U.S. Department of the Interior / U.S. Geological Survey

The Great Salt Lake

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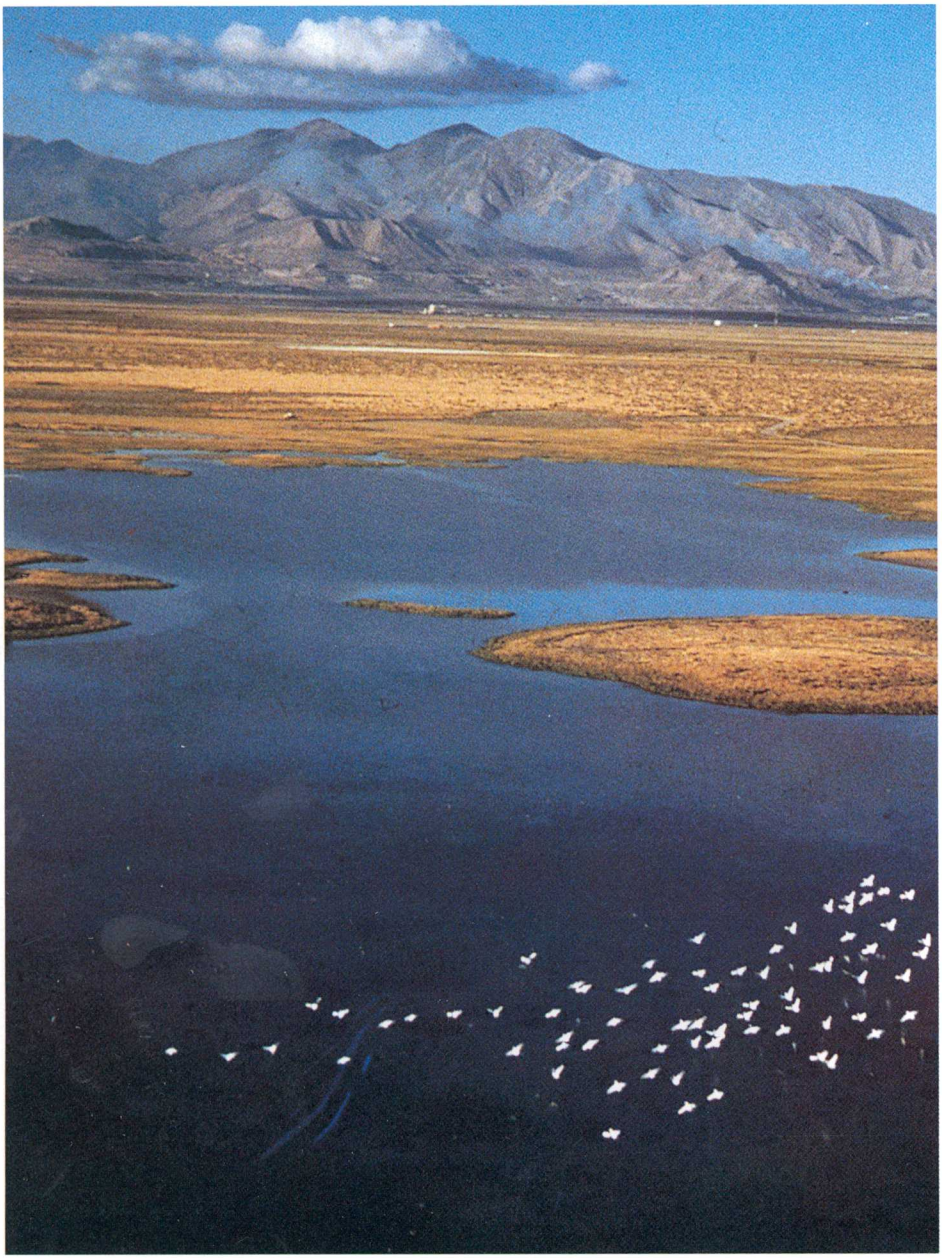
The Great Salt Lake

