake by plants and the eventual consumption of contaminated plants by wildlife. All contaminants can be toxic to wildlife at certain levels. As with wildlife, people can absorb heavy metals through the food they consume (Anonymous 2003b).

With the increase of oil and gas activity, structures such as flare and sump pits have created the occurrence of man-made salt licks within their habitat. A study in Northern Alberta, the Great Bear Project (Arocena, 1995), sampled soil and water near flare pits, concluding that contents for metals potentially damaging to the environment exceeded the assessment criteria set up by Canadian Council of Minister of the Environment (CCME 1991).

To determine if animals in areas of high oil and gas development are unhealthy compared to animals that live in areas of low or nil oil and gas activity, symptoms of wildlife need to be documented and tissue samples collected. To date, very little information has been recorded or officially documented. The step taken in the this study is to document the presence of contaminants in harvested animals, in this case, moose.

Methods:

Ten (10) moose were harvested in each of the two study areas to collect tissue samples. Seven (7) females and three (3) males were harvested from the Control Area (CA), and six (6) females and four (4) males from the Treatment Area (TA). Harvesting required shooting the moose with a high powered rifle. Immediately upon shooting a moose, skinning commenced in preparation for recovering the meat and collecting tissue samples. Targeted tissues were: liver, kidney, heart, lungs, reproductive, stomach, and headtail fat. Only liver, kidney and headtail fat were collected from one female harvested in the TA.

Two sets of samples were collected from the liver, kidney, heart, lungs, reproductive organs and stomach. One set consisted of a portion of tissue approximately 50 g, and the other 15 g. The largest possible sample of the headtail (fat of the tailbone, just under the skin) fat was taken. Additional information collected from most moose (15 in all) included weights of the liver, kidney and heart if they had not been damaged by the rifle shell, presence of unusual growths (cysts, lumps or warts) and total length of the animal. A Berkley digital fish scale was used with an accuracy of 0.1oz to measure to an accuracy of 1 oz for all weights, and a metric carpenter's tape measure to measure lengths. Weights measured in pounds and ounces were converted to kilograms. The external appearance and condition of moose were recorded, and evidence of ticks or hair loss was noted.

Tissue samples were immediately placed either in a jar with 10% formalin solution for preservation, or in a plastic bag. Bags and jars were labeled with the type of tissue, and placed in a cooler with ice packs for travel to Fort St. John and thence to laboratories. All tissues sampled were analyzed for a range of metals and EPH and PAH (Table 1). Norwest Laboratories of Surrey, BC, was contracted to perform the EPH analysis. Pacific Rim Laboratories performed the PAH analysis.

EPH was analyzed using EPH in solids by GC/FID (BC Ministry WLAP 2000). Metal analysis used US EPA methodology for mercury (Hg) in sediment by cold vapour atomic absorption spectrum.

A two-group *t*-test or Analysis of variance (ANOVA) was used to test differences between the means of the two study area populations. Both tests provide the same *p* value; however, the ANOVA summary includes a correlation coefficient that can be used to predict how well one variable predicts another. All statistical analysis was performed using SYSTAT Software Inc. Systat version 10.2 (2002) $\alpha = 0.05$.

Results

Table 1 shows mean concentrations of metals discovered in moose tissues, and compares the means from the CA with those from the TA. Of the 28 metals sought by laboratory analysis (Table 1), fourteen had significantly higher concentrations in the TA. Cadmium and molybdenum were each found to be significantly different in four tissues and potassium in two. All other metals from this group showed significant differences in one tissue only. Cadmium (lung, stomach, kidney and liver) was found in significantly lower concentrations in the TA, while molybdenum (stomach, reproductive, kidney, and liver) was found in significantly higher concentrations in the TA.

