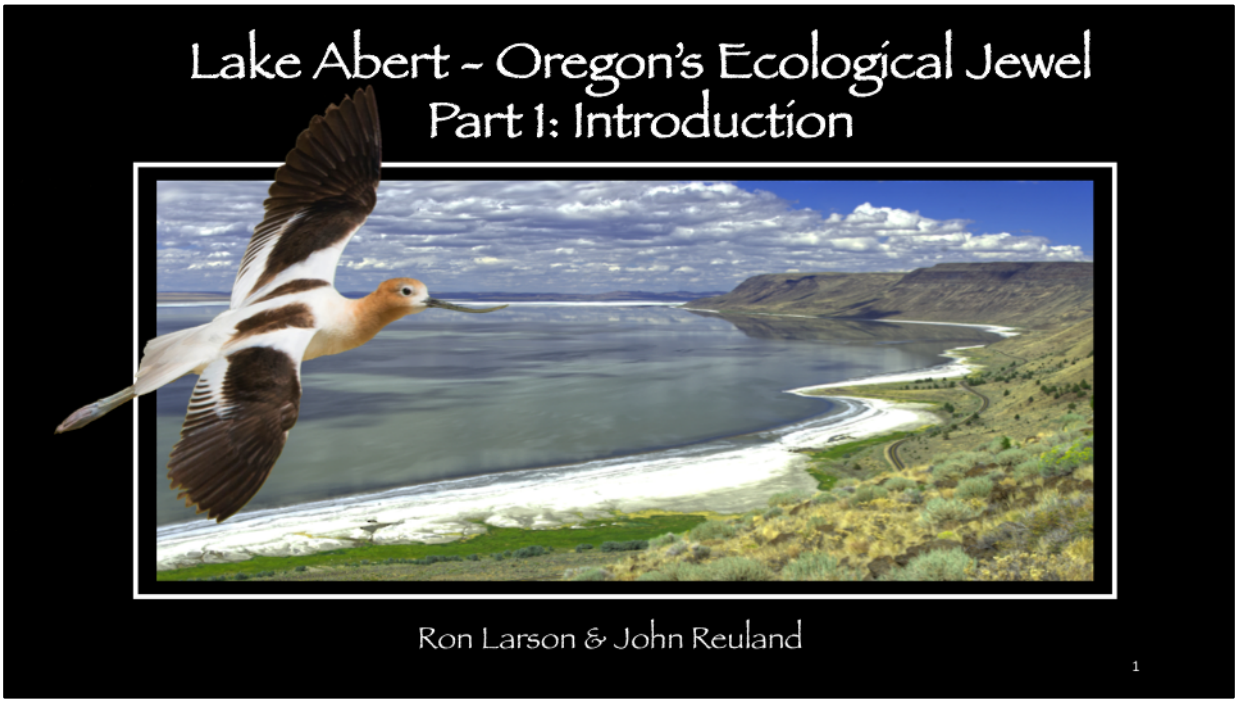
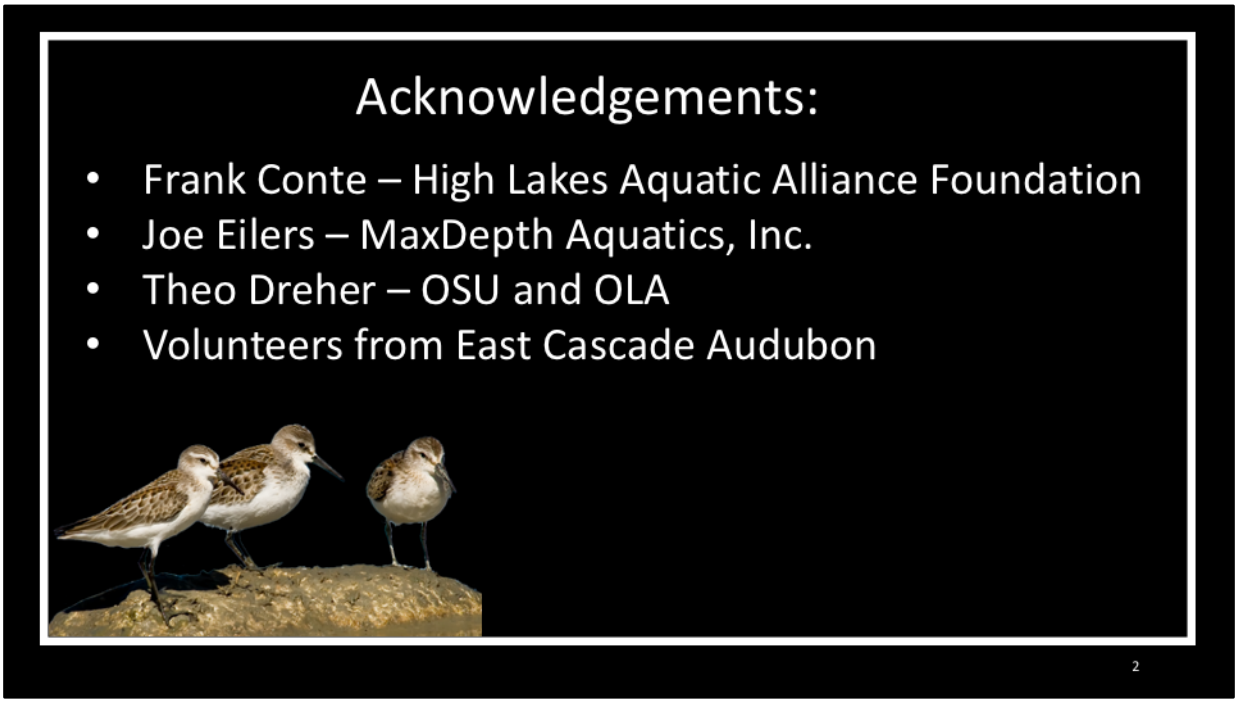
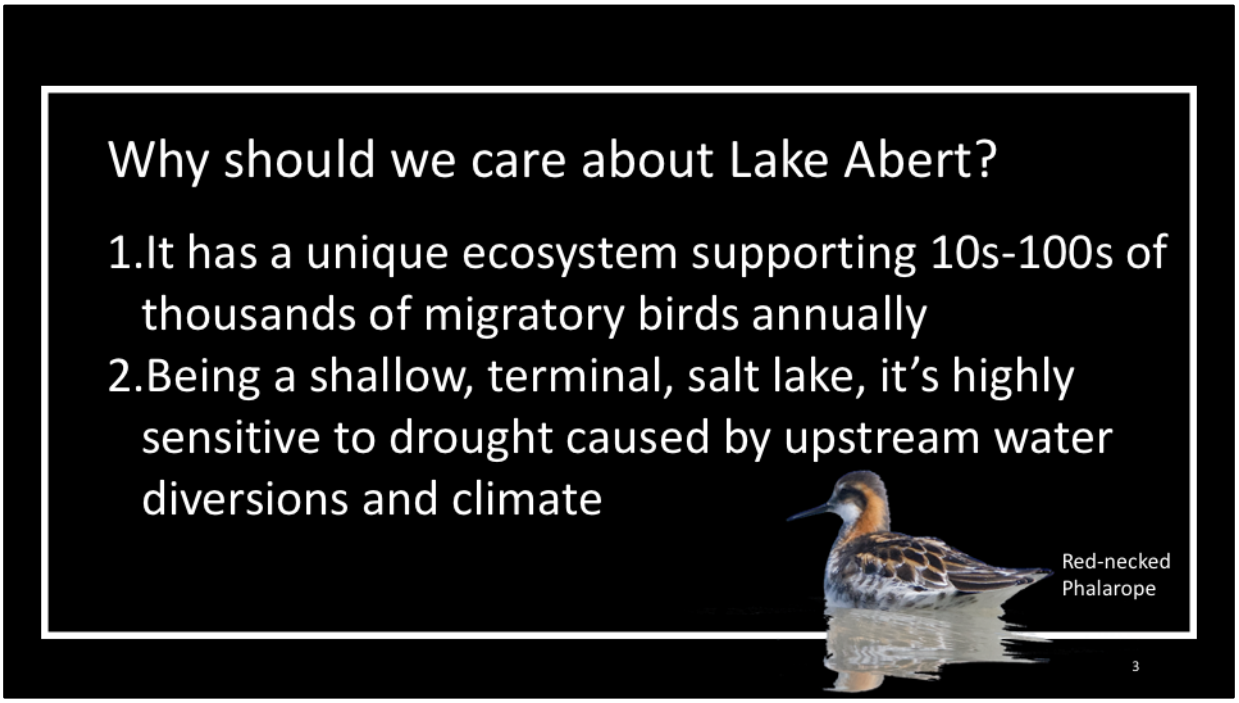