by W.R. Hassibe and W.G. Keck



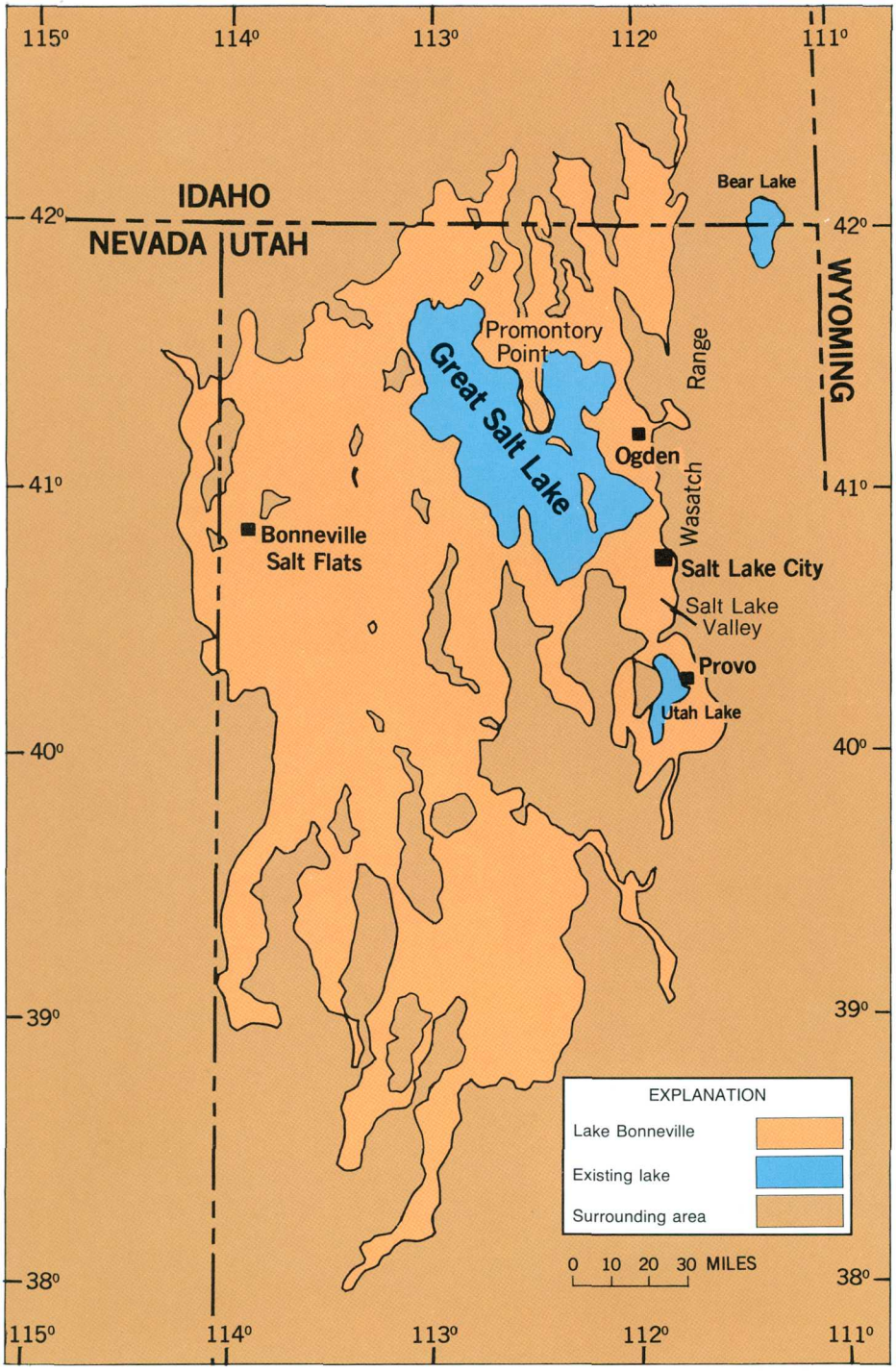
Pelicans in flight over marsh area at southern end of Great Salt Lake *(photo by Glen Collett).*

The western part of the conterminous United States is often thought of as being a desert without any large bodies of water. In the desert area of western Utah, however, lies Great Salt Lake, which in 1986 covered approximately 2,300 square miles and contained 30 million acre-feet of water (an acre-foot is the amount of water necessary to cover 1 acre of land with water 1 foot in depth or about 326,000 gallons). To emphasize its size, the Great Salt Lake is the largest lake west of the Mississippi River, larger than the states of Rhode Island and Delaware.

How the Great Salt Lake Was Created

The origin of Great Salt Lake can be traced back to ancient Lake Bonneville, which covered much of western Utah and small parts of Idaho and Nevada during the Pleistocene Epoch (commonly known as the Great Ice Age) most recently between 23,000 and 12,000 years ago. Prior to the Ice Age, faulting (massive shifting of rocks) and mountain building gave a distinctive physical appearance of alternating mountain ranges and basins to this region of the Western United States. In the warmer and drier period that has followed the Ice Age, Lake Bonneville receded; the Great Salt Lake as it is seen today is a descendant of that ancient lake. The mountains that surround the lake still bear the shoreline markings of Lake Bonneville, which give the onlooker a visual appreciation of the depth and extent of the ancient lake.

Map of Lake Bonneville with Great Salt Lake at present size. ➔


115°
114°
113°
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42°
41°
40°
39°
38°
IDAHO
NEVADA
UTAH
WYOMING
Bear Lake
Promontory Point
Great Salt Lake
Range
Wasatch
Ogden
Bonneville Salt Flats
Salt Lake City
Salt Lake Valley
Provo
Utah Lake
EXPLANATION
Lake Bonneville
Existing lake
Surrounding area
0 10 20 30 MILES

