Temporal trend studies of mercury in Mackenzie River burbot (*Lota lota*), Fort Good Hope, NT

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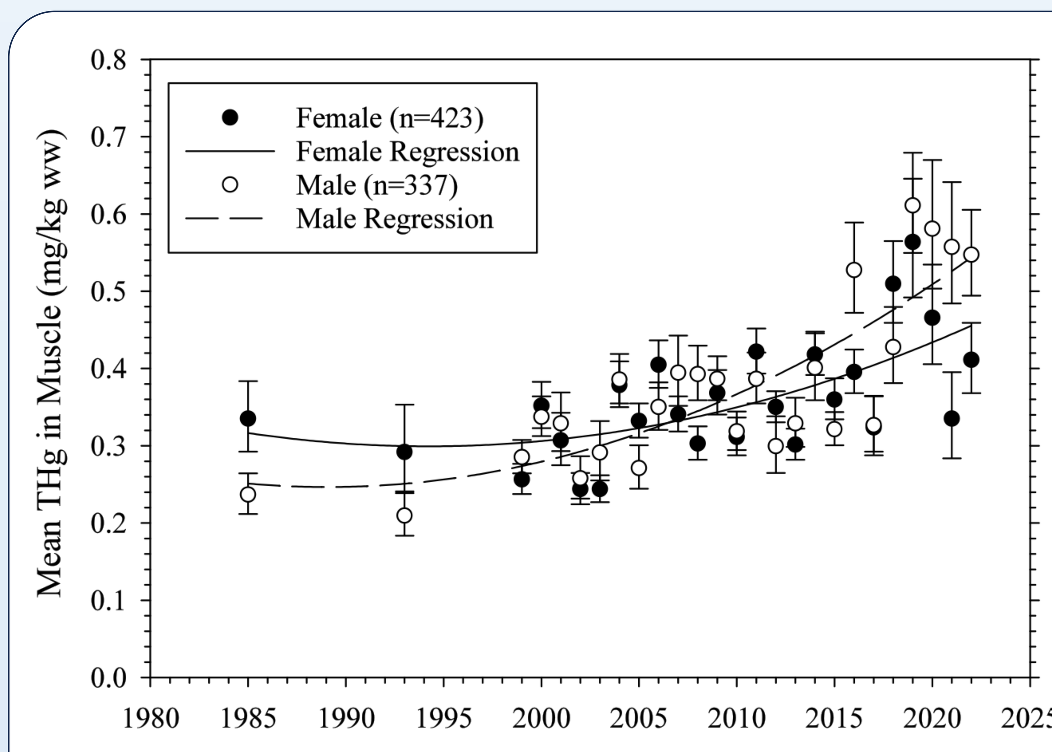
Introduction

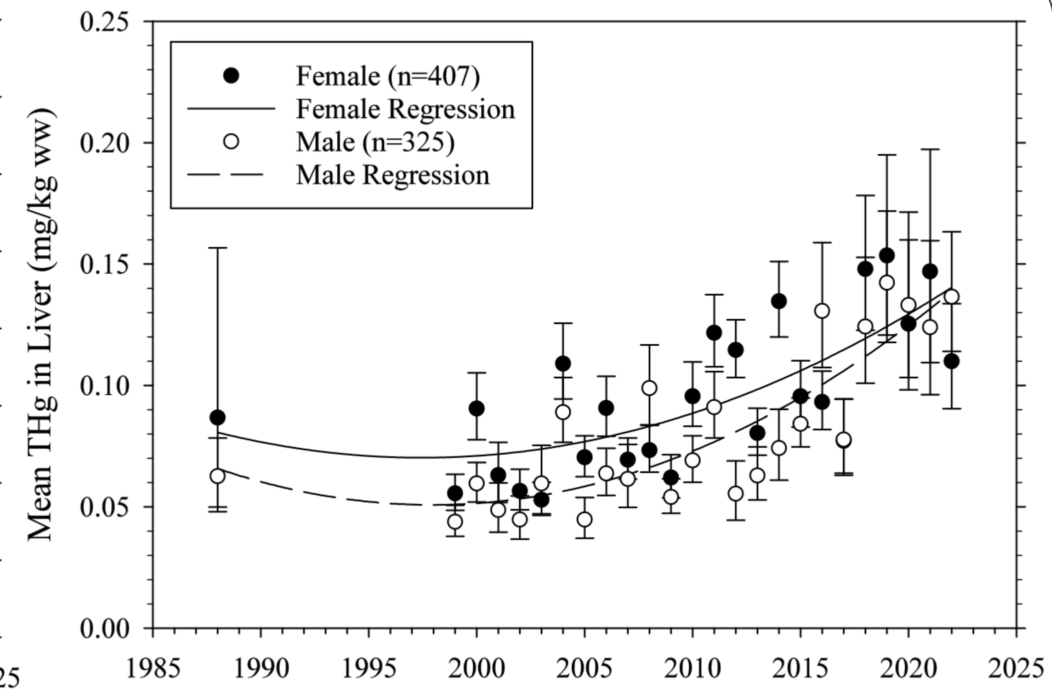
- As part of a long-term community-based monitoring project, this study is primarily focused on the concentrations and trends of mercury (Hg) in burbot (*Lota lota*) harvested from the Mackenzie River by residents of Fort Good Hope, NT.
- Contaminants such as Hg can biomagnify across trophic levels and bioaccumulate in country foods, including burbot, which is typically consumed seasonally by community members. The purpose of this study is both to establish a baseline dataset as well as to inform the community of Fort Good Hope and regional health authorities about consumption safety and guidelines.
- Impacts of warming in the Mackenzie River drainage basin over previous decades include warmer ambient temperatures affecting surface water temperatures and flow, changes in precipitation with increased rain and evapotranspiration, the thawing of permafrost with increasing microbial activity, and releases of nutrients and Hg to surface waters.

