6th Grade Strand 4: Great Salt Lake is Changing

Digital Lesson Folder

WESTMINSTER COLLEGE
Great Salt Lake Institute

The following teaching resources were created by Megan Black in partnership with The Great Salt Lake Institute at Westminster College.

Resource I: How is the Great Salt Lake Changing

How is Great Salt Lake Changing?

How is Great Salt Lake Changing?

Analyze the following visual and quantitative data. Look for changes over time. How is Great Salt Lake changing? What evidence in the data supports your claim?

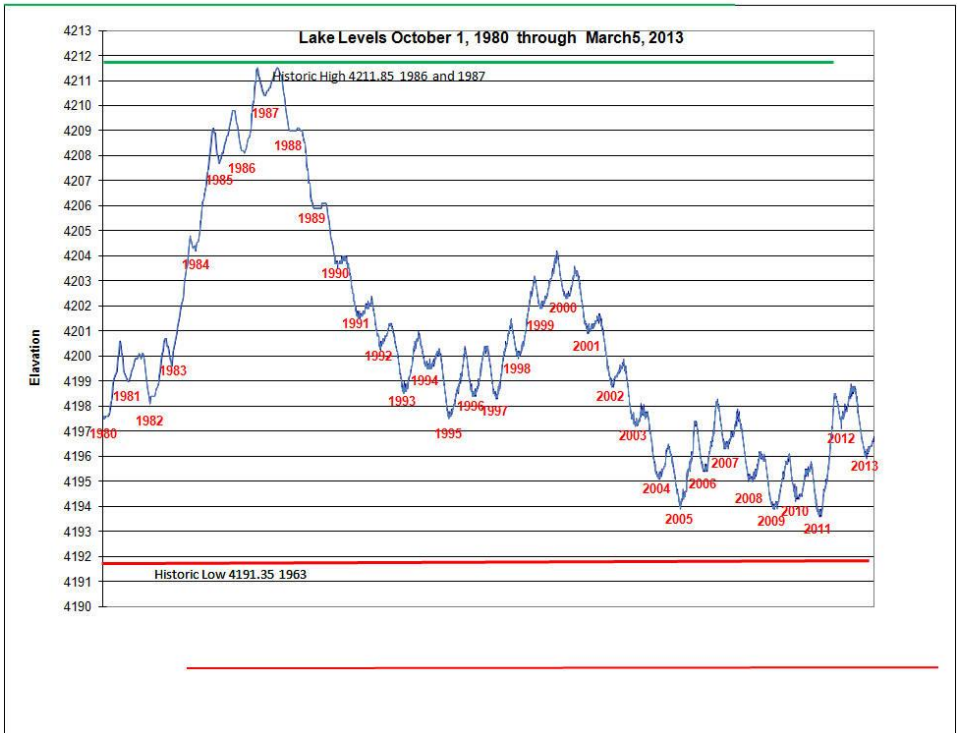
Time - lapse video

Watch the following YouTube time-lapse video: http://tinyurl.com/gslchange

Aerial photos of the lake

Photo Credits: Before NASA Earth Observatory **After** NASA Earth Observatory

Photo Credits: Before NASA Earth Observatory **After** NASA Earth Observatory



Graph of lake elevation (lake levels from 1980 - 2013):

Retrieved from: http://gslycorg.ipage.com/weather/gsl_highs_and_lows.html

Data table of lake elevation (lake levels from 1990 - 2016):
Retrieved from: https://waterdata.usgs.gov/

Box Elder County, Utah Hydrologic Unit Code 16020310 Latitude 41°15'19", Longitude 112°29'46" NAD27 Gage datum 4,189.8 feet above NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

Water Year	62614, Lake or reservoir water surface elevation above NGVD 1929, feet
1990	4,203.492
1991	4,201.284
1992	4,199.492
1993	4,197.561
1994	4,197.488
1995	4,197.572
1996	4,197.704
1997	4,198.192
1998	4,200.639
1999	4,202.446
2000	4,202.113
2001	4,200.363
2002	4,198.499
2003	4,196.715
2004	4,194.889
2005	4,194.943
2006	4,195.931
2007	4,196.036
2008	4,194.655
2009	4,194.015
2010	4,194.024
2011	4,195.002
2012	4,197.045
2013	4,195.589
2014	4,193.936
2015	4,192.242
2016	4,190.488
** No Incomplete data have been used for statistical calculation	

Images of Spiral Jetty - Land art in the North Arm of GSL

Source: Robert Smithson, *Spiral Jetty*, 1970. © Holt-Smithson Foundation/Licensed by VAGA, New York. © Aero-graphics, Salt Lake City

April 30, 2012

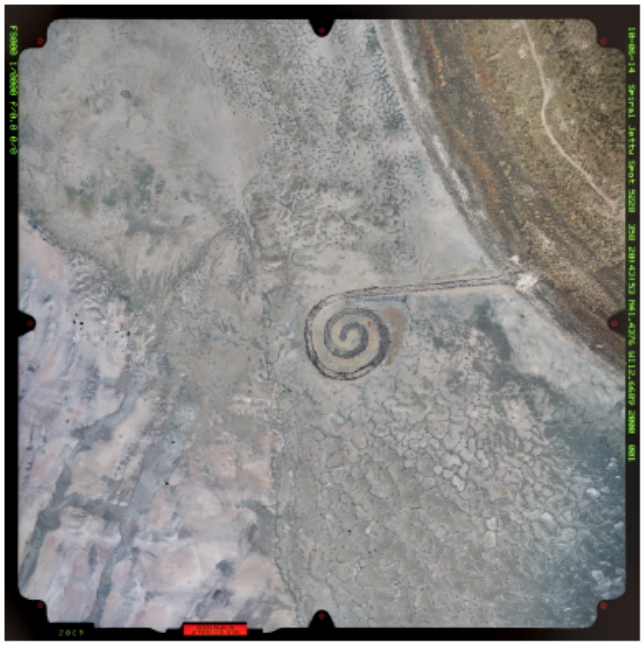
October 3, 2012

April 27, 2013

October 1, 2013

May 1, 2014

October 6, 2014



April 30, 2015

October 9, 2015

STANDARD EXAMINER

Is drought to blame for drop in Utah's Great Salt Lake? Not likely

THURSDAY , OCTOBER 01, 2015 - 11:46 AM

BENJAMIN ZACK/STANDARD-EXAMINER

Salt and mineral deposits build up in small pools off the former shore of Antelope Island State Park as the Great Salt Lake levels drop. As the lake decreases in size, the water becomes more highly concentrated with minerals.

The Great Salt Lake is notoriously capricious. Since 2010, it's elevation has been on a steady downward trend. It's now flirting with a record low.

- **MORE:**How will the disappearing lake affect the air you breathe? (http://www.standard.net/environment/2015/10/11/As-Great-Salt-Lake-dries-up-Utah-air-quality-concerns-blow-in.html)

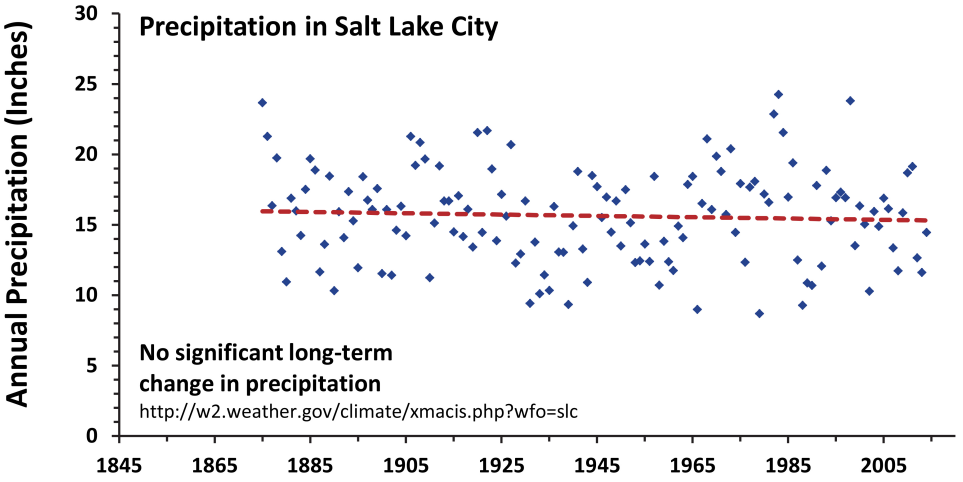
While it's easy to point to the state's recent drought as the reason, some lake and water experts have assembled the evidence and found it's not entirely the cause. It's mostly caused by people.

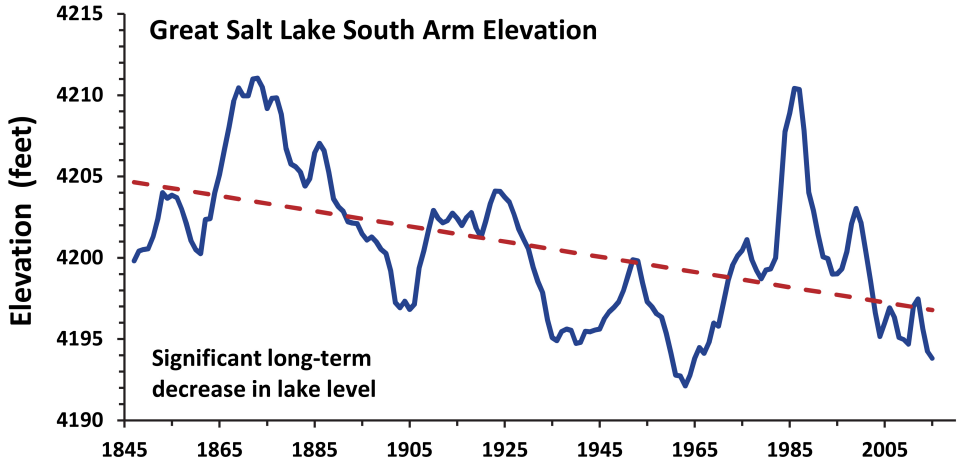
Wayne Wurtsbaugh, a limnologist at Utah State University (http://works.bepress.com/wayne_wurtsbaugh/), is wrapping up a study he conducted with a few other USU scientists and the Utah Division of Water Resources. It compares trends in precipitation to levels of the Great Salt Lake.

