TAHOE: STATE OF THE LAKE REPORT 2013

UC DAVIS
TAHOE ENVIRONMENTAL RESEARCH CENTER

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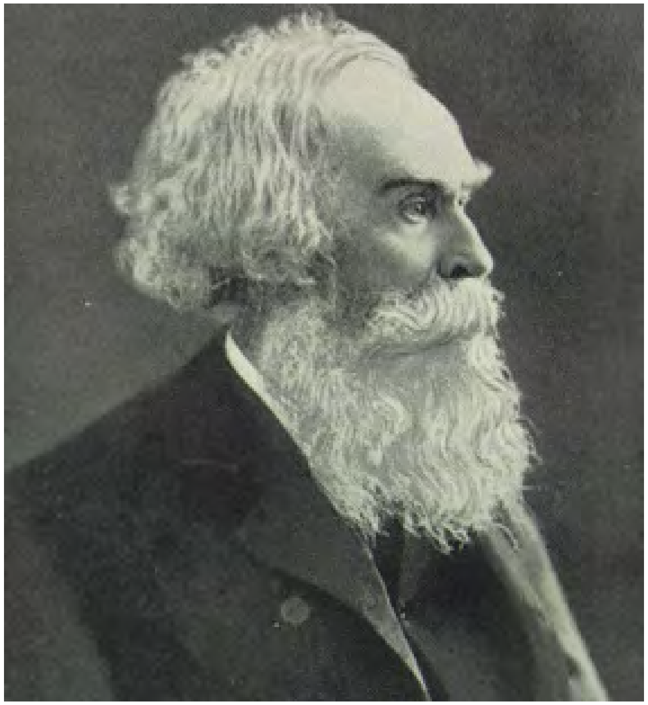

John LeConte

1818-1891

THIS YEAR'S REPORT IS DEDICATED TO THE LEGACY OF PROFESSOR JOHN LECONTE, THE FIRST PROFESSOR APPOINTED BY THE FLEDGLING UNIVERSITY OF CALIFORNIA, WHO TOOK THE FIRST CLARITY MEASUREMENTS IN LAKE TAHOE 140 YEARS AGO.

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INTRODUCTION

The University of California, Davis, has conducted continuous monitoring of Lake Tahoe since 1968, amassing a unique record of change for one of the world's most beautiful and vulnerable lakes.

In the UC Davis Tahoe: State of the Lake Report, we summarize how natural variability, long term change and human activity have affected the lake's clarity, physics, chemistry and biology over that period. We also present the data collected in 2012. The data shown reveal a unique record of trends and patterns – the result of natural forces and human actions that operate at time scales ranging from minutes to decades. These patterns make clear that Lake Tahoe is a complex ecosystem, behaving in ways we don't always expect. This was exemplified this year by the decrease in the abundance of Cyclotella in the lake, and the corresponding increase in summer clarity. While Lake Tahoe is unique, the forces and processes that shape it are the same as those acting in all natural ecosystems. As such, Lake Tahoe is an analog for other systems both in the western U.S. and worldwide.

Our role is to explore this complexity and to use our advancing knowledge to suggest options for ecosystem restoration and management. Choosing among those options and implementing them is the role of those outside the scientific community and needs to take account of a host of other considerations. This annual report is intended to inform non-scientists about some of the variables that affect lake health. Until recently, only one indicator of Lake Tahoe's health status was widely reported: the annual clarity (often called the Secchi depth, after the instrument used to collect the clarity data). In this report we publish many other environmental and water quality factors that all provide indicators of the lake's condition.

This report sets the context for understanding the changes that are seen from year to year and those that are observed over a time scale of decades: Was Lake Tahoe warmer or cooler than the historical record last year? Are the inputs of algal nutrients to the lake declining? How much are invasive species affecting Lake Tahoe? And, of course, how do all these changes affect the lake's famous clarity?

The data we present are the result of efforts by a great many scientists, engineers, students and technicians who have worked at Lake Tahoe throughout the decades since sampling commenced. I would, however, like to acknowledge (in alphabetical order) the contributions of Brant Allen, Veronica Alumbaugh, Nancy Alvarez, Patty Arneson, Janet Brewster, Sudeep Chandra, Bob Coats, Mariza Costa-Cabral, Michael Dettinger, Angie Elliot, Kristin Fauria, Bill Fleenor, Alex Forrest, Allison Gamble, Alfredo Gimenez, Charles Goldman, Gyembo Gyeltshen, Scott Hackley, Tina Hammell, Bruce Hargreaves, Alan Heyvaert, Simon Hook, Andrea Hoyer, Debbie Hunter, Peter Hunter, Camille Jensen, Anne Liston, George Malyj, Parker Martin, Tom Mathis, Kristin Reardon, John Reuter, Bob Richards, John Riverson, Dave Rizzo, Goloka Sahoo, Heather Segale, Todd Steissberg, Raph Townsend, Alison Toy, Josh Viers, Shohei Watanabe, Katie Webb, and Brent Wolfe to this year's report.

Funding for the actual data collection and analysis comes from many sources. While many additional water quality variables could be tracked, funding ultimately limits what we measure. Current funding for the long-term monitoring and analysis is provided by the Lahontan Regional Water Quality Control Board, the Tahoe Regional Planning Agency, the U.S. Forest Service, the U.S. Geological Survey and UC Davis. Our monitoring is frequently done in collaboration with other research institutions and agencies. We are grateful for the participation of our colleagues in the Tahoe Science Consortium. In particular we would like to acknowledge the U.S. Geological Survey (USGS), the Desert Research Institute (DRI), the University of Nevada, Reno (UNR), the National Aeronautics and Space Administration (NASA), and the U.S. Forest Service. Some data are also collected as part of research projects funded through a variety of sources. Without these data there are many questions that could not even be asked let alone answered.

This year we are presenting updates on some recent research, as well as providing updates on the lake monitoring efforts. These new research results highlight some of the most exciting findings of work that is still in progress, and will be reported on fully in the months and years to come.

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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 a basis for monitoring of the progress toward attainment of Tahoe's restoration goals and desired conditions.

This annual Tahoe: State of the Lake Report presents data from 2012 in the context of the long-term record. While the focus is on data collected as part of our ongoing, decades-long, measurement programs, this year we have also included sections summarizing current research on using autonomous gliders for examining the detailed distribution of water quality across the lake; projected 21st century trends in Tahoe's hydroclimatology; drought adaptation by forests; our addition of real-time water quality monitoring in deep water off the west shore; measuring the blueness of Lake Tahoe; and the possible changes in shoreline position on account of extended droughts.

The UC Davis Tahoe Environmental Research Center (TERC) has developed sophisticated computer models that help scientists better predict and understand how Lake Tahoe's water moves and how the entire ecosystem behaves. Long-term data sets are essential to refine the accuracy of those models and to develop new models as knowledge increases and new challenges arise. In times of rapid change, reliable predictive models are indispensable tools for Lake Tahoe Basin resource managers.

With respect to weather 2012 was not a particularly unusual year for Lake Tahoe. The winter of 2011- 2012 was relatively dry (seventy one percent of the long term average). The fraction of precipitation that fell as snow continued the downward trend at 41 percent. Temperatures were closer to normal, with the exception of the fall months that were distinctly warmer than the long-term average. The number of days with below freezing temperatures fell precisely on the long-term trend line of declining below-freezing days. As a consequence, the peak in the timing of the snowmelt was again earlier than historical conditions, occurring on May 4.

Lake level rose by only 1.3 feet during the snowmelt, compared with 3.9 feet the previous year. During summer and fall, lake level fell by 2.3 feet, producing a net loss for the year. The rate of increase of the volume-averaged lake temperature rose in 2012, although the long term rate of increase has slowed in recent years. The annual average surface temperature (based on monthly readings) was 52.8 deg F in 2012, the highest value ever recorded for Lake Tahoe. Most of this increase came after the summer, as July surface temperatures were relatively cool at 63.3 deg F. Other consequences of climate change could also be seen in the rising temperature of the deep waters of the lake. In the last 37 years bottom temperatures have increased by one deg. F.

Lake Tahoe did not mix to its full depth in 2012. Instead, the maximum depth of mixing was only 820 feet, reached in March. Oxygen levels in the deepest part of the lake are currently being monitored to determine the rate at which oxygen is being lost when mixing does not occur. The lack of

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[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, water year data are from Oct. 1, 2011 through Sept. 30, 2012. Calendar year data are from Jan. 1, 2012 through Dec. 31, 2012.*

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.1)

mixing was due to the high stability index the lake had during 2012, the highest recorded in 45 years. The upper 330 ft of the lake stayed stratified for 203 days, a month longer than what was typical when the record began.

River releases from Lake Tahoe to the Truckee River occur at the dam in Tahoe City. Water temperature has been monitored there by the USGS since 1993. Though the data set is incomplete, there is evidence that the summer time release temperatures have increased significantly over that period, suggesting potential impacts on downstream fish spawning.

The input of stream-borne nutrients to the lake declined significantly in 2012 due to the lower precipitation. On the west side of the lake, the pollutant loads were reduced by a factor of four from 2011. Biologically, the primary productivity of the lake continued its long-term increase in 2012, with the annual average value of 243.98 grams of carbon per square meter being the highest value ever recorded. 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 productivity, the concentration of chlorophyll in the lake has remained relatively constant. In 2012, there was a reduction in the species Cyclotella. A large increase in the numbers of this species over the last five years has been linked to climate change and has resulted in summertime clarity reductions. This year's reduction coincided with an improvement in clarity.

For the second straight year clarity improved in Lake Tahoe. The annual average clarity improved by 6.4 feet over the previous year to 75.3 feet. This value is within 3 feet of the interim clarity target of 78 feet. However, it is important to recognize that year-to-year fluctuations are the norm, and the target must be seen as being a value that can be sustained over several years. This improvement occurred in both summer and winter. The reasons for the improvement are three-fold: it was a dry year meaning watershed pollutant loads were low, the lake did not undergo deep mixing which limits the transport of deep stored nitrogen, and the numbers of Cyclotella decreased to their lowest levels in five years.

The summertime clarity improved by over 13 feet. While certainly encouraging, examination of the long term trend shows that there have been many periods of apparent improvement only to be overtaken by continued decline.

In new research, some valuable new tools are beginning to provide new insights into the processes that drive change in Lake Tahoe. An underwater glider that operated in the lake for 11 days in May provided the first ever "snapshots" of water quality across an east-west transect. What the data confirmed was the presence of giant "internal waves" deep in the lake, that could move algae and pollutants vertically over 150 feet. Possibly more important was the successful installation of a water quality monitoring station in 360 feet of water off the west shore. Connected to shore by an underwater cable, this station provides data from top to bottom every 30 seconds. This is the first such station in any lake worldwide.

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

ABOUT LAKE TAHOE AND THE TAHOE BASIN

- Maximum depth: 1,645 feet (501 meters), making it the 11th deepest lake in the world and 2nd deepest lake in the United States
- Average depth: 1,000 feet (305 meters)
- Lake surface area: 191 square miles (495 square kilometers)
- Watershed area: 312 square miles (800 square kilometers)
- Length: 22 miles (35 kilometers)
- Width: 12 miles (19 kilometers)
- Length of shoreline: 72 miles (116 kilometers)
- Volume of water: 39 trillion gallons
- Number of inflowing streams: 63, the largest being the Upper Truckee River
- Number of large lakes worldwide with annual clarity exceeding Tahoe's: 0
- Number of outflowing streams: one, the Truckee River, which leaves the lake at Tahoe City, Calif., flows through Truckee and Reno, and terminates in Pyramid Lake, Nev.
- Length of time it would take to refill the lake: about 600 years
- Average elevation of lake surface: 6,225 feet (1,897 meters)
- Highest peak in basin: Freel Peak, 10,891 feet (3,320 meters)
- Latitude: 39 degrees North
- Longitude: 120 degrees West
- Age of the lake: about 2 million years
- Permanent population: 55,000 (2010 Census)
- Number of visitors: 3,000,000 annually

ABOUT THE UC DAVIS TAHOE ENVIRONMENTAL RESEARCH CENTER (TERC)

The UC Davis Tahoe Environmental Research Center (TERC) is a world leader in research, education and public outreach on lakes, their surrounding watersheds and airsheds, and the human systems that both depend on them and impact them. TERC provides critical scientific information to help understand, restore and sustain the Lake Tahoe Basin and other lake systems worldwide. We partner closely with other institutions, organizations and agencies to deliver solutions that help protect Lake Tahoe and other lakes around the world.

TERC's activities are based at permanent research facilities in the Tahoe Basin and at the University's main campus in Davis, California, about 90 miles west of the lake.

Our main laboratories and offices are in Incline Village, Nevada, on the third floor of the Tahoe Center for Environmental Sciences building. On the first floor, we operate the Thomas J. Long Foundation Education Center, a learning resource that is free and open to the public.

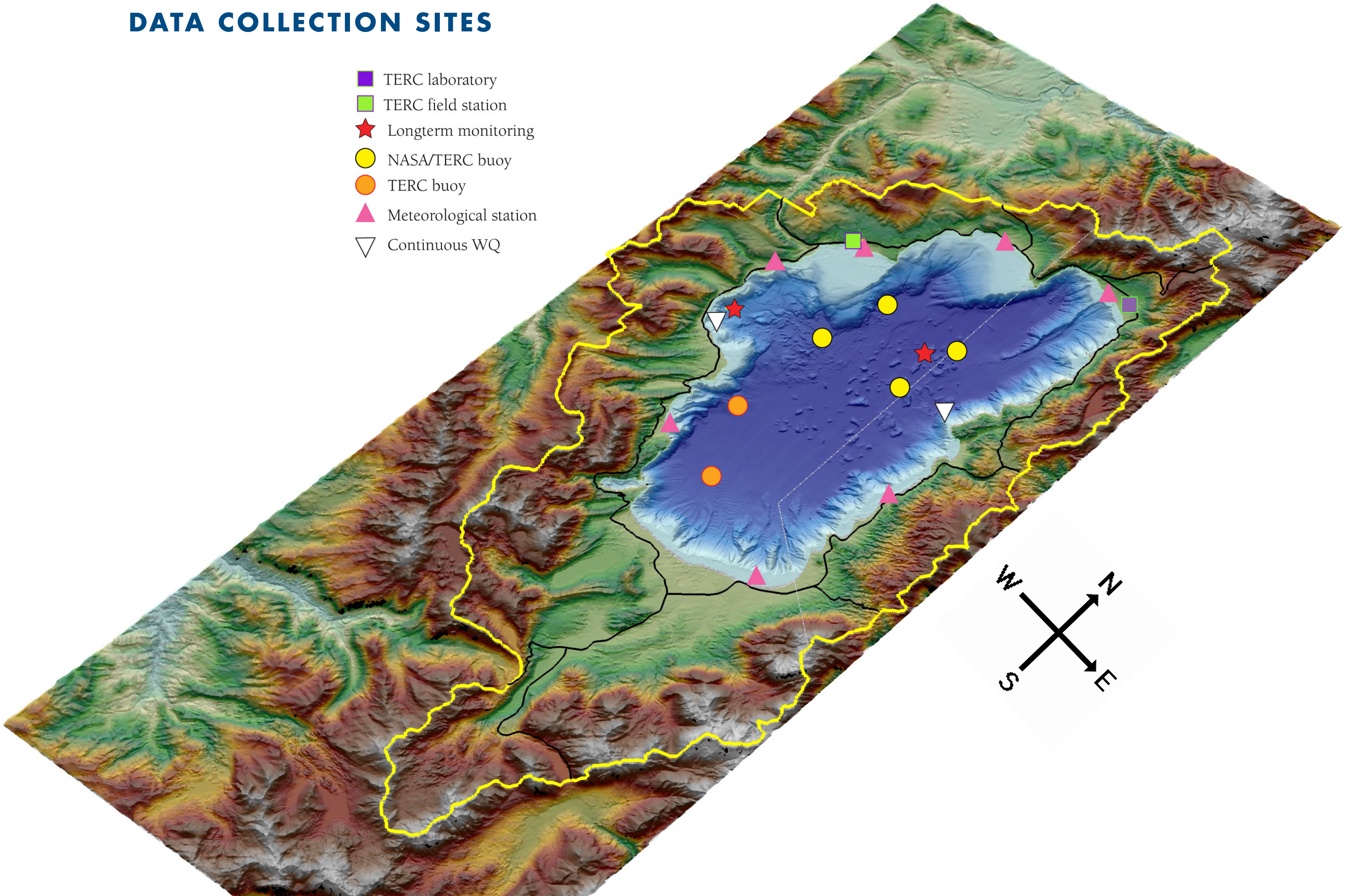
In Tahoe City, Calif., we operate a field station (housed in a fully renovated, former state fish hatchery) and the Eriksson Education Center. Tahoe City is also the mooring site for our research vessels, the John LeConte and the Bob Richards.

Our secondary laboratories and offices are located on the UC Davis campus at the Center for Watershed Sciences and in Wickson Hall.

Our website (terc.ucdavis.edu) has more information about our programs, including:

- Information for potential students, staff, faculty, and research collaborators;
- Access to near-real-time data gathered by our growing network of sensors;
- A list of publications;
- Exhibits and events at the Education Centers; and
- Information about supporting our research and learning programs.

MAP OF TAHOE BASIN DATA COLLECTION SITES



TAHOE: STATE OF THE LAKE REPORT 2013

RECENT RESEARCH UPDATES

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RECENT RESEARCH UPDATES

Overview

While the State of the Lake Report is primarily intended to focus on the trends emerging from long term data collection efforts, this section presents the results of some current and short term projects. In some cases the projects are complete, but in most cases they are a preview of some new and exciting research directions. This year we focus on five areas: an underwater Glider experiment, the projected 21st century trends in Tahoe's hydroclimatology, drought adaptation by forests, new efforts on collecting real-time data on Tahoe's water quality and measuring the blueness of Lake Tahoe.

The University of Minnesota, Duluth's Glider just prior to descending into Lake Tahoe for the start of its 11 day mission to traverse Lake Tahoe 17 times.

Research divers Brant Allen and Katie Webb preparing to lay the first section of the underwater cable for Tahoe's first real-time water quality monitoring station.

Cleaning the underwater radiometer at Buoy TB3, a joint project between TERC and NASA/JPL to continuously measure the changing light conditions in the lake.

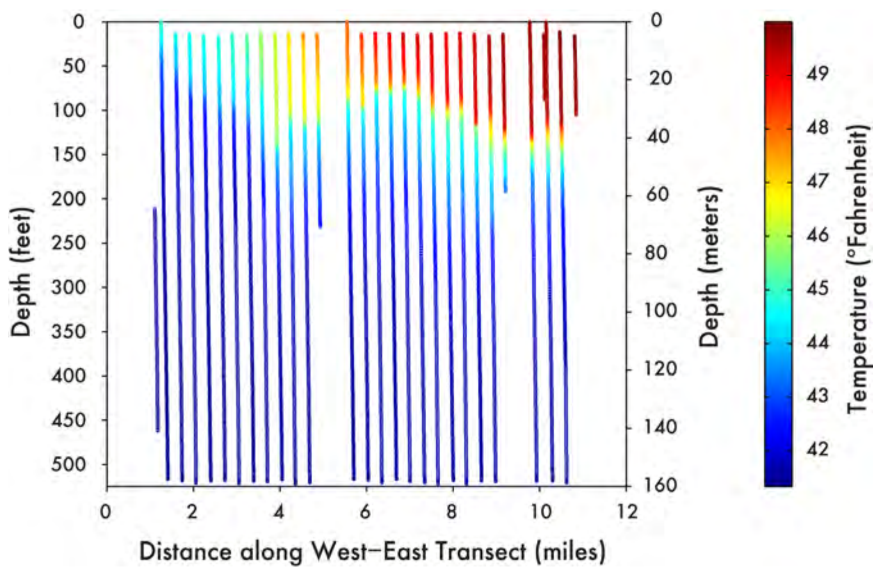
RECENT RESEARCH UPDATES

Underwater Glider experiment

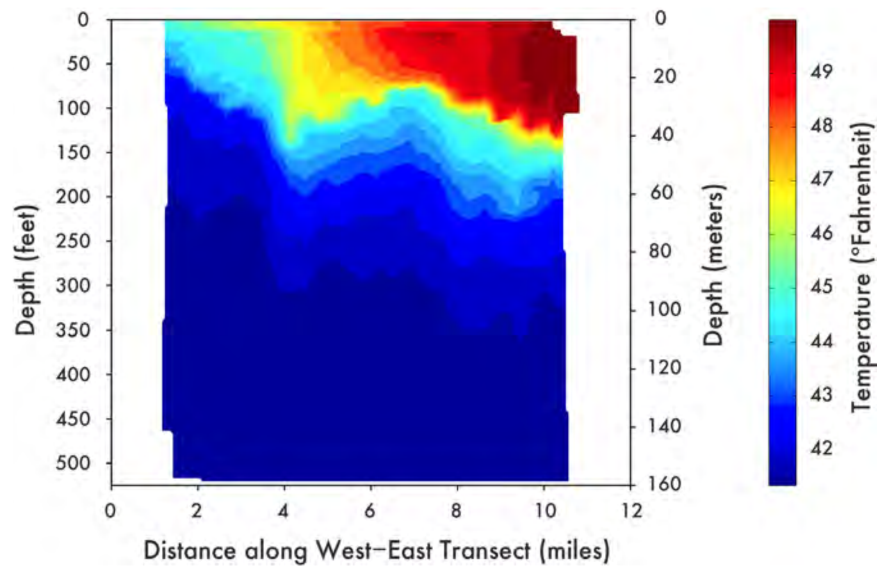
Underwater Gliders are ultra-low powered instrument packages that can measure a range of water quality variables in oceans and lakes. They operate by repeatedly diving and rising while traveling along a pre-determined path, and taking measurements while they do so. They have the ability to do this for months at a time under conditions that make conventional sampling dangerous.

In a collaboration with Dr Jay Austin of the Great Lakes Observatory, University of Minnesota, Duluth, TERC conducted a Glider experiment in Lake Tahoe from May 11- May 22, 2013. The Glider conducted 17 measurements transects on the same east-west line, diving repeatedly to a depth of over 500 feet.

The panels show the data collected during the transect that commenced at 2:02 PM on May 21, and concluded at 5:30 AM on May 22. The west shore is at 0 miles on the horizontal scale and the east shore is at 12 miles. The first panel shows the raw temperature data, superimposed on the trajectory lines taken by the Glider. The Glider was set to only collect data while descending.



Raw temperature data collected by the Glider along each of its 29 dives along the east-west transect.



Temperature contours along a transect from west (left) to east (right) across Lake Tahoe. The severe tilt is due to a wind-driven “upwelling.” This is a common springtime event in Lake Tahoe.

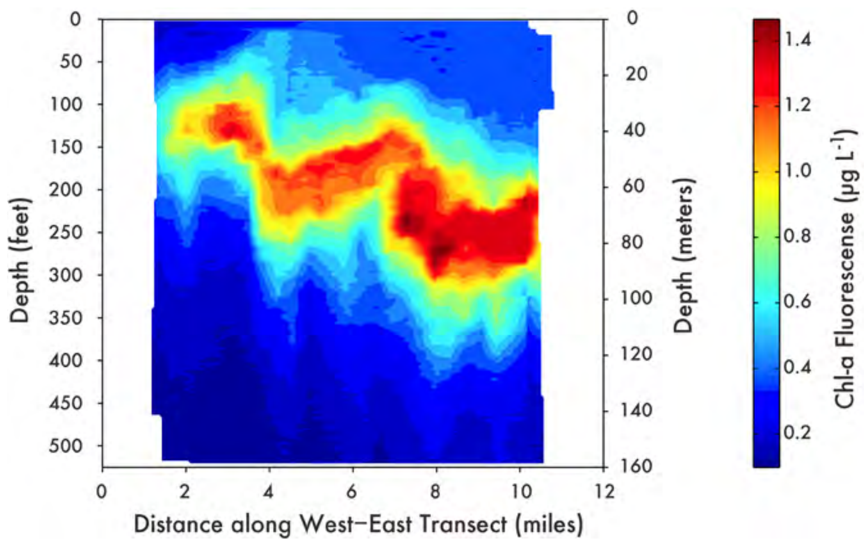
RECENT RESEARCH UPDATES

Underwater Glider experiment, continued

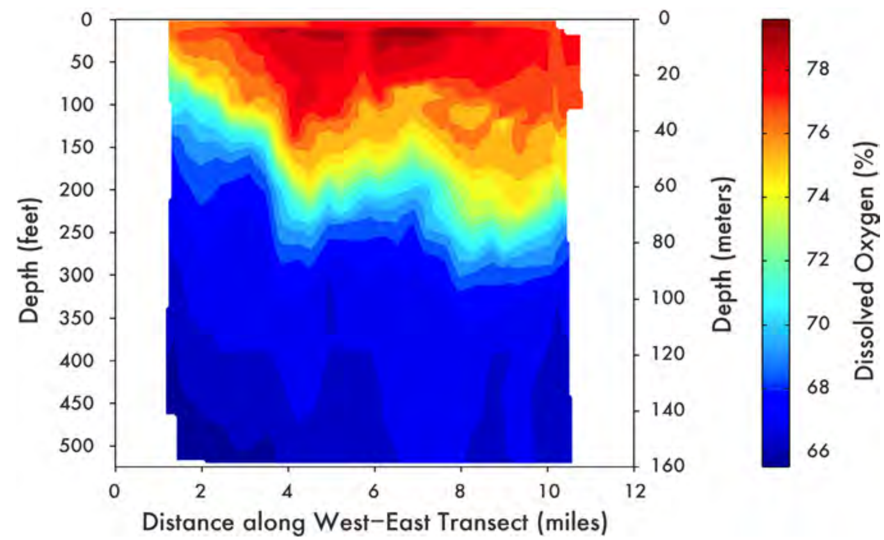
This transect took place under extremely windy conditions, with the wind from the south west. This caused an “upwelling”, where water from as deep as 150 feet on the west shore is raised up to the surface in a giant “internal wave”. Warm surface water is pushed eastward toward Nevada.

This transport impacts all other water quality parameters. Chlorophyll, a measure of algal abundance, that has its highest values in a deep layer centered at about 200 ft, also rises in the west and sinks in the east in response to the induced wave motion. Dissolved oxygen, which tends to have higher concentrations near the surface and lower concentrations at depth, is similarly distorted.

These results highlight the extreme natural variability that is present in Lake Tahoe at short timescales. This variability needs to be understood in order to analyze the long term trends in water quality. Similarly, the lake motions themselves are responsible for transporting pollutants within the lake and need further attention.



Chlorophyll fluorescence contours along a transect from west(left) to east (right) across Lake Tahoe.

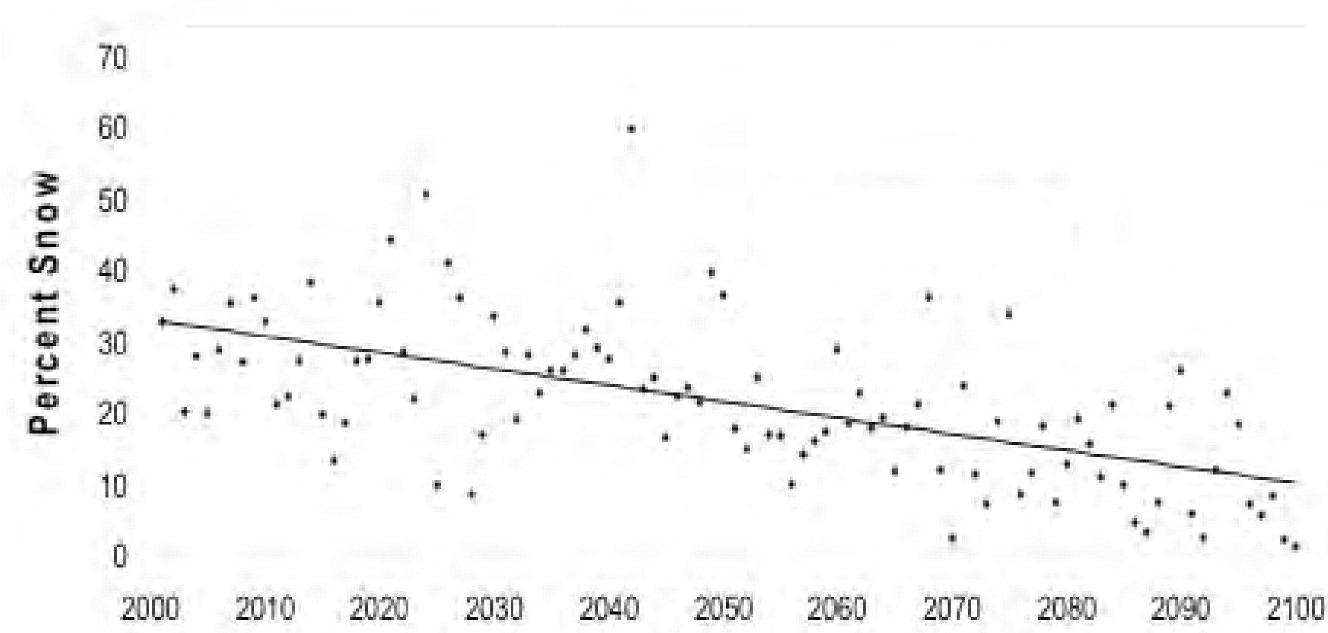


Dissolved Oxygen (percent saturation) contours along a transect from west (left) to east (right) across Lake Tahoe.