Oregon has an amazing diversity of lakes, but Lake Abert is exceptional, being its only hypersaline lake, and because of its incredible ecosystem, which is the topic of this talk.

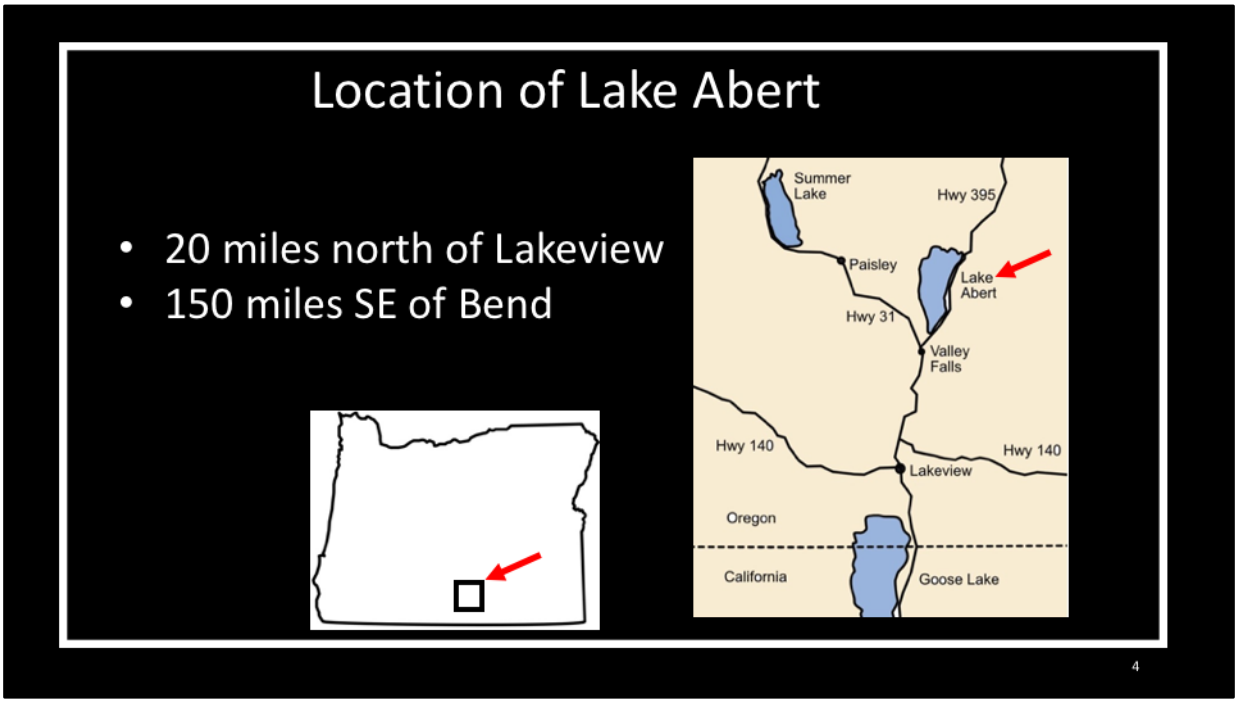
We have been making observations at the lake for a decade and feel fortunate to work in such an amazing environment. Where else can you study a lake amid such dramatic geology, see coyotes searching the shoreline for prey, view big-horn sheep foraging on the steep slopes of Abert Rim 1,000 feet above, and find the remains of thousand-year-old Indian villages.



