The State of Bear Lake Science 2018

Sept 7, 2018

Representatives attended from Bear Lake National Wildlife Refuge (F&WS), USGS, Idaho Water Resources, Idaho DEQ, Idaho Fish & Game, Utah Water Resources, Utah DEQ, Utah Division of Wildlife, Utah Forestry, Fire & State Lands, Bear Lake Regional Commission, Utah State University, Idaho State University, Trout Unlimited and some great Bear Lakers.

Welcome & Overview – Claudia Cottle

A Symposium to use the synergistic and symbiotic talents in the room to focus the science of Bear Lake.

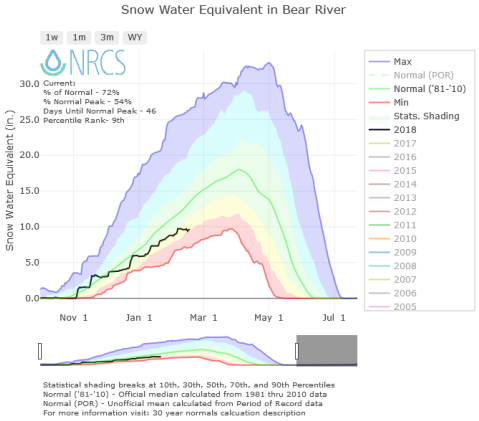
Bear Lake – physical things to think about as they affect the lake

- Chemistry – color, clarity & optics
- Thermal regimes
- Winds
- Waves
- Currents
- Ice
- Acoustics

The Water

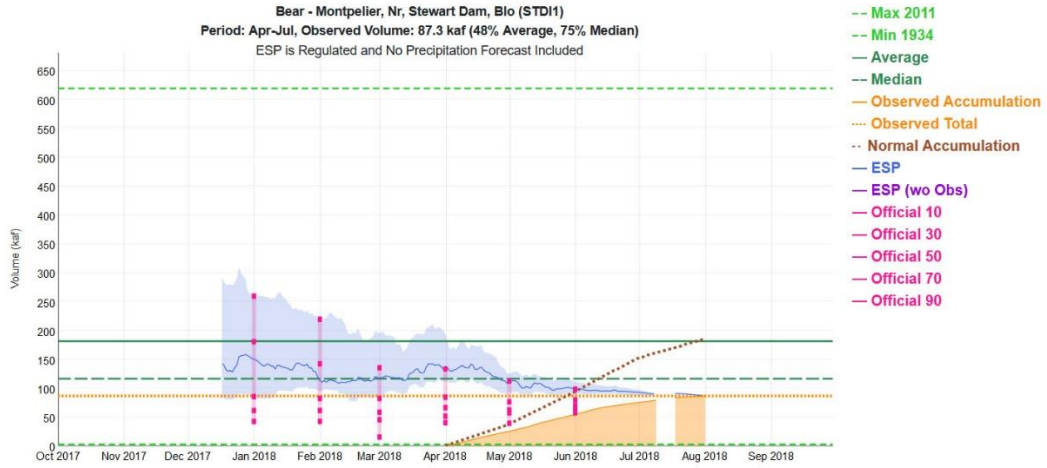
<u>Water Quantity</u> – Patrick Kormos, NOAA, CRBFC

Colorado River Basin Forecast Center, CRBFC, produces the water supply forecasts for the Bear River system using 35 years (1981-2015) of data by modeling snow, hydrology, soil moisture and surface flow inputs in a mass balance type of equation. The forecast is for 10 days in the future at 23 points in the Bear Basin and includes temperatures and precipitation from January through July. 35 hydrographs from 35 years of data. Summarized for the median with the 10%, 25%, 50%, 75% and 90% confidence levels. Incorporates the diversion data. Four important flow points along the river – Woodruff Narrows Reservoir, Bear River at Border, Smith's Fork and Bear River at Stewart Dam.



https://www.wcc.nrcs.usda.gov/ftpref/states/ut/iCharts/basinCharts/POR/WTEQ/UT/Bear%20River.html

