Great Salt Lake

Great Salt Lake is the largest lake west of the Mississippi River. It is one of the saltiest bodies of water in the world, and a remnant of the ancient freshwater Lake Bonneville. At the average level (4,200 ft above sea level) Great Salt Lake is 75 miles long and 35 miles wide at its widest point. The lake is quite shallow, with an average depth of only 14 feet. At its greatest depth the lake is approximately 34 feet deep.

The lake is located at the bottom of a flat basin (the Great Basin). A slight rise in the level of the lake results in a significant increase in the area of the lake. At its average level of 4,200 feet, the area of the lake is 1,700 square miles. In 1987 when the lake was at its highest level of 4,211.85, the surface area increased to 2,400. At its historic low in 1963 (4,191 ft) the lake was half the size it reached in 1987. Since 1849 when the first scientific measurement of the lake was taken, the shoreline has varied by as much as 15 miles!

There are eight official islands in Great Salt Lake. During low lake levels, some of the islands actually become peninsulas. The designation of islands occurred during the high water level of 1875, when eight islands were exposed. The islands range in size from 28,000 acre Antelope Island, to 22 acre Hat Island. The islands of Great Salt Lake will be discussed in greater detail later.

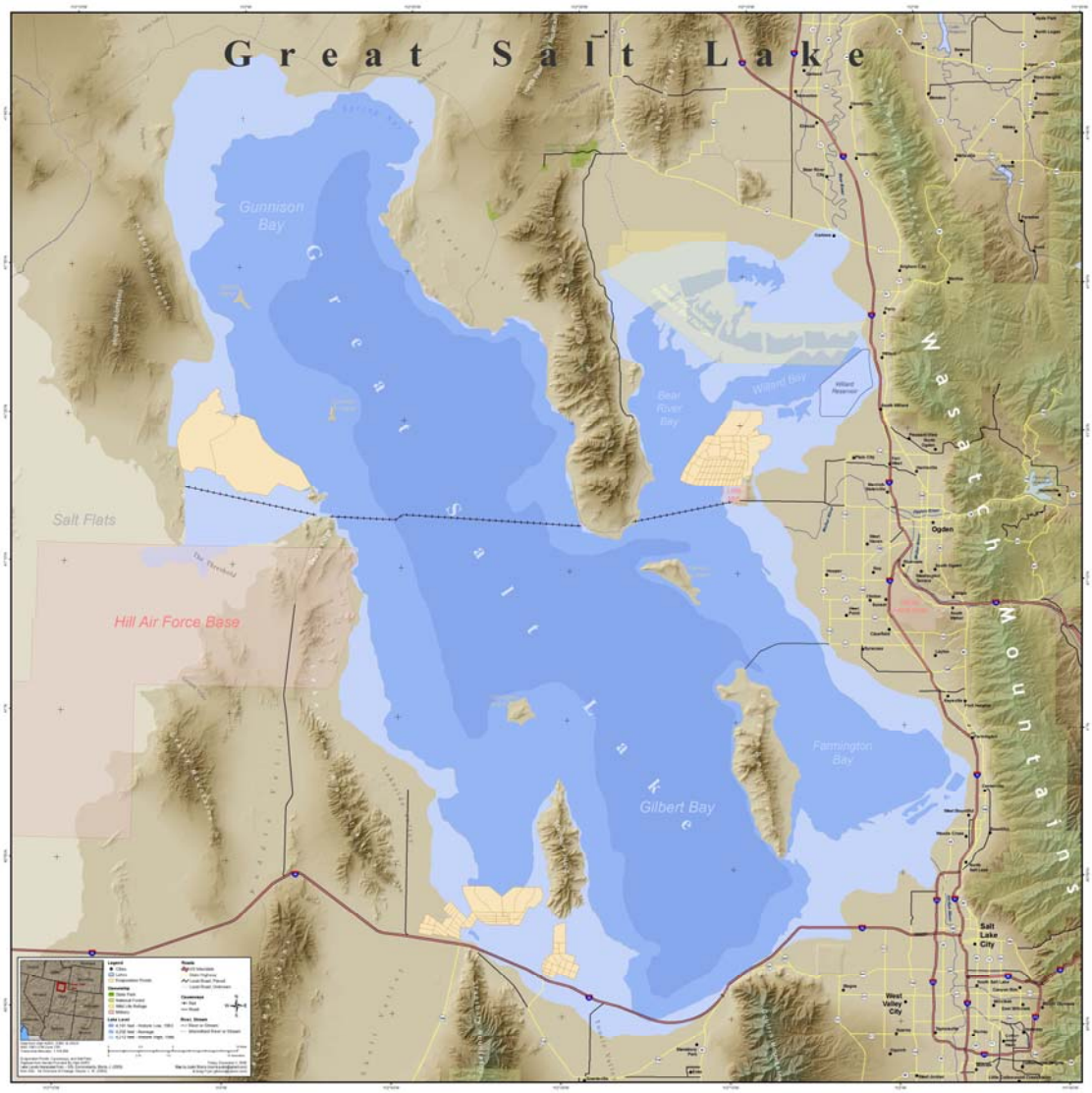
Why is the Lake Salty?