This work would have been impossible without the help of others and we want to acknowledge Frank Conte, Joe Eilers, and Theo Dreher, in particular, for their continued interest and support of this project. Also, we greatly appreciate the help of many volunteers from East Cascades Audubon, who traveled long distances to estimate the numbers of waterbirds using the lake. Their efforts have provided critical information that has helped us understand how changes in water levels and salinities affect the entire ecosystem.



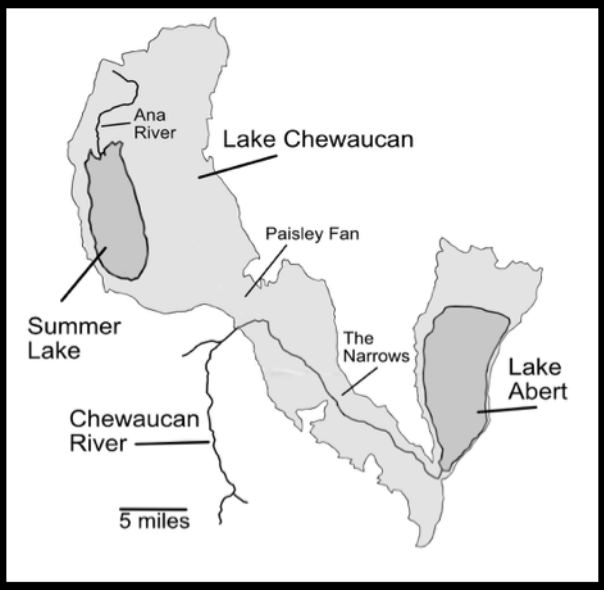
Why should we care about the lake? First, it has a unique ecosystem, including seasonally, 10s to 100s of thousands of migratory waterbirds. Secondly, being shallow and mostly only a few feet deep, and is a terminal lake, meaning it has no outlet, it is especially sensitive to reduced inflows resulting from upstream water diversions and climatic drought. Another factor is, what we learn here may be applicable to other western salt lakes, which are few in number, and under threats, such as the Great Salt Lake, which is critically-important to many waterbird species.



The lake is located in southeastern Oregon, 20 miles north of Lakeview and 150 miles southeast of Bend.

Paleolake Chewaucan

Lake Abert, along with Summer Lake, are the remains of Paleolake Chewaucan covered 500 miles^2 and was several hundred feet deep during the Pleistocene.



