Analysis of Arsenic Speciation and Total Mercury Levels in Fish from the Mushkegowuk Territory

Traditional food consumption is one of the main sources of nutrient intake among many First Nation communities. Contaminants, like mercury and arsenic, in traditional foods can sometimes present health risks to First Nations communities.
In 2017, 50 fish (Cisco, Lake Whitefish, Northern Pike) and freshwater mollusca samples were harvested from the Albany River on the west coast of James Bay in Ontario. These fish are consumed as a traditional food in the Mushkegowuk Territory. These fifty samples were analyzed for total mercury (Hg) and twenty different ICP-MS metals (i.e., Be, Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Sr, Mo, Cd, Sb, Ba, Tl, Pb). A subset of 27 fish samples and 2 mollusca composite samples of 5 (with consistent mass while covering the maximum number of mollusca samples possible) were further analyzed for six different organic and inorganic species of arsenic (i.e., arsenate, arsenite, arsenobetaine, arsenocholine, dimethylarsinic acid (DMA) and monomethylarsonic acid (MMA)).

Camelia Tavakoli, Brian Laird, Kelly Skinner, Heidi Swanson
School of Public Health Sciences, University of Waterloo
ctavakol@uwaterloo.ca

Mercury and Arsenic

- Mercury (Hg) and arsenic (As) present in First Nations' traditional foods may result in health risks to the consumers.
- Both natural and anthropogenic activities contribute to Hg and As in the environment and biota
- Fish consumption is the primary source of Hg intake in the average Canadian population
- Methylmercury is generally the predominant form of Hg in wild-harvested fish
- Inorganic forms of As are highly toxic and carcinogenic compared to some organic forms (e.g., Arsenobetaine, Arsenocholine)
- Arsenobetaine is often the predominant form of As in fish, but relatively little information on As speciation is available for freshwater fish

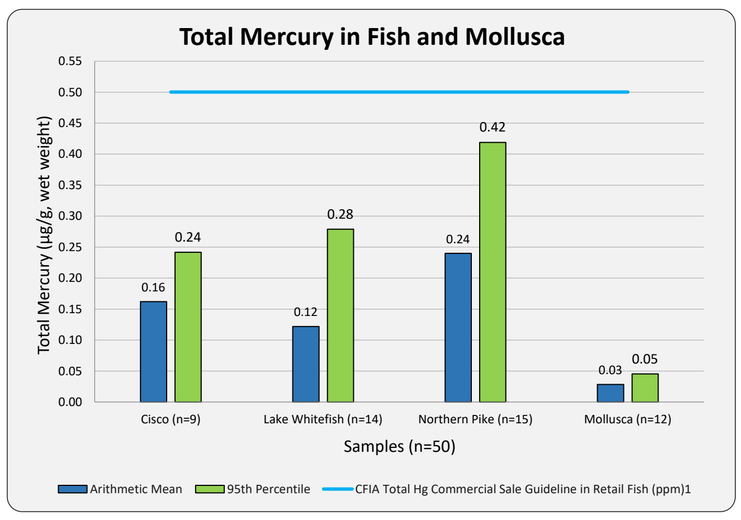

Figure 1. Arithmetic Mean and 95th Percentile Total Mercury Concentration per Sample