Great Salt Lake is salty because it is a terminal lake, meaning that it does not have an outlet. Four rivers, the Bear, Jordan, Ogden and Weber feed into the lake. They provide a constant supply of fresh water, and carry with them dissolved and suspended minerals (such as salt), sand, and rock particles. These minerals and sand are deposited in the lake. The only way water leaves the lake is through evaporation. As water evaporates, minerals are left behind to accumulate. It is estimated that more than two million tons of salt are brought into the lake each year. There is a constant fluctuation in lake level, depending on snow run off, precipitation and evaporation. The salinity of the lake fluctuates with the level of the lake.

Great Salt Lake has ranged in salinity from about 5 percent to 27 percent over the past 22 years. This is two to nine times saltier than the ocean's 3 percent. At present Farmington Bay is approximately 5 percent salt, while the North arm is 26 percent and the South arm is 14 percent.

The Great Salt Lake is broken into three distinct areas.

Farmington Bay– this area of the lake is between the north and south causeways of Antelope Island.
Gilbert Bay– this section of the lake is north of Antelope Island and south of the railroad causeway. Most of the lake's recreation takes place in the Gilbert Bay section.
Gunnison Bay– is the North Arm of the Great Salt Lake. It is located north of the railroad causeway and west of the Promontory Mountains. No fresh water rivers empty into this part of the lake. The railroad causeway allows little mixing with the areas of the lake that do receive freshwater, thus causing the North Arm to be much saltier than the rest of the lake.



Map by Justin Morris (morris.justin@gmail.com) and Greg Fryer (gfnoma@yahoo.com). Data from Utah AGRC, ESRI, & USGS

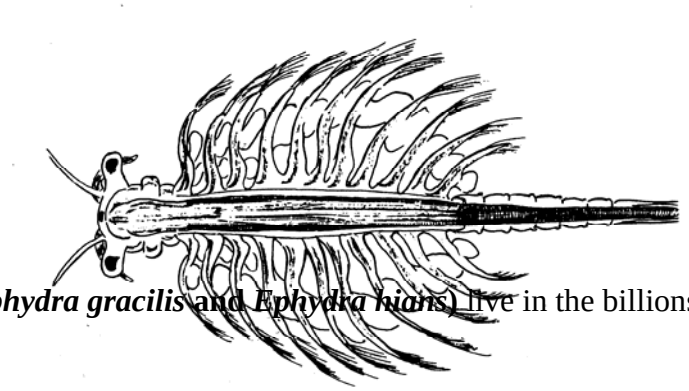
Life in the Lake

Many view Great Salt Lake as a barren and desolate "dead sea." This is far from true. Great Salt Lake is thriving with life and activity. The lake and its surroundings form complex ecosystems that are distinct from one another yet interrelated. The marsh and salt flat ecosystems depend on the lake ecosystem. These ecosystems support a large number of species.

Few species can survive in Great Salt Lake itself. Algae and bacteria grow abundantly in the saline waters. They provide food for brine shrimp and brine flies, which also have an amazing tolerance for salt. The algae are microscopic, but are visible in colonies. They make food through photosynthesis and grow abundantly during the summer. They produce spores and overwinter in this form. There are several types of algae in Great Salt Lake, the most common are two species of *Dunaliella* (green algae). *Dunaliella salina* is found in the more saline waters of the north arm. This species produces beta-carotene in large quantities, turning the water quite red. *Dunaliella virdis* is found in the less saline south arm, and casts a green look to the water.