Presence of metals varied among the tissues sampled, and differences between tissues in the concentrations of metals were apparent between the two study areas. Notable are the number of times the reproductive (6), kidney (7) and liver (4) tissues showed significant differences in concentrations of various metals. Significantly higher concentrations of beryllium, lead, molybdenum, selenium, silver and vanadium were found in reproductive tissues of moose harvested from the TA. In the TA, kidney tissues showed significantly higher differences in concentrations of barium, calcium, molybdenum, sodium, and strontium, while cadmium and zinc concentrations were significantly higher in the CA. Levels of cadmium in liver tissue were significantly higher in the CA, while the levels of iron, mercury and molybdenum were significantly higher in the TA.

The lung tissues showed a significant difference in the levels of cadmium and potassium, with the TA having higher concentrations of potassium and the CA having higher concentrations of cadmium.

The stomach tissue showed a significant difference in the levels of cadmium, molybdenum and zirconium, the CA having higher concentrations of cadmium and molybdenum. The TA had higher concentrations of zirconium.

The heart tissue showed a significant difference in the levels of potassium. The TA had a greater concentration of this element than the CA. The headtail fat showed a significant difference in the levels of silver. The TA had a higher concentration of silver than the CA.

Of all the tissues sampled for EPH, only lung tissues showed statistically significant differences in moose between the CA and TA. Comparing the two study areas, analysis of EPH from C11-C40 revealed that only C32, C33, C37 and C38 showed significant differences (Table 2). In each case, the value of EPH is greater within the TA than in the CA.

Analysis of PAH revealed no statistically significant differences between moose from the two study areas.

Conclusion

Analysis of tissue samples undertaken for this study revealed contamination suggestive of links to petroleum activity. Of the 28 metals analyzed, 14 of them had significantly higher concentrations in the TA. Molybdenum in stomach, reproductive, kidney, and liver tissues was significantly higher in the TA, as were beryllium, lead, molybdenum, selenium, silver and vanadium in reproductive tissues from the TA. Kidney tissues showed significantly higher concentrations of barium, calcium, molybdenum, sodium, and strontium in the TA. However, cadmium (lung, stomach, kidney and liver) and zinc were significantly higher in the CA. Only lung tissues showed statistically significant differences in EPH between moose from the CA and TA. Comparing the CA and TA, analysis of EPH revealed that only C32, C33, C37 and C38 showed significant differences. In each case, the concentrations of EPH are greater in the TA than in the CA. Analysis of PAH revealed no statistically significant differences between moose from the two study areas.

Drawing a definitive conclusion that would link oil and gas activities to the health of moose in the Del Rio and Monias (Treatment) areas is difficult without strong evidence from the laboratory analysis. However, before one draws any conclusion, one must take into consideration all possibilities. In 2004, the Ministry of Water, Land and Air Protection conducted a census in all of Management Unit (MU) 7-32 (Rowe 2004), covering the TA for the present study. The census revealed a moose population estimate of 3431± 21.38% moose in an area of 3683 km^2. This approximates to nearly one moose for every square kilometer in this Management Unit. Winter habitat capability maps for MU 7-32 reveal this area to be of high capability. Ten moose were sampled out of a possible population of 3431, or approximately 0.29 percent of the population. This is a small proportion of the available moose population in the TA.

It is possible that a larger sample size of moose harvested in the TA may have added robustness to this study. First Nations hunting in this area have been discussing the possibility of contaminated moose in this area for a number of years. Our results do not rule out the possibility that there are contaminated moose in the TA, and that these moose are contaminated by oil and gas activity.

Acknowledgements

We would like to thank Health Canada for funding the project and all the First Nations individuals that participated. Particularly we thank Kori Dokkie for her assistance, Sandra Fauchs and Angle Adolf for their time as community coordinators, Tom Hale and all other First Nations hunters for their time and efforts. We would also like to thank the Band Councils of Moberly and Saulteau First Nations.

