Use of Hg Stable Isotopes to Track Environmental Methylmercury Sources of Estuarine Fish

Miling Li[1], Amina Schartup[1], Amelia Valberg[1], David Krabbenhoft[2], Marina Biasutti-Brown[3], Elsie Sunderland[1,4]

[1]Harvard T.H. Chan School of Public Health, Boston, MA, United States [2]U.S. Geological Survey, Middleton, WI, United States [3]Nunatsiavut Government, Goose Bay, Labrador, Canada [4] School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, United States.

Background

- Estuarine fish obtain methylmercury (MeHg) from **diverse environmental sources** including
  - rivers/watershed inputs
  - atmospheric deposition
  - water column methylation
  - benthic sediment production
- Hg stable isotope signatures can be a powerful tool to **trace processes and sources of Hg** in the environment:
  - Large mass-independent fractionation (MIF) of the odd-mass-number isotopes of Hg (^{199}Hg, ^{201}Hg) occurs primarily during **photochemical reactions**
  - Positive Δ^{199}Hg in MeHg/Hg II in remaining water and aquatic organism
  - No MIF observed along food chain (Δ^{199}Hg constant over trophic transfer)
  - Mass-dependent fractionation (MDF) but no MIF occur during **microbial methylation and demethylation/reduction**.
  - No MDF observed along food chain up to fish (δ^{202} Hg does not change)
- **Objectives: This study uses mercury (Hg) stable isotopes to help refine our understanding of environmental sources of MeHg uptake in estuarine fish.**

Hypothesis

Various estuarine fish species receiving their MeHg exposures from multiple environmental sources are reflected by their stable Hg isotope signatures (Fig.1)

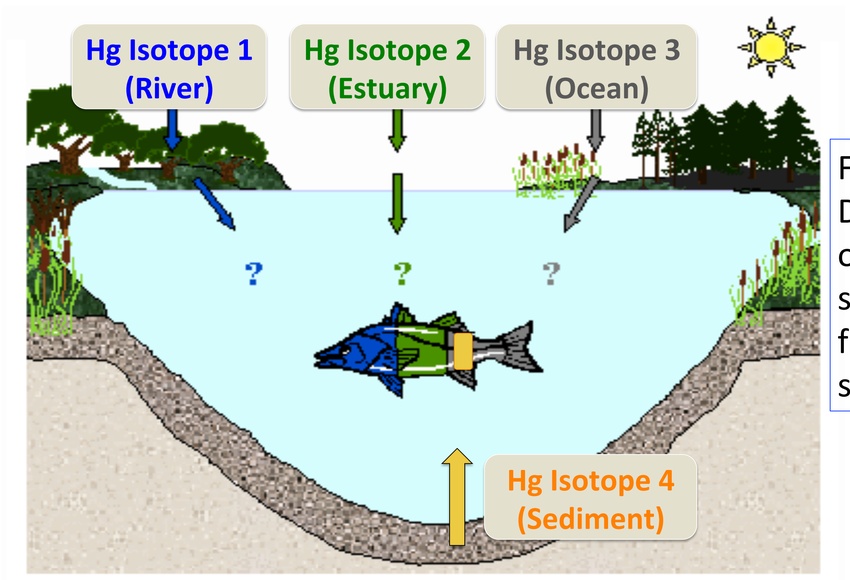

Figure 1. Demonstration of fish isotope signatures from multiple sources.

Modified Image from http://www.biology.ualberta.ca/metaalicus/

Methods

We compared Hg stable isotopic compositions among different fish species caught in three locations (red circles) from an estuarine fjord (Lake Melville) in Labrador, Canada.

