

EXECUTIVE SUMMARY

The UC Davis Tahoe Environmental Research Center (TERC) and its collaborators are dedicated to the study of Lake Tahoe and its ecosystems. This dedication has produced an extensive long-term dataset that helps researchers understand ecosystem function and provides science-based evidence to elected officials and public agencies who are making policy decisions around the basin. As the impacts of climate change become more apparent in and around the lake, this comprehensive dataset is the foundation of understanding that allows researchers to monitor changes at all levels of the lake and for decisions to be made about new technologies, methodologies, and policies

that need to be employed to continue to monitor and preserve the lake's health. This report is focused on how climate change will impact every level of the lake and the surrounding forest and how TERC researchers are documenting and responding to those changes.

The changes in question range from the things that are most apparent to residents and visitors, like observed seasonal shifts in lake clarity, algae growth, and the potential of Harmful Algal Blooms (HABS), to the least apparent to the casual observer, like changes in the population of the zooplankton that may be hard to see but can have an outsized impact on the health and clarity

of the lake. Climate change is not only impacting species that are native to the lake but also making it easier for aquatic invasive species to gain a foothold in establishing themselves in the lake. These outside invaders have the potential to create very visible changes to the lake, and their presence needs to be studied and monitored to quantify their associated ecosystem impacts.

TERC research is not limited to how climate change is impacting life at and below the surface of Lake Tahoe. Researchers also look at the impacts on the surrounding forest health and across other lakes in the Sierras. From wildfires, drought, and parasitic invaders, TERC researchers are

dedicated to understanding what pressures the forest is facing and working on strategies to make it more resilient to environmental change. Researchers are also studying the impact of wildfires, which are becoming more frequent and severe, and their associated smoke and ash-fall are having on the chemistry of Lake Tahoe and lakes beyond the basin. The impacts of climate change have no boundaries, and as such, research must go beyond Tahoe.

In order to adequately monitor Lake Tahoe, TERC has continued to develop and invest in new technologies to observe the lake in real-time. Lake Tahoe is monitored by 25 permanent

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“Previous year” for some parameters means data collated in terms of the water year, which runs from October 1 through September 30; for other parameters, it means data for the calendar year, January 1 through December 31. Therefore, for this 2024 report, Water Year data are from October 1, 2022 through September 30, 2023. Calendar year data are from January 1, 2023 through December 31, 2023.

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.1)

monitoring stations in the lake and the use of remote sensing from autonomous underwater vehicles, satellites, aerial drones, and helicopters. This means that Lake Tahoe is a perfect laboratory to develop and test new monitoring technologies. As such, TERC is partnering with the Center for Information Technology Research in the Interest of Society (CITRIS) and created the Environmental Robotics Lab @ Tahoe. Through this partnership, TERC is continuing to develop and deploy glider technologies to not only study the inner workings of Lake Tahoe but also deploy them beyond the basin to study the impacts of climate change in critical climates such as the Arctic.

Finally, this report will cover reasons for hope and the importance of education and philanthropy in TERC's efforts to protect Lake Tahoe. It is the residents and visitors who love the lake who have the power to preserve it for future generations to enjoy. All this and more are covered in the following pages, and by reading this report and sharing the information you learned here with friends and family, you are taking the first step necessary to become a steward of Lake Tahoe.

This Tahoe: State of the Lake Report 2024 presents data from 2023 in the context of the long-term record. While we report on the data collected as part of our

ongoing measurement programs, we also include sections summarizing some of the current research that is being driven by the important questions of the day and concerns for the future. These include:

- Climate change is a regional issue. From wildfire smoke blowing south last summer from Northern Canada to regional heat waves breaking new records this year to harmful algal blooms (HABs) affecting lakes and rivers across the country, the problems we face today cross state and national boundaries
- Another big winter brought cold air temperatures that impacted both winter water temperatures and the percentage of precipitation that fell as snow. Snow represented 63 percent of the 2023 total precipitation over the water year (WY).
- Because of these colder temperatures, the lake didn't warm as much, and annual average water temperatures came in below the long-term trend line. However, nearshore temperature monitoring shows that overall lake temperatures are still rising, with the last couple of years showing the warmest temperatures on record, especially in the nearshore.