Geographic Setting of the Lake

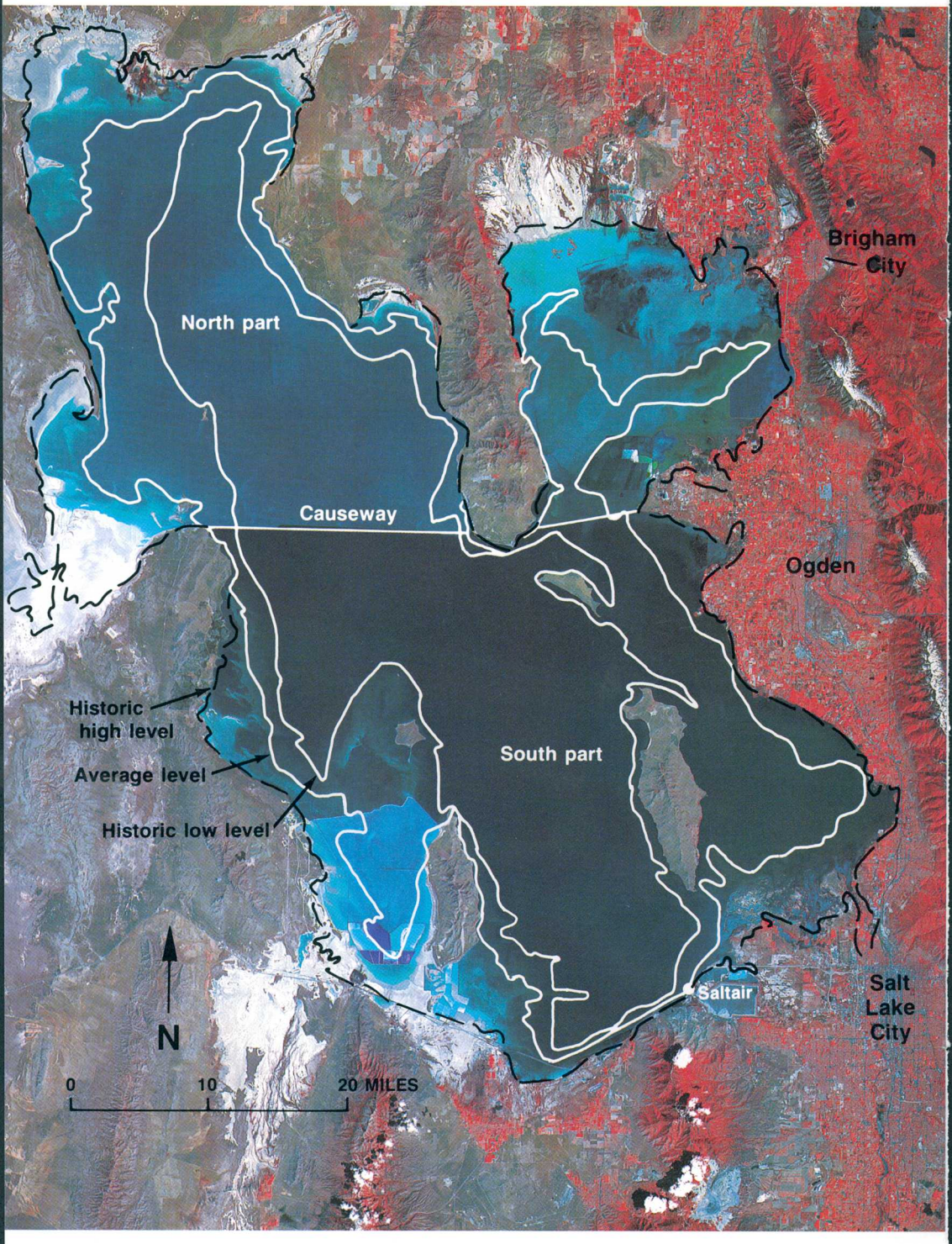
Great Salt Lake lies within the physical region of the Western United States known as the Great Basin; the lake itself is in one of the lowest parts of this basin, approximately 4,200 feet above sea level. Because Great Salt Lake is in such a low area within the basin, it is a terminal lake—it has no outlet to the sea. The lake is approximately 70 miles long and 30 miles wide, with a maximum depth of 43 feet when the lake was at an elevation of 4,209.25 feet.

Reference map of Utah and the surrounding States.

East of the lake lies the Wasatch Range, an imposing mountain chain, which reaches elevations of over 11,000 feet. These mountains contribute significantly to the inflow of water into Great Salt Lake. The three major population centers in Utah—Salt Lake City, Ogden, and Provo—lie at the base of the Wasatch Range.

West of the lake is the Great Salt Lake Desert, a flat expanse that is nearly barren of vegetation. It is in this desert that the Bonneville Salt Flats are located. This area was once flooded by ancient Lake Bonneville; the salt crust, in part a product of the lake's desiccation (drying up process) during thousands of years, has made the Salt Flats a natural setting for numerous attempts to set land-speed records.

View to the east, with the Wasatch Range in background, shows terraces of former Lake Bonneville *(photo by Robert Miller).*


Brigham City
North part
Causeway
Ogden
Historic high level
Average level
Historic low level
South part
Saltair
Salt Lake City
N
0
10
20 MILES

Why Great Salt Lake Is Unique

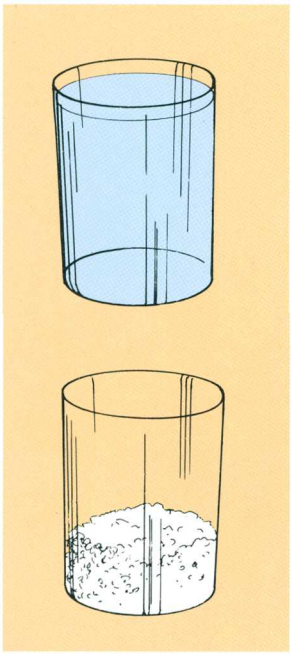
The combination of size and salt content makes Great Salt Lake unique among lakes in the Western Hemisphere.