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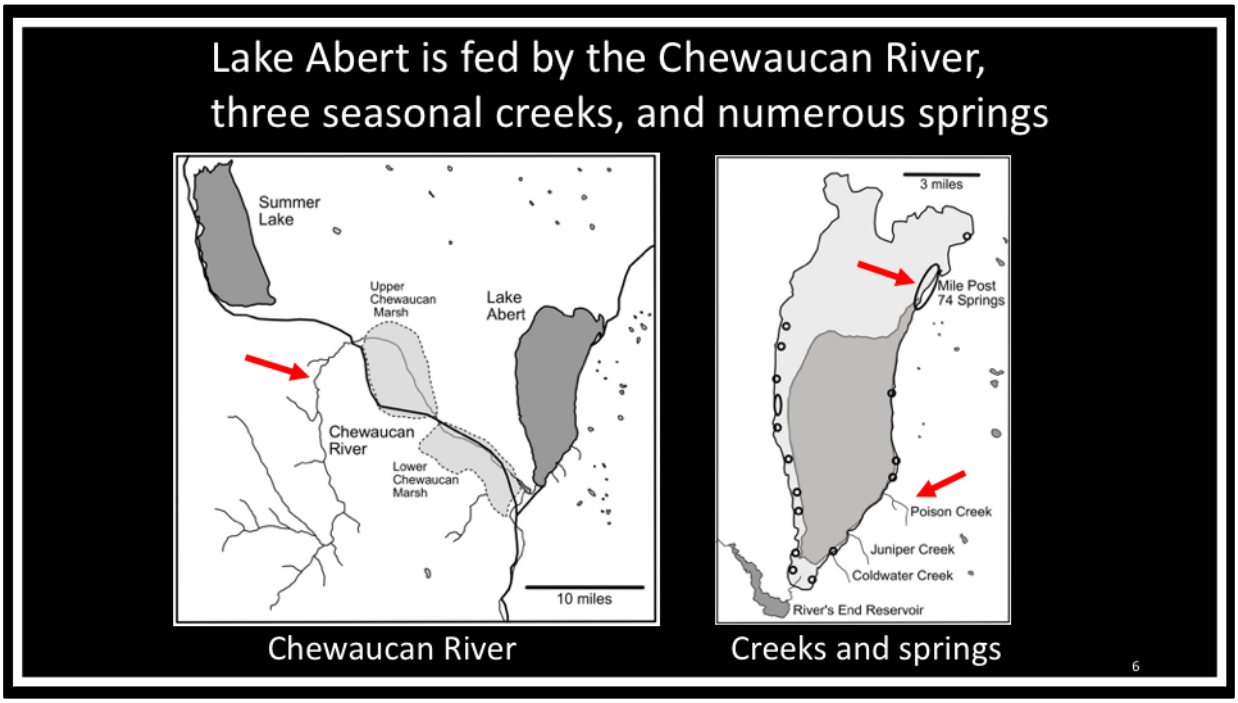
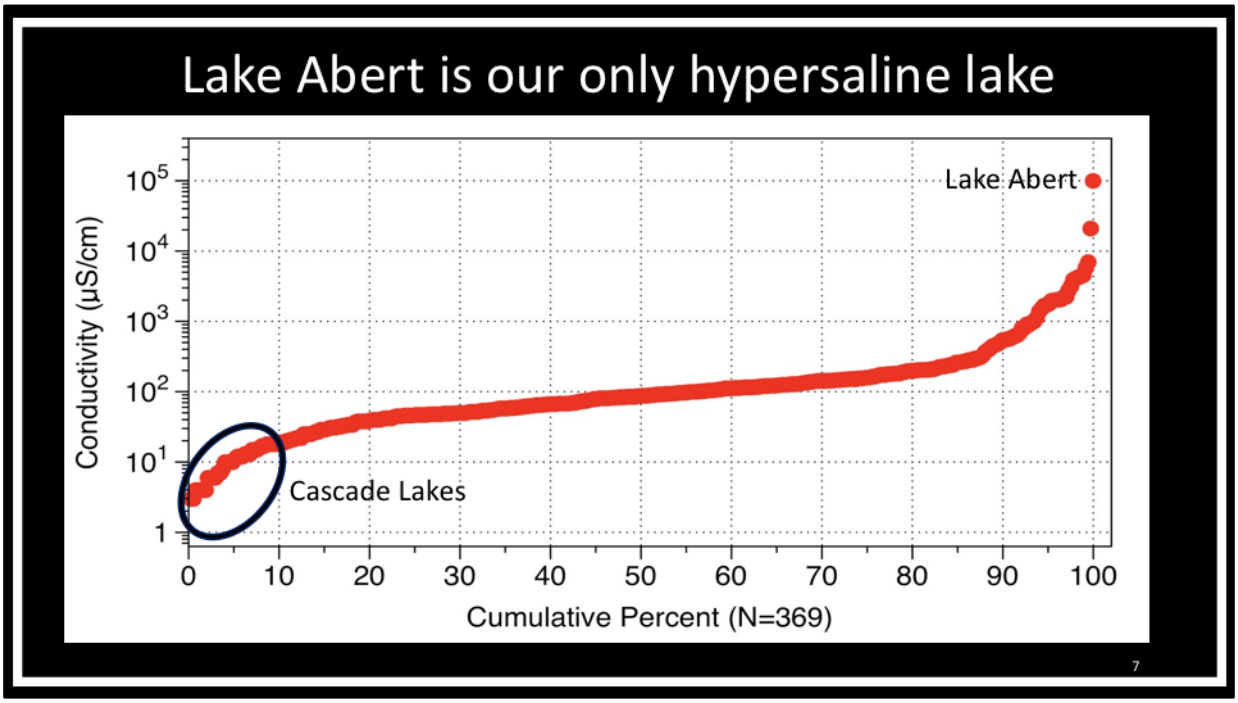
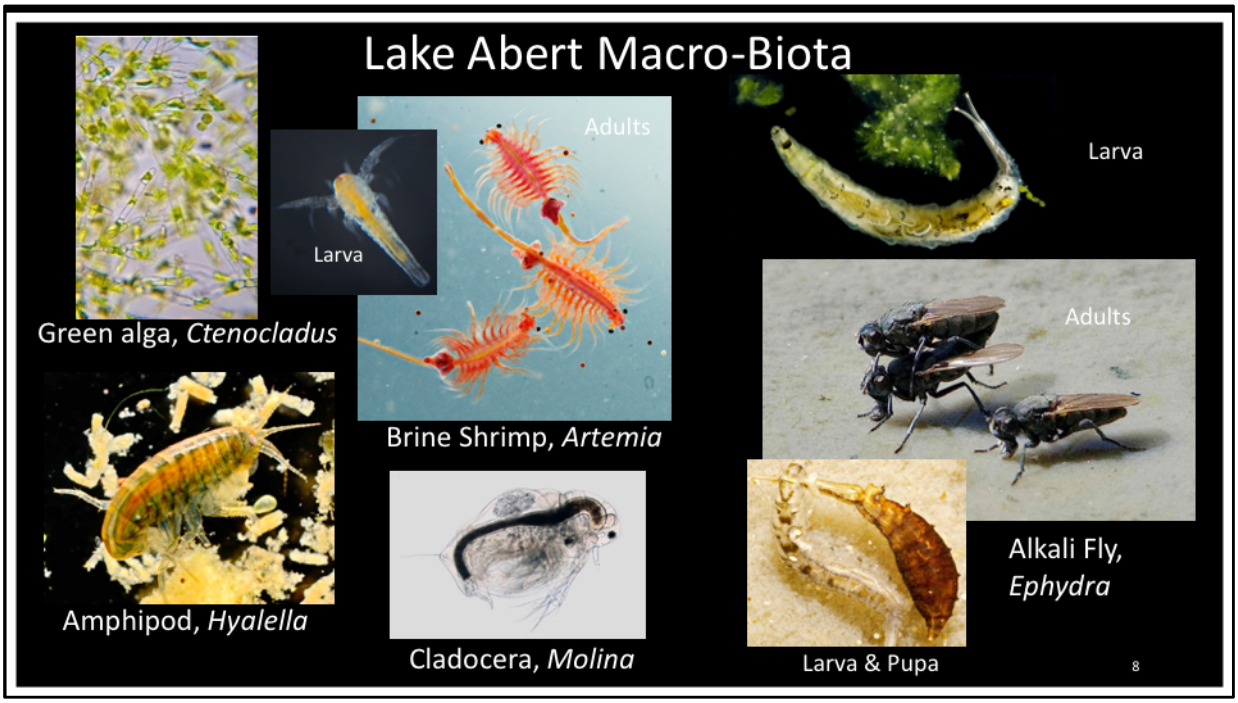
Lake Abert, and its sister, Summer Lake, are the remains of Paleolake Chewaucan, a large and deep lake during the Pleistocene about 15,000 years ago.