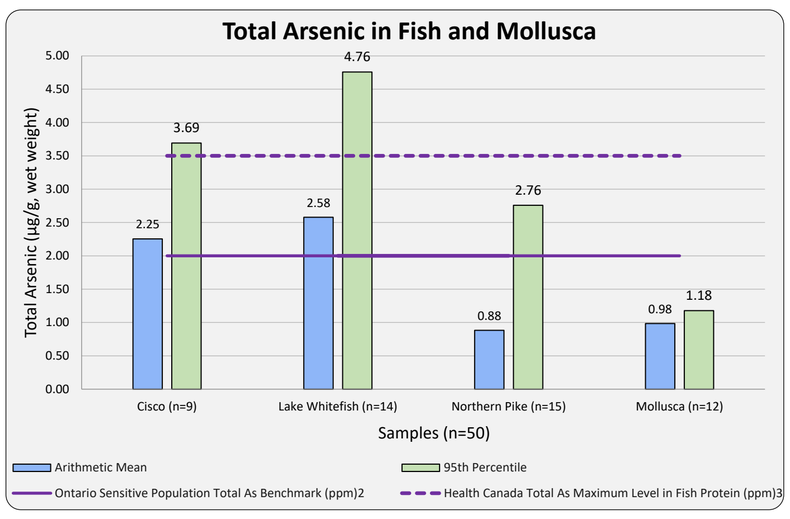

Figure 2. Arithmetic Mean and 95th Percentile Total Arsenic Concentration per Sample

Total Mercury and Total Arsenic Concentrations

- Total Hg concentrations in all fish and mollusca samples are below the Canadian Food Inspection Agency (CFIA) Commercial Sale Guideline of 0.50 ppm for retail fish. The mean total Hg concentration is the highest in Northern Pike followed by Cisco, Lake Whitefish and mollusca
- Approximately 44% of Cisco, 64% of Lake Whitefish and 7% of Northern Pike samples are above Ontario's sensitive population total As benchmark of 2.0 ppm. Additionally, 11% of Cisco and 29% of Lake Whitefish samples were above Health Canada's total As maximum level of 3.50 ppm in fish protein
- The observed levels of total As and total Hg are below the usual range reported in Canada.
- The observed levels of total Hg appeared similar, if not lower, than the usual ranges reported from inland lakes in Canada[4,5,6]
- The observed levels of total As appeared mostly higher than the usual ranges reported from inland lakes in Canada[7,8,9]

Arsenic Speciation

- Arsenobetaine, generally regarded as non-toxic, makes up 74% to 99% of total As levels
- Inorganic As (arsenate and arsenite) contributed to no more than 7% of total As levels. Also, MMA+DMA contributed to 0.2% to 22% of total As levels
- Arsenocholine is not detected in any of the Northern Pike samples but is detected in 71% of Cisco and 50% of Lake Whitefish samples
- DMA is only detected in 29% of Cisco and 50% of Lake Whitefish samples
- Since less than 50% of samples within each species of fish and mollusca had arsenate, arsenite and MMA above the limit of detection (LOD), their arithmetic means are not reported in table 1

	Cisco	Lake Whitefish	Northern Pike	Mollusca
Sample size	7	12	8	2
Arsenobetaine				
% > LOD	100	100	100	100
Mean	1.9394	2.0671	0.8852	0.0939
Arsenocholine				
% > LOD	71	50	0	100
Mean	0.0056	0.0042	< LOD	0.0058
Dimethylarsinic acid				
% > LOD	29	50	100	0
Mean	< LOD	0.0144	0.0170	< LOD

Table 1. Arsenobetaine, Arsenocholine, and Dimethylarsinic Acid Arithmetic Mean Concentration (µg/g, wet weight)

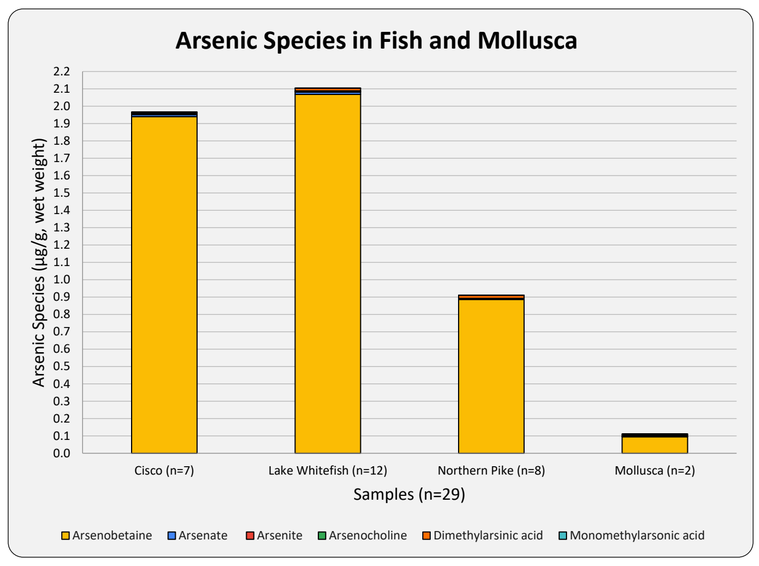

Figure 3. Mean Arsenic Species Concentration per Sample

Next Steps...

