The mercury cycle and fish in the Adirondack lakes

Paper by Driscoll et al., 1994
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2 March 2016

Long Lake, NY
Photo from longlakemarina.com
Importance of the study

Mercury increases up the food chain

- Water
- Plankton
- Aquatic insects
- Insect-eating fish
- Fish-eating fish
- Humans

Mercury concentration
Methylmercury Chemistry
Background Information

- FDA action level in fish: 1 µg/g (wet weight)
- Consumption advisory in Canada and some US states: 0.5 µg/g
- Low ionic strength → high fish tissue mercury
- pH and fish tissue Hg
  - Increased Hg inputs from atmosphere and adjacent terrestrial ecosystems
  - Acid waters – increase Hg partitioning, lower fish production, increase MeHg production, decrease demethylation, increase permeability of fish gills to MeHg
Mercury Cycle

FIGURE 1: Schematic diagram summarizing the mercury cycle in lake ecosystems.
Study Objectives

- Determine concentrations of THg and MeHg in fish tissue in Adirondack lakes
- Evaluate mechanisms regulating the [Hg] in fish
Study Sites
Methods: Study Sites

- Many of the lakes were in the Oswegatchie-Black drainage area with low pH and high [DOC]; two lakes were drainage lakes.
- 2 lakes had complete or nearly complete DO depletion during summer.
Methods: Wetlands & Fish

- % wetland estimated from topographic maps
  - aerial photos indicate the topo maps may be most indicative of near-shore wetlands, underestimating upland wetlands

- Index species: yellow perch
- Minimum 60 fish caught per lake
- 30 fish across age distribution – tissue analyzed for Hg
Methods: Water Chemistry

- Clean grab sampling, storage, and major solute analysis techniques used
- Total dissolved Hg
- Total MeHg
Results: Water Chemistry

- Lakes generally acidic with low-ionic-strength
- ANC: below 0 to greater than 200 µeq/L
- pH: below 5 to approximately 7.0
- [DOC]: 3.4-26.5 mg C/L
  - Nearshore wetlands increased [DOC]
- Seepage lakes Hg < 1 ng/L and low MeHg
- Drainage lakes Hg < 1 ng/L to > 5 ng/L
- Mean Hg\(_{(aq)}\):Hg\(_{tot}\) = 0.61
- Very high MeHg in lakes with anoxic summer hypolimnion
  - MeHg\(_{tot}\) = 20% Hg\(_{tot}\) in anoxic lakes vs MeHg\(_{tot}\) = 10% Hg\(_{tot}\)
Results: Water Chemistry

- Decreasing pH $\rightarrow$ increasing $[\text{Hg}_{\text{tot}}]$ and $[\text{MeHg}]$
- DOC $> 6$ mg C/L $\rightarrow$ increasing $[\text{Hg}_{\text{tot}}]$ and $[\text{MeHg}]$
- $[\text{Hg}_{\text{tot}}]$ and $[\text{MeHg}]$ correlated with % near-shore wetlands
Results: Fish

- Hg increased with fish length, weight, age (except in one seepage lake)
- Increases in mercury from baby fish to above 2 years
- [Hg] relatively constant between ages 3 to 5 years (mean = 0.5 µg/g)
- Increases in [Hg] in fish older than 5 years
Results: Fish

- Anoxic hypolimnion – high [MeHg] in water and fish age 3-5+
- [DOC] > 8 mg C/L → [Hg] in fish decreases
  - High [DOC] will bind MeHg and reduce bioavailability
- BF = MeHg$_{\text{fish}}$: MeHg$_{\text{water}}$
Results: Fish

- Total dissolved Al significantly correlated with fish [Hg] in all 1 lakes
- Multiple regression: [Hg] increased with Al and decreased with increasing DOC
Summary

- Increased Hg in fish tissue with lower pH
- Higher Hg in Adirondacks than in Upper Peninsula of Michigan study
- 26% of Adirondack yellow perch exceeded 0.5 µg/g and 7% exceeded FDA Action Level
- Complexity of bioavailability – [DOC] threshold and presence of other metals (e.g. Al)

<table>
<thead>
<tr>
<th>Lake systems</th>
<th>Location</th>
<th>Total Hg (ng/L)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote lakes</td>
<td></td>
<td></td>
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<tr>
<td>Drainage (14)</td>
<td>Adirondacks</td>
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<td>this study</td>
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<td>Seepage (2)</td>
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<td>this study</td>
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<td>Great Lakes</td>
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<td>7–19</td>
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Discussion Questions

1. What might contribute to high [Hg] in Adirondack vs. Michigan Lakes?
2. What are some of the natural acid sources in the Adirondack forests?