FRIENDS of *Great Salt Lake*

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The Last Lonely View by Charles Uibel

The mission of FRIENDS of Great Salt Lake is to preserve and protect the Great Salt Lake Ecosystem and to increase public awareness and appreciation of the Lake through education, research, advocacy, and the arts.

Executive Director's Message

Great Salt Lake - The Gift That Keeps on Giving – Just Add Water

" He (Farooq Azam) turned and looked up at the peak in front of him. "Once I do that (find out what is happening to the Chhota Shigri Glacier in the Himalayan peaks of Northern India) the next step will be to decide what has to be done. But these things don't depend on science. They depend on politics."
-The End of Ice: Exploring a Himalayan glacier by Dexter Filkins, New Yorker Magazine, April 4, 2016

I was the last speaker of the day at a symposium hosted by Wayne Wurtsbaugh, Professor of Aquatic Ecology, Limnology, and Fish Ecology, Utah State University, and Steve Burian, Associate Professor of Civil and Environmental Engineering, University of Utah. The symposium was organized to bring together scientists, academia, government, the private sector and non-governmental organizations from Lake Urmia, Iran, and Great Salt Lake, Utah to share recent findings, accomplishments, and challenges in their work on lake and wetland management.
Held at the Department of Environmental Quality this past March, the anticipated outcome is to "strengthen existing relationships and build new collaborations leading to a knowledge corridor supporting the sustainability of Great Salt Lake, Lake Urmia, and other wetlands and water resources in Iran and Utah. "

It was a rich and briny experience. But it was also an "Aha" moment for me because I realized how much we – the Great Salt Lake home team – already have going for us and our Lake – politics aside. Along with the economic significance of $1.3B annually and 7,700 full time jobs that Great Salt Lake directly contributes to our state and the region, we have an indispensable toolbox to work with. We have an extraordinary endowment of science, which continues to inform our understanding about the system. We have effective collaboration that supports open communication and participation. And we have a growing recognition about the importance of integrating these abilities so that we can fulfill our responsibility to effectively sustain this hemispherically valuable ecosystem for future generations.

The takeaway from this shared experience is that at all costs we never want to find ourselves and Great Salt Lake in such dire straits as Lake Urmia. Located in an important agricultural rich area and once teeming with brine shrimp, bird populations, an impressive suite of vegetation and wildlife, and human recreational opportunities, the system is now a mere shadow of its former self. This is because of increases in agricultural lands, shifts to water intensive crops, and upstream water diversions compounded by drought. The lack of water lowered its volume and increased salinity levels that prohibited brine shrimp from surviving. And dust storms from the exposed lakebed plague the 6.4 million people who live within the region.

Urmia is holding on by a thread of hope thanks to the conviction that was expressed by the visiting Iranians at this gather – politics aside. But there's so much that needs to be done to control dust, bring water back into the Lake and target selected parts of the system for restoration. This symposium was a testament to how small the world is and the universality that exists among all communities gifted with these unique systems and their unique values with water as the lifeblood of their existence.

For more of the story about Lake Urmia, you can read the piece by Dr. Ali Chavoshian, UNESCO Regional Director for Middle East in the Fall 2015 issue of this newsletter. But we don't have to look to the other side of the world for similar examples that can provide us with important insights that hopefully, will prevent us from making the same mistakes for Great Salt Lake.

That's why Phill Kiddoo is one of our keynote speakers at the 2016 GSL Issues Forum, May 11-13th at the University of Utah. Kiddoo is Air Pollution Control Officer for the Great Basin Unified Air Pollution Control District. He's part of a huge team, and long-term strategy to bring the Owens Valley Planning Area back into air quality compliance after it was designated a "serious non-attainment area" for PM_{10} particulate matter by the EPA in 1987. This designation was the result of water diversions of the sole tributary of Owens Lake (California) by Los Angeles. The exposed lakebed became the source of wind-blown dust events that gained national attention.

Although steps are being taken to rectify the problem, they come with enormous costs. His presentation abstract makes this quite clear. "From 2000 through the 2017-18 budget year, the price tag to control PM_{10} emissions at Owens Lake is projected to surpass $2.1B. After construction is complete in 2017, projection of costs for ongoing operations and maintenance with purchasing of water from other sources to offset the 60,000 - 95,000 acre feet of water used on Owens Lake for dust mitigation, an additional $75,000,000 (75M) will be spent annually."
Another saline system operating in a relative state of life

support is Salton Sea. Located in a closed desert basin in Riverside and Imperial counties in southern California, it is California's largest lake and home to an impressive 424 species of migratory birds some of which are threatened. Much like Great Salt Lake - its location, food sources and wetland values make it a significant interior wetland site in North America for aquatic bird communities.

In 2003, spurred by California's "over use" of Colorado River water, a series of agreements among the State of California, the Federal Government and a group of California irrigation/water districts with rights to Colorado River water culminated in a legislative outcome called the Quantification Settlement Agreement (QSA). One of the provisions in the QSA included a transfer of agricultural irrigation water out of the Salton Sea basin. This would have an obvious affect on inflows to the Sea, reduce water levels, increase salinity in the system, and expose lakebed playa affecting air quality. Sound familiar? Associated legislation and proposed bonding support set the stage for a commitment from the state to restore the Salton Sea Ecosystem. This prompted the creation of the Salton Sea Restoration Study and Programmatic Environmental Impact Report (PEIR) to identify a preferred alternative to "restore important ecological functions of the Salton Sea that have existed for about 100 years." Implementation of the preferred alternative rests with the California State Legislature. As of 2013, no decision had been made. Recognizing the sense of urgency and to prepare for the work ahead, the California Department of Water Resources, California Department of Fish and Wildlife, U.S. Bureau of Reclamation, and the U.S. Geological Survey took the initiative to develop a Monitoring and Assessment Plan. You'll hear more about this at the Forum from Doug Barnum, U.S. Geological Survey, Salton Sea Science Office, and Bruce Wilcox, Asst. Secretary Salton Sea Policy, California Dept. of Natural Resources.

Here in the Great Salt Lake State, the Division of Water Resources has been mandated through the 1991 Bear River Development Act to develop 220,000 acre feet annually of the surface waters of the Bear and its tributaries. The rationale is two fold. One is to ensure that Utah exercises its fair share of water though the 1958 Bear River Compact amended in1980, that allocates water from the Bear among, Utah, Idaho and Wyoming. The other is to prepare for the projected doubling of Utah's population by 2050. The Division has a notion that Utah is running out of water and believes that mega water development projects that cost billions of dollars are the solution.

The Bear River provides the lion's share of inflows into the Great Salt Lake Ecosystem. Millions of migratory birds rely on the system for resting, foraging, and nesting as a part of their hemispheric journey. Bear River Bay is designated an Important Bird Area by National Audubon because of the extraordinary bird use that occurs there. The Bay is also an important food source for the third largest breeding population of American White pelicans in North America.