Water Supply Forecast



https://www.cbrfc.noaa.gov/wsup/graph/front/espplot_dg.html?year=2019&id=STDI1

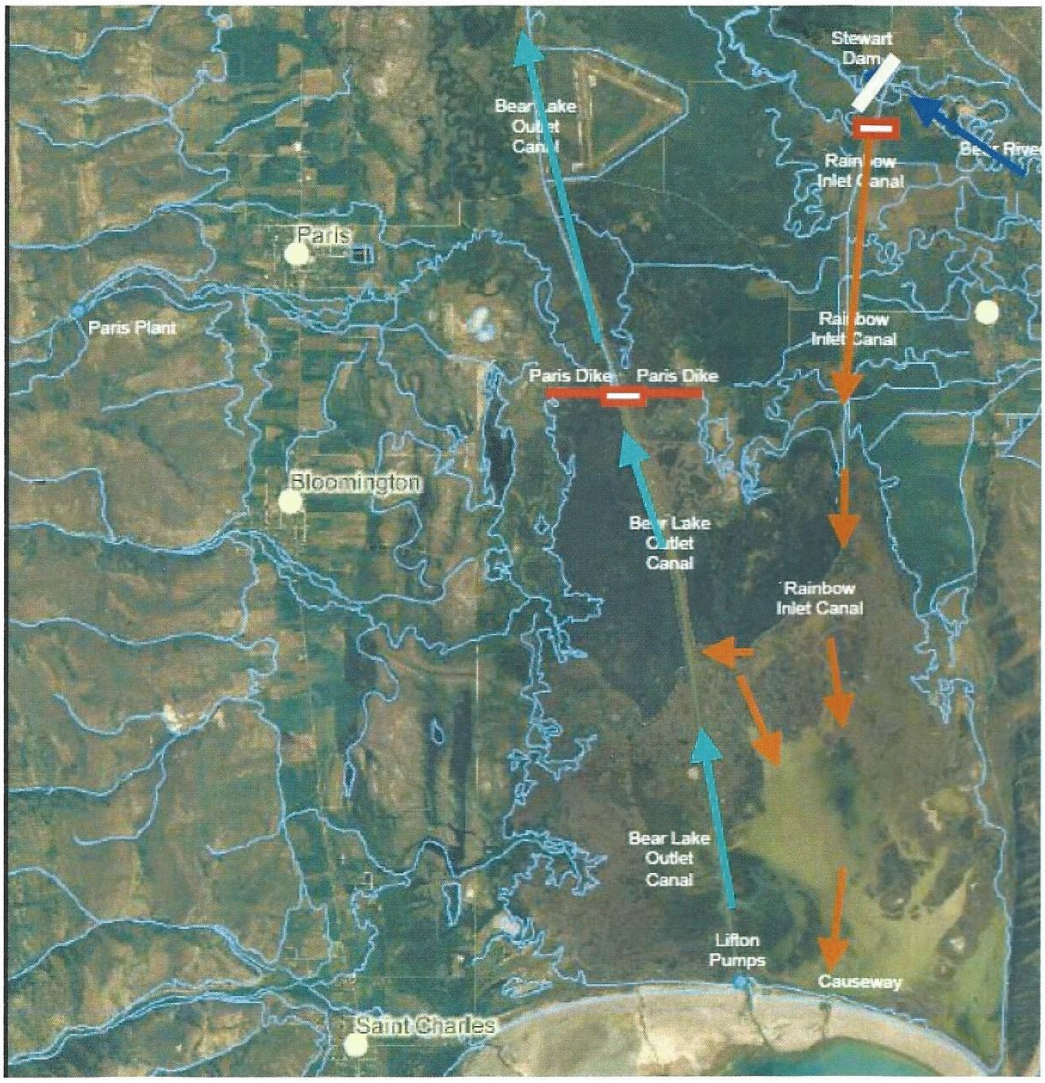
Water Quantity – Connely Baldwin – PacifiCorp hydrologist

Smith's Fork contributes one half of the river flow reaching Bear Lake.

Idaho Power, Utah and Wyoming do some "cloud seeding" that adds to the snowpack in Smith's Fork.

The Plumbing

Bear River/Bear Lake Water Paths - Detail

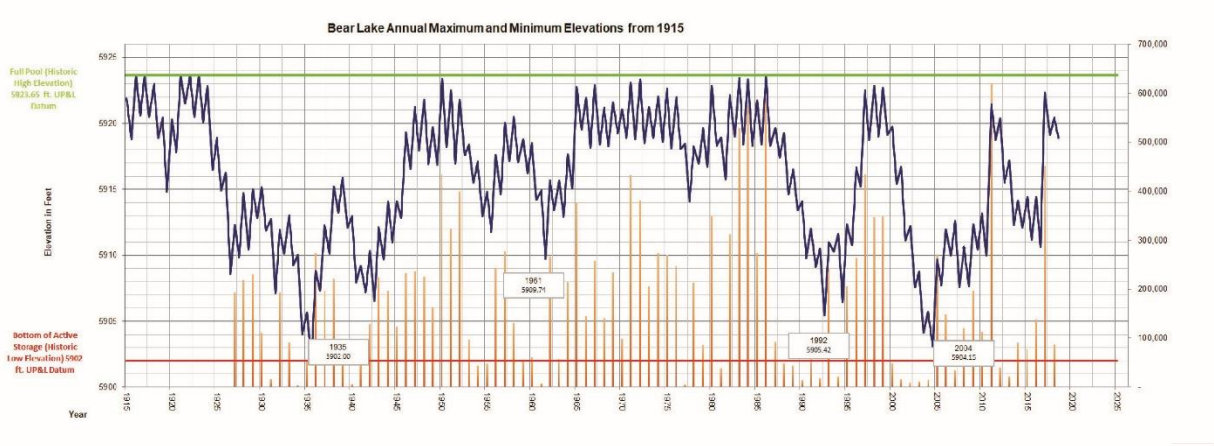


- Prior to 1986, water from Mud Lake entered Bear Lake "backwards" at Lifton. Since then, to improve water quality, water enters Bear Lake at the Causeway.
- There are 7 gates at Paris Dike with a capacity of 5,000 cfs.
- The new control structure at Paris Dike was built in 1998.
- Lifton Pumping Station has 5 fixed-flow pumps with a capacity of 1600 cfs. It also has 2 sluice gates.
- The Causeway has a capacity of 5,500 cfs

Mud Lake is still playing a role in sediment settling and water quality for Bear Lake.