REFERENCES

1. Anonymous. 2003a. Moose. Northwest Territories Contaminants Fact Sheet. Indian and Northern Affairs Canada. Yellowknife, NWT.
2. Anonymous. 2003b. Heavy Metals. Northwest Territories Contaminants Fact Sheet. Indian and Northern Affairs Canada. Yellowknife, NWT.
3. Arocena, J.M. 1995. Great Bear Project: Qualitative assessment of metals and hydrocarbon content in the soils and water on traditional food sources for Treaty 8 Tribal Association. Environmental Health Research Group, UNBC and Health Canada
4. Health Canada. 2004. Contaminated Sites Program. Federal Contaminated Site Risk Assessment in Canada. Parts I, II, and III: Guidance On Peer Review of Human Health Risk Assessment For Federal Contaminated Sites in Canada. Ottawa, ON.
5. D'Have, H.; J. Scheirs, V.K. Mubiana, R. Verhagen, R. Blust, and W. De Coen. 2005. Non-destructive pollution exposure assessment in the European hedgehog (*Erinaceus europaeus*): I. Relationships between concentrations of metals and arsenic in hair, spine and soil. Environ. Toxicol. Chem. 24: 2356-2364.
6. Morrissey, C.A.; L.I. Bendell-Young, and J.E. Elliott. 2005. Assessing trace-metal exposure to American dippers in mountain streams of south-western British Columbia, Canada. Environ. Toxicol. Chem. 24**:** 836-845.
7. Rowe, M. 2004. Pine-Moberly moose population census: Estimate of moose population parameters in British Columbia Wildlife Management Unit 7-32. Ministry of Water, Land and Air Protection. Fort St. John. 16 pp.
8. Smithwick, M., D.C.G. Muir, S.A. Mabury, K.R. Slolmon, J.W. Martin, C. Sonne, E.W. Born, R. J. Letcher, and R. Dietz. 2005. Perfluoroalkyl contaminants in liver tissue from East Greenland polar bears (*Ursus maritimus*). Environ. Toxicol. Chem. 24: 981-986.

Table 1. Metal Concentrations in Moose Tissues Showing Significant Differences Between Control and Treatment Areas

Tissue	Metal	Control Area Mean *(µg/g)*	Treatment Area Mean *(µg/g)*	*df*	*F*	*p*
Lung	Cadmium	0.309	0.117	1,17	6.659	0.019
	Potassium	2722	2992	1,17	4.842	0.042
Stomach	Cadmium	0.150	0.076	1,16	8.538	0.010
	Molybdenum	0.024	0.040	1,16	5.292	0.035
	Zirconium	0.022	0.033	1,16	4.585	0.048
Reproductive	Beryllium	0.007	0.009	1,15	7.284	0.016
	Lead	0.110	0.157	1,15	5.251	0.037
	Molybdenum	0.023	0.036	1,15	6.314	0.024
	Selenium	0.120	0.217	1,15	9.659	0.007
	Silver	0.074	0.090	1,15	8.727	0.010
	Vanadium	0.074	0.089	1,15	6.169	0.025
Heart	Potassium	3199	3647	1,17	5.371	0.033
Headtail Fat	Silver	0.077	0.117	1,15	5.136	0.039
Kidney	Barium	0.550	0.354	1,18	6.788	0.018
	Cadmium	41.320	16.013	1,18	16.235	0.001
	Calcium	99.90	114.89	1,18	7.094	0.016
	Molybdenum	0.291	0.422	1,18	33.251	0.000
	Sodium	1557	1833	1,18	5.797	0.027
	Strontium	0.073	0.101	1,18	4.649	0.045
	Zinc	37.16	31.17	1,18	6.803	0.018
Liver	Cadmium	9.315	3.783	1,18	16.426	0.001
	Iron	218.540	323.300	1,18	8.466	0.009
	Mercury	0.005	0.008	1,18	5.061	0.037
	Molybdenum	1.220	1.400	1,18	7.755	0.012

Table 2. Concentrations of Extractable Petroleum Hydrocarbons Showing Significant Differences Between Study Areas

EPH	Control Area Mean *(µg/g)*	Treatment Area Mean *(µg/g)*	*df*	*F*	*p*
C32	2.300	4.222	1,17	4.674	0.045
C33	2.300	4.333	1,17	5.361	0.033
C37	2.600	5.222	1,17	4.946	0.040
C38	2.300	4.333	1,17	5.037	0.038