The Office of the Utah Legislative Auditor General released a May 2015 report titled A Performance Audit of Projections of Utah's Water Needs. The purpose of the report was to "determine the reliability of the division's projections of water demand and supply" and to "review options for extending Utah's currently developed water supply." The audit identified three important findings: reliability of water use data needs to improve, conservation and policy choices can reduce demand for water, and growth in future water supply should be reported to policy makers. These findings support arguments from economists, Lake industries, the conservation community and a growing public awareness that the Division must do a better job in accounting for existing water resources, and that developing the Bear River would imperil Great Salt Lake and its ecosystem services.

Nevertheless, insights from the audit were ignored by sponsors and supporters of SB 80 that was signed into law at the end of the 2016 Utah Legislative Session. SB 80 will allow a percentage of revenue generated for transportation to be earmarked for water infrastructure projects that includes developing the Bear. This maneuver flies in the face of fiscal responsibility in two ways. It creates a piggybank for unnecessary expenditures and it jeopardizes the known economic generator of Great Salt Lake , its recreation and tourism, the brine shrimp industry, mineral extraction operations, its hemispheric habitat, and the health of Utah's growing population. Now that's politics.

Walt Baker, Director of the Utah Division of Water Quality couldn't have said it better, "It behooves us all to have a stake in the Lake."

In saline,
Lynn

What you can do:
Visit www.fogsl.org and read the legislative audit.

Contact us to be a part of a campaign to oppose Bear River water development.

Help others understand what's at risk for all of us if we continue to divert water from Great Salt Lake.

Friends' Organizational Statement

FRIENDS of Great Salt Lake is a membership-based non-profit 501c3 organization founded in 1994. The mission of FRIENDS is to preserve and protect the Great Salt Lake Ecosystem and to increse public awareness and appreciation of the lake through education, research, advocacy, and the arts. The long-term vision of FRIENDS is to achieve comprehensive watershed-based restoration and protection for the Great Salt Lake Ecosystem.

FRIENDS has a very active Board of Directors and an Advisory Board consisting of professionals in the scientific, political, literary, eduction, and broadcast communities. The organization sponsors an array of programs, activities, and materials in pursuit of its mission.

Every two years, FRIENDS hosts the Great Salt Lake Issues Forum to provide a focused discussion about the Lake for policy makers, researchers, planners, industry and other stakeholders. The goal of each Forum is to encourage constructive dialogue about the future of the lake's ecosystem and its resources, and to illuminate the complexities involved in research, management and planning for the lake.

The Friend of the Lake award, given at each forum, acknowledges a citizen, business or organization working to promote Great Salt Lake awareness in the community.

In 1997, Bruce Thompson was hired as Education Director to initiate a regional education project designed to enhance both the knowledge about and care for the future of Great Salt

In 1998, the Utah Chapter of the Wildlife Society awarded FRIENDS the Conservation Achievement Award..

In 2000, Project SLICE, a 4th grade curriculum using Great Salt Lake as a system of study, was initiated. The Lakeside Learning field trip program, a component of SLICE, continues to grow.

In 2002, the Doyle W. Stephens Scholarship Award was established. The scholarship provides support to undergraduate and graduate students engaged in new or on-going research that focueses on Great Salt Lake.

In 2002, Lynn de Freitas was awarded the outstanding volunteer educator award by the Utah Society for environmental Education.

In 2006, FRIENDS was the recipient of the Calvin K. Sudweeks Award from the Utah Water Quality Board for outstanding contibutions in the water quality field.

Janessa Edwards, hired in 2014 as Education & Outreach Director, is working to strenghten the Lakeside Learning Field Trip Program and FRIENDS community outreach.

In 2014, FRIENDS of Great Salt Lake awarded the First Annual Alfred Lambourne Prize to Dr. Marden Pond, Sound Artist, for his musical composition entitled "Sanctuary."

In 2015, FRIENDS awarded The 2nd Annual Alfred Lambourne Prize to Max Rosenzweig. Also this year, Chris Mansfield was named the Doyle W. Stephens Scholarship Recipient. Kimmy Ertle was hired in 2015 as Membership Coordinator.

In 2016 our Lakeside Learning Field Trip Program was recognized as the Environmental Education Program of the Year by the Utah Society for Environmental Education.

On the Cover

The Last Lonely View by Charles Uibel. Seeing water lines as geological time lines is easy. Trying to peer around the marks left by commerce into an unspoiled wilderness is impossible.
In this picture, Francis Peak radar towers are visible. So are dirt roads on the Promontory Mountains.These land marks can serve as reference points tying you back to that with which you are familiar, demonstrating that you can never escape your own culture. Disappointing as they are to see in a picture, they also give me an "Oh wow" moment in real life. Oh wow, there's Salt Lake City. Oh wow, that must be where the trains cross.
It's fun to piece together the wide open world in ways that are impossible to conceive of beforehand, but it comes with a guilty price tag; you know that you too are filling in that empty wilderness with your own foot and thought-prints.
http://www.greatsaltlake.photography

Creative Expression Inspired by Our Inland Sea

Untitled #34, Marjory's World series by Rebecca Reeve
Submitted for the 2015 Second Annual Alfred Lambourne Prize

Creative Expression Inspired By Our Inland Sea

Word-Watch – Conversations Around Margins of Great Salt Lake

1.

Poems need chat space.
Margins call for dialogue—shared exploration
to refresh
words, updates to startle
virgin wilderness.
Chinese masters add daylight
in every
syllable, balance haikus and cinquains
on turns of air.
Spring leans
against summer—blossoms
fall
to the next line.
Their absence above is never
loss.
Readers have room
to scold
if bluebirds
seem too happy or a raven
too cynical.

2.

If you don't see the sharp-shinned hawk
this poem takes to heart—
how it skims marshland, hooked beak
etching air; how it undresses
hollow bones, swallows
the song
of a yellow warbler, leaves
a feathered circle
of death—
frame these words with your voice.
The poem won't mind. The hawk ignores
all
but the kill.

3.

Paper doesn't double talk
like a burrowing owl
or mimic chukar chatter. Word-falls
choke pages until they speak.
Every season has a patterned voice
of affirmation.
It's November.
Cirrus strands obey wind, override
sunshine and blue sky.
Jumbled sounds announce
sky-busting swans. As these tundras pedal
on take-off, water forgets itself, rises
with each web
splash. Seven-foot wings covet
pockets of air.
A seasonal flock strings near lakeside mountains, heads
and bodies arrowed north, hoots
high, resonant, klooo kwooo, klooo kwooo—
sound flung ahead, as always.
If, as some say, hounds can be heard
in those cries, swans are the hunted—baying dogs,
far afield, mythically powerless
to end the pursuit.
One after another, feathers brilliant
as salt sheen, thousands
upon thousands
wheel
and ribbon
down
in a shuffle
of water.
After a twilight ruffle, pairs float mute
as empty pages, inhale
every drop
of the moon.
If you haven't witnessed
a storm of wings
upending air
and water,
sheet these pages in the wind, add
notes on the drying edges.
The poem appreciates
attention.
The swans will be caught up
in the tangle
of their own leaving.

4.

