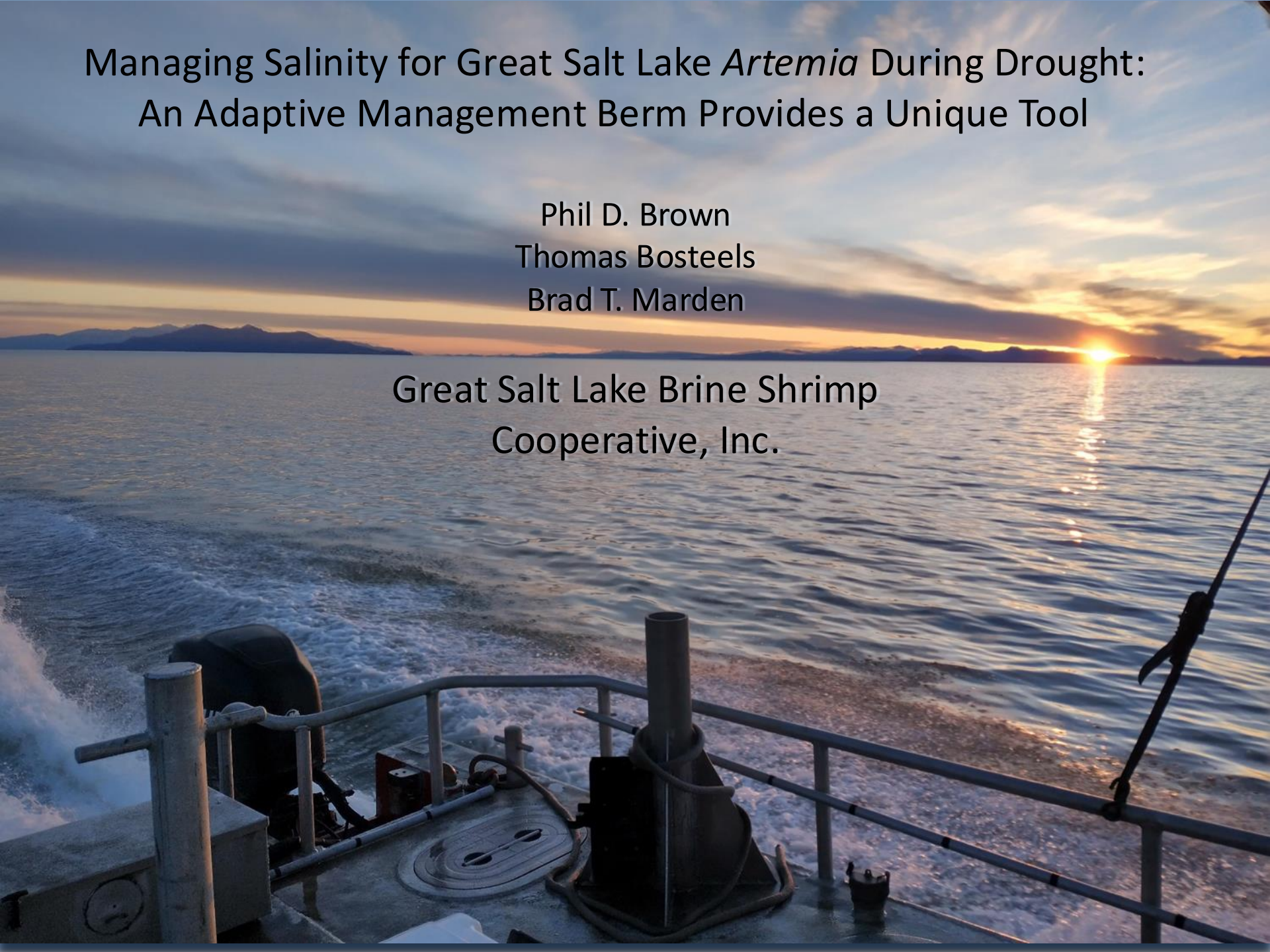
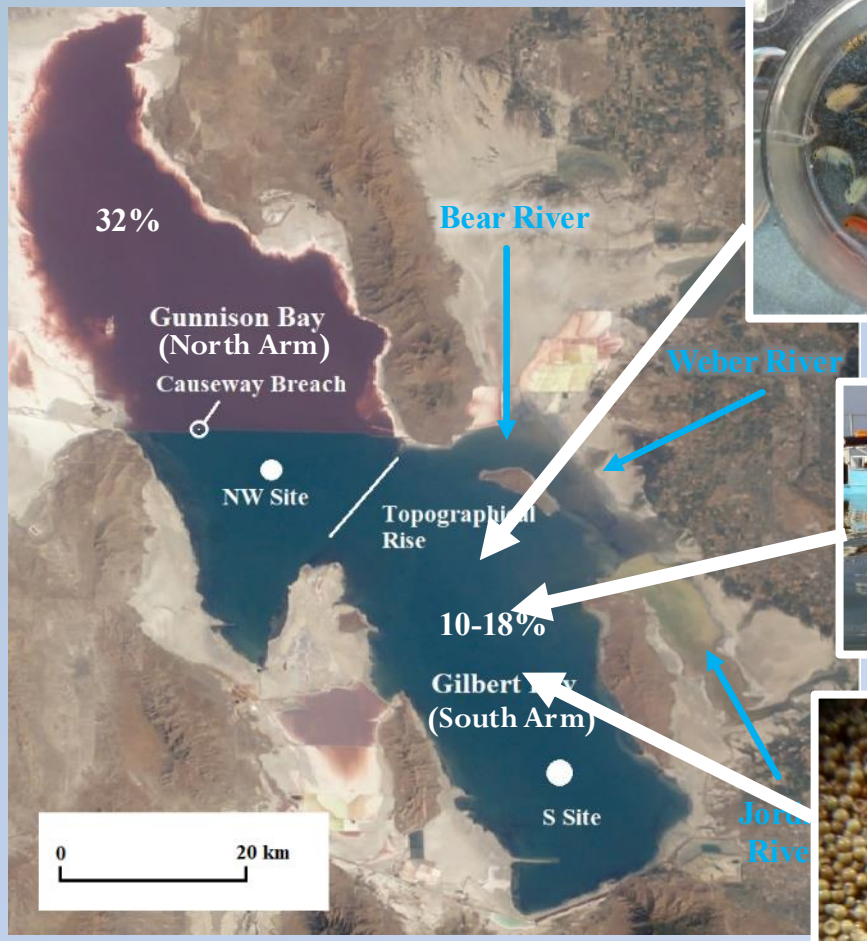
Managing Salinity for Great Salt Lake *Artemia* During Drought: An Adaptive Management Berm Provides a Unique Tool