Twenty-nine species of bacteria grow in Great Salt Lake. Bacteria are a food source for brine shrimp, but play another important role. Bacteria act as an organic recycler. It causes the decay in dead algae, animals, and organic wastes.

Brine shrimp (*Artemia salina*) are small arthropods (animals with an exoskeleton, segmented body and jointed appendages) about 1/4 inch long. They are an important food source for migratory and shoreline birds and insects. They are found in high concentrations in the lake from April to September. Brine shrimp reproduce every two or three days. Eggs can be hatched within the female, who then gives birth to live shrimp. Brine shrimp cannot survive when the water gets cold for winter. In the fall brine shrimp lay trillions of eggs that float on the surface of the lake until spring when it is warm enough to hatch. The eggs are so small that 150 eggs can fit on the head of a pin. Commercial harvesting of the eggs is a multi-million dollar industry. Dried brine shrimp eggs can lay dormant for many years and hatch when placed in salt water. Shrimp eat huge amounts of algae, keeping the algae population in check.

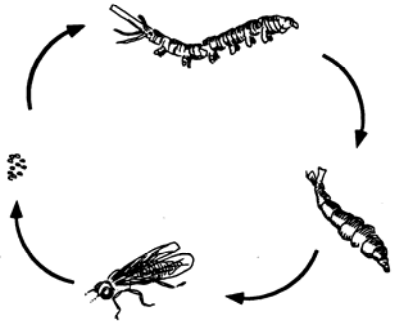


Brine flies (*Ephydra gracilis* and *Ephydra hians*) live in the billions along the shores of

Great Salt Lake. They grow to 1/4 inch long and live for three to four days along the shore line. Eggs are laid in the lake about 100 at a time. They hatch into worm-like larvae. The larvae develop into a pupal, or cocoon state. Adults emerge from the pupal case in an air bubble which pops the young adult to the surface of the water. Adult brine flies rub a waxy substance from their abdomen over their bodies making them waterproof. Because three stages of the flies' life cycle are aquatic, they are completely dependent on the salty waters of the Great Salt Lake.

Brine flies eat algae and organic matter. They fly in swarms on the beaches, yet they don't bite and seldom land on people. Brine flies are a major food source for millions of birds.

Brine flies and brine shrimp are **keystone species,** meaning they have a particularly large effect on the ecosystem. The removal of these two species would change the basic nature of the ecological community. Brine shrimp and brine flies make life possible on and in Great Salt Lake.



The **marshes** of Great Salt Lake are found where streams and natural springs enter the lake. The marshes are naturally brackish, meaning they are slightly salty. Some marshes have been diked off and are fresh water. Marshes support an amazing number of species. A complex community of microscopic organisms, algae, small crustaceans, insects, bulrush, spikerush, cattail and other species thrive in the marshes. Thousands of birds find food or nest in the marshes.

Commonly found birds are avocets, heron, pelicans, ducks, and black-necked stilts. Fish such as chub and carp are sometimes found in marshes, as well as snakes, frogs and muskrats. Water in the marshes gets saltier the closer to the lake. Only highly salt tolerant plants live in the saltier parts of the marshes.

The **salt flats** surrounding the lake and are often flooded by the fluctuating lake level. Low areas, called playas, collect water when it floods. Salts are left behind in the soil as the water evaporates. Tiger beetles are one of the few species that are able to survive in

this harsh environment. They eat brine flies that blow away from the lake.

Haolphytes are salt tolerant plants that grow near the salt flats. Pickleweed and salt grass are halophytes that have adapted to regulate concentrations of salts. On the outer edges of the salt flats, where precipitation washes much of the salt away, greasewood and shadscale are larger dominating plants.

Halophytes have different ways of dealing with salt.