RECENT RESEARCH UPDATES

Projected 21st century trends in Tahoe's hydroclimatology

TERC, in collaboration with Hydroikos Associates; the US Geological Survey/ Scripps Institute of Oceanography; Tetra Tech, Inc.; Northwest Hydraulic Consultants; and Hydrology Futures, LLC., completed a SNPLMA funded study to provide a first assessment of the extent to which climate change needs to be considered in ongoing efforts to protect and manage the unique waters of Lake Tahoe. The results are published as a series of five papers in the journal Climatic Change (copies available upon request).



The decline in the percentage of precipitation as snow in the next 100 years under the GFDL-A2 scenario.

RECENT RESEARCH UPDATES

Projected 21st century trends in Tahoe's hydroclimatology, continued

Key findings of the study till the end of the 21st Century included, for the range of scenarios tested:

1. Air temperature increases as high as 10 °F

2. The fraction of snow to rain could fall to 0.1-0.2, leading to reduced water storage in the spring snow pack and increases in drought severity

3. Changes in stream low-flow conditions could render the lower reaches of some streams completely dry more often

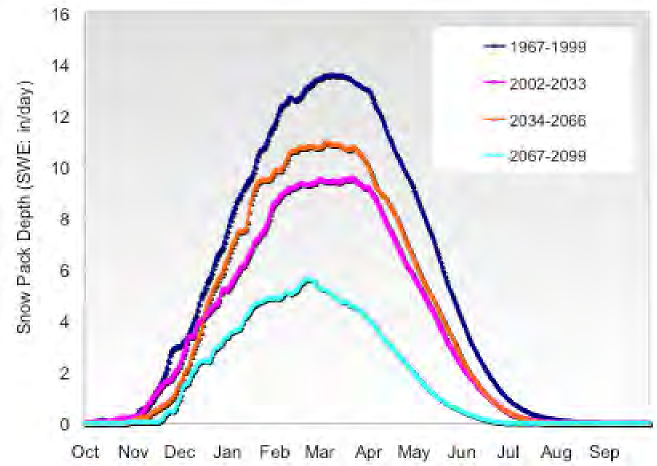
4. Dramatic increases in flood magnitude

5. Sediment and nutrient loading to Lake Tahoe from streams should not increase substantially

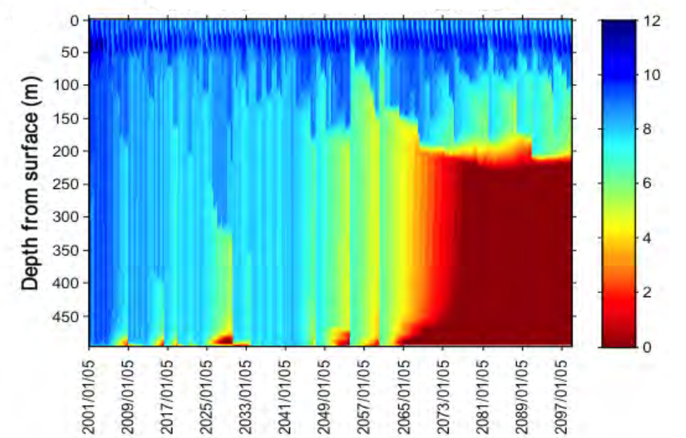
6. Overall fine sediment load reductions should still be achievable if storm water treatment facilities are properly sized

7. Lake Tahoe could cease to mix to the bottom for extended periods, resulting in complete oxygen depletion in the deep waters with loss of habitat and an increase in sediment nutrient release,

8. Lake surface level is more likely to drop below the natural rim for extended time periods.



Estimated snow pack depths at different time intervals under the GFDL-A2 model scenario.



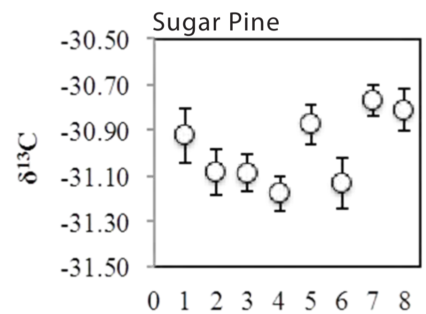
Estimated dissolved oxygen concentration in Lake Tahoe over the next 100 years under the GFDL-A2 model scenario. Note the complete loss of oxygen below 200 m after 2065.

RECENT RESEARCH UPDATES

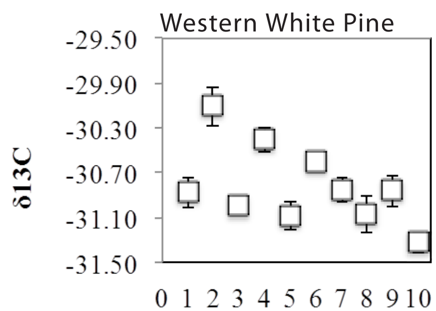
Drought adaptation by forests

Experiments have been established by researchers from UC Davis and the USDA Forest Service Pacific Southwest Research Station to evaluate ecologically important plant traits in sugar pine, western white pine, and white bark pine, three co-dominant and dominant tree species in the Lake Tahoe Basin. Determining water-use efficiency by measuring the carbon stable isotope ratio, $\delta^{13}C$, may improve our understanding of drought adaptation and provide information about how populations of forest tree species will respond to global climatic change (e.g. adaptation from standing variation). The less negative value of $\delta^{13}C$ corresponds with higher water use efficiency.

Sugar pine seedlings at the Institute of Forest Genetics.



Population	Number
Bliss SP	1
Carnelian Bay	2
Glenbrook	3
Granlibakken	4
Heavenly	5
Sand Pit	6
Sugar Pine Point	7
Tunnel Creek	8



Population	Number
Armstrong Pass	1
Blackwood Cyn	2
Echo Lake	3
Flume	4
Heavenly	5
Incline Lake	6
Jakes Peak	7
Meiss Mdw	8
Montreal Cyn	9
Mt Watson	10

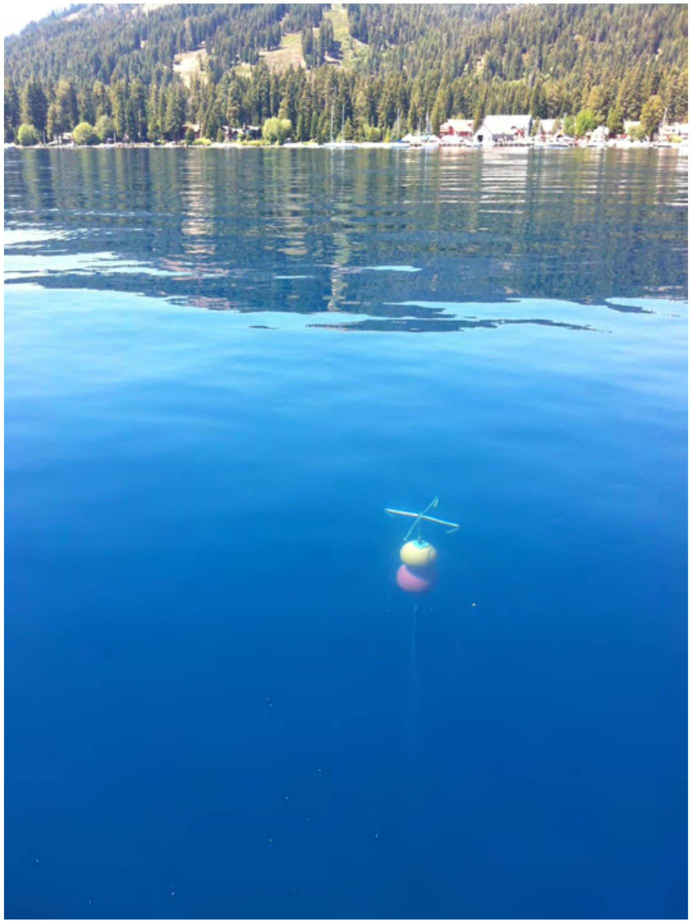
RECENT RESEARCH UPDATES

Real-time monitoring of water quality in Lake Tahoe

A vertical array of temperature, pressure and dissolved oxygen measuring instruments are installed at a depth of 120 m off the west shore of Lake Tahoe, adjacent to TERC's long-term Index station. A 600 m long underwater cable from the shore connects to the array and provides power and transmits data to the internet every 30 seconds.

The temperature acts as a tracer for mixing processes in the lake, allowing us to understand the mechanisms by which dissolved oxygen is transferred to the deep water. This is a critical question that needs to be addressed in order to better understand climate change impacts on Lake Tahoe. The pressure data are being used to study the long period waves at the surface of the lake (seiches) and to also relate their impact on internal processes in the lake.

This project is made possible through a collaboration with Obexer's Marina, who are providing the terminus land site for the underwater cable. Funding to launch the project was provided by the UC CITRIS program and private donors.



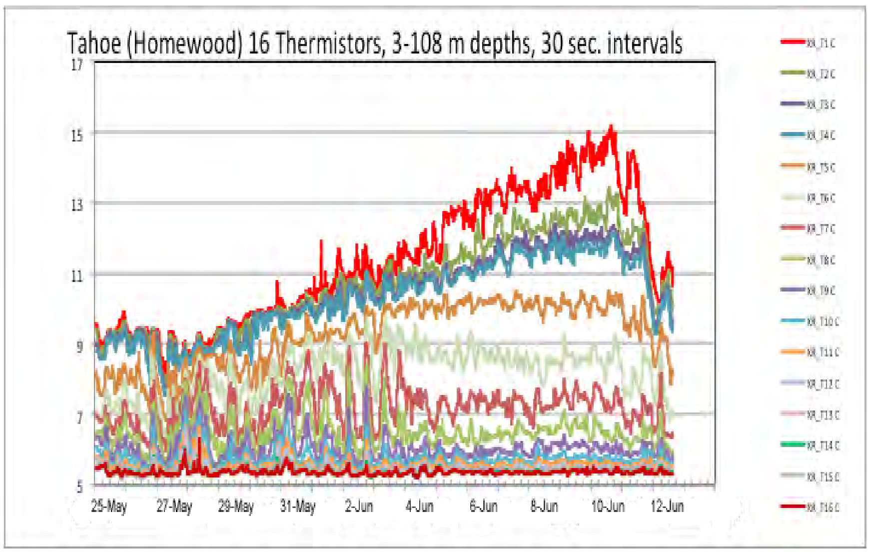
The sub-surface buoy atop the instrument array at Homewood.

RECENT RESEARCH UPDATES

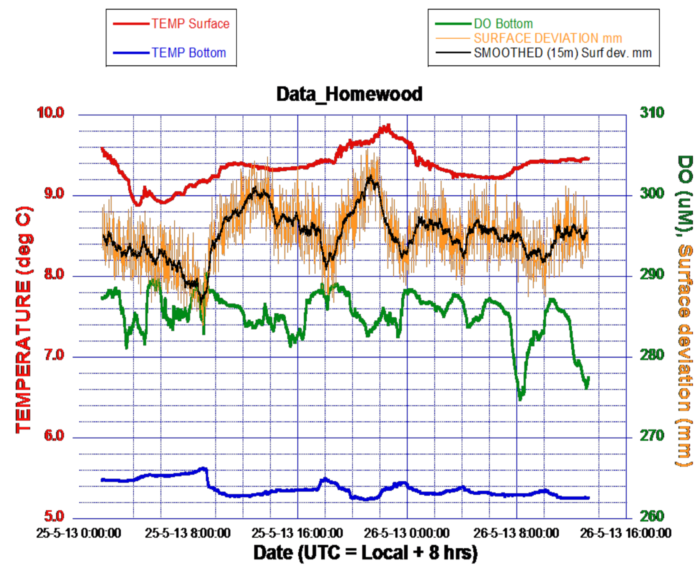
Real-time monitoring of water quality in Lake Tahoe, continued

The left panel represents nineteen days of temperature traces that show the gradual warming of the surface water through June 12. The peak temperature was 15 °C (59 °F).Intense winds for the next three days cooled the surface layer of the lake by 4 °C (8 °F) in two days. Note that the bottom temperatures are virtually unchanged.

The right panel shows thirty six hours of data from the real time station. The green trace shows the variations in the dissolved oxygen concentration at the lake bottom. The black trace is the fluctuation of the lake surface. The red and blue lines are the surface and bottom temperatures, respectively.



All 16 temperature traces for 19 days. Note the rapid cooling at the end of the record.High winds forced the mixing of the lake surface.



Oxygen fluctuations at the bottom of the lake were not expected. They appear to vary in the opposite direction to the lake level.

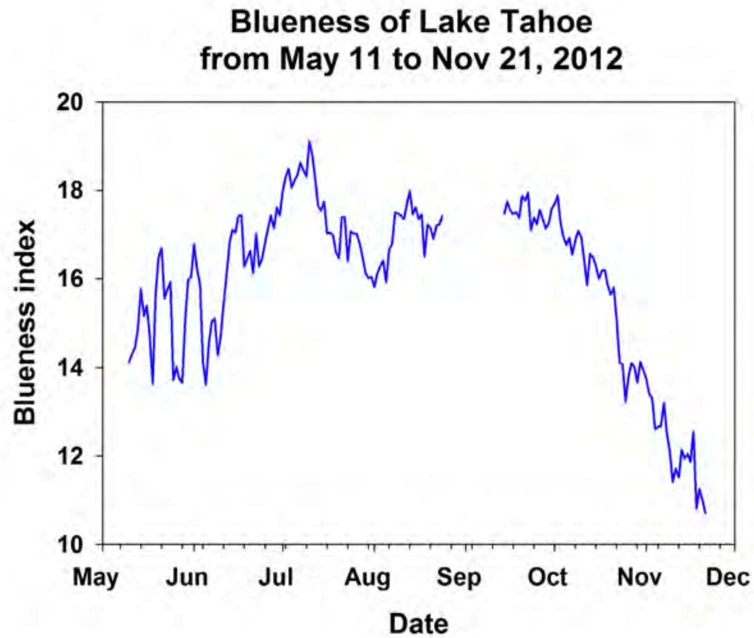
RECENT RESEARCH UPDATES

Measuring the blueness of Lake Tahoe

Most people are familiar with the slogan "Keep Tahoe Blue", yet the goal for Lake Tahoe has always been phrased in terms of clarity rather than color. Using hyperspectral radiometric measurements that measure the light upwelling from the lake, it is possible to quantify the actual color of the lake water. This is being done using instruments deployed upon a buoy in the center of Lake Tahoe (TB3) in collaboration with NASA/JPL. Measurements are being taken every 30 minutes during daylight hours. It is planned to start transmitting data in real time in 2013.

The importance of this data is that it can help understand what drives changes in lake color at a range of time scales, from hours to years. These measurements are unique and are part of what is being done to better understand the linkages between water quality contaminants and the spectral response of lakes. A long term goal of the project is to use remotely sensed imagery from satellites to provide similar data for lakes world-wide.

Radiometric profiles are taken regularly to calibrate the buoy sensors.

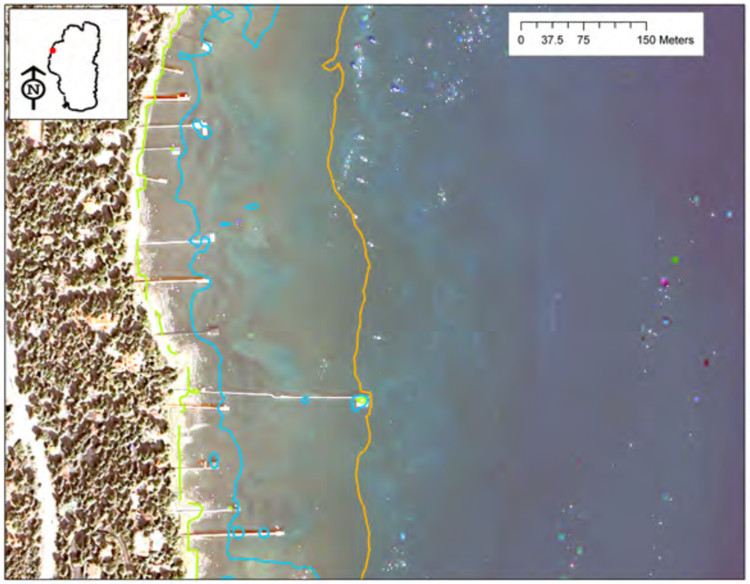


Quantification of water color for a 7 month period in 2012. The values shown are the *b** coordinate values of the *CIE L* a* b** color space. Higher values indicate increased "blueness." The decrease in blueness is evident in fall and winter. Short term fluctuations in blueness are seen in May and June. Data gap around September was due to instrument maintenance.

RECENT RESEARCH UPDATES

Shoreline change due to prolonged drought

In a dry year lake Tahoe typically loses 1.5 feet of water level. Predictions of future climate conditions in the basin point to more extreme events in the future. A 5-year drought could conceivably reduce the lake level to 6215.5 feet, or 5 feet below the record 1992 levels. How would the shoreline look under those conditions. The images below show the shoreline positions corresponding to the natural rim of the lake (without the dam), the 1992 drought shoreline, the 5 year drought shoreline, and the shoreline corresponding to the ancient drought 5000 years ago when lake level was lower by 40 feet for hundreds of years.



Three shorelines positions for McKinney Bay, CA. Green – the natural rim, blue- the 1992 drought, and orange – a possible 5 year drought. Note the dock positions.

Four shorelines positions for Incline Village, NV. Green – the natural rim, blue- the 1992 drought, orange – a possible 5 year drought, and red – the ancient drought. Note the dock positions.

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METEOROLOGY

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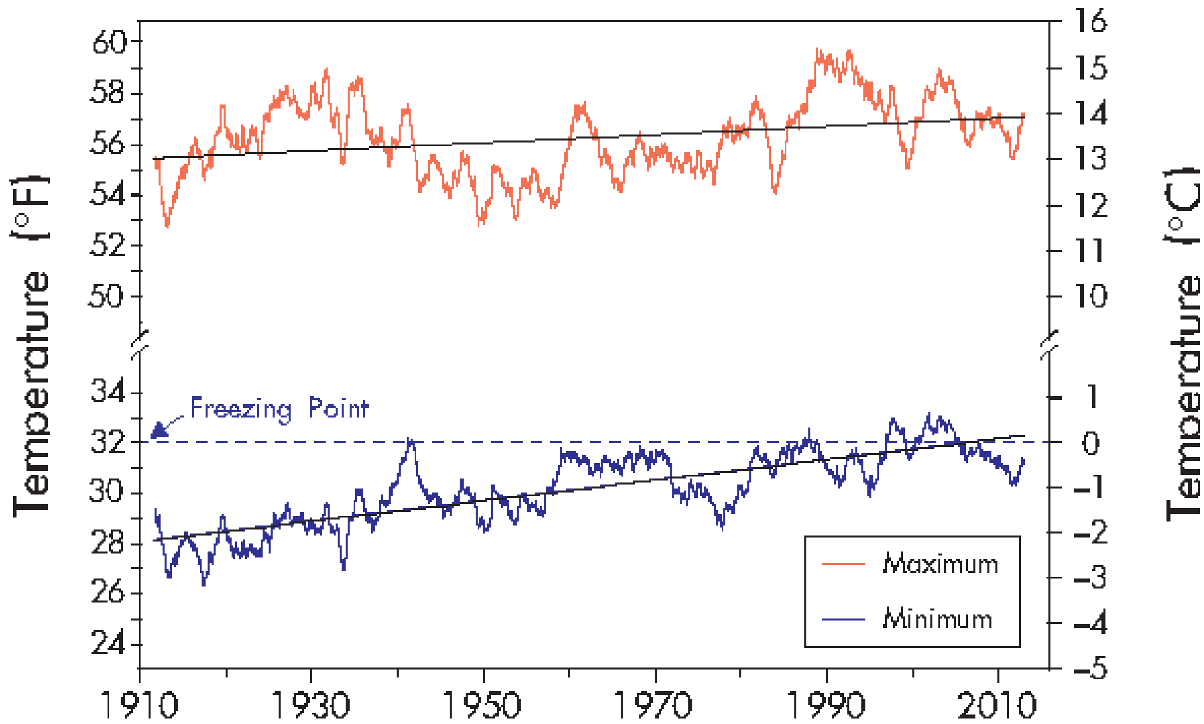
METEOROLOGY

Air temperature

Daily since 1911

Daily air temperatures have increased over the 100 years measured at Tahoe City. The long-term trend in daily minimum temperature has increased by more than 4 °F (2.2 °C), and the long-term trend in daily maximum temperature has risen by less than 2 °F (1.1 °C). The trend line for the minimum air temperature now exceeds the freezing temperature of water, which points to more rain and less snow, as well as earlier snowmelt. These data have been smoothed by using a two-year running average to remove daily and seasonal fluctuations. 2012 was warmer than the previous year, which came at the end of a decade-long cooling trend.

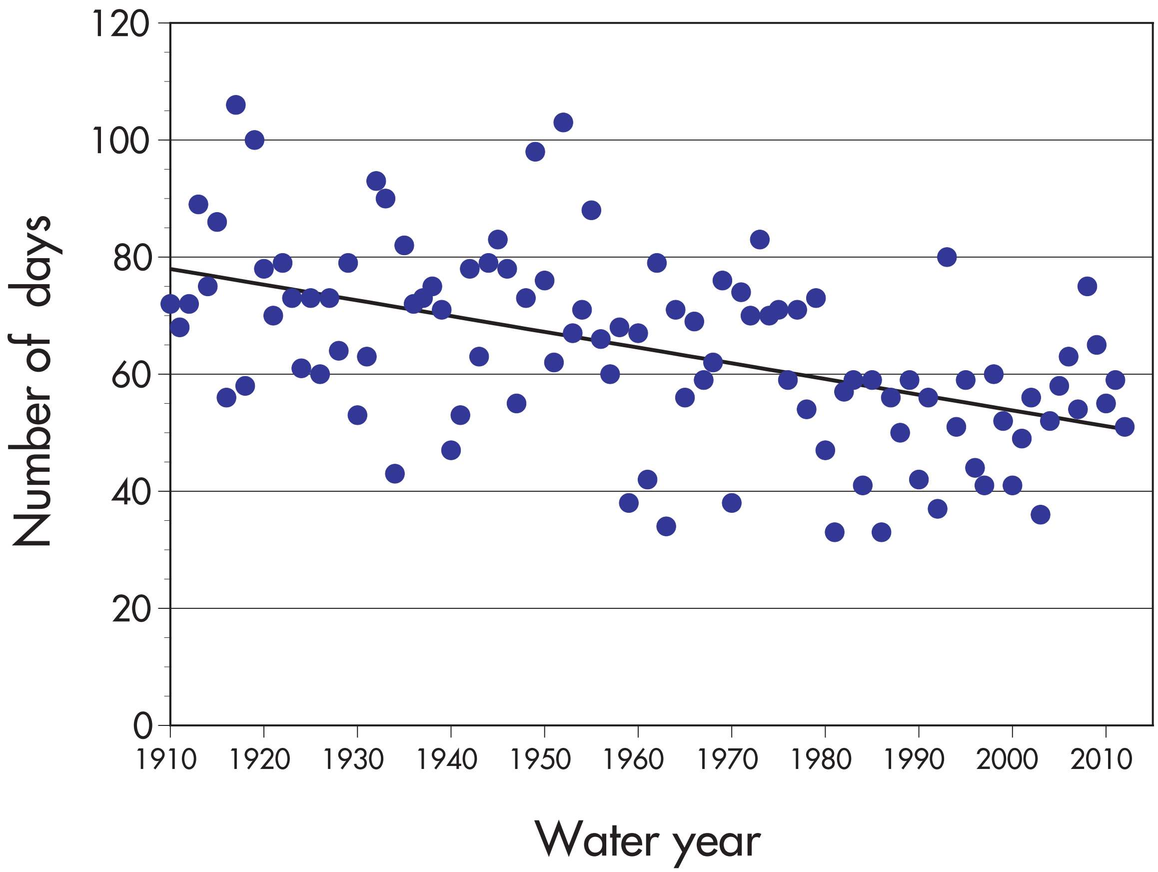


METEOROLOGY

Below-freezing air temperatures

Yearly since 1910

The method used for this analysis sums the number of days with daily average temperatures below freezing between Dec 1 and March 31 for each Water Year. Although year-to-year variability is high, the number of days when air temperatures averaged below freezing has declined by about 25 days since 1911. In 2012, the number of freezing days fell directly on the long-term trendline.

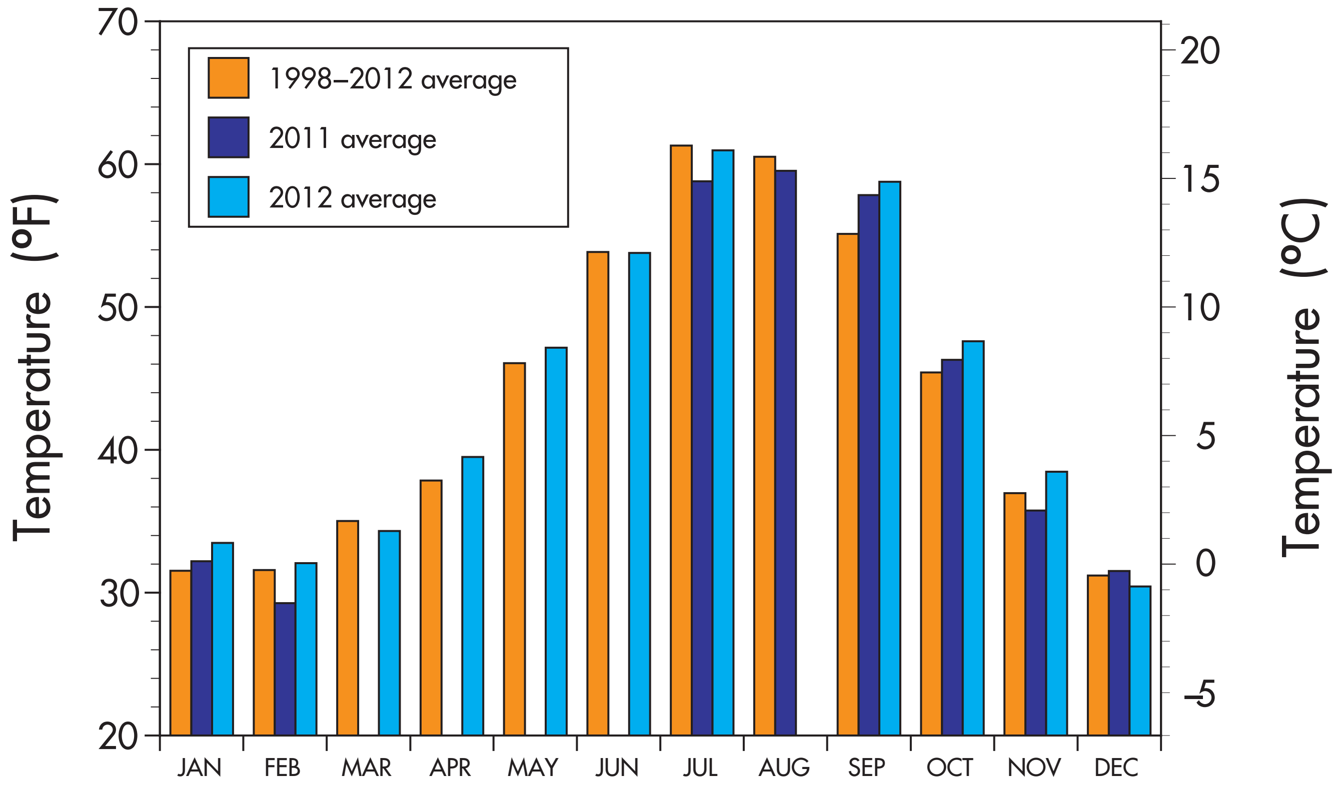


METEOROLOGY

Monthly air temperature

Since 1998

In 2012, monthly air temperatures were generally similar to values in the previous year and to the long term average. A notable exception was that 2012 was warmer than the long term average in the fall months of September through November. Any month with more than 25 percent of the daily data missing was not plotted.