Phil D. Brown
Thomas Bosteels
Brad T. Marden

Great Salt Lake Brine Shrimp Cooperative, Inc.



Great Salt Lake structure

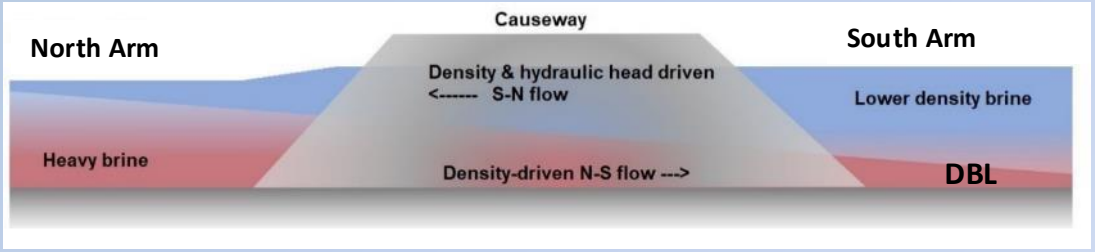


- s divide the lake
- ke railroad causeway separates Arm (Gunnison Bay) from South ilbert Bay).
- South Arm receives all 3 inflowing rivers
- ited South Arm flow
- erence as a result
- The *Artemia* population and harvest is in y year
- ange of 10-18%

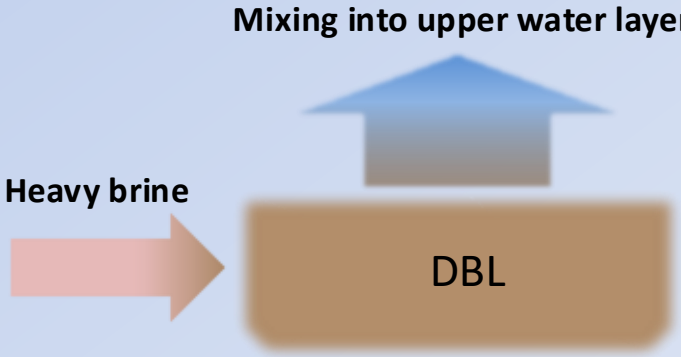
The influence of the main causeway and its culverts

The midlake causeway permits bidirectional flow through culverts

- South Arm lighter brine flows into North Arm at the surface
- North Arm heavy brine flows beneath into South