The reason the lake is salty

As water flows over or moves beneath the Earth's surface, it dissolves minerals from the soils and rocks. The streams that originate in the Wasatch Range and other nearby mountains all flow into Great Salt Lake, bringing in water with varying percentages of dissolved minerals. Since Great Salt Lake has no outlet, all the minerals from these tributaries remain within the lake. It is estimated that more than 2 million tons of minerals are added to the lake each year; in 1986, the lake had a dissolved mineral content of 4-5 billion tons. These figures vary as the salinity of the lake fluctuates.

Great Salt Lake is one of the saltiest bodies of water in the world. Only the Dead Sea, which forms part of the boundary between Israel and Jordan, has a higher salt content than the Great Salt Lake. The percentage of salt in the waters of Great Salt Lake varies depending on the level of the lake—when the lake's level is low, it is more salty than when it is high. Percentages of salts as great as 27 percent have been found in the lake, which make it about 8 times as salty as sea water. This high mineral content gives the water its buoyancy and allows swimmers to float without fear of sinking. This high salinity, however, also prevents most aquatic life forms from existing in the lake waters and has been a key

Landsat thematic mapper image of Great Salt Lake, Utah. The lake was imaged on June 25 and July 2, 1984, during two passes of the Landsat satellite. The southern part of the lake crested at 4,209.25 feet on July 1, 1984. The level is within 0.1 foot of the peak as shown on the image. The satellite image is capable of delineating the shoreline more completely than ground surveying or aerial photographic methods. The southern and northern parts of the lake are separated by a causeway, producing great differences in water quality in the two halves of the lake and thus differences in the color of the water.



Glass showing water taken from the lake and then the remaining salts after evaporation.

factor in the lack of overall development of the lake's recreational potential. In 1986 when the lake was at a historic high level, the salinity was only about 5 percent. At that salinity, the famed buoyancy was no longer present.

Why the lake level fluctuates

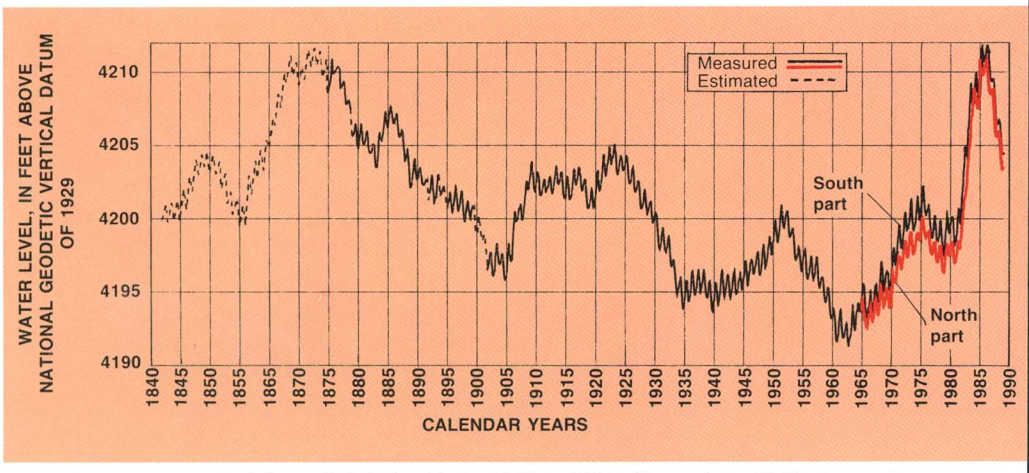
Water-level fluctuations of Great Salt Lake are a subject of concern and interest to local planners, environmentalists, industries along the shore, governmental officials, and the general public. As shown by the chart on page 9, the lake level has varied considerably since 1847, the start of the lake's historical records.

A comparison between the amount of water entering the lake versus the amount removed shows why the lake level is so variable. The water entering the lake consists mainly of inflow from the Bear, Weber, and Jordan Rivers, and other smaller surface streams. Precipitation adds about half as much as the surface inflow, while ground-water inflow contributes a small amount of water.

The lake loses water only by evaporation; water evaporates from the lake surface and from evaporation ponds into which lake water has been pumped for mineral production. As long as inflow exceeds evaporation, the lake level will rise; should either the inflow decrease or the evaporation increase, the lake level will decline. Due to the shallowness, a small change in the water depth results in a large change in the area flooded. Hence, the position of the shoreline is extremely variable.

The lake might be compared to a small pond. If the winter is moderately wet and the summer is not excessively warm, the pond will probably remain the same size. On the other hand, if the winter and spring are dry and the summer is hot, the level of the water will probably drop. In some cases, such as after a prolonged drought, the pond may dry up completely. This is how the Great Salt Lake fluctuates, although on a much grander scale.

Will Great Salt Lake dry up completely? Or will it expand and flood the nearby parts of Salt Lake City? A prolonged period of wet weather in 1982-86 did indeed cause the lake to flood parts of Salt Lake City and to threaten the transcontinental railroad and highways that run along the shores of the lake. A lengthy dry period would also greatly alter the size of the lake.



