Microbial-what? A reflection and ecological perspective on under-appreciated ecosystems

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Have you ever encountered a large lake in a desert environment? What if it was the 4th largest terminal lake in the world? It's the Great Salt Lake, in north-western Utah. The lake is not only fourth-largest in the world, but it is hypersaline, which means it is an extreme ecosystem because of its high salinity, and not very hospitable to traditional life forms. You might think, if it is hypersaline, nothing is living in there, right? Surprisingly, that is not the case, because while there are no vertebrates (fish or amphibians) living in the lake, there are two very special invertebrates (organisms without a backbone).

The Great Salt Lake is unique not only for its hypersalinity, but also for major anthropogenic alterations made to its hydrology. A railroad causeway was constructed across the lake, near the Promontory Mountains, in 1959, which essentially divided the lake in two hydrologic units, commonly referred to as the north and south arms. Due to the inflow of freshwater from the southern arm, which does not mix with the north arm, the south arm has lower salinity than the north arm. In fact, the north arm is often super-saturated with salt, which makes an extremely hostile environment in which only hardy bacteria and Archaea can live!

Hypersaline lakes such as Great Salt Lake are not amenable to the typical freshwater fish and insects and snails we often think about when we see lakes and ponds. The highly saline water is a form of stress on organisms- think about if you ever swallowed seawater by accident- YUCK! Hypersaline lakes may seem boring because of the lack of familiar, charismatic animals, but stay with me! For example, brine shrimp, Artemia franciscana, are highly abundant in the southern part of the lake. They thrive in the high salinities (10-15% salinity). If you are from the generation that remembers those small aquarium sea monkeys, those are brine shrimp cysts that hatch from the Great Salt Lake! Another critter that lives in the lake is the brine fly. Brine shrimp are the only animals that live in the open water (dubbed pelagic species) and the brine flies are the only animals living on the benthos (bottom of the shallow lake zone).

Besides the brine shrimp providing childhood amusement in the fun theme of sea monkeys, why do these animals matter?

To answer this question, I need to start from the bottom, and need to throw in some history about Great Salt Lake (GSL). GSL is a remnant lake of Pleistocene-era Lake Bonneville, which was a HUGE lake back in geologic time. At one point during its existence, Lake Bonneville covered parts of Idaho and Nevada. Over the course of ~30,000 years, Lake Bonneville underwent major changes in water level, leaving behind the GSL that we know today. Since GSL has no outlet, it has accumulated much sediment and salts throughout millenia. Also over this long period of time, as the water chemistry developed to be hypersaline, a very unique assemblage of algae and bacteria developed.

It is this unique assemblage of primary producers (mainly algae and cyanobacteria, which can fix atmospheric N into forms available for plants and algae) that forms the basis of life in GSL. At the bottom of the lake, there are fault lines where groundwater feeds into the lake. This groundwater carries with it dissolved carbonates (think of the stuff that coral reefs are made of). If you are a small algal cell or aquatic insect, you probably want something sturdy and stable for habitat and feeding space. This is where the story begins.

Along these faults, where the carbonates seep through, cyanobacteria and algae take in the carbonate and carbon dioxide to carry out photosynthesis. They create green, lush biomass, and as these small primary producers grow and eventually die, their remains are incorporated into the carbonate skeleton, and form layers upon layers of life and death. These algae, mainly cyanobacteria (blue-greens) can photosynthesize (they take carbon dioxide out of the water and produce oxygen), which makes calcium and magnesium carbonates precipitate (settle out on the bottom of the lake).

So, let's get back to those brine flies I mentioned. Who cares, right? A fly? How is that any different than a housefly? Well I will tell you a thing or two.

Collins (1980a and b) described the population ecology of Ephydra cinerea Jones (=Ephydra gracilis; this is the current scientific name of brine fly; scientific names of animals and plants can change at the whim of taxonomists, but that's a discussion for another time) in the GSL. When we talk about the populations of organisms, we refer to their life histories. The brine fly is a true fly, in the order Diptera, so it is in the same taxonomic (think of a big, really big, family tree) order as mosquitoes and houseflies! But fear not, brine fly adults do not bite! And, the adults only live for about a week! That's such a short time to be a flying insect, but oddly enough that is the case for many insects. Although brine flies spend such a short period of time on land, the larval stage is the longest one-anywhere from one to 6 months. This means the larvae, which are admittedly wormy like little things, spend a lot of time feeding on algae and other food particles in GSL.

The adult flies mate and the females lay eggs (roughly 75) on the lake's surface. After that, the eggs are dispersed by the reckoning of waves and currents. Once the eggs are submersed into the brine water, they adhere to any substrate.

Substrate….we talked about those algae that photosynthesize and assist in the precipitation of carbonates. These algal carbonate structures are formally called microbialites. These are sedimentary (rock) structures that have more to them than meets the eye. They are a coalescence of rock, sand, clay, brine shrimp fecal pellets, and algae. They are also the home base for the brine fly larvae. You see, once the eggs land on a substrate (sand, clays, rocks, microbialites), they hatch in about one week, and the young larvae can move, and if they seek a different substrate, they can do so freely. Many studies have shown that brine fly larvae have a preference for these microbialites, as larval densities on them can reach over 1000 individuals per m^2. The larvae live on these substrates and graze on their surfaces for algae and diatoms.

I have, hopefully without too many detours, demonstrated how important the microbialites are for brine flies, but now you may ask, what's so special about the brine flies?

If you have ever been to GSL, or read about it in National Geographic, you may have seen lots and lots of birds on the shores of Antelope Island or on the playa wetlands of Bear River Migratory Bird Refuge. So many birds-pelicans, eared grebes, Wilson's phalaropes, California gulls, Caspian terns-use the GSL as their stop-over resting place before continuing on their migrations. Flocking to the shores of GSL every year are millions of these migratory birds, and they come to GSL because of good quality habitat for recovering, and for a dependable food source to replenish their muscles after such a long flight.

When I was at a GSL meeting this past August 2016 in Salt Lake City to hear about recent findings and research on the lake, one professor reported her findings on the microbialites. She started talking about how from aerial photos one can see hundreds of Wilson's phalaropes seemingly in a perfect line formation in the lake-they were flocking to the microbialites. Why? Because that is where the highest abundance of their major food source-brine flies-lives.

If microbialites matter for the flies, and flies matter for the birds, and if we like to see birds, then doesn't it seem logical to say that microbialites matter for us even? Think about it: you probably never heard of microbialites before, but you probably know some birds, and probably have a family member or friend who is crazy about birds.

Or, if you are like me, you are crazy about the not-so-charismatic critters that most people never think about or see. But I see the connections between the organisms we don't see and those we do see; everything is connected. The GSL is a large food web, composed of the algae and brine flies, brine shrimp and phytoplankton, and waterfowl and migratory birds. If you take a moment to think about it, it truly is incredible that birds that have flown thousands of miles stop at GSL to feed and take reprieve from their exhausting travel. And to think the food that gives the charismatic phalaropes and grebes the energy to fly originates from the bottom of the lake, where the brine flies graze on the microbialites, just incredible.

Stay tuned for more as I continue to learn more about the Great Salt Lake!