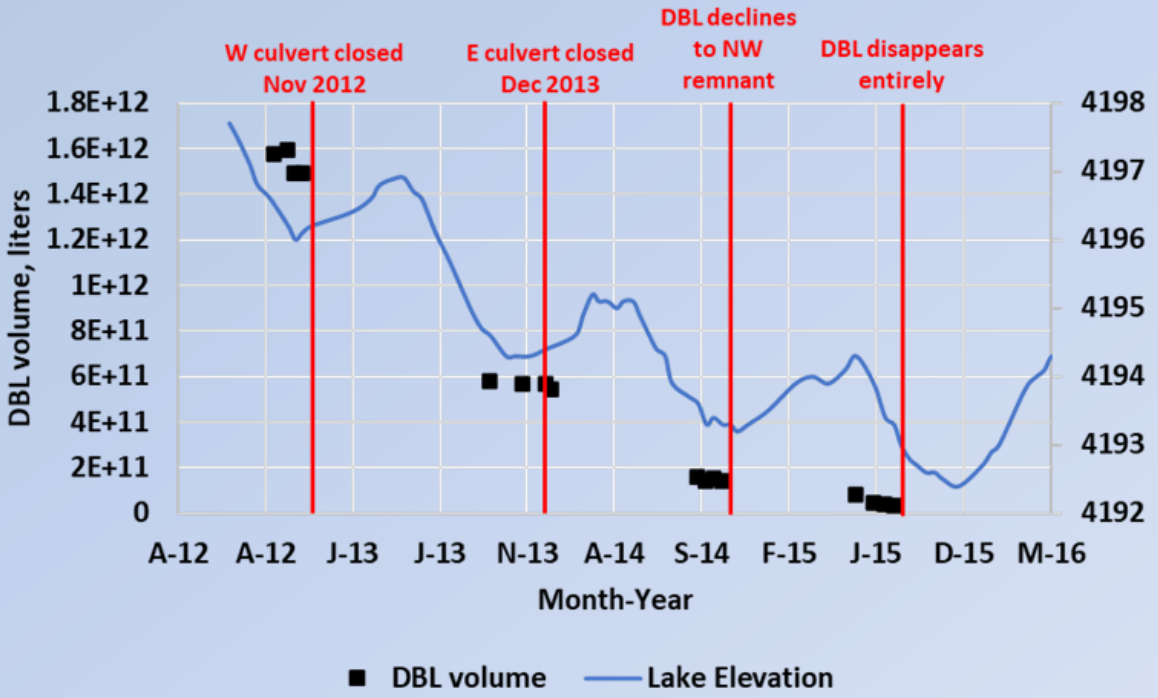
Sealed permanently in 2012 and 2013



- The heavy brine forms a deep brine layer (DBL) in South Arm
- The heavy brine eventually mixes into South Arm upper waters, adding salt to the bay

A timeline of culvert closure and DBL erosion

6.2 liter vertical sample of the water column at the interface of the DBL and upper oxic water layer



- Old culverts sealed in 2012 and 2013
- No heavy brine return flow to replenish DBL
- DBL dissolved into upper waters by 2015
- South Arm uniform in salinity from surface to benthos

New bridge and breach opened December 2016

Photo by Ames Construction, general contractor of the project

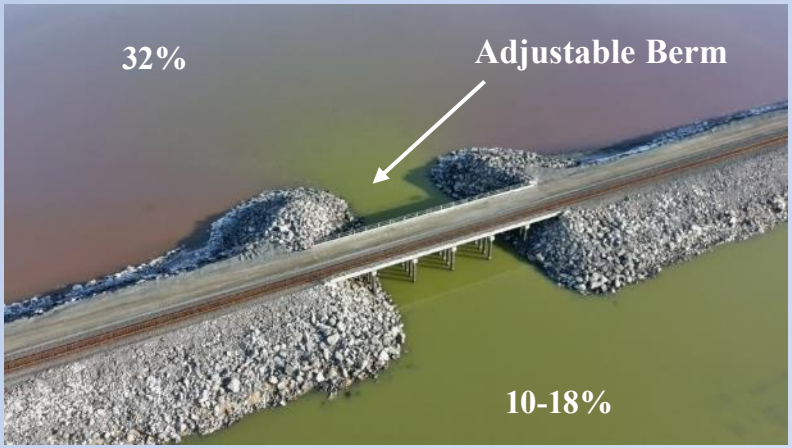
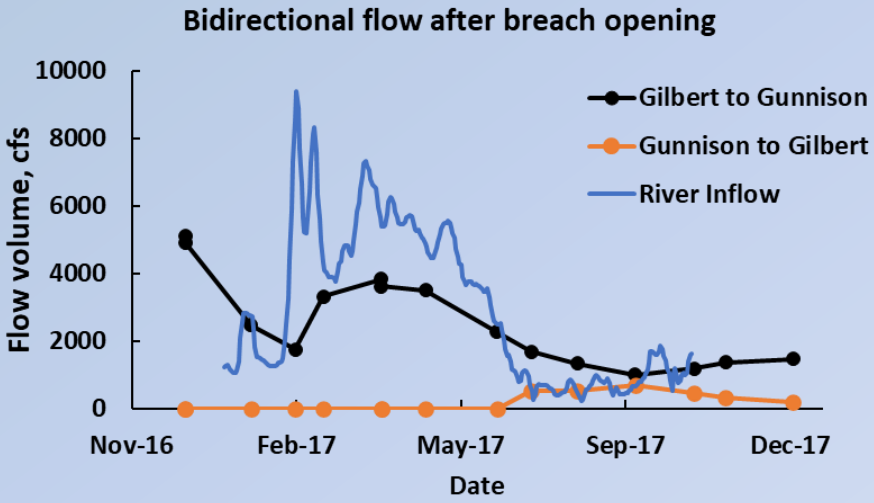