No manuscripts speak
of the Lake's beginnings. No prophets
tame the waters.
For eons, Selene slips
above the round of earth, mirrors
her pocked face
in the Lake's salty luster.
Rain and snow fail. The Lake
recedes. Out of nowhere,
like a colossal Lazarus, garments flapping
in the wind,
ghost dust sweeps
across barren ground, climbs the sky, mushrooms
in a frenzy of fierce energy belied
by refined blessings
of copper twilight.
Exposed rim of lake bed—sun-struck, salt-bright, poised
for airy flight—
releases
toxic shades
of selenium—cold as iron.
Molecules ride the wind, cast off
metallic gloss.
In their wake, lungs cry
for elemental
air, for storms fragrant with sweet cedar, sagebrush,
balm
of moonlit
pine.
If you desire the perfume
of Gilead,
place your request
where the poem ends
in silence.
The Great Salt Lake brags
in its own splendor leavened
with stardust
from before water was
before the word
of God.

Maurine Haltiner
Submitted for the 2015 Alfred Lambourne Prize

The Great Salt Lake Alliance 18 Years of Working on Behalf of the Great Salt Lake Ecosystem

Eighteen years ago, the proposed Legacy Highway and its most damaging, impracticable alternative– Alignment C – was threatening a significant number of highly productive wetlands along the eastern shore of Great Salt Lake in Davis County. FRIENDS and others were busy at work developing a campaign to oppose the proposed roadway and raise awareness about the impacts it would have on the Lake.

As the world is small when it comes to people in the watershed who recognize the importance of Great Salt Lake, we were invited to a lunch meeting to discuss the highway and explore ways to develop new partnerships to protect the Lake. The meeting was hosted by officers of the Utah Wetlands Foundation – William Olwell, Bob Valentine, and Dr. Maunsel Pearce, with invited guests that included FRIENDS, The Nature Conservancy of Utah, National and Great Salt Lake Audubon, the League of Women Voters of Salt Lake and Utah, Western Resource Advocates, Utah Waterfowl Association, and well known Lake advocates Ella Sorensen, Cullen Battle, and Bob Adler.

Two important outcomes came from that meeting. The development of an effective campaign that morphed a highway into a parkway along with the Legacy Nature Preserve consisting of 2,100 acres of wetland, upland and riparian habitats, and the largest mitigation site in Utah's history. The other outcome was formation of the Great Salt Lake Alliance, which has become a coalition of Great Salt Lake conservation interests that include the aforementioned groups with the addition of other conservation organizations that have an interest in the Lake. Dr. Maunsel Pearce has served as Chair since its formation eighteen years ago.

The purpose of Great Salt Lake Alliance is to provide opportunity for healthy dialog and cooperation among groups represented in efforts to preserve the stability and integrity of the Lake. And to create a forum to expand those discussions with resource managers directly tied to those issues so that concerns and recommendations are shared outside of the coalition.

The Alliance has a history of involvement on an array of fronts beyond the Legacy Parkway. To list them all would require more room than this one page allows. However, some highlights of Alliance activities over the past 10 years include:

Worked in tandem with The Nature Conservancy of Utah, to develop a Conservation Action Plan for Great Salt Lake to identify key ecological components of the system and associated steps to preserve them.

Hosted a series of meetings with the Division of Forestry, Fire and State Lands in the Department of Natural Resources, and that has jurisdictional responsibility for managing Great Salt Lake to discuss the draft of the 2010 Great Salt Lake Comprehensive Management Plan. The Alliance submitted formal comments on the draft with an emphasis on sustainability of the system and increased opportunities for public engagement

Encouraged the Division of Water Quality, in the Department of Environmental Quality to develop a plan for determining site – specific numeric water quality standards for Great Salt Lake, beginning with selenium, the first numeric standard. The Alliance represented the environmental concerns for the Steering Committee for this project.

Submitted formal comments to the Division of Water Quality recommending inclusion of Great Salt Lake in the 303-d list of impaired waters in Utah because of mercury contamination in 3 species of waterfowl and hyper-eutrophication from nutrients in Farmington Bay.

Continues to serve as a conservation stakeholder on the Great Salt Lake Technical Team that meets quarterly with the Division of Forestry, Fire and State Lands to discuss Great Salt Lake related issues and hear about ongoing research.

The Alliance continues to believe that the major threats to the health and stability of the Lake are diminished water quantity influenced by water diversions and diminished water quality from human impacts.

It takes a watershed to work together to preserve and protect Great Salt Lake. The Great Salt Lake Alliance is an important contributor to that effort. As we all move forward to ensure that the Lake remains Great and is there for future generations, the Alliance helps lighten the load.

Happy Birthday to the Great Salt Lake Alliance!

In saline and celebration,
Lynn

The Great Salt Lake Ecosystem Program
A Collaborative Effort With Impressive Results

It's early January and the Great Salt Lake's (GSL) temperature is down to -1.5°C (29.5°F). Most lakes would be frozen at this temperature but GSL is so salty, ranging in salinity from 14-28% (3-5 times saltier than the ocean), that it doesn't freeze. You might expect a large, bitter-cold and salty lake in the middle of the desert to be vacant this time of year, but surprisingly this is the busy season on GSL. In fact, if you were looking from an aerial view you would see a plethora of commercial fishing boats with fishermen working hard to ¬harvest the durable, over-wintering eggs of brine shrimp. You will likely see another more modestly sized boat labeled "Great Salt Lake Ecosystem Program" filled with biologists working hard to research, manage and conserve the avian and aquatic communities of GSL.

How will harvesting brine shrimp from Great Salt Lake affect the birds that rely on them as a food source? What is the best way to manage the brine shrimp harvest? Is it possible to overharvest brine shrimp? Is it possible to under-harvest brine shrimp? These are just some of the questions that have inspired the work of the Great Salt Lake Ecosystem Program (GSLEP).

The GSLEP celebrated its 20th anniversary in December of 2015 at one of its Technical Advisory Group (TAG) meetings. During the celebration, old photos and amusing stories were shared among a diverse group of scientists, brine shrimp industry representatives, government agencies, and stakeholders. These accounts demonstrated the commitment and dedication of those who have and continue to work on the Lake. It wasn't too unusual for a TAG meeting these days, as they are often inviting and insightful meetings wherein participating members discuss and regularly present data on Great Salt Lake. The meetings frequently consist of polite and productive debates on the best methods to study and conserve this valuable resource.

The motive to study GSL and involve the state government dates all the way back to the early 1950's when Sanders Brine Shrimp Company began to harvest brine shrimp adults out of GSL to be used as food in the tropical fish industry. Brine shrimp are abundant in GSL and have a rather exceptional method of survival. Brine shrimp can either give live birth if conditions are suitable (plenty of food, moderate temperatures) or they can create eggs that can remain viable (unhatched but alive) for hundreds, or even thousands of years. These tough, coated eggs are called 'cysts' and their durability is what makes them so valuable. Once the harvesters realized that cysts could be taken out of the lake, dried, and then hatched out into living brine shrimp, they eventually began harvesting cysts instead. Presently, Great Salt Lake cysts are harvested by the millions of pounds and are being sold to aquaculturists, primarily as a food source for prawns (shrimp) in Asia, Mexico, Central and South America and Europe.