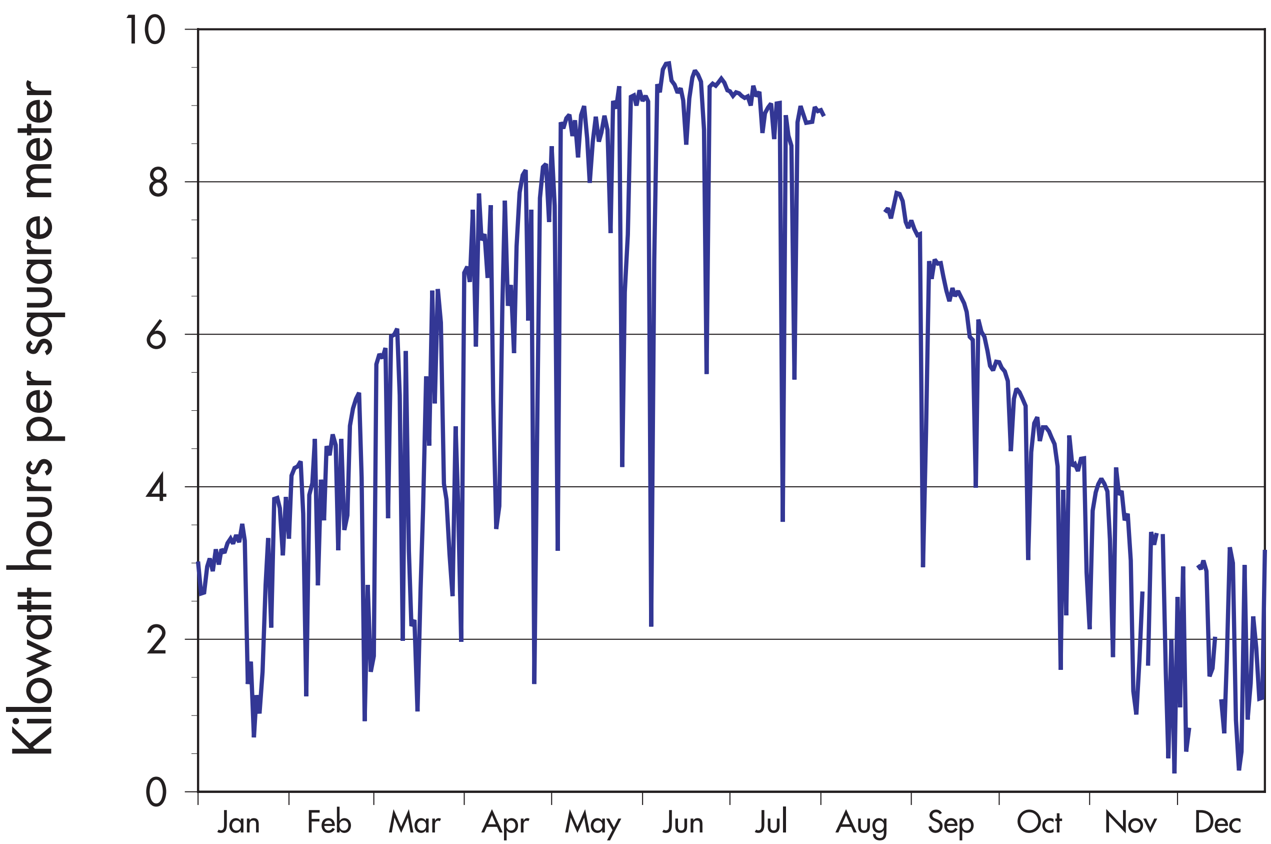


METEOROLOGY

Daily solar radiation

Daily in 2012

Solar radiation showed the typical annual pattern of increasing then decreasing sunlight, peaking at the summer solstice on June 21 or 22. Dips in daily solar radiation are due primarily to clouds. Smoke and other atmospheric constituents play a smaller role. It is noteworthy that solar radiation on a clear day in mid-winter can exceed that of a cloudy day in mid-summer. Data for August are missing due to instrument calibration. The station where these data are collected is located on the U.S. Coast Guard dock at Tahoe City.

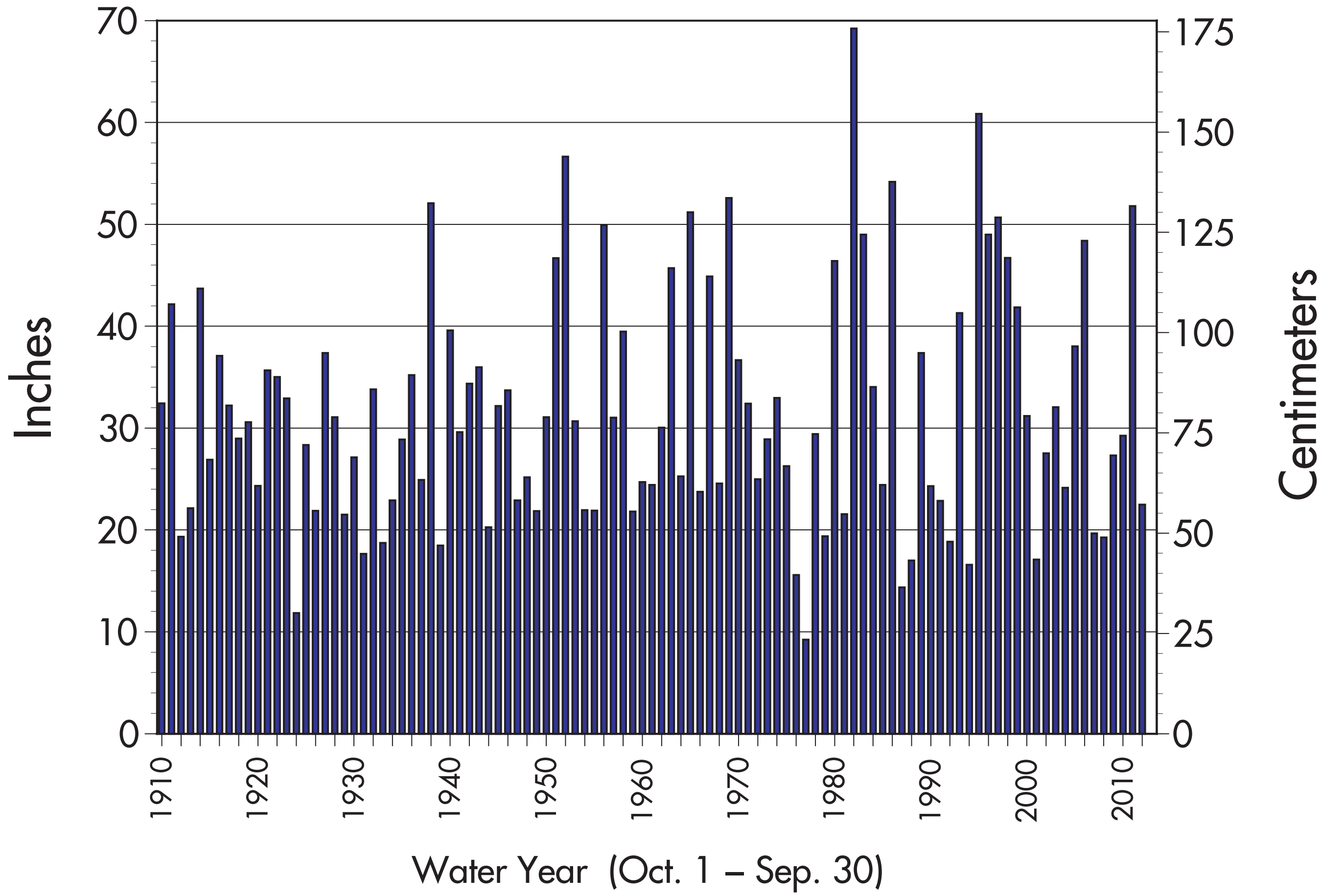


METEOROLOGY

Annual precipitation

Yearly since 1910

From 1910 to 2011, average annual precipitation (water equivalent of rain and snow) at Tahoe City was 31.59 inches. The maximum was 69.2 inches in 1982. The minimum was 9.2 inches in 1977. 2012 was well below average, with 22.48 inches of precipitation. Generally there is a gradient in precipitation from west to east across Lake Tahoe, with almost twice as much precipitation falling on the west side of the lake. (Precipitation is summed over the Water Year, which extends from October 1 through September 30.)

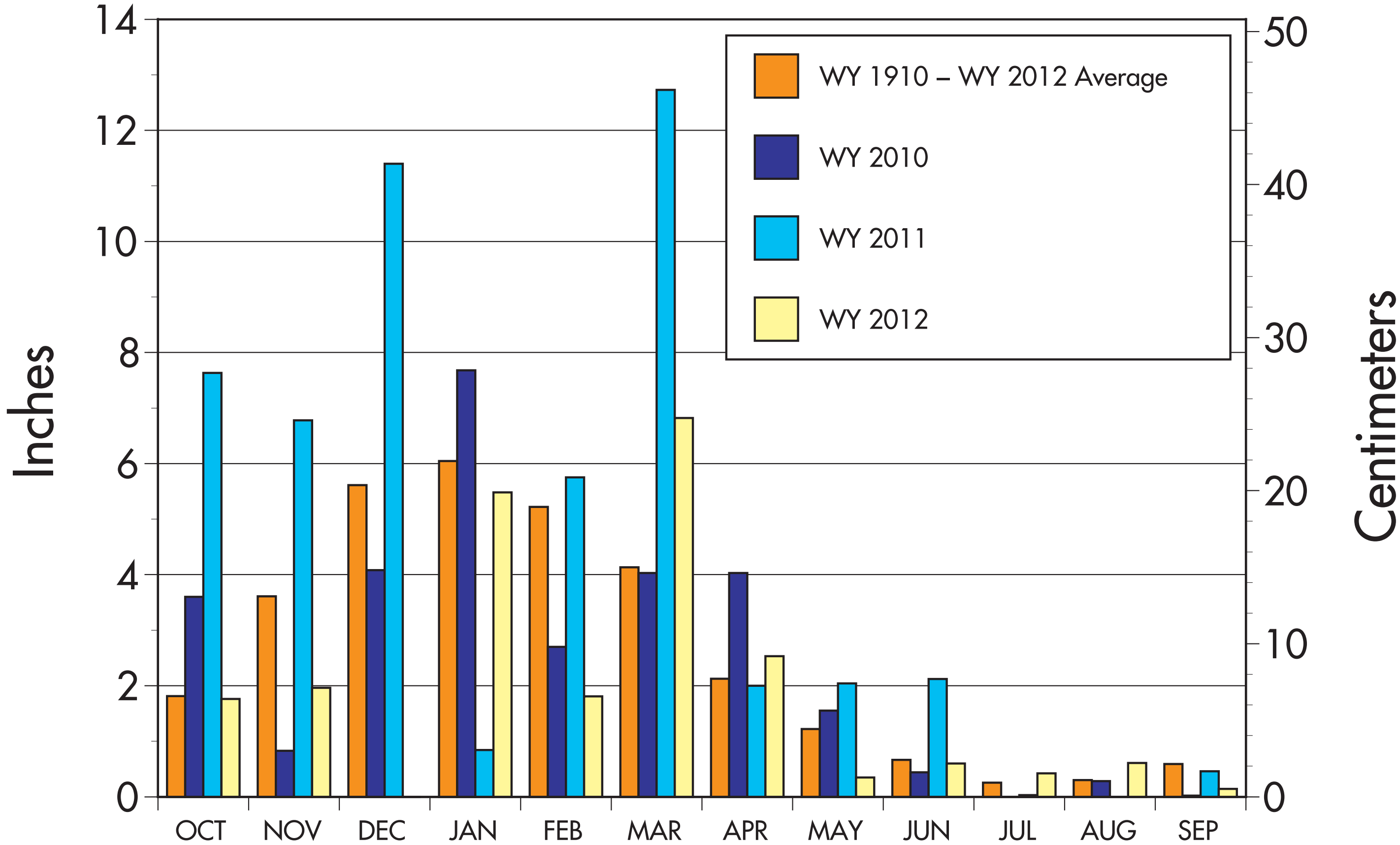


METEOROLOGY

Monthly precipitation

2010, 2011, 2012 and 1910 to 2012 Average

2012 was well below average in total precipitation, and this is clearly evident in the comparison of the monthly precipitation with the previous two years and the long-term average. The monthly precipitation for Jul-2010, Aug-2011, and Dec-2011 was 0 inches. The 2012 Water Year extended from October 1, 2011, through September 30, 2012.

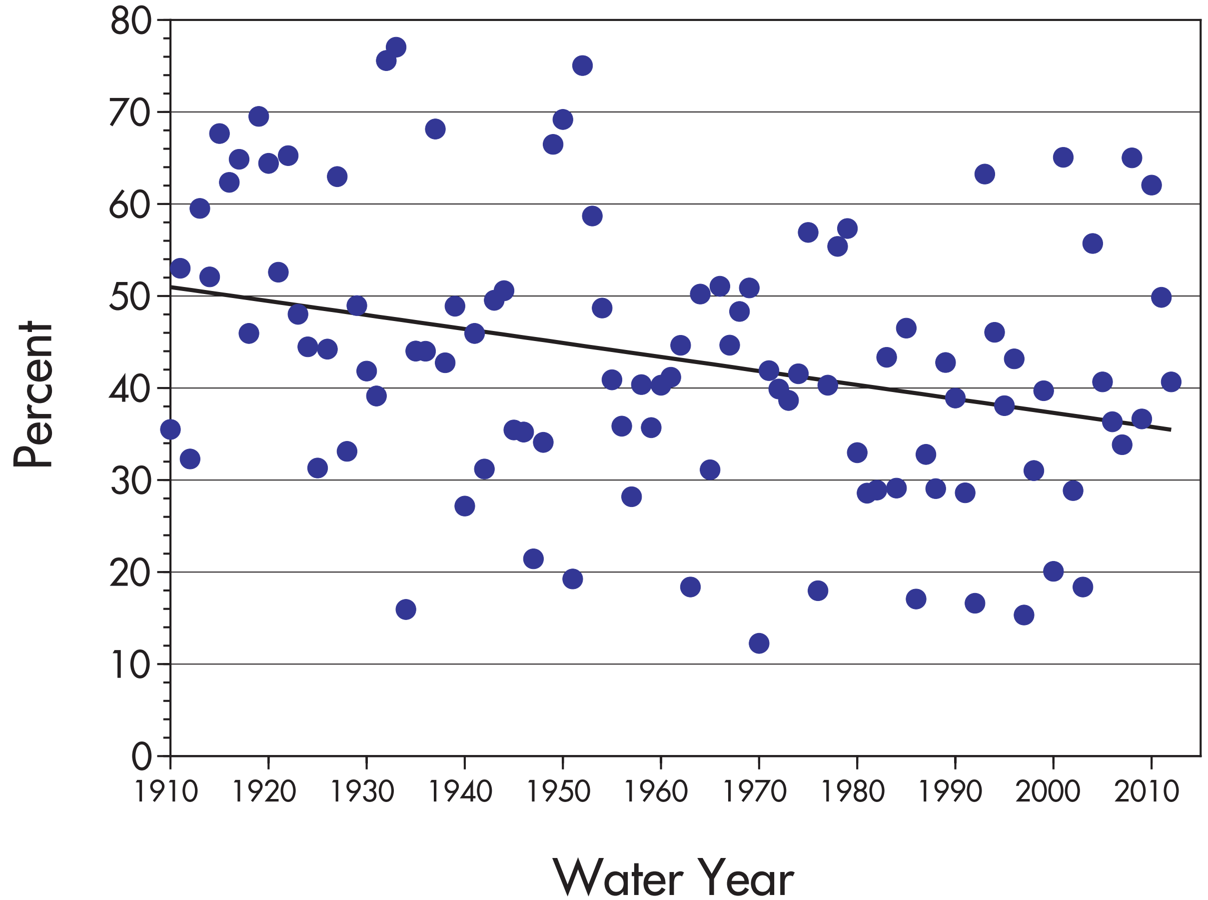


METEOROLOGY

Snow as a fraction of annual precipitation

Yearly since 1910

Snow has declined as a fraction of total precipitation, from an average of 51 percent in 1910 to 36 percent in present times according to the line of best fit. In Tahoe City, snow represented 41 percent of the 2012 total precipitation, slightly above the long-term trend. These data are based on the assumption that precipitation falls as snow whenever the average daily temperature is below freezing. (Precipitation is summed over the Water Year, which extends from October 1 through September 30.)



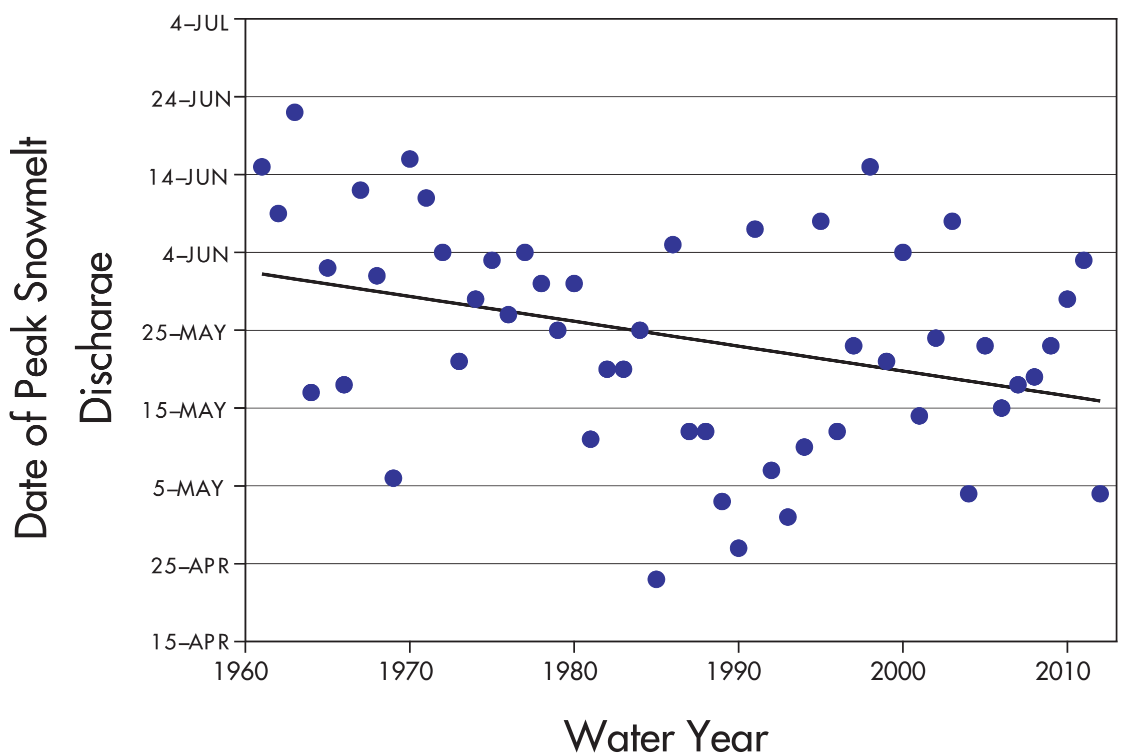
METEOROLOGY

Shift in snowmelt timing

Yearly since 1961

Although the date on which peak snowmelt occurs varies from year to year, since 1961 it has shifted earlier an average of 2 weeks (16.3 days). This shift is statistically significant and is one effect of climate change on Lake Tahoe.

In 2012, peak discharge was one of the earliest recorded, occurring around May 4. Peak snowmelt is defined as the date when daily stream flows reach their yearly maximum. Daily stream flows increase throughout spring as the snow melts because of rising air temperatures, increasing solar radiation and longer days. The data here are based on the average from the Upper Truckee River, Trout Creek, Blackwood Creek, Ward Creek, and Third Creek.



TAHOE: STATE OF THE LAKE REPORT 2013

PHYSICAL PROPERTIES

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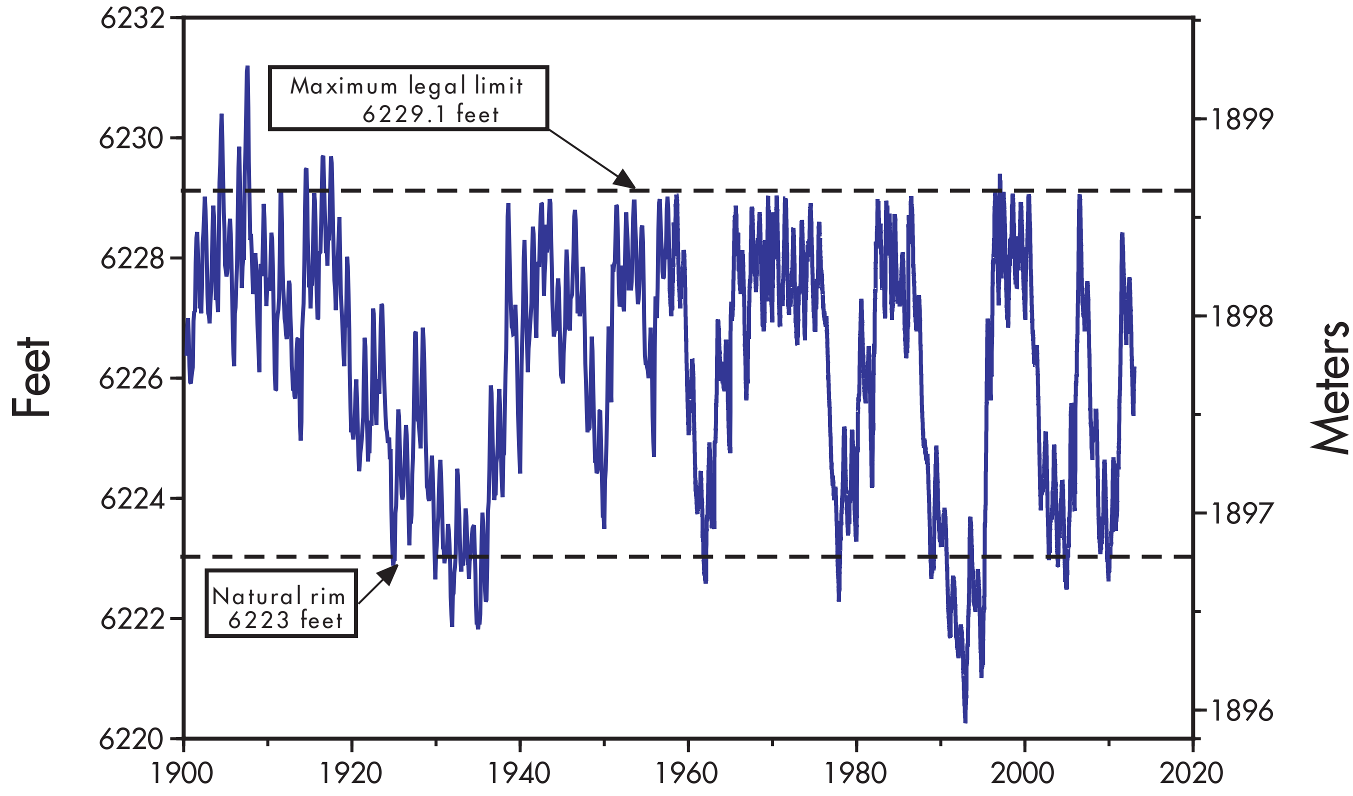
PHYSICAL PROPERTIES

Lake surface level

Daily since 1900

Lake surface level varies throughout the year. It rises due to high stream inflow, groundwater inflow and precipitation directly onto the lake surface. It falls due to evaporation, in-basin water withdrawals, groundwater outflows, and outflow via the Truckee River at Tahoe City. Overall, lake level fell during 2012. The highest lake level was 6227.68 feet on June 5, and the lowest was 6225.37 feet on November 28. In 2012, the lake level rose by only 1.3 feet during snowmelt, compared with 3.9 feet in 2011.

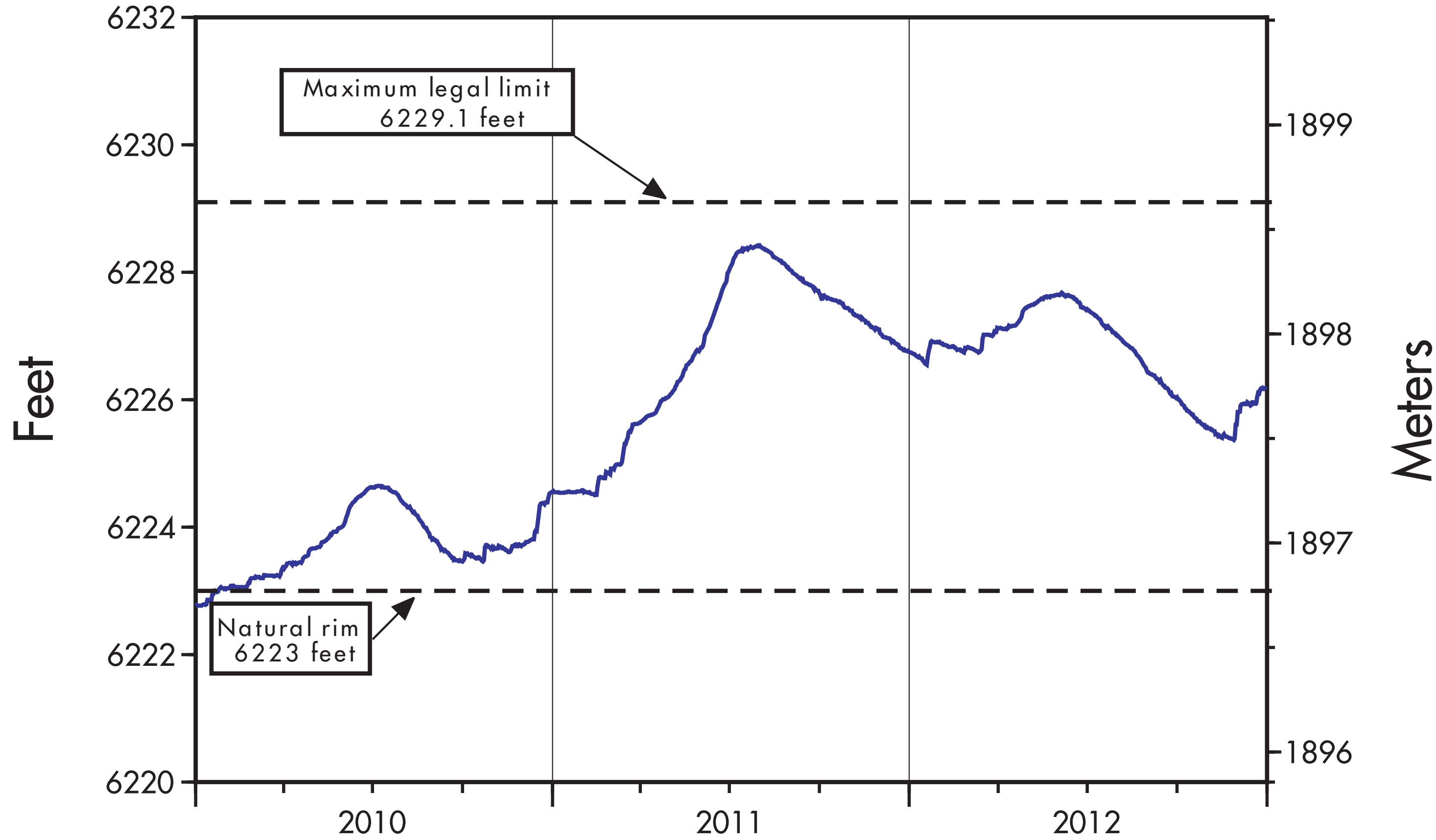


PHYSICAL PROPERTIES

Lake surface level, continued

Daily since 2010

Identical data as used on page 8.1 except the period displayed is shortened to 2010-2012. This more time resolved presentation of recent lake level data allows us to see the seasonal patterns in higher definition. Data clearly show the lake level below the natural rim at the beginning of 2010 as well as the timing of highest yearly lake levels in late spring following snowmelt. The effects of the very early snowmelt in 2012 on lake level are clearly evident.

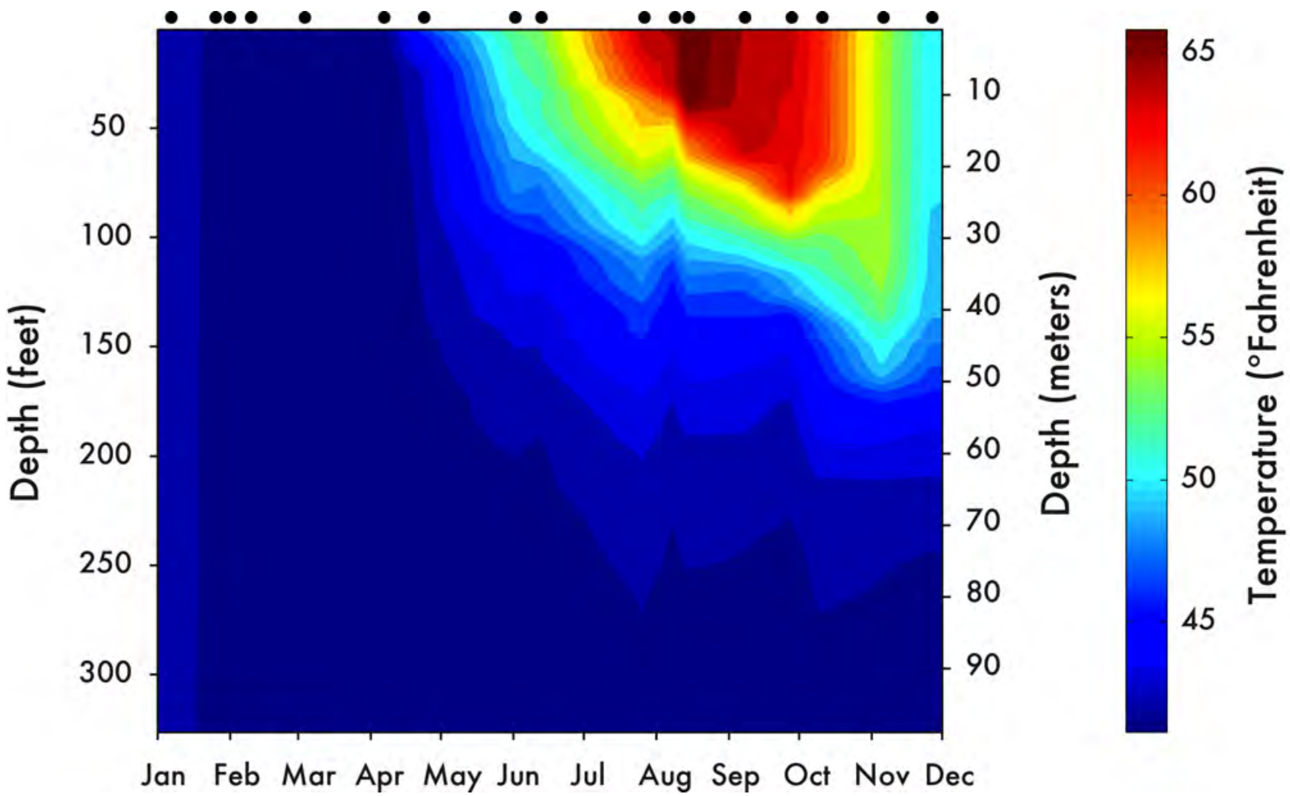


PHYSICAL PROPERTIES

Water temperature profile

In 2012

Water temperature profiles are measured in the lake using a Seabird CTD at the times indicated by the dots along the top of the figure. The temperature is accurate to within 0.005 °F. Here the temperature in the upper 330 feet is displayed as a color contour plot. In 2012, the lake temperature followed a typical seasonal pattern. In late March, the lake surface was at its coldest but complete vertical mixing down to 1625 feet did not occur. The beginning of the 2012-2013 winter mixing is evident at the end of the plot, with the surface layer both cooling and deepening. By the end of 2012, mixing had proceeded to only 80 feet, a relatively shallow amount. Arrows indicate days on which profiles were measured.