Photo by Drs. Som Dutta and Brian Crookston, Utah State University

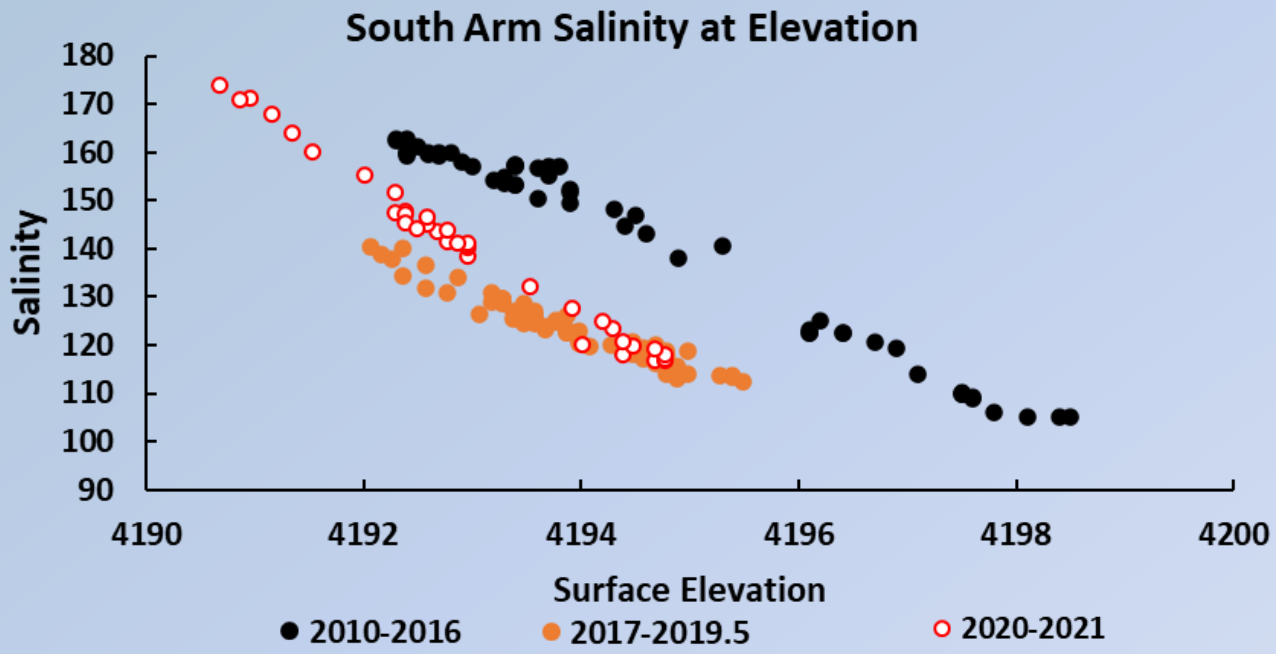


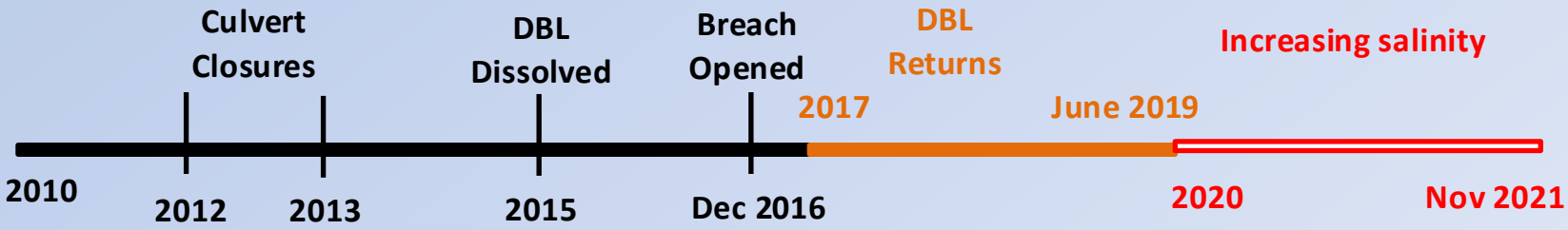
Large unidirectional flush of water for 5 months:

- Hydraulic head had built up after 3 years of disconnect from Gilbert Bay inflows
- Large spring runoff in 2017