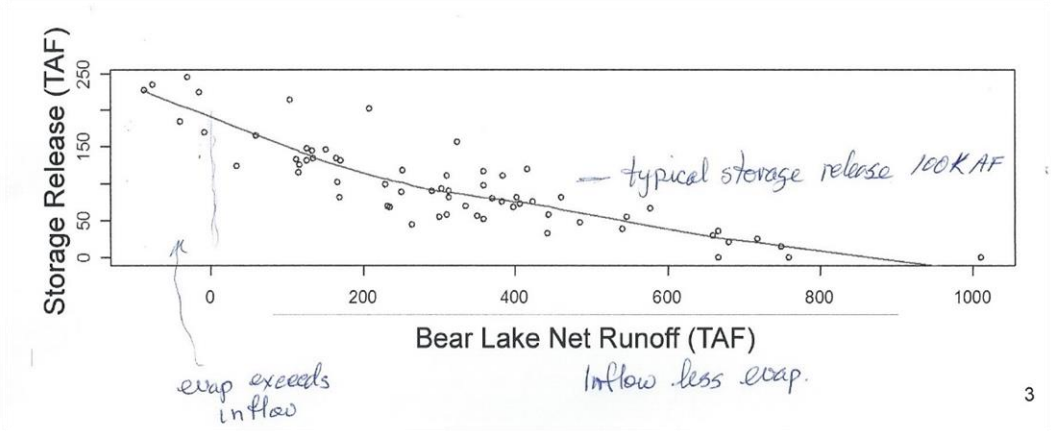
Mud Lake volume approx. 14,000 AF. At 3,500 cfs into Rainbow (about 7,000 AF/day), the resident time in Mud Lake is about 1-2 days.

Bear Lake volumes and key elevations (from tour handout)



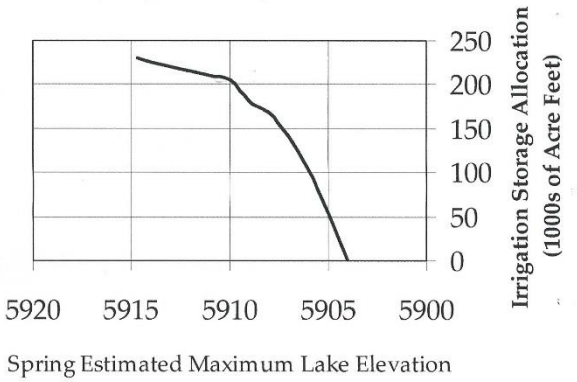
Bear Lake elevation on left x axis, date along y axis and net inflow, in orange, on right x axis. Lake levels don't necessarily reflect the supply of water at Stewart Dam.

Expected Demand on Irrigation Storage Water as a function of Natural Flow – using data before the Bear Lake Settlement Agreement was implemented.



Evaporation can exceed inflow(resulting in decreasing lake levels while storing all available water) or can exceed storage for the year (in low runoff years).

Bear Lake Settlement Agreement



Rations the Irrigator's use of storage as the lake level drops, extending the supply in case of an extended drought.

At elevations above 5914.7 ft UP&L datum, there is a full allocation of 245,000 AF. Below 5904 there is zero allocation.

Questions about Water Quantity

What additional data does NOAA and PacifiCorp need to improve forecasting?

NOAA
- a gage on Thomas Fork
- Additional SNOTEL sites
- Diversion data is getting better and better but there are some gaps in real time
- A model of return flows

PacifiCorp - uncertainty of weather is a major factor
- Soil moisture data gap is being improved
- NRCS (Randy Julander) identified places as the "best" spots to put additional SNOTEL sites
- Idaho NRCS has identified areas that would benefit from additional SNOTEL sites.
- Lack of data on diversions and return flows in upper and central divisions lead to spring forecast uncertainty. Need a water balance on that stretch in the Spring.

Would gages on the tributaries to Bear Lake help?

PacifiCorp – does a backdoor analysis of tributary flow and groundwater input. These volumes are usually very small compared to Bear River inflows at Stewart.

Does cloud seeding help or is it just robbing Peter to pay Paul?

PacifiCorp – cloud seeding adds condensation nuclei that helps precipitation form. Cloud seeding only as good as the number of storms that pass through. Todd Adams, UT Water Resources, – 3 studies have shown a positive downwind effect for about 100 miles. Usually increases precipitation 10-15% so if 10% of the moisture in a storm falls to the ground, cloud seeding would increase that to 11%.

Are knowing the tributary flows and groundwater contribution important?

Water Quality – Cory Angeroth, USGS

2 Automated Water Quality & Weather Monitoring Platforms were installed on Bear Lake on April 12, 2018

A 5-year study to build a near-continuous data set to assess spatial and temporal water quality variability – through depth and through time.

