Mercury in water and biota from Great Salt Lake, Utah: Reconnaissance-phase results

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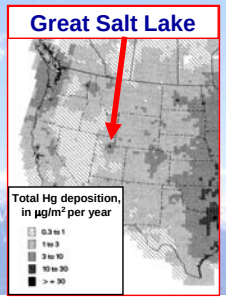
Little is known about Hg cycling in Great Salt Lake



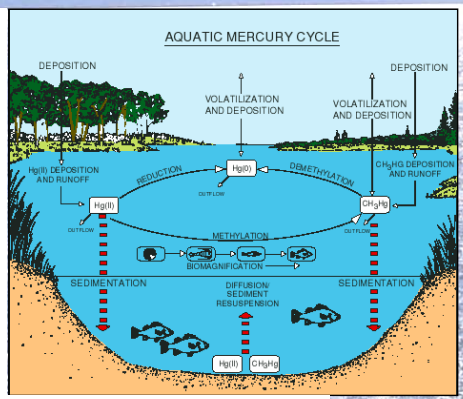
U.S. Environmental Protection Agency, 1997

Mercury sources adjacent to GSL

Great Salt Lake (GSL) is the fourth largest terminal lake in the world and may be the most important inland shorebird site in North America (Aldrich and Paul, 2002). In addition to supporting migratory dependent waterbirds, the brine shrimp (*Artemia franciscana*) population residing in GSL supports a shrimp industry with annual revenues typically exceeding 100 million dollars. Atmospheric deposition is presently the major mercury (Hg) source to most aquatic ecosystems (Krabbenhoft and Rickert, 1995). Based on statistics published in 1997, numerous local point sources for atmospheric Hg deposition to GSL exist (U.S. Environmental Protection Agency, 1997). Based on data compiled from the 1990s, annual Hg deposition adjacent to GSL is elevated, ranging from 3 to 30 µg/m².

Mercury methylation in GSL

The lipophilic nature of methylmercury (CH_3Hg) and its ability to pass the blood/brain barrier makes it much more toxic to organisms than inorganic forms of Hg. The chemical and physical conditions present in GSL may be ideal for high rates of Hg methylation. Previous work has shown that marine sediments rich in organic matter and dissolved sulfide have rapid CH_3Hg production rates in conjunction with rapid rates of sulfate reduction (King and others, 2000). Sulfate reduction is the principal process leading to the production of CH_3Hg . Rates measured in water from GSL were higher than 6,000 nmoles/cm³/day, one of the highest rates reported in a natural environment (Ingvorsen and Brandt, 2002).

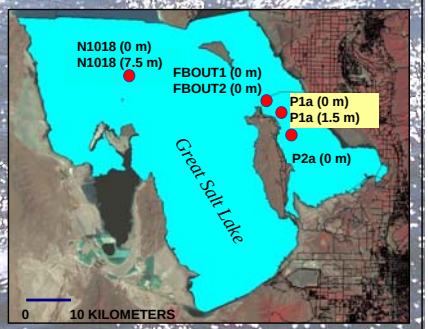


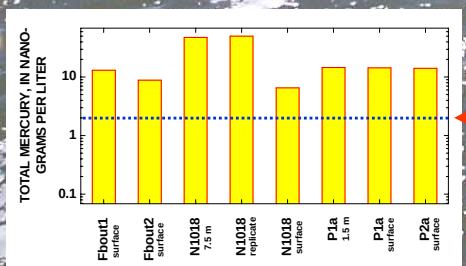
Mercury Pollution: Integration and Synthesis, 1994

Elevated concentrations of total Hg found in water

Aquatic life standard exceeded

During August 2003, unfiltered water samples were collected from the south arm of GSL. Samples were analyzed for total Hg and CH_3Hg concentrations by the USGS mercury research laboratory in Madison, Wisconsin. Initial results indicate high levels of total Hg (exceeding 45 nanograms per liter (ng/L) and CH_3Hg (exceeding 25 ng/L) in anoxic regions of the lake where high rates of bacterial-mediated sulfate reduction have been documented. The concentration of CH_3Hg measured in GSL is among the highest ever measured by the USGS mercury laboratory.





Total mercury concentration standard in water from marine systems for protection of aquatic life when methyl mercury is 5 percent of the total mercury concentration (British Columbia Ministry of Environment, Lands and Parks, 2001)

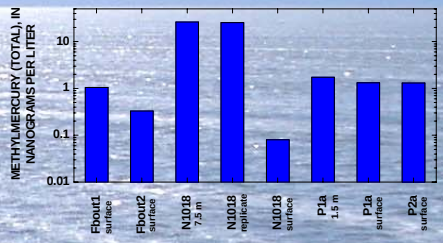
Elevated levels of methyl Hg found in water

Deep brine layer contains methylmercury

Percentage of total Hg concentration as methyl Hg in water samples collected from Great Salt Lake, August 2003.