Methods

- A total of 855 burbot were harvested between 1985 and 2022, typically collected annually and during the winter. Collections are organized by the Fort Good Hope Renewable Resources Council and burbot are shipped whole and frozen to the University of Manitoba for processing.
- Burbot are measured for morphometrics, aged via otolith, and analyzed for total Hg (THg) in dorsal muscle and liver. A subset was also analyzed for bulk stable isotopes ($\delta^{13}C$ and $\delta^{15}N$). The study is an extension of the monitoring program described by Carrie et al. (2012) that correlated increasing Hg with increasing algal carbon.
- Two metrics of fish health were used to evaluate the condition of harvested burbot. Body condition was estimated using Fulton's K = $100*W/L^3$, where W is the whole body, or round weight, (g) of the burbot and L is the fork length (mm). Liver Index (LI) was calculated as 100*L/W, where L is liver weight (g) and W is the round weight (g).

Results





Figures 1 (left) and 2 (right). Temporal trends of THg in burbot muscle (1) and liver (2) between 1985 and 2022. The THg concentration in muscle and liver are highly correlated. The data are fitted with a second-degree regression line, and the increase is greater in males than in females.

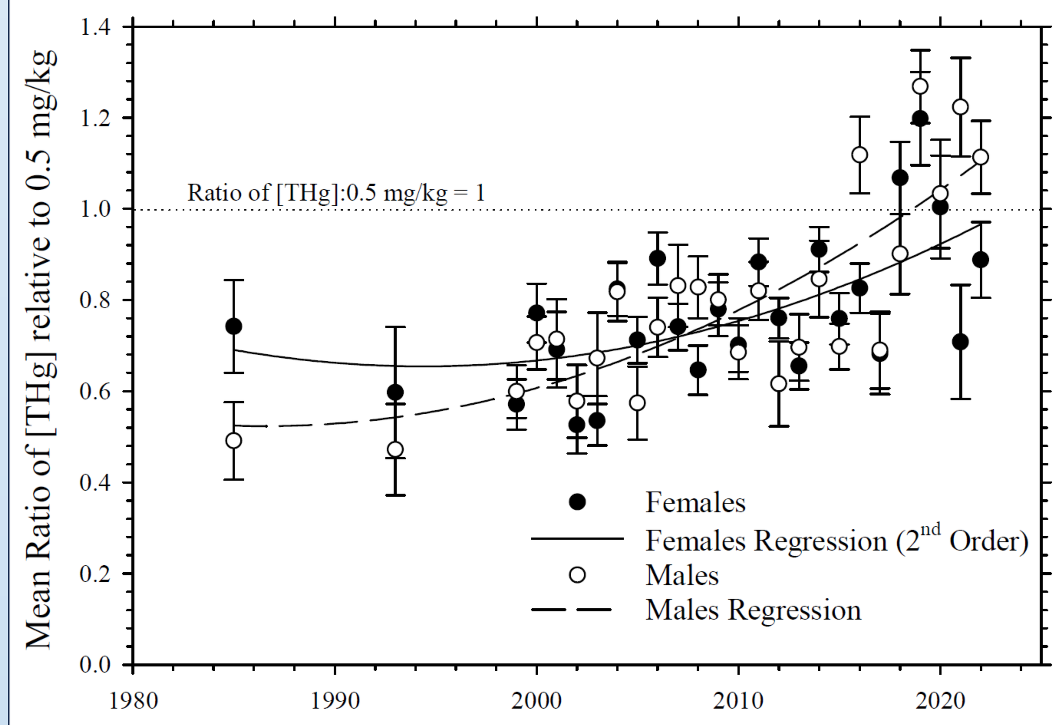


Figure 3. Proportion of the sample population relative to the Health Canada guideline for Hg (0.5 mg/kg ww). The two sexes are compared equally, although males started lower in the earlier years.

