EXECUTIVE SUMMARY

The long-term data set collected on the Lake Tahoe ecosystem by the University of California, Davis and its research collaborators is an invaluable tool for understanding ecosystem function and change. It has become essential for responsible management by elected officials and public agencies tasked with restoring and managing the Tahoe ecosystem. This is in large part because it provides an independent basis for assessing the progress toward attainment of Tahoe's restoration goals and desired conditions while at the same time building our understanding of the natural processes that drive the ecosystem.

UC Davis Tahoe Environmental Research Center (TERC) has developed sophisticated computer models that better predict and understand how Lake Tahoe's water moves and how the entire ecosystem behaves. Long-term data sets are an essential element in constantly refining the accuracy of those models and in developing new models as knowledge increases and new challenges arise. These models are used to address a variety of questions: where would a contaminant spill be carried? what are the likely next locations for the spread of invasive species within the lake? will lake oxygen be depleted by climate change? and what will the consequences be? The application of these models this year has helped refine the source of the pollutants that are reducing lake clarity.

This annual Tahoe: State of the Lake Report presents data from 2014 in the context of the long-term record. While the focus is on data collected as part of our ongoing, decades-long measurement programs, we have also included sections summarizing current research on the first ever quantification of Tahoe's blueness, the impacts of the ongoing drought, the water loss from evaporation, results from the first year of operation of TERC's Nearshore Water Quality Network, and the fluctuations of lake temperature and the use of temperature data to create lake music.

While water clarity and lake blueness have long been considered to be one and the same, a newly developed Blueness Index (based on measurements of the wavelength of light leaving the lake) has shown that this is not the case. On the contrary, at times of year when clarity increases, blueness is seen to decrease. In the last three years, Lake Tahoe's blueness has been increasing. What the research is revealing is that while clarity is controlled by fine particulates, blueness is controlled by algal concentration. This new knowledge will help agencies implement programs that will help restore both clarity and blueness.

The largest water loss from Lake Tahoe is from evaporation. Using data collected over the last 14 years in collaboration with NASA-JPL, a newly developed model allows for instantaneous evaporation estimates to be made for the lake. Results show that evaporation from the lake surface during the year equals approximately 51 inches of water, with August being the month of maximum evaporation. One inch of evaporation is equivalent to 3.5 billion gallons.

(CONTINUED ON NEXT PAGE)

[1]*"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 2015 report, water year data are from Oct. 1, 2013 through Sept. 30, 2014. Calendar year data are from Jan. 1, 2014 through Dec. 31, 2014.*

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.1)

New data from the nearshore water quality network shows for the first time just how variable water quality can be. Algal concentrations at different parts of the shoreline can vary by a factor of two, while seasonal variations at the same site can be even greater. During a storm, turbidity increases by a factor of 100 at sites where wave breaking is occurring.

Continuously measured lake temperature data is showing just how variable temperature can be due to oscillations occurring at all depths. These data are also being used to generate the "music" of the lake, the sounds that we would hear if our audible range was large enough. By transforming the recorded frequencies, we can hear the lake's melody for the first time.

2014 saw the continuation of warming and drying conditions for a third year at Lake Tahoe. The winter of 2013-2014 had the lowest number of freezing days (29) recorded in over a century of data collection. Precipitation was only 61 percent of the long-term average. The fraction of precipitation that fell as snow was well below the general downward trend that has been recorded, being only 18 percent. The depth of the April snowpack was the lowest recorded in 100 years of record keeping. Monthly precipitation was well below the long term mean for all months except the summer months of July, August and September, possibly portending a change toward wetter summers.

