

SCIENCE:

An iconic lake and its region begin to feel impacts of climate change

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INCLINE VILLAGE, Nev. -- Brant Allen is one of many to have been captured by Lake Tahoe's charm. For him, it turned a six-month research project into a 25-year career dedicated to preserving the clarity of the lake.

On a scuba dive one night in winter, Allen remembers, "I could look up through the water, and it was calm enough on the surface that I could see the stars. That was a pretty amazing experience. That's probably about as close as you can get to feeling like you're in outer space where you're weightless and you see the stars above you, while just floating through the water."



Researchers fear that rising temperatures are dulling the brilliant blue that earned Lake Tahoe the title "Lake of the Sky." Photo by Julia Pyper.

But today, warming waters threaten to undermine efforts to keep Lake Tahoe blue.

It's been more than 20 years since Allen's scuba dive, and he says the waters haven't quite been the same since. Now a senior researcher at the University of California, Davis, Tahoe Environmental Research Center (TERC), Allen says he's discovered more invasive species coupled with algal blooms.

Indeed, UC Davis research shows that the lake's clarity in summer has diminished in recent decades - - summer clarity last year was the second worst on record -- and climate change is believed to be part of the cause.

Lake Tahoe sits on the border of California and Nevada, wedged between the Sierra Nevada Mountains. The 1,645-foot-deep lake is one of the deepest and oldest in the world at about 2 million years.

Travelers have been visiting the lake to take in its beauty for more than two centuries, and its pristine waters have earned it the title "Lake of the Sky." But that reputation could be in jeopardy.

Shorter winters are one culprit

The annual average temperature of Lake Tahoe's surface waters has risen about 1.5 degrees Fahrenheit since 1968, when UC Davis started collecting measurements on a biweekly basis.

Tahoe isn't alone. In the first comprehensive global survey of lake temperatures released in 2010, NASA found that the surface temperatures of 167 large lakes worldwide have risen at an average rate of 0.45 degree Celsius (0.81 degree Fahrenheit) per decade. Some lakes warmed as much as 1 degree Celsius (1.8 degrees Fahrenheit) per decade.

A warmer lake creates toxic algal blooms and a richer broth for invasive species. But Geoff Schladow, the director of TERC, says his greatest concern is that the warming trend is inhibiting the surface waters from mixing with water farther below, which is an essential part of keeping lakes healthy.

Mixing brings oxygen to the depths of the lake, which helps keep phosphorus and other chemicals locked up in tiny pieces of sediment. When little or no oxygen gets to the bottom of the lake where the sediment settles, the contaminants trapped inside are released.

According to the UC Davis "State of the Lake 2012" report, the upper waters now remain stratified for nearly 20 more days than they did 43 years ago, which it says is "a likely outcome of climate change."

Lake Tahoe currently mixes fully about every four years, but as temperatures rise that interval could lengthen.

"In the event that the winter is getting shorter and shorter, we believe mixing to the bottom may occur less frequently, and our model results suggest it may stop altogether at some point in the next century," Schladow said.

Buildup of bottom sediments is another

There's an almost infinite amount of sediment in a 2-million-year-old lake. If oxygen levels reach a critical point, a huge influx of nutrients could be released into Lake Tahoe at lower levels and eventually make their way to the top.

"One of the predictions in climate change is that there are going to be extremes, so it isn't as if it's just going to get hotter," Schladow added. "There's going to be some big winter storms in all likelihood, the lake will mix, and suddenly we could have all these nutrients coming to the surface."

If that prediction comes true, the Lake of the Sky could suddenly become a lake of clouds.

TERC research shows Lake Tahoe has already lost 30 feet of clarity over the past 40 years, in part due to the changing climate. Secchi data -- gathered by lowering a white disc into the water until it disappears -- show that clarity has been reduced from 100 feet to 70 feet.

Clarity is important to Lake Tahoe, not just because it's the cornerstone of the lake's pristine beauty and related tourism industry, but because poor water clarity is an indicator of the ecosystem's overall well-being.

Summer clarity last year was the second worst on record, according to TERC. Scientists think the cause may be related to climate change, which has made the lake increasingly hospitable to the microscopic algae cell *Cyclotella*. The cell population has exploded over the past five years, coinciding with low summer clarity.

Controlling storm runoff

About 3 million people come to Lake Tahoe each year for the mountains, the beaches and the boating. But few visitors will notice the permeable concrete gutters, strategically placed rock piles and netting that are all designed to control water flow and limit the amount of sediment entering the lake.



One of Incline Village's "best management practices," an infrastructure project designed to reduce sediment polluting the lake. Photo by Julia Pyper.

The city of Incline Village is home to a host of these stormwater management devices -- dubbed best management practices, or BMPs. The hillsides are covered in plants known to guzzle water and dotted with deep sewers that collect sediment so clearer water ends up in the lake.

"Our best BMP is taking water that runs along the surface and allowing it to soak back into the soil where it can be treated and fine particles and nutrients are actually removed by natural processes," said Jessica Schwing, stormwater management program leader at the Tahoe Regional Planning Agency, an organization created by federal and state mandates in 1969.

When the area around Lake Tahoe was developed, 70 percent of the marshes, which act as water filtration systems, was destroyed. One of TRPA's tasks is to find ways to re-create those natural systems because nearly three-quarters of the sediment coming into the lake comes from the built environment.

Sewers and other BMPs aren't glamorous. But they're effective. And climate change could make them even more necessary.

Results from a UC Davis study that combined two downscaled climate models with a distributed hydrologic model for the Tahoe Basin found that precipitation is likely to shift from snowfall to rain and that large, destructive floods could occur more frequently by midcentury. The increase in rainfall and flooding would likely wash even more sediment into the lake.

'Effort, blood and sweat' pay off

"The threats of climate change and the impacts are already starting to be realized at Tahoe, and it is a very serious concern," said Darcie Goodman Collins, executive director of the League to Save Lake Tahoe, a 55-year-old environmental organization.

"But the league really does feel that [by] working with our community and identifying some of the bigger issues, we can help control the impacts or at least slow down some of the impacts on the lake," she added.

More than \$1 billion has been spent on projects to improve the clarity and environmental conditions of Lake Tahoe over the past decade. Schladow says the investment is starting to pay off.

Though summer clarity is worsening, Lake Tahoe's winter water clarity has been improving in recent years. Last year, winter clarity improved by nearly 12 feet over 2010. Overall clarity, which had been declining at a linear rate, is now holding flat.

"A tremendous amount of time, effort, blood and sweat has been put into [preserving] Tahoe," said Robert Richards, captain of the TERC research vessel for 35 years, who retired in 2004. "That extreme brilliant-blue, azure color of the lake is getting rarer." But, he added, "it's still one of the most beautiful lakes in the world."

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