Water Quality Parameters

- ❑ Depth
- ❑ Water temperature and conductivity
- ❑ pH and ORP
- ❑ Optical dissolved oxygen
- ❑ Turbidity
- ❑ Total algae

  - 4 to 6 times/day depending on battery life
  - Measurements every 2 meters

Weather data is compiled every 3 minutes and uploaded every 15 minutes.

Weather Parameters

- ❑ Wind speed and direction
- ❑ Barometric pressure
- ❑ Air temperature and relative humidity
- ❑ Four component net radiometer

Evaporation will be estimated using the Bowen Ratio Energy Budget method (measures energy dynamics of all inflows and outflows). Better tributary & groundwater flows and temperatures would greatly increase the accuracy of this method.

USGS working on proposals for automated lake level gage, drone flyover with infrared sensing and better groundwater knowledge.

Bear Lake Data publicly available on the web

USGS website http://ut.water.usgs.gov
Weather data - www.mesowest.utah.gov
Lake level and stream flows www.BearRiverBasin.org.

Project Manager at USGS is Ryan Rowland, 801-908-5036. rrowland@usgs.gov

A presentation of each year's finding will be given at the Bear River Commission Water Quality meeting in November.

Comments – Lynn VanEvery, Idaho DEQ, We've never had this type of seasonal, spatial and temporal coverage in an oligotrophic/mesotrophic lake. Bear lake is very healthy water quality wise. DEQ usually looks at eutrophic lakes (over-the-limit). This will be a data set that is unparalleled in the West and set the standard for future water quality efforts.

Water Quality – Mike Allred, Utah DEQ

A brief history of how water quality efforts got to where they are now at Bear Lake and on the Bear

- Public comments at the 1997 Bear River Compact Review led to the formation of the Commission's Water Quality Committee
- 1991 Bear River Water Quality Task Force formed
- In 2001, the Bear River Water Quality Task Force initiated water quality sampling along the entire Bear River and inlet& outlet of Bear Lake 4 times a year. Still ongoing after 12 years.
- Water Quality Task Force meets twice a year and reports to the Bear River Commission Water Quality Committee.
- Public involvement is key to obtaining input on potential projects.

All these efforts have created more interstate cooperation in the water quality world.

Utah & Idaho have identified 6 points on Bear Lake where water quality samples at taken yearly for a chemical analysis.

https://deq.utah.gov/division-water-quality >Interactive Map>Databases & Information

Water Quality – Lynn VanEvery, Idaho DEQ

Bear Lake's water quality is high. As water leaves the lake the quality degrades as it picks up sediment.

The hydrograph below Bear Lake is flipped. Normally, high flows occur in the Spring while Summer flows are declining. Below Bear Lake, the flows are high all Summer and this transports sediment.

How the States manage water quality, as they deal with water quantity delivery from Bear Lake, is a key issue. Water quantity drives water quality.

How/can we maintain ecological systems that can support most all uses?

All the communities along the Bear in Idaho have stepped up to meet NPDES requirements for waste water treatment. From a non-point source perspective, over $12M has been spent recently to improve water quality. Over $18M in Utah – primarily in Cache Valley. There needs to be a balance of money spent between on-the-ground projects and scientific studies/monitoring.

Questions & Discussions about Water Quantity

Tyler Allred - There is a disconnect between WQ issues (BL not considered impaired) because WQ does not pick up the problem of silt around the edges of the lake – this is a recreational issue, not WQ issue. WQ data doesn't pick this up (silt and muck) but a survey around the edges may pick this problem up better.

The Land

Wind, Waves & Currents – Wes Thompson, BioWest geologist & Bear Lake homeowner

Wave & particle physics - There is shoreline movement of sand both onshore and out into the lake. This movement has both in-out and lateral components due to long-shore drift.

Most sand entered Bear Lake about 18,000 years ago? The sand above the high-water mark is stored high & dry.

Ice plays a big part in building winter sand berms

Vegetation also can trap sand & sediment off shore.

Beach raking, tilling & mowing helps reduce flies and helps re-mobilize the sand for more enjoyable recreation, but permits are needed.

Jetties and harbors influence sand deposition by interrupting the wind, waves and currents. Aerial photograph comparisons show that fine particles & muck will deposit on the leeward side and prevent sand movement along the shoreline.

The effects of gravity on sand deposition get an extra boost each time the lake is drawn down thereby trapping the sand in deeper water. When the lake rises quickly, some sand is left behind and not effected by the waves for long enough to move it shore-ward. This is a "lost" resource unless we can physically move it shoreward again.

Should we consider beach replenishment operations like is done on the ocean coasts? Todays thoughts can easily turn into big projects that may take 20 years to come to fruition.

Where did the sand come from? There are no new sources and the source of existing sand is not well documented. Our sand budget is static.

In 2018 the "muck" returned. It is silt, not clay. The plant material that washes up is probably upland plants that have grown on the exposed shoreline and when the lake comes up, they die and decay. Has anyone looked into the mineralogy of the sediment/sand?

Scott Tolentino – there is 20 years of Secchi disk data for Bear Lake at Utah State at the Utah Water Watch database. https://extension.usu.edu/utahwaterwatch/ There is also Secchi disk data at the 6 sites that ID/UT sample.