(http://www.standard.net/Great-Salt-Lake)

"It's not like droughts don't have an effect,"Wurtsbaugh said. "But … roughly, the lake would be about 10 feet higher right now if we hadn't been diverting water."

Since people began taking measurements in the Salt Lake Valley around the 1850s, there have been wet years and dry years. Lake levels respond accordingly. As Wurtsbaugh eliminated the noise and looked at the long-term trend, he found the amount of precipitation over time remained steady. But the lake keeps dropping. He's concluded it's because of diversions along most of the lake's main tributaries — specifically, the Weber, Ogden and Jordan rivers — funneling water away from the lake for human use.





A forthcoming study conducted by scientists at Utah State University and the Utah Division of Water Resources found that while annual precipitation in Salt Lake City has roughly stayed the same, the Great Salt Lake's elevation has steadily dropped. Even with recent drought, the lake would be roughly 10 feet higher today, instead of approaching record lows, if its tributary rivers didn't have diversions. (Wayne Wurtsbaugh/Utah State University)

If those diversions were out of the picture, an extra 10 feet at the Great Salt Lake would closer to 2000 levels. The lake's Islands would be islands. Antelope Island would only have a thin sliver of sandy beaches at its crescent-shaped bays. Boats would be able to dock right at the edge of the Great Saltair. Farmington Bay would be covered by several feet of water — even with the past five years of drought.

Looking to the future, the lake could face more diversions and lower levels. With Utah's population set to double by 2050, state officials are looking to one of the lake's largest and last untapped sources of water, the Bear River. The proposed Bear River Project will dam and divert 220,000 acre-feet. Conservative estimates say it will also drop the lake by another six inches.

That might not sound like a lot, but as Wurtsbaugh points out, the lake covers a long, flat bowl. In some areas, dropping the lake by one foot moves the shoreline back by a mile (http://learn.genetics.utah.edu/content/gsl/physical_char/).

“Because of the shape of the basin, the farther down we go, the more we’re getting down to flatter and flatter sections,” Wurtsbaugh said. “A little drop exposes a lot more.”

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Explore the project (http://www.standard.net/Great-Salt-Lake)

• We're losing the Great Salt Lake; Here's why you should care (http://www.standard.net/environment/2015/10/11/We-re-losing-the-Great-Salt-Lake-Here-s-why-you-should-care.html)

• Millions of birds face dire future as Great Salt Lake shrinks (http://www.standard.net/environment/2015/10/11/Millions-of-birds-face-dire-future-as-Great-Salt-Lake-shrinks.html)

• As Great Salt Lake dries up, Utah air quality concerns blow in (http://www.standard.net/environment/2015/10/11/As-Great-Salt-Lake-dries-up-Utah-air-quality-concerns-blow-in.html)

• Déjà vu: is Lake Urmia's demise a warning for Great Salt Lake? (http://www.standard.net/environment/2015/10/11/Deja-vu-is-Lake-Urmia-s-demise-a-warning-for-Great-Salt-Lake.html)

• Why is the Great Salt Lake so smelly? That's a trick question (http://www.standard.net/environment/2015/10/11/Why-is-the-Great-Salt-Lake-so-smelly-That-s-a-trick-question.html)•

• Marinas in jeopardy as Great Salt Lake continues to dry up (http://www.standard.net/environment/2015/10/11/Marinas-in-jeopardy-as-Great-Salt-Lake-continues-to-dry-up.html)

- As Great Salt Lake shrinks, fate of nesting pelicans unknown (http://www.standard.net/environment/2015/10/11/As-Great-Salt-Lake-shrinks-fate-of-nesting-pelicans-unknown.html)

GSL Lake Level Factor Cards

Print and cut the cards. Each day for one week have students select a card and follow the directions on their card to add water to their lake or place their lake under the clamp lamp in the classroom.

Note: To make sure the measurements are correct for the model, place a petri dish bottom filled with 40 mL of water. Check the amount of water that has evaporated after 24 hours. This should be the amount of water students need to replenish in a normal snowfall year.

It is spring. A normal snowfall year has resulted in normal amounts of runoff from the Jordan, Weber, and Bear Rivers. ADD 15 mL of water to your lake	It is spring. A normal snowfall year has resulted in normal amounts of runoff from the Jordan, Weber, and Bear Rivers. ADD 15 mL of water to your lake	It is spring. A normal snowfall year has resulted in normal amounts of runoff from the Jordan, Weber, and Bear Rivers. ADD 15 mL of water to your lake
High above average snowpack has resulted in springtime flooding. Large amounts of runoff are reaching GSL. ADD 20 mL of water to your lake.	It is spring. A normal snowfall year has resulted in normal amounts of runoff from the Jordan, Weber, and Bear Rivers. ADD 15 mL of water to your lake	It is spring. A normal snowfall year has resulted in normal amounts of runoff from the Jordan, Weber, and Bear Rivers. ADD 15 mL of water to your lake
Water from the Jordan, Weber, and Bear Rivers has been diverted to be used for household use and watering lawns. Only some water reaches the lake. ADD 10 mL of water to your lake.	Water from the Jordan, Weber, and Bear Rivers has been diverted to be used for household use and watering lawns. Only some water reaches the lake. ADD 10 mL of water to your lake.	Water from the Jordan, Weber, and Bear Rivers has been diverted to be used for household use and watering lawns. Only some water reaches the lake. ADD 10 mL of water to your lake.

Agriculture in northern Utah relies on freshwater. Water is diverted from rivers to water the fields. This water then evaporates and does not make it to GSL. ADD 10 mL of water to your lake.	Agriculture in northern Utah relies on freshwater. Water is diverted from rivers to water the fields. This water then evaporates and does not make it to GSL. ADD 10 mL of water to your lake.	Agriculture in northern Utah relies on freshwater. Water is diverted from rivers to water the fields. This water then evaporates and does not make it to GSL. ADD 10 mL of water to your lake.
It has been an unusually hot summer causing more evaporation from the surface of GSL. Place your lake under the clamp lamp for one hour.	It has been an unusually hot summer causing more evaporation from the surface of GSL. Place your lake under the clamp lamp for one hour.	A below normal snowpack has led to a decrease in spring runoff and the amount of water reaching GSL. ADD 10 mL of water to your lake.
As population grows on the Wasatch Front, so does the demand for water. Water is diverted from the Jordan, Weber, and Bear Rivers to use for agriculture and to deliver to homes. ADD 5 mL of water to your lake.	As population grows on the Wasatch Front, so does the demand for water. Water is diverted from the Jordan, Weber, and Bear Rivers to use for agriculture and to deliver to homes. ADD 5 mL of water to your lake.	As population grows on the Wasatch Front, so does the demand for water. Water is diverted from the Jordan, Weber, and Bear Rivers to use for agriculture and to deliver to homes. ADD 5 mL of water to your lake.

Great Salt Lake Bird Game

The following game is meant to help students understand the interactions between birds and other living and nonliving components of Great Salt Lake ecosystem. The game allows students to compare these interactions when water in GSL is at normal and low levels.

While playing the game, students will visit four stations: pelicans, phalaropes, eared grebes, and ducks. At each station students will collect data on the number of birds that started at the station, the number of birds that survived at the end of playing the game, and the factors that affected the birds' survival.

Set-up:

1. Print 2 copies of the station cards, both the normal water level and low level cards.
2. Create stations by placing the 2 station cards, 2 dice at each station, and a cup of 10- 15 beans or counters.
3. Provide students with the data recording sheet.
4. Divide the students into four groups. Send one group to each station.

Playing the game:

1. Be sure students start with the normal lake level card.
2. Have each student take 1 bean, this represents their "bird life".
3. One student should read the background information on the station card.
4. Then each student should roll the dice and use the key on the station card to determine their fate.
5. After each student has rolled once, the students will roll a second time. If a student did not survive in round 1, they will need to put their bean back in the cup, and sit out during round 2.
6. After groups have completed 2 rounds, have them return the beans to the cup and fill in their data recording sheet.
7. Then have students restart the game, this time using the low lake level card.
8. Students again play 2 rounds, and then fill in their data recording sheet.
9. Rotate stations, so that students become a new bird, and play the game at the next station.

Wrap-up:

1. Ask students to analyze their data, specifically looking for differences between the normal water level outcomes and the low level outcomes. Ideally students will notice that the survival rate declined for each bird species when the water level was low.
2. Continue to analyze the decline in survival rate by asking students to explain the reason not as many birds survived. List the reasons on the board for each bird, (e.g., coyotes could reach the fledglings on the island, not enough brine shrimp in high salinity waters, etc.).
3. Ask students what they learned about other organisms in the lake while playing the game. How did lower water levels affect those organisms? Why? List the other organisms on the board and how the lower water levels affected them. (e.g, coyote populations might increase as they have more access to prey.)

Name: _____

Great Salt Lake Bird Game Data Collection Sheet

Introduction: During this game you will visit 4 stations. At each station you will become one of the birds that relies on the Great Salt Lake ecosystem. Begin by using the Normal Lake Level sheet. Roll the dice, find out what happens to you and your classmates. If you survive play a second round. What happens this time? Record your data in the Normal Lake Level row on the chart. Once you have played the Normal Lake Level sheet, play two more rounds with the Low Lake Level sheet. How do the results of the game change? Record your data in the Low Lake Level row on the chart.

Data Collection: As you visit each station fill in the data charts below.