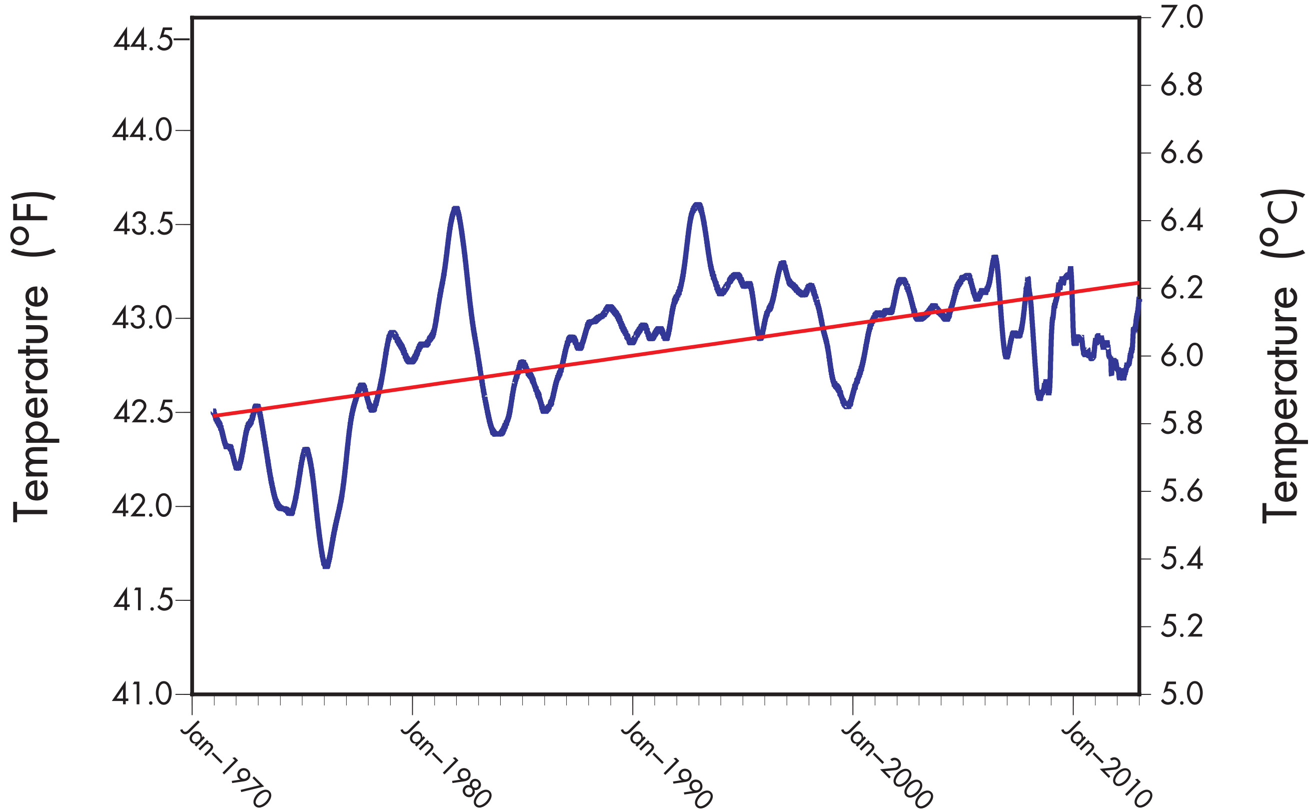


PHYSICAL PROPERTIES

Average water temperature

Since 1970

The trend in the volume-averaged temperature of Lake Tahoe has increased by approximately 0.7 °F since 1970. The monthly temperature profile data from the lake has been smoothed and deseasonalized to best show the long-term trend. Up till the late 1990s the warming rate was considerably greater, but a high number of deep mixing years since 1997 have slowed the warming rate.

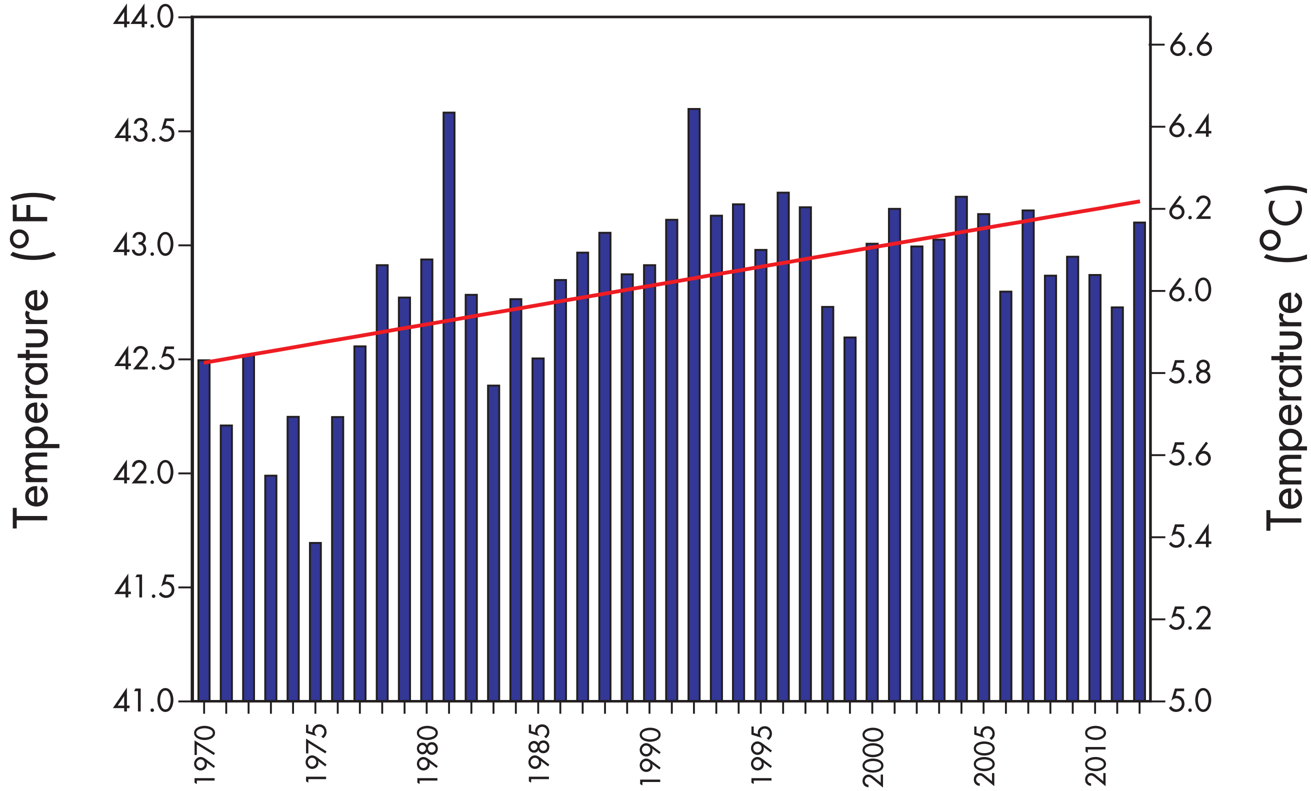


PHYSICAL PROPERTIES

Annual average water temperature

Since 1970

The volume-averaged temperature of the lake for each year since 1970 is shown. In 2012 the volume-averaged temperature increased by 0.4 °F over the previous year. The years with the largest decreases in temperature generally correspond to those years in which deep mixing occurred.

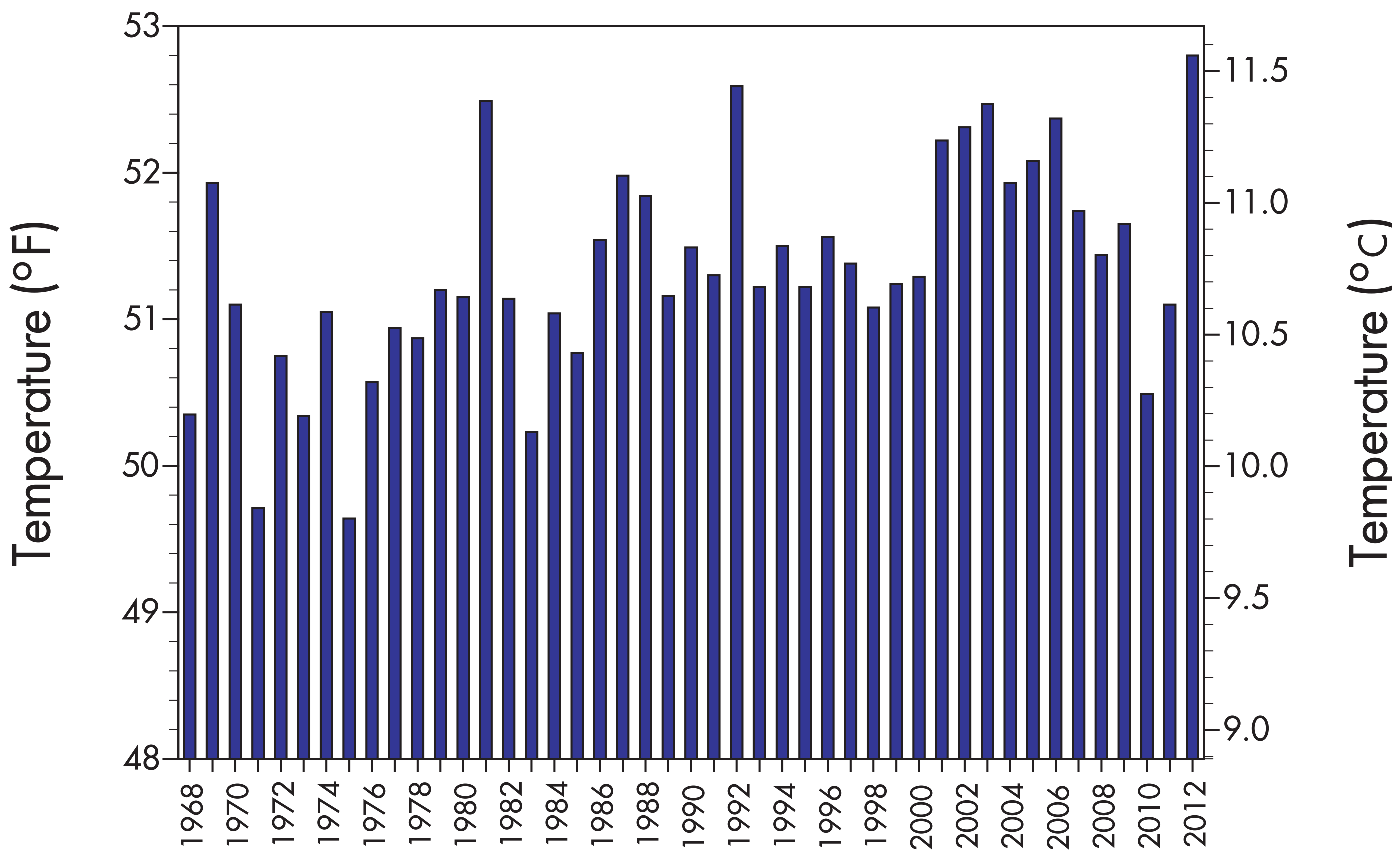


PHYSICAL PROPERTIES

Surface water temperature

Yearly since 1968

Surface water temperatures have been recorded monthly at the mid-lake station since 1968 from the R/V John LeConte. Despite year-to-year variability, water temperatures show an increasing trend. The average temperature in 1968 was 50.3 °F. For 2012, the average surface water temperature was 52.8 °F, an increase of 1.6 °F over 2011, making it the warmest year yet recorded.

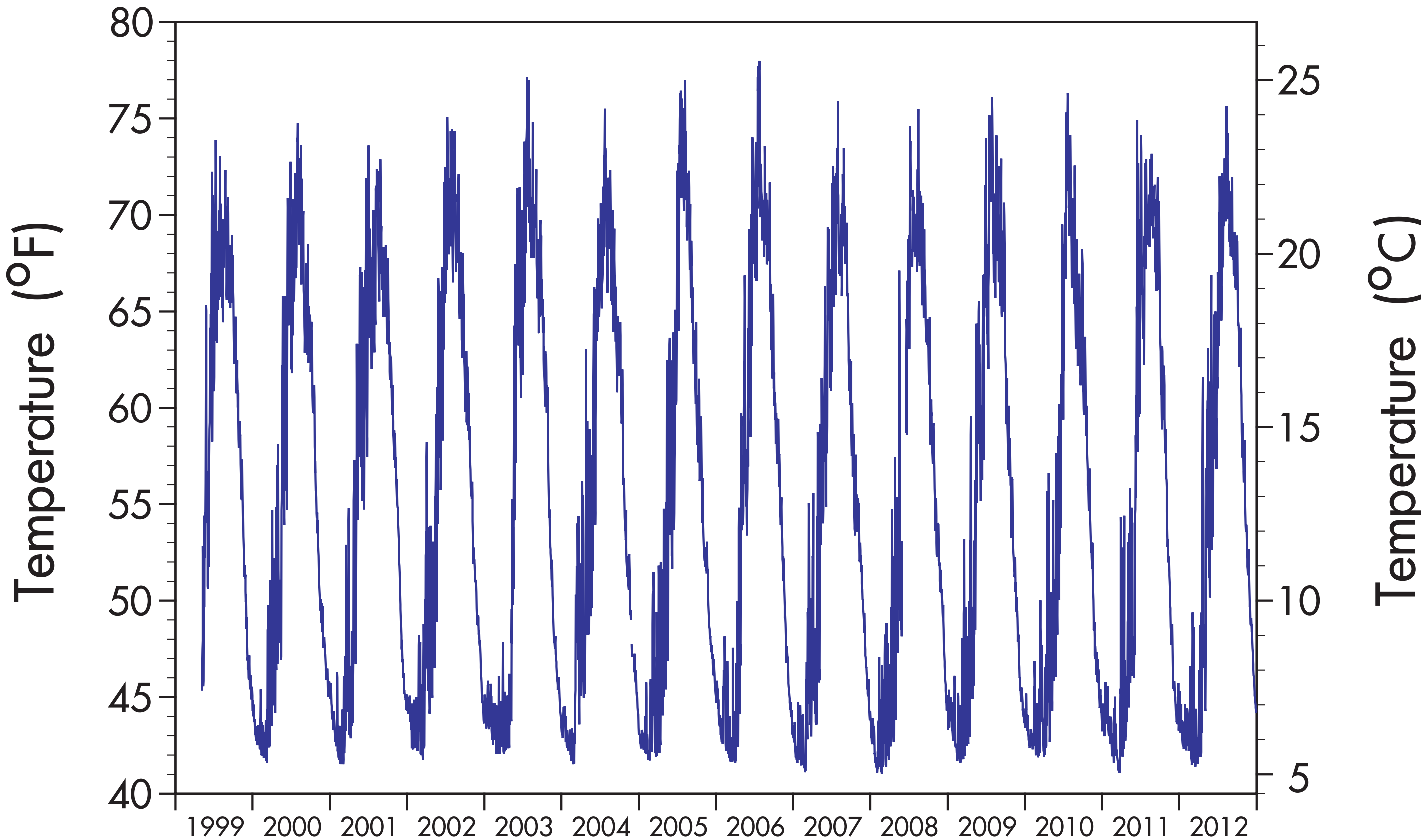


PHYSICAL PROPERTIES

Maximum daily surface water temperature

Surface temperature measured since 1999 every 15 minutes

Maximum daily surface water temperatures were slightly higher in 2012 than the previous year. The highest maximum daily surface water temperature was 75.65 °F, which was recorded on August 14, 2012. The lowest maximum daily surface water temperature was 41.41 °F, which was recorded on March, 18, 2012. These data are collected in real-time by NASA and UC Davis from 4 buoys located over the deepest parts of the lake.

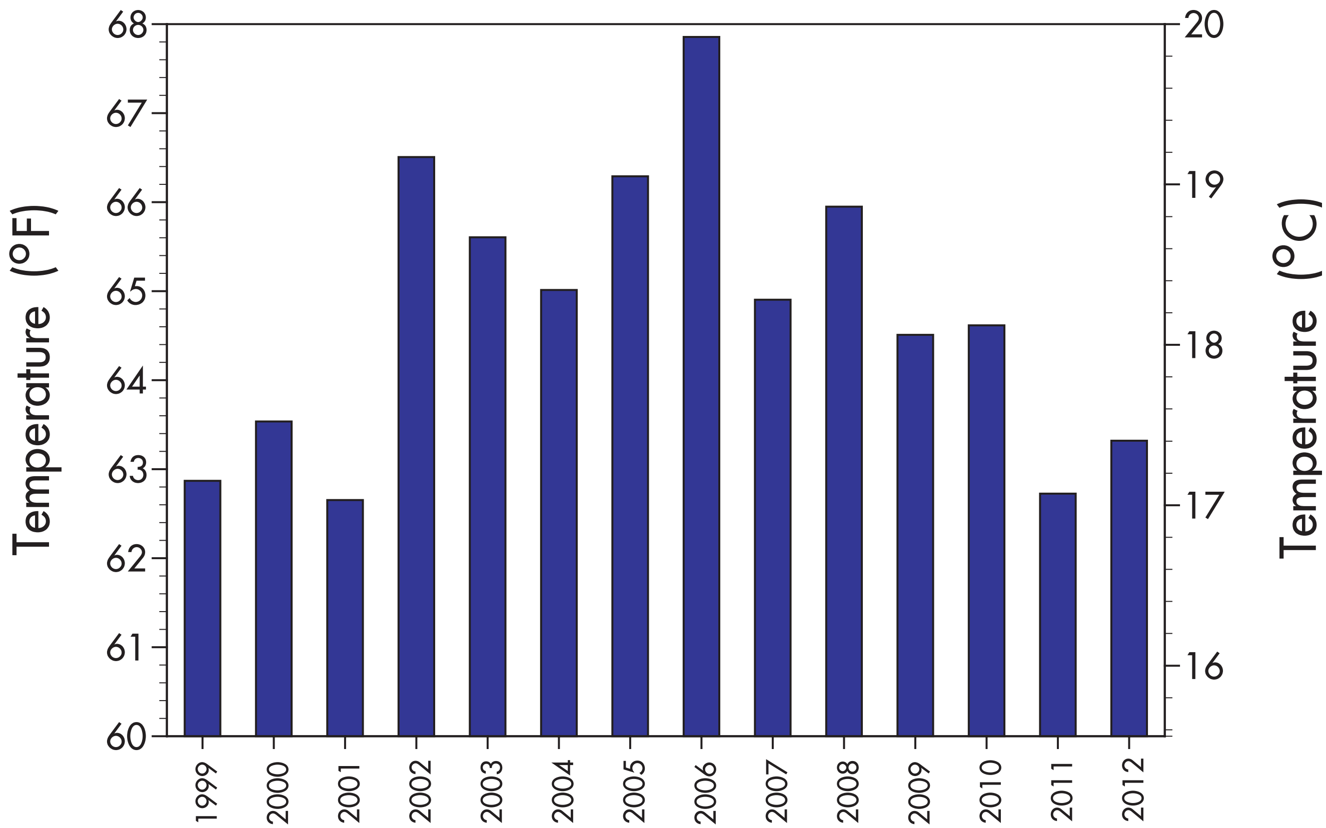


PHYSICAL PROPERTIES

July average surface water temperature

Measured since 1999 every 2 minutes

Since 1999, surface water temperature has been recorded every two minutes from four NASA/UC Davis buoys. Shown here are 14 years of average surface water temperatures in the month of July when water temperatures are typically warmest. In 2012, July surface water temperature averaged 63.3 °F, compared with 62.7 °F in 2011. This increase is most likely attributable to the absence of deep lake mixing in 2012, an event that cools the surface layers of the lake. The average for the 14 year period is 64.7 °F.

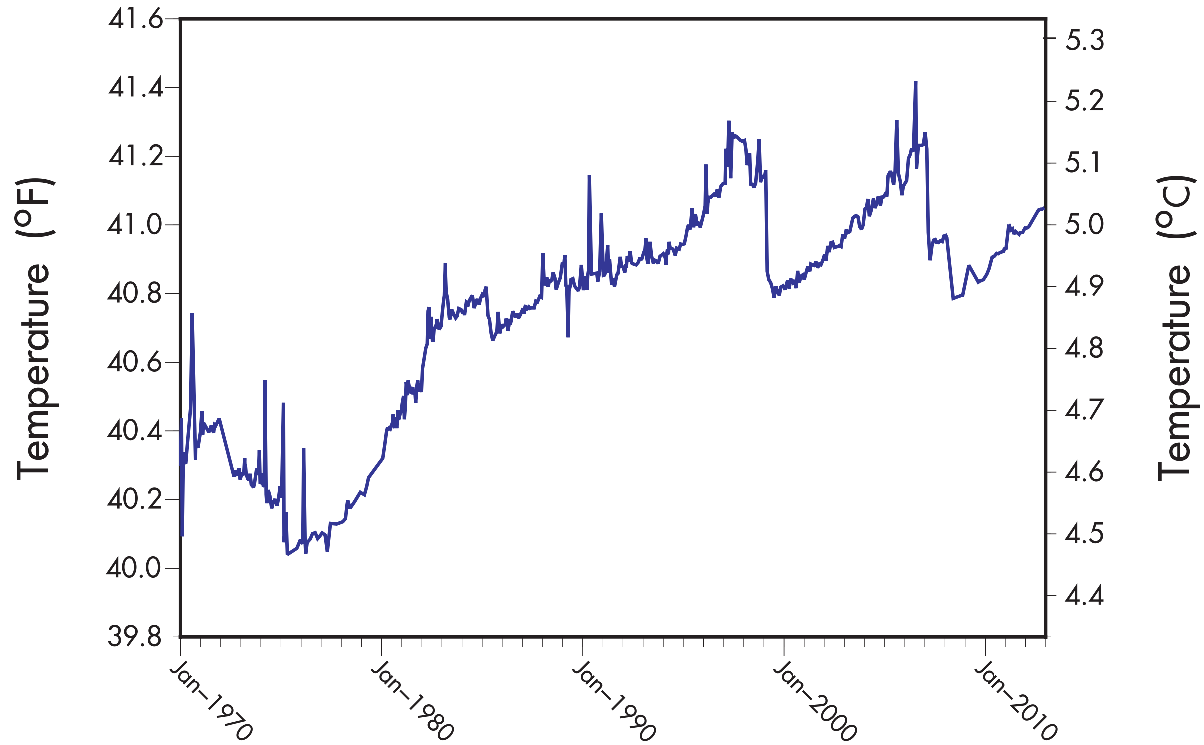


PHYSICAL PROPERTIES

Deep water temperature

Since 1970

The water temperature at a depth of 1320 feet (400 m) is indicative of conditions in the deeper waters (hypolimnion) of Lake Tahoe. Since 1970 the deep water temperature has increased by approximately 1 °F. This increase has not been steady but is punctuated by occasional drops in temperature. These coincide with times when the lake mixes all the way to the bottom, an event which allows a huge amount of heat to escape from the lake. The short spikes of temperature increase are temporary effects caused by sloshing of internal waves.

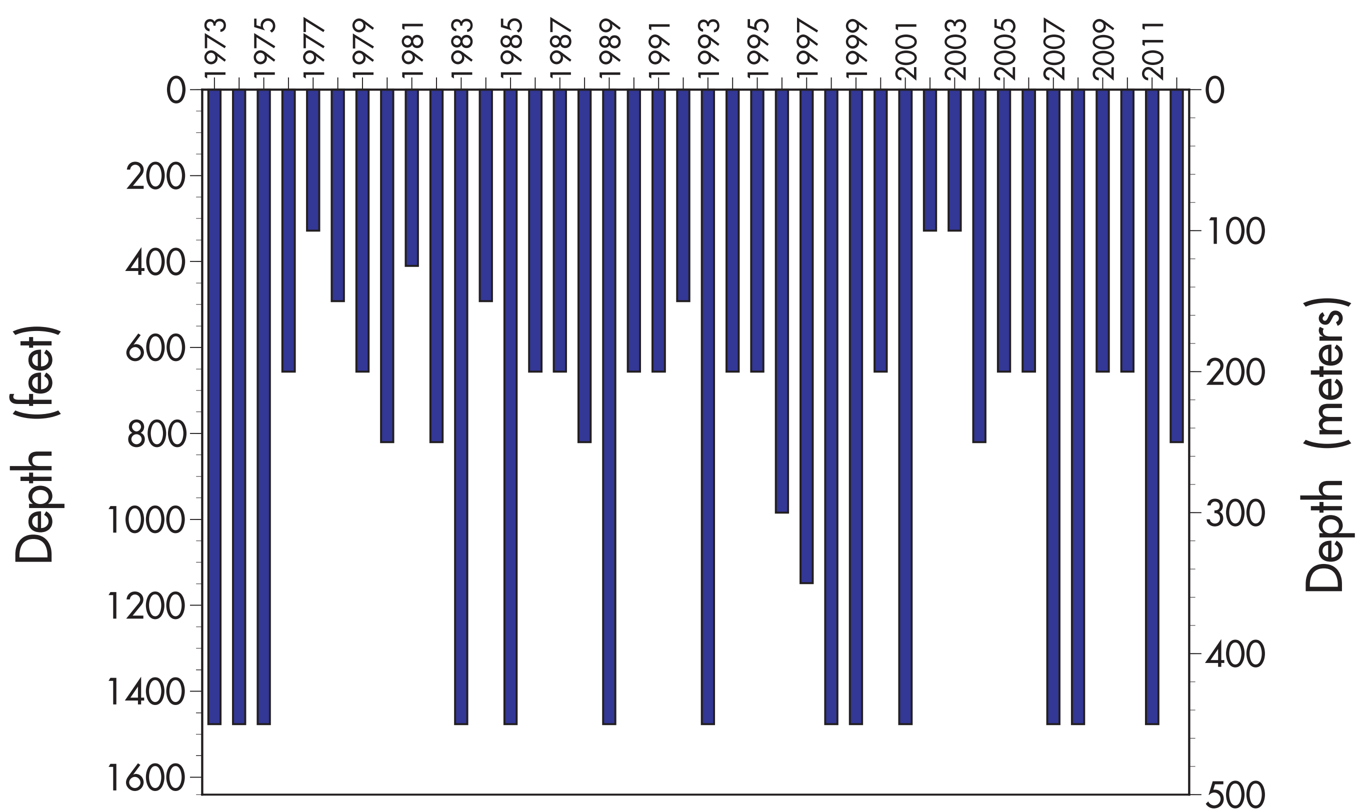


PHYSICAL PROPERTIES

Depth of mixing

Yearly since 1973

Lake Tahoe mixes each winter as surface waters cool and sink downward. In a lake as deep as Tahoe, the wind energy and intense cooling of winter storms helps to determine how deeply the lake mixes. Mixing depth has profound impacts on lake ecology and water quality. Deep mixing brings nutrients to the surface, where they promote algae growth. It also moves oxygen to deep waters, promoting aquatic life throughout the water column. The deepest mixing typically occurs in February to March. In 2012, Lake Tahoe mixed to a depth of only 820 feet (250m). This lack of deep mixing most likely contributed to the warmer surface temperature and the improved clarity.