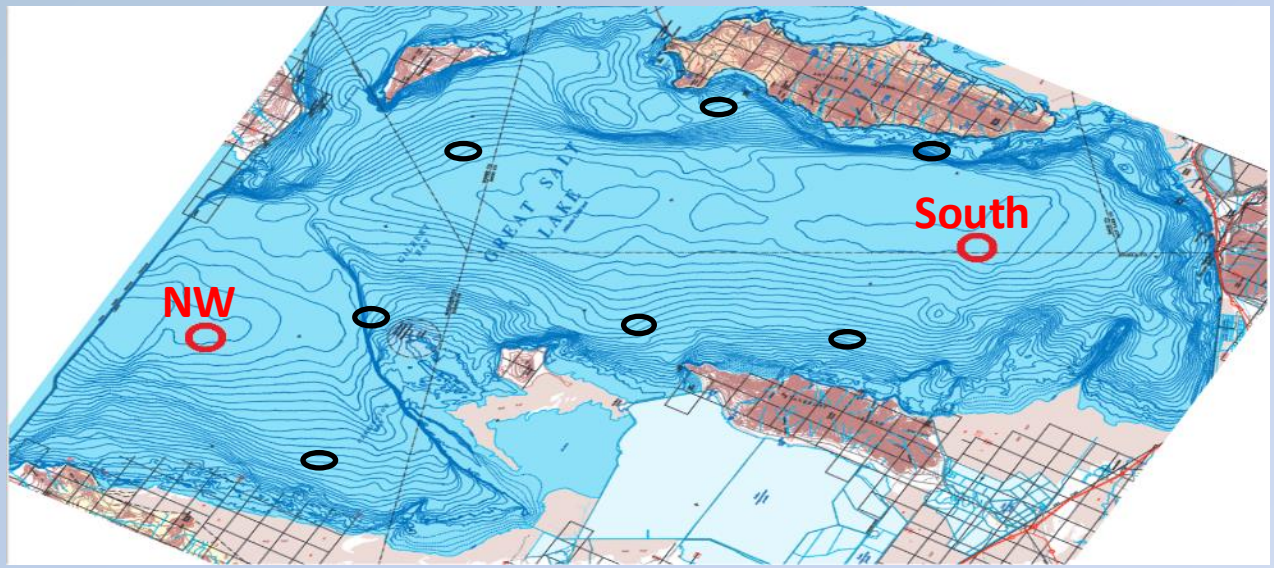
Exported South Arm water and salt into the North Arm

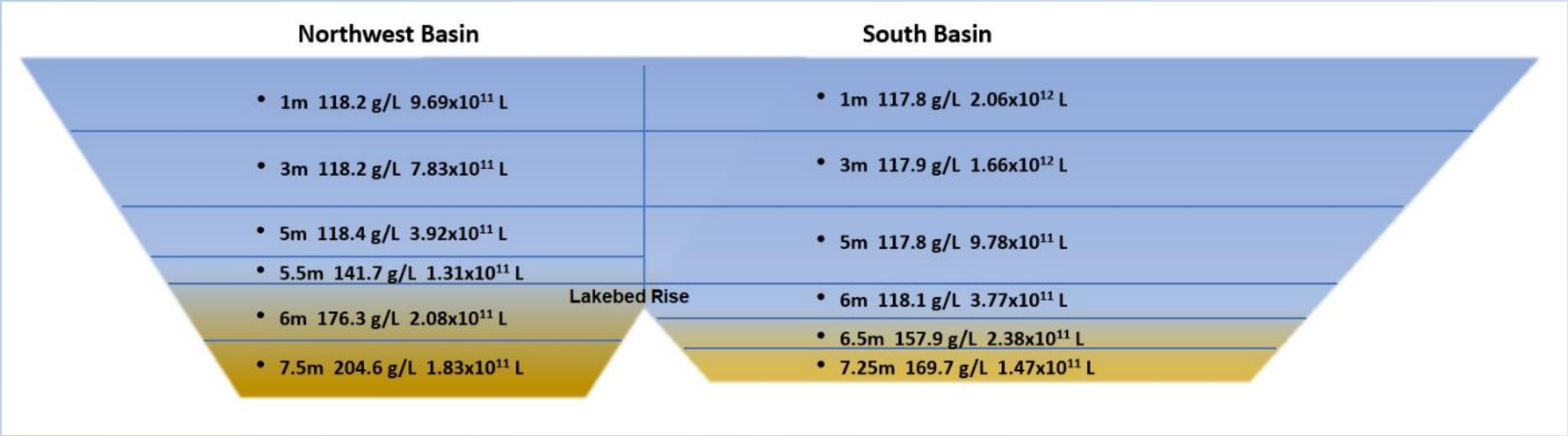
Changing salinity-elevation relationships