Changes of water level of Great Salt Lake, Utah, 1847 to 1990. Since about 1966, the northern and southern parts of the lake have differed in water level, the data for which are shown in black for the southern part and red for the northern part.

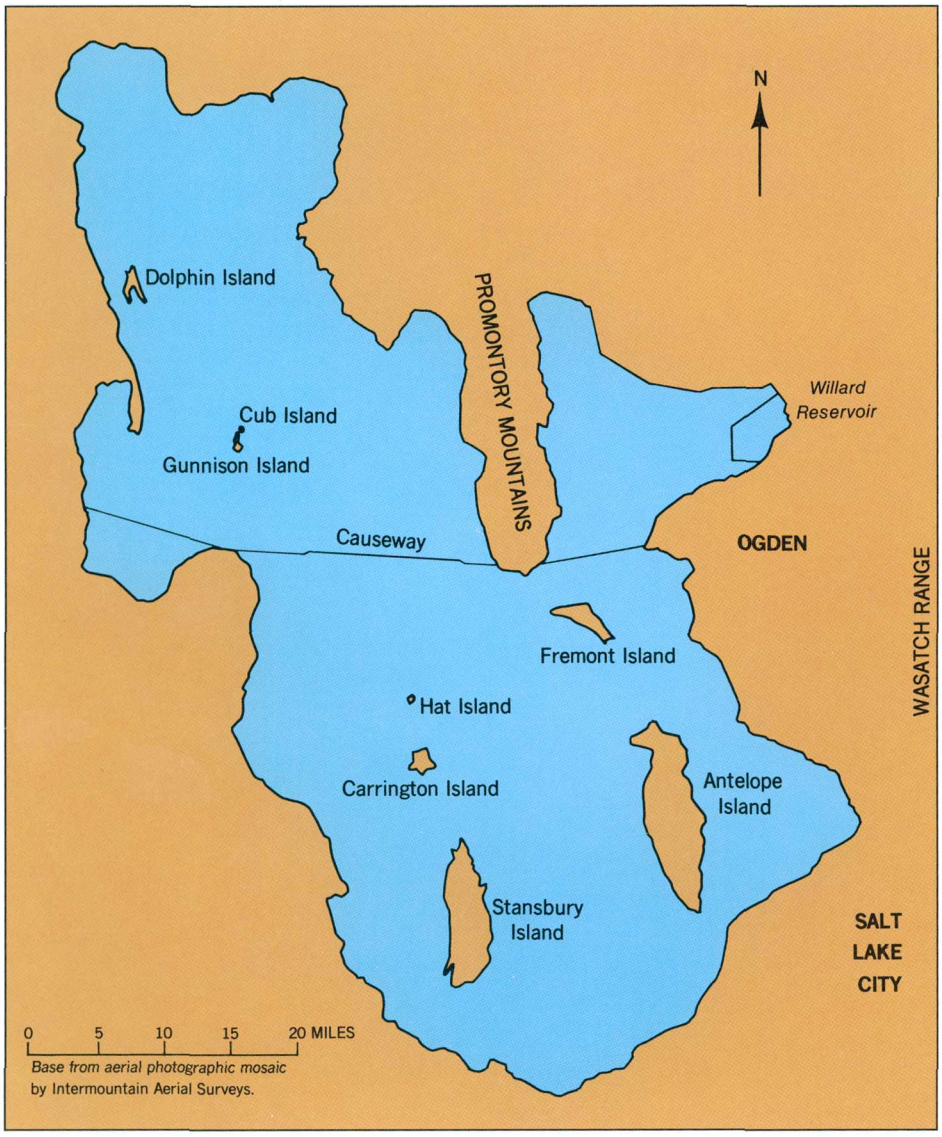
The Lake's Effect on Local Weather

The surface-water temperature of the Great Salt Lake varies from the upper 20's (°F) in January to about 80 °F early in August. Even when the water temperature is in the 20's (°F), the lake does not freeze, due to the high salt content of the water; but icebergs have been observed floating on the lake's surface, formed from freshwater that flows into the lake from tributaries and freezes on the surface before it mixes with the brine. The lake thus offers a moderating influence to the bitter cold air that occasionally visits the surrounding communities.

The lake's relative warmth, however, can contribute to extremely heavy snowfalls. During the spring and fall, there may be a large difference between the temperature of the lake water and that of an overriding storm air mass. During these times, the "warmer" air directly over the lake rises into the "colder" stormy air, and causes a rapid updraft and a subsequent heavy snow. The snow falls on the lake or is blown toward nearby communities, depending on the upper-level steering winds. The same phenomenon occurs along the shore of the eastern Great Lakes. When this "lake effect" occurs together with a naturally intense storm, the results can be startling. More than 24 inches of snow have been known to fall in a 24-hour period along the Wasatch Range.

Islands in the Lake

There are eight named islands in the lake that have never been totally submerged during historic time. All have been connected to the mainland by exposed shoals during periods of low water. They range in size from Antelope Island with an area of 23,175 acres to Hat Island with an area of 22 acres. In addition, the lake contains numerous small islands, shoals, or rocks



Antelope Island with Egg Island in foreground *(photo by Lloyd Austin).*

that are fully or mostly submerged at high water levels. The islands are mostly privately owned. The State owns all of Antelope Island, and other small areas are under State or Federal ownership.