> **Pickleweed** is one of only a few plants that can tolerate salty ground – up to 6% salinity, or about twice that of ocean water. The benefit of having achieved this unusual adaptation is that it now finds itself with very little competition. Salt is toxic to most plants, but a hint as to how pickleweed solves that problem is found in its succulence – the thick, spongy shape of its stems and leaves. After the water, salt and all, is drawn up from the ground by its roots, the plant immediately begins separating the salt it doesn't want from the water it does. The salt gets stored away inside of tiny chambers within the plant. The sponginess we feel when we squeeze it is all those spaces inside filled with either stored water or discarded salt. Pickleweed is edible; the best time to eat pickleweed is in May or June, before it has accumulated a summer's worth of salt. The plant turns red in fall, spreading its seeds for the next year.
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> **Greasewood** is the most common shrub found near Great Salt Lake. It has spiny branches and small, narrow sausage-shaped succulent leaves that are filled with salt solution. When the leaves cannot absorb any more salt, they die and fall off, ridding the plant of the excess salt. Greasewood grows in an area known as the saline plain, which is above the area of the salt playa where pickleweed, inkweed, iodine bush, and salt grass are found.
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> **Shadscale**. Scattered among the greasewood is shadscale, a small spiny shrub with rounded silvery leaves. The leaves have a thick covering of special salt-secreting hairs. When the hairs get full of salt solution they explode, covering the leaf with shiny white coating of salt crystals.
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> **Iodine Bush** is a low-growing, straggly branching woody shrub that has round, succulent, gray-green jointed stems. The branches are alternate, and have succulent green segments arranged in a chain, like miniature sausages. Its name was probably given to this plant because when you crush its leaves, a brown color

emerges. It can tolerate salt concentrations of 3-4% but, like the other halophytes, it prefers less salt. Iodine Bush deals with saline soils in much the same way pickleweed does, by separating the salt from the water and storing the salt within the many cell vacuoles.

Salt Grass. This grass has straight stems with leaves that taper to a sharp point. It is a perennial grass that has long underground rootstocks that run near the surface of the ground. The grass stems grow from this rootstock and appear in long straight lines. Salt grass needs a good supply of water in order to survive. It can grow in salty soils because it secretes salt crystals through special glands on the surface of the leaves.

Oolitic Sand

A unique feature of the shorelines and sediments of Great Salt Lake is oolitic sand. Typical sand is formed from fragmented rock particles. Oolitic sand, however, is formed by concentric layers of aragonite (a form of calcium carbonate $CaCO_3$) coating a mineral grain or brine shrimp fecal pellet. This is similar to how a pearl is formed. Ooids refer to the egg shaped grains making up oolitic sand. The shape of the ooids gives the beaches a slippery feel. Oolitic sand is often used in flower drying because it is light weight and doesn't smash the flower petals.

Calcium is abundant in Great Salt Lake because of nearby limestone rocks. As a constant supply of dissolved calcium is brought into the lake, the water easily reaches its saturation point and calcium begins to precipitate out. The precipitate forms around a nucleus, such as a mineral grain or brine shrimp fecal pellet. The grains are rolled around the lake floor by the agitation of the lake. Aragonite continues to precipitate, forming concentric layers around the nucleus as it rolls around the lake bottom.

Oolitic sand is also found on some beaches in Indonesia, the Persian Gulf, the east coast of Florida, and in the Bahamas. Conditions conducive to oolitic sand formation are: ample amounts of calcium, shallow warm water, and lots of wave action to agitate the water. Calcium precipitates as water is warmed. This could explain the marble sized ooids in the Bahamas, locally called "grape stones."

Lake Bonneville

Lake Bonneville was created by a series of geologic events. Eighteen million years ago, the continental crust underlying much of the western United States was stretching in an east-west direction. The stretching caused rocks on the Earth's crust to fracture along faults, causing uplift. The area between these faults sank while the crust continued to stretch. The result: alternating parallel valleys (basins) and mountains (ranges). The continual stretching of the valleys and the deposition of sediments from eroded mountains, caused valleys to be filled in, forming flat-bottomed basins.

A series of volcanic eruption in what is now southern Idaho also played a role in the formation of Lake Bonneville. The lava from these volcanic eruptions diverted the course of the Bear River. About 50,000 years ago the river began flowing southward into western Utah through Cache Valley into the Great Basin. By 30,000 years ago, the diversion was complete, sending larger amounts of water into the basin.