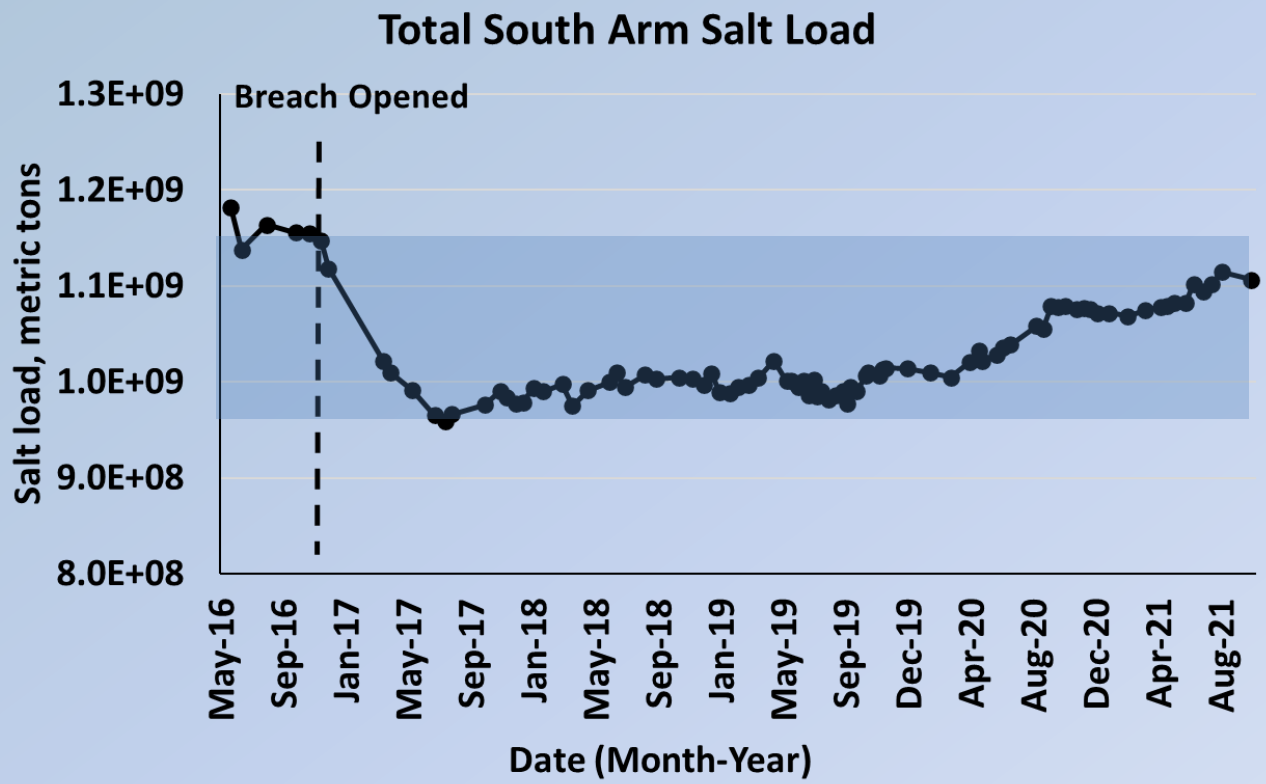


Calculating South Arm salt load from monitoring data





Export and return of salt load, 2017-2021

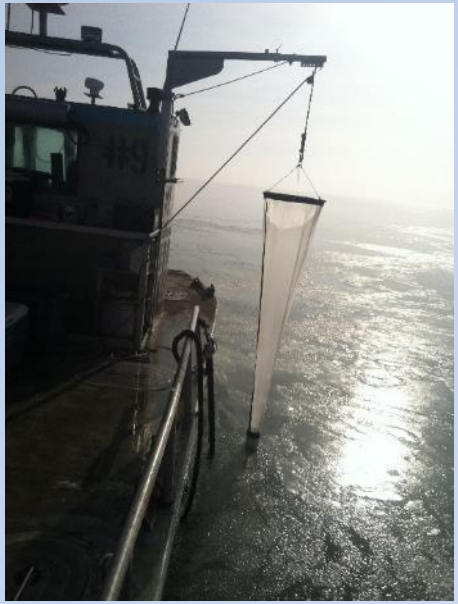


- 17% export of South Arm salt load to North Arm
- Gradual return of ~90% of it over the next three years
- Unwelcome at low GSL volumes
- Concerning trend
- <u>Endpoint was unknown</u>

Long term data informs management

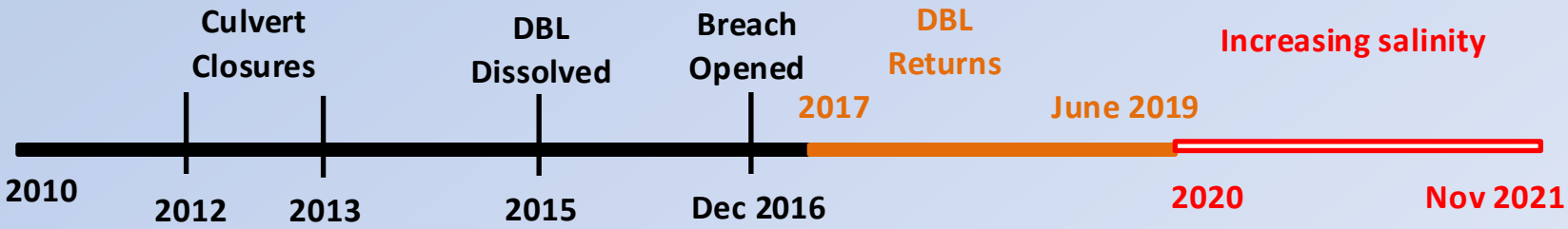
Principles of salt movement demonstrated

- Salt exported from South when hydraulic forcing is strong (i.e. spring runoff)
- Salt returns through breach when hydraulic forcing is low
- Modifying the berm may allow managers to manipulate this



Years of data collection provided unexpected results

- Unique observation of salt movement
- Informative for potential adaptive management