Long term questions –

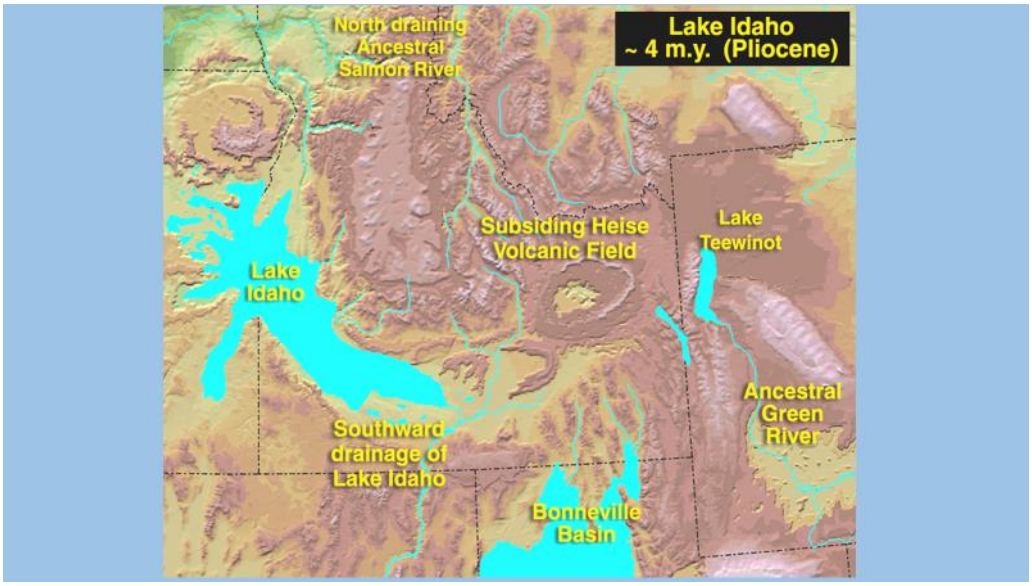
- What is the assimilative capacity of Bear Lake, for the muck ?
- Is Mud Lake still filtering Bear River water or is it contributing to sedimentation in Bear Lake? Paired sediment studies, bedload studies.
- Will the turquoise blue become green or brown?
- What is the long-term turbidity trend? Is anyone measuring or reporting it?

Geology of the Bear Lake Area – Dr. Paul Karl Link, Idaho State University, Geology & Geosciences

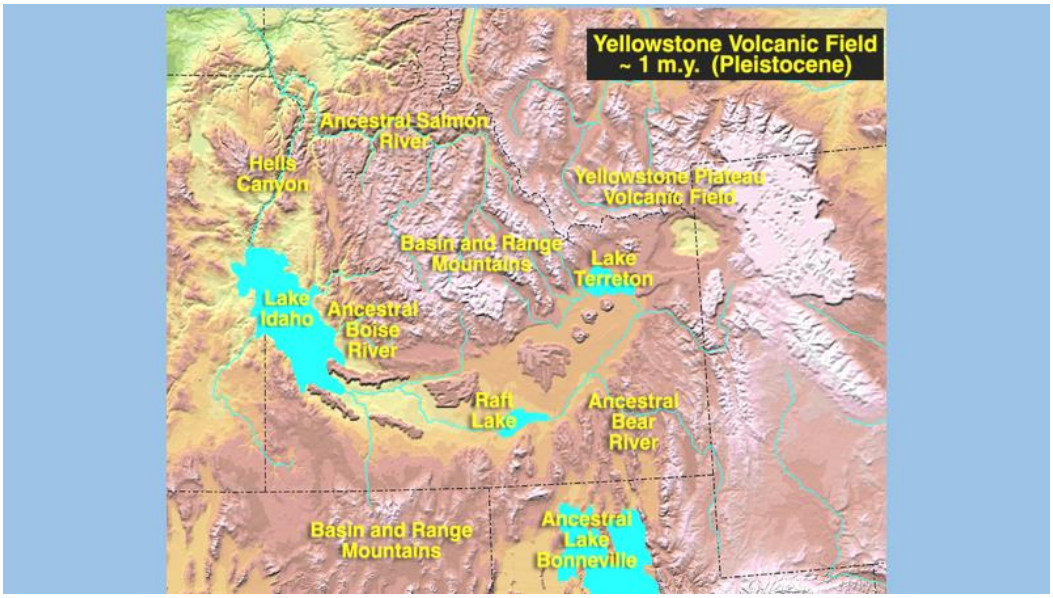
Coauthor of new geological map of Idaho

Bear Lake is part of the Mesozoic Thrust Belt

There are active faults on each side of Bear Lake (faults that have moved w/i the last 12,000 years) forming a graben. The east fault is more active so that is where the deepest part of the valley/lake is. The slip rate is 1.1 meters per 1000 years which is comparable to the Wasatch Fault, Teton Fault or the Borah Fault. Bear Lake is in Earthquake Zone 2 (most active) surrounding the Yellowstone hotspot. The east mountains around the lake are mostly sandstones and the west side is mostly limestones (karst topography). Lake Bonneville came up to Gem Valley (Grace area) but Bear Lake was not part of Lake Bonneville. About the time of Lake Bonneville, Bear Lake was much larger & about 60-80 feet deeper. The northern end of the lake then was in the Georgetown narrows near present day Nounan.



