The Great Salt Lake Doesn't Stink…But Farmington Bay Does!

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Standing on the causeway to Antelope Island, many things are striking…the beauty of the sun over the lake, the incredible serenity of the landscape…the stifling odor coming from Farmington Bay. The causeway, which was first constructed in 1969 and then rebuilt in 1993, serves as the only entrance to Antelope Island. It also serves as a barrier between Farmington Bay estuary, where the Jordan River flows into the lake, and the rest of the Great Salt Lake. Our research, both through the mid-1990s and more recently in October 2000 has illustrated many differences between Farmington Bay and the southern basin (Gilbert Bay) of the Great Salt Lake. We believe that many of the differences we found are due to high levels of nutrient input into Farmington Bay from the Jordan River and sewage treatment plants along the shore.

The most striking difference between the basins is the productivity. Farmington Bay supports very high densities of algae, while the Great Salt Lake (Bridger Bay) has much lower concentrations. Water transparency, measured by determining the depth a white Secchi disk disappears from view, was shallower in Farmington Bay -- 0.6 m compared to 1.8 m in the Lake proper. This indicates that Farmington Bay has higher algal densities and growth. We also used chlorophyll *a* concentrations as a measure of algal biomass. In Farmington Bay average chlorophyll concentrations ranged from 11 to 70 $\mu g\ L^{-1}$ during our 1994 survey, and in 2000 there was 42 μg Chl. *a* L^{-1} (Fig. 1). Even higher concentrations have been measured at the south end of Farmington Bay near the discharges of the Jordan River and a sewage canal (UWRL 1988). In contrast, averages in the Great Salt Lake proper were between 0.2 and 12 $\mu g\ L^{-1}$ in 1994 and there was only 5 $\mu g\ L^{-1}$ in 2000. When classified according to these values, the Great Salt Lake is placed into a category of lakes known as mesotrophic, while Farmington Bay is classified as hypereutrophic. Oligotrophic lakes have low nutrient inputs and low algal densities, while hypereutrophic lakes have excessive nutrients and algae. Mesotrophic lakes fall somewhere in between. When the productivity in a lake increases due to increased nutrient loading from the surrounding environment, it is said to undergo cultural eutrophication, or a shift to a more productive trophic state. The chlorophyll levels in Farmington Bay indicate that it is undergoing eutrophication, most likely due to nutrient inputs from the Jordan River and other development surrounding the bay.

A further difference between Farmington Bay and the Great Salt Lake proper is the composition of the plankton community. In October 2000 the community in the Great Salt Lake was dominated by green algae, in particular *Spermatozopsis* spp., while the community in Farmington Bay was more diverse (Fig. 2). It was composed mainly of diatoms, particularly the diatom *Nitzschia* spp., but also contained large numbers of the filamentous cyanobacteria *Spirulina major*. Photosynthetic cyanobacteria are notorious indicators of eutrophication. They are also well known for the often overwhelming, unattractive, and foul smelling blooms they can produce in polluted water. Noxious odors and blooms are detrimental to tourism and general usage of the lake. We did not find any cyanobacteria in the Great Salt Lake proper, although they have been found there when salinities are lower.

We also examined some physical and chemical characteristics of Farmington Bay and the Great Salt Lake proper. Salinity was higher in the lake, averaging 88 $g\ L^{-1}$ compared to 65 $g\ L^{-1}$ in Farmington Bay. These different salinity levels probably contribute to the difference in algal species composition between the basins. The green algae that were found in the Lake proper are much more tolerant of highly saline conditions than the cyanobacteria found in Farmington Bay. Distribution of oxygen in the water column was also different between the two basins (Fig. 3). In the Great Salt Lake proper, oxygen was constant from the surface to the lake bottom where we measured it. In Farmington Bay, on the other hand, oxygen decreased dramatically, falling to zero in the layer below 2 m (6.6 ft) that is physically stratified because of intruding high-salinity water that underflows from the main lake. This layer occurs in a limited area, because most of the Bay is < 2 m deep. The low oxygen concentration is the result of high levels of algae and other organic matter that settles to the bottom and is decomposed by microbes that use up oxygen in the process. There are distinctly different chemical processes that happen in this anoxic (literally, without oxygen) layer. When we collected samples from near the sediments, the water smelled strongly of rotten eggs, a smell that is indicative of hydrogen sulfide gas. This gas is only present in the absence of oxygen. It is also a smell that often plagues communities surrounding the lake. Decomposing algal mats and anoxic conditions at the sediment-water interface throughout Farmington Bay also contribute to the odor (Israelsen et al. 1985). We have spent many days working on the larger lake and have never encountered foul odors there, indicating that it is the condition that society has created in Farmington Bay that is the problem -- not the lake itself. In contrast, smells emanating from Farmington Bay can range from mildly pleasing "marine" aromas to ones that gag you. The DEQ Designated Uses for Farmington Bay are primary and secondary contact recreation, aquatic wildlife, and mineral extraction. When you can taste the odors wafting from the bay, recreational use is obviously deterred, and residents in nearby communities are also impacted.