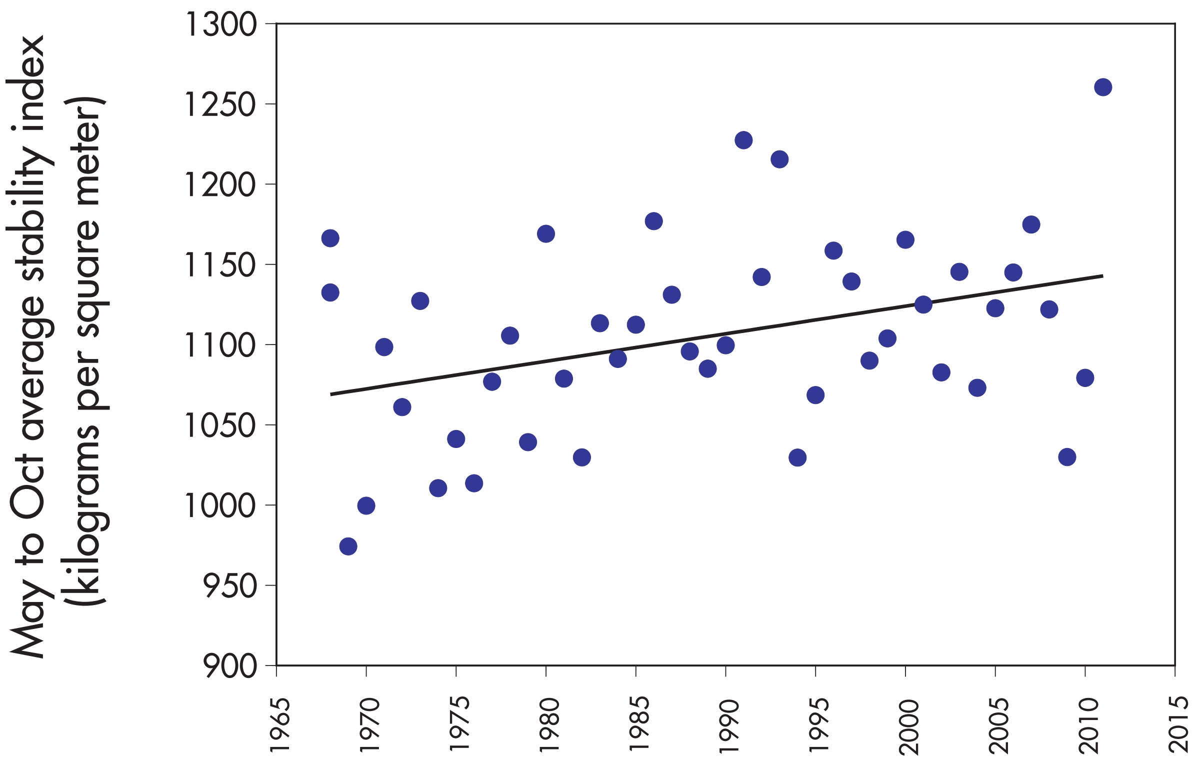


PHYSICAL PROPERTIES

Lake stability

Since 1968

When the lake has a vertical distribution of temperature, it has a corresponding density distribution, with warm and lighter water at the surface, and colder, denser water at depth. The stability index is a measure of the energy required to fully mix the lake when its density is stratified. Plotted here is the average stability index for the upper 100 meters (330 feet) of Lake Tahoe for the period of May through October each year. The values are derived from temperature profiles taken at the Index Station at approximately 10-20 day intervals. There has been an overall increase in lake stability in the last 45 years. In 2012, the lake stability was at an all time high.



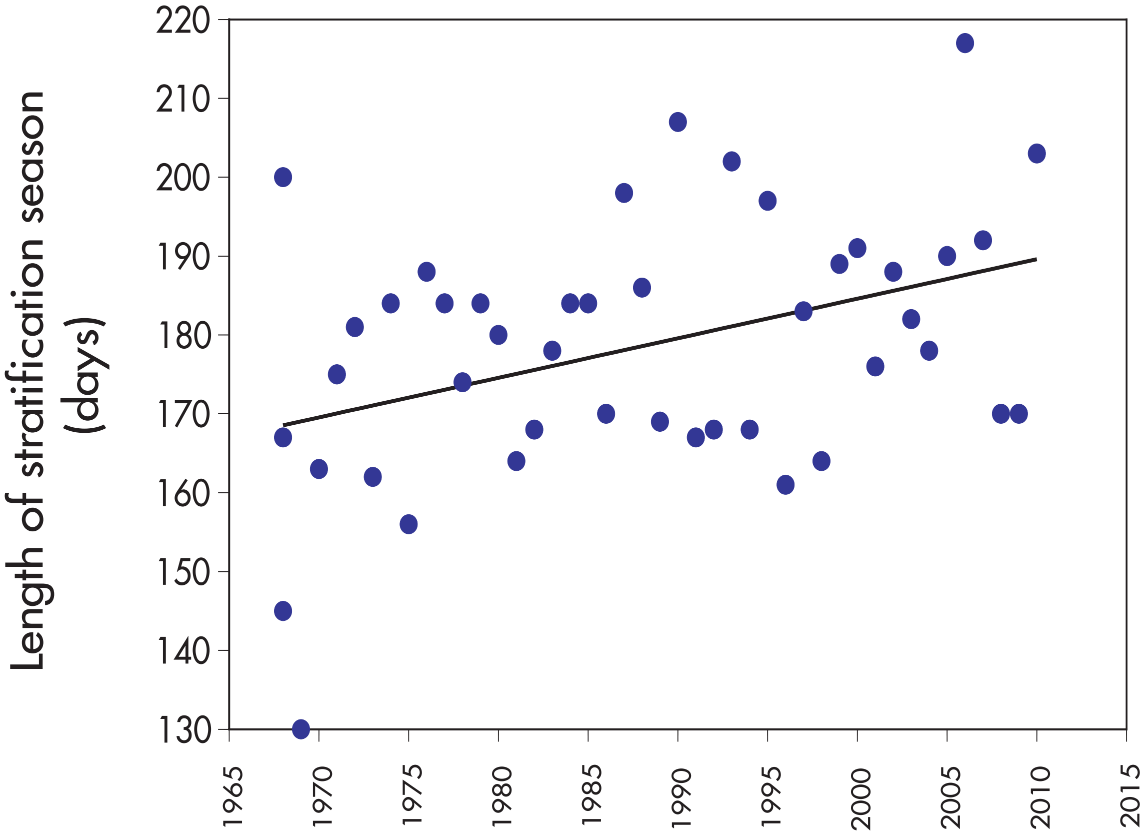
PHYSICAL PROPERTIES

Stratified season length

Since 1968

The stability index, a measure of the energy required to fully mix the lake, can be evaluated for every day of the year. We define the stratification season as the length of time when the stratification index exceeds a value of 600 kilograms per square meter. Since 1968 the length of the stratification season has lengthened, albeit with considerable year-to-year variation.

Overall the stratification season has lengthened by approximately three weeks.

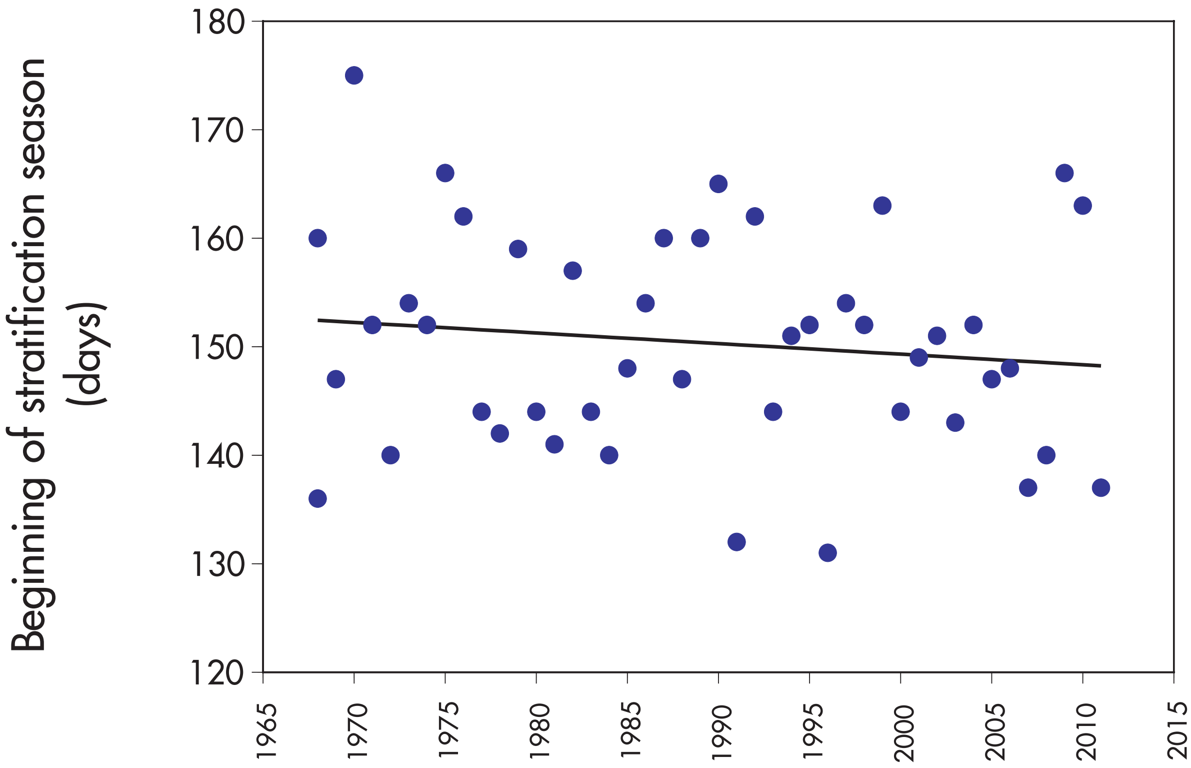


PHYSICAL PROPERTIES

Beginning of the stratification season

Since 1968

The length of time that Lake Tahoe is stratified has lengthened since 1968 by approximately three weeks. The commencement of stratification appears to occur earlier in the year by approximately three days on average.

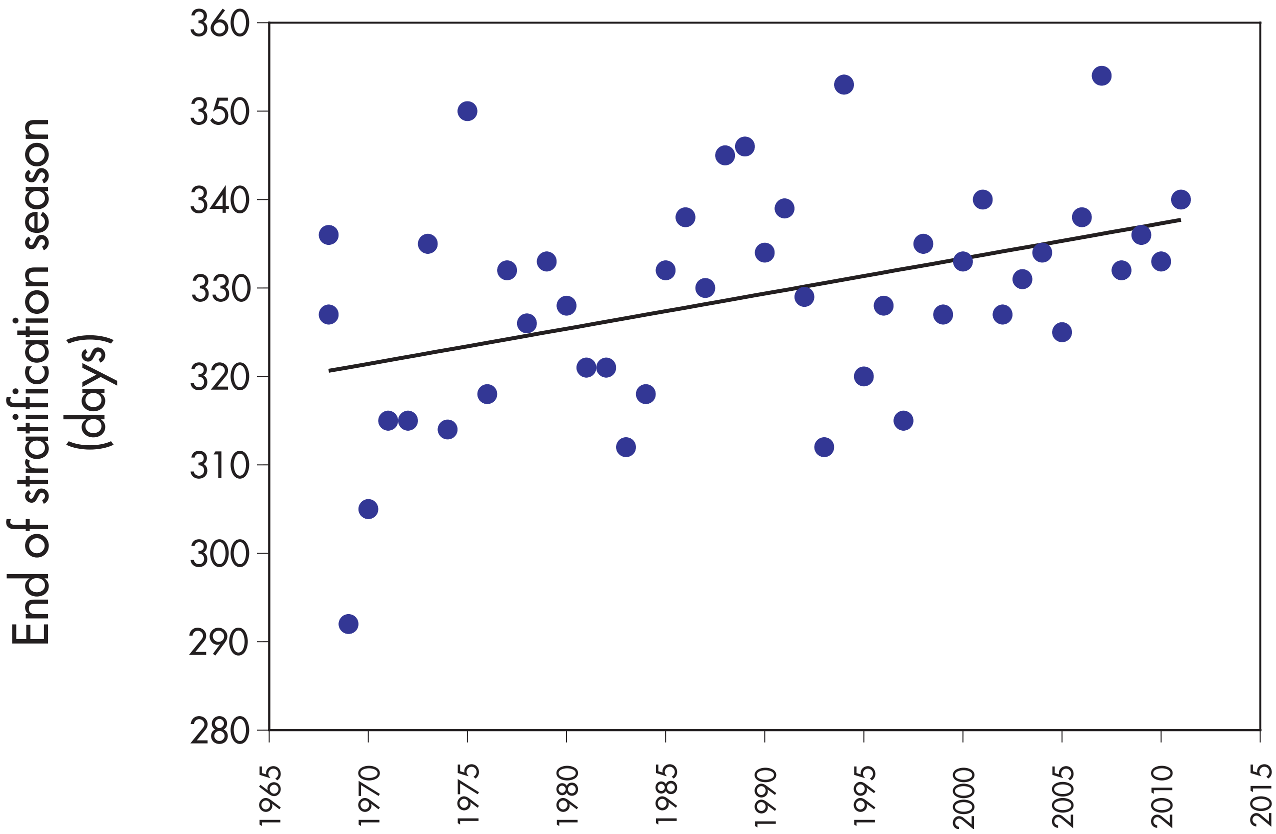


PHYSICAL PROPERTIES

End of stratification season

Since 1968

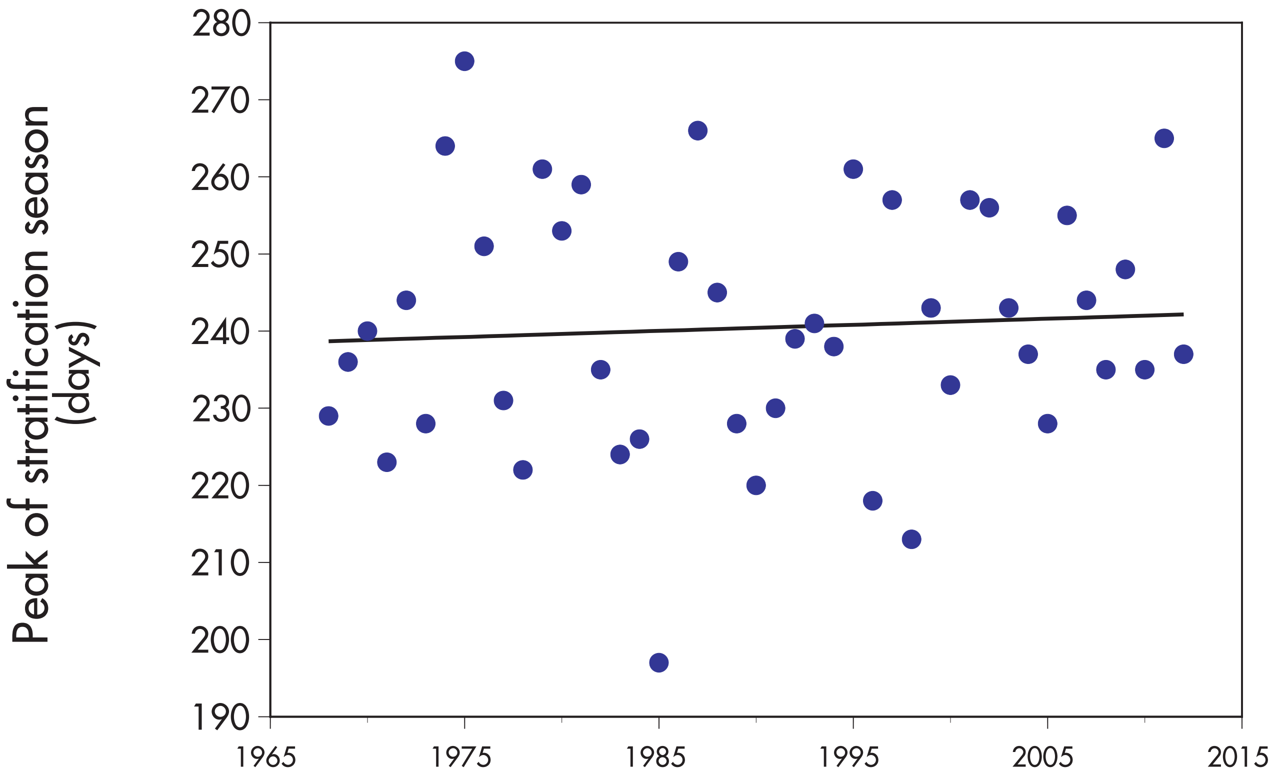
The length of time that Lake Tahoe is stratified has lengthened since 1968 by approximately three weeks. The end of stratification appears to have been extended by approximately 18 days on average. In other words, the fall season for the lake has been considerably extended.



Peak stratification value

Since 1968

The maximum value that the stability index obtains for each year has been plotted. As can be seen, the strength of the stratification has not changed significantly since 1968. However, as the previous figures indicate, the length of time for which the lake remains density stratified has increased.

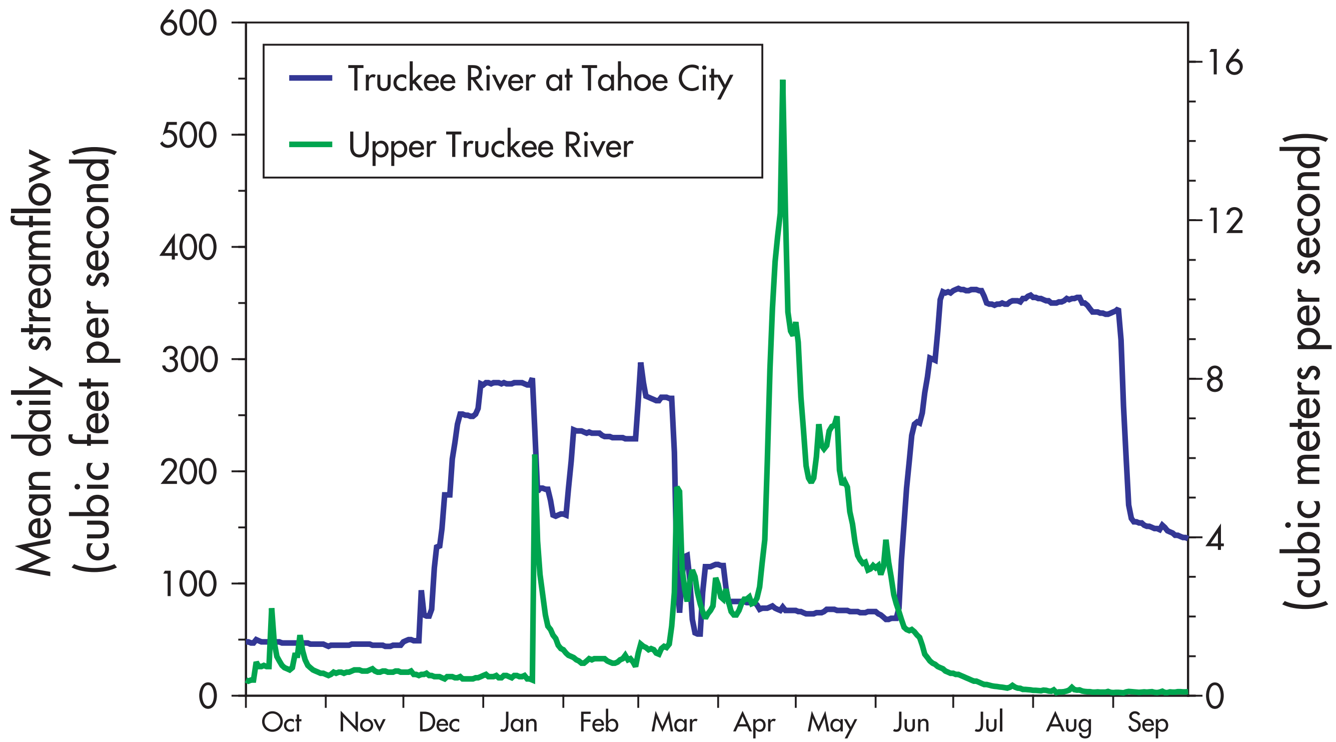


PHYSICAL PROPERTIES

Mean daily streamflow of Upper Truckee River vs. Truckee River

Water Year 2012

The Upper Truckee River, the largest inflow into Lake Tahoe, has a natural annual hydrograph for a snow-fed stream. The small peaks in the hydrograph represent rain events or short warm periods in winter or spring. The major peak in the hydrograph represents the maximum spring snowmelt. The peak in 2012 was 678 cubic feet per second on April 26, two-thirds of the previous year's peak. The Truckee River is the only outflow from Lake Tahoe. It is a regulated flow, with release quantity controlled by the Federal water master. The release rates are set according to downstream demands for water and concerns for flooding. The maximum discharge in 2012 was 368 cubic feet per second on June 26 (50% higher than the previous year), and the peak temperature of the discharge was 72.7 °F on August 15. Streamflow data are collected by the US Geological Survey under the Lake Tahoe Interagency Monitoring Program (LTIMP).



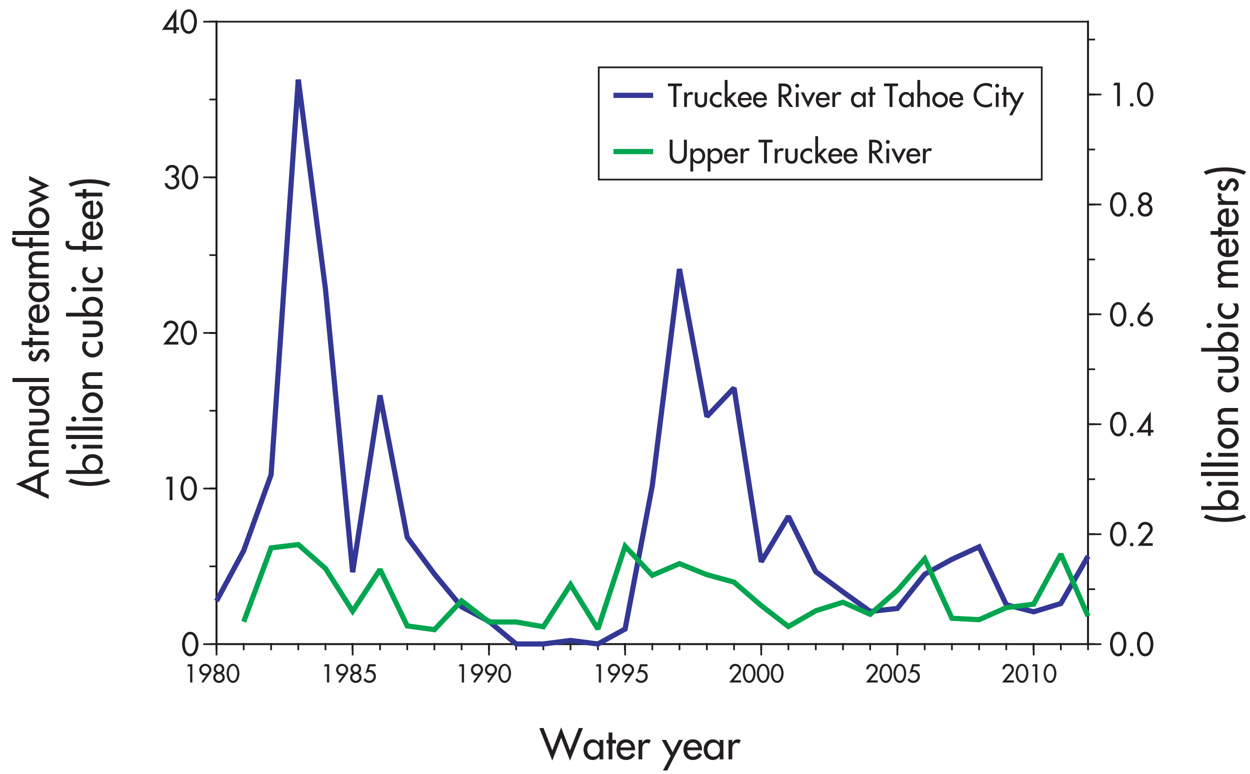
PHYSICAL PROPERTIES

Truckee River summer discharge and lake elevation

Since 1980

Flow into Lake Tahoe (e.g. Upper Truckee River) and discharge out of Lake Tahoe (Truckee River at Tahoe City) have shown considerable variation since 1980. The large peaks in discharge from the lake correspond to years when precipitation (and therefore total inflow) was the greatest, e.g. 1982-1983, 1986, 1995-1999. Similarly, the drought-like conditions in the early 1990s and the low precipitation years in the beginning of the 2000s also stand out. Since many of the pollutants of concern for Lake Tahoe's clarity enter along with surface flow, year-to-year changes in clarity are influenced by precipitation and runoff.

In 2012 discharges into and out of the lake were well below the long-term averages. The Upper Truckee River inflow volume was 1.80 billion cubic feet (long-term average 3.09). The Truckee River discharge was 5.65 billion cubic feet (long-term average 7.29).

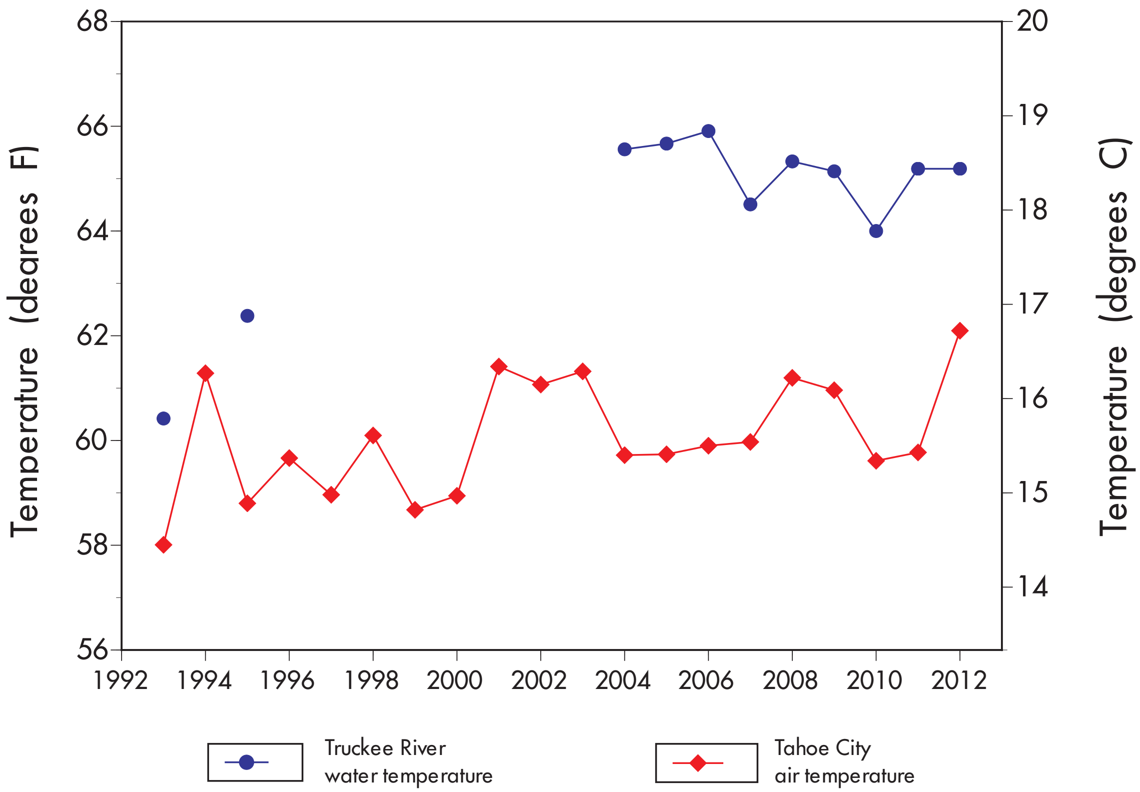


PHYSICAL PROPERTIES

Truckee River Summer Water Temperatures

Since 1993

Water temperature of the Truckee River as it departs Lake Tahoe in the summer months (July-September) is measured by the US Geological Survey. Data gaps prevent a complete pattern, but the measurements suggest that a 4-5 °F rise in the average temperature has occurred during the period since 1993. Average air temperatures from Lake Tahoe for the same period also suggest a temperature rise but at a lower rate. Rising river temperatures impact downstream fish spawning.



PHYSICAL PROPERTIES

Annual Discharge Volume for Upper Truckee River and Truckee River

Since 1980

Flow rate of the Truckee River as it departs Lake Tahoe in the summer months (July-September) and lake level is measured by the US Geological Survey. Here the relationship between these two variables is evident, with mean daily river discharge typically showing a one year lag from the mean lake elevation. Gage height is measured relative to a datum of 6,220 feet. Release of water from Lake Tahoe is controlled by the Federal Water Master.

