Mercury in the Biostrome Community of the Great Salt Lake

Wayne Wurtsbaugh & Caleb Izdebski
Utah State University

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Great Salt Lake

- Area ~ 4300 km²
- Mean depth 4.5 m
- Mean Chl a 21 µg/L
Birds
Western Hemispheric Shorebird Reserve (1991)

Abundant Artemia
Gunnison Bay (30% salinity)

Gilbert Bay (10-15%)

Farmington Bay (0-9%)

Railway Causeway

Greater Metropolitan Salt Lake City

Mining District
Extremely high Mercury Levels in the Great Salt Lake

Generally, mercury in the Great Salt Lake is **10-100 times higher** than in other lakes that have been measured.*

<table>
<thead>
<tr>
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<th>Total Hg</th>
<th>% Methyl Hg</th>
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<tbody>
<tr>
<td>Great Salt Lake</td>
<td>2 - 8 µg/L</td>
<td>30 - 60 %</td>
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<tr>
<td>Idaho</td>
<td>0.5 - 2 µg/L</td>
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<tr>
<td>Maryland</td>
<td>0.05 - 0.4 µg/L</td>
<td>1 - 27%</td>
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*Data of David Naftz, USGS
Source of High Mercury Unknown

- Natural concentration in salt lake?
- Long-range atmospheric deposition?
- Legacy mining contributions & recycling?

- **Current atmospheric Hg deposition to lake**\(^1\) 36 kg/yr
  - is not abnormally high

- **Legacy gold/silver mining Hg use in Utah**\(^2\) (1864-present)
  - 19,900,000 kg
  - (136,000 kg/yr)

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\(^1\) Peterson & Gustin (2009)

\(^2\) C.L. Ege, Selected Mining Districts of Utah, UGS Misc. Pub. 05-5 2005
Mercury methylation rates are likely high:

\[ \text{Hg}^0 \rightarrow \text{Methyl Hg} \]

\[ \text{SO}_4^{2-} \rightarrow \text{H}_2\text{S} \]
Few fish, but still there is a Human Health Issue — Consumption Advisories on 3 Species of Ducks

Northern shoveler

Goldeneye
(Diet: 70 % brine fly larvae)

Cinnamon teal
Goldeneye increase Hg levels ~8X after arriving at Great Salt Lake and feeding on brine fly larvae.

Vest et al.

Mercury (µg / g wet weight)

\[ Hg_{\text{mg}} = 2.616 + 0.007x - 0.0004x^2; r^2 = 0.33 \]
Biostrome Distribution in Gilbert Bay

Study Sites

- Oolitic sand 31%
- Biostromes 11% (23%)
- Fine alluvium 7%
- Seiche-influenced alluvium 4%
- Beneath deep brine layer (47%)

Mounds, ca. 1-m high

Photo: Dave Liddell
**Stromatolites (Biostromes)**
Dominant hard substrate for periphyton, brine fly larvae & pupae

**Aphanothece sp.**
(cyanobacteria)

**Food Web Importance:**
Principal Brine Fly Habitat

**Ephydra cinerea**
Simple Food Web

Cyanobacteria → Brine fly larvae → Goldeneye, grebes, avocets, gulls, etc.
Stromatolite Sampling Methods

– Brine fly larvae & pupae:
  Bucket Sampler & SCUBA
  Scrub stromatolite surface with brush

Sample pumped to boat & sieved

Sampled 5 times (June – December)
at 3 stations and 2 depths per station
Biostrome Sampling Methods

Stromatolite chunks broken off underwater
- Chl a extracted
- Periphyton removed
  - With & without acidification to remove carbonates

Adult brine flies collected on shore with net
- All Hg analyses by cold vapor atomic fluorescence spectrometry at the U.S. Geological Survey Wisconsin Mercury Research Laboratory
Abundance of Periphyton on Stromatolites Compared to Phytoplankton

Periphyton on biostromes is a very important component of primary production for Gilbert Bay

*Based on May-October phytoplankton in Gilbert Bay (2002-2005), and summer periphyton values*
Brine fly larvae very abundant on biostromes
Dissolved Mercury Concentrations Over Biostromes

Draft Data

Bar chart showing dissolved mercury concentrations at three stations (1, 2, 3), with blue bars representing total dissolved Hg and red bars representing dissolved methyl Hg. Station 1 has the highest dissolved mercury concentration, followed by Station 2 and then Station 3.
Mercury Concentrations In Brine Flies were High & Increased Significantly Through Successive Stages

ANOVA
P < 0.000

Draft Data
Biomagnification of Mercury in Great Salt Lake Food Web

Draft Data

* Winter Concentrations (dry wt) From Vest, J. et al. (2009)
Selenium Concentrations

Se (μg/L) or (μg/g) + s.e.

Water  Periphyton  Brine Fly Larvae  Brine Fly Pupae  Brine Fly Adult  Goldeneye*

Wurtsbaugh, WA (2009)

*Goldeneye data from Vest, J. et al. 2009

4X Biomagnification
Conclusions

- Stromatolites/periphyton and brine flies are important in the economy of the lake, and important in the diets of many bird species, likely rivaling the importance of brine shrimp as a food source.

- Mercury concentrations are high in biostromes and in brine flies, but biomagnification not important in the periphyton → brine fly larvae transfer.

- Goldeneye ducks have very high mercury concentrations: either there is very high biomagnification in the brine fly → duck transfer, or the ducks are obtaining mercury from elsewhere.
Questions?

• Funding provided by the Utah Division of Water Quality
**Gilbert Bay Food Web**

- **Biostrome Periphyton**

  - **Brine Fly Larvae**
    - BN stilts 52%
    - Avocets 20%
    - Goldeneye 70%
    - Falaropes 56%

- **Brine Fly Adults**
  - Eared grebe 11%
  - Calif. gulls

- **Other Animals**
  - Eared grebe
  - Falaropes
  - Goldeneye
  - BN stilts
  - Avocets

- **Selenium Study**
  - Hypothesized, literature

**Misc. Invertebrates**

- Sediment Periphyton
  - 69%
- Periphyton/detritus
  - 11%
- Freshwater Periphyton & detritus
  - 80%
- Sediment
  - 48%
- Invertebrates
  - 52%
- 20%
Substrate Summary: All Sites

Brine Fly Larvae & Pupae Densities (2006)

Density (#/m²) ± s.e.