Exposure of Fish in the Athabasca and Slave Rivers to Metals Potentially Derived from Oilsands Operations

B. Tendler[1], E. Ohiozebau[2], A. Hill[1], G. Codling[2], J.P. Giesy[1,3,4], E. Kelly[5], P. Hodson[6], J. Short[7], P.D. Jones[1,2]

1. Toxicology Centre, University of Saskatchewan, Saskatoon, Canada 2. School of Environment & Sustainability, University of Saskatchewan, Saskatoon, Canada 3. Dept. of Biomedical Veterinary Sciences, University of Saskatchewan, Saskatoon, Canada 4. Dept. of Biology and Chemistry, City University of Hong Kong, Hong Kong, SAR, China 5. Environment and Natural Resources, Government of the Northwest Territories, Canada 6. Department of Biology, Queens University, Kingston ON, Canada 7. DJWS Consulting LLC, Juneau AK, USA

University of Saskatchewan
School of Environment and Sustainability

Introduction

- Much of the current open-pit mining activities in the Alberta oilsand are adjacent to the Athabasca River.
- Contaminants associated with oilsands include metals, polycyclic aromatic hydrocarbons (PAHs), and naphthenic acids, some of which are persistent, toxic, mutagenic and potentially carcinogenic.
- Concerns have been expressed about the potential effects of emissions on the environment and human health by communities in the Athabasca River basin as well as by communities in the downstream Slave and Mackenzie river basins.
- Local communities have also reported an increase in the occurrence of lesions and deformities in fishes which has raised their concerns
- These concerns have been heightened by uncertainties concerning the origin of contaminants, natural or anthropogenic, and magnitudes of exposure.

Objectives

This research was conducted to describe spatial and temporal distributions of metals in tissues of fishes from selected locations along the Athabasca and Slave Rivers.

Methods

Sample Collection:

- Fish were collected in the summer fall and winter of 2011 and the spring of 2012 from 8 sites along the Athabasca Slave and Peace Rivers.
- Target sample size for each site was 30 individuals of each of 5 species (Goldeye - *Hiodon alosoides*, Whitefish - *Coregonus clupeaformis*, Northern Pike - *Esox lucius*, Walleye - *Sander vitreus*, Burbot - *Lota lota*).
- A total of 1498 fish were collected during these samplings.
- Each fish was examined externally and internally.
- Muscle, liver, bile, and blood plasma samples were taken for further analysis of indicators of condition and health.

