Fish Otoliths as Bioindicators of Arsenic Exposure in Pacific Northwest Lakes

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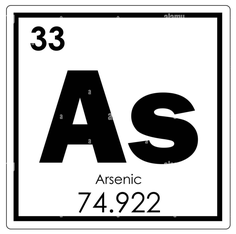
Background



- A copper smelter owned by ASARCO ran for 100 years in Ruston, WA within the southern part of the Puget sound. Effects of metal emissions from the plant are still found.
- Long-term exposure to arsenic (As) found in the sediment of surrounding Pierce County lakes poses a threat to human health as As is a known class 1 humancarcinogen. (Martinez et al. 2011)

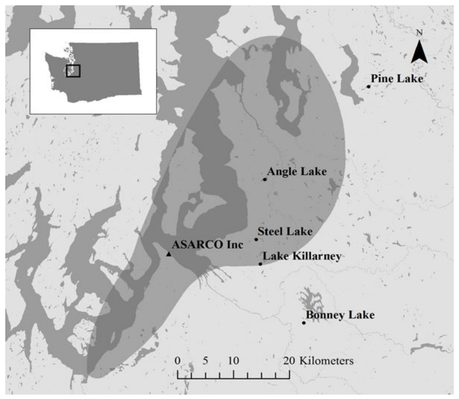
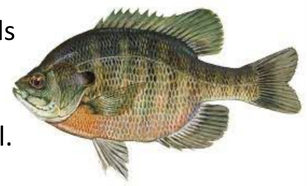


Figure 1: The map shows Steel Lake and Lake Killarney relative to the ASARCO. (Food for thought: Urban lakes contaminated with arsenic pose consumption risk | Urban@UW)

- Lake Killarney and Steel Lake are both shallow and have high levels of As, over 200 µg g in the sediment therefore so do fish species found in them. (Hull et al. 2019)
- These two fish species are abundant in freshwater systems around the Pacific Northwest and seen as sentinel species to track pollutants across aquatic ecosystems. Fish otoliths have been used as a pollutant monitor in previous studies. (Mounicou et al. 2019)
- Arsenic poses a toxic threat to human health whenever humans are exposed to the containment in drinking water or consumable food. This poses a threat to local fisherman who catch for subsistence.



Pumpkin Seed

Bluegill

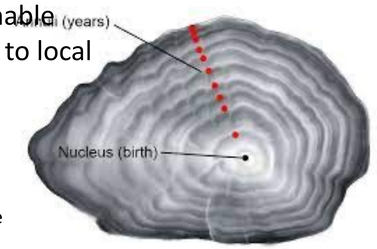


Figure 2: The red dots on the otolith represent the age of the fish.

Methods

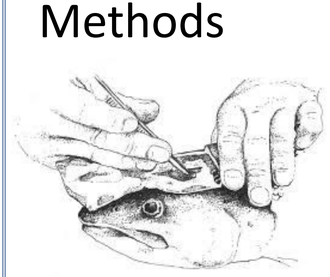


Figure 3: Dissection of Otoliths from fish.

Otolith Removal

- Place fish down on counter and hold the head steady.
- Using a sharp knife slice 1 cm behind eye socket at a 30 degree angle.
- Remove otoliths from within their respective cavities with forceps. (Government of Canada 2018 Dec 5)