4M years ago, Lake Idaho, Bear River not in existence. Bear Lake could have been.



1M years ago, there is a Bear River draining into the Snake River thru the Blackfoot River. *UGSG Special Paper 450* Bear Lake was probably in existence.

Lake Thatcher, about 100K years ago was not fed by the Bear River, but by local streams. This is verified by the fish fossils.

About 50,000 years ago, a lava intrusion near Grace, initially damned the Bear River near Bancroft and then diverted the Bear River southward into Lake Bonneville. That additional water eventually caused Bonneville to breakout at the north end of Cache valley. How the Bear River cut through the Oneida Narrows mountains is still a geological uncertainty.

Bear Lake has been cut off from the Bear River for about 12,000 years, which is why it is so clear and has unique water chemistry.

The sand in Bear River is mostly from the Uintas and has a signature red color.

The oil in Wyoming is Phosphoria formation-based oil and probably migrated from this region to Wyoming with the plate tectonic movement.

During the last two glaciation periods, glaciers were present in the Bear Lake valley in Paris Canyon, Bloomington Canyon and St Charles Canyon. 12K and 30K years ago.

Sediment – Dr. Patrick Belmont, Utah State University

Hydrology 101

Sediment is composed of mud (which is silt & clay), sand, gravel & boulders and organic material.

Why should we care about sediment? – Habitat degradation, controls light penetration(affects aquatic plant growth), clogs respiratory and feeding structures in organisms and transports nutrients and contaminants.

Is Bear River messed up? How much and what type of sediment is being delivered to Mud Lake and Bear Lake? A certain amount of sediment is natural - too little or too much causes problems.

What matters in the study of sediment - The hydrology, The land use, The soils – surficial and bedrock geology, The grain size (wash load, suspended load & bed load) – affects different parts of the channel and Sediment Storage capacity – natural and human caused "legacy effects"? *Science paper – Coon Creek*

Sediment transport through water sheds is complicated.

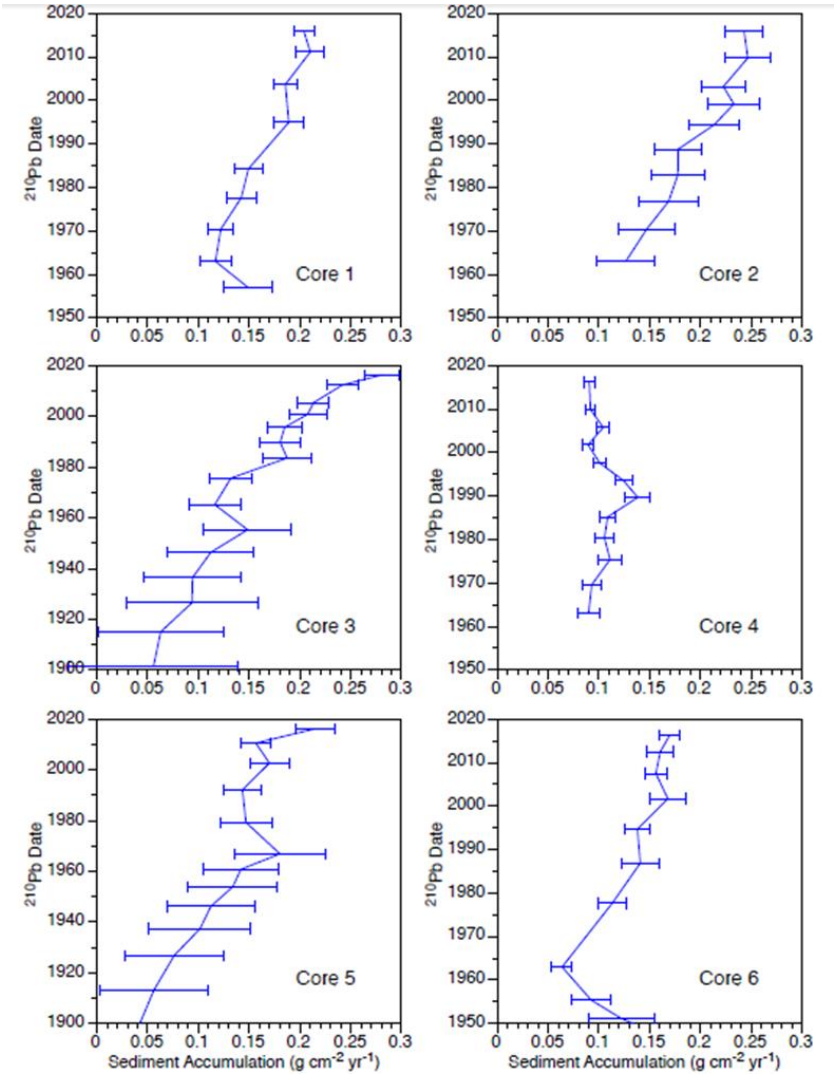
How are different grain sizes transported thru the river network?
Where are sediment bottlenecks?
What are implications for habitat degradation and recovery?