Goldeye (*Hiodon alosoides*) GE

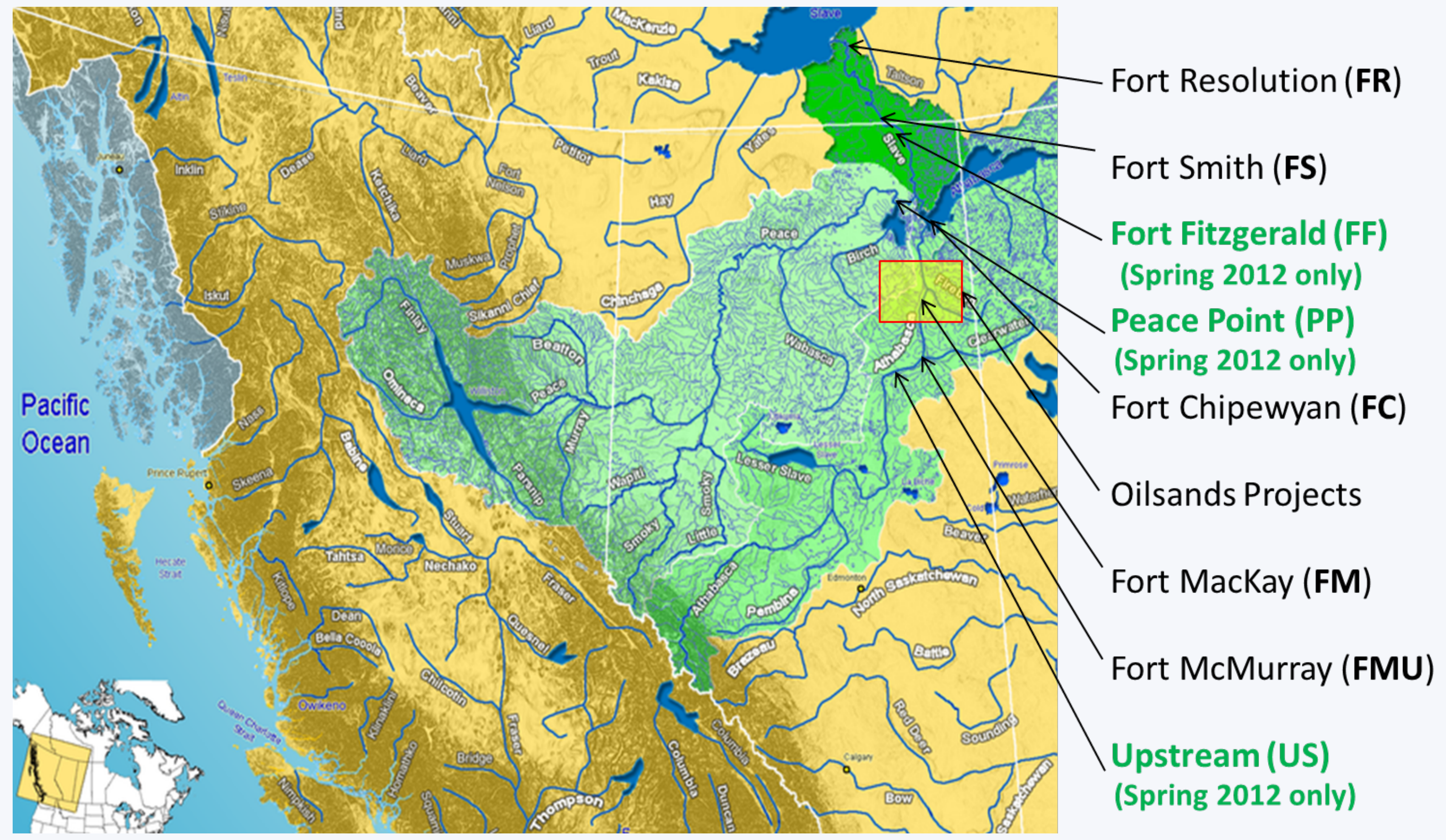
Pike or Jackfish (*Esox lucius*) JF

Walleye or Pickeral (*Sander vitreus*) WE

Whitefish (*Coregonus clupeaformis*) WF

Loche Mariah, Burbot (*Lota lota*) BB

Methods



Quantification of Metals:

- Approximately 0.1 g of dry muscle was added to a 15 mL Teflon vial and digested in concentrated nitric acid (69%) and hydrogen peroxide (30%).
- Digests were evaporated until dry at approximately 70°C.
- 5 mL of 2% nitric acid was added to dried digest which was then filtered (0.45 micrometre pore size) and transferred into 8 mL HDPE vial for storage and analysis.
- Concentrations of 20 metals were measured by ICP-MS.

Results

- Most of the metals analysed showed little or no location associated variability for the summer and fall samplings.
- Thallium(Tl), Vanadium(V), Selenium(Se), and Mercury(Hg) did show location associated variability.
- Se concentrations varied little among sites in summer, but in the fall were greater on the Slave River.
- A steady increase in the concentration of thallium in fish muscle was noted at sites proceeding down the Athabasca/Slave system.
- Thallium also showed a relationship between concentration and trophic level as the higher trophic level JF and WE had greater concentrations.