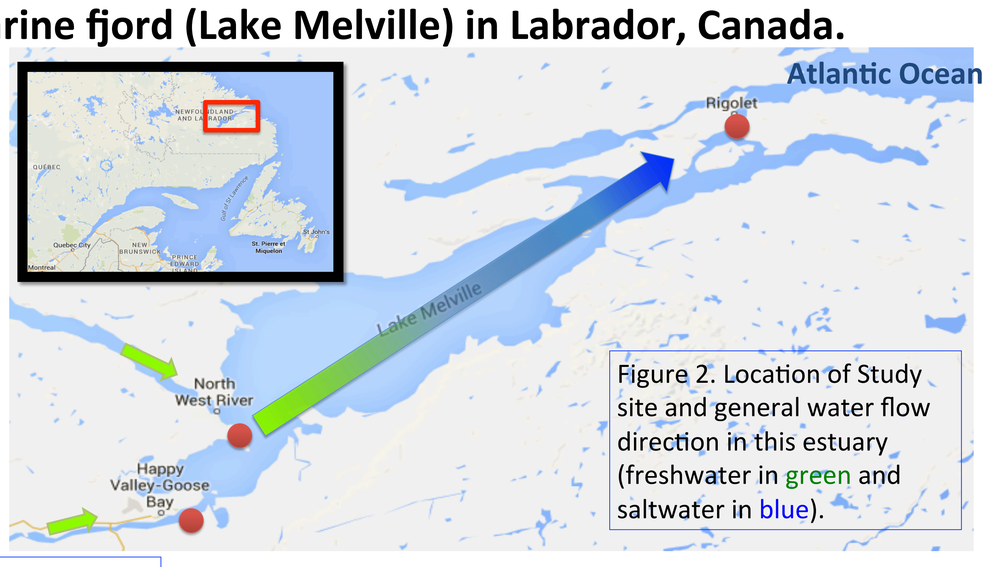

Figure 2. Location of Study site and general water flow direction in this estuary (freshwater in green and saltwater in blue).

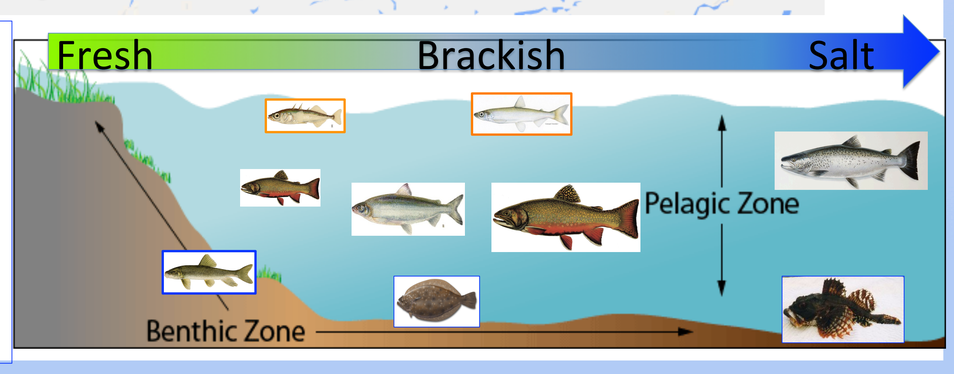

Figure 3. Major habitats of sampled fish species (pelagic and benthic species in orange and blue border, respectively, with rest of species are bethopelagic. All fish were caught at ≤ 6ft.

Results

We observed wide ranges of Δ^{199} Hg values (0.6~3.4‰) and relatively narrow ranges of δ^{202} Hg values (-0.8~0.8‰) in the estuarine fish.

- Fish species living in surface water have higher Δ^{199} Hg values than those of benthic species (Fig.4)
- Large variability of Hg isotope ratios in some benthic species (sucker and flatfish), indicating strong pelagic-benthic coupling in shallow water column.

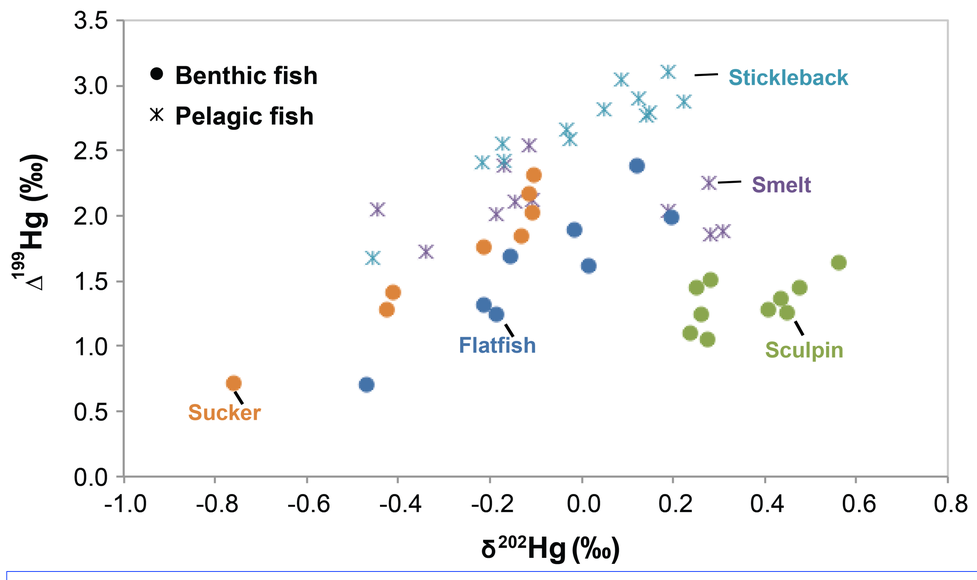

Figure 4. Hg isotope signatures of benthic and pelagic fish from Lake Melville

- δ^{202} Hg values gradually increase from species spending most of their lifetime in freshwater to those with foraging habitat in the open ocean (Fig.5). These data suggest both microbial demethylation/reduction and photodegradation of MeHg occur in the estuary prior to incorporation of MeHg into food web.