How is sediment effectively monitored – grab samples, turbidity probe, rigorous USGS sampling, ADCP (Acoustic Doppler Current Profiler),

A case study on the Upper Mississippi, at Lake Pipin, where sediment and nutrients were problems, originally pointed to Agricultural practices. $250M and over 11,00 projects were earmarked to correct the problem. Sediment fingerprinting and sediment budgets identified some cliffs as a major contributor and agricultural conservation problems with drain tiles actually exacerbated the problem. Local conservation strategies were changed and money re-directed.

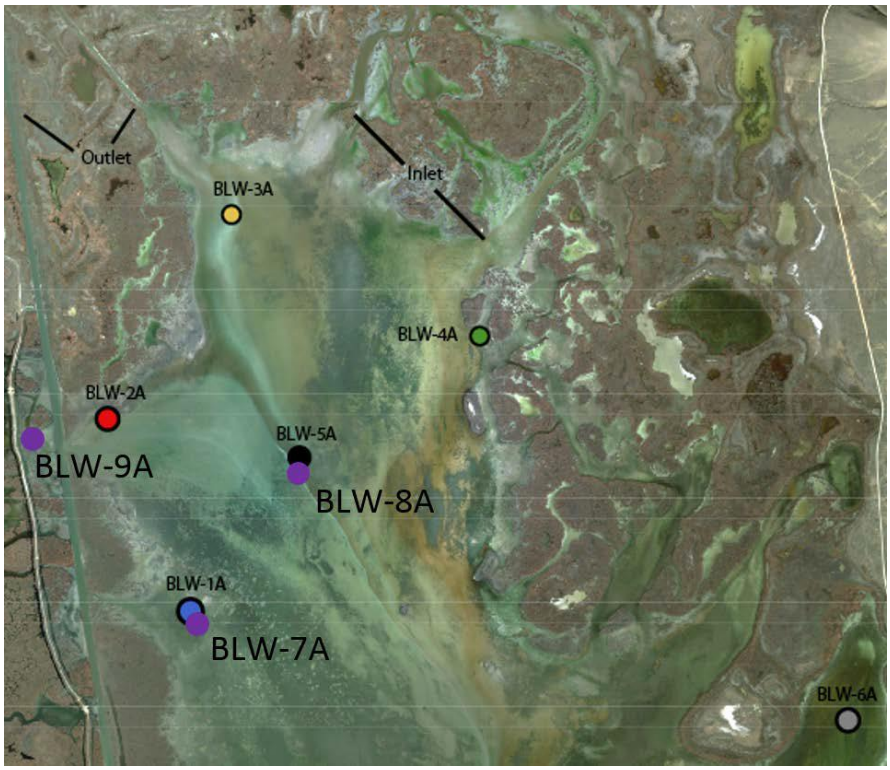
Mud Lake/Bear Lake Sediment Study

There don't appear to be any big systematic shifts in the hydrology of the Bear River. There is more variability in the flows in recent decades.



Sedimentation rates for each of the extruded Mud Lake cores, based on sediment deposition ages and measurements of moisture content and bulk density. Error bars indicate propagated two standard errors.

In Mud Lake, the rate of sedimentation has increased over the last 100 years especially since the 1980s. Mud Lake is losing about 1 foot per 50 years of storage capacity but is still acting as a sediment trap (most of the time) for Bear Lake.



9 cores were taken in Mud Lake. Three cores were left intact and photographed at high resolution. The other 6 cores were sliced in 1 cm sections, dated utilizing Lead 210 and Cesium 137 and an Elemental analysis for the cores showed a shift about 100 years ago for all elements and a big shift 10 years ago for REES (Rare Earth Elements) like Silver and Mercury. The cause of the REES shift is unknown (cloud seeding has been going on since the 70s). It is not known if the levels of Ag and Hg are near the toxic levels.

Preliminary Diatom studies of the Mud Lake Cores by Dr Janice Brahney, show changing water quality over time. From Planktonic glacial lake to sandy benthic lake, deep water to shallow water to mesotrophic lake (last 50 years).

Comparison of aerial photographs (15 sets of imagery from 1980 to 2016) identified two sets of photos taken at nearly identical lake levels. Bear Lake was within 0.04 feet of the same level when aerial photos were taken in 1980 and 2011. Comparing the shorelines shows dramatic deposition along the northwest and north shoreline and some erosion along the northeast shoreline. In 1992 and 2004 (2004 level about 1 foot higher) also show considerable deposition in most areas of the lake.

Another comparison of aerial photos taken in 2003, 2006, 2012 and 2016 show 10% of the sandy beach in the northwest corner has been lost to vegetation.

Another study mapped sculpin (one of Bear Lake's endemic fish) habitat around Bear Lake. As water level decreases, so does the amount of sculpin habitat.

When the water level is 6 meters (19.7 feet or Bear Lake at elevation 5,903.95) below full pool, 97% of the habitat is high & dry.

Animals & Fish – Scott Tolentino, Utah Division of Wildlife Resources

UDWR is full time on Bear Lake and does most of the sampling for both states. Gill netting is used to monitor fish populations .