Our evidence shows that there are distinct differences between Farmington Bay and the Great Salt Lake proper. The next question to ask is what can be done to improve the water quality in Farmington Bay so that it is more similar to that of the larger lake. Currently there are no numeric criteria used by the State to govern water quality in the lake; it is one of the only bodies of water in the country without such regulation. The Great Salt Lake is a unique system, and numeric water quality standards should be established to permit greater enjoyment of the lake. Reduced nutrient input into Farmington Bay will help reduce the productivity levels and cyanobacterial dominance in the system. Currently, the treated sewage effluent from approximately 500 thousand people flows or is piped into the shallow, contained Farmington Bay, thus greatly increasing the concentration of nutrients and causing the algae to flourish. Total phosphorus concentrations in Farmington Bay always exceed the State's suggested level of 25 $\mu g\ P\ L^{-1}$ set for freshwater, and they often exceed 100 $\mu g\ P\ L^{-1}$. Total nitrogen concentrations are also in the eutrophic range (UWRL 1988). Tertiary treatment of the sewage could be done to remove the nutrients, but this would be extremely costly. Wastewater reuse to fertilize golf courses, parks and crops would also divert the nutrients causing problems in Farmington Bay.

Sometimes, "the solution to pollution is dilution." In this case, larger breaches could be made in the causeway separating the two basins to allow greater mixing of the water and dilution of the nutrients from Farmington Bay into the main lake. Pipes or canals could also be used to deliver the nutrients to the much larger main lake. Because brine shrimp production in the main lake is likely limited by nutrient-dependent algal production (Wurtsbaugh 1988), it is conceivable that this resource, and the birds that are dependent on the shrimp, could benefit by moving the nutrients into the main lake. Such an action would obviously need to be approached with extreme caution, as it would not be wise to simply shift the problems in Farmington Bay to the rest of the lake, particularly when fluctuating salinity conditions throughout the system complicate the biological responses (Stephens 1990). The sediments of Farmington Bay also contain toxicants from past water quality abuses (UWRL 1988), and any remediation must insure that their impacts are minimized. Breaching or water diversions would increase salinity levels in Farmington Bay, and this could have consequences for the marshlands surrounding the bay. Clearly, more work is needed to determine the best and most cost-effective alternatives to solve this serious problem.

Our surveys and earlier studies in the Great Salt Lake highlight the dramatic differences between the two basins. Extreme nutrient loading to the relatively contained Farmington Bay is primarily responsible for these differences. Water quality criteria must be established for Farmington Bay and the main lake, and steps taken to meet them. The lake is too valuable to be used as a dumping ground for the Wasatch Front's wastes. With sufficient commitment, conditions in Farmington Bay can improve to a point where algal densities will decrease, and the bay will become a friendlier place. Who knows, perhaps one day we will be able to enjoy the beauty of Antelope Island and the lake without being assaulted by the odor that is now considered typical of the Great Salt Lake.

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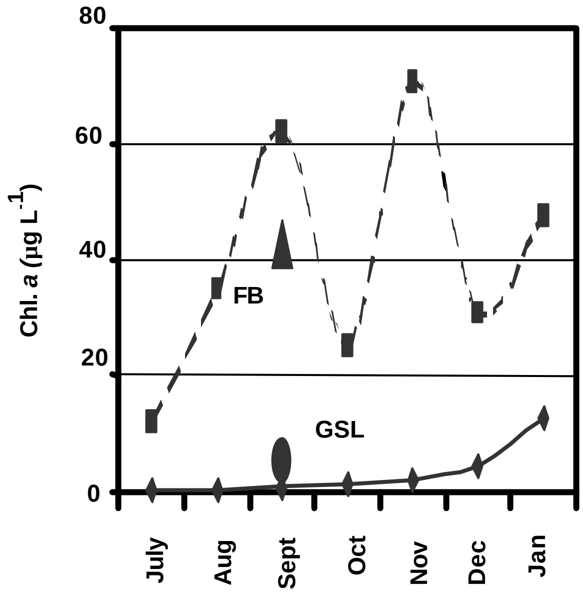