The lake is fed by the Chewaucan River, which is the largest source of water. Also there are three small, seasonal streams located on its SE side, with Poison Creek being the largest. Additionally, numerous, mostly small springs are located around the lake, the largest being the Milepost 74 Springs Complex on the NE side. Because annual precipitation averages less than 1 foot and annual evaporation losses equals nearly 4 feet, lake levels can be highly variable, and they depend a lot on inflows from the river to maintain them and salinities within tolerable limits. Once the salinity reaches 15%, ecosystem productivity declines substantially, owing to the high energetic cost of osmoregulation.



Lake Abert is our only hypersaline lake, as this graph of the conductivity of over 300 Oregon lakes, shows. Conductivity is a measure of the salt, or dissolved mineral, content of water. Pure water has a conductivity near zero. The axis along the left side of the graph is a log scale of conductivity written in scientific notation, so the conductivity of Lake Abert is ~10 to the fifth or and 100,000 units and is more than 10,000 times greater than that of some Cascade lakes, and 1,000 times greater than most other Oregon lakes. The lake just below Abert is Soda Lake in the Warner Basin and is the remains of paleolake Warner.

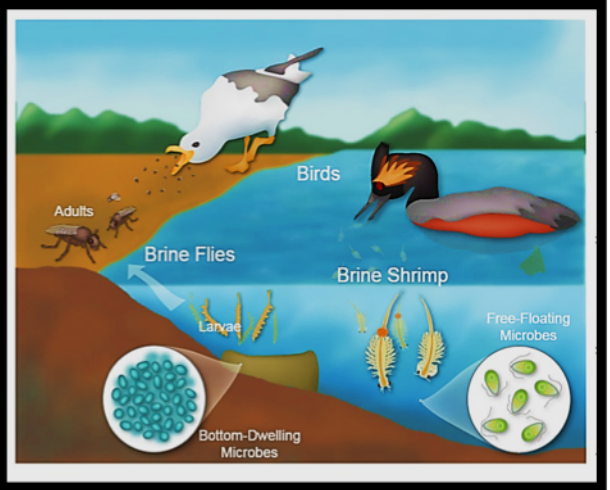


The macro-biota of the lake is dominated by a few species, primarily the filamentous green alga - *Ctenocladus*, the brine shrimp - *Artemia,* and the alkali fly - *Ephydra.* The cladoceran *Molina,* is only present in the lake when salinities are <4%, and the amphipod *Hyalella* is found in the springs and spring runs around the lake. Preliminary studies on microbes suggests they are especially diverse, possibly due to the broad changes in salinity that the lake undergoes.

Although the macro-biota is not rich in species, those organisms that do tolerate the high salt content, can be present in truly incredible numbers, as is shown by this photo of adult alkali flies covering the shore. Under these conditions, adult flies are present in thousands per square foot over the shore, and even out on the lake, and that's just one of the four life stages of the fly present in the lake.

Lake Abert's Ecology

- Few species have adapted to harsh conditions
- Adapted species can be numerous
- Simple food web: microbes and algae → shrimp and flies → waterbirds