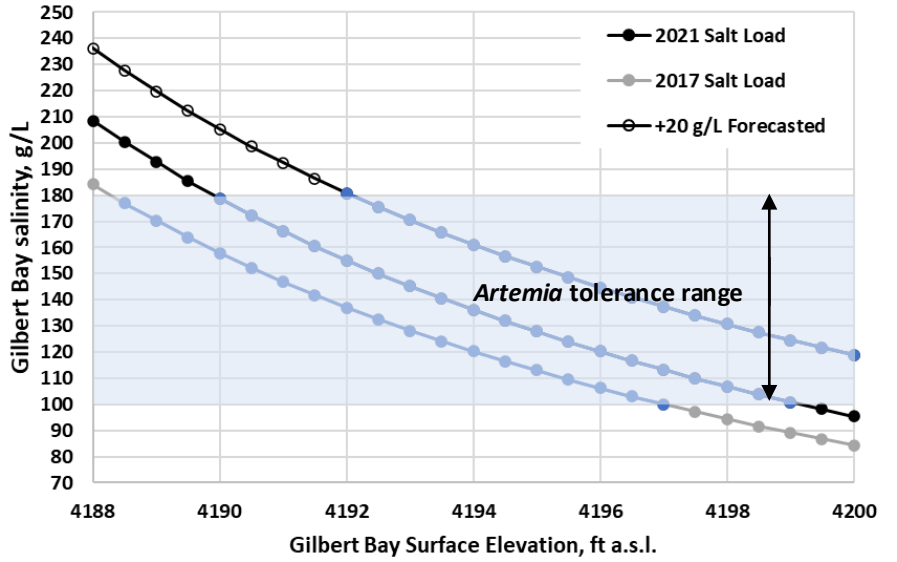
Management Implications

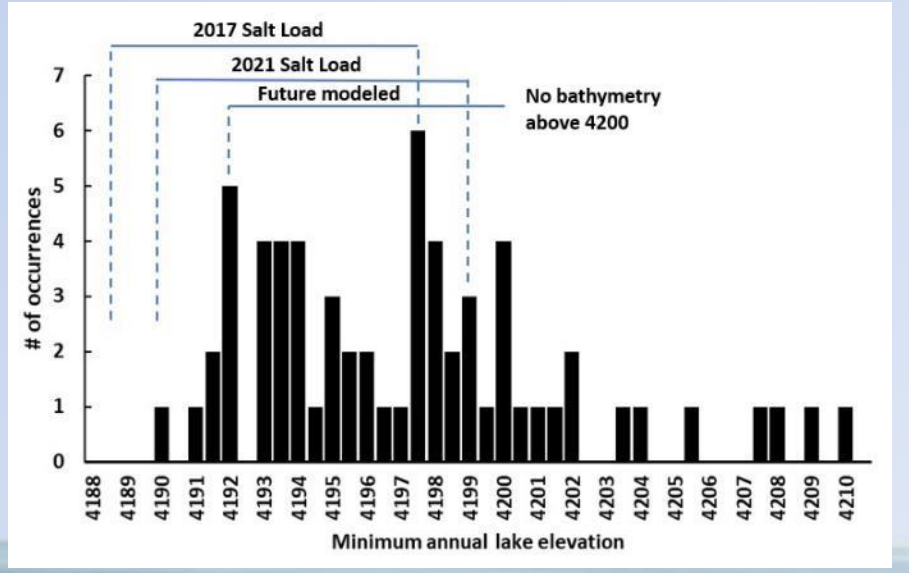
Short Term Options

- Raise berm after spring runoff, yet before return flow
- Raise berm for several years to allow hydraulic head to rebuild, then open
- Raising the berm may reduce or eliminate the return flow at low lake elevations

Long Term Strategies

- Target salt loads which keep South Arm in 100-180g/L salinity range across the largest range of probable lake elevations
- Avoid frequent berm changes





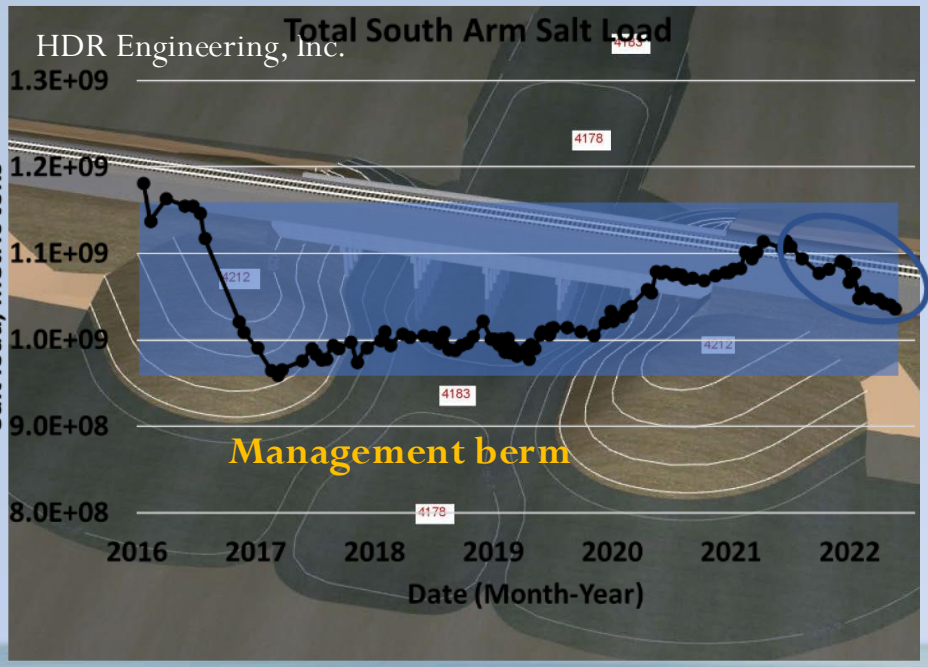
Management actions

Results presented to the Salinity Advisory Committee in 2021

- Government scientists verified our findings
- Committee recommended raising the management berm to stop return flow
- State government secured funds and approved the change