TAHOE: STATE OF THE LAKE REPORT 2013

NUTRIENTS AND PARTICLES

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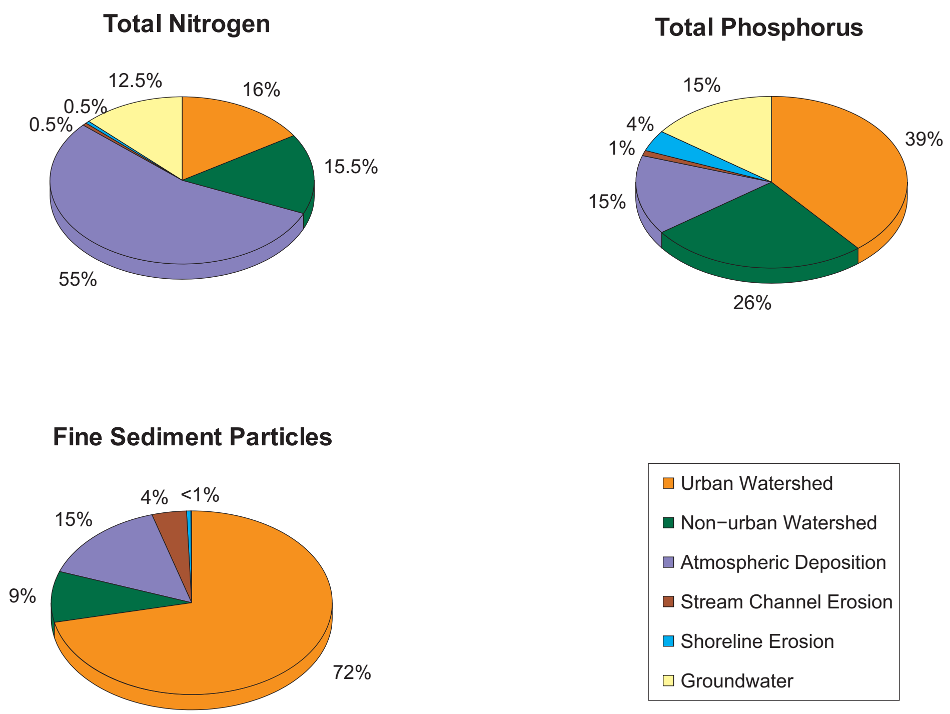
NUTRIENTS AND PARTICLES

Sources of clarity-reducing pollutants

Previous research has quantified the primary sources of nutrients (nitrogen and phosphorus) and particulate material that are causing Lake Tahoe to lose clarity in its upper waters. Extremely fine particles, the major contributor to clarity decline, primarily originate from the urban watershed (70-75 percent), even though these areas cover only 10 percent of the land area. For nitrogen, atmospheric deposition is the major source (55 percent). Phosphorus is primarily introduced by the urban (39 percent) and non-urban (26 percent) watersheds. These categories of pollutant sources form the basis of a strategy to restore Lake Tahoe's open-water clarity by agencies including the Lahontan Regional Water Quality Control Board, the Nevada Division of Environmental Protection, and the Tahoe Regional Planning Agency. (Data were generated for the Lake Tahoe TMDL Program and this figure also appeared in previous year's State of the Lake Reports.)

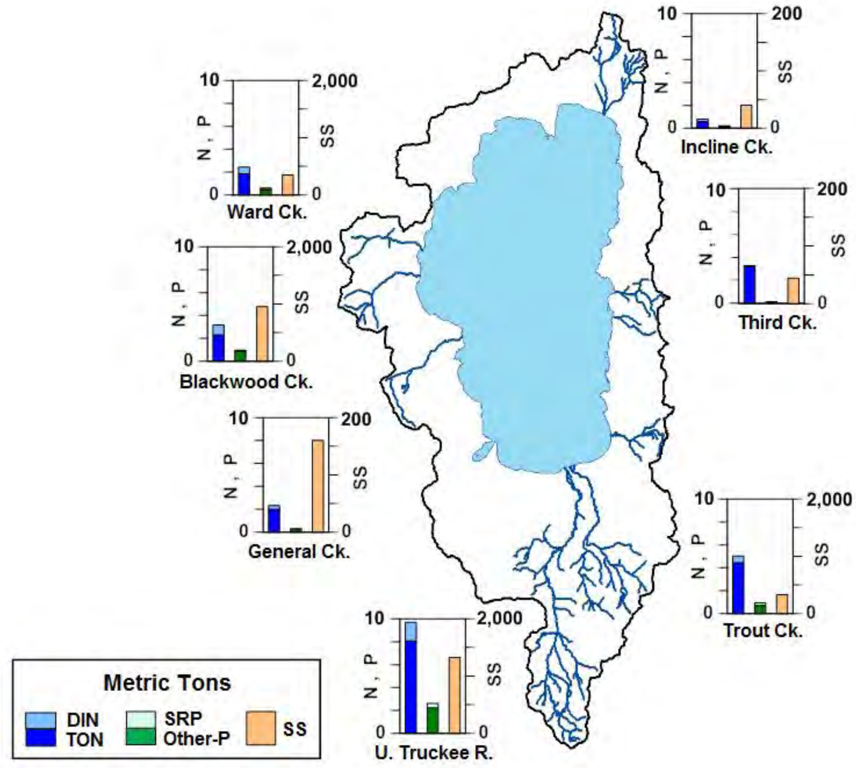


NUTRIENTS AND PARTICLES

Pollutant loads from seven watersheds

In 2012

The Lake Tahoe Interagency Monitoring Program (LTIMP) measures nutrient and sediment input from seven of the 63 watershed streams – a reduction of three streams since 2011. Most of the suspended sediment contained in the 7 LTIMP streams is from the Upper Truckee River, Blackwood Creek, Trout Creek and Ward Creek. Over 75 percent of the phosphorus and nitrogen comes from the Upper Truckee River, Trout Creek and Blackwood Creek. Pollutant loads from the west-side streams were a factor of four lower in 2012, compared with 2011. This was largely due to the drier year that the basin experienced. Blackwood Creek suspended sediment loads have exceeded those of the Upper Truckee River for the last five years. For the eastside streams, Incline Creek pollutant loads fell relative to Third Creek particularly for nitrogen.



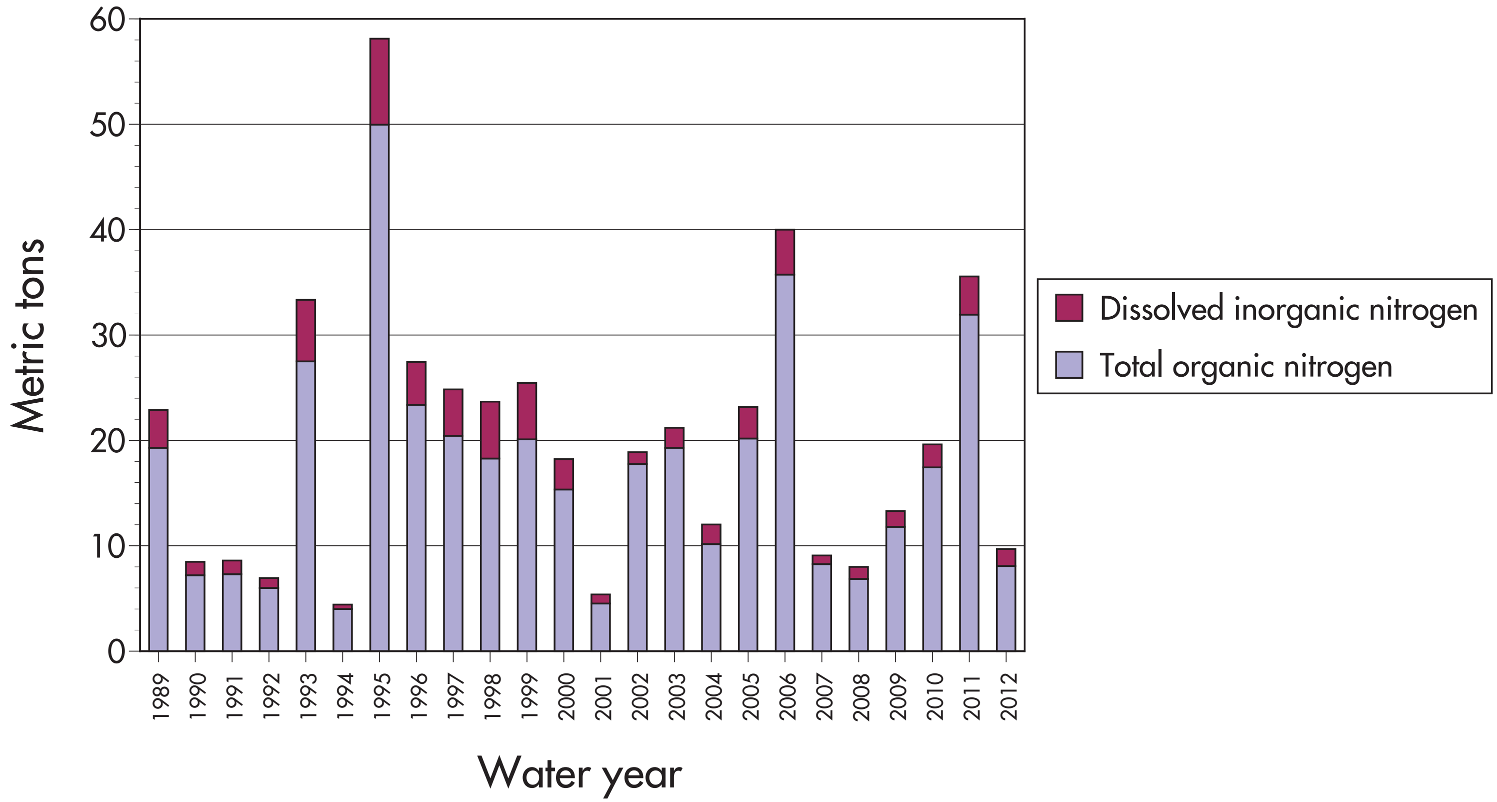
The LTIMP stream water quality program is supported by the U.S. Geological Survey in Carson City, Nevada, UC Davis TERC and the Tahoe Regional Planning Agency. Additional funding was provided by the USFS – Lake Tahoe Basin Management Unit.

N = Nitrogen
P = Phosphorus
DIN = Dissolved Inorganic Nitrogen
SRP = Soluble Reactive Phosphorus
TON = Total Organic Nitrogen
SS = Suspended Sediment

Nitrogen contribution by Upper Truckee River

Yearly since 1989

Nitrogen (N) is important because it, along with phosphorus (P), stimulates algal growth (Fig. 9.1 shows the major sources of N and P to Lake Tahoe). The Upper Truckee River is the largest of the 63 streams that flow into Lake Tahoe, contributing about 25 percent of the inflowing water. The river's contribution of dissolved inorganic nitrogen (nitrate and ammonium) and total organic nitrogen loads are shown here. The year-to-year variations primarily reflect changes in precipitation. For example, 1994 had 16.6 inches of precipitation and a low nitrogen load, while 1995 had 60.8 inches of precipitation and a very high nitrogen load. Similarly 2012 had 22.48 inches of precipitation and 2011 had 51.78 inches of precipitation. This below-average precipitation in 2012 resulted in a nitrogen load that was almost one quarter of the previous year's. (One metric ton = 2,205 pounds.)

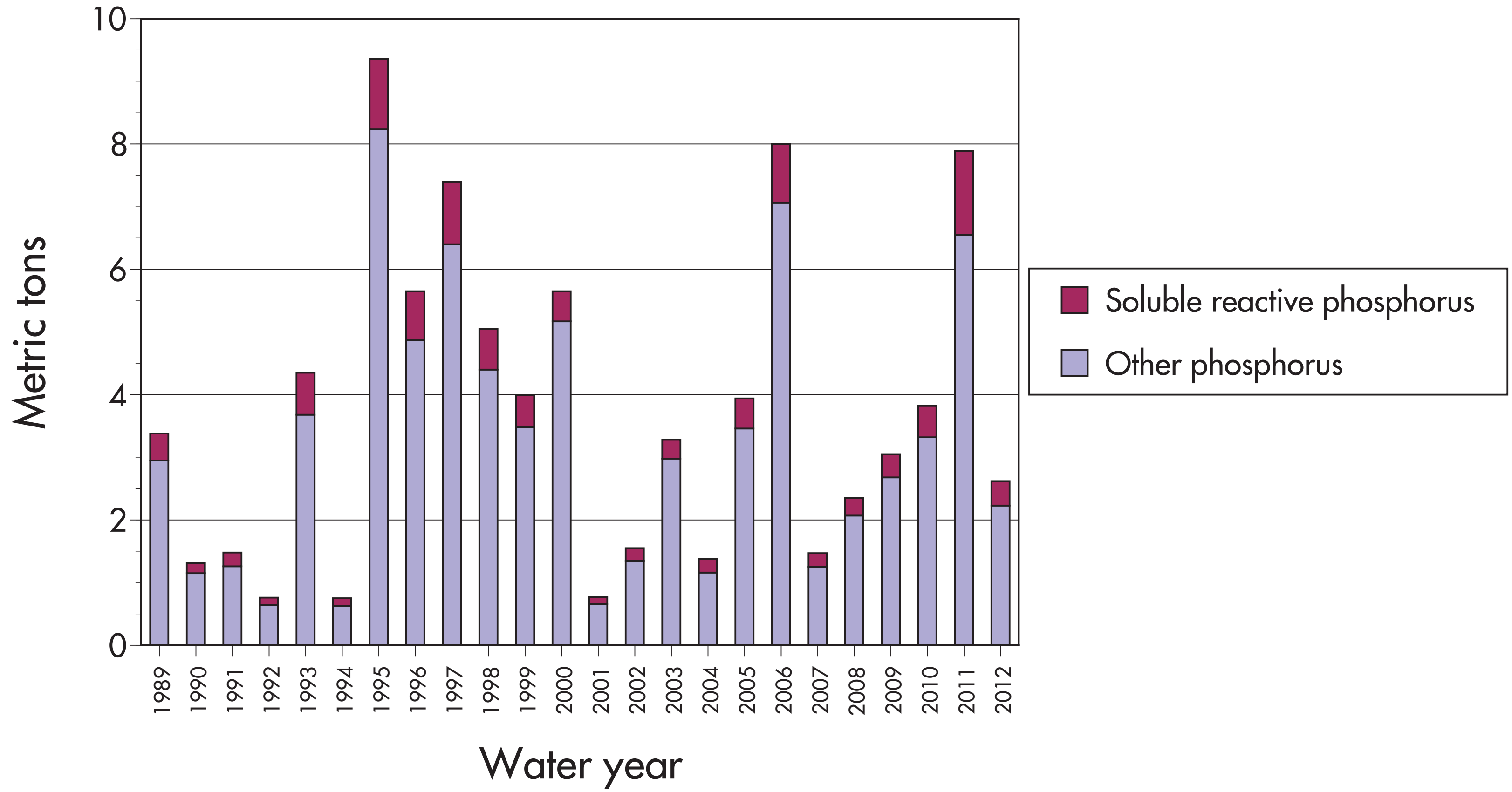


NUTRIENTS AND PARTICLES

Phosphorus contribution by Upper Truckee River

Yearly since 1989

Soluble reactive phosphorus (SRP) is that fraction of phosphorus immediately available for algal growth. As with nitrogen (Fig. 9.3), the year-to-year variation in load largely reflects the changes in precipitation. Below average precipitation in 2012 resulted in a factor of three reduction of the phosphorus load over the previous year. Total phosphorus is the sum of SRP and other phosphorus, which includes organic phosphorus and phosphorus associated with particles. (One metric ton = 2,205 pounds.)

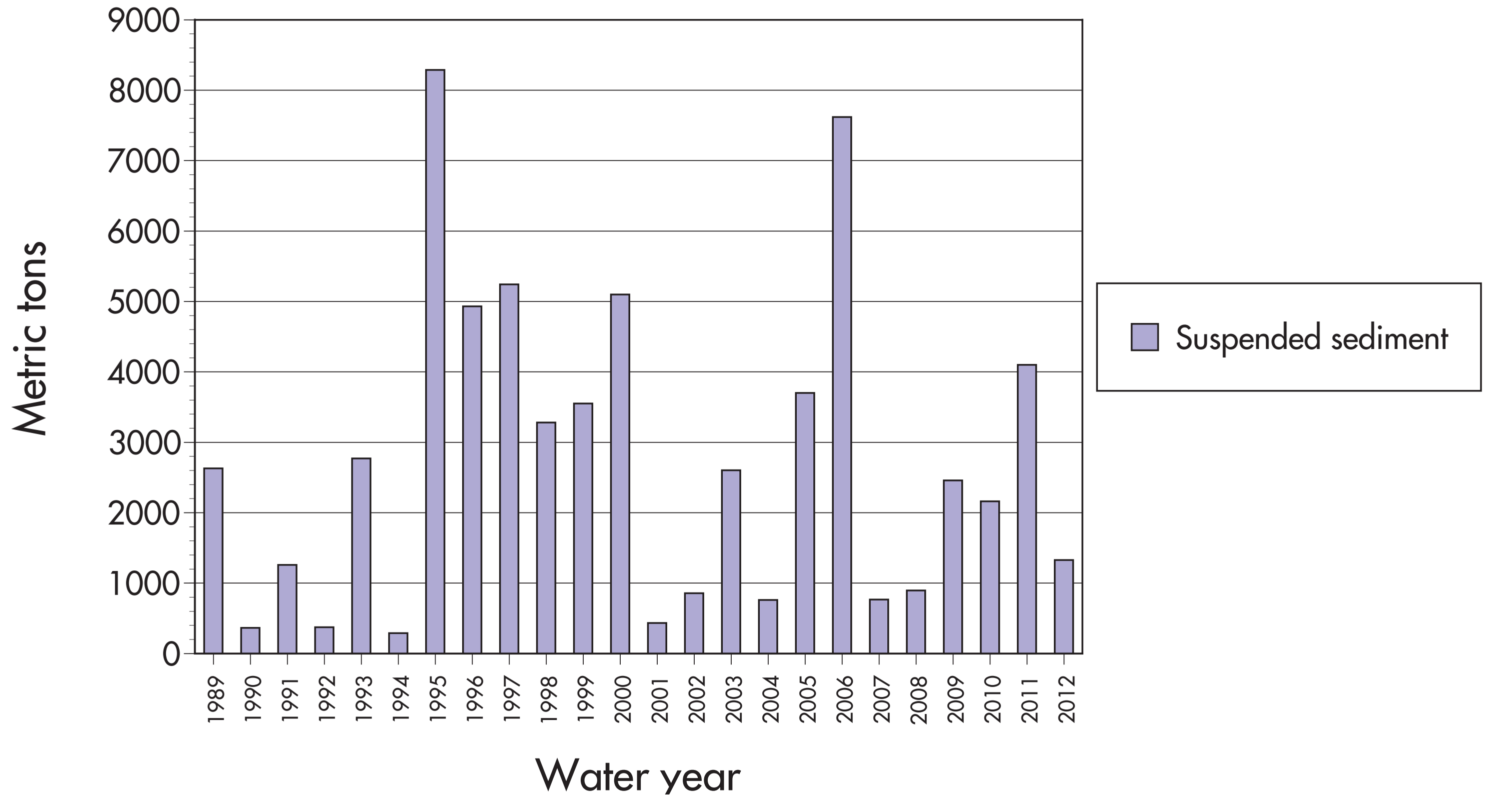


NUTRIENTS AND PARTICLES

Suspended sediment contribution by Upper Truckee River

Yearly since 1989

The load of suspended sediment delivered to the lake by the Upper Truckee is related to landscape condition and erosion as well as to precipitation and stream flow. Certainly, inter-annual variation in sediment load over shorter time scales is more related to the latter. Below average precipitation in 2012 resulted in a factor of three decrease of the suspended sediment load compared with the previous years. This and the previous two figures illustrate how greatly changes in hydrological conditions affect pollutant loads. Plans to restore lake clarity emphasize reducing loads of very fine suspended sediment (less than 20 microns in diameter). Efforts to restore natural stream function and watershed condition focus on reducing loads of total sediment regardless of size.

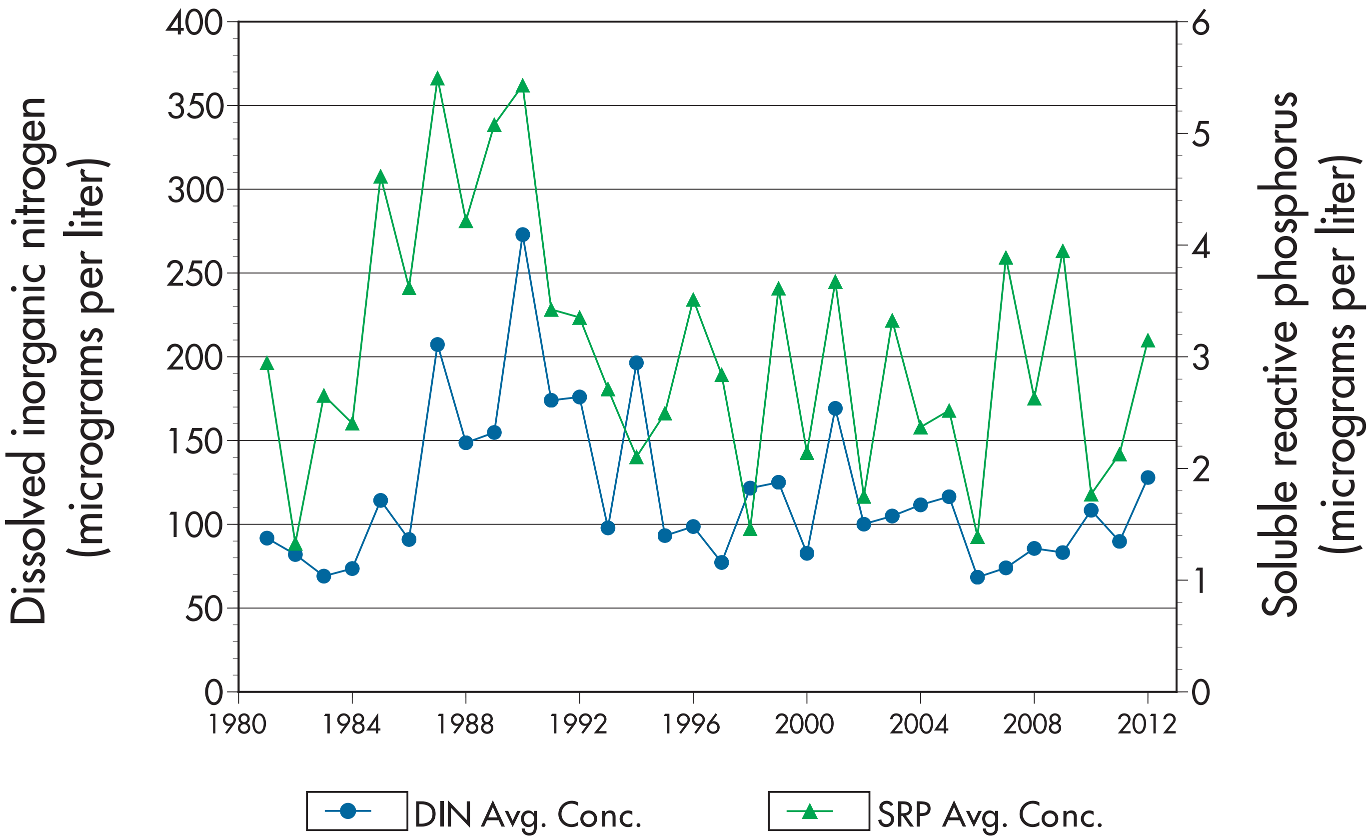


NUTRIENTS AND PARTICLES

Nutrient concentrations in rain and snow

Yearly since 1981

Nutrients in rainwater and snow (called wet deposition) contribute large amounts of nitrogen, but also significant phosphorus, to Lake Tahoe. Nutrients in precipitation have been measured near Ward Creek since 1981, and show no consistent upward or downward trend. Annual concentrations in precipitation of dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) vary from year to year. In 2012, concentrations of DIN and SRP increased significantly over the previous year. This may be due to the lower precipitation in 2012.

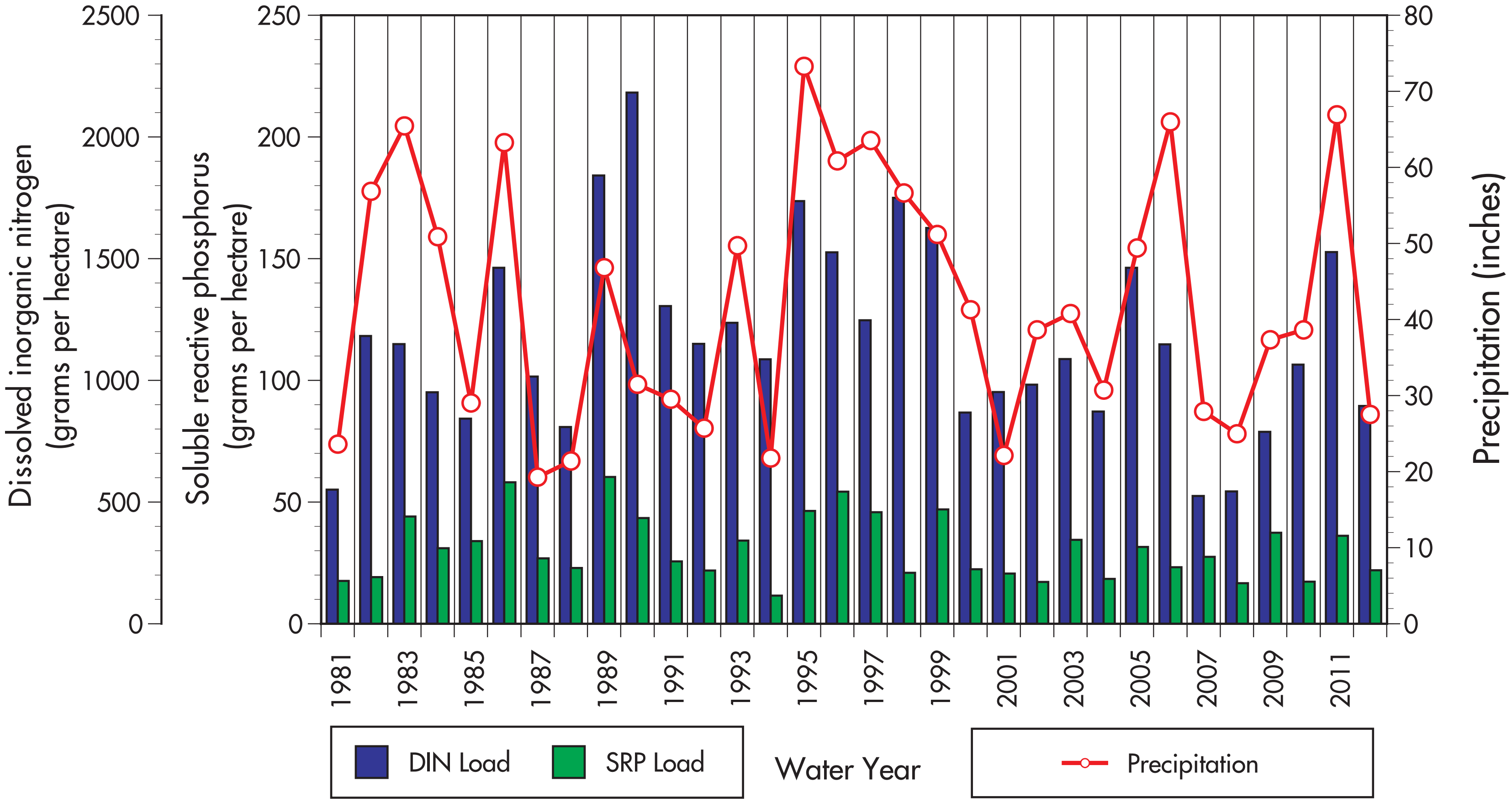


NUTRIENTS AND PARTICLES

Nutrient loads in rain and snow

Yearly since 1981

The annual load for wet deposition is calculated by multiplying the concentration of dissolved inorganic nitrogen (nitrate and ammonium) and soluble reactive phosphorus (in the previous graph) by total annual precipitation. While nitrogen and phosphorus loads from precipitation have varied from year to year at the Ward Creek monitoring site, no obvious long-term trend has emerged. In 2012, the nitrogen and phosphorus loads were within the range seen in previous years.