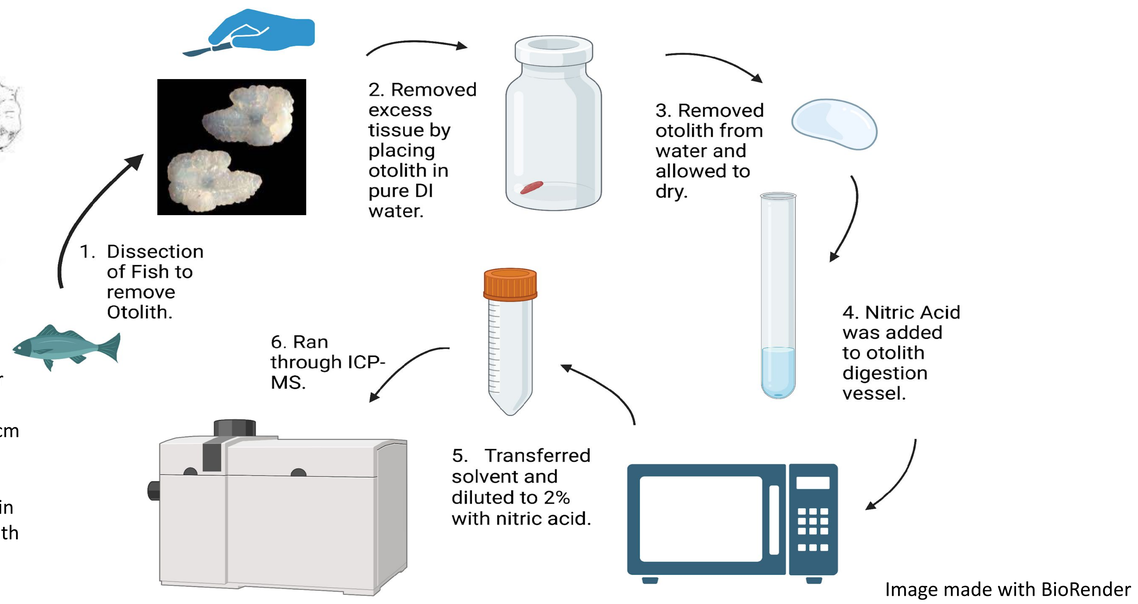


Image made with BioRender

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Mounicou S, Frelon S, Le Guernic A, Eb-Levadoux Y, Camilleri V, Février L, Pierrisnard S, Carasco L, Gilbin R, Mahé K, et al. 2019. Use of fish otoliths as a temporal biomarker of field uranium exposure. The Science of the Total Environment. 690:511–521. doi:https://doi.org/10.1016/j.scitotenv.2019.06.534. [accessed 2023 Jun 6]. https://pubmed.ncbi.nlm.nih.gov/31301492/.

Results

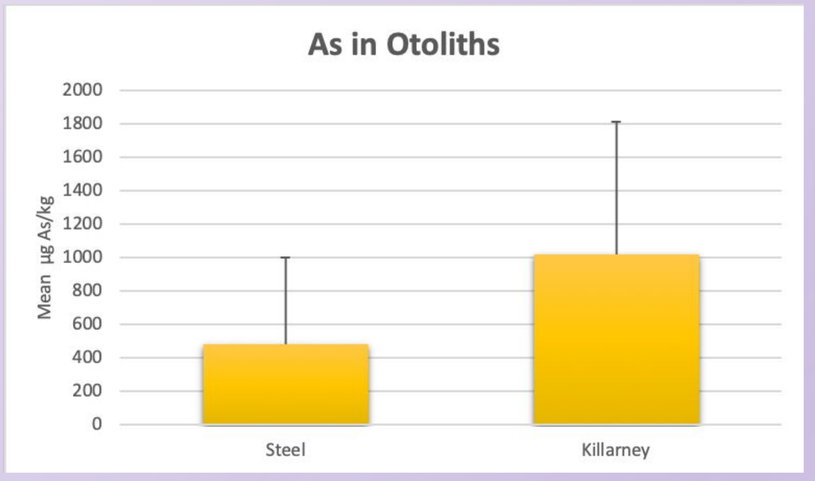

Figure 4: Of 39 fish samples analyzed between Lake Killarney and Steel Lake, Killarney had a higher amount of As found in the otoliths than Steel Lake. Lake Killarney has a mean concentration of 1,022 ug As/kg (n= 19 fish) whereas Steel lake had 478 ug As/kg (n=20 fish).