Source: University of Utah

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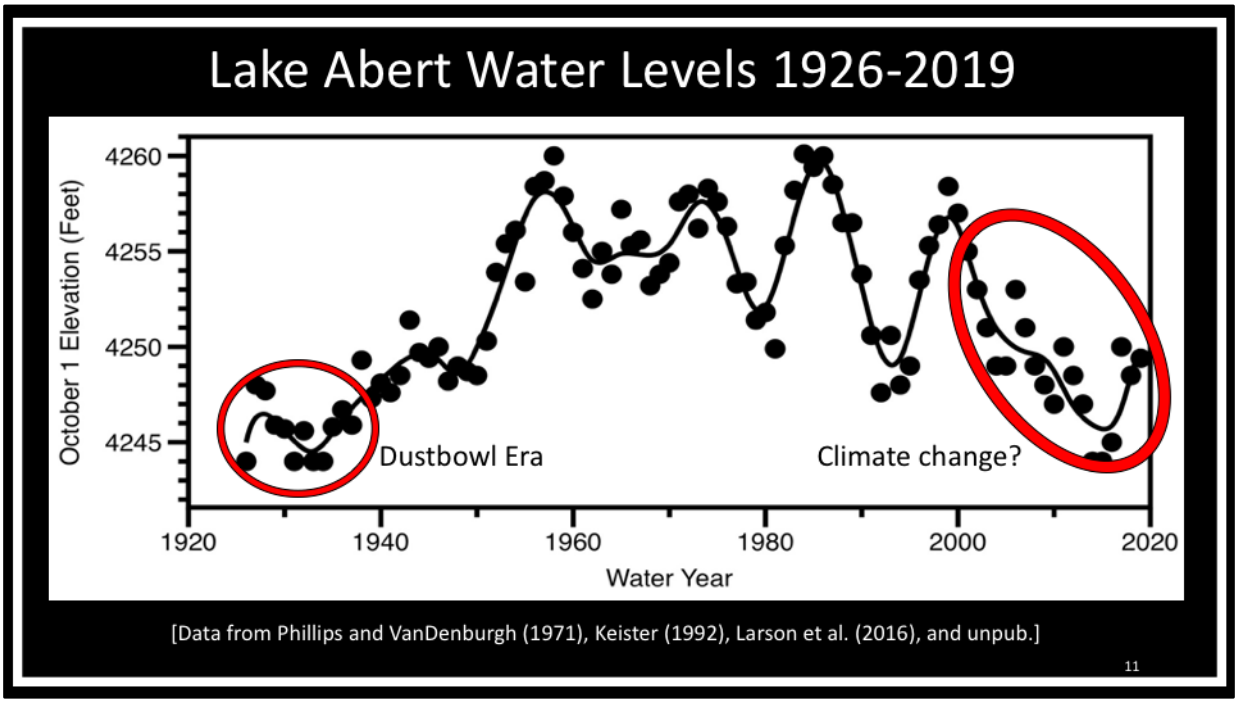
The low macro-biota diversity means that the food web is simple, with energy going from microbes and algae to shrimp and flies, and finally to birds. Furthermore, it suggests that there is an efficient transfer of energy up to the apex predators, which are birds. No fish or predatory insects normally live in the lake owing to the high salinity, which is up to 7x that of the ocean.



Based on a variety of data, we have been able to document water levels in the lake for nearly a century, from the 1920s to today. What it shows is the lake was especially low for over a decade during the Dust Bowl era of the 20s and 30s. That event was followed by increasing water levels to about 1960, then high but variable levels to about 2000, and finally, by declining levels. That variability makes it impossible to determine if or how climate change is affecting the lake, so further studies are needed.

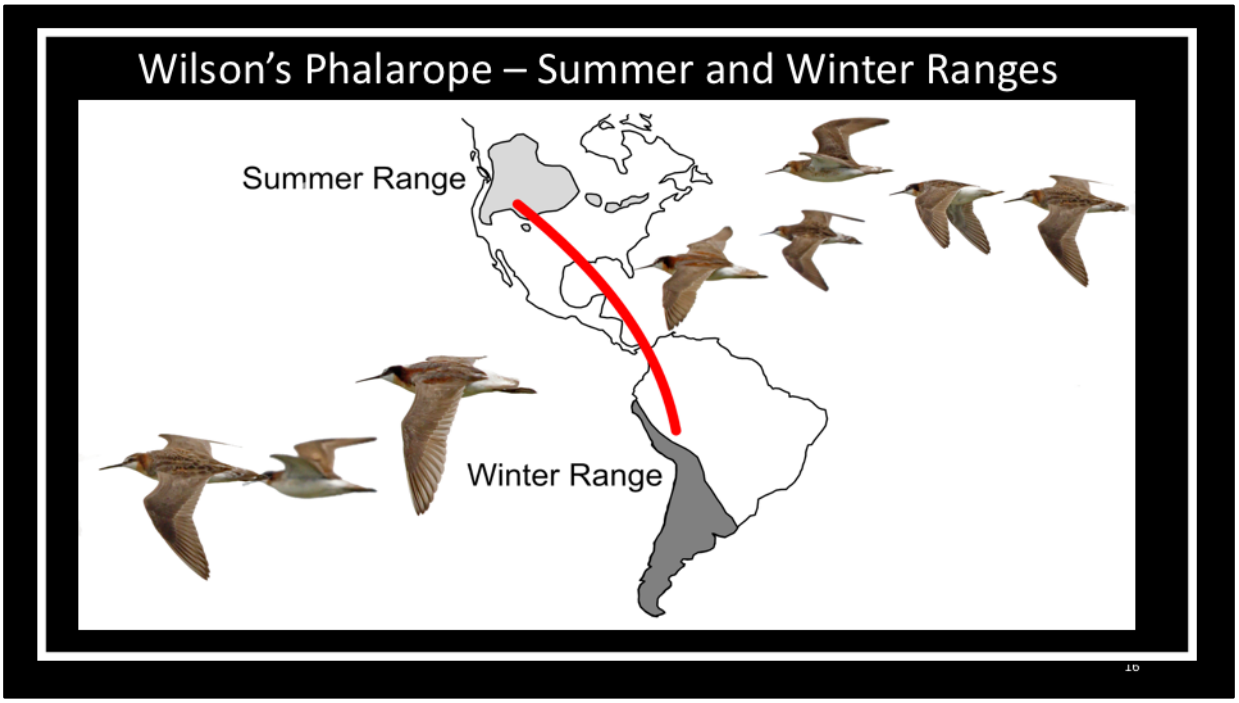
I have not included a graph of salinities in this presentation because it would show similar, but opposite changes to these, as you would expect, thus, when water levels were high, salinities were low, and visa versa.