Homesteading was tried on a number of islands but it failed, mostly because of the lack of fresh-water. The larger islands—Antelope, Stansbury, and Fremont—were used for grazing because the salty lake water prevented the cattle and sheep from wandering off. Only Freemont and Antelope Islands are truly habitable. The smaller, more inaccessible islands are the nesting grounds for migratory birds. The nesting birds, especially the pelicans, are shy by nature and may abandon their nests if disturbed. Therefore, the smaller islands are off limits to people during the nesting season.

Recent History of Great Salt Lake

There is some disagreement over when Great Salt Lake was discovered, but it is commonly held that explorer Jim Bridger became the first non-native to see the lake in the winter of 1824-25. Bridger reportedly came back with the story that he had discovered an arm of the Pacific Ocean.

Many explorers, surveyors, and trappers visited the lake's shores after 1825, but the first thorough exploration of the lake was conducted by John C. Fremont and his party in 1843. The first accurate map of the lake was made during this investigation, which included Kit Carson as a member of the party. While Fremont was engaged in mapping activities, Carson and others reportedly carved a cross near the summit of the island that now bears Fremont's name.

When the Mormons (the name frequently used to refer to members of the Church of Jesus Christ of Latter-day Saints) arrived in Utah in 1847, they made quick use of the lake and its

Saltair in its heyday *(photo from Utah State Historical Society).*

islands. The larger islands were used for grazing. Swimming in the lake and picnicking on the beaches were favorite pastimes, and celebrations along the shore on the Fourth of July were an annual event from the time the first pioneers arrived. Guests of church leader Brigham Young were often taken on boat rides to Antelope Island, where weekend excursions were held.

Probably the most colorful and dynamic period in the lake's history occurred between 1870 and 1940. The combination of the unique swimming and the lake's location on the transcontinental railroad lines led to the construction of many popular bathing resorts during the period. Several of the resorts featured bathing beaches, boat docks, dance halls, and even hotels. In 1893, the largest and most elegant of all the resorts, Saltair, was built at a cost of more than $350,000 by the Salt Lake and Los Angeles Railroad Company. Saltair boasted a dance hall that could accommodate 1,000 couples and became the most popular of the resorts. It remained nationally known tourist attraction until the lake water receded in the 1930's and left it high and dry. The original Saltair resort was destroyed by fire in 1970.

Saltair resort, recreated (rebuilt) in 1983 after fire destroyed the original, lies partially submerged but having good boat access on June 10, 1986. The lake peaked at 4,209.25 feet on July 1, 1984 *(photo by Doyle Stephens).*

The Impact of the Railroad

Railroad activity has had an enormous effect on Great Salt Lake. The great body of briny water proved an obstacle in the path to the completion of the transcontinental railroad line. The tracks were routed north over the Promontory Mountains where, in 1869, a golden spike was driven to mark the completion point of the first transcontinental railroad. As time went on, the climb over the mountains proved a serious bottleneck because the locomotives could not efficiently pull heavy loads over the summit. Efforts were made to find a new route, and it was eventually decided to build a bridge directly across the lake. The most feasible route crossed the lowest part of the peninsula of the Promontory Mountains where the mountains jutted into the lake. Construction began in 1902, and in late 1903, a 12-mile-long trestle of 28,000 wooden pilings crossed Great Salt Lake and made the railroad an integral part of the lake.

After World War II, the Federal Government and the Southern Pacific Railroad jointly financed a causeway to replace the trestle across the lake. The causeway, built of 50 million cubic yards of rock, sand, and gravel, allows faster speeds and greater safety than the old trestle for the trains crossing the lake.

The causeway and trestle divide the lake *(photo by Al Cooper).*

The causeway resulted in a color division of the lake's water; a train wreck is on the causeway *(photo by Owen Burnham).*

The old trestle stands on wooden legs and the lake waters move freely back and forth beneath it. The causeway, however, is nearly solid, and has effectively divided the lake with little interflow between the north and south parts. The lack of adequate mixing has caused an imbalance in the lake level; at times the south part, into which the main tributaries flow, is more than 2 feet higher than the north part.

The division has also caused an imbalance in the salt content of the waters and the consequent growth of different kinds of algae on each side of the causeway. Because the water north of the causeway receives less water inflow than the south part, the north part has a higher percentage of salt. The type of algae that grow in the north and more saline part of the lake make the water appear pink in color when compared to the blue waters of the south part. On August 3, 1984, a 300-foot-wide breach was made in the causeway. This eliminated the color difference between the two parts of the lake and is gradually reducing the salinity and level differences.

Lifeforms In and Around the Lake

Due to the high salt content of the water, most forms of aquatic life cannot live in the lake. Certain species have adapted, however, and, in fact, have flourished. Forms of algae (primitive plants without true root systems), bacteria (single-cell microorganisms that are either living or parasitic), and protozoa (single-cell organisms that are the most primitive form of animal life) all exist in the lake. Due to their primitive nature, the algae, bacteria, and protozoa have been able to adapt to the lake's high salinity.