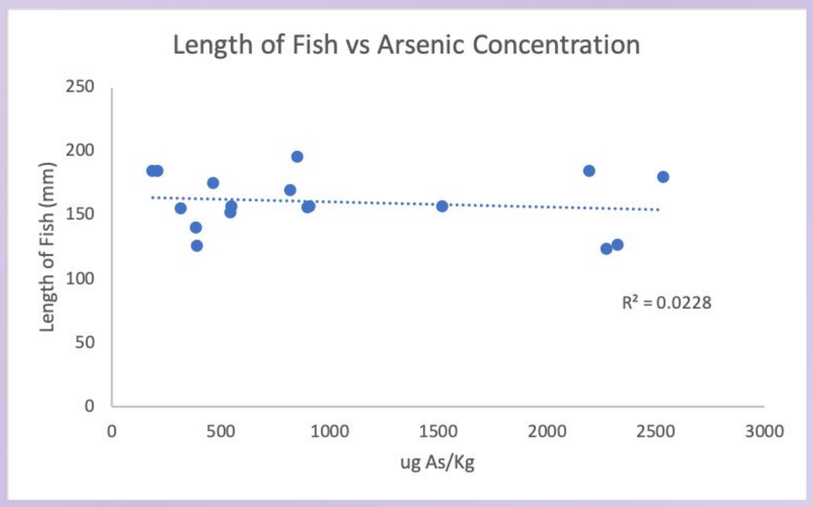

Figure 5: Slight negative correlation between the length of the fish (a surrogate for age) and the arsenic concentration found within the samples taken from Lake Killarney only.

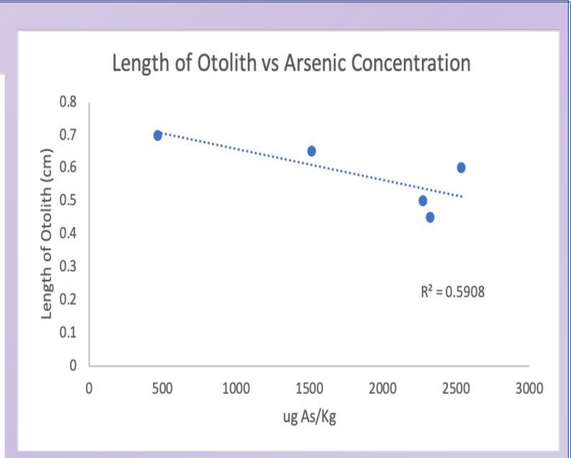

Figure 6: A slight negative correlation was found between the length of the otoliths and As concentrations when looking at the samples in Lake KIllarney. Only five otoliths were unbroken, these fish samples had been used in previous studies without keeping the otolith in tact in mind. . In order to compare the otolith for age the otolith needed to be whole otolith, unbroken.

- Fish were euthanized for a different study, and that method damaged many otoliths. Therefore the number of whole otoliths that could be aged was small. We estimated fish age for Lake Killarney samples by length in cm. (Determining the Age of Fish (E1774))
- Difference between lakes for As concentrations found in fish muscle tissue in a previous study are consistent with our results in otoliths (Hull et al. 2019).
- Although sample size is small, we see a negative correlation between length of fish and otoliths in relation to As concentrations. The larger the fish the less As found in otoliths.
- Shallow lakes have higher levels of As concentrations than deep lakes, therefor we expected fish within these lakes to have higher As concentrations as well. Our findings supported the hypothesis.

Conclusion

- Although there is not a strong correlation between length of fish/otolith and As concentrations we do find that younger/smaller fish have a higher concentration of As in Lake Killarney than older/larger fish.
- One reason for this could be diet. Smaller younger fish eat down the food chain where arsenic concentrations are higher whereas larger fish eat further up the food chain were concentrations are lower (Hull et al. 2021). Smaller fish eat plankton where larger fish eat snails and other organisms.

Future Direction

- In previous studies looking at fish muscle tissue no visible trend was found between age and As concentration (Hull et al. 2019). We expect that muscle tissue concentrations change over the season as prey species change and As is mobilized. On the other hand, metals in otoliths integrate metal exposure over the year. Therefore using otoliths as bioindicators for fish exposure could be a better choice than muscle tissue.
- In this study we found low As concentrations and had a small samples for digestion and analysis. A future method with better detection for lower amounts could be useful.