Bird: _____

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level			
Low Lake Level			

Bird: _____

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level			
Low Lake Level			

Bird: _____

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level			
Low Lake Level			

Bird: _____

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level			
Low Lake Level			

Analysis:

1. Review your data. What patterns do you notice?

2. How did the number of birds that survived differ between the normal lake level game and the low lake level game?

3. What caused birds to not survive during the low lake level game?
    a. Pelicans:

    b. Grebes:

    c. Phalaropes:

    d. Ducks:

4. How were other populations of organisms affected by the low lake levels?

Name: Key

Great Salt Lake Bird Game Data Collection Sheet

Introduction: During this game you will visit 4 stations. At each station you will become one of the birds that relies on the Great Salt Lake ecosystem. Begin by using the Normal Lake Level sheet. Roll the dice, find out what happens to you and your classmates. If you survive play a second round. What happens this time? Record your data in the Normal Lake Level row on the chart. Once you have played the Normal Lake Level sheet, play two more rounds with the Low Lake Level sheet. How do the results of the game change? Record your data in the Low Lake Level row on the chart.

Data Collection: As you visit each station fill in the data charts below. Answers will vary. Below is a sample

Bird: Pelican Fledgling

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level	7	6	Father got fish from Farmington Bay. Safe in nest; mild weather.
Low Lake Level	7	4	Bald eagle took me from my nest.

Bird: Wilson's Phalarope

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level	7	7	Found brine shrimp. Survived.
Low Lake Level	7	5	The salinity in the lake was too high, the brine shrimp didn't hatch. Did not survive.

Bird: Eared Grebe

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level	7	7	Found enough brine shrimp to survive.
Low Lake Level	7	2	The salinity in the lake gets too high, and the brine shrimp don't survive. Did not survive.

Bird: Duck

	# of birds at start of game	# of birds after 2 rounds	What happened to you? Be specific.
Normal Lake Level	7	7	Survived. Found plants in Willard Bay.
Low Lake Level	7	4	Survived. Found snails and invertebrates for food.

Analysis:

5. Review your data. What patterns do you notice?

We always started with the same number of birds in our group. During the normal level rounds most of the birds survived. During the low lake level rounds some of the birds did not survive.

6. How did the number of birds that survived differ between the normal lake level round and the low lake level round?

Fewer birds survived during the low lake level round than during the normal lake level round.

7. What caused birds to not survive during the low lake level game?
   a. Pelicans: Fledglings eaten by coyotes. Parents couldn't find food.
   b. Phalaropes: Less brine shrimp b/c of high salinity water.
   c. Grebes: Less brine shrimp b/c of high salinity water. Disease spreads through warm waters.
   d. Ducks: Do not find food in wetlands. Avian botulism, a disease, spreads.

8. How were other populations of organisms affected by the low lake levels?

Brine shrimp populations declined because of high salinity in the water. Coyote populations could have increased because they were able to reach pelican nesting sites.

Pelican Station - Normal Lake Level

Background Information: Great Salt Lake is an important breeding ground for adult American White Pelicans. Each year, about 20,000 adult pelicans visit the lake to breed: find a mate, make a nest, lay eggs, and raise young. The pelicans rely on islands in the lake to help protect their nests from predators such as coyotes. At this station you will be a pelican fledging, your survival will depend on how well your parents are able to access food and if you can avoid being eaten by predators.

Image Source: https://wildlife.utah.gov/gsl/waterbirdsurvey/awpe.htm

Play the game: Each student should take a bean. This bean represents your life as a pelican fledging. Take turns rolling the dice to see what happens to you.

Roll:

2) **You are safe in your nest. The weather is mild. You survive.**
3) **Your mother returned from Bear River Bay with fish. You survive.**
4) **A bald eagle takes you from your nest. You do not survive.**
5) **Your nest is on Gunnison Island where predators cannot reach you. You survive.**
6) **Normal snowmelt has resulted in many fish in the Bear River Migratory Bird Refuge. There is plenty to eat. You survive.**
7) **Your mother has returned to the nest with plenty of fish for you and your brother. You survive.**
8) **An unusual summer rainstorm has flooded your nest. You do not survive.**
9) **Your father flew to Pyramid Lake, Nevada and returned with fish. You survive.**
10) **Your mother returned from Utah Lake with fish for you. You survive.**
11) **Your father collected fish from the wetlands near Farmington Bay. You survive.**
12) **Your father and mother work together to collect food and care for you and your brother. You survive.**

Pelican Station - Low Lake Level

Image Source: http://wildlife.utah.gov/blog/wp-content/uploads/2015/10/pelicans_Gunnison.jpg

Play the game: Each student should take a bean. This bean represents your life as a pelican fledging. Take turns rolling the dice to see what happens to you.

Roll:

2) **You are safe in your nest. The weather is mild. You survive.**
3) **Your mother flew to Bear River Bay, but could not find fish because of the low water levels. You do not survive.**
4) **Your father flew to Bear River Bay and returned with fish. You survive.**
5) **A land bridge forms between the shore and Gunnison Island where you live. A coyote crosses the bridge and preys on you. You do not survive.**
6) **Your mother has returned to the nest with fish for you and your brother. You survive.**
7) **A bald eagle takes you from your nest. You do not survive.**
8) **Because there are less fish in the Bear River Bay, your father flew to Pyramid Lake, Nevada and returned with fish. You survive.**
9) **A coyote crosses a land bridge that forms when lake levels are low. The coyote captures you. You do not survive.**
10) **Your father found a few fish near Farmington Bay. You survive.**
11) **Your father and mother work together to collect food and care for you and your brother. You survive.**
12) **A coyote crosses a land bridge and preys on you. You do not survive.**

Wilson's Phalarope - Normal Lake Level

Background Information: About 500,000 Wilson's Phalaropes visit Great Salt Lake each year. Great Salt Lake is a crucial stop during the phalarope migration. With a steady supply of brine flies and brine shrimp the birds can double their weight while at GSL.
Image Source: https://wildlife.utah.gov/gsl/waterbirdsurvey/wiph.htm

Play the game: Each student should take a bean. This bean represents your life as a Wilson's Phalarope. Take turns rolling the dice to see what happens to you.

Roll:

2) **You forage along the shore on Antelope Island and find many brine flies. You survive.**
3) **You spin around in the water, which pulls many brine fly larvae to the surface. You feed on the larvae. You survive.**
4) **Swimming in the water you are able to catch many brine shrimp. You survive.**
5) **Along the shoreline you find many brine flies. You survive.**
6) **During your migration to lakes in Argentina you stop at GSL and eat brine fly larvae, brine flies, and brine shrimp. You survive.**
7) **Car oil from runoff into the lake gets into your feathers. You are unable to move around the lake and forage for food. You do not survive.**
8) **You find an area with many brine shrimp. You survive.**
9) **You forage along the shore on Antelope Island and find many brine flies. You survive.**
10) **You spin around in the water, which pulls many brine fly larvae to the surface. You feed on the larvae. You survive.**
11) **Swimming in the water you are able to catch many brine shrimp. You survive.**
12) **Along the shoreline you find many brine flies. You survive.**

Wilson's Phalarope - Low Lake Level

Play the game: Each student should take a bean. This bean represents your life as a Wilson's Phalarope. Take turns rolling the dice to see what happens to you.

Image Source: http://www.audubon.org/field-guide/bird/wilsons-phalarope

Roll:

2) **You forage along the shore on Antelope Island and find brine flies. You survive.**
3) **Brine fly larvae tolerate water with high salinity. You feed on the larvae. You survive.**
4) **The salinity of the water in the South Arm of GSL becomes too high. You are unable to find enough brine shrimp. You do not survive.**
5) **Along the shoreline you find many brine flies. You survive.**
6) **You are unable to find enough brine shrimp to gain the weight you need to migrate to Argentina. You do not survive.**
7) **You spin around in the water, which pulls many brine fly larvae to the surface. You feed on the larvae. You survive.**
8) **You find an area with some brine shrimp, but not enough. You do not survive.**
9) **You forage along the shore on Antelope Island and find brine flies. You survive.**
10) **Brine fly larvae tolerate water with high salinity. You feed on the larvae. You survive.**
11) **The salinity in the South Arm has reached 25% because of the low lake levels. Brine shrimp cysts do not hatch. You cannot find enough food. You do not survive.**
12) **Along the shoreline you find many brine flies. You survive.**

Eared Grebes - Normal Lake Level

Background Information: Over 2 million Eared Grebes stop at GSL during their migration as the birds move from wintering grounds and breeding sites. Scientists estimate that the grebes need to eat about 30,000 brine shrimp per day in order to build up reserves needed to complete their migration.
Image Source: https://wildlife.utah.gov/gsl/waterbirdsurvey/eagr.htm

Play the game: Each student should take a bean. This bean represents your life as an Eared Grebe. Take turns rolling the dice to see what happens to you.

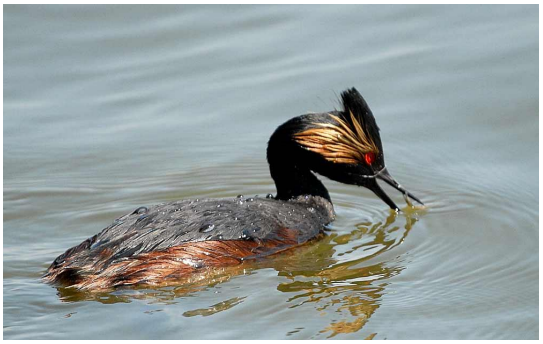
Roll:

2) **You are able to eat 30,000 brine shrimp per day. You gain enough energy reserves to continue your migration. You survive.**
3) **You swim through the water and feed on brine shrimp. You survive.**
4) **Many brine shrimp cysts hatched this spring. There are plenty of brine shrimp to eat. You survive.**
5) **You find brine shrimp in the eastern marshes of GSL. You survive.**
6) **You spend your days along the causeway that leads to Antelope Island. There are plenty of brine shrimp here. You survive.**
7) **You are able to double your weight in preparation for your nonstop flight to your wintering ground in Mexico. You survive.**
8) **You are one of 2 million eared grebes at GSL. Fortunately there are many brine shrimp here. You survive.**
9) **You arrive at the North Arm of GSL. There are not enough brine shrimp in the high salinity water. You do not survive.**
10) **You are able to eat 30,000 brine shrimp per day. You gain enough energy reserves to continue your migration. You survive.**
11) **You swim through the water and feed on brine shrimp. You survive.**
12) **Many brine shrimp cysts hatched this spring. There are plenty of brine shrimp to eat. You survive.**

Eared Grebes - Low Lake Level

Play the game: Each student should take a bean. This bean represents your life as an Eared Grebe. Take turns rolling the dice to see what happens to you.