Figure 1. Chlorophyll *a* concentrations in Farmington Bay (FB) and in the south basin of the Great Salt Lake (GSL). Data collected July 1994 to December 1995. Single data points collected September 2000.

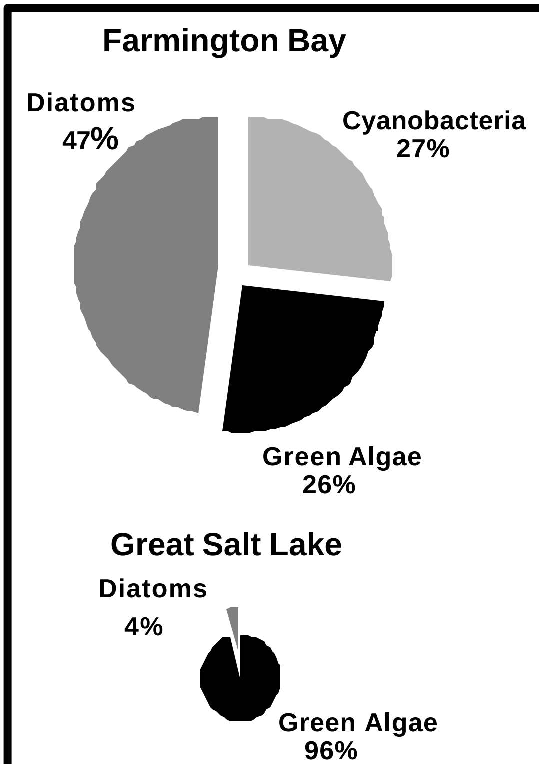

Figure 2. Relative frequency of phytoplankton types in our samples collected in October 2000. Sizes of the respective circles represent the relative concentration of chlorophyll *a* at the two sites. FB chlorophyll to GSL chlorophyll equals 9:1.

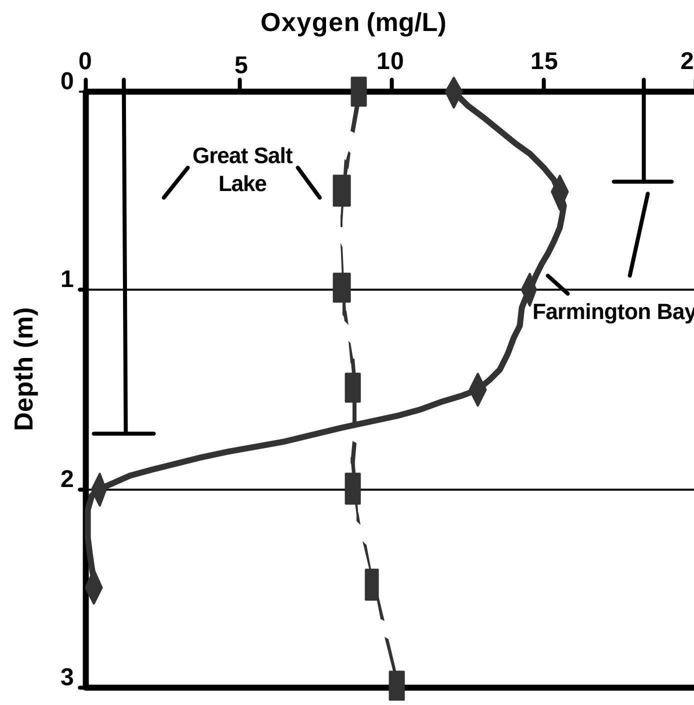

Figure 3. Dissolved oxygen (mg/L) profiles and Secchi depths from 2000 sampling. The profile in the Great Salt Lake was taken on the west side of Antelope Island in Bridger Bay. The profile in Farmington Bay was taken 1-km SE of the breach in the causeway. The vertical lines with bars on the end indicate the Secchi disk visibility.