The growth of the aquaculture industry during the 1980's resulted in a substantial increase in the value of cysts. As a result, the harvest industries began to invest in new technologies that allowed them to harvest GSL cysts in massive quantities. During the same time, stories about the collapse of major fisheries due to overharvest, like the northern cod harvest, were circulating in the news. The increase in competition for cysts in combination with the technological advances made some of the harvesters begin to worry about a similar situation happening on GSL. Consequently, the harvest industry took the initiative by asking the Utah Division of Wildlife Resources (UDWR) to step in and manage the brine shrimp resource and harvest. The actions of a few forward thinking individuals ultimately led to the creation of the Great Salt Lake Ecosystem Program. It is frightening to think that if it were not for the work of a few dedicated and persistent individuals, where the Great Salt Lake Ecosystem would be.

A couple of years prior to the push from harvesters for the state to intervene, the UDWR hired Dr. Gary Belovsky to initiate and direct a study on the GSL ecosystem. The goal was to develop guidelines to ensure a sustainable harvest of cysts. In order to do this, Dr. Belovsky needed to know how many cysts were in the lake, how many of them survived through the winter, and how many were needed after the harvest to ensure a viable population remained in the lake. Prior to the early 1990's there was very little research done on GSL. In fact, scientists knew virtually nothing about the system. Needless to say, beginning to understand GSL was no easy task.

In 1996, the UDWR created the GSLEP to oversee the brine shrimp harvest and monitor the lake's waterbird populations. The GSLEP and Dr. Belovsky began working together on collecting sufficient data in order to understand the complex relationships between brine shrimp and their environment.

The GSL appears to be a simple ecosystem because a limited number of species can survive in the hypersaline environment. The basic food web consists of algae that the brine

shrimp and brine flies feed on, and the brine shrimp and brine flies are eaten by resident and migratory birds. This system seems simple; however, the interactions among these components in combination with environmental variables are incredibly complex. Dr. Belovsky designed a sampling routine in collaboration with the GSLEP and the U.S. Geological Survey (USGS) to collect data from randomly selected sites in the south arm of GSL (Gilbert Bay) in order to better understand the population dynamics of brine shrimp.

Not long after the data collection began, Dr. Belovsky received a call while he was out elk hunting in Montana. The UDWR was about to open the harvest season and they wanted to know how many cysts needed to be left in the lake after the season for a healthy population of shrimp to be able to regenerate in the spring. What a simple question, right? That is like asking what the ideal number of people living in the state of Utah would be. So, Dr. Belovsky did some rough calculations inside his truck on the back of an envelope and came up with 21 cysts per liter. He admits today that it wasn't much better than a guess. After all, he only had a couple of years of data on GSL at that point in time.

Dr. Belovsky's calculations had some negative ramifications for the harvest industry. It meant that the harvest would be stopped when the brine shrimp population reached 21 cysts per liter in the lake. The harvesters were also aware of the lack of information behind the calculation since there were only two years of data on GSL at this point in time. This was truly a one-of-a-kind undertaking; nowhere else in the world had there been any work done on a commercial brine shrimp harvest in a saline lake system. Essentially, anyone could provide a theory about how to manage this ecosystem, and they might be right. There were about as many opinions on how to manage the GSL as there were interested parties, and each one was very insistent that they were right. Good science with additional data collection ultimately won out thanks to the support of influential folks in the brine shrimp industry. This early show of support and trust eventually blossomed into the relationships that exist today.

Over the years, Dr. Belovsky's model has proven to be extremely useful. There have been very productive years where harvesters have taken 25-30 million pounds of biomass out of the lake during the winter, and the spring shrimp population has not been impacted. Dr. Belovsky's data analysis also shows that the harvest actually leads to a more productive shrimp population. The model shows that it's possible to leave too many cysts in the lake. If a huge number of cysts hatch in the spring, the population could experience a severe crash by eating all of their food and starving to death. In fact, scientists are almost certain that in the past, before there was a harvest, the brine shrimp population crashed during some years and then took several years to recover. During these times, it is also likely that migratory bird populations suffered as well. The harvest actually helps the brine shrimp population stay below its carrying capacity, which, in turn, helps the eared grebes and other birds that rely on them for a food source.

More recent research by Dr. Belovsky has shown that the amount of food available for each shrimp present in the lake is the primary factor that influences brine shrimp productivity. Salinity and temperature do play a role, but the impact on shrimp is not as strong as food. It is especially important for the shrimp to have food in the spring, so they can jumpstart new generations as the water gets warmer. An all-inclusive, ecosystem-based model is currently being developed between GSLEP and Dr. Belovsky as well. This model is going to include parameters such as how many shrimp are eaten by eared grebes, changes in lake elevation, salinity, temperature and many others. The goal of this ecosystem-based model is to be able to predict what will happen to the lake and its' resources during certain environmental circumstances. This model will help managers make more informed decisions regarding GSL.

The current relationships that exist today between scientists and the brine shrimp industry required building trust and teamwork through some bumpy and uncomfortable times. With 20 years of solid scientific data collected, the cooperation and appreciation has grown on both sides. The Great Salt Lake Ecosystem Program would not be as successful in managing and conserving GSL without working in the interest of both the industry and the ecosystem. The program has also gained an appreciation for the many issues the harvest industry faces now because of their mutual cooperation. The GSLEP works with the brine shrimp industry to compare and contrast data collected on the lake. This cooperation helps refine the methods of data collection and helps in our understanding of the brine shrimp resource and the GSL ecosystem.

The TAG meetings are now a place where environmental groups, state agencies and the harvest industry can put their minds together and evaluate the data collected on GSL in order to ensure that the science behind the management is solid. It's also a place where new ideas, questions and concerns can be raised about GSL. Without the cooperation of these private and public partners, GSLEP would not be the successful program that it is today.

A list of participants at the last TAG meeting included representatives from the brine shrimp industry, Intermountain West Joint Venture, Utah Division of Water Quality, United

States Geological Survey, Avian West, FRIENDS of Great Salt Lake, and many others. The GSLEP cooperates with almost all of the in-state universities and some out-of-state universities as well. This kind of collaboration is incredibly extraordinary, and the GSLEP has been so successful with this that other lakes around the world are mimicking our management techniques and now competing with the GSL brine shrimp industry.

Great Salt Lake research is ongoing at the GSLEP and many more things still need to be learned. If you see a big boat out on the lake it is likely GSLEP biologists out on our routine brine shrimp sampling effort. Currently, GSLEP biologists go out on GSL to sample for brine shrimp densities of all age classes (cysts, nauplii, juveniles, adults) once a week during the harvest season (October through January) and biweekly the rest of the year. The sample run is roughly a 120-mile round trip and takes about 8 hours, barring any mechanical issues (which can happen when combining hypersaline water and mechanical objects).

If you see an airboat in the shallows, there's a high probability it is GSLEP biologists collaborating with Utah State University to study the waterbirds of GSL. The GSLEP has coordinated with USU and has successfully helped four students with their PhD research on a variety of avian studies. For example, we now know that eared grebes staging at GSL in the fall consume 26,000 to 30,000 brine shrimp per day! In fact, grebes eat mostly brine shrimp in October and November, but when the water starts to cool and the adult shrimp die, they begin to eat brine shrimp cysts. We have also learned that common goldeneyes eat mostly brine fly larvae off of the bottom of the lake and that other duck and shorebird species change their diet depending on the season. GSLEP has also helped with a variety of other bird research on GSL, including the International Snowy Plover Survey and the Western Colonial Waterbird Survey.