Image Source:
http://vancouverislandbirds.com/aaamay0714293egrebe.jpg



Roll:

2) **You are able to find the 30,000 brine shrimp per day you need. You survive.**
3) **You swim through the water and feed on brine shrimp. You survive.**
4) **The salinity of the water in the South Arm of GSL becomes too high. You are unable to find enough brine shrimp. You do not survive.**
5) **You find brine shrimp in the eastern marshes of GSL. You survive.**
6) **You spend your days along the causeway that leads to Antelope Island. There are brine shrimp here. You survive.**
7) **You are able to double your weight in preparation for your nonstop flight to your wintering ground in Mexico. You survive.**
8) **The salinity of the water in the South Arm of GSL becomes too high. You are unable to find enough brine shrimp. You do not survive.**
9) **There is less water in the lake, making the water warmer and leaving less space for you to swim. A disease spreads through the grebe population. You do not survive.**
10) **You swim through the water and feed on brine shrimp. You survive.**
11) **The salinity in the South Arm has reached 25% because of the low lake levels. Brine shrimp cysts do not hatch. You cannot find enough food. You do not survive.**
12) **You find just enough brine shrimp. You survive.**

Duck Station - Normal Lake Level

Background Information: Many different species of duck are found on Great Salt Lake such as teals, mallards, and gadwalls. Ducks are found near the wetlands on GSL's eastern shore. The ducks rely on these freshwater wetlands for food.
Image Source: https://wildlife.utah.gov/gsl/waterbirdsurvey/agwt.htm

Play the game: Each student should take a bean. This bean represents your life as a duck living in Great Salt Lake. Take turns rolling the dice to see what happens to you.

Roll:

2) **You are a green-winged teal and find plenty of food in Ogden Bay. You survive.**
3) **You are able to find plenty of plants to eat in the Bear River Migratory Bird Refuge. You survive.**
4) **You forage for food in shallow waters. You survive.**
5) **You have landed in Farmington Bay. There is plenty of food for you in the wetlands along the shore. You survive.**
6) **You are a gadwall, and are able to snatch food from a diving duck as it resurfaces. You survive.**
7) **You find snails and other small invertebrates in the wetland grasses. You survive.**
8) **You are a mallard. You feed by dabbling, tipping over and grazing on underwater plants. You find plants in Ogden Bay. You survive.**
9) **You forage in the Bear River Bay. There is plenty to eat in the freshwater wetlands surrounding the bay. You survive.**
10) **You eat a plastic bag floating on the water. You do not survive.**
11) **You are able to find plenty of plants to eat in the Bear River Migratory Bird Refuge. You survive.**
12) **You spend most of your day foraging for food in shallow waters. You survive.**

Duck Station - Low Lake Level

Play the game: Each student should take a bean. This bean represents your life as a duck living in Great Salt Lake. Take turns rolling the dice to see what happens to you.

Gadwall Image Source: https://www.allaboutbirds.org/guide/Gadwall/id

Roll:

2) **You are able to find plants to eat in the Bear River Migratory Bird Refuge. You survive.**
3) **You forage for food in shallow waters. You survive.**
4) **You have landed in Farmington Bay. The wetlands are very dry because freshwater has been diverted before it reaches GSL. You do not find food. You do not survive.**
5) **You are a gadwall, and are able to snatch food from a diving duck as it resurfaces. You survive.**
6) **You find snails and other small invertebrates in the wetland grasses. You survive.**
7) **Lower lake levels means more crowding on the lake for ducks and warmer waters. Avian botulism, a disease, spreads through the duck population. You do not survive.**
8) **You forage in the Bear River Bay. There is plenty to eat in the freshwater wetlands surrounding the bay. You survive.**
9) **With less space, disease spreads between birds more easily. You catch a disease. You do not survive.**
10) **Higher summer water temperatures and low lake levels have led to the spread of the disease avian botulism. You do not survive.**
11) **You forage for food in shallow waters. You survive.**
12) **You have landed in Farmington Bay. Unfortunately, avian botulism is spreading through the area. You catch this disease. You do not survive.**

STANDARD EXAMINER

Déjà vu: is Lake Urmia's demise a warning for Great Salt Lake?

THURSDAY , OCTOBER 08, 2015 - 3:32 PM

Lake Urmia in Iran has dropped to nearly 10 percent (http://www.theguardian.com/world/iran-blog/2015/jan/23/iran-lake-urmia-drying-up-new-research-scientists-urge-action) its average size, with only five percent (http://www.nytimes.com/2014/01/31/world/middleeast/its-great-lake-shriveled-iran-confronts-crisis-of-water-supply.html?_r=0) its average water, causing regional turmoil. It serves as a cautionary tale of how a great salty waterbody can suddenly disappear before the people living nearby realizing there's a problem.

(http://www.standard.net/Great-Salt-Lake)

Iran might be half a world away, but Lake Urmia has a lot in common with Utah's Great Salt Lake. Both have causeways that have changed the salinity. In a good water year, both would be roughly the same size. Both support vast numbers of migratory birds. Both are surrounded by dense, urban populations with religious cultures that value large families.

Wayne Wurtsbaugh, a limnologist at Utah State University, calls Urmia a "dead ringer" for the Great Salt Lake.

“But two things are different,” he said. “They have a longer growing season in Urmia, so they can divert and use water for a longer period. They also had a 3,000- or 4,000-year head start in building up their population.”

Lake Urmia 1972-2014

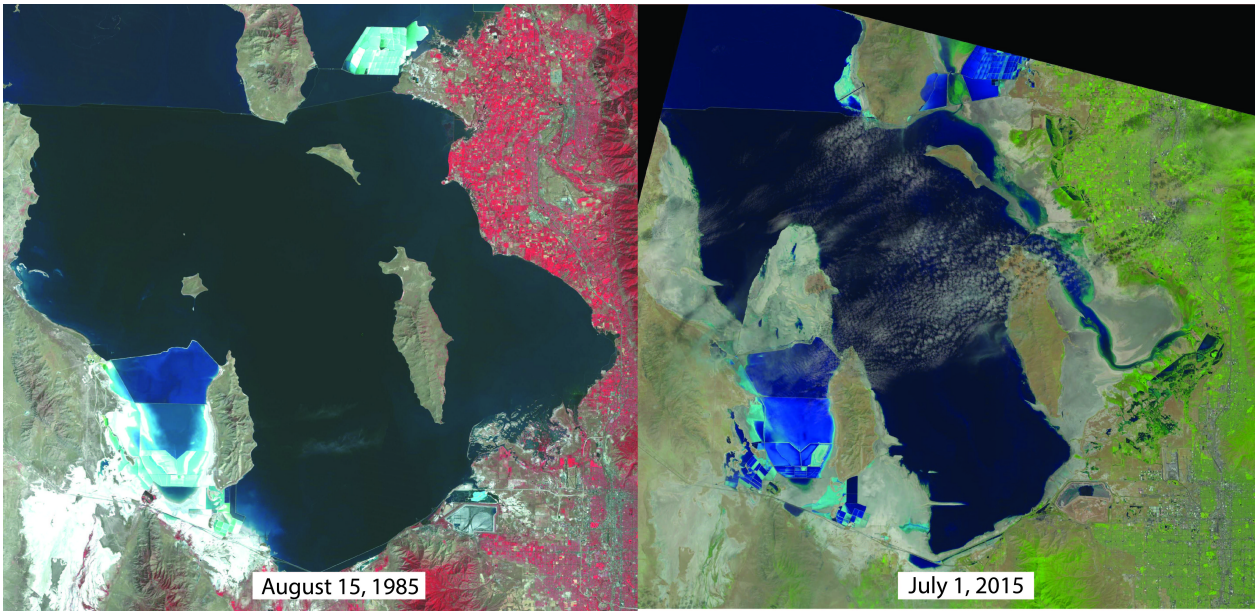
Now that the lake’s nearly gone, the Urmia’s remaining waters have become so intensely salty that the brine shrimp and brine flies are gone.

“And with that, they’ve lost all the birds, including the charismatic one, their flamingoes,” Wurtsbaugh said. “So the goal is to get salinity back to a level to bring back the brine shrimp and birds. And also to get water on the salt flats so you don’t have salt dust blowing around, impacting people’s health.”

Iranian politicians have campaigned on the promise of bringing the lake back. They’ve commited to spending billions on its restoration. They’ve tapped Wurtsbaugh and other inland waterbody researchers (link to pdf (http://www.undp.org/content/dam/iran/docs/News/2014/April%202014/Experts%20search%20for
to figure out how to manage the lake’s ecosystem. But the Great Salt Lake and saline lakes throughout the world are facing the same threats. Wurtsbaugh’s research has shown that Great Salt Lake has steadily dropped over time — from drought, but mostly from diversions.

“So going back to Lake Urmia, we’re doing the same thing, but because we don’t have as big a population, or quite as much development and a shorter growing season, we’re not doing it as fast,” Wurstbuagh said. “(We have) to try and convince people it’s drought-plus … you can’t divert water and evaporate it out in our fields and lawns and not expect it to have an effect on the lake.”

Great Salt Lake



This aerial photograph show the changes of the Great Salt Lake's volume at its high point in 1985 and its near-low point last summer. A forthcoming study by Utah State University and the Utah Division of Water Resources estimates the lake's elevation would be around 10 feet higher today if not for the dams and diversions on rivers feeding the lake. (U.S. Geological Survey)

Lake Urmia

The images show Iran's Lake Urmia on August 13, 2011 (top), and August 25, 1998 (bottom).