Utah's fisheries plan for Bear Lake is balancing conservation of the endemic species with providing angling opportunities (sport fishing) for the public.

Bear Lake has 4 endemic fish (found nowhere else in the world). The BL Sculpin is the most dependent on higher water levels in the lake for spawning habitat. The Cisco prefer the same rocky cobble for spawning but will also spawn in other available habitat.

The fish trap on Swan Creek has been easily meeting its goal (250,000 eggs) for egg collection and has been passing fish upstream of the trap for natural spawning. BCT spawners have also been moved to St Charles Creek because there is more habitat for spawning and the fry.

Habitat improvements in the Bear Lake tributaries have led to an increase in natural recruitment of Bonneville Cutthroat Trout (BCT). Bear Lake used to have about 80-85% stocked BCT. The recent gill netting surveys have been shown that now 70% of BCT are now native. This has allowed Utah & Idaho to stock less hatchery raised BCT in the lake. Since 2000, about 170,000 BCT have been stocked in BL yearly.

Eggs from naturally spawned BCT have a 2-5 % survival rate. Hatchery raise eggs have about 90% survival rate.

Stocking Lake Trout has caused problems in other lakes but not in Bear Lake. There doesn't seem to be any recruitment in the lake. Lake Trout can live in BL for up to 40 years. Recent stocking has been with triploid fish (sterile) but these fish go through the motions of spawning but lay infertile eggs.

The goal of the joint fisheries plan between Idaho and Utah is to keep some trophy sized lake trout while focusing on BCT and insuring the lake has a healthy BCT population. BCT's diet is primarily other fish but recently zooplankton has started showing up as a component of their diet. Probably due to higher water where zooplankton can grow quickly. Pelicans can almost halt a BCT spawning run but the higher lake levels give the fish much less exposure to Pelican predation. St Charles is especially exposed on low water years.

There has not been stocking of sterile Rainbow in recent years.

Cisco populations are monitored closely by using hydroacoustic surveys. They are to small to catch in gill nets. Cisco come closer to the surface a night to feed on plankton and zooplankton. Cisco populations are well about the target population of 2.5M fish. The current population is about 7M.

Bear Lake is less than 2 mg/l of chlorophyll-a which puts it a highly oligotrophic lake (very low production/sterile). Chlorophyll-a is a measure of the carrying capacity of the lake. The high water (inundated shoreline vegetation) improves stocked fish survivability.

Arnie Brimmer – Idaho Fish & Game

IDF&G monitors the sculpin populations by conducting trawls.

Idaho has been concentrating on habitat restoration instead of fish stocking – mostly in St Charles & Fish Haven Creeks - Unscreened diversions and Fish Barriers.

Above lake level 5916, BCT have pretty good fish passage to the tributaries for spawning. Below that it becomes problematic for the fish, not only for spawning but for the juveniles to return to the lake.

Idaho & Utah are evaluating changing the restriction on keeping native BCT but have agreed that more study is needed – accurate counts of spawning BCT, better data on numbers of juvenile returning to Bear Lake, carrying capacity of the tributaries & solid growth data of juveniles.

Bear Lake BCT are quite pure genetically (high 90s) – very low hybridization and extremely low introgression (several generations).

Biologists don't want to see the lake full or low all the time – want to see fluctuations (these fluctuations move the sand, rock, etc.).

<u>Plants</u>

Very little is documented about what aquatic plants are growing in Bear Lake

Conclusion – JoAnna Ender-Wata

The purpose of this Bear Lake Science symposium was to utilize our collective synergies to arrive at a more symbiotic understanding of the science of Bear Lake - What we know and what "WE" need to know to better manage this resource.

Yesterday, the Bear River Commission toured the northern Bear Lake valley with similar goals, across state lines, to achieve a better understanding of the hydrology of the Bear River, Mud Lake and Bear Lake.

We invite you to throw out your ideas and questions about what you've heard. What questions do "WE" have about the lake? What new studies do we need? What monitoring or data do we need to help formulate future management of Bear Lake? How do we adequately and

consistently address the science and data needed for Bear Lake? Is there a future need for symposium like this?

An email questionnaire will be sent to each of you as you ponder these thoughts to solicit your ideas.

Thank you

Comments & Thoughts at the Conclusion

One opinion was voiced that we should quit manipulating Bear Lake for our purposes and summer time uses – let things happen naturally. A counter opinion voiced was that we do manipulate Bear Lake because we take the water out for irrigation, so it is not a truly natural system.

Should we develop a matrix of parameters for different lake levels similar to what FFSL has done for Great Salt Lake?

Dave Cottle – Each of the entities here today should be thinking about what studies they need as we go forward. What information do each of you need to better manage Bear Lake in the future? We should go forward collectively instead of as separate entities.

Wes Thompson – What is the carrying capacity of Bear Lake? How should we manage this in 20 years, in 50? Is there a ceiling? What is it? Tourism vs natural functions, vs wildlife resources, etc.

Sands Brooke – Is more coordination needed between Utah and Idaho on policy? Should all decisions affecting this resource be coordinated across state lines?

Wes Thompson – How do we identify funding for the future work that needs to be done?