If you see a truck on a wetland dike, there is a good chance it is GSLEP biologists helping gather data for a long-term study on migrating waterbird populations of GSL. This GSLEP organized survey is a slimmed down version of an intense, 5-year waterbird survey (1997-2001) that relied on numerous volunteers from the community. The goal of the survey is to examine the relationship of migratory waterbirds within the GSL ecosystem. Results of this study show that lake elevation plays a major role in the location of certain bird species.

If you see a plane flying above GSL, it is likely biologists at GSLEP conducting annual aerial surveys to estimate the population size of eared grebes on GSL. We now know that over four million eared grebes stop on GSL each year to eat brine shrimp, which is over half of the North American population. There are also up to 20,000 adult American white pelicans that breed on Gunnison Island, using the island as a safe place free from disturbance to raise their chicks. There are about 500,000 Wilson's phalaropes visiting each year, which is the largest staging concentration in the world. More than 5,000 snowy plovers come to GSL to nest and raise chicks. Nearly 500 bald eagles spend the winter around GSL feasting on fish exposed in impounded wetlands drawn down to prevent ice damage. Needless to say, there is still a lot to be learned about GSL. The positive and constructive relationships that the GSLEP has built between various public and private entities are without a doubt going to aid in future research regarding Great Salt Lake.

Ashley Kijowski is a wildlife biologist with the GSL Ecosystem Program

Brine shrimp boat and floating cysts by J. Luft

Underground Secrets of Great Salt Lake

Great Salt Lake occupies the lowest spot in a watershed of thousands of square miles. Precipitation washes sediments, dissolved salts, plastic bags, fish carcasses, leaves, discarded automobile tires and all sorts of things downstream, ever downstream, until finally, they reach the lake, where the heavy things settle to the bottom, the water mixes in, and in an ideal world, layers of sediment build up over time, one on top of the other, and the water level rises and falls depending on the difference between what comes in and what evaporates.

The stratified sediments in the ideal lake should look like the stacked sweetness of a ten layer red velvet cake were you to cut into them, but the actual lake is a little more complex. Sometimes water evaporates faster than it comes in, and the level drops, forcing the inflowing streams to cut into the deposits they have been laying down, moving them about and carving canyons and gorges in the lakebottom sediments. Sometimes the runoff is torrential, and the mouth of the river spits forth and waves around erratically like a snaking high-pressure garden hose, adding new deposits while moving older ones around this way and that. The complex interactions of the water and the load of solids it conveys form stream and river deltas—complex arrangements of wetland solids and liquids, levees, sloughs, distributaries, meanders, marshes and channels. The entire south end of Great Salt Lake is a complex, convoluted river delta, the most fertile and diverse biological habitat in the region.

For over 10,000 years this delta has been being built, rebuilt, moved, destroyed, and rejuvenated, and people have been there every step of the way. Hunting and gathering, and later farming, people flocked to and concentrated in the wetlands, for these are the richest and most productive lands in the region. Waterfowl, fish, ungulates, root vegetables, seeds, greens, grasses and insects lured people to the marshes, where they camped along the edges of the meanders, in the wetlands, and their archaeological record, the only evidence we have of those who dominated this region for over 50 times as long as the Europeans have been here, is their legacy.

Over the years the geomorphological processes of the lake edge and river delta have moved sediments around, destroyed sites, covered them over, exposed them, revealed and hidden them many times. During the extremely wet periods of the 1980s, great expanses of the lakeshores of the Great Basin were flooded, and when the lakes receded, erosion exposed scores of archaeological sites, sites which had never before been visible. The Stillwater Marshes of Western Nevada revealed hundreds of ancient sites as did the shores of Great Salt Lake, and among those sites were the mortal remains of many individuals. From along the shores of Great Salt Lake over 70 human burials were revealed, interments which, because they could not be protected in place, were excavated by the State of Utah.

The entire southern and eastern shore of Great Salt Lake, where fresh waters spread out before entering the briny lake, was home to people for many thousands of years, and the archaeological and cultural record they left behind is rich and incredibly valuable, both scientifically, and culturally to the region's Native people. And those sites are unlikely to be visible on the surface. Sedimentation has buried most of them, and they lie quietly, darkly, beneath the surface, silent evidence of those who lived and died, raised children, sang, danced, prayed, teased, joked, argued, ate, loved, and pondered the meaning of their lives in this place so close to the modern freeway.

The area being considered for the new Utah State Prison is rich with ancient river delta deposits, and is certainly the resting place of many ancient sites, and perhaps the remains of the original occupants of this place. Sites such as these are afforded protection under both state and federal law, and it is incumbent on the builders to make certain that they are not destroying the legacy of the ancient ones. A concerted effort to go beyond looking at the surface, to use every tool available to them to find and protect or mitigate the damage to the sites over which they propose to build their walls of confinement is necessary. The secrets of the ancient marsh dwellers must be sought out and their stories re-told lest they be lost forever.

Kevin T. Jones is an archaeologist and writer who lives in Great Salt Lake City.

View from Lee Creek by L. de Freitas

Great Salt Lake Education

2016 Enviromental Education Program of the Year

Each year the Utah Society for Environmental Education (USEE) accepts nominations for organizations and people who are providing exemplary efforts in environmental education throughout the state of Utah. Nominations pour in from all over the state in the areas of volunteer of the year, program of the year, business of the year and educator of the year. To be nominated in any of these areas is an honor within itself as this recognition is coming from others who work in the field of environmental education and have noted the high quality of work that has occurred by the nomination recipient. This year FRIENDS of Great Salt Lake was honored with the highly prestigious Program of the Year Award for their Lakeside Learning Field Trip Program.

FRIENDS of Great Salt Lake believes that education is the key to making the connection between the increasing population of the valley and the demand on natural resources, in particular water. To achieve this, they start by educating a new generation of environmentally minded leaders through the Lakeside Learning Field Trip Program. Since the inception of the Lakeside Learning Field Trip program 14 years ago, 21,300 Utah 4th grade students have participated in this outdoor classroom at Antelope Island State Park. Currently, they offer these field trips free of charge to public schools, and award each public school with $150.00 transportation grant to offset the increasing cost of school buses. Each year they accomplish this with a staff of one full-time education director, one part-time assistant, and one part-time AmeriCorps member.

With the Great Salt Lake as their classroom, they explore ways to help young learners make connections in the natural world through a hands on experience. The field trips combine informal environmental education strategies while incorporating science, tech, engineering, art and math (STEAM) to reinforce the Utah Common Core State Standards. The Lakeside Learning Field Trip Program emphasizes learning through participation. They focus on providing teachers with a rich opportunity to look at their present education modules with the local landscape in mind, and acquire new activities that are interdisciplinary and hands on. As students walk through waist high salt grass and taste pickle weed they experience firsthand the value of Utah's wetlands and the life that flourishes within them. Engineering and art merge as students use their creativity to construct a watershed model out of organic materials.