The cause of Urmia's depletion has been disputed. The Iranian government blames climate change and drought, while many citizens blame damming of rivers by the government. Protesters expressed concern over the increasing exposure of the lakebed, including the possibility that windblown dust could carry harmful salts to nearby agricultural fields or endanger human health.

A study published in 2007 concluded that both drought and increased demand for irrigation water contributed to the lake's falling water levels and rising salinity. The study cited growing populations in the surrounding area and the consequent need for potable water. (NASA)

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STANDARD EXAMINER

As Great Salt Lake dries up, Utah air quality concerns blow in

TUESDAY , SEPTEMBER 29, 2015 - 4:46 PM

Benjamin Zack/THE STANDARD-EXAMINER

Wind picks up dust, sand and particulates off the dried lakebed of the Great Salt Lake and blows it towards the Wasatch Front on Saturday, Sept. 5, 2015. As the lake levels drop, more light sand and minerals become exposed to the open air.

The sky above Ogden turned pallid as a white haze crept along the Wasatch Front around 2 p.m., Sept. 4.

The winds that day blew in from the south, as they often do, rolling across a largely dry Farmington Bay past Antelope Island (http://stateparks.utah.gov/parks/antelope-island/). The mountains faded. Views of the valley vanished. Drivers found their cars speckled with a fine, white silt. State air monitors reported elevated particulate pollution in Ogden — all from dust

blown in from the exposed bed of the Great Salt Lake (https://en.wikipedia.org/wiki/Great_Salt_Lake). Air quality experts aren't sure what's in that dust or what it's doing to our lungs.

(http://www.standard.net/Great-Salt-Lake)

The Great Salt Lake has dropped to near-record lows. A changing climate and proposed water projects for a growing Wasatch Front population mean a lower lake could become the new normal. A growing urban population also means more people could be exposed to health harms from lakebed dust.

WHERE THE DUST BLOWS

The Wasatch Front already sees dust plumes linked to late winter and springtime storms, said Seth Arens, a scientist with the Utah Division of Air Quality. (http://www.airquality.utah.gov/)

Story continues below photos

Most of that dust usually blows in from miles away. Milford Flats, about 250 miles south in Beaver County, is often a source. It's the site of a 2007 wildfire (ttp://www.researchgate.net/publication/257522219_Meteorological_characteristics_of_dust_storm the largest in Utah history, which burned the vegetation that would normally keep sediment on the ground.

(http://www.standard.net/environment/2015/10/11/Millions-of-birds-face-dire-future-as-Great-Salt-Lake-shrinks.html)

A lot of dust also comes from Sevier Lake, about 200 miles south, a dry lakebed and a source of dust since the 1880s.

"However, with all the growing salt flats around the Great Salt Lake itself, it's (also) going to start generating dust," Arens said.

Dust from the Great Salt Lake's bed is particularly problematic. Because it only blows a few miles before it reaches Wasatch Front cities, it carries finer particulates that can enter the respiratory tract and embed in lungs. Although it's formed from a different source, fine particulate pollution is also what causes breathing problems during winter inversions (http://www.standard.net/Environment/2015/01/24/Eight-things-you-should-know-about-inversions-in-the-Top-of-Utah).

Arens said his department "isn't in the business of scaring people." He doesn't want dust fears to become overblown.

Story continues below photos

The Great Salt Lake in 1985 versus 2015.

"We don't get very many of these events. This isn't going to be this apocalyptic dust cloud that's coming over the valley," he said.

But anecdotally, he said, Division of Air Quality forecasters saw more dust events blowing from the lake this season. Arens figures it's because the exposed lakebed is parched.

"April was the first time I'd seen a (dust storm) that was so pronounced. Since I've been out on the lake this summer, I've seen two or three more," he said. "We had such a dry, warm winter ... the lake's really low. If you look at satellite images, it's just a narrow strip."

If the lake stays low, or keeps losing water, meteorologists studying wind patterns and dust chemistry are particularly about future consequences for people living along the Wasatch Front.

"If the lake were to completely dry up, we've got decades of nasty chemicals, mercury and other toxins that have built up in the lake bed," said Erik Crosman, a researcher in atmospheric science at the University of Utah (http://www.utah.edu/). "I think it'd be a situation where they'd have to divert water back on the playa. It'd be a big health hazard."

THE LAKEBED'S 'UNCHARTED TERRITORY'

Like Arens, Crosman said Utah doesn't experience enough powerful wind storms where dust would be a perpetual problem. But it'd be problematic enough.

"I already see the nasty white dust," he said. "It doesn't feel good to me, to breath that air. So you could imagine, a few days of that could be pretty bad. I don't think you could argue that it's no more than a nuisance."

And if dust blowing in from dry lakes and scorched land 200 miles south can blow in and spike particulate levels along the Wasatch Front, it's hard to think having a dry lake bed right along the Wasatch Front wouldn't cause at least occasional major problems with whiteouts along the Interstate 15. Even for only a short time, visibility could be bad for planes, too. Salt Lake International Airport, (http://www.slcairport.com/) the Ogden-Hinckley Airport (http://flyogden.com/) and Hill Air Force Base (http://www.hill.af.mil/) are all less than 10 miles from the lake.

If dust becomes a perpetual problem, potentially caustic, toxic dust would land on vegetation, cars and structures. It's hard to think it wouldn't cause breathing problems.

"We're kind of uncharted territory with lake being near record lows now," Crosman said. "I don't think anyone really knows what would happen."

But there's a gloomy precedent for fallout from dry lakes in the U.S., starting with California's Owens Lake, which dried up in the 1920s.

In 1989, the L.A. Times wrote of a caustic blowing dus (http://articles.latimes.com/1989-04-02/news/mn-1380_1_owens-lake-dus)t that caused bloody noses, watery eyes and irritated lungs. The airborne sediments were also laden with cancer-causing heavy metals from decades of mining the Sierra Nevada mountains.

Owens Lake dust also had an economic fallout. Dust storms caused major whiteouts. Plumes shut down operations at the China Lake Naval Weapons Center, 70 miles south, for five to 10 days at a time. It cost the military millions.

In 1990s, the U.S. Geological Survey reported visibility issues (http://geochange.er.usgs.gov/sw/impacts/geology/owens/) at nearby national parks, forests and wilderness areas.

After some drawn-out lawsuits, the air problem cost the City of Los Angeles (http://mynewsla.com/government/2014/11/14/dwp-reaches-deal-air-quality-managers-dust-pollution-owens-lake/) $1.3 billion in mitigation efforts. Each year, the city releases around 25 billion gallons of water onto the dry lakebed, which is becoming increasingly difficult as California grapples with a crippling drought.

It's not hard to see parallels between the Owens Valley and Great Salt Lake Valley. But there are differences, too. Owens Lake covered an area about one-sixth the size of the Great Salt Lake. The Owens Valley is also fairly rural, and the dry lake dust threatens the health of around 40,000 residents. The Great Salt Lake stretches along an urban area with a population of over 2 million.

Mercury pollution is another looming problem unique to the Great Salt Lake, and mercury contamination is largely tied to the state's own mining history.

Samples collected from the Great Salt Lake's depths show some of the highest mercury levels recorded (http://learn.genetics.utah.edu/content/gsl/monitor/) in the U.S. The water mostly keeps humans from becoming exposed to the toxin. It has, however, moved up the lake food chain from brine shrimp to birds. In 2005, the Utah Department of Health began warning against eating several species of duck (http://waterfowladvisories.utah.gov/) found on the lake.

The Utah Division of Forestry, Fire and State Lands owns the lakebed and minerals in the waterbody. While the division has funded mercury research on the lake for several years, this is the first year they requested studies on lakebed dust (http://www.ffsl.utah.gov/index.php/grant-programs/state-lands-research-grants).

STATE-FUNDED STORY

A state grant of around $40,000 went to Greg Carling, an assistant professor in geological sciences at Brigham Young University. His research will provide the state's first glimpse into what's blowing around in the lakebed dust.

"We have anecdotal evidence that dust from the Great Salt Lake is making its way to the Wasatch Front, but we don't have any quantitative measures on dust plumes from the lake, and we don't know anything about what's in the dust," he said. "There's potentially a problem there, but we don't know what it is."

Carling's PhD work found that dust storms can raise the levels of mercury, uranium and lead that settle on Wasatch Mountain snowpack by a factor of five. But he conducted that research several years ago, before the Great Salt Lake dropped and exposed several square miles of lakebed.

For his Great Salt Lake study, Carling will provide the state's first glimpse of what trace metals and minerals are found in the lakebed. He'll develop a fingerprint tied to the unique chemistry found at different dust sources. With those chemical fingerprints, he'll tease out how much dust blowing along the Wasatch Front comes from the Great Salt Lake.

"When we get these dust storms we see on our cars, and we see on the windows, the big question is, where did that dust come from?" he said. "Depending on where you're at, the answers might be a little different."

At least when it comes to mercury, Carling is cautiously optimistic. The contaminant loses its toxicity as it's exposed to the air and baked by the sun.

"I'm assuming that's probably what happens," Carling said. "We may have slightly higher mercury concentrations in (Great Salt Lake) dust, but hopefully it's not going to be a huge problem."

Carling will send his dust study results to the Division of Forestry, Fire and State Lands by the end of June 2016.

While part of Carling's study will help unearth what kinds of metals and minerals are embedded in the lakebed, he said understanding the health impacts is another matter.

"That's going to be a lot of years of study and looking at local health records over time," he said. "We're just getting a first look of what's there."

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STANDARD EXAMINER

Marinas in jeopardy as Great Salt Lake continues to dry up

FRIDAY , OCTOBER 09, 2015 - 3:27 PM

Leia Larsen

Four boats await moving at the Great Salt Lake Marina on March 1, 2015. According to park officials, around 90 boats have been pulled from the marina in the past year as water levels drop.