(CONTINUED ON NEXT PAGE)

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.2)

- On the meteorological front, extremes are the new normal. Looking at the monthly totals, precipitation was double the long-term (1910-2023) monthly average in December, February, and March due to a sequence of large storms last winter.
- The annual average water temperature was 41.9 °F (5.5 °C), which was well below the trend line. However, the surface water temperature was 52.7 °F (11.5 °C), which was right on the long-term trend line, showing continued summer warming.
- Clarity monitoring showed highs and lows in 2023.

The clarity of Lake Tahoe's famed blue waters in 2023 continued its years-long trend of improving during the winter and deteriorating during the summer. In the winter of 2023, observations documented the 10th-best clarity measurement in the historical record. But the summer of 2023 contained the 5th-worst clarity measurement in the historical record.

- A deep mixing event on March 3, 2023, helped with winter clarity. Deep water mixing plays a critical role in winter clarity, as clearer bottom waters are mixed in with surface waters. The

Lake mixed fully, and the duration of the 2023 mixing period was one of the longest recorded. This resulted because of the timing of a series of storms affecting the region.

- Deep mixing contributed to the disappearance of the high nitrate region in the bottom half of the lake. Nitrate was uniformly distributed until May, when the surface nitrate was being depleted, and a sharp "nitricline" was evident at a depth of 250 feet.
- Phosphorus mainly entered the lake in association with fine particles during runoff events in May through

June. The relatively elevated values near the surface in May suggest that in 2023, nitrogen was the nutrient that limited algal growth, rather than phosphorus in the spring. Due to deep mixing in March, the preceding high phosphorus levels were rapidly diluted through the entire water column.

- Runoff from the heaviest winter snowfall in 70 years brought an influx of inorganic particles and a rapid drop in clarity in May.
- The dominant phytoplankton species, *Cyclotella*, has decreased since 2017, while another, slightly

(CONTINUED ON NEXT PAGE)

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.3)

larger algae, *Synedra*, is increasing. Changes among the phytoplankton and zooplankton communities within the lake also have the potential to impact clarity. Nonnative Mysis shrimp are beginning to return, while zooplankton species are also experiencing changes in their populations.

- In 2023, diatoms comprised approximately 56 percent of the total abundance of algal cells, following a two-year period of major composition change with unusual dominance of cyanobacteria. This shift was likely associated with the smoke and ash deposition from the Caldor Fire.
- The lake level was below the natural rim until the end of 2022. By July 21st, it reached its highest at 6228.3 feet, which was less than one foot below the maximum legal limit. In late summer, normal evaporative loss took hold, and the lake level ended the year at 6227.2 feet above sea level.
- In 2023, TERC had 12,988 visitor contacts through tours, field trips, lectures, and community events, a 46 percent increase over the previous year. This trend is expected to continue with new UC Davis science exhibits in the Tahoe City Visitor Center, which opened in February 2024, and the Kings Beach Visitor Center, which opens on August 15, 2024.
- Lake Tahoe is a laboratory. TERC researchers are advancing new technologies, using and refining equipment such as gliders and the new Wirewalker and analytical tools such as eDNA.
- Keeping hope. The data can seem bleak, but Lake Tahoe has the benefit of dedicated researchers, engaged citizens, and fantastic educational resources that are all working together to ensure its beauty and health for generations to come.
- UC Davis TERC recently joined the Association of Science and Technology Center's Seeding Action Network. Our new "Active Hope for Tahoe's Environmental Future" project aspires to cultivate a culture of environmental stewardship within the Tahoe Basin community. By harnessing existing research and data on Lake Tahoe's environmental health and forming partnerships with local schools, community organizations, and stakeholders, this initiative aims to forge a resilient and sustainable future for the region.