Once on the island, excitement is at its peak! Lakeside Leaders channel this excitement into a discussion about real world connections that help students understand ways they can help protect these animals and their home. At the water's edge Lakeside Learners are introduced to the lake's two main aquatic specimens, brine shrimp and brine flies. Collection cups and magnifying glasses are distributed as students wade in Great Salt Lake. Students continuously scoop cups of water, make observations, identify, and count the specimens before returning them to the Lake.

The experiences connecting the students to their local landscape will serve as a catalyst for a new generation of environmentally engaged learners. It is the program's hope that this approach gives students a comprehensive sense of place and helps to increase student understanding of the complex relationships between home, community, the Great Salt Lake ecosystem, and real world connections.

It is easy to see why FRIENDS of Great Salt Lake's Lakeside Learning Field Trip won the 2016 Utah Environmental Education Program of Year Award.

Carolyn Bollwerk
Utah Society for Environmental Education

FoGSL Board Member Cindy Lund, and Education Director Janessa Edwards

Great Salt Lake At A Glance

Courtesy USGS

Dr. Ephydra - We Welcome Your Questions Via Email or Phone

E • phy' • dra, a noun; a genus of two species of brine flies that live on the bottom of the Great Salt Lake as larvae and pupae, and along the shores of the Lake as adults.

Water Development Has Lowered Great Salt Lake

Utah's Great Salt Lake is valuable as an environmental, cultural, and economic resource. An economic analysis estimated that recreation ($136 million), brine shrimp cyst harvest ($57 million) and mineral extraction ($1,131 million) contributed to an overall economic value of $1.32 billion per year. The lake produces abundant brine flies, brine shrimp and other invertebrates that attract millions of birds each year during spring and fall migrations. Notably, the lake is the namesake of Utah's capital city, which underscores its cultural significance.

Maintaining these valuable functions is threatened by water development that is causing the lake to drop significantly. Since the lake is in a closed basin, it rises during wet periods and falls during droughts, and a common misconception is that only climatic fluctuations influence its water level. *However, an analysis of precipitation and stream flows from the Wasatch Mountains indicates that although there have been wet and dry periods, there has been no long-term trend in precipitation and streamflow to Great Salt Lake over the last 168 years* (Fig. 1A). However, water extractions for agriculture, urban-industrial use, diked wetlands and salt ponds have continually increased since the pioneers arrived. On average, these uses are now depleting the natural water supply by an average of 39% (Fig. 1B). This has caused the Great Salt Lake to shrink (Figure 2C, red line). *Even through precipitation and streamflow from the mountains has not decreased, the lake is now markedly lower than when the pioneers arrived in 1847.*

This decline in lake level is more obvious when compared against a hydrological model that estimates lake elevation without consumptive water use (Figure 1C, blue line). This analysis shows that without consumptive water use, the long-term lake level trend since 1847 would have been flat with a natural mean elevation of 4,207 feet. *Put another way, the lake is now 11 feet lower than it would have been if we were not diverting water for agricultural, industrial, urban and impounded wetland uses*. This 11- foot elevation drop has reduced the volumn of the Lake by 48%.

Any future water developments will cause the lake to decline even more.

Impacts of lowered lake levels—Water diversions and drought have exposed about 50% of the lake bed (Fig. 2). However, shallow Bear River and Farmington Bays have been particularly impacted, with more than three-quarters

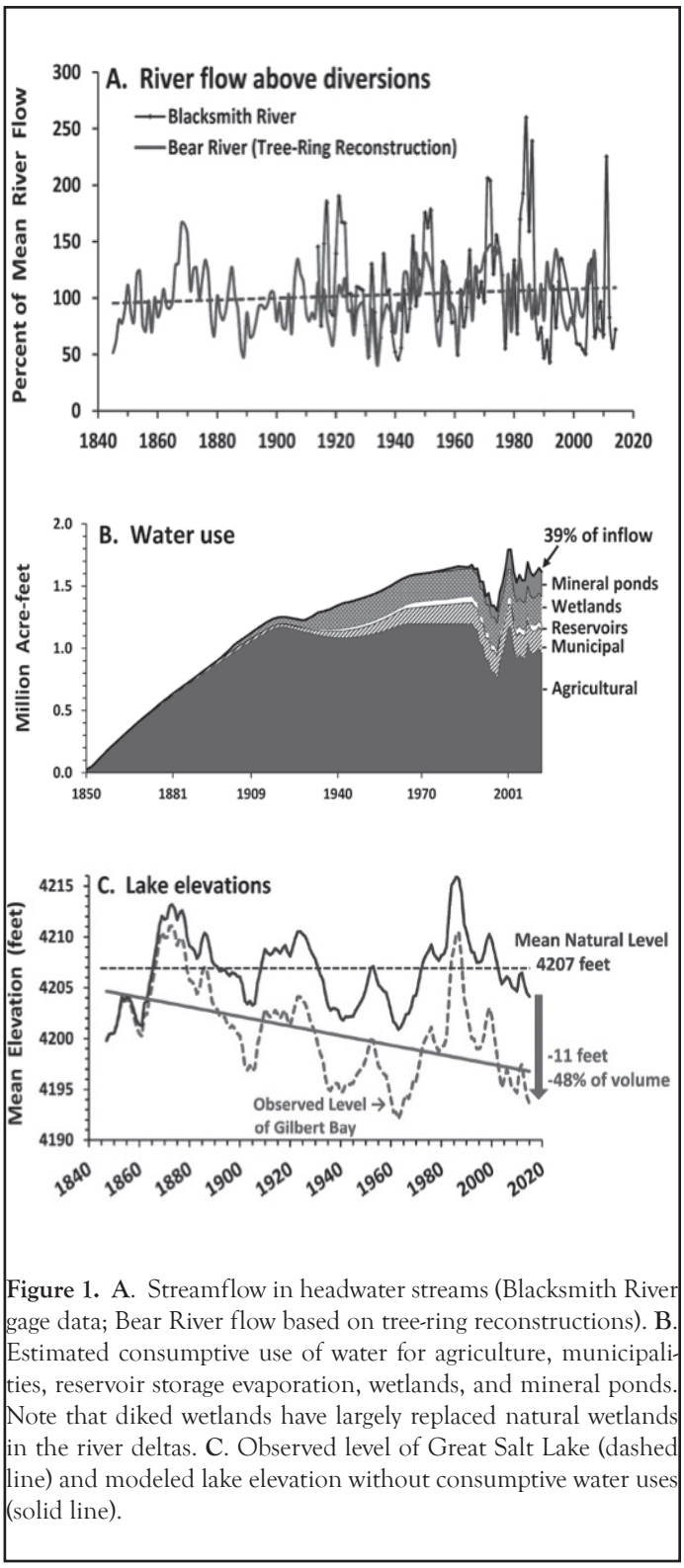


Figure 1. A. Streamflow in headwater streams (Blacksmith River gage data; Bear River flow based on tree-ring reconstructions). **B**. Estimated consumptive use of water for agriculture, municipalities, reservoir storage evaporation, wetlands, and mineral ponds. Note that diked wetlands have largely replaced natural wetlands in the river deltas. **C**. Observed level of Great Salt Lake (dashed line) and modeled lake elevation without consumptive water uses (solid line).

of their beds exposed. These bays are essentially fresh-water estuaries that produce abundant food resources that support a high density and diversity of birds, so their decline is particularly harmful ecologically.