The climate at this time was much cooler and wetter than it is today because it was during the Wisconsin Ice Age. Increased rainfall and lower rates of evaporation resulted. In the mountains, larger amounts than normal of snowfall and the cooler weather caused glaciers to form on the higher peaks. These glaciers melted seasonally, adding to water entering the basin. Several freshwater lakes had formed in the Great Basin area. They gradually deepened until around 25,000 years ago, when they merged forming Lake Bonneville.

Lake Bonneville had its ups and downs. The lake is believed to have climbed to the rim of the Basin then dried up completely two or three times. This was caused by periods of abundant precipitation followed by periods of severe drought, the result of tremendous climatic changes.[2] (Miller, Past and Present) At its highest point, Lake Bonneville was 1,200 feet deep and covered 20,000 square miles. At this depth, the peaks of the mountains west of the present Great Salt Lake, were islands. Of the islands of Great Salt Lake, only the highest peak of Antelope Island was above water. At Lake Bonneville's highest level, Salt Lake City would a have been under 850 feet of water, and cities on Great Salt Lake's shore such as Syracuse would be under 1,000 feet. Lake Bonneville was 345 miles long and 145 miles wide. It covered several counties in Utah, and extended into Idaho and Nevada.

Around 14,500 years ago, while the lake was at its highest, the waters of the lake broke through the rim at Red Rock Pass (present day southern Idaho). The level of the lake was lowered by 350 feet in less than a year. The lake remained at this level, known as the

Provo level, for 1000 years. The climate warmed and became arid once again, and the lake level had fallen 1,000 feet by 12,000 years ago. It is said that the lake became saline about 10,000 years ago as water continued to evaporate.

The most conspicuous reminders of Lake Bonneville are the terraces etched by its ancient shoreline. These terraces can be easily seen along the Wasatch Front. Distinct terraces were formed along the mountain side from the constant wave action of the lake. The most distinct terraces are the Provo and the Bonneville. At the Provo and Bonneville lake levels, the lake was a threshold lake, meaning that it had an outlet to the sea. This resulted in a more stable shoreline. At the Gilbert and Stansbury lake levels the lake was a terminal lake, meaning there was no outlet. The level of the lake fluctuated with the seasons. The terraces are relatively flat areas which follow a contour line. The edges of the terraces are often comprised of boulder fields, as wave action from Lake Bonneville transported finer sediments away leaving large boulders exposed.

Grove Karl Gilbert, geologist of the Wheeler Survey, was the first to thoroughly survey the ancient shoreline of Lake Bonneville. He and his men mapped the terraces and were able to tell the extent of the ancient lake. It was actually Gilbert that gave the lake the name Lake Bonneville. He named it in honor of Captain B. L. E. Bonneville, whom he assumed had explored Great Salt Lake in 1833. Actually, Captain Bonneville was in the West for three years, but never came to Great Salt Lake.

Terraces of Lake Bonneville

Stansbury Level: This terrace was created as Lake Bonneville was rising from its predecessor (a small pre-ice age saline lake). It's shoreline can be seen about 300 feet above current lake level (4500 feet). It was formed as the lake (a basin lake at the time) fluctuated near this level for nearly 3,000 years (from 20,000 to 23,000 years ago). The Stansbury Terrace is indistinct in many places as it was formed by a basin lake and is the oldest of the Lake Bonneville Terraces.

Bonneville Level: This is the most dramatic of the terraces. It was formed as Lake Bonneville reached its highest level (5240 feet) about a thousand feet above the current lake level. At this point Lake Bonneville obtained an outlet to the sea and became a threshold lake. Lake Bonneville held this level (off and on) for 1500 years until the flood at Red Rock Pass in Idaho.

Provo Level: The second highest terrace is also the second most distinct. It formed after

Lake Bonneville dropped 350 feet as a result of the flood at Red Rock Pass. The lake held this level for about 1000 years until it began the descent to current lake levels due to a warmer, drier climate.

Gilbert Terrace: This level formed around 11,000 years ago as the lake fluctuated near this level for several hundred years. It is found 50 feet above the current lake level. The Gilbert Terrace is indistinct and is hard to find in many places on the island.

Lake's Affect on the Mainland

Great Salt Lake has a great moderating effect on the weather of the Salt Lake Valley. Temperature ranges would be much more extreme (colder in the winter, hotter in the summer) without the influence of the lake. Like any large body of water, the lake holds heat for long periods of time. During colder months, the lake releases heat that was absorbed in the warmer months.