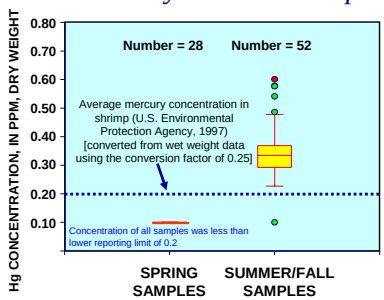
Sample site	Methylmercury, as percent of total mercury
FBOUT1 (0 m depth)	8.0
FBOUT2 (0 m depth)	3.7
N1018 (7.5 m depth)	55
N1018 (7.5 m depth) (replicate)	51
N1018 (0 m depth)	1.2
P1A (1.5 m depth)	12
P1A (0 m depth)	9.2
P2A (0 m depth)	9.3

All of the water samples from GSL exceed the total Hg standard for protection of aquatic life in marine systems (British Columbia Ministry of Environment, Lands and Parks, 2001). This standard is based on the ratio of CH_3Hg to total Hg concentrations. In water samples with CH_3Hg making up 5 percent of the total Hg concentration, the standard is 2 ng/L (total Hg). The aquatic life standard increases as the proportion of CH_3Hg relative to total Hg decreases. The percentage of CH_3Hg contributing to total Hg in water samples collected from GSL ranges from 1.2 to 55 percent.

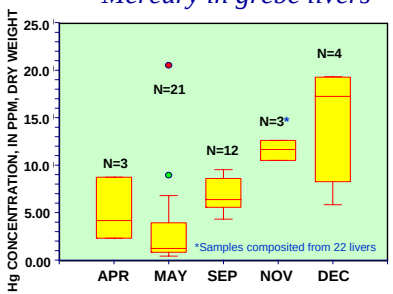


Hg content in biota indicates bioaccumulation

Mercury in brine shrimp



Mercury in grebe livers



The migration and molting habits of eared grebes make them an ideal population for the reconnaissance evaluation of Hg bioaccumulation. A large population of eared grebes (1.5 million in 1997) from throughout North America utilize GSL during the molt migration beginning in August and continuing through December and January (Aldrich and Paul, 2002). The seasonal changes in Hg concentration in eared grebe livers indicate bioaccumulation during the fall molting period when the grebes feed exclusively on brine shrimp. Brine shrimp samples collected during the summer and fall have a higher Hg concentration (median concentration = 0.34 ppm), with 51 out of 52 samples exceeding the average Hg concentration in shrimp of 0.16 ppm (U.S. Environmental Protection Agency, 1997). Total Hg and CH_3Hg levels in GSL water and biota appear elevated when compared to standards intended to protect aquatic life; however, the amount of data presently available is limited and further study is warranted.

References

Aldrich, T.W., and Paul, D.S., 2002, Avian ecology of Great Salt Lake, *in* Gwynn, J.W., ed., Great Salt Lake: An overview of change, Utah Department of Natural Resources Special Publication, p. 343-374.

British Columbia Ministry of Environment, Lands and Parks, 2001, Ambient water quality guidelines for mercury: Overview report—First update: accessed September 19, 2004, at URL http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/mercury.html#table1

Ingvorsen, K., and Brandt, K.K., 2002, Anerobic microbiology and sulfur cycling in hypersaline sediments with special reference to Great Salt Lake, *in* Gwynn, J.W., ed., Great Salt Lake: An overview of change, Utah Department of Natural Resources Special Publication, p. 387-398.

King, J.K, Kostka, J.E., Frischer, M.E, and Saunders, F.M., 2000, Sulfate-reducing bacteria methylate mercury at variable rates in pure culture and marine sediments: Applied and Environmental Microbiology, vol. 66, no. 6, p. 2430-2437.

Krabbenhoft, D.P., and Rickert, D.A., 1995, Mercury contamination of aquatic ecosystems: U.S. Geological Survey Fact Sheet 216-95, 4 p.

Mason, R.P., and Sveinsdottir, A.Y., 2003, Mercury and methylmercury concentrations in water and largemouth bass in Maryland reservoirs: accessed September 22, 2004, at URL http://www.dnr.state.md.us/streams/pubs/ad-03-1_Hg_bass.pdf

U.S. Environmental Protection Agency, 1997, Mercury study report to Congress: USEPA Report 452/R-97-004.