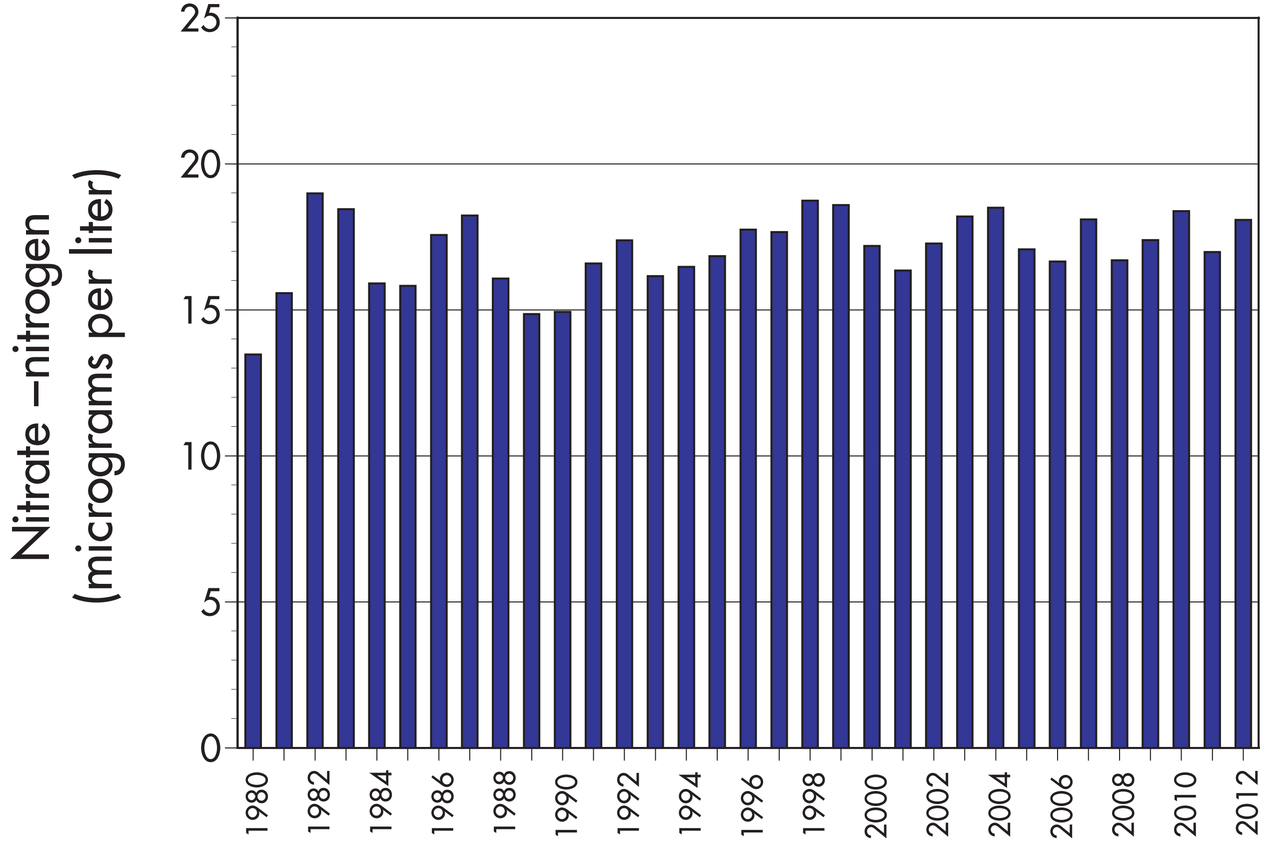


NUTRIENTS AND PARTICLES

Lake nitrate concentration

Yearly since 1980

Since 1980, the volume-weighted annual average concentration of nitrate-nitrogen has remained relatively constant, ranging between 13 and 19 micrograms per liter. In 2012, the volume-weighted annual average concentration of nitrate-nitrogen was 18 micrograms per liter. These measurements are taken at the MLTP (mid-lake) station. Water samples could not be collected in March or September 2012 due to weather conditions. However, the two collections in October (10/2/12 and 10/18/12) were representative of the Sept-Oct 2012 period.

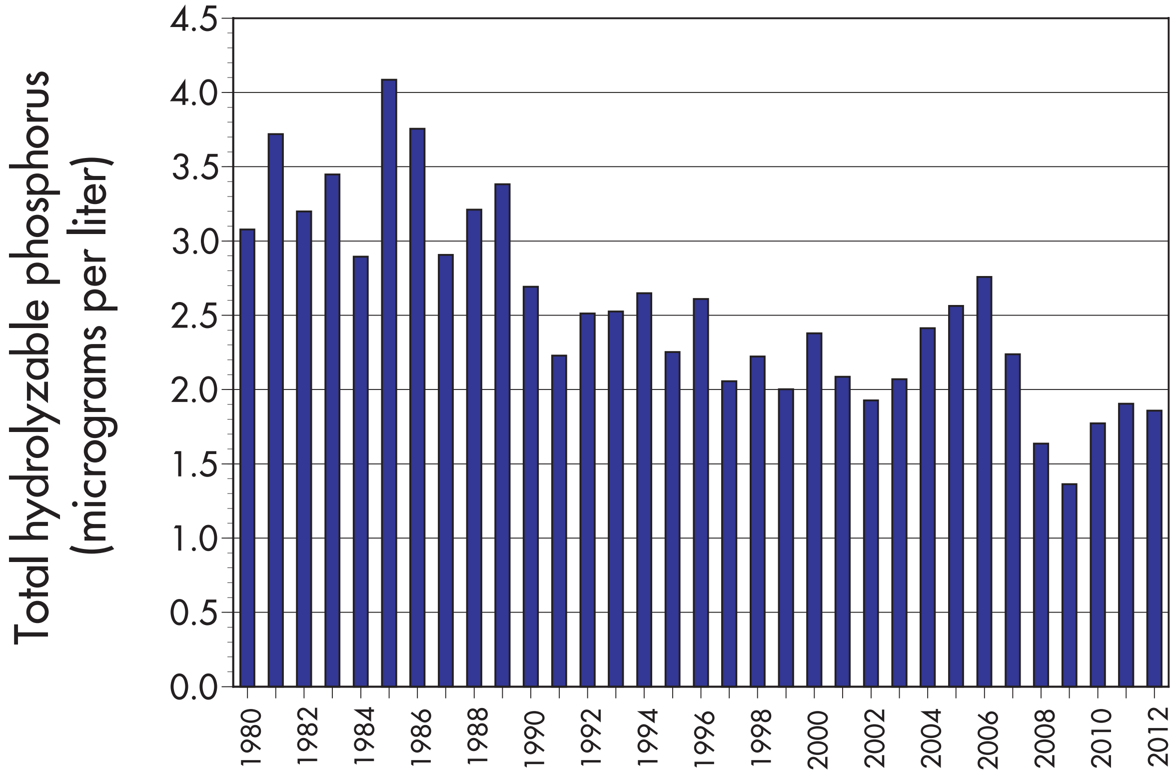


NUTRIENTS AND PARTICLES

Lake phosphorus concentration

Yearly since 1980

Phosphorus naturally occurs in Tahoe Basin soils and enters the lake from soil disturbance and erosion. Total hydrolyzable phosphorus, or THP, is a measure of the fraction of phosphorus algae can use to grow. It is similar to the SRP that is measured in the streams. Since 1980, THP has tended to decline. In 2012, the volume-weighted annual average concentration of THP was approximately 1.8 micrograms per liter, a slight decrease over the previous year. Water samples could not be collected in March or September 2012 due to weather conditions. However, the two collections in October (10/2/12 and 10/18/12) were representative of the Sept-Oct period.



TAHOE: STATE OF THE LAKE REPORT 2013

BIOLOGY

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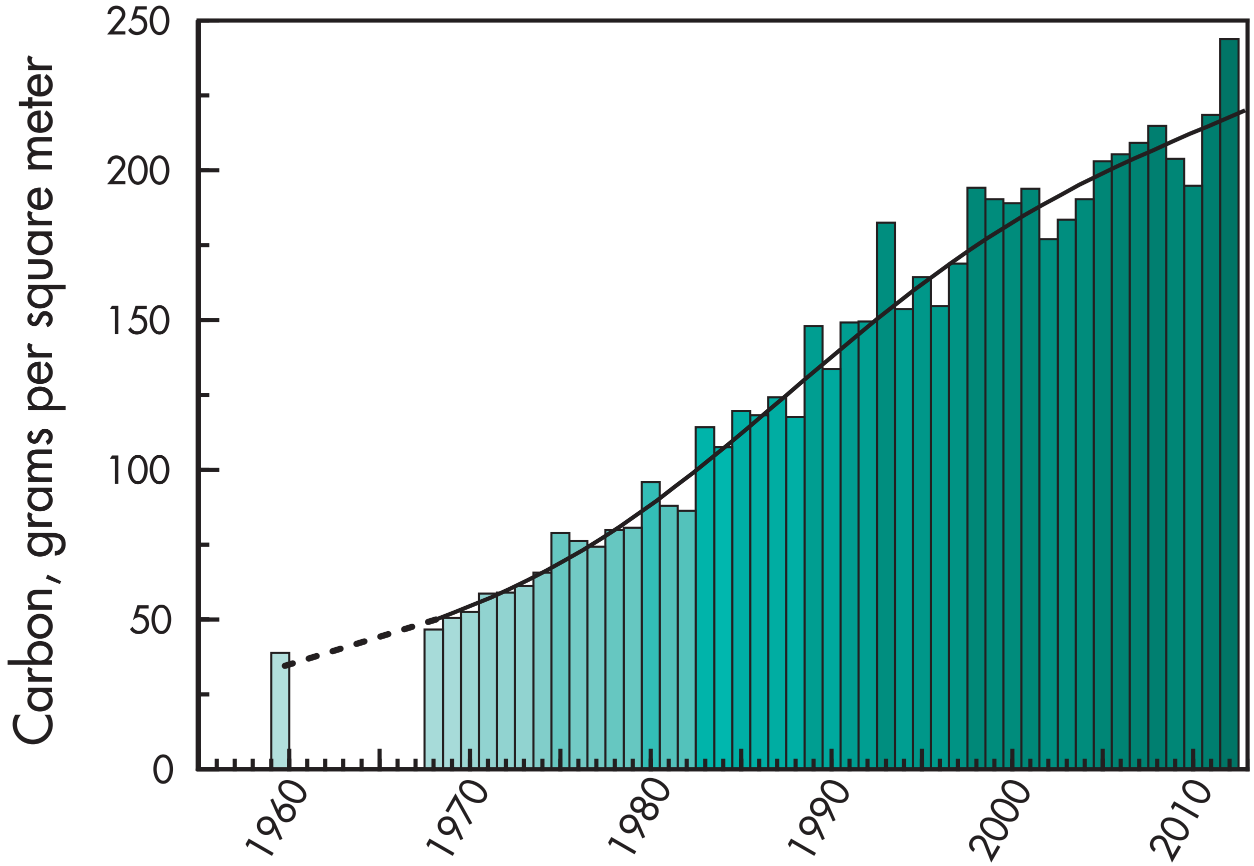
BIOLOGY

Algae growth (primary productivity)

Yearly since 1959

Primary productivity is a measure of the rate at which algae produce biomass through photosynthesis. It was first measured at Lake Tahoe in 1959 and has been continuously measured since 1968. Primary productivity has generally increased over that time, promoted by nutrient loading to the lake, changes in the underwater light environment and a succession of algae species. In 2012, primary productivity was 243.8 grams of carbon per square meter.



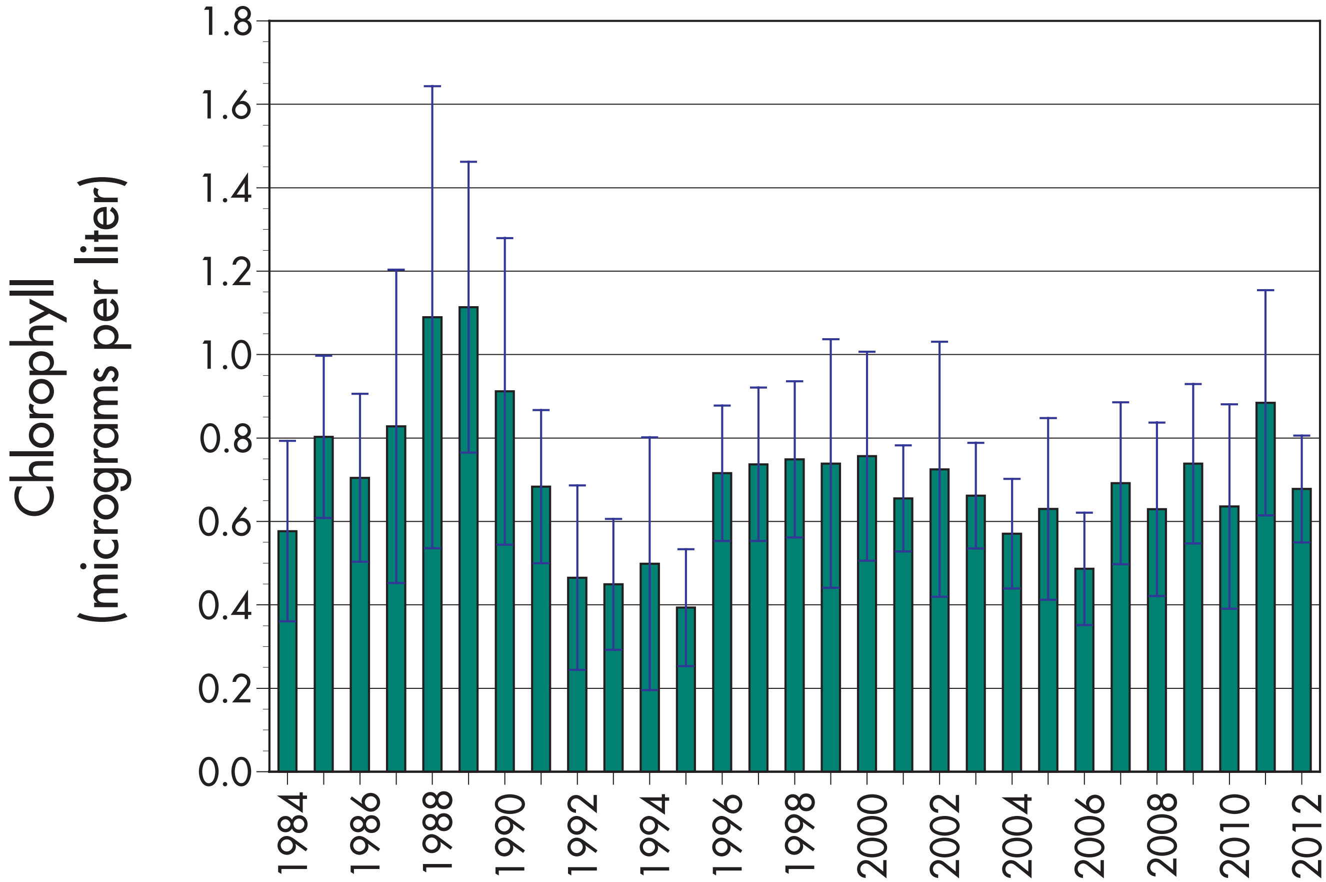
BIOLOGY

Algae abundance

Yearly since 1984

The amount or biomass of free-floating algae (phytoplankton) in the water is determined by extracting and measuring the concentration of chlorophyll *a*, a photosynthetic pigment that allows plants to absorb energy from light. Though the value varies annually, it has not shown a significant increase since measurements began in 1984. The annual average value for 2012 was 0.68 micrograms per liter.

The average annual chlorophyll *a* level in Lake Tahoe has remained relatively uniform since 1996. For the period of 1984-2012 the average value was 0.71 micrograms per liter.

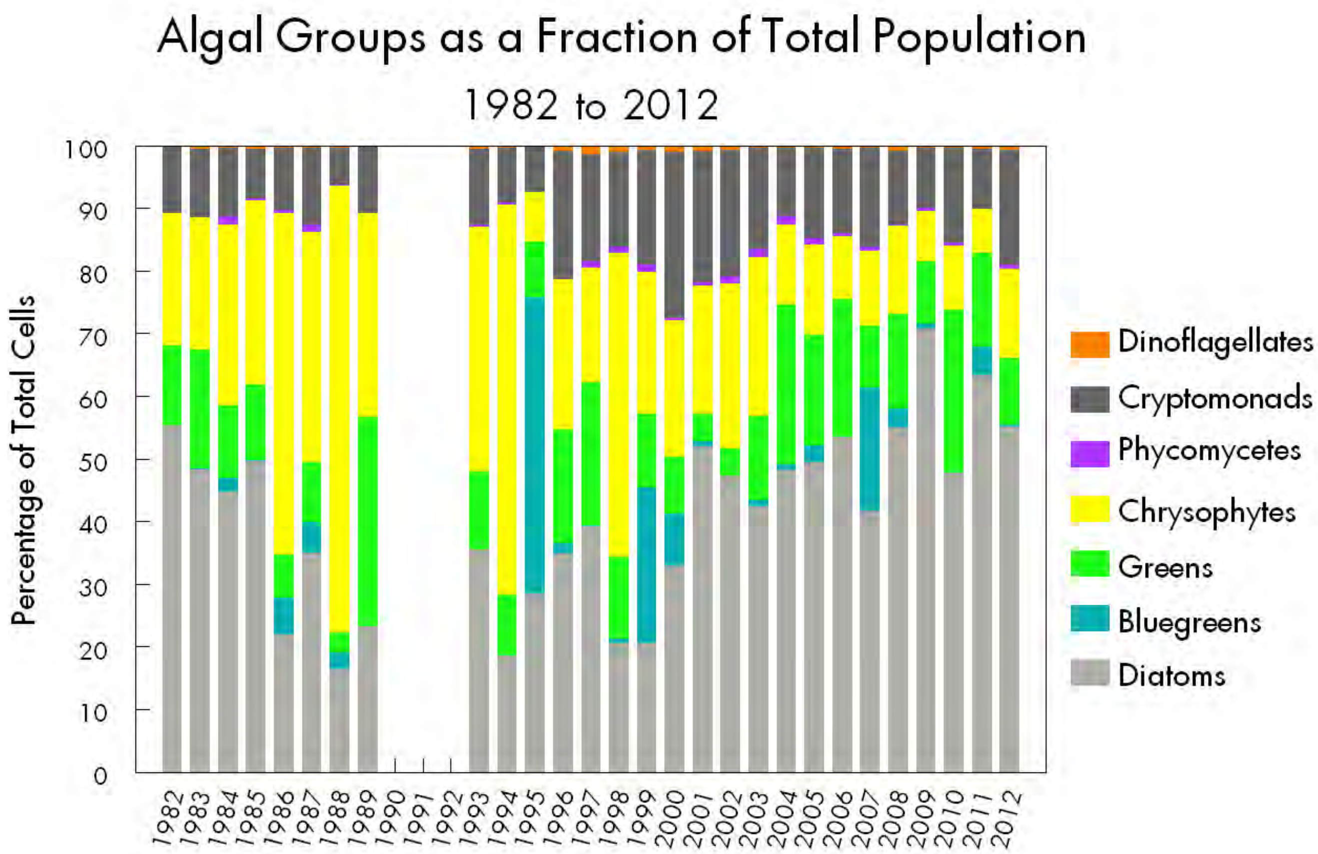


BIOLOGY

Annual distribution of algal groups

Yearly since 1982

The amount of algal cells from different groups varies from year to year. Diatoms are the most common type of alga, comprising 40 to 60 percent of the total abundance of algal cells each year. Chrysophytes and cryptophytes are next, comprising 10 to 30 percent of the total. While the proportion of the major algal groups show a degree of consistency from year-to-year, TERC research has shown that the composition of individual species within the major groups is changing, both seasonally and annually, in response to lake condition.

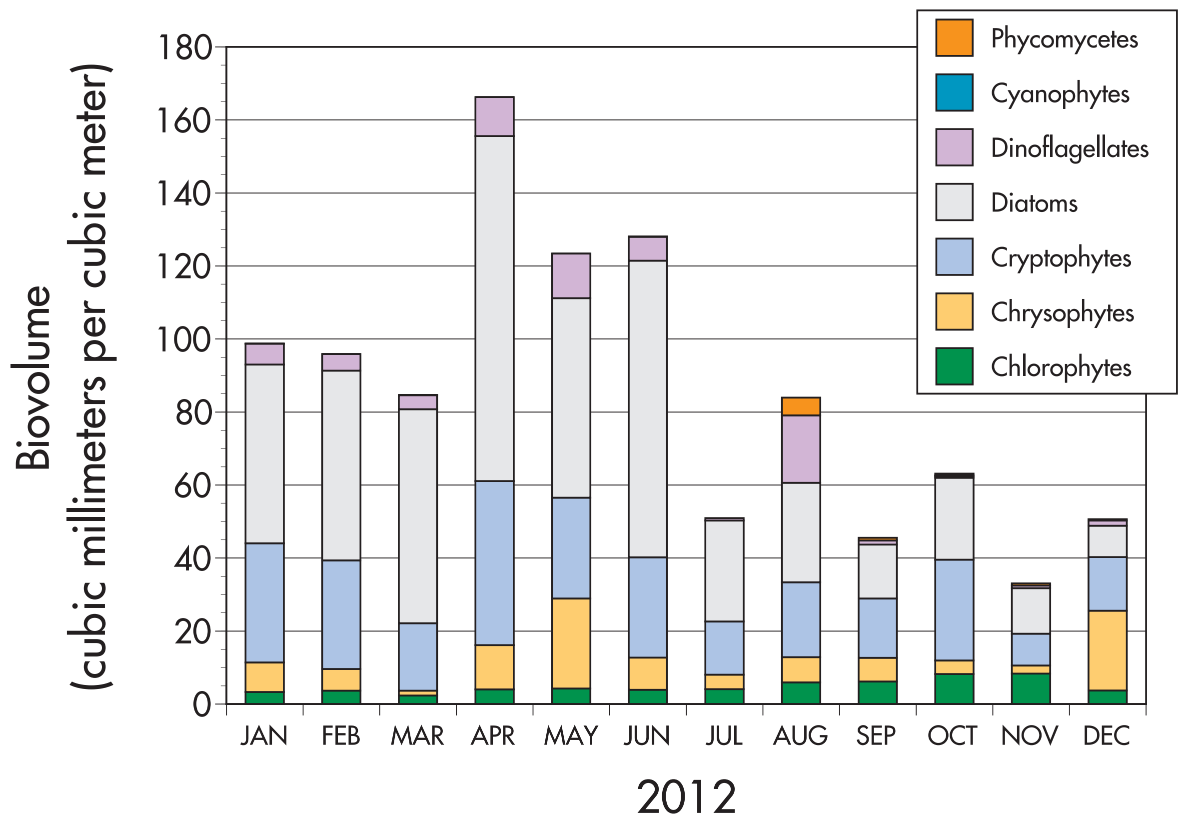


BIOLOGY

Algal groups as a fraction of total population

Monthly in 2012

Algae populations vary month to month, as well as year to year. In 2012, diatoms again dominated the phytoplankton community, especially in the first six months of the year. Diatom concentrations peaked in April (the "bloom") and stayed high through June. In the previous year (2011), the spring bloom occurred two to three months later, highlighting the natural variability in the lake's biota.

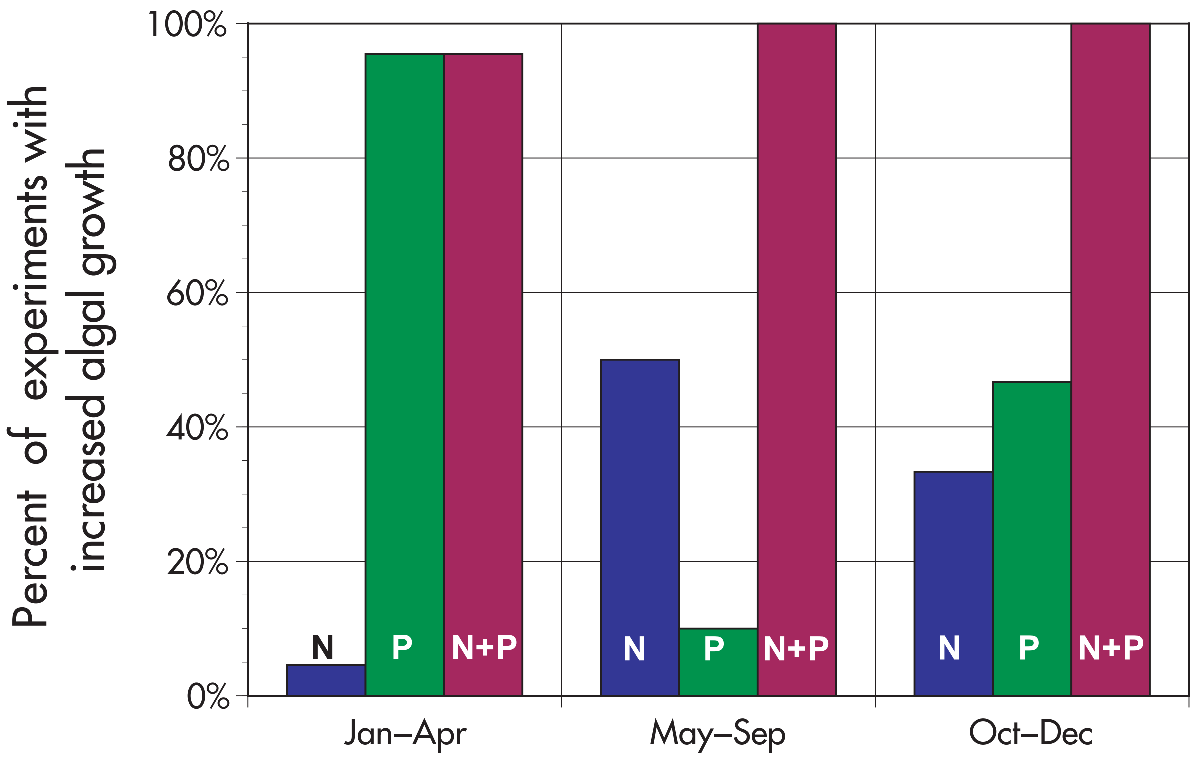


BIOLOGY

Nutrient limitation of algal growth

For 2002 - 2012

Bioassays determine the nutrient requirements of phytoplankton. In these experiments, nutrients are added to samples of lake water and the change of algal biomass is measured. Phytoplankton response to nutrient addition for the period 2002-2012 is summarized in the panels below. Between January and April, algal growth was limited largely by phosphorus (P). From May to September, Nitrogen (N) added by itself was more stimulatory, but the lake was co-limited, as shown by the greater response to adding both nutrients. Phosphorus is slightly more stimulatory from October to December, but co-limitation was again the dominant condition. These results highlight the role of nutrients in controlling algal growth. They also underscore the synergistic effect when both are available.

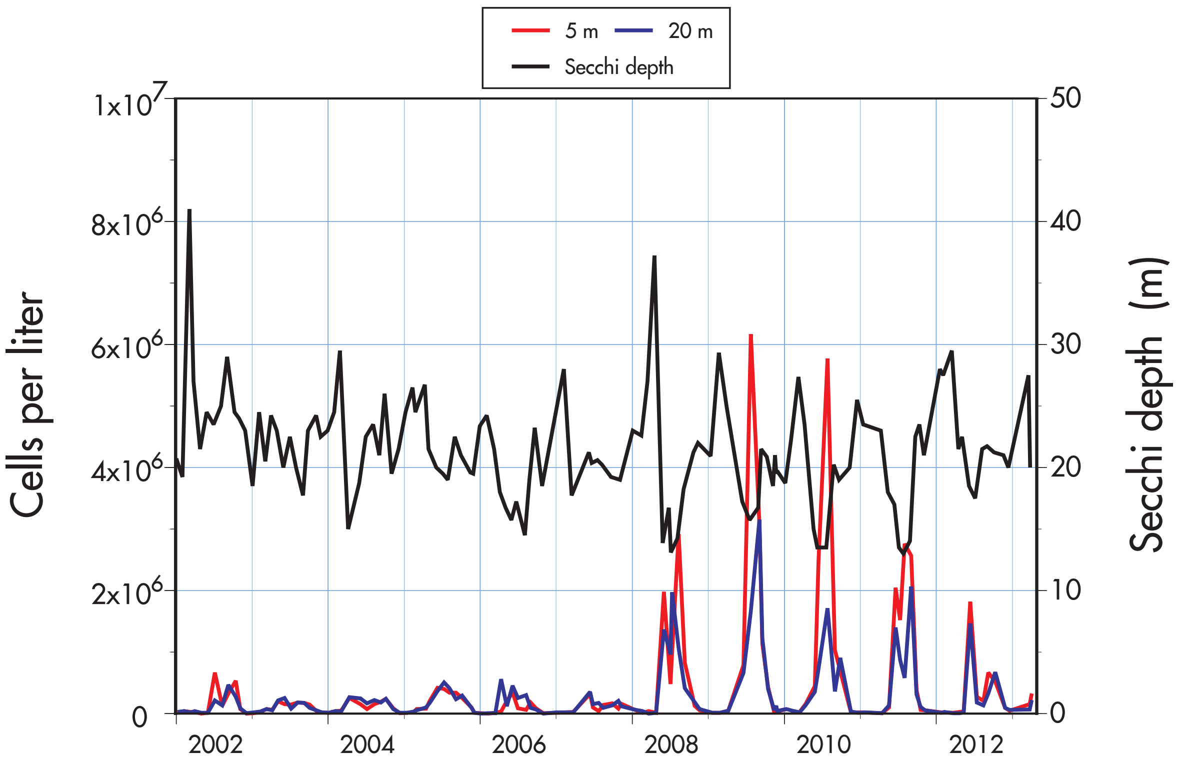


BIOLOGY

Predominance of Cyclotella sp.

From 2002 through 2012

In 2008, one species of algae, Cyclotella, started to dominate the make up of algae at Lake Tahoe. The cells range in size from 4 - 30 microns in diameter. During the summer, the smallest cells, 4 - 5 microns control the community in the upper euphotic. This size range is ideal for light scattering, and the growing numbers of Cyclotella in 2008-2011 were believed to be in large part responsible for the major decline in summer clarity in those years. In 2012 the concentration of Cyclotella cells decreased to the lowest level in five years, and summer clarity showed an improvement over the previous four years. The red and blue lines below indicate the concentrations of Cyclotella at depths of 20 m (66 ft) and 5 m (16.5 ft) respectively. The black lines indicate the individual Secchi depths taken since 2002. The summer values of Secchi depth coincide perfectly with the changes in Cyclotella concentration.