"**Lake Effect**" storms are notorious in the Salt Lake Valley. These storms usually develop when a cold air mass moves in above the warmer Great Salt Lake. As the warmer, moisture-laden air rises, it meets with the cold air mass causing the moisture to condense and fall as heavy precipitation. Lake effect doubled with a naturally intense storm, may cause some interesting precipitation levels on the Wasatch Front. Salt Lake or Toole may get two feet of snow while Ogden gets a couple of inches and Provo receives none.

As with the ocean and other large bodies of water, water heats up slower than land, but it also gives off heat slower. The water remains relatively stable while the land around it fluctuates in temperature greatly. During the day, when the land is warm and the water is cooler, the warm air above the land rises and the cool air above the lake moves in under the warm air on the land. This causes an inland breeze. At night the land cools off rapidly while the lake retains heat. The warm air over the lake rises and the cool air over the land moves in under it. This results in the seaward breeze in the evening.

Buoyancy of Great Salt Lake Water

Salt dissolved in Great Salt Lake increases the density of the water. Buoyancy is a

function of density. It is the ability for an object to be uplifted, or float, because of the greater density of the water. The higher the density of the water, the greater the buoyancy. This gives the lake its famous "float like a cork" quality.

The dense water of Great Salt Lake causes waves to wreak havoc on shorelines and man-made structures. As storms brew, the waves on the lake hit with much more force than in fresh water. Being on the lake in a storm can be a terrifying experience.

Islands of the Great Salt Lake

Antelope Island is the largest island in Great Salt Lake. Its 26,000 acres is home to a wide variety of wildlife. It was named by John C. Fremont for the abundant antelope (pronghorn) found on the island. The island is now most famous for its large bison herd. Forty natural springs provide needed water for wildlife and also create freshwater wetlands on the fringes of the island. Large numbers of birds rely on the island for nesting and breeding. The island was first inhabited by Native Americans, then by pioneers and ranchers. The island is now a State Park, and has some of the most spectacular views of Great Salt Lake.

Fremont Island
Artifacts of Native Americans were found on Fremont Island, suggesting that they resided on this island as well. Fremont Island, 2,945 acres, was named in honor of John C. Fremont who performed the first scientific study of Great Salt Lake. He and Kit Carson surveyed the lake in their "India Rubber" boat. Standing on a high peak on Fremont Island, Fremont was able to perform triangulations and draw a map of the lake. In the mean time Kit Carson chiseled a cross on a peculiar rock near the summit.

Fremont Island was stocked with sheep and cattle in 1859 by the Miller brothers from Farmington. They would visit the island periodically to clean the spring and check on the animals. Needing fresh air because of his tuberculosis, Judge U. J. Wenner and his family made their home on Fremont Island from 1884- 1891.

The most intriguing story of Fremont Island is that of Jean Baptiste. Jean Baptiste, a convicted grave robber, was exiled to Fremont Island in 1862. He had reportedly robbed over 300 graves in the Salt Lake City Cemetery, where he was employed as a grave digger. Unable to protect him from the public in jail, it was decided that he be exiled. Several weeks after transporting him to the island, the Millers made a routine check of the island. Baptiste was gone. Apparently he had torn planks from a cabin to make a raft and escaped to the mainland. He was never seen in the area again. Area folklore says

that Baptiste returned to the island while Judge Wenner, the judge that convicted him, lived there.

Fremont Island is privately owned and not accessible to the public.

Stansbury Island
Stansbury Island, which is really a peninsula most of the time, is administered by the Bureau of Land Management and private ownership. The island is 22,314 acres with partial public access. A bike trail on Stansbury can be biked (or hiked) year round. Stansbury Island has pictographs showing evidence of Native American activity on the island. The island was named for Howard Stansbury, who headed the Stansbury Survey in 1849-1850.

Hat/ Bird Island
Hat, or Bird Island is managed by Utah Division of Wildlife Resources. It is the smallest recognized island with only 22 acres. It is protected as a Gull and Heron rookery. There is no public access to the island.

Dolphin Island
Dolphin Island, named for it dolphin shape, is a 60 acre island accessible to the public from the west shore of the Great Salt Lake. It is sovereign land and is located in the North Arm of the lake. When the lake falls to 4,198 feet the island becomes a peninsula.