Lake level rose by only 11" during the spring snowmelt, well below the typical rise. Lake Tahoe fell below the natural rim on October 16, 2014, signaling the cessation of outflow via the Truckee River. The lake had a final level of 0.49 feet below the rim at the end of 2014. The volume-averaged lake temperature increased in 2014 by 0.2 °F (0.11 °C) over the previous year. Following the cooler temperatures of the last decade, 2014 exceeded the long-term trend of increasing temperature. Similarly the annual-averaged surface temperatures were at an all-time high in 2014 at 53.0 °F. The maximum daily surface water temperature in 2014 was significantly warmer than it has been for the last 4 years, and for the winter-time maximum, it was the warmest surface water temperature that has been observed for the length of the record. Other consequences of climate change could also be seen in the rising temperature of the deep waters of the lake. In the last 38 years bottom temperatures have increased by over 1.0 °F.

Lake Tahoe did not mix to its full depth in 2014, the third consecutive year in which this has not happened. Instead, the maximum depth of mixing was only 440 feet (134 m), reached in March. The lack of mixing was due to a third year of above average lake stability, driven by the generally warmer weather. Lake stability (the resistance to mixing) in 2014 was the highest since continuous record keeping began in 1968. The upper 330 feet of the lake stayed stratified for 199 days, almost a month longer than what was typical when the record began.

The input of stream-borne nutrients to the lake was low again in 2014 due to the low precipitation and subsequent run-off. The last three years have all had nutrient and particle loads well below the long-term mean.

Overall in-lake nitrate concentrations have remained relatively constant over the 33 years of record. In 2014, however, the

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.2)

volume-weighted annual average concentration of nitrate-nitrogen reached an all-time high of 20.0 micrograms per liter. This increase is in part due to absence of deep mixing this year; nutrients from the bottom of the lake were not brought up to levels where they can be utilized by phytoplankton. The lack of deepwater mixing allows a continued build-up of nitrate in the deep water. By contrast, in-lake phosphorus concentrations display a downward trend over the same period, having decreased by almost 50 percent.

Biologically, the primary productivity of the lake continued its long-term increase in 2014, with the annual average value of 217.1 grams of carbon per square meter. The reasons for this increase are believed to be linked to a long-term shift towards smaller algal species that have the ability to process nutrients faster. Despite the increase in lake productivity, the concentration of chlorophyll in the lake has remained relatively constant over time. In 2014 there was a continued decrease in the abundance of diatom cells in the lake, down from the peaks experienced in 2009 to 2011. In particular the concentration of Cyclotella was reduced. This small-sized diatom can exert a large influence on lake clarity. Higher numbers of this group over the last six years compared to historical values have been linked to climate change and have resulted in summertime clarity reductions. This year's continued reduction coincided with an improvement in clarity.

Periphyton, or attached algae, on the rocks around the shoreline continues to show variability from site to site. The long-term monitoring program has helped identify those areas of the shoreline that are consistently displaying periphyton levels that are undesirable. Overall conditions in 2014 were greatly improved compared to 2013. In 2014, concentrations were at or below their historic lows at many sites. The two most urbanized sites, Tahoe City and Pineland, were one half to one sixth of their values in 2013. This decrease is not believed to be part of a long term trend, but linked to the low water levels and the reduced nutrient input. TERC's real-time nearshore water quality network will play a crucial role in future efforts to better understand the causes of these changes by creating a link between nearshore water quality and measured meteorology, streamflow and stormwater flow. This understanding will provide a scientific basis for nearshore restoration.

This year the annual average Secchi depth, a measure of lake clarity, continued the long-term halt in clarity degradation. The value for 2014 was 77.8 feet (23.7 m), an increase of 7.6 feet (2.3 m) over 2013, and well above the lowest value recorded in 1997 of 64.1 feet (19.5 m). Year-to-year fluctuations are the norm, and the long-term goal must be seen as attaining a level of clarity which on average meets the basin's standards. Summer (June-September) clarity in Lake Tahoe in 2014 was 78.7 feet (24.0 m), almost a 13 foot improvement over the value from 2013. This coincided with a continued decline in the concentration of small algal cells in 2014, as well as sharply lower stream inflows. Another contributing factor was the shallow depth to which the lake mixed to during the previous winter.

This report is available on the UC Davis Tahoe Environmental Research Center website (http://terc.ucdavis.edu).