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The Role of Geology in Supporting Mono Lake's Ecosystem

When John Muir first observed Mono Lake in 1864, he described it as "Frost and fire working together in the making of beauty" (Lee Vining). Although some people have called Mono a dead lake, it is in fact one of the most productive lakes – in terms of the number of creatures it supports – on earth (Dept. of Agriculture). The geological forces that shaped the Mono Lake region have also created an unusual environment that supports this unique ecosystem.

Mono Lake, which existed well before the Bishop Tuff volcanic eruption over 760,000 years ago, is one of the oldest lakes in North America (Dept. of Agriculture). The Sierra Nevada Mountains, as well as both active and dormant volcanoes, surround Mono Lake ("Volcanic Eruption…"). Water flows down to Mono's area of relatively low elevation and is trapped. For this reason, the lake is a closed hydrological basin, which means that water flows into the lake, but the only way for it to escape is through evaporation ("Chemistry…"). The streams that feed Mono dissolve and carry minerals, then deposit them in the lake (Dept. of Agriculture). Because it is located in a desert climate, up to four vertical feet of water per year can evaporate off the lake, leaving an estimated 280 million tons of dissolved solids behind in the water. Minerals are also added by volcanic eruptions that occur from time to time around the Mono Lake region ("Chemistry…"). These processes put the mineral content of Mono Lake at nearly ten percent (Dept. of Agriculture).

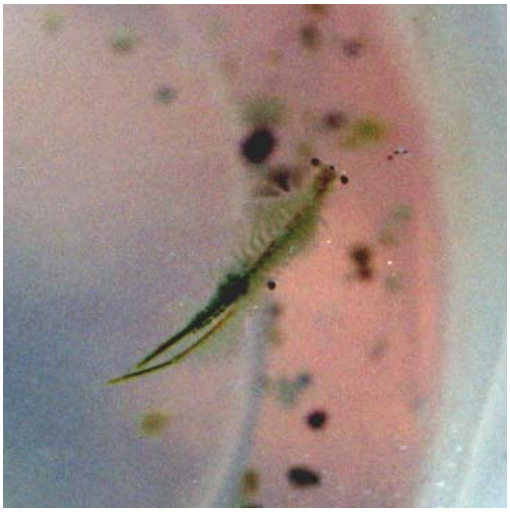
Areas of higher elevation surround Mono Lake, making the lake a closed hydrological basin

Depending on its level, Mono Lake is two to three times saltier than the ocean ("Chemistry…"). Nevertheless, salt is not the only prominent mineral in the lake. Chlorides, carbonates, and sulfates are the major chemical components of Mono. It is extremely alkaline, with a pH of 10 – which is about the same pH as household glass cleaner ("Statistics…" and "Chemistry…").

Although the harsh chemical content of Mono Lake makes it impossible for fish to survive, other forms of wildlife are able to thrive in the unusual habitat that the lake provides (Dept. of Agriculture). The Mono Lake food chain, which supports so much life, is actually relatively simple. Algae is eaten by brine shrimp and alkali flies, which are then eaten by birds (Carle 17.) The chemicals in the lake provide nutrients to fertilize the algae. These chemicals are stirred up each year as cold autumn temperatures cause the top layers of water to cool and become denser than the water below them. The heavy water sinks to the bottom as the light water floats to the top, bringing with it a fresh mixture of minerals from the bottom of the lake. In this way, the climate of Mono Lake causes a constant supply of fertilizer to be brought to the algae (Carle 80.)

A healthy supply of algae is essential for brine shrimp, which feed on the pea-green colored vegetation (Carle 26, 34). Mono Lake is the only natural body of water in the world where this species of brine shrimp live (Carle 67). These shrimp are constantly

digesting bits of algae as they swim (Carle 34). Brine shrimp have bug eyes that pop out of their bodies so that they can see in all directions. Each shrimp also has a total of 22 legs (11 on each side) and a tail that is nearly as long as its body, which acts as a rudder (Carle 33-34). Roughly the size of a human thumbnail, they are too small to be a practical source of food for humans ("Brine Shrimp…"). However, people do commercially harvest and freeze dry the shrimp as food for tropical fish (Carle 113). More importantly, they are also a perfect source of food for many of the birds that live around or visit Mono Lake. The plentiful population of the brine shrimp is part of their appeal. In fact, between four and six trillion shrimp live in Mono Lake during the summer, especially in August, when their numbers peak ("Brine Shrimp…" and Carle 55). There are so many shrimp in Mono that even the millions of birds that flock to the lake each summer are unable to substantially impact the numbers of shrimp. Only in the autumn, when Eared Grebes arrive by the millions, do birds put a serious dent in the brine shrimp population ("Brine Shrimp…").

