TAHOE: STATE OF THE LAKE REPORT 2014

PHYSICAL PROPERTIES

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