Navigating a 54-foot yacht through the Great Salt Lake Marina's (http://www.gslmarina.com/) tight harbor takes finesse. It doesn't help that a drought-induced dropping lake and years of accumulating sediment last March meant only about three feet of water was left in the harbor. But Dave Ghizzone, owner of Gonzo Boat Tours and Rentals (http://utah.com/gonzo-boat-rentals-and-tours), knows the marina well. Even when his propellers churned up sand and turned the water murky, he remained unfazed.

(http://www.standard.net/Great-Salt-Lake)

"You can see what we're up against here," he said, motioning toward the narrow rocky banks at the marina's mouth. "We have a very small margin of error we have to hit pretty much perfectly every time, and if we miss it, we'll hit a prop."

As his retrofitted dinner yacht, christened "Sunset," moved from the tortuous, shallow marina to calm, open water, Ghizzone spoke of a lake worth the struggle.

Editor's note: This is an edited and updated version of a story originally published on March 4, 2015.

"This is the most unique lake on Earth, it really is," he said. "We call it 'the sickness.' Once it gets in your blood, you're hooked."

Even with the allure of its waters, prolonged drought and the capriciousness of the Great Salt Lake have caused a flood of anxiety among boaters and boat business owners like Ghizzone.

Utah State Parks (http://stateparks.utah.gov/) manages marinas at Great Salt Lake State Park (http://stateparks.utah.gov/parks/dead-horse/map/) and on Antelope Island (http://stateparks.utah.gov/parks/antelope-island/). Even in a good water year, those are the only two major boat access points on the entire 75-mile lake. But the lake is now so low that the Antelope Island one has dried up and closed. Most of the boats that dock at the Great Salt Lake are beached in the parking lot or storage units. The water is so shallow they would topple over as the keels hit the lakebed.

But when it came time for the Legislature to allocate $1.5 million this year to dredge the State Park marinas to keep them open, lawmakers nearly left Great Salt Lake boaters high and dry. All the funds were instead funneled to the marina at Utah Lake State Park. (http://www.standard.net/Recreation/2015/03/04/Park-director-to-boaters-Get-out-early-and-often)

The news came as a blow to Ghizzone. He rented kayaks, motorboats, paddleboards and pedal boats at Antelope Island before its marina dried up. His business now completely depends on rentals and dinner cruise tours out of the Great Salt Lake Marina. Along with a sailing rental business, Sailing Solutions, he's one of only two concessionaires operating on the Great Salt Lake. Neither was consulted in the state's decision, Ghizzone said, but they need the marina dredged to stay in business.

According to Utah State Park information, Utah Lake State Park was last dredged in 2003. The mouth of the Great Salt Lake Marina was dredged in 2008, but the marina itself hasn't been dredged since 1979 or 1980.

"I've been dealing with a lot of depressed slip renters trying to figure out where they're going to go, how they're going to get out, where they're going to store, or if they're going to California and just give up," said Dave Shearer, harbormaster at the Great Salt Lake Marina. "The water situation we're having now is just devastating to this community."

Sailors and business owners sent several letters to state lawmakers and raised hell through the media. At the eleventh hour, the state Legislator scraped another $1.5 million to dredge the Great Salt Lake Marina just before the ending of the 2015 session. That was last spring, but the marina's boats remain stranded. With all the designing, engineering, wetlands scoping and project bidding, dredging won't happen until at least this winter.

In the meantime, the Great Salt Lake Marina will store beached boats (http://www.standard.net/News/2015/04/24/Boats-removed-from-Great-Salt-Lake-for-dredging-project) for free and Utah State Parks loses revenue.

Great Salt Lake Marina has 320 rentable slips total. Boaters at the Great Salt Lake typically rent slips and sail year-round because its waters don't freeze. Renting a slip costs about $1,500 a year, and those funds are the primary source of the park's revenue.

The Great Salt Lake State Park receives between 250,000 and 300,000 visitors annually. About half those are slip renters, according to Jeremy Shaw, the park's ranger.

"We're going to accommodate those boats the very best we can, whether keeping them in slips or keeping them in dry storage at the park, we'll do everything possible to accommodate our boaters," Shaw said in March. "But long-term, we're going to see a pretty good reduction in revenue."

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STANDARD EXAMINER

Mineral extraction on Great Salt Lake has local, national and global impact

SATURDAY , APRIL 30, 2016 - 10:01 AM

Leia Larsen

Heavy equipment packages salt near ponds leased to U.S. Magnesium on Dec. 8, 2015. While the company's primary product is magnesium metal, its ponds also produce road salts.

LEIA LARSEN, Standard-Examiner Staff

Tom Tripp sat in U.S. Magnesium's Rowley conference room, rapping a pencil against a can of Fresca.

"If you think of aluminum foil, it's kind of soft, that's why it molds over your leftovers," he said. "This can, it's pretty thin. It'd be a bag except this aluminum has 1.5 percent magnesium in it."

That's what magnesium is mostly used for, alloying with aluminum. Pretty much anything made out of aluminum, apart from foil, has magnesium, from soda cans to pots and pans to the bleachers at little league games.

The number two use of magnesium is auto parts, because magnesium is also lightweight.

"So if you put it in an automobile, it makes it lighter and the fuel efficiency better," Tripp said, popping open the beverage.

After that, magnesium is used for steel production, chemicals, pharmaceuticals, anti-aircraft avoidance systems, fireworks — all kinds of things.

The U.S. Magnesium (http://usmagnesium.com/) plant where Tripp, the company's technical services manager, sat drinking his soda is situated along the Great Salt Lake's western shore. It is the only producer of magnesium in North America, and with the exception of a small operation out of Brazil, it's the only producer of magnesium metal in the Western Hemisphere.

So what would it mean for magnesium — and the price of all the products it goes into — if the Great Salt Lake's water levels keep dropping, and like other saline lakes in the world, ultimately disappears?

Tripp took a drink and slid can along the table.

"Well, that means you'd be almost completely dependent on China for magnesium," he said. "And the price worldwide would probably go crazy."

The market of commodities is complex, but Gabriel Lazoda, an associate professor in economics at the University of Utah, agrees with Tripp.

"When they start having that kind of pricing power, what they tend to do is increase the price," he said. "And that decreases the quantity. That's the type of squeeze that gets put on consumers."

China dominates the magnesium industry, producing over 80 percent of the world's primary supply, according to a 2013 report (http://minerals.usgs.gov/minerals/pubs/commodity/magnesium/myb1-2013-mgmet.pdf)by the U.S. Geological Survey.

It's hard to say how much magnesium the Great Salt Lake provides — because U.S. Magnesium is the only producer on the continent and their information is proprietary. Tripp estimates their contribution is about 14 percent, and the Great Salt Lake Advisory Council, created by the Utah

Legislature, cites that figure (http://www.gslcouncil.utah.gov/docs/2012/Jan/GSL_FINAL_REPORT-1-26-12.PDF), too.

While the U.S. doesn't produce a huge chunk of the world supply of magnesium, its citizens use a whole lot of it and consumers, whether they know it or not, prefer that competing industries exist to help keep the cost of cans, cars and golf clubs low.

The reason China has such a stranglehold on the magnesium market is the same reason it dominates the world supply of a lot of commodities — abundant low-cost labor, laxer environmental regulations and cheap coal to burn for energy.

The only reason U.S. Magnesium is able to compete is because of a somewhat controversial anti-dumping tariffs and because it uses the sun to extract the mineral from Great Salt Lake brine.

"We have 65,000 acres of infill solar ponds," Tripp said. "In the course of a year, we're evaporating 40 billion gallons of water."

And not having to generate power to harvest all the raw magnesium saves Tripp around $2 billion annually, he figures.

"We get this big value from solar evaporation. We don't have mining costs, which tend to be high, so the lake gives us unique advantages," Tripp said.

For centuries — millennia, really — rivers flowing from the Wasatch Mountains have dissolved ore from rocks and carried them to the Great Salt Lake and its massive precursor, Lake Bonneville. As Lake Bonneville dried up, its minerals concentrated (http://geology.utah.gov/popular/general-geology/great-salt-lake/commonly-asked-questions-about-utahs-great-salt-lake-lake-bonneville/#toggle-id-6) down to what's now the Great Salt Lake and the Bonneville Salt Flats.

Because the Great Salt Lake is so big and shallow, a massive amount of water evaporates off its surface every day — around 2.6 billion gallons (http://learn.genetics.utah.edu/content/gsl/physical_char/), or enough to fill 3,900 Olympic-size swimming pools.

The Great Salt Lake has no outlet, so while the water evaporates, the only way salt minerals leave the lake is if they're taken out.

Five companies currently extract salt and minerals from the lake through evaporation. Mineral extraction on the Great Salt Lake brings over $1 billion to the Utah economy each year.

Apart from magnesium, salt for roads and potassium for fertilizer are the other important products mined from the lake.

While dropping lake levels help concentrate those valuable minerals even more, the loss of water is taking an economic hit on the extraction industries.

U.S. Magnesium, for example, had to move its pumps to get water to its evaporation ponds. That cost over $500,000, Tripp said. If the lake continues dropping, they'll have to dig canals, which takes complicated permits and costs millions of dollars. Those growing operation costs cut into profits.

"When you're a commodity, you don't get to set the worldwide price. It's not like your cost goes up and you suddenly get to increase the price," Tripp said. "Take salt, there's a worldwide price for salt. Suddenly your salt costs more (to extract), so your profit is less."

Compass Minerals (http://www.compassminerals.com/who-we-are/locations/ogden-utah/) (formerly Great Salt Lake Minerals), which employees around 375 people at its Ogden plant, had to extend canals to reach the lake's low water this year. Their target product, potassium, is used in sulfate of potash (https://en.wikipedia.org/wiki/Potash), and is sold to farms in Florida and California to grow fruit and nuts. (Potash is a combination of salts and other mined minerals that contain potassium in a water-soluble form.) The fertilizer produced by Compass Minerals helps increase yields, ever more important as the nation's farmland gets gobbled up by urban development (https://e360.yale.edu/digest/most-productive-us-farmland-disappearing-at-fastest-rate-report-says/2627/).