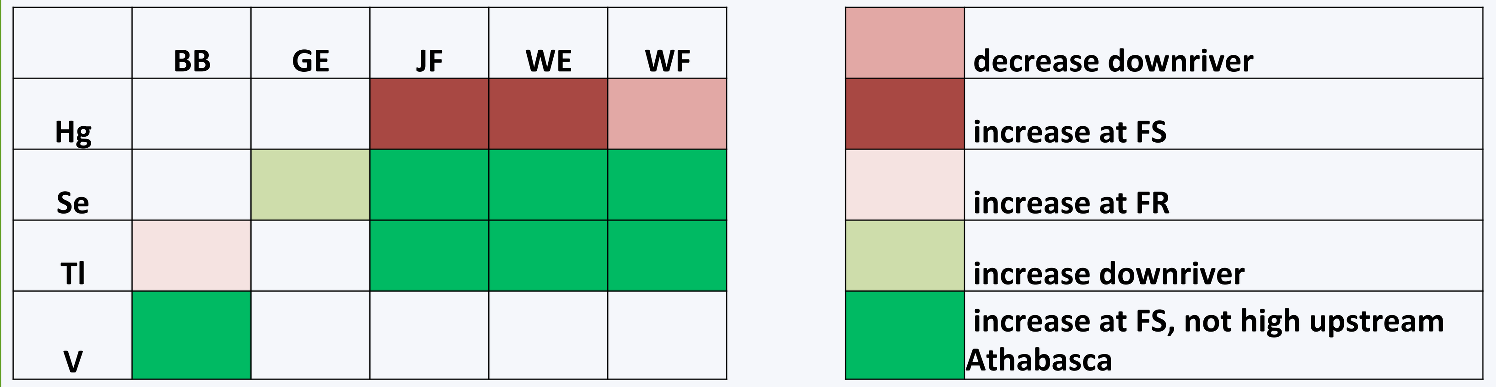


Figure 1. Metal Concentration trends for metals of interest.

Results

- Concentrations of Vanadium (V) were significantly (p<0.05) greater at Fort Resolution and Fort Smith on the Slave River than those in fish from sites on the Athabasca River.
- Concentrations of Selenium (Se) varied little among locations during summer. During the fall, selenium concentrations were greater in Slave River than Athabasca River.
- Concentrations of Mercury (Hg) were greater in JF and WE on the Slave River.