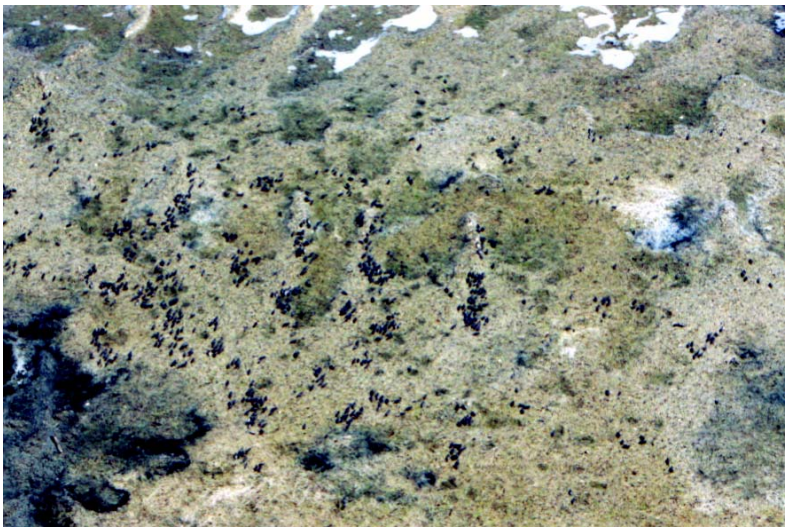


A brine shrimp in a specimen jar

Brine shrimp share the Mono Lake algae with alkali flies. Alkali flies, also known as brine flies by lay people and *Ephydra hydropyrus hians* by scientists, are

harmless to humans. Unlike other species of flies, alkali flies are vegetarians who feed almost exclusively on algae. As the result, they shy away from people (Carle 29). People, however, do not shy away from them. The Kuzedika Native Americans collected alkali fly pupae as one of their main food sources. These Mono Lake Paiutes also traded the pupae, and became known as the "fly eaters" by their Yokut trading partners. Mono Lake gets its name from a derivation of the Yokut word for fly eater (Dept. of Agriculture).

Alkali flies use the waters of Mono Lake to develop in both their larval and pupal stages. These young insects are perfectly adapted to the habitat Mono has created. The larvae absorb food by scraping the algae off of rocks and digesting it. They cope with the alkaline water by storing carbonates in a glandular pocket. As carbonates amass, larvae add calcium to the sac to create a tufa-like (explained later) substance. The immature flies are so well adapted to life in Mono Lake that they even have the ability to adjust the length of their pupa stage from three days to ten weeks, depending on lake temperatures (Carle 30.)



Alkali fly larvae in Mono Lake

Once the adult alkali fly is ready to emerge from its pupa, it temporarily severs its head from its body. Next the top of the pupae case is forced open by an inflating pupa sac. The head is then reattached to the body and the fly floats to the top of the lake ("Mono's Alkali Fly…"). This scenario is, of course, contingent upon the fly living long enough to reach its adult stage. The Kuzedika were not the only ones to discover the tasty and nutritious nature of kutsavi – their word for fly larvae (Carle 31). The birds of Mono Lake eat both the pupa and the adult flies. Because they contain more fat and protein, most birds prefer alkali flies to brine shrimp. Birds on Mono gorge themselves by swallowing massive amounts of flies. Despite this fact, the insects are able to thrive through their sheer numbers, just like the brine flies. The adult flies have also adapted to their habitat in other ways. Each fly possesses small hairs that it uses to trap an air bubble around its body. The fly then uses this bubble as a source of oxygen to breathe when it travels below the surface of the water to consume algae or to lay eggs. They are able to walk down underwater rocks to do these tasks with the help of hooked claws attached to their feet ("Mono's Alkali Fly…").