The more advanced lifeforms in Great Salt Lake are the brine fly and brine shrimp. Both exist in large numbers. The larvae (newly hatched wingless form of an insect) of the brine flies live beneath the waters and feed upon the algae and bacteria. Eventually they change into pupae (the dormant form of an insect) and float to the surface where the wind blows them to shore. There, after a third transformation to the adult stage, the brine flies gather in large numbers.

Pelicans on Gunnison Island *(photo by Fritz Knopf).*

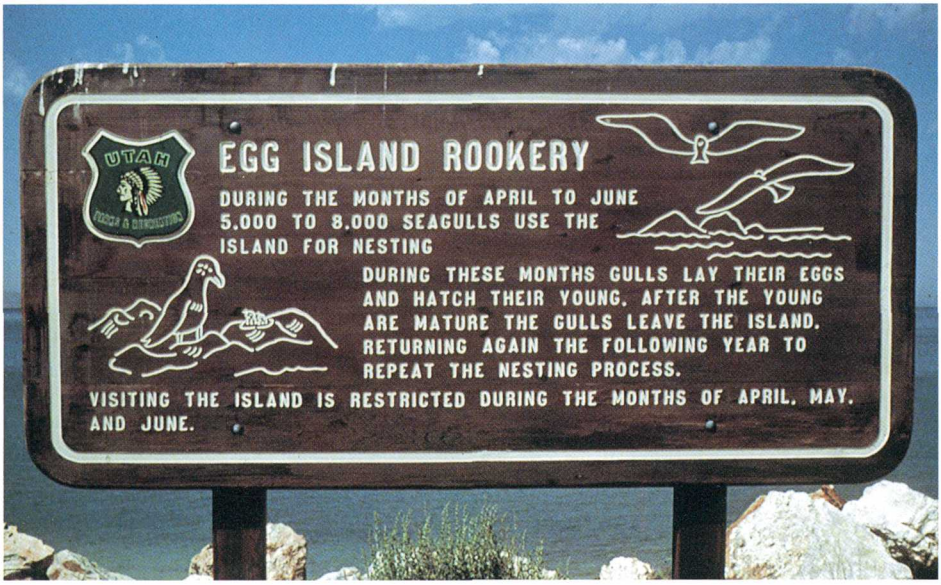
The brine shrimp are the largest form of life living in the lake, some being almost half an inch long. Great numbers of adults are in the water during the summer, and the shrimp eggs are sometimes so numerous that they cover large areas of the lake and drift with the currents.

Both the brine fly and shrimp have been used for unique purposes. The Paiute Indians formerly used the brine fly pupae as dough, which they baked into bread called *Koo-chah-bie*. The adult brine shrimp are netted, frozen, and sold as food for tropical aquarium fish. The shrimp eggs are also collected in large numbers, dried, sold, and eventually hatched by fish fanciers throughout the world as living food for their tropical fish.

Various other insects, including mosquitoes and gnats, inhabit the freshwater marshy areas along the shore where tributaries flow into the lake. These areas provide an excellent breeding ground. Local government agencies have been involved for many years in an energetic program to control the mosquitoes and other insects that are a health hazard to the public.

Five different species of migratory colonial-nesting birds use the more inaccessible islands in the lake, which are relatively free from predators, for nesting grounds during the spring and summer. Many migratory birds also nest in the numerous bird refuges and waterfowl-management areas along the lake shores or use them as temporary stopovers during migration periods. The bird refuges and wildlife-management areas were inundated in 1985 by the rising waters of the lake, causing some changes in these patterns.

Gulls (commonly called seagulls), pelicans, cormorants, terns, and herons make Great Salt Lake their home during the nesting season. The gulls and pelicans are by far the most numerous.



Egg Island *(photo by Lloyd Austin).*

The birds build their nests in remote areas in early spring and leave in summer as soon as the young can fly. They return again the next year to rejoin some of the gulls that have adapted to the relatively cold winters and have remained near the lake throughout the year.

The herons, cormorants, terns, and pelicans are fish eaters but nest on islands in the lake without fish. Thus they must travel many miles to feed. The pelicans have been known to fly as far as Utah Lake, a round trip of about 100 miles, to find fish. On the other hand, the gulls have adapted their habits so that they eat most anything and do not have to leave the lake area.

Many of the migratory birds that stop at the freshwater marsh areas are ducks, geese, or other game birds. They provide excellent hunting at numerous private gun clubs and public shooting grounds along the lakeshore.

Economic Benefits of the Lake

In addition to its yield of brine shrimp, the lake yields large quantities of minerals dissolved in the brine. The lake water is pumped into evaporation ponds along the shore, and then the salts that precipitate when the water evaporates are scraped up and processed.

Common table salt (sodium chloride) is the mineral extracted in the largest quantitiy—about 400,000 tons per year. But of greater potential value are the other minerals obtained from the lake—magnesium, used as a light-weight structural metal; and potash, used as fertilizer.

Approximately 3,000 barrels of crude oil have been produced from shallow wells along the lake shore.