As we saw in the previous graph showing changes in water levels over time, the lake started declining recently in about year 2000, and in 2014, reached it lowest levels in over 80 years. The first obvious signs that these changes were affecting the ecosystem was in August 2010, when a mass die-off of brine shrimp occurred. Before they died, the shrimp turned bright-red owing to production of hemoglobin, which was likely in response to low dissolved oxygen concentrations caused by increasing salinities and warm weather.

Then, by September 2013, low water levels and resultant high salinities near 20% led to formation of salt deposits along the shore and lake bed. Some of the salt crystals that formed, primarily of the mineral called trona, a form of sodium bicarbonate, or baking soda, were particularly large, being several cm long, as shown in the photos on the right.

Then finally, in July 2014, I was shocked when I saw what had happened to the lake. It had dramatically shrank to about 5% of its largest surface area, and what was left of it was blood-red, owing to a massive bloom of bacteria-like Archaea, which are called extremophiles because they only occur at exceptionally high salinities near 25%, which is well above what macro-biota can tolerate.

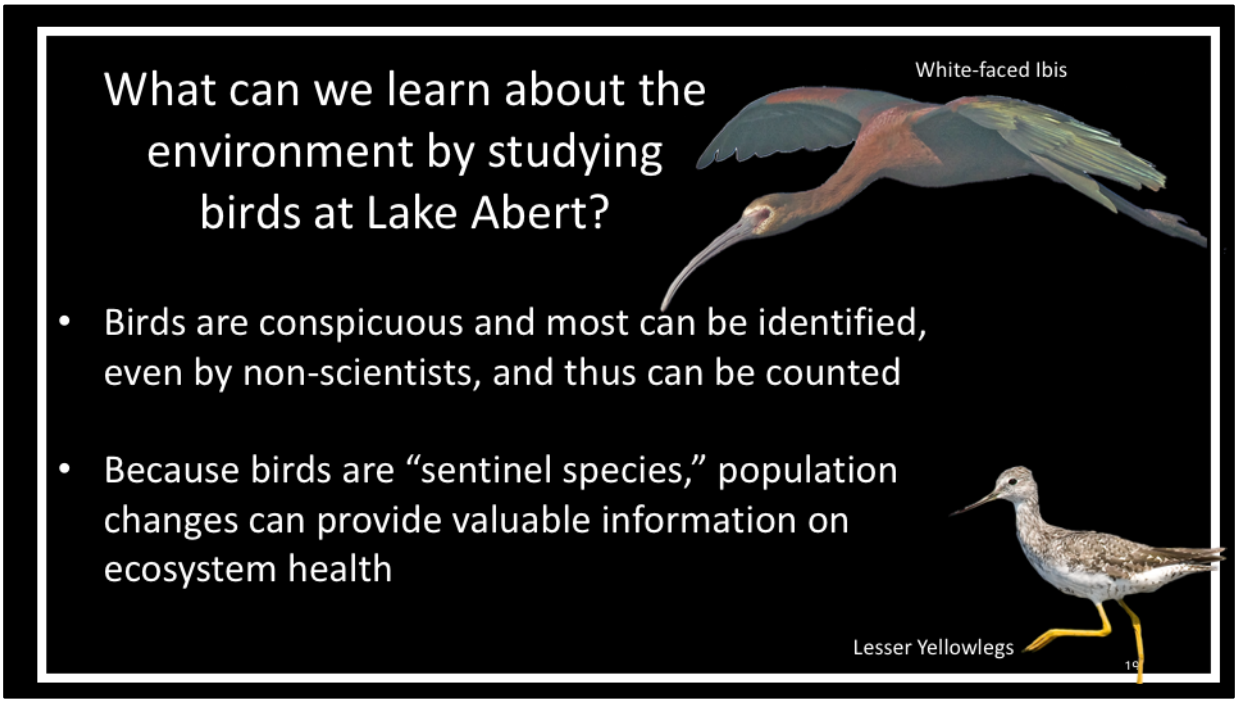
Now, I will focus on the birds that seasonally come to the lake. As I mentioned earlier, birds are the apex predators at the lake, and because they do not need to compete with other predators, they can occur in large numbers.



Most birds migrate to the lake after they have nested, primarily to feed on shrimp and flies, and before they migrate south to wintering areas. For some, like the Wilson's Phalarope, a 60-gram shorebird that is quite abundant at the lake, the south-ward migration is a several-thousand-mile, non-stop flight to South America. Such an amazing effort requires substantial energy reserves, and in fact, during the 1-month they are feeding at Northern Hemisphere salt lakes, phalaropes can double their body weight, and become temporarily flightless. When they arrive in their wintering habitat, they have lost most of that fat.

As was mentioned in reference to the previous slide, phalaropes feed heavily during the brief time they are at the lake. Here, they were feeding at the surface of the lake in a behavior known as “vortex feeding,” whereby they swim in a tight circle creating a vortex that brings suspended prey, such as shrimp or fly larvae, to the surface where they can reach it. At this time, there were an estimated 100,000 phalaropes scattered over the lake.