The geology of Mono Lake makes it an ideal sanctuary for many birds, not only because it supplies them with a consistent and abundant source of food, but also because it makes safe nesting sites available to them. These refuges come in two forms: predator-free islands and tufa towers (Carle 15).

Paoha Island is located near the center of Mono Lake. Paoha, which means "Spirits of the Mist", is less than 2,000 years old (Dept. of Agriculture and USGS "Photos of Paoha and Negit…"). The island is composed primarily of lake sediments. These sedimentary layers were pushed up from the surrounding water as the result of a

growing magma chamber below it. On the north and east edges of the island there are signs of very recent volcanic activity. Craters and cooled lava flows may be no more than 150 to 280 years old, which is very young in terms of geological time (USGS Paoha caption). The island is so valuable to birds because it provides them with a safe place secluded from humans, coyotes, and other mammals (Carle 15).

Like Paoha, Negit Island offers asylum for the birds of Mono Lake. Unlike Paoha, Negit is completely composed of igneous rock (Sierragatewaymap.com Negit). This black island, which is smaller than Paoha, is a cinder cone. Negit Island's name means "Blue Winged Goose" (Dept. of Agriculture). It was also created less then 2,000 years ago, and parts of the island may be no more than 200 years old. Three different vents located at the tops of three parallel flows comprise Negit Island (USGS Negit caption).

Mono Lake's tufa towers are perhaps one of its most famous features. These mysterious formations are created by chemical processes similar to those that make stalagmites in caves. Two water sources, one filled with carbonates, the other with calcium, must be present. Mono Lake provides the carbonates and springs beneath the lake provide the calcium. When these two chemicals mix, they form the solid material calcium carbonate (Carle 20). The calcium carbonate, which is commonly known as limestone, precipitates out of the solution. As it accumulates over many years, it forms tufa ("Tufa Towers…"). This tufa is invaluable for birds, such as Violet-green swallows, as secure perching and nesting locations (Carle 26).

Tufa formations on Mono Lake

The geological conditions of Mono Lake have created a perfect niche for the over 300 species of birds that are found around the lake. Some birds visit Mono as a pit stop during long migrations for the plentiful food supply. Others nest on the islands and in the tufa ("Mono Basin Birds…"). Because over 100 species of birds rely on Mono Lake as a migratory rest stop, the Western Hemisphere Shorebird Reserve Network (WHSRN) has designated Mono Lake as an area of critical habitat ("Mono Basin Birds…").

One example of a bird species that relies on Mono Lake is the California gull. Like many other species of gulls, California gulls spend their winters near the shores of California. However, in March their reproductive instincts send many of these birds away from the coast (Hite 1). Because California gulls prefer inland nesting sites, Mono Lake is a very popular nesting location for them (Carle 15). Between 44,000 and 65,000 adults arrive to breed on Mono Lake ("Birds of the Basin..."). In fact, nine out of every ten California gulls found in the state are born on either Negit Island or Paoha Island. The islands are essential havens for the gulls' nests, protecting the eggs and chicks from coyotes and other land predators (Carle 15). The birds are at a particularly high risk of these dangers, since they nest on the ground (Hite 1).

California gulls also desire Mono Lake because it provides large amounts of easily accessible and reliable food (Carle 15, Hite 1). Unlike their fish-eating cousins,

California gulls rely on brine shrimp as their primary food staple. They have also been known to feed on cicadas from nearby trees, ground squirrels, tourist donations, and even Violet-green swallows (Hite 2).

Violet-green swallows are beautiful little birds that make their nests in the holes of tufa towers. Those that stay on Mono Lake feed primarily on alkali flies, catching the flies as they run down the shore with their mouths agape. Although they only stay on Mono until midsummer, these birds are an impressive sight to see (Carle 26). The back of a violet-green swallow is dark and glossy with both green and purple feathers. The underside of the swallow is white, as is part of its face (Peterson book 248). This bird has been described by ornithologists as "gregarious," and often travels in flocks. It mates in monogamous pairs and raises one brood a year (Alsop 49).

A violet green swallow perches on a tufa formation

Like violet-green swallows, the ospreys that inhabit Mono Lake also build their nests in tufa towers. Because ospreys are much larger, their nests are also much larger and are located at the tops of the tufa (Carle 57). Ospreys have dark brown backs with a purplish hue, a white and brown head, and a white underside (Alsop 152). Ospreys are fish-eating hawks with long, sharp beaks and large talons perfectly suited to impale their prey (Carle 57, 68). One might ask why fish-eating hawks are living on a fishless lake.

