Climate change at Lake Tahoe: What does the future hold? What can we do?

Zachary Hymanson
UC Davis Tahoe Environmental Research Center

Contact: Geoffrey Schladow
gschladow@ucdavis.edu

Issue
The fact that the world’s climate is changing is widely accepted, and Lake Tahoe is not immune. Results from long term monitoring in the Tahoe Basin show increasing trends in air and water temperature, as well as increases in the portion of the year with warm conditions. Increasing the duration of warm conditions translates into less vertical mixing of water, which is the primary way dissolved oxygen is delivered to the bottom of Lake Tahoe. This mixing process is critical to the survival of deep-water fish and other aquatic organisms. Chronic oxygen depletion also can lead to chemical changes in the lake bottom, triggering nutrient releases from bottom sediment, and reductions in water quality.

Water quality in Lake Tahoe is largely regulated through a series of management strategies and policies adopted by government agencies in 2012, and collectively referred to as the Lake Tahoe Total Maximum Daily Load (LT-TMDL). Briefly, the LT-TMDL identifies the pollutants of greatest threat—nitrogen, phosphorus, and fine sediment particles. And research has quantified the total annual loads and relative sources of these pollutants (Figure 1). Research also has shown these pollutants affect the clarity of Lake Tahoe through light scattering and attenuation, and by stimulating the growth of light absorbing phytoplankton (microscopic, free-floating algae). Lake Tahoe’s clarity has declined since measurements were first collected in 1968, and restoring Lake Tahoe’s clarity is considered an important socioeconomic goal; federal, state, and regional agencies have all adopted regulations to protect Lake Tahoe’s renowned clarity.

Policy Implications
Implementation of the LT-TMDL has focused on the control of fine sediment particles from urban areas, which contribute 67 percent of the sediment load despite comprising only 10 percent of the total Tahoe Basin land area. The implementation strategy also is pragmatic in that it focuses regulations and management actions on factors most directly controlled by humans: control of urban erosion and stormwater runoff, and road maintenance. Recent results suggest this strategy may be working: annual winter (December-March) measurements of lake clarity show a trend of definite improvement, since about 1997 (Figure 2).

Yet recent science suggests a greater emphasis is needed on policies and management strategies that reduce the influx of nutrients from all sources to help preserve and restore Lake Tahoe’s clarity under a changing climate.

For more policy briefs, click here.
Research Findings

A characteristic of lakes is that they thermally stratify during the warm part of the year. The warmer, lighter water at the surface floats on top of the cooler, denser water below. When this occurs the supply of oxygen to the deeper parts of the lake is cut off because stratification inhibits vertical mixing. Scientists at the Tahoe Environmental Research Center have measured and modeled temperature stratification in Lake Tahoe for the past and the future, respectively (Figure 3).

Long-term records of air and water temperature in Lake Tahoe show an increasing trend in both due to the effects of climate change, leading to the expectation that the period of lake stratification also will increase. The results show that since 1968, stratification has increased by 22 days, starting 5 days earlier in the spring and ending 17 days later in the fall. By 2100 the duration of stratification is expected to increase by an additional 38 days, 16 more in the spring and 22 more in the fall. This overall lengthening in the stratification season from 6 months in 1968 to 8 months in 2100, due to climate change, is anticipated to have substantial impacts on the lake’s water quality and ecology, including chronic deep-water depletion of dissolved oxygen.

When deep-water oxygen is chronically depleted or absent, nutrients which have been stored in the lake’s bottom sediments for thousands of years can undergo chemical changes, through a process known as internal loading, resulting in their release back into the water. This can lead to the release of an almost limitless supply of nutrients into the lake, including the two of primary concern: nitrogen and phosphorus. Nutrient releases of this kind would dramatically affect Lake Tahoe’s water quality.

What can be done to mitigate the loss of oxygen in Lake Tahoe’s deep water? The best we can do is slow the rate of oxygen decline, so that a new balance between Lake mixing and oxygen consumption can be attained without oxygen levels dropping to zero for prolonged periods. This may be possible by reducing the amount of organic material (i.e., phytoplankton) produced in the lake. Reducing the influx of nutrients into Lake Tahoe is the most direct way to control phytoplankton production, and a comprehensive strategy addressing all nutrient sources is warranted that: (1) reduces the mobilization of nutrients from the non-urban watershed; (2) reduces atmospheric deposition of nitrogen and phosphorus; and (3) restores intervening wetlands and floodplains to intercept nutrients in waters flowing into Lake Tahoe.

Further Reading

This policy brief is drawn from the full report: Tahoe: State of the Lake Report 2014. S.G. Schladow. UC Davis, Tahoe Environmental Research Center. The full report is available at: http://terc.ucdavis.edu/stateofthelake/


For more policy briefs, click here.