Here, a post-breeding, or a juvenile Wilson's Phalarope is feeding on adult alkali flies, showing it has perfected its stealthy hunting technique.



What can we learn about the environment by studying birds at Lake Abert? First, unlike most species, birds can be identified and counted by non-scientists, thus, it's possible to involve birders in a citizen-science project, such as this one. And, because birds are sentinel species, population changes can reflect variations in the environment, and thus tracking their numbers can provide valuable information on ecosystem health.

Lake Abert - Peak Waterbird Counts

Species	Peak Numbers	Season and Year
Wilson's Phalarope	200,000-300,000	Summer 2013
Red-necked Phalarope	50,000	Summer 1995
American Avocet	35,000	Summer 1993
Eared Grebe	40,000	Fall 2012
American Widgeon	20,000+	Summer 1998
Northern Shoveler	17,000	Fall 1995
Western Sandpiper	12,000	Spring 1994
American Coot	11,500	Fall 1995

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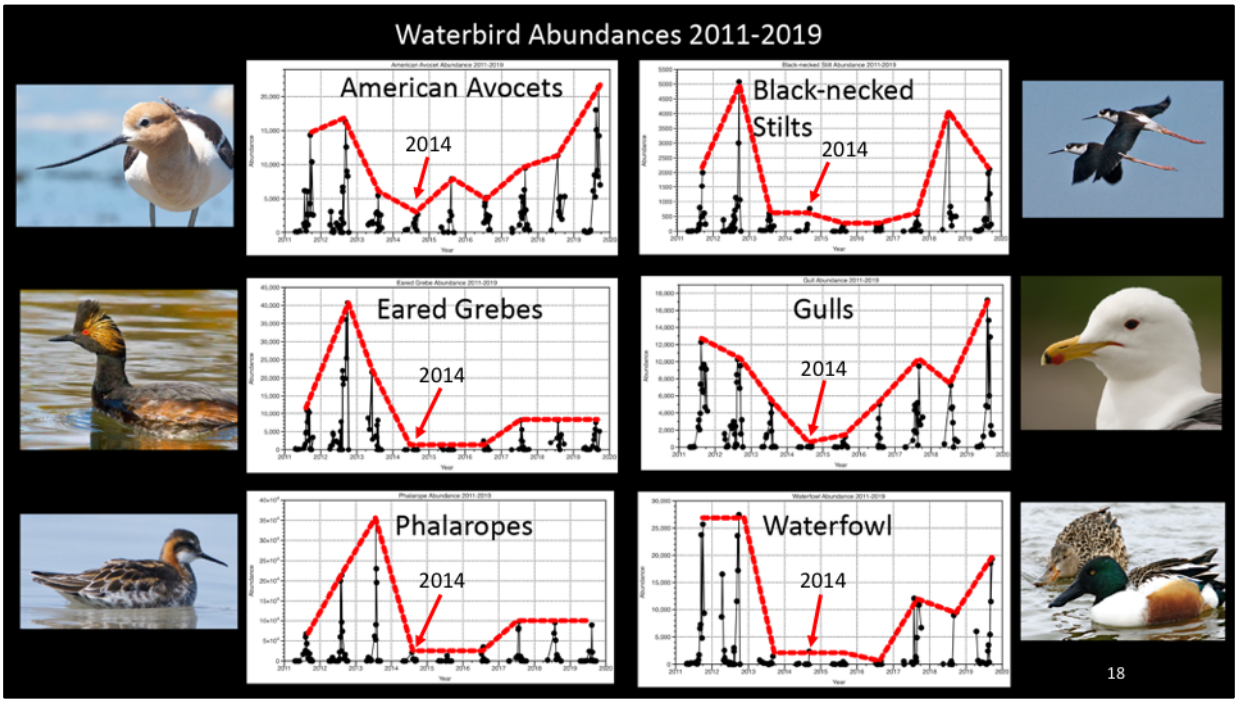
As I mentioned previous, birds can be quite abundant at the lake and this table provides a summary of the numbers of birds that can be present at the lake seasonally. These are the highest counts, and over time, abundances have varied considerably as we shall see in the next slide.



Now, lets look at how some bird populations have varied at the lake during the 2011 to 2019 period when they were counted. Along the bottom of the graphs are dates and along the left sides are numbers of birds seen. Focus on the relative changes in abundance as shown by the dashed, red lines. The red arrows point to 2014, when the lake was nearly dry and salinities extremely high. The graphs show that all of these birds declined in 2014, with some, such as Black-necked Stilts and waterfowl, remaining low in abundance for several more years, and have only recently increased. For two birds, Eared Grebes and phalaropes, they still have not recovered to their pre-2014 numbers. From this we can infer that severe droughts adversely impact birds, and if this happens too frequently, it could lead to permanent declines, and possibly even put them at risk of extinction.

So, is there a long-term solution to the water shortages at Abert? Yes, but it means that we must value water for all aquatic ecosystems because of the beneficial services they provide, such as biodiversity support. Furthermore, we must make sure there is an appropriate balance between out-of-stream and instream water uses, so that these ecosystems, and the species that depend on them, are sustained. Currently, Oregon law provides no minimum instream flow for the Chewaucan River above the lake, so upstream diversions can remove most of the water.

"Yet few Oregonians know it's illegal to pump any water out of a stream without a water right and perfectly legal to pump the last water out of a stream with one."

Rick Bastasch – **The Oregon Water Handbook**

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I will leave you with this quote from Rick Bastasch's 1998 book, *The Oregon Water Handbook*.

Thank You!