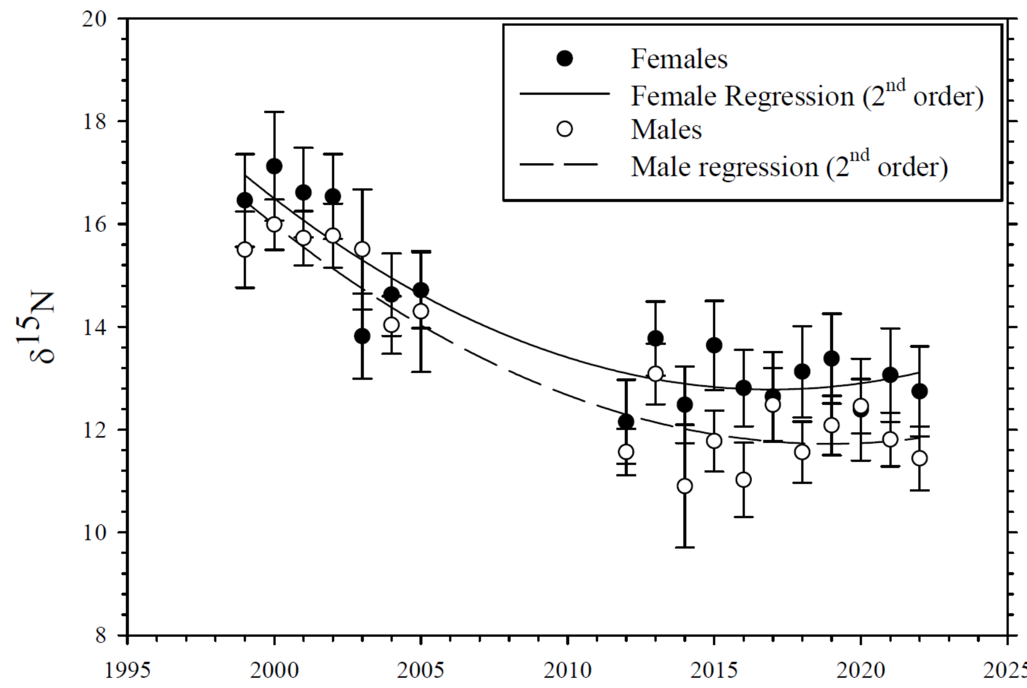
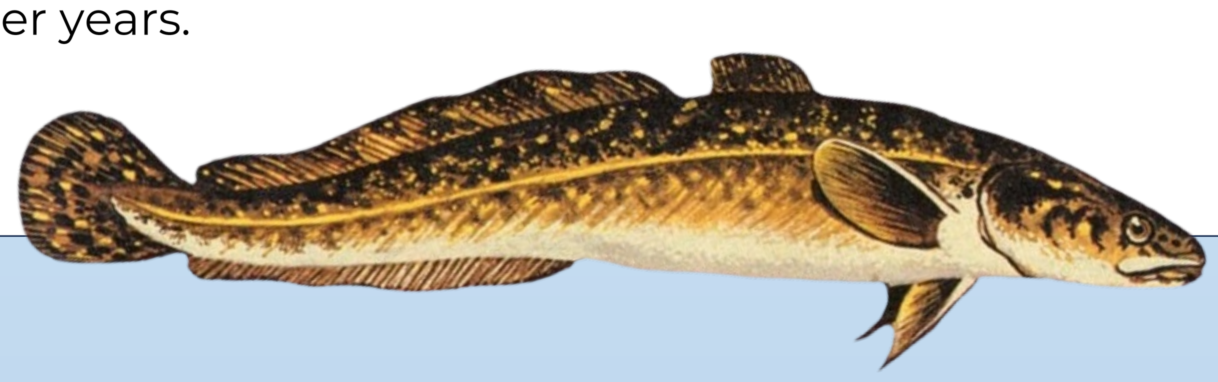


Figure 4. Trends in $\delta^{15}N$ in burbot from 1995 to 2022. Data are corrected for age. Both male and female burbot declined in $\delta^{15}N$ over the period.