The increase in exposed lake bed from water withdrawals and drought has increased dust emissions that increase hospital visits for respiratory and cardiovascular diseases, including asthma and lung infections. Increased dust storms from lake drying has occurred in numerous other closed basins nationally and internationally, including Owens Lake in California. That lake became one of the largest sources of particulate matter (PM10) pollution in the country, causing the City of Los Angeles to spend $1.3 billion to mitigate dust and alleviate health problems. However, the present and future magnitude of dust pollution on the Wasatch Front population is unknown, and additional studies are needed to assess this growing threat.

The exposed lake bed also creates problems for the mineral extraction industry located around the periphery of the lake and for the boating community. As lake level drops, it becomes difficult and expensive to deliver brine to salt ponds and processing plants, and marinas either become useless or need expensive dredging. The significant loss of freshwater to the lake also caused its salinity to rise. Current salinities are adequate for the important brine flies and brine shrimp inhabiting Gilbert Bay. However, additional losses of fresh water from further water development or drought could cause the lake's salinity to increase and stress these important organisms, thus reducing food supplies for birds and impacting the brine shrimp cyst harvest industry.

In summary, water use and development has significantly decreased the elevation, volume and area of Great Salt Lake, reducing its varied economic, cultural and economic values. These problems are similar to other closed basin lakes like the Aral Sea, Oregon's Lake Abert, and California's Owens Lake that have been even more severely impacted. Utahans must consider how water developments in the past, and those proposed for the future, affect the lake, the important resources it provides, and human health. Water conservation, improved agricultural water use efficiency, and designating water rights for Great Salt Lake are promising strategies to manage water for human uses while protecting Great Salt Lake's valuable ecosystem.

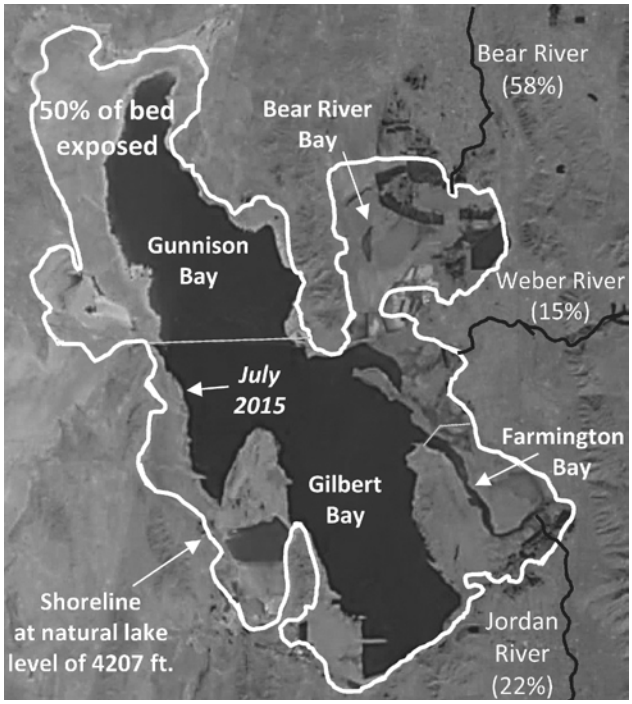


Figure 2. Great Salt Lake. The white line shows lake shoreline at its average natural elevation of 4,207 feet and the July 2015 NASA photograph shows the lake near its record-low level, exposing half the lake bed.

Wayne Wurtsbaugh1, Craig Miller2, Sarah Null1, Peter Wilcock1, Maura Hahnenberger3, Frank Howe1,4
Utah State University1; 2Utah Division of Water Resources; 3Salt Lake Community College; 4Utah Division of Wildlife Resources

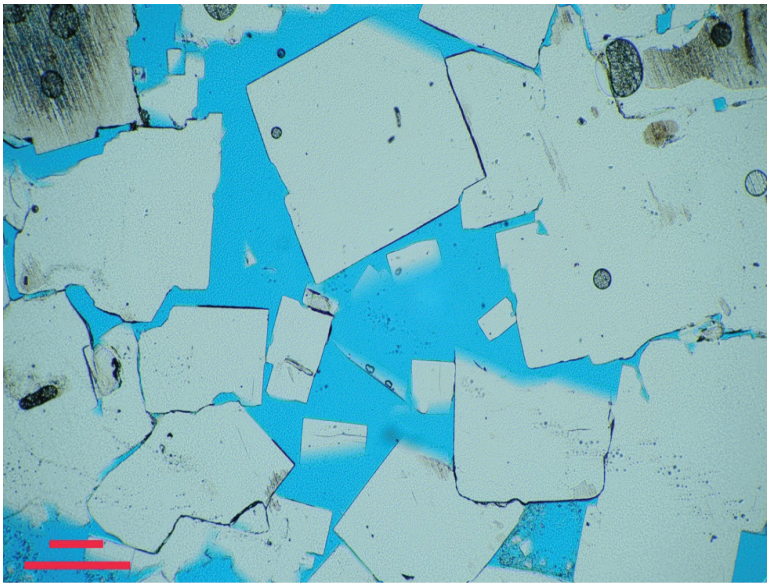
Based on a white paper published February 24, 2016 (http://works.bepress.com/wayne_wurtsbaugh)

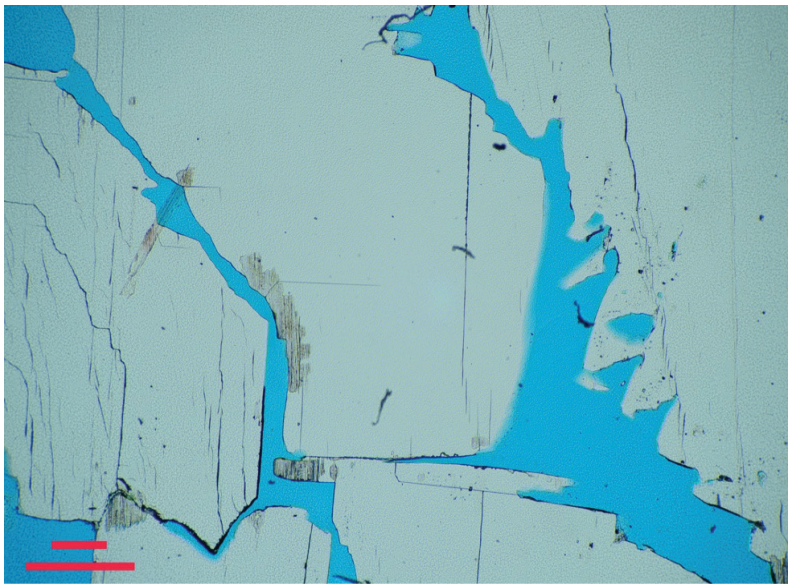
Investigating the Salt Crust in Gunnison Bay - More Than Meets the Eye

In 1959, the rock-fill railroad causeway across Great Salt Lake that separates Gilbert and Gunnison Bays was completed, and since that time, Gunnison Bay has been significantly saltier than Gilbert Bay. For much of that time, Gunnison Bay has been saline enough that a salt crust precipitated on its floor. The salt crust is primarily composed of the mineral halite, also known as sodium chloride or table salt. The crust is a significant phenomenon and important to understand because, at times, it sequesters large amounts of the lake's salt (20% or more), thereby changing the overall salinity of the lake brine.