The lake is the only commercial source of sulfate of potash in North America and the fertilizer is all used domestically.

"The Great Salt Lake provides an essential mineral that's critical to putting food on the plate of U.S. consumers," said Joe Havasi, director of natural resources for Compass Minerals.

Compass Minerals' representatives are quiet about how lower lake elevation is affecting its Great Salt Lake business, but officials with the Utah Division of Forestry, Fire and State Lands say the company has spent "quite a bit of money and time extending their intake this year." The division knows this because it is in charge of issuing permits to mineral companies and collects royalties based on how much the companies extract.

Compass Minerals moves water from the north arm to its evaporation ponds through a 21-mile underwater canal called the Behrens Trench. (http://epod.usra.edu/blog/2014/06/behrens-trench.html) The process is getting trickier as water evaporates and salt builds up.

Compass Minerals operates off the north arm of the lake, which is significantly saltier than the rest of the lake because of the Union Pacific Railroad Causeway, which effectively cut off all freshwater sources to that part of the lake. Now a salt crust below the water is building up as thick as eight feet (http://www.standard.net/Environment/2015/11/20/Great-Salt-Lake-oddity-created-by-causeway-to-get-makeover) in some areas.

According to scientists working with the Utah Department of Natural Resources, salt keeps accumulating in the Behrens Trench and needs to be cleared.

So, dropping water levels and concentrating minerals, "it's kind of double-edged" for Compass Minerals, said Andew Rupke with the Utah Geological Survey.

"It makes it easier to get to the potash because you don't have to evaporate as much, but you have trouble with loading," he said.

Even as the costs mount, Tripp and Havasi said they aren't worried about those companies completely drying up on the Great Salt Lake, but both said they're concerned about the health of the ecosystem on which their industry depends.

"This (is) a watershed issue, not just a lake issue," Havasi said.

Water diversions have made the lake 11 feet lower than it would naturally be today, according to a white paper recently published by scientists with Utah State University.

Tripp and Havasi also said they worry about the proposed Bear River development project that could drop the elevation another 8 inches.

Mineral industries' salt ponds account for 1.4 feet of that drop, which isn't insignificant. But Compass Minerals has been lauded recently (http://www.standard.net/Environment/2016/04/27/Oil-Gas-and-Mining-board-recognizes-Compass-Minerals-for-Great-Salt-Lake-protection.html) for efforts to reduce water needs while expanding operations.

"We've really grown in the appreciation of the health of the lake," Havasi said. "We're aligned with so many stakeholders with many different interests. But one common thing is, we all want water to flow to the lake so the lake will be healthy."

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STANDARD EXAMINER

U.S. brine shrimp industry could be in peril if Great Salt Lake keeps shrinking

FRIDAY , APRIL 29, 2016 - 7:48 PM

BENJAMIN ZACK/Standard-Examiner

Brine shrimp harvesting camps, bottom, and mineral collection ponds, background fill the northeast corner of the Great Salt Lake.

LEIA LARSEN, Standard-Examiner Staff

If you want to get a sense of what a bizarre, globally interconnected economy we live in, look no further than the tiny brine shrimp living in the Great Salt Lake.

Americans chow down around four pounds per person of shrimp and prawns a year. In 2014, we imported 567,551 tons of shrimp to eat. We consume more shrimp than any other seafood, including tuna and salmon.

And that might not be possible if not for the non-charismatic, durable brine shrimp living in the Great Salt Lake — and the people fishing for them.

“Shrimp, when they’re first born, don’t have good survival rates if fed artificial feed,” said Don Leonard, CEO of the Great Salt Lake Brine Shrimp Cooperative. “The easiest way to understand it is, we provide baby food for baby shrimp and fish.”

Leonard’s industry harvests brine shrimp eggs, or cysts, because those eggs have evolved to endure some pretty intense situations. (http://www.sciencedirect.com/science/article/pii/0094576575900958) They can sit dormant for months or even years, then hatch with just a little water. They’ve even hatched after traveling through outer space. (http://learn.genetics.utah.edu/content/gsl/artemia/)

Once people figured out cysts could also be canned, shipped and hatched to feed baby shrimp, seafood farming suddenly became possible.

“There aren’t many places close to the U.S. where shrimping occurs naturally. You have to have fairly warm water,” said Gabriel Lozada, an associated professor in economics at the University of Utah.

So, brine shrimpers on the Great Salt Lake began shipping cysts to warm places like Thailand and Ecuador, and those places shipped farmed prawns back to the U.S.

“The eggs are very tough … they’re pretty lightweight, and not expensive to export throughout the world,” Lozada said. “Then all you have to do is open the can and put eggs in the water. Lo and behold, they’ll hatch. It’s a very convenient food source.”

Since the mid-1980s, U.S. consumption of shrimp has more than doubled. Now, 90 percent of the shrimp (http://www.bls.gov/opub/btn/volume-3/shrimp-disease-in-asia-resulting-in-high-us-import-prices.htm) on our plates is imported.

At one point, the Great Salt Lake supplied almost all of the world’s cyst supply for farmed shrimp but competition has since sprung up in countries with fewer environmental regulations and labor costs. Most of the 17 companies operating on the Great Salt Lake now mostly pool their resources as members of the Great Salt Lake Brine Shrimp Cooperative.

But Utah still supplies somewhere between one-third to half of the world supply. That means a lot of the shrimp consumed in the U.S. indirectly comes from the Great Salt Lake.

“Name another industry in Utah that supplies one-third of the world’s product,” Leonard said.

And if brine shrimp harvesting on the Great Salt Lake collapses, it could drive up the cost of seafood worldwide, Lozada said.

Today, brine shrimp harvesting contributes just under $57 million to the state's economy. But as the Great Salt Lake shrinks, the vitality of the brine shrimping industry is threatened.

The low water is already taking its toll. Leonard said the co-op spent $2 million dredging harbors for their boats.

"It hits us the most operationally," he said. "We have large boats we need to get on and off the lake with a lot of product on board. It's a shallow lake anyway."

The brine shrimp harvest season is short, generally running from October to January. The brine shrimp harvesters actually approached the state in the 1990s and asked them to regulate their industry. The fear was overfishing.

"As an industry, we don't want to wake up one day and read the headline 'industry depletes the lake,'" Leonard said. "I defy you to find another industry, anywhere, that went to the government and said 'please regulate this resource.'"

Once the Great Salt Lake Ecosystem Project (http://wildlife.utah.gov/gsl/) (GSLEP) biologists, part of the Utah Division of Wildfire Resources, find 20 cysts per liter or fewer in the lake's water, they call off all brine shrimp harvesting, no matter what.

If the brine shrimp industry disappears, apart from losing a multi-million dollar industry, the state's biologists could also lose an important funding source.

The state collects royalties on the brine shrimp harvests, which are used to fund GSLEP. Beyond counting shrimp populations, that program has lead to research on the Great Salt Lake ecosystem to help better understand the lake than Utah ever has before.

"Early on, I don't think there was much interest (in the lake). People didn't think there was that much out here," said Maureen Frank, a graduate student at Utah State University who studies birds on the lake with help from GSLEP. "Until commercial shrimp harvesting began, it was like … why would we care what's out there?"

MINIATURE COWS

Harvesters aren't the only ones depending on brine shrimp to thrive. Millions of migratory birds eat them, too. The Utah Division of Wildlife Resources, through GSLEP, regularly samples the lake to determine how many shrimp there are.

As the water in the lake drops, the salinity increases. So does the water temperature. Brine shrimp can handle some pretty warm, salty water, but the algae they eat can't.

"Think of them as miniature cows — they eat the phytoplankton, all this algae, out of the water," said Kyle Stone, a GSLEP biologist, during sampling last summer.

Brine shrimp eggs are tenacious, but one bad year can mean fewer algae, a crash in brine shrimp populations and a lot of damage to the harvesting industry.

"If it were to drop a few more feet, I'd be concerned about the salinity levels," Leonard said. "There is an ideal range of salinity for brine shrimp, and we're at the upper end of that."

Adult brine shrimp can survive in water with 30 percent salinity (http://wildlife.utah.gov/gsl/brineshrimp/salinity.php) but ideally need salinity levels at around 15 percent to produce the optimal amount of cysts. To start hatching, the eggs need to be at around 10 percent salinity, which is why they often float — to reach the fresher water at the top of the lake.

The Great Salt Lake's southern half is at around 15 percent salinity. The lake's north arm, cut off from any freshwater sources by the Union Pacific railroad causeway, is between 26 and 28 percent salinity. There are no brine shrimp in the north arm.

A dropping lake also means more exposed beach, which isn't great for the cysts, either. While they can survive tough conditions, UV light destroys viability.

"All those brine shrimp eggs that sit at the surface potentially wash up on shore and get stranded there. It takes them out of the system, essentially," said Jim Van Leeuwen, who's worked with GSLEP for 15 years.

And if the brine shrimp populations aren't stable, there are more global consequences.

"You might have more fishing pressure if people move away from farmed shrimp to wild shrimp," Lozada said.

That could harm sea turtle populations and other sensitive, for example, where other nations don't have special regulations

"The economy is this really complicated web," Lozada said. "When you disturb one part of it, it can be hard to figure what the effects are going to be on all the other parts."

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STANDARD EXAMINER

Your favorite Utah outdoor activity is likely tied to the Great Salt Lake

WEDNESDAY , MAY 04, 2016 - 6:00 AM

BENJAMIN ZACK, LEIA LARSEN/Standard-Examiner

Large change to the Great Salt Lake can change recreational opportunities both on the lake and around the region.

LEIA LARSEN, Standard-Examiner Staff

It might not have the allure of red rock country; it might not draw big dollars like the winter sports industry. But the notion that the Great Salt Lake has no appeal for tourists — or for hikers, bikers, boaters and birders — is misguided.

