

1-1-2014

The Great Salt Lake's Two Deep Brine Layers

Wayne A. Wurtsbaugh
Utah State University

Recommended Citation

Wurtsbaugh, Wayne A., "The Great Salt Lake's Two Deep Brine Layers" (2014). *Watershed Sciences Faculty Publications*. Paper 558.
http://digitalcommons.usu.edu/wats_facpub/558

This Article is brought to you for free and open access by the Watershed Sciences, Department of at DigitalCommons@USU. It has been accepted for inclusion in Watershed Sciences Faculty Publications by an authorized administrator of DigitalCommons@USU. For more information, please contact becky.thoms@usu.edu.



The Great Salt Lake – Two Deep Brine Layers

Wayne Wurtsbaugh, Utah State University

Two major causeways that divide the Great Salt Lake have radically changed salt balances different sections of the lake, and have caused deep brine layers to form. For you scrabble buffs limnologists call these layers monimolimnions.

In 1959 the Southern Pacific Railway built a 13-mile rock-fill causeway across the main lake, dividing it in half. This division caused the south arm (Gilbert Bay) to have a higher elevation and lower salinities than the north arm (Gunnison Bay).

The high-density brine from Gunnison then flows back through the causeway fill material, through a breach, and until recently, through two culverts constructed to allow equilibration and salt transfer (Fig. 1). This brine settles into the deepest sections of Gilbert Bay, and because it is denser than the overlying layer, mixing between the two layers is limited. Approximately 45% of Gilbert Bay's bottom is covered by the deep brine layer (Fig. 2). Similar phenomenon occurs in Farmington Bay when Gilbert Bay water passes through the automobile causeway bridge material and underflows the fresher water in Farmington^{2,3}. However, in this case, the overlying mixed layer is only about 2 feet thick, whereas in Gilbert, the mixed layer is about 24 feet thick.

Algae and detritus produced in the upper mixed layer fall into the deep brine layer and decompose (Fig. 3). This decomposition strips oxygen from the water, releases nutrients, and promotes other microbial processes that produce high levels of hydrogen sulfide (Fig. 4). This rotten egg gas is very toxic, and levels in the deep brine layers of both bays exceed EPA's chronic criteria for protecting invertebrates by more than 200 fold^{3,5}. Consequently, the lack of oxygen and toxicity of the deep brine layers result in dead zones where brine shrimp, brine fly larvae and other invertebrates can't survive.

Fig. 2. Extent of the deep brine layers in Gilbert and Farmington Bays. The deep brine layer in Gilbert is shown at a depth of 23, and at a lake level of 4200, based on the USGS map of R. Baskin. The extent of the layer in Farmington Bay is shown at a depth of 3.5 and is only approximate because the bay's morphometry has not been carefully mapped.

Very high levels of mercury also accumulate in Gilbert Bay's deep brine layer^{6,7}, and much of it is in the highly toxic methylmercury form (Fig. 4). Concentrations of methylmercury measured there are some of the highest ever reported in the United States. Some of this mercury may come from the sediments where heavy metals have accumulated due to smelting activities in the Salt Lake Valley. Levels may also be high because much of the sedimenting algae and detritus don't fall to the bottom because the high-density brines keep them in suspension, and they consequently release small amounts of mercury into the deep brine layer.

The high sulfide and mercury levels in the deep brine layers affect the upper mixed layer because there is constant movement

Fig. 1. Bi-directional flow paths through the culverts and causeway fill that cause a deep brine layer in Gilbert Bay.

of the brine and contaminants upward. This occurs due to the continuous flow of heavy brines from the northern sources in Gilbert and Farmington Bay. Turbulence caused by winds fshaves, off the tops of the deep brine layers and mixes the salts, hydrogen sulfide and mercury into the upper water column where they then affect brine shrimp, brine flies and other organisms. One estimate indicates that 25% of Gilbert Bay's deep brine layer and mercury is mixed into the upper layer each year. The amount of mixing in Farmington Bay is much greater, because the deep brine layer is only protected from a thick overlying layer. When high winds mix hydrogen sulfide from Farmington's deep brine layer, it reacts with oxygen in the upper layer, and the entire water column loses its oxygen. This process occurs in darkly-stained deep brine layer California's Salton Sea, and kills all of the organisms in the sea. The release of hydrogen sulfide from Farmington Bay is also a major source of lake stink.

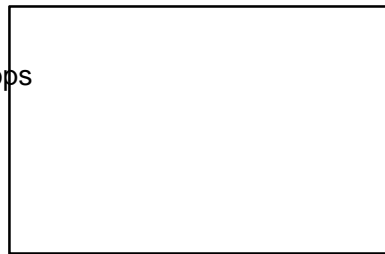


Fig. 3. Twenty liter Cubitainers of water collected Aug. 3, 2010 from (left and right), and from the center

Gilbert Bay's deep brine layer is in the spotlight now because the SP Railroad recently closed the culverts that allowed much of the brine to move from Gunnison to Gilbert Bay. The loss of these lines will cause Gilbert to become fresher, potentially to the detriment of the brine shrimp and to the mineral extraction industries in the south. However, the decreased flow of brine should diminish the magnitude of the deep brine layer. A bridge is planned to replace the culverts and allow bi-directional flow of salts and water between the two bays. The size and configuration of this bridge will effect both the overall salinity of Gilbert Bay, and also the size of the detrimental deep brine layer. Consequently, managers and the railroad are building salt and hydrological flow models that are helping them construct a bridge that will minimize the negative effects of the causeway on the lake's uses.

Fig. 4. Salinity and toxic hydrogen sulfide and methyl mercury in the water column of Gilbert Bay. The gray area shows the deep brine layer starting at a depth of 21 feet (Aug. 3, 2010).

References

1. J.W.Gwynn. A lake divided. <http://geology.utah.gov/wahgeo/gsl/lakedivided.htm>
2. J.W. Gwynn. 2002 Great Salt Lake: Overview of change, p 107. Utah Dept. Natural Resources, Salt Lake City.
3. W. Wurtsbaugh, et al. 2012. Eutrophication & metal concentrations in three bays of the Great Salt Lake. http://digitalcommons.usu.edu/wats_facpub/550/
4. W. Wurtsbaugh, A.M. Marcarelli. 2004. Hydrogen sulfide in Farmington Bay and the Great Salt Lake. http://digitalcommons.usu.edu/wats_facpub/533/
5. EPA. 2006. National recommended water quality criteria. <http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm>
6. D. Naftz, et al. 2013. Monitoring change in the Great Salt Lake. *ES&S* 94, 289.
7. E.F. Jones and W.A. Wurtsbaugh 2014. The Great Salt Lake's monimolimnion and its importance for mercury bioaccumulation in brine shrimp *Artemia franciscana*. *Limnol. Oceanogr.* 59, 141