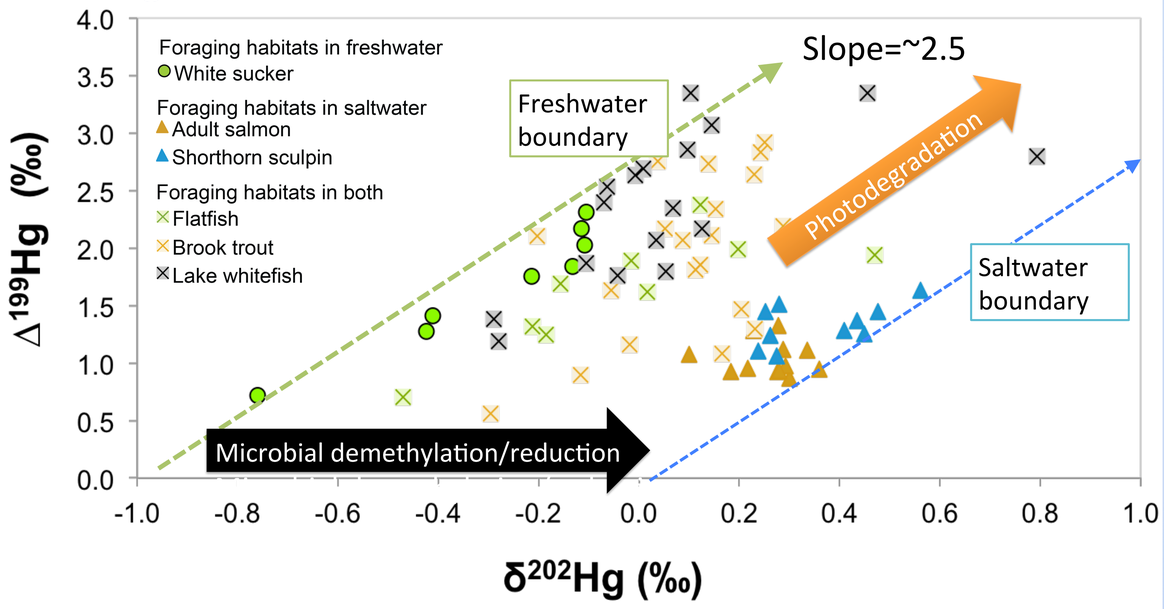

Figure 5. Hg isotope signatures of fish with various foraging habitats.

- Observed large variations in the isotopic composition in some fish species (e.g. flatfish) can be explained by their food and habitat preferences in different life stages (Fig.6).

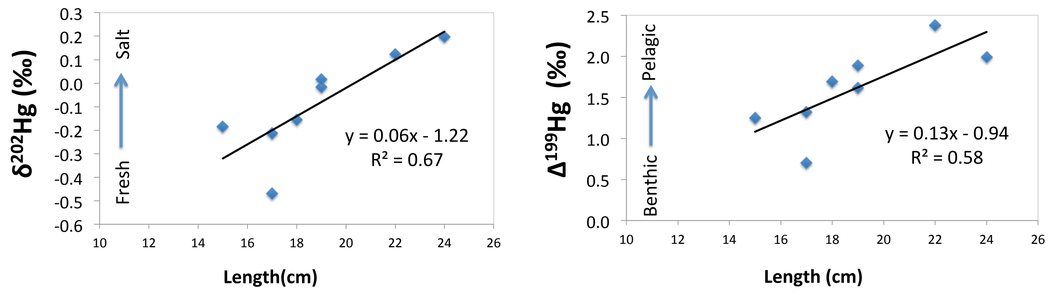

Figure 6. Hg isotope signatures of flatfish in different sizes.

Coming up …

- More fish Hg isotope data, seals and human hair…
- C,N data to elucidate predation-prey relationship which helps to identify the dominant Hg sources for each species
- Sediment Hg isotope analysis: explore whether variability of sediment can possibly explain large variation in Δ^{199}Hg of benthic species

Acknowledgements: This work was funded Nunatsiavut Government, Canada. We are grateful to Runsheng Yin (University of Wisconsin, Madison) for the technical assistance with Hg isotope analysis. We are also thankful to Inuit anglers who caught and provided fish samples for our study.

Contact information: Miling Li milingli@mail.harvard.edu
4th floor West, Landmark Center. 401 Park Drive, Boston, MA 02215, U.S.