Gunnison Island
Gunnison Island is also managed by Utah Division of Wildlife Resources. It is one of the largest American White Pelican rookeries in the US. Up to 18,000 pelicans breed each year on the island. Adult pelicans will fly as far as Utah Lake to catch fish to feed themselves and their young. They sacrifice closeness to a food supply for the protection the lake gives them from predators. It also is home to numerous other birds. The island is 163 acres with no public access allowed. This island was once unsuccessfully homesteaded.

Carrington Island
Carrington Island was named by Captain Stansbury in honor of Albert Carrington, a member of the Mormon community, who acted as an assistant on his survey. The island is managed by the BLM and is accessible to the public by boat. During World War II, the island was used for aerial bombing practice. This island was also unsuccessfully homesteaded.

Cub Island

The tiny one acre island lies just to the north of Gunnison Island. It is BLM. land and public access is allowed, but very difficult.

Other small islands not considered "official island" are: Egg Island, Badger Island, White Rock Island, and Black Rock Island. These islands are accessible to the public, but those with Gull rookeries are closed during the breeding season (April 1– July 1).

Commonly Asked Questions

How deep is the lake?

From Utah Department of Natural Resources, Division of Water Resources, 1988

Average: 14 feet

Deepest: 34-40 feet

Around the causeway: 4-5

What is the temperature of the lake?

70° in the summer

Why is Great Salt Lake Salty?

There are no outlets in the Great Salt Lake. Rivers flow in, but the only way water leaves the lake is through evaporation. Minerals (such as salt) are left behind to accumulate.

How Salty is Great Salt Lake?

Farmington Bay is 5%, the South Arm is 8-15%, and the North Arm is 28%. The differences are due to fresh water flowing into the southern part of the lake and not being able to flow freely into the North Arm (due to the railroad causeway).

How big is Great Salt Lake?

At its average level of 4,200 above sea level, the lake is 75 miles long and 35 mile wide at its widest point.

Are there fish in Great Salt Lake?

No. Brine shrimp and brine flies live in Great Salt Lake, and feed off of algae.

What makes the lake stink?

The unpleasant odor is caused by decaying plant and animal material (algae, brine shrimp and brine flies) in the shallow water and around the lake's shores, especially in Farmington Bay.

What animals live on Antelope Island?

Bison (700), mule deer (500), pronghorn antelope (230), California big horn sheep (120), coyotes, jack rabbits, cottontail rabbits, badgers, bobcats, kangaroo rats, mice, red fox, chuckar partridge, lizards, and snakes (gopher, blue racer, garter– none of which are poisonous).

Why are there so many birds?

Great Salt Lake is one of the most important avian breeding and migratory staging areas in the United States. The birds gorge on the plentiful brine shrimp and brine flies.

Are off-highway vehicles allowed on the island?

No!

Are dogs allowed on the island?

Yes. Dogs are allowed on the island, but they are to be kept on a leash at all times. Dogs are **not** allowed on the Frary Peak trail.

Are horses allowed on the island?

Yes, horses can be ridden on designated trails and anywhere on the North 2,000 acres of the island (except the beach and Bridger Bay Campground).

Is cross-country skiing allowed on the island?

Yes, but there is seldom enough snow to ski.

Are snowmobiles allowed on the island?

No! Wildlife use the north end of the island for winter grazing, creating a potential conflict with snowmobiles.

Are there boat rides available from the island?

Yes, through Gonzo Boat Rentals & Tours. 801-698-6288. gonzofun.DG@gmail.com

Is there camping on Antelope Island?

Yes. Antelope Island has two campgrounds. Bridger Bay has 26 paved pull-outs, grills, picnic tables and pit toilets. On the beach (1/4 mile from Bridger Bay) are flush toilets and showers. Reservation for Bridger Bay can be made by calling (800) 322-3770. White Rock Bay has 5 group-use camping sites with pit toilets, picnic tables, and grills. Reservations may be made by calling (801) 773-2941.

What is the Fielding Garr Ranch House?

It is the oldest continually inhabited Anglo-built home in the state of Utah. The ranch complex consists of: an adobe house, a bunk house, spring house, sheep shearing barn, blacksmith shop, and corrals.