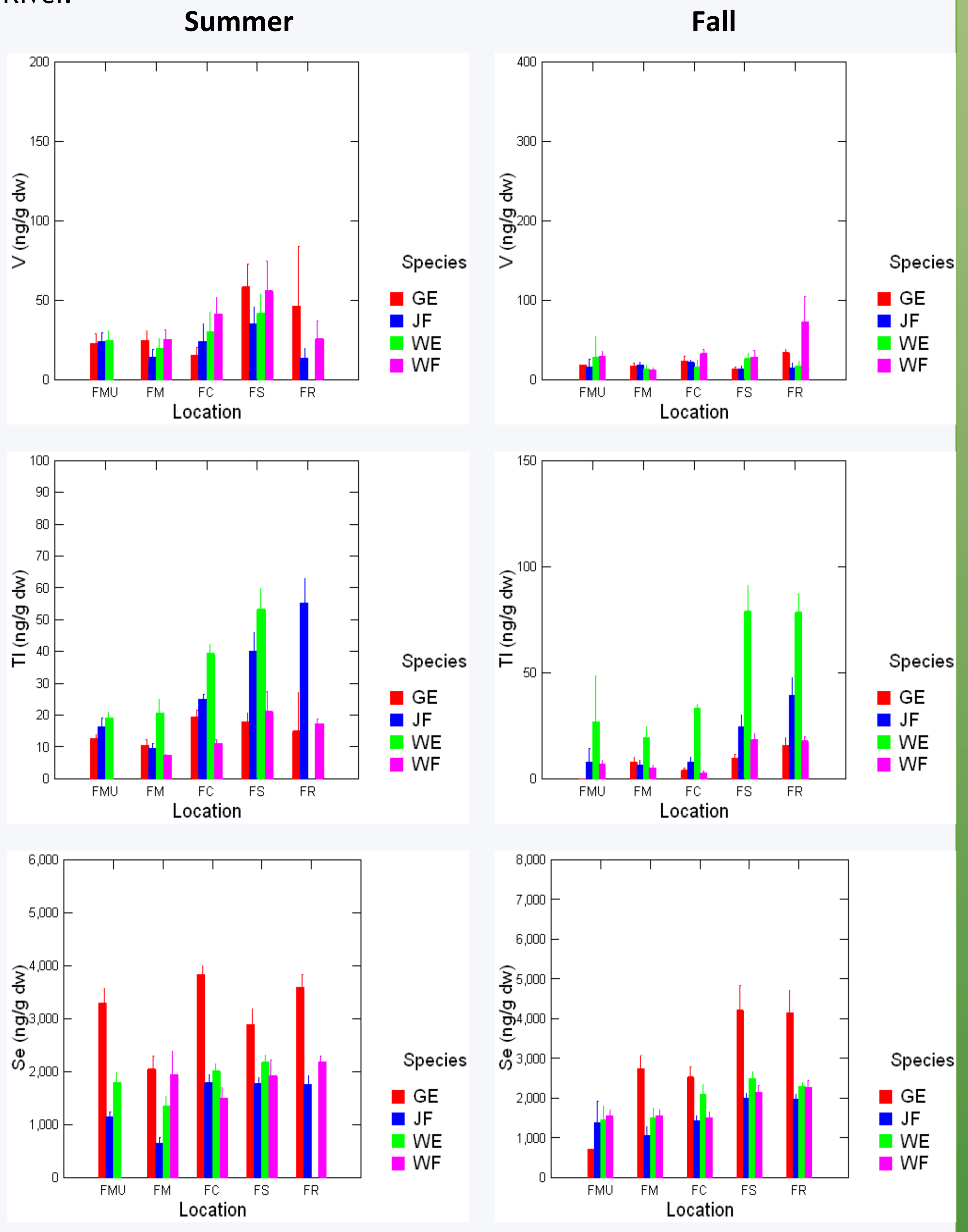


Figure 2. Metal concentrations (V, Tl, Se) for all Species by Season.