<u>Berm was raised in July 2022</u>

- A simple 4 foot increase in berm height using rock fill
- Heavy brine return flow has been halted
- Salt load in Gilbert Bay is no longer increasing



A rare opportunity

Owens Lake

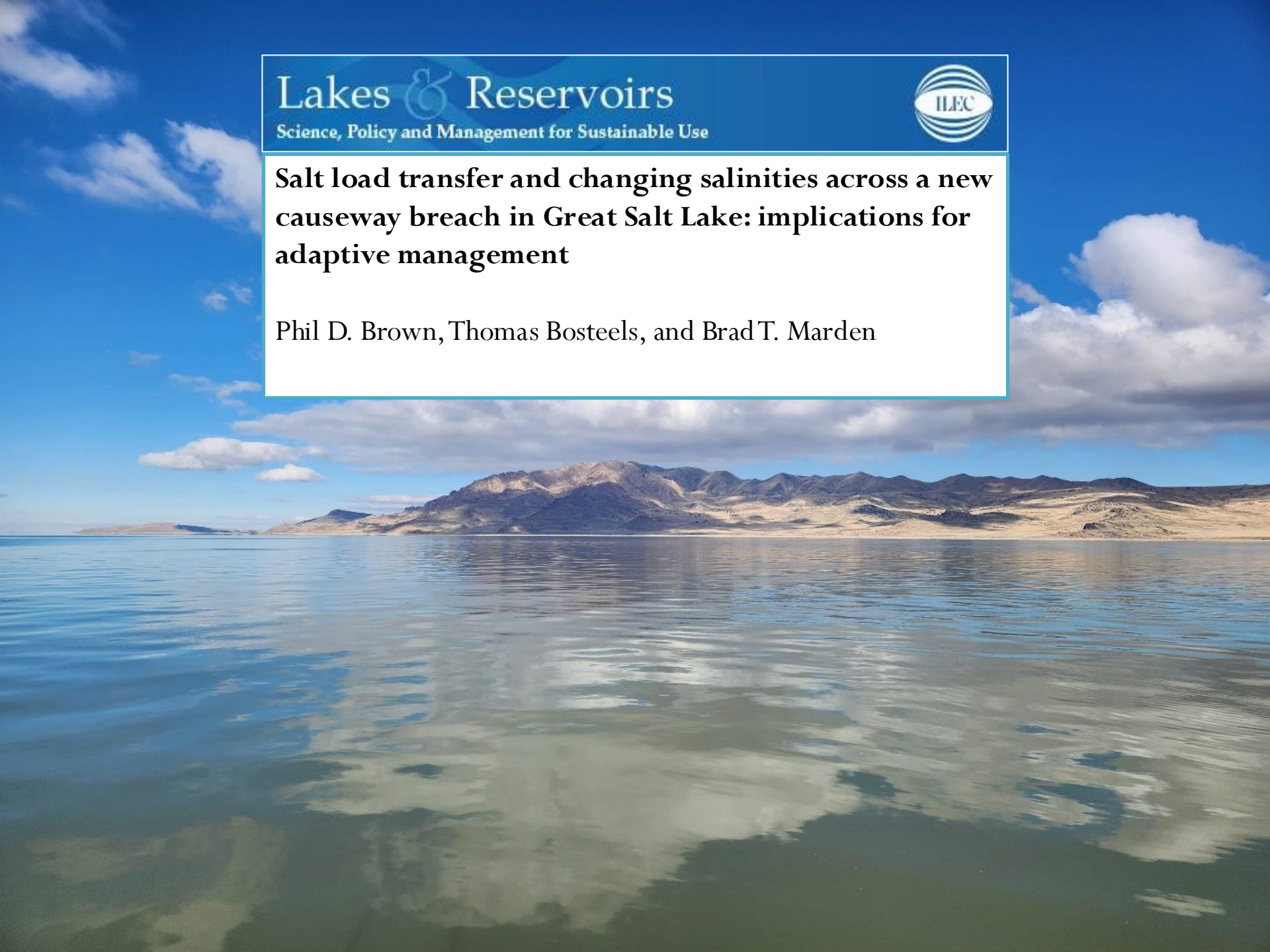
Abert Lake

Aral Sea

Lake Urmia

Great Salt Lake is in a fortunate position

- Causeway location “protects” ~60% of original GSL lake volume
- Adaptive management structure and framework in place
- Other lakes either have no such protections, or the topography & available water allow a much smaller percentage of restoration.



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Science, Policy and Management for Sustainable Use

Salt load transfer and changing salinities across a new causeway breach in Great Salt Lake: implications for adaptive management

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