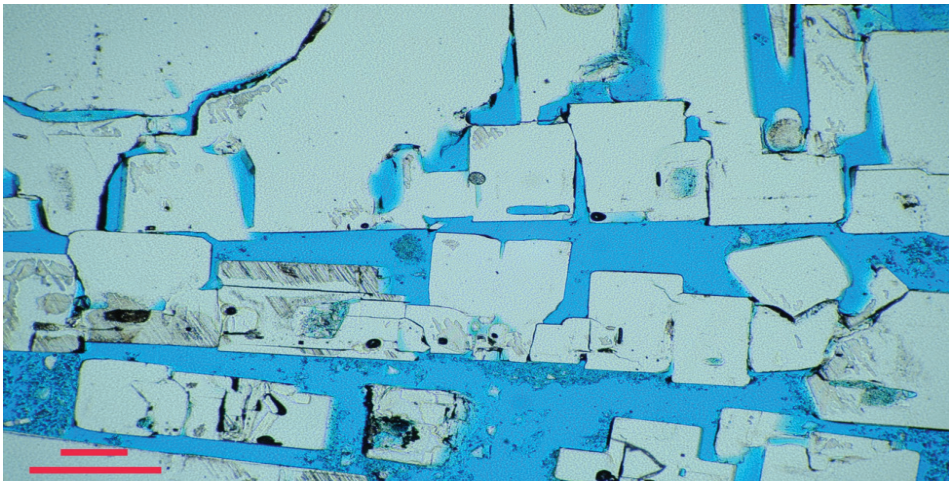
With funding from the Utah Division of Forestry, Fire and State Lands, the Utah Geological Survey began studying the salt crust in the latter part of 2015. We are doing a near-shore investigation of the extent and thickness of the crust. Another aspect of our research is to provide a basic description of the salt crust, and one way we are examining the crust is using thin sections. Thin sections are slices of rocks or minerals affixed to a microscope slide that are cut thin enough to be translucent or transparent. Our thin sections come from large samples of the salt crust. We extracted blocks of the crust, about 8 to 10 inches on a side, by drilling several holes around them, cutting between the holes with a saw, and prying out the blocks. We then cut the blocks into slabs and selected areas on the cut faces of the crust for thin section preparation. Petrographic microscopes are used to examine thin sections with polarized light. Thin sections can help in identifying minerals and give a better look at the microstructure of a rock.
They also provide great images!

Under the microscope, halite crystals are clear in polaized light, and this image of the salt crust shows how halite crystals often form with a cubic shape. The blue represents colored epoxy that was forced into the salt crust sample to keep it together while the thin section was being prepared and to show where pore space in the crust is.
The red lines are for scale.
The upper line is 0.01 inch and the lower line is 0.5 mm.
The scale bars are the same for all photomicrographs.

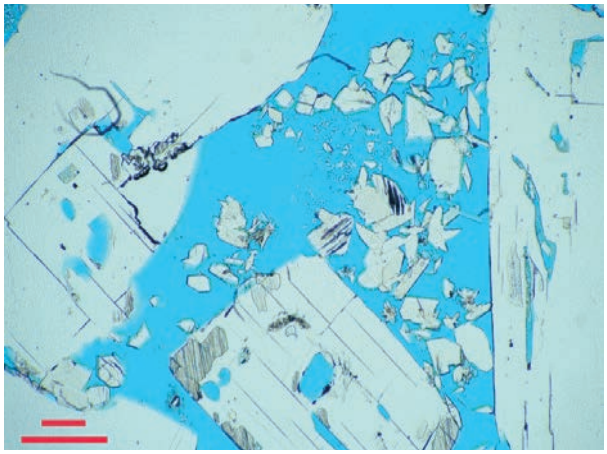


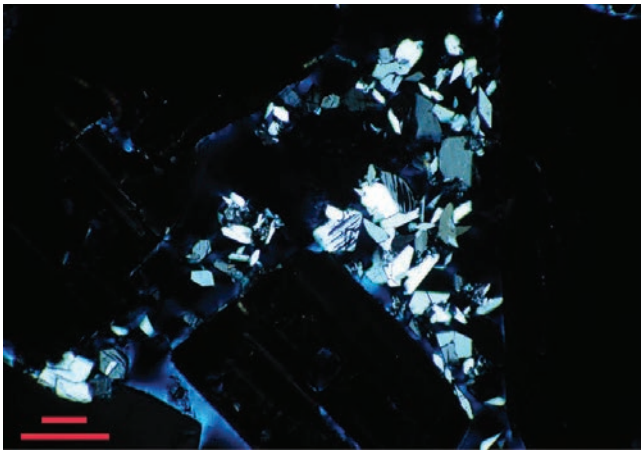


Larger crystals of halite do not tend to show the nice crystal facets that smaller crystals do. This is likely because the larger crystals grow into each other, disrupting the growth pattern. However, there is often some pore space between larger crystals, suggesting that some dissolution may have occurred along the crystal interfaces after they formed.



Some of the salt in Gunnison Bay forms as "rafts" on the surface of the brine during hot summer days. In some areas these rafts accumulate on the floor of the lake and become part of the salt crust. The layering that these salt crystals show probably represents an accumulation of rafts that is preserved in the salt crust.





While halite is the most common mineral in the crust, microscopic examination has also revealed what are likely small amounts of gypsum in between halite crystals. In plane-polarized light (left) all the minerals are clear. However, in cross-polarized light (right), halite is black and gypsum shows white and gray colors. The prismatic shape of some of the crystals also suggests that they are gypsum.

Each aspect of our study, including looking at thin sections, will hopefully help us to better understand the dynamics of the salt crust. Our intent is to monitor the salt crust over time and see how it responds to changing lake conditions, such as changes in lake elevation or modifications to the causeway. We also hope that longer term monitoring will help us better understand the relationship of the salt crust to lake salinity levels and how salt cycles through the lake system. The full results of our investigation will eventually be made public through a Utah Geological Survey publication.

Andrew Rupke
Industrial Minerals Geologist, P.G
Utah Geological Survey

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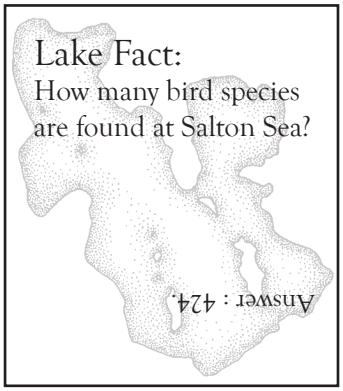
The Utah Pole by Charles Uibel

In memory of Nina Dougherty 1933 - 2016
Sharp, witty, gentle and always ready for a good laugh - FRIENDS and the Lake were very fortunate to have known and worked with Nina on so many important conservation fronts.
She was a gift to us all.

Lake Fact:
How many bird species are found at Salton Sea?



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Fremont Island - Great Salt Lake. looking west, summer 2015 by Kirk Henrichsen
Submitted for the 2015 Second Annual Alfred Lambourne Prize