Industry along the lake *(top photo by Al Cooper; bottom photo by George Pyper).*

Recreation and the Lake

Recreational activities abound on the lake today. A State park at the north end of Antelope Island provides hiking, picnicking, and camping areas, and a possible glimpse of a small herd of free-roaming buffalo. The rising lake waters of 1984-86 flooded the road to Antelope Island, thus necessitating the use of a ferry to take visitors to the island. The lake has always attracted sailors because of its size. Sailboating has become increasingly attractive recently, however, because of the use of synthetic materials that resist corrosive powers of the brine. Powerboat racing, pleasure boating, and fishing are popular in Willard Bay Reservoir, a freshwater bay that is diked off to prevent saltwater intrusion from the lake. There is excellent game-bird hunting in the marshy areas along the lakeshore.

Wave action along shores of Great Salt Lake *photo courtesy of Utah Division of Parks and Recreation).*

Aerial view of boat harbor at Great Salt Lake (when the water was at about 4,200 feet—May 1978) *(photo by Al Cooper).*

West Desert Pumping Project

The West Desert pumping project was designed, constructed, and funded by the State of Utah in an attempt to control the rising level of the Great Salt Lake. Main features of the project include a pumping station at Hogup Ridge, inlet and outlet canals, four trestles, almost 25 miles of dikes, a 37-mile natural-gas pipeline, a 10-mile access road between Lakeside and the pumping station, and a shallow 320,000-acre evaporation pond in the desert area west of the Newfoundland Mountains.

The project was designed to expand the area and the natural evaporation process of the Great Salt Lake. Three pumps capable of a combined rate of 1.5 million gallons-per-minute diverted water from the north part of the lake into a 4.1-mile outlet canal and into the evaporation pond. By the end of the first year of operation, the pumps had discharged approximately 500,000 acre-feet of water. A weir, constructed in the dike that extends southeast from the southern tip of the Newfoundland Mountains, regulated the evaporation pond's water level and allowed for water rich in salts to return to the Great Salt Lake.

Construction on the project began in June 1986 and the first pump was turned on in April 1987. The pumping project was shut down in June 1989 because the level of the lake had declined almost 6 feet since reaching its record peak of 4,211.85 feet above sea level in June 1986 and March 1987. The Utah Division of Water Resources credits the project with "over one-third of that decline." Project facilities have been mothballed in order to be available for use in the event of future lake flooding.

Excerpted from *Utah Department of Natural Resources Annual Reports, 1986-1987* and *1988-1989.*

Conclusion

Some visitors may feel that the briny water and the arid setting provide an element of inhospitality to the lake. Perhaps so. But the same factors also provide an aura of individuality that is matched only in one other place in the world—the Dead Sea in the Holy Land.

Sunset on Great Salt Lake *(photo courtesy of Utah Division of Parks and Recreation).*

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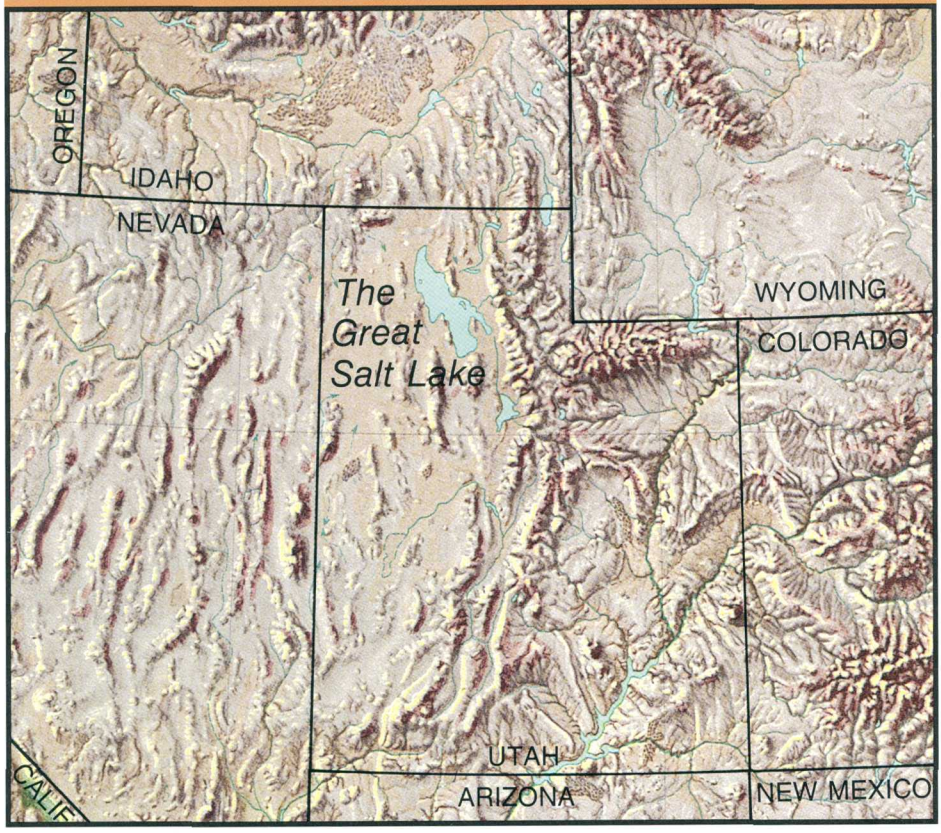

Shaded-relief map of Utah and the surrounding States

As the Nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.