The ospreys of Mono Lake use the tufa for its nesting locations and feed on the fish from nearby Rush Creek and Grant Lake Reservoir (Carle 68). Both males and females incubate eggs and care for their young. Similar to the violet-green swallows, osprey couples are monogamous and raise one brood annually (Alsop 152).

Although phalaropes do not nest on Mono Lake, its existence and health is extremely important to the birds' survival. Mono Lake hosts over 140,000 phalaropes every summer. The Wilson's phalaropes arrive first from their nesting sites in Canada. These little birds double their weight from one to two ounces within a month. The red-necked phalaropes arrive later. Both species of phalaropes gain a great deal of weight very quickly. By spinning in tight circles at the water's edge, these birds have developed a way to stir up food from the bottom of the lake by creating a small whirlpool. Mono Lake supplies them with ample nourishment of alkali flies and brine shrimp that they need for their long journey to South America. The phalaropes spend about two months at Mono, then travel straight to their winter destination in the Southern Hemisphere. The birds depend upon the energy they receive from resting and dining at Mono, because they will make no other stops for 2000 miles. The phalaropes fly day and night for two days until they reach their destination (Carle 63-64).

A Wilson's phalarope, courtesy of Gallery Books

Phalaropes travel in flocks of several hundred, moving and turning in perfect unison like schools of fish (Carle 63). However, all phalaropes do not travel together. Shortly after they have laid their eggs, female phalaropes abandon their nests and head south. The male phalaropes stay behind to incubate and raise the young. Wilson's phalarope fathers leave Canada with the juveniles in mid-August. Male red-necked phalaropes leave their youths behind in July. The adolescent red-necked phalaropes head south in August and early September (Richards 60-63).

Eared-grebes are one of the most mysterious birds to visit Mono Lake. In the fall, they arrive from their nesting grounds in Canada 800,000 strong. These grebes time the flight perfectly so that they always depart and reach their destination at nighttime. Their secret arrivals and departures have never been observed and recorded by humans (Carle 82-83). Grebes have red eyes, which may help them see better when they are deep underwater (Carle 84). This adaptation may be very helpful to the grebes, which spend almost their whole lives on the water. In fact, the legs of a grebe are so far back on its body that it cannot even stand up on land (Carle 83). The legs are positioned like propellers to help the grebe swim. Its feet, which are lobed, open and close against the water to further aid the swimming process. When a grebe wishes to submerge below the water, it has adapted the ability to either plunge down or sink by compressing the air trapped in its feathers (*Video Guide…*).

Ornithologists are uncertain about how many eared-grebes are alive in the world today. Some estimate that as many as twenty-five percent of the entire population may visit Mono at once (Carle 83). They gorge themselves on brine shrimp until cold autumn temperatures kill the crustaceans off. In this month's time, they will double and

sometimes nearly even triple their weight (Carle 83 and "Birds of the Basin…"). Then one night the eared-grebes fly away to Central America, arriving as they did at Mono, in the darkness (Carle 83). They will make this 3,000 mile journey in just three days ("Birds of the Basin…").

Only a very small percentage of the many bird species on Mono Lake have been mentioned. Mono Lake is a unique and productive habitat, but it is also a fragile one. Since 1941, the city of Los Angeles has been diverting water away from the streams that feed Mono Lake. Until restrictions were placed in 1983, vast amounts of water were being taken away from the Mono Basin and sent to the people of LA. This caused the lake level to fall drastically. Toxic dust storms formed, jeopardizing both humans and wildlife. The evaporating lake threatened to become too saline to support brine shrimp and alkali flies, which thus endangered all of the birds on Mono Lake. A land bridge formed from the shore to Negit Island, making the bird nests susceptible to coyotes. Fortunately, restrictions on water diversion have been enacted with the help of the Mono Lake Committee, an environmentalist group. These restrictions are protecting the lake, for now (McQuilkin). The geological forces that have shaped Mono Lake must be allowed to run their natural course if the lake's ecosystem is to endure. After all, these geological forces are responsible for Mono Lake's unique biology.

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