- Further analysis of organic and inorganic As content among species of fish and mollusca
- Perform statistical analysis adjusting for fish size
- Quantify ICP-MS metals in the fish and mollusca samples
- Analyze contaminant (total Hg and species of As) to nutrient ratio among species
- Create a probabilistic model to estimate nutrient intake and contaminant exposure using Ecozone-specific FNFNES dietary data
- Communicate findings to regional and community partners in the Mushkegowuk Territory

References

1. 1. Canadian Food Inspection Agency (CFIA), 2018. Appendix 3 - Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products. Retrieved November 15, 2022, from https://inspection.canada.ca/food-safety-for-industry/archived-food-guidance/fish-and-seafood/manuals/standards-and-methods/eng/1348608971859/1348609209602?chap=7#s20c7
2. Gandhi, N., Drouillard, K. G., Arhonditsis, G. B., Gewurtz, S. B., & Bhavsar, S. P. (2017). Are fish consumption advisories for the Great Lakes adequately protective against chemical mixtures?. Environmental health perspectives, 125(4), 586-593.
3. Health Canada, 2020. List of contaminants and other adulterating substances in foods - Canada.ca. Government of Canada. Retrieved November 15, 2022, from https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/contaminants-adulterating-substances-foods.html
4. Lescord, Johnston, T. A., Branfireun, B. A., & Gunn, J. M. (2+A1018). Percentage of methylmercury in the muscle tissue of freshwater fish varies with body size and age and among species: Percentage of MeHg in fish. Environmental Toxicology and Chemistry, 37(10), 2682–2691. https://doi.org/10.1002/etc.4233
5. DEPEW, BURGESS, N. M., JACOBS, K., LEBLANC, J. E., ST. LOUIS, V. L., CAMPBELL, L. M., ROBIN ANDERSON, M., BAKER, R., BHAVSAR, S. P., BODALY, R. A., ECKLEY, C. S., EVANS, M. S., GANTNER, N., & GRAYDON, J. A. (2013). An overview of mercury concentrations in freshwater fish species: a national fish mercury dataset for Canada. Canadian Journal of Fisheries and Aquatic Sciences, 70(3), 436–451. https://doi.org/10.1139/cjfas-2012-0338
6. ockhart, Stern, G. A., Low, G., Hendzel, M., Boila, G., Roach, P., Evans, M. S., Billeck, B. N., DeLaronde, J., Friesen, S., Kidd, K., Atkins, S., Muir, D. C. G., Stoddart, M., Stephens, G., Stephenson, S., Harbicht, S., Snowshoe, N., Grey, B., … DeGraff, N. (2005). A history of total mercury in edible muscle of fish from lakes in northern Canada. The Science of the Total Environment, 351, 427–463. https://doi.org/10.1016/j.scitotenv.2004.11.027
7. de Rosemond, Xie, Q., & Liber, K. (2008). Arsenic concentration and speciation in five freshwater fish species from Back Bay near Yellowknife, NT, CANADA. Environmental Monitoring and Assessment, 147(1-3), 199–210. https://doi.org/10.1007/s10661-007-0112-6
8. de Rosemond, Xie, Q., & Liber, K. (2008). Arsenic concentration and speciation in five freshwater fish species from Back Bay near Yellowknife, NT, CANADA. Environmental Monitoring and Assessment, 147(1-3), 199–210. https://doi.org/10.1007/s10661-007-0112-6
9. Che´telat J, Cott PA, Rosabal M, Houben A, McClelland C, Belle Rose E, et al. (2019) Arsenic bioaccumulation in subarctic fishes of a mineimpacted bay on Great Slave Lake, Northwest Territories, Canada. PLoS ONE 14(8): e0221361. https://doi.org/10.1371/journal.pone.0221361