Conclusions

- Body condition of males and females remained constant from 1985 to 2022, suggesting that environmental conditions and availability of food items remained favorable for the population. However, the liver index indicated that the size of the liver relative to the total body weight declined since 2000. Liver is the primary site of lipid storage in burbot and the decline in size may be related to early signs of changes in the diet or the adverse health effects of increasing Hg levels in the population.
- The mean concentration of Hg in burbot muscle rose from 0.35 mg/kg ww to over 0.5 mg/kg ww between 1985 and 2022. Hg concentration in muscle varied significantly ($p<0.05$) with age, harvest year, and sex. Hg concentration increased to a greater extent in males, doubling in grouped data between 1985-1990 and 2020-2022, while the ages of harvested burbot remained constant. Over the same period (1985 – 2022), the proportion of the burbot population exceeding Health Canada guidelines for Hg (0.5 mg/kg ww) increased from 0% to approximately 50%. If the trend continues, most of the harvested burbot will exceed 0.5 mg/kg ww within a few years.
- The decline in $\delta^{15}N$ in both male and female burbot between 1985 and 2022 indicates that the burbot are feeding at a lower trophic level or that the riverine aquatic community has changed significantly during that time. Dietary data are not available for the burbot population in this region of the Mackenzie River but the declining $\delta^{15}N$ may indicate a change in major food sources (e.g., consuming more lower trophic levels species such as whitefish) in recent decades.
- Preliminary conclusions of the study are that the increases in Hg concentration in burbot reflect changes in Mackenzie River water chemistry and, possibly, the aquatic community. These changes are the result of variations in the terrestrial and freshwater environment from a warming climate. Hg has been shown to be released with nutrients and dissolved organic matter from thawing permafrost and thaw slumps, discharging ground water, increased precipitation in the form of rain, and increasing surface flow (Bring et al., 2016; DeBeer et al., 2015; DeBeer et al., 2021; Vonk et al., 2015).

References

- Bring, A., Fedorova, I., Dibike, Y., Hinzman, L., Mård, J., Mernild, S. H., Prowse, T., Semenova, O., Stuefer, S. L., & Woo, M.-K. (2016). Arctic terrestrial hydrology: A synthesis of processes, regional effects, and research challenges. Journal of Geophysical Research: Biogeosciences, 121(3), 621–649. https://doi.org/10.1002/2015JG003131
- Carrie, J., Stern, G. A., Sanei, H., Macdonald, R. W., & Wang, F. (2012). Determination of mercury biogeochemical fluxes in the remote Mackenzie River Basin, northwest Canada, using speciation of sulfur and organic carbon. *Applied Geochemistry*, *27*(4), 815–824. https://doi.org/10.1016/j.apgeochem.2012.01.018
- DeBeer, C. M., Wheater, H. S., Quinton, W. L., Carey, S. K., Stewart, R. E., MacKay, M. D., & Marsh, P. (2015). The Changing Cold Regions Network: Observation, diagnosis and prediction of environmental change in the Saskatchewan and Mackenzie River Basins, Canada. Science China Earth Sciences, 58(1), 46–60. https://doi.org/10.1007/s11430-014-5001-6
- DeBeer, C. M., Wheater, H. S., Pomeroy, J. W., Barr, A. G., Baltzer, J. L., Johnstone, J. F., Turetsky, M. R., Stewart, R. E., Hayashi, M., Van Der Kamp, G., Marshall, S., Campbell, E., Marsh, P., Carey, S. K., Quinton, W. L., Li, Y., Razavi, S., Berg, A., McDonnell, J. J., … Pietroniro, A. (2021). Summary and synthesis of Changing Cold Regions Network (CCRN) research in the interior of western Canada – Part 2: Future change in cryosphere, vegetation, and hydrology. Hydrology and Earth System Sciences, 25(4), 1849–1882. https://doi.org/10.5194/hess-25-1849-2021
- Vonk, J. E., Tank, S. E., Bowden, W. B., Laurion, I., Vincent, W. F., Alekseychik, P., Amyot, M., Billet, M. F., Canário, J., Cory, R. M., Deshpande, B. N., Helbig, M., Jammet, M., Karlsson, J., Larouche, J., MacMillan, G., Rautio, M., Walter Anthony, K. M., & Wickland, K. P. (2015). Reviews and syntheses: Effects of permafrost thaw on Arctic aquatic ecosystems. Biogeosciences, 12(23), 7129–7167. https://doi.org/10.5194/bg-12-7129-2015
- Burbot illustration: NOAA, Great Lakes Environmental Research