“Visitors come here, they stay here, they want to see iconic places and have these very meaningful experiences with natural resources that they can’t get anywhere else,” said Bob Barrett, manager of the Bear River Migratory Bird Refuge (http://www.fws.gov/refuge/bear_river_migratory_bird_refuge/). “And they’re willing to spend a significant amount of their income to do these things.”

Around 1 million people visit the Great Salt Lake each year to recreate and to enjoy its unique landscape. Those visitors walk along the Spiral Jetty in the north and on Stansbury Island nature trails in the south. They hunt at 25 private duck clubs and five different state Waterfowl Management Areas. They spend around $74.6 million annually, according to a 2012 study.

But with the dropping lake levels, much of the recreation tourists and residents of the Wasatch Front enjoy — and the dollars that come with it — also fall under threat.

“As we look at challenges in the future for the state of Utah, with water, pollution and growth, one of the greatest assets Utah has when it comes to its economy is outdoor recreation,” Barrett said.

Here are some of the outdoor assets threatened by the lake’s declining elevation.

Skiing

With all its salt, the Great Salt Lake doesn’t freeze. When winter weather moves over the lake, it collects extra water and dumps it as snow in the nearby mountains. Lake effect storms account for between 5 to 10 percent of the total snow in the Wasatch, which might not sound like much.

“But in any given winter, the difference between getting a big lake effect and not getting one can have more significant impacts on (the) ski season,” said Erik Crossman, an atmospheric scientist working at the University of Utah.

Lake effect snow also tends to come early in the season and help build a base for Christmas visitor traffic. Non-resident skiers and snowboarders spent around $1 billion in Utah during the 2012-13 season, according a 2014 economic study.

As the lake shrinks and more lakebed becomes exposed, blowing dust becomes problematic for snow. (http://earthobservatory.nasa.gov/IOTD/view.php?id=7842)

Experts say snowpack is melting earlier, part of which seems to be brought on by dust collecting on snow.

Because dust is darker than snow, it absorbs more heat from the sun. Dust-covered snow could melt out as much as a month earlier, a disastrous prospect for both the ski season and water supplies in northern Utah.

Biking and hiking

Antelope Island has around 10 trails for all ability levels. Stansbury Island has a nine-mile loop. Road cyclists also bike through the Bear River Migratory Bird Refuge and along the Davis County Causeway leading to Antelope Island.

Antelope Island is the second-most visited state park in Utah, falling just behind Dead Horse Point near Moab. Only around one-quarter of the island's visitors come from the Wasatch Front, according to park officials. Around 40 percent of those visitors come from places outside the U.S.

While a dropping lake doesn't impact hiking and biking activities directly, it does impact the scenery enticing visitors to summit Frary Peak or survey Stansbury Island.

As more water is diverted there won't be much more lake for those hikers and bikers to look at.

"People say 'let's dam Bear River. And the other side wants to make more evaporation ponds," said Jolene Rose, a biologist at Antelope Island State Park.

Decisions like that have a domino-effect that impacts the lake more than they think.

Birdwatching

Over 250 bird species visit the lake to the east and rest during migration. They also draw avian enthusiasts from around the globe. Around 200,000 people visit the Bear River Migratory Bird Refuge each year and 60 percent of those visitors travel more than 100 miles to get there, according to Kathi Stopher, the refuge's visitor services manager.

All that bird tourism helps boost the economy.

For every dollar the government appropriates to national bird refuges like Bear River, $4.87 goes back to local economies, according to the National Wildlife Refuge Association.

Birders also visit over 10 Waterfowl Management Areas and public birdwatching sites around the lake, from Locomotive Springs in the north to Timpie Springs in the south.

The Division of Forestry, Fire and State Lands estimates waterfowl viewing in Utah had an economic value of $100 million to $189 million in 2008.

The dropping lake, however, puts pressure on birds.

"The birds are here for three reasons. Water, water and water," said Barrett, the bird refuge manager. "As we change the system, lessening the amount of water and the amount of habitat associated with those waters, that has a tremendous impact on wildlife populations, especially water-dependent wildlife populations."

Waterfowl hunting

Hunters make around 100,000 trips to the Great Salt Lake ecosystem, visiting both public lands and private clubs, according to a 2012 economic report (http://www.gslcouncil.utah.gov/docs/2012/Jan/GSL_FINAL_REPORT-1-26-12.PDF).

One of the most popular public sites for waterfowl hunting, Bear River Migratory Bird Refuge (http://www.fws.gov/refuge/bear_river_migratory_bird_refuge/), saw hunter visits jump dramatically in recent years.

“From last year to this year’s hunt season, we’ve seen a 67 percent increase in hunting use,” said Kathi Stopher, visitor services manager at the refuge.

And since most of the refuge’s visitors aren’t local, those hunters benefit the local economy.

“We know when water fowlers come into town, if they’re aren’t part of local hunting clubs, they spend money on lodging and on miscellaneous things, like food and supplies,” Stopher said.

In 2010, waterfowl hunters from the public spent $180 per day (http://www.gslcouncil.utah.gov/docs/2012/Jan/GSL_FINAL_REPORT-1-26-12.PDF) on their trips, according to the 2012 report. Private club hunters spent around $563 each day. Those waterfowl hunters spent an estimated $26.5 million total on their trips, and another $35.4 million on equipment bought within the Salt Lake City area.

But the waterfowl depend on the wetland habitat around the lake. As the Great Salt Lake drops in elevation, that habitat is threatened by loss of water and blowing dust from the exposed lakebed.

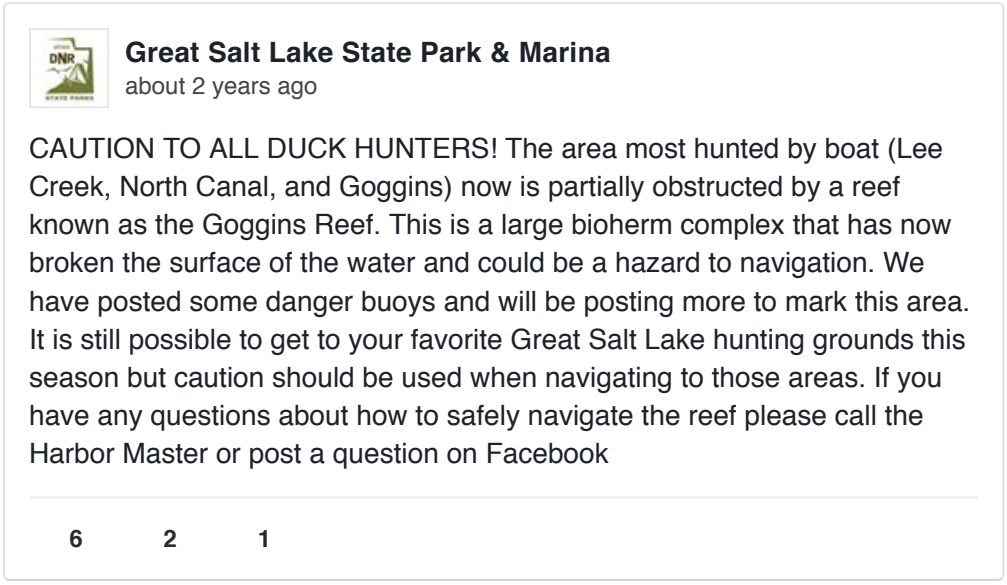
“If you get habitat that’s inundated constantly by that accumulation of salts ... it impacts the soils and the plants. It makes them much less productive,” said Refuge Manager Barrett. “There’s a fine line between very productive habitat and less productive habitat.”

Boating

The Great Salt Lake lures a passionate group of sailors (http://www.standard.net/Environment/2015/10/11/Marinas-in-jeopardy-as-Great-Salt-Lake-continues-to-dry-up) who have been stuck high and dry as the water levels fall.

The lake has only two public access points for boats. The marina at Antelope Island is out of water. Sailors, kayakers, paddleboarders and rowers at the marina at Great Salt Lake State Park await much-needed dredging. Rocky bioherm reefs are surfacing and becoming navigational

hazards for duck hunters.



Great Salt Lake State Park & Marina
about 2 years ago

CAUTION TO ALL DUCK HUNTERS! The area most hunted by boat (Lee Creek, North Canal, and Goggins) now is partially obstructed by a reef known as the Goggins Reef. This is a large bioherm complex that has now broken the surface of the water and could be a hazard to navigation. We have posted some danger buoys and will be posting more to mark this area. It is still possible to get to your favorite Great Salt Lake hunting grounds this season but caution should be used when navigating to those areas. If you have any questions about how to safely navigate the reef please call the Harbor Master or post a question on Facebook

6 2 1

But even Utah boaters who have never spent time on the Great Salt Lake still benefit from it.

The Division of Forestry, Fire and State Lands (http://www.ffsl.utah.gov/) collects royalties from mineral companies on the lake. It's the division's main source of funding. The Utah Legislature appropriates (http://le.utah.gov/lfa/reports/cobi2015/LI_RDA.htm) those funds to projects throughout the state.

In 2015, Great Salt Lake royalties helped fund (http://le.utah.gov/lfa/reports/cobi2015/LI_RDA.htm) access improvement at Bear Lake and dredging the marina at Utah Lake.

They funded removal of navigational hazards from rivers, like fences, concrete and abandoned pipelines. They helped stabilize the banks of the Jordan River. They funded more inspections for invasive quagga mussels.

"(The Great Salt Lake) allows us to do a lot of good restoration work on the Green and Colorado rivers, on the Jordan River, on Utah Lake. It's important for all our sovereign lands for sure," said Laura Ault, sovereign lands program coordinator. "So we have concerns about lower lake levels."

Last year, FFSL collected just under $10.7 million in royalties from the Great Salt Lake. Ault said if the lake keeps falling, it could impact mineral companies on the lake as their cost of operation keep going up.

Combine that with a drop in the global price for the minerals companies harvest from the lake, and "you could have a perfect storm, potentially," Ault said.

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