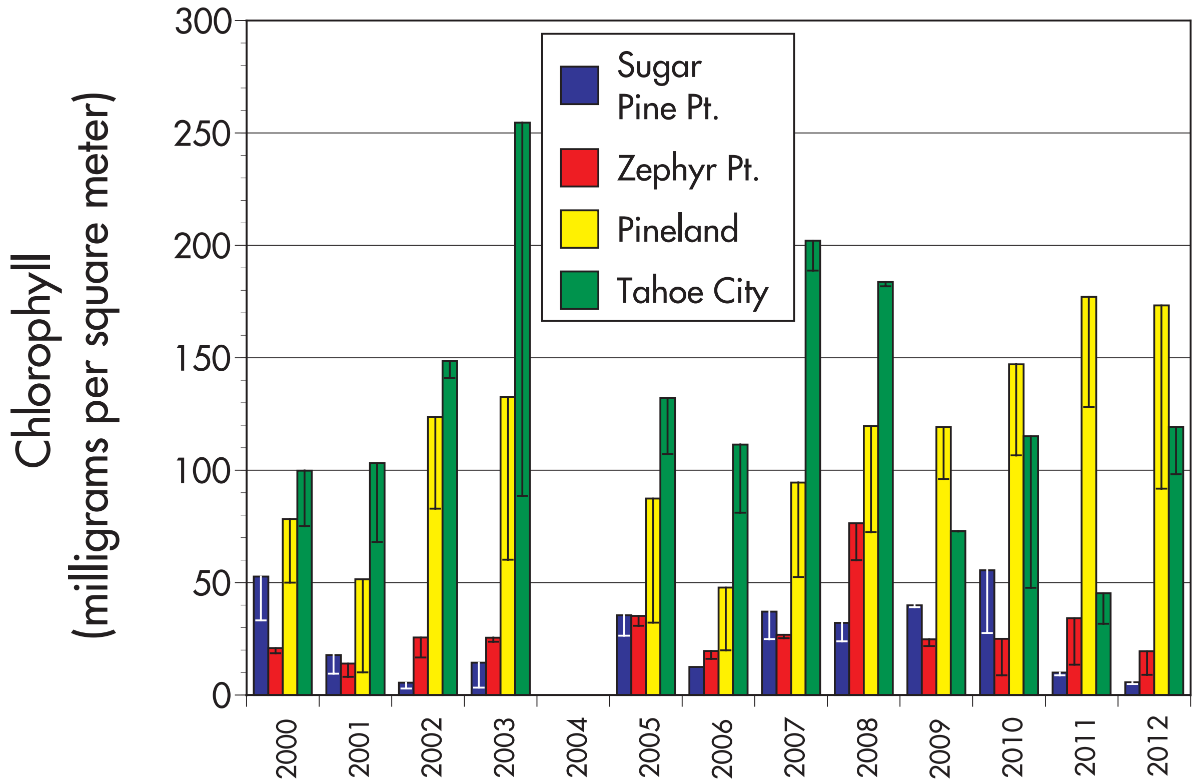


BIOLOGY

Shoreline algae populations

Yearly since 2000

Periphyton, or attached algae, makes rocks around the shoreline of Lake Tahoe green and slimy, or sometimes like a very plush white carpet. Periphyton is measured eight times each year, and this graph shows the maximum biomass measured at four of the sites. In 2012, concentrations at Sugar Pine Pt. (no urban influence) and Zephyr Pt. (low urban influence) were below the long-term average. The site with the most periphyton (Pineland) is close to an urban area, and was relatively high this year. The Tahoe City value was about average for that site. To date, no statistically significant long-term trend in maximum periphyton biomass has been detected at any of these individual locations. Monitoring periphyton is an important indicator of near-shore health.

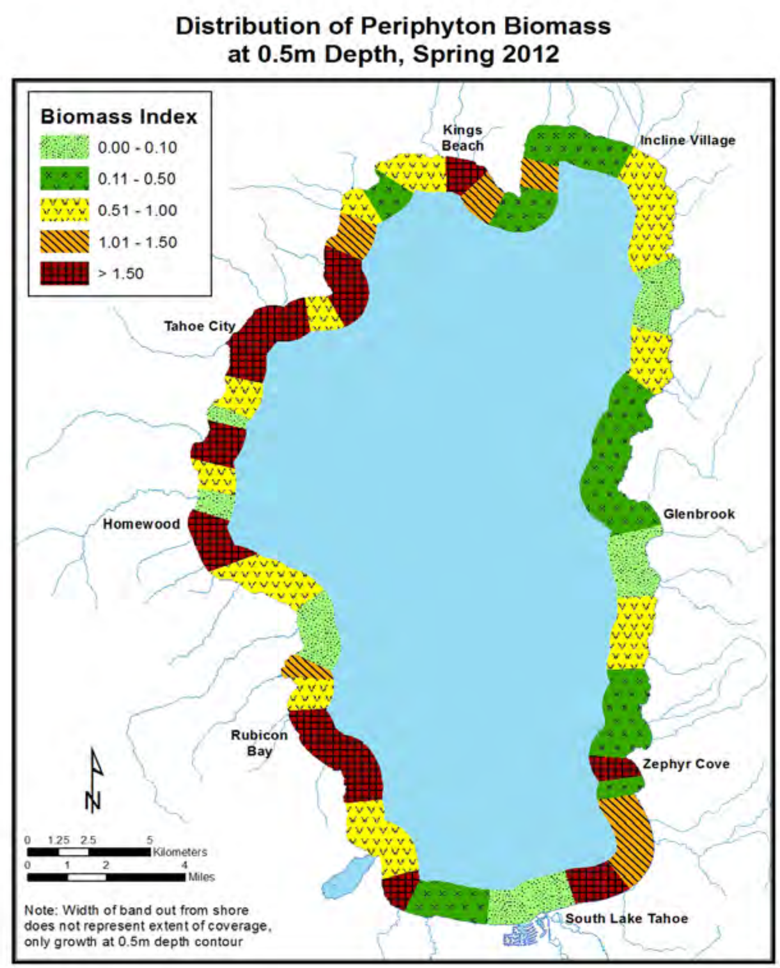


BIOLOGY

Shoreline algae distribution

In 2012

Periphyton biomass was surveyed around the lake during the spring of 2012, when it was at its annual maximum. Nearly 45 locations were surveyed by snorkel in 1.5 feet of water. A Periphyton Biomass Index (PBI) is used as an indicator to reflect what the casual observer would visually detect looking into the lake from the shoreline. The PBI is defined as the percent of the local bottom area covered by periphyton multiplied by the average length of the algal filaments (cm). Zones of elevated PBI are clearly seen. (The width of the colored band does not represent the actual dimension of the onshore-offshore distribution. Similarly its length does not represent the longitudinal extent.) Overall conditions in 2012 were similar to 2011.



TAHOE: STATE OF THE LAKE REPORT 2013

CLARITY

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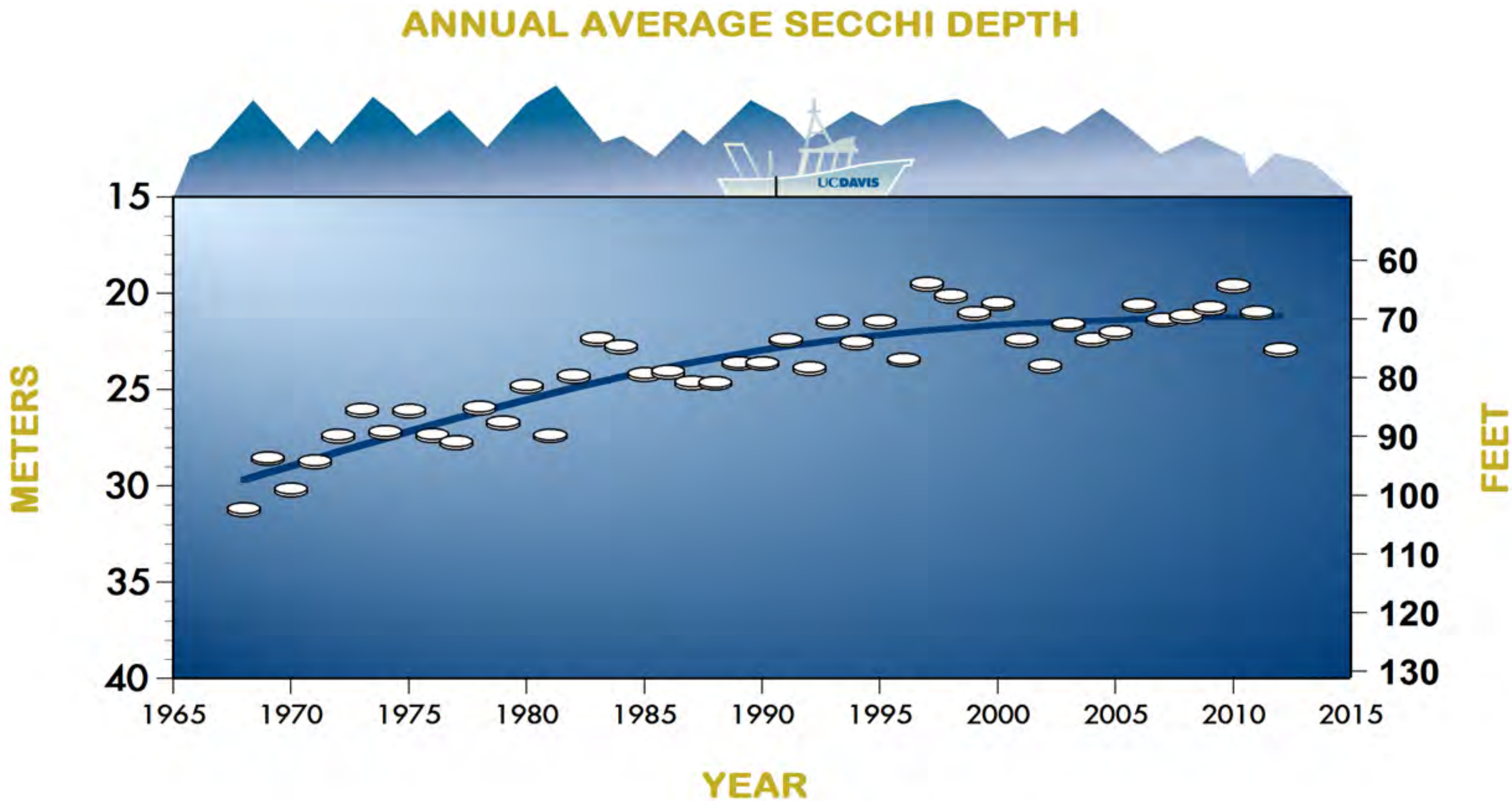
CLARITY

Annual average Secchi depth

Yearly since 1968

In 2012 the annual average Secchi depth was 75.3 feet, an improvement of 6.4 feet over the previous year. This was the second consecutive year of improved annual average clarity. The annual average clarity in the past decade has been better than in recent decades. In 1997-1998, annual clarity reached an all-time average low of 65.1 feet. From 2003-2012 the average clarity was 70.1 feet. The clarity level is the average of 22 individual readings taken throughout the year. The highest individual value recorded in 2012 was 107 feet, and the lowest was 57 feet. It is important to understand the causes of clarity change and to evaluate past actions and future investments. Some critical knowledge gaps are in the monitoring of urban stormwater flows.

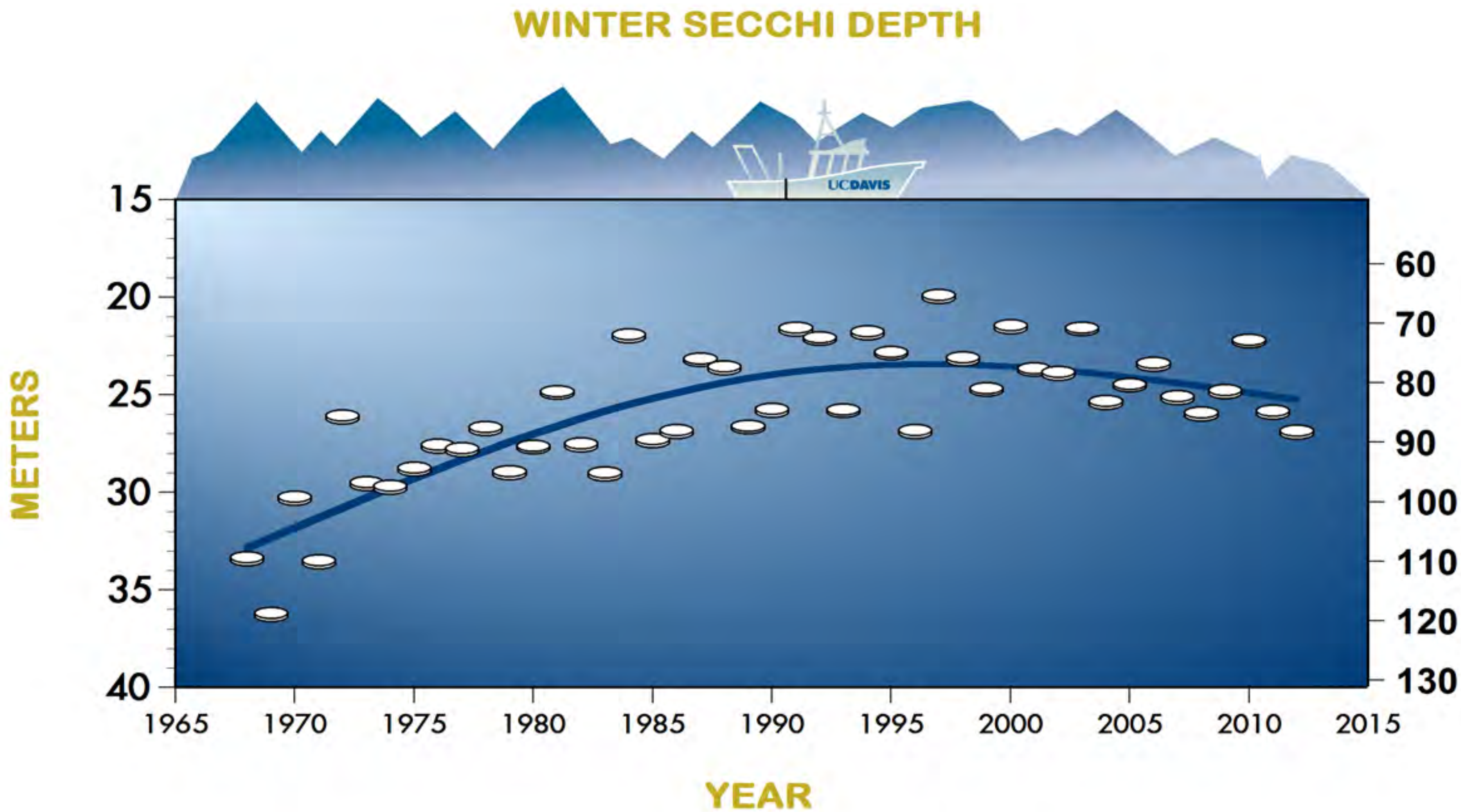


CLARITY

Winter Secchi depth

Yearly since 1968

Annual winter (December-March) Secchi depth measurements from 1968 to the present indicate that winter clarity at Lake Tahoe is showing definite improvement. In 2012, the winter clarity increased to 88.3 feet, well above the worst point seen in 1997. The reasons behind the continued improvement in winter clarity are not fully understood, but possibly tied to reductions in the quantity of fine particles from urban stormwater. Dry conditions in 2012 contributed to the trend. Urban stormwater is the largest source of fine particles to Lake Tahoe, and generally enters the lake in winter. A comprehensive, regional urban stormwater monitoring plan is needed to determine if recent capital investments in stormwater projects have indeed reduced these loads.

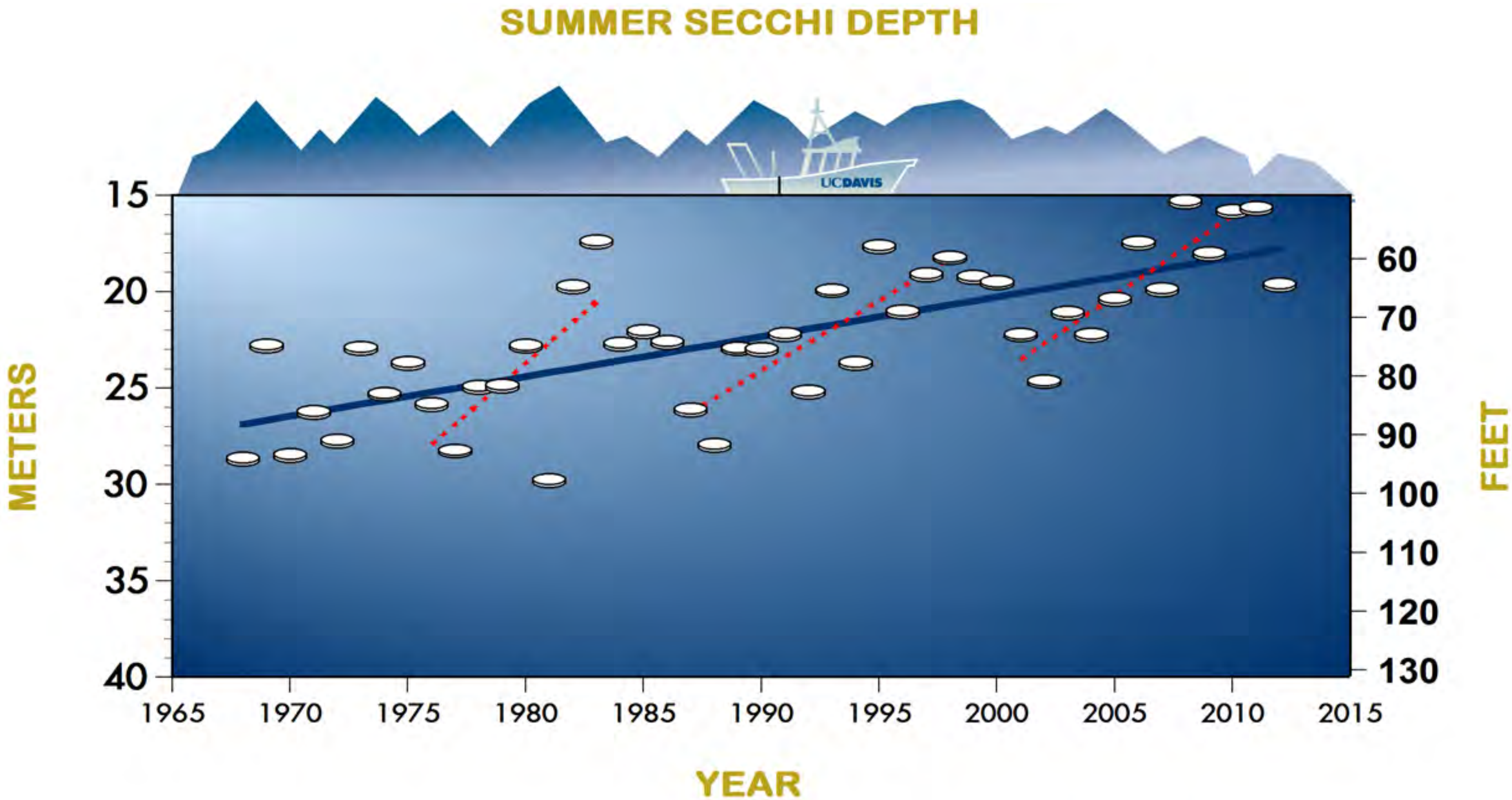


CLARITY

Summer Secchi depth

Yearly since 1968

Summer (June-September) clarity in Lake Tahoe in 2012 was 64.4 feet, an improvement of over 13 feet from 2011. This coincided with a decline in the concentration of small algal cells in 2012. Despite this improvement, the summer trend is dominated by a consistent long-term decline but with a noticeable 10-15 year cyclic pattern. The red dashed lines are linear regressions for the periods: a) 1976 to 1983, b) 1987-1998, and c) 2001 to 2011. The most recent improvement may be a continuation of this cyclical trend. The reasons behind this periodicity are being investigated.

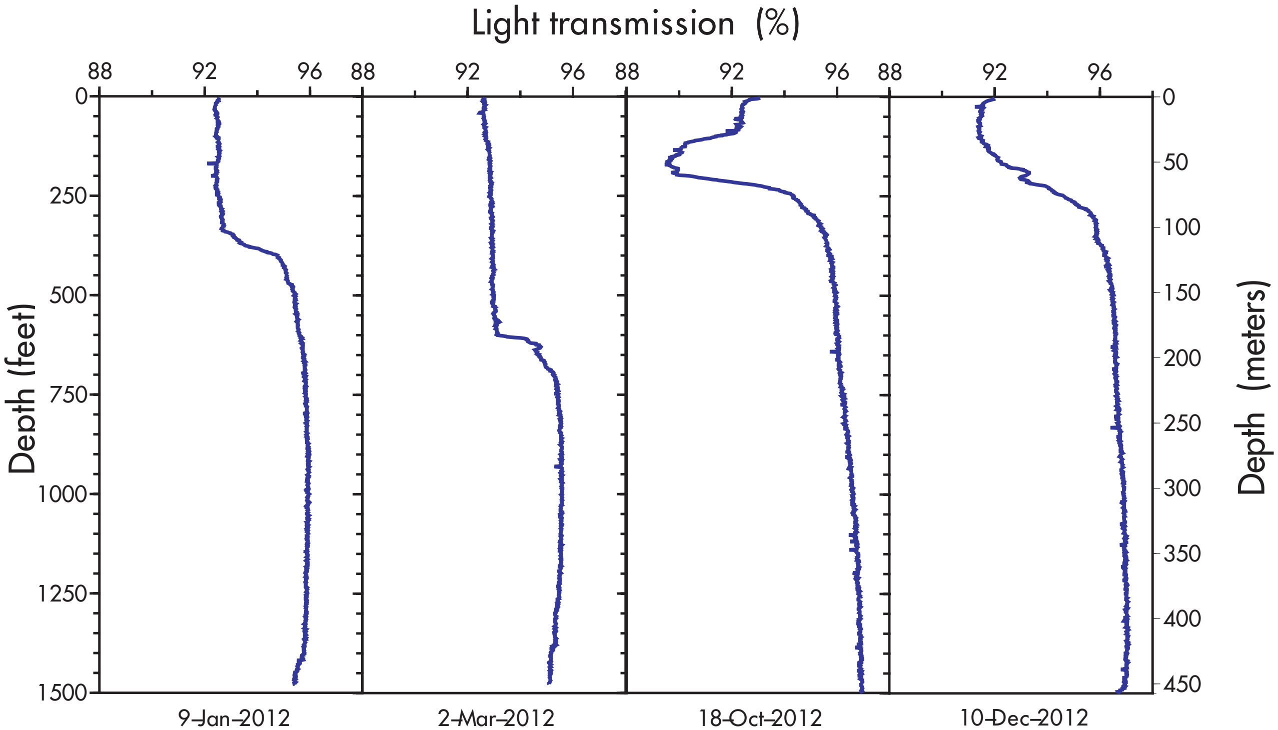


CLARITY

Light transmission

In 2012

A light transmissometer measures what percentage of a given wavelength of light is transmitted over a 10 inch path length. Here, the light transmission through the full depth of the lake is shown at four times a year. It is evident that the lowest light transmission is in the surface layers where typically less than 93 percent of light is transmitted. The highest light transmission is in the very deepest parts of the lake where as much as 96 percent of the light can be transmitted. The reason is that fine particles are believed to aggregate into larger particles that rapidly settle out in the deep water.



TAHOE: STATE OF THE LAKE REPORT 2013

EDUCATION AND OUTREACH

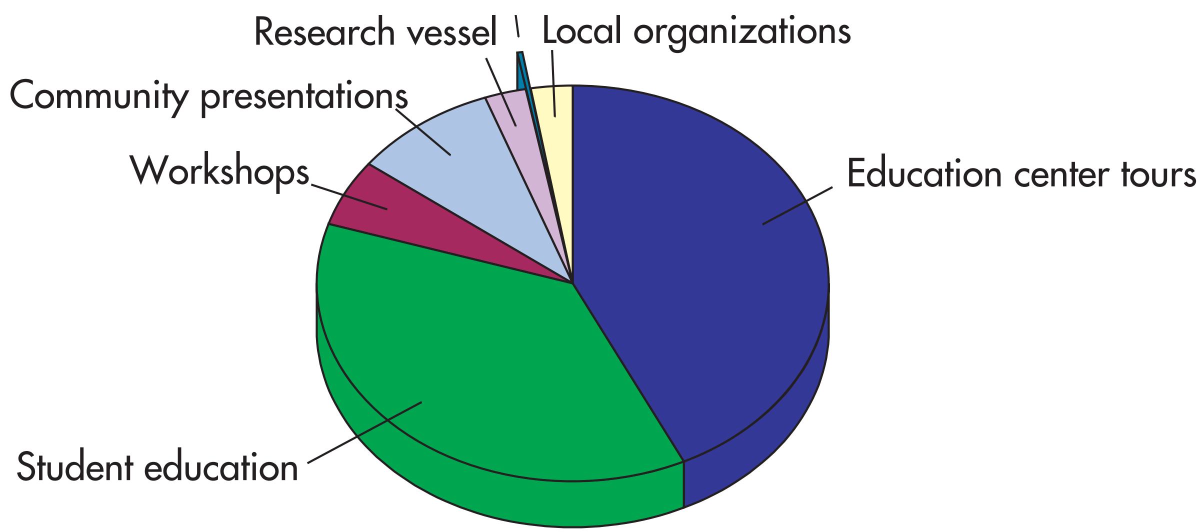
UCDAVIS
TAHOE ENVIRONMENTAL RESEARCH CENTER

EDUCATION AND OUTREACH

TERC education and outreach

In 2012

Part of TERC's mission is education and outreach. During 2012, TERC recorded 11,817 individual visitor contacts. The majority represented student field trips and visitors to the Thomas J. Long Foundation Education Center at Incline Village. In addition, TERC hosts monthly public lectures and workshops, makes presentations to local organizations and takes a limited number of visitors out on our research vessels. TERC organizes and hosts annual events and programs including Children's Environmental Science Day, Science Expo, Youth Science Institute, Trout in the Classroom program, Project WET workshops, Summer Tahoe Teacher Institute and a volunteer docent training program. TERC also partners with numerous groups to deliver education in the Tahoe basin. In 2012, these included AmeriCorps, COSMOS, Sierra Watershed Education Partnerships (SWEP), Space Science for Schools, Young Scholars and many others.



TOTAL NUMBER OF CONTACTS: 11,817

EDUCATION AND OUTREACH

TERC educational exhibits

In 2012

Hands-on science exhibits such as the new “Shaping Watersheds Interactive Sandbox” will join the research vessel, laboratory and award-winning 3D movie “Lake Tahoe in Depth” to provide guests with the latest Lake Tahoe research. Several new 3D visualizations, including “Lakes of the World” and “Following a Drop of Water”, are also being developed as part of a larger informal science education project funded by the National Science Foundation.

Two new aquariums join the exhibit area providing visitors a close-up look at both the native and non-native fish that live in the lake.

The new Interactive Sandbox exhibit captivates young and old visitors alike with evolving color contours that reflect the sculpted sand surface, and water flow simulations showing the passage of floods through the created watershed.

Visitors will be able to learn about lakes and reservoirs around the world in a new 3-D visualization.

Two larger aquariums (a generous gift from Trout Unlimited) with native and non-native fish found in Lake Tahoe were recently added.

EDUCATION AND OUTREACH

TERC educational programs

In 2012

In addition to providing education center tours for the general public, the TERC Education Team also provides high quality informal science education to more than 4,100 fifth- and sixth-grade students by hosting 70 - 80 field trips each year.

Trout in the Classroom is an educational program designed to teach students about the ecology, biology, and history of trout and other aquatic life. This year, we raised Lahontan cutthroat trout in an aquarium in the science center. Students from schools around the region also raised trout for release into local waterways.

A small group of select high school students participate in the afterschool Youth Science Institute from January through May. Participants work with scientists, conduct science experiments and share science activities with other students.

School groups visit for informal science education programs on water, geology and biology.

AmeriCorps member Kylee Wilkins helps students gather the young Lahontan cutthroat trout for release into Lake Tahoe.

Youth Science Institute participants conduct multiple science activities over the 16-week program.

EDUCATION AND OUTREACH

TERC educational programs, continued

In 2012

Each year we train new volunteer docents at our annual June Docent Training. Our volunteer docents become local experts and lead tours at two science centers. Volunteers also participate in garden work each year to make the Tahoe City Field Station native plant demonstration garden a beautiful community resource.

Visitors that come to our science centers can view exhibits, watch 3-D movies, and participate in citizen science by conducting water quality monitoring, investigating plant phenology, and bird watching. Public participation in scientific research is educational for adults and children and provides useful data for scientists.

Additionally, for the past several years, TERC has hosted a summer Tahoe Teacher Institute for educators from both California and Nevada.

Visitors can wear lab coats for family photos and conduct citizen science including water quality monitoring, plant phenology, and bird watching.

Volunteer docents lead tours at our two science centers and make science come alive for visitors.

Teachers come to Lake Tahoe for the Tahoe Summer Institute to improve their proficiency in environmental science topics and learn new science activities.

EDUCATION AND OUTREACH

TERC special events

In 2012

TERC hosts monthly lectures throughout the year on various environmental issues, new scientific research and related regional topics of interest.

Special events hosted annually include Project WET training workshops (February), Science Expo (March), Green Thumb Tuesdays (July - August), Children's Environmental Science Day (August), Earth Science Day (October), and Family Science Day (December)

The annual Science Expo held each March brings in more than 600 third-, fourth- and fifth-grade students for hands-on science activities.

Public lectures are held monthly at the Incline Village location and Green Thumb Workshops are held at Tahoe City Field Station throughout the summer.

Children's Environmental Science Day is held annually each August with hands-on science activities designed for kids ages six and up.