Results

Metal	Site	BB Mean ± SE (n) *	p-value	GE Mean ± SE (n)*	p-value	JF Mean ± SE (n)*	p-value	WE Mean ± SE (n)*	p-value	WF Mean ±SE (n)*	p-value
Hg	FMU	540±81 (3)	0.712	1251±252 (11) A	0.678	1416±256 (10) A	0.240	2475±733 (12) A	<0.001	514±134 (10) A	<0.001
	FM	691±162 (2)		1022±95 (20) A		1397±371 (19) A		1309±139 (20) A		179±21 (20) C	
	FC	340±24 (4)		952±102 (19) A		1294±158 (20) A		811±78 (15) B		190±38 (20) C	
	FS	734±114 (8) A		973±125 (20) A		1427±311 (21) X	0.010	1813±264 (20) A		216±32 (18) B	
	FR	839±116 (30) A		1241±188 (12) A		1031±190 (21) A		1399±306 (10) A		353±44 (20) A	
Se	FMU	1848±166 (3)	0.308	3060±340 (11) AB	0.005	1205±106 (13) B	<0.001	1717±146 (13) BC	<0.001	1612±133 (10) BC	<0.001
	FM	1476±121 (2)		2397±205 (20) B		843±118 (19) C		1432±137 (20) C		1546±78 (19) C	
	FC	2282±164 (4)		3262±216 (19) AB		1639±105 (20) A		2041±106 (15) AB		1509±105 (20) C	
	FS	1984±201 (8) A		3549±353 (20) A		1879±80 (21) A		2338±108 (20) A		2069±136 (18) AB	
	FR	1806±71 (30) A		4053±456 (12) A		1869±94 (21) A		2303±94 (10) AB		2233±89 (20) A	
Tl	FMU	8.94±0.42 (3)	0.003	11.51±1.50 (11) A	0.234	14.45±2.36 (13) B	<0.001	20.94±3.61 (13) C	<0.001	6.75±1.51 (10) B	<0.001
	FM	0.05 (2)		9.26±1.28 (20) A		8.02±1.32 (19) B		19.96±3.10 (20) C		6.32±0.70 (20) B	
	FC	8.88±3.38 (4)		12.04±2.13 (19) A		16.84±2.22 (20) B		37.4±2.00 (15) B		6.85±1.26 (20) B	
	FS	8.43±1.36 (8) B		13.70±1.82 (20) A		32.82±4.00 (21) A		66.16±6.97 (20) A		20.30±2.70 (18) A	
	FR	15.99±1.53 (30) A		15.44±2.98 (12) A		47.72±5.41 (21) A		78.54±7.96 (10) A		17.59±1.19 (20) A	
V	FMU	46.6±2.0 (3)	0.031	22.3±5.4 (11) A	0.141	22.3±4.4 (13) A	0.208	25.3±5.8 (13) A	0.265	35.7±8.0 (10) A	0.096
	FM	20.5±2.1 (2)		20.9±3.4 (20) A		16.3±2.8 (19) A		16.8±3.6 (20) A		18.8±3.4 (20) A	
	FC	12.7±3.2 (4)		18.5±3.8 (19) A		23.7±5.1 (20) A		25.5±8.0 (15) A		37.0±5.6 (20) A	
	FS	66.3±16.4 (8) A		35.6±8.7 (20) A		25.0±5.7 (21) A		34.1±6.4 (20) A		40.7±8.4 (18) A	
	FR	28.8±3.6 (30) B		36.0±4.2 (12) A		14.0±4.0 (21) A		17.7±5.7 (10) A		49.2±16.5 (20) A	

Figure 3. Concentrations of metals by species and site. Summary statistics (means, SE = standard error of the mean; n = sample size). Sites sharing a letter (A,B,C), within a metal/species grouping are not significantly different at α = 0.05 (Tukey family-wise error rate for multiple comparisons). Hypothesis tests conducted using ANOVA after data transformation (rank, log base 10, or power). Hg analyses conducted using ANCOVA with log base 10 transformed data (response and covariate) using length or weight as a covariate). X = significant interaction in ANCOVA (p = 0.05). Text in red addresses to subjectively assess trends across species.

Conclusions

- Concentrations of Se were different in summer and fall. The increased concentration in summer could be caused by the influx of contaminants after snow melt.
- Thallium, but not V or Se appear to biomagnify, since fishes of higher trophic levels have equal or higher concentrations than those at lower trophic levels.
- V and Tl have been previously associated with discharges from petroleum based activities, including oil sands activities.
- Greater concentrations of metals along the Slave River are potentially due to upstream activities.
- Increases in V and Tl at the downstream sites pose interesting questions of bioaccumulation and chemodynamics, further research is planned.
- Spring sampling has been completed and metals are being quantified to better understand spatial and temporal distribution of their concentrations.
- Two sites were added downstream of Athabasca Basin for the spring sampling (FF, PP) to better understand metal distribution.

Acknowledgements

This project would not have been possible without the assistance provided by First Nations and Métis communities of Ft Resolution, Ft Smith, Ft Chipewyan, Ft MacKay and Ft McMurray and by numerous Provincial and Federal agencies. Funding was provided by the Boreal Songbird Initiative (BSI), Aboriginal Affairs and Northern Development Canada (AANDC) and the Government of the Northwest Territories, which supported sampling in the NWT. Tim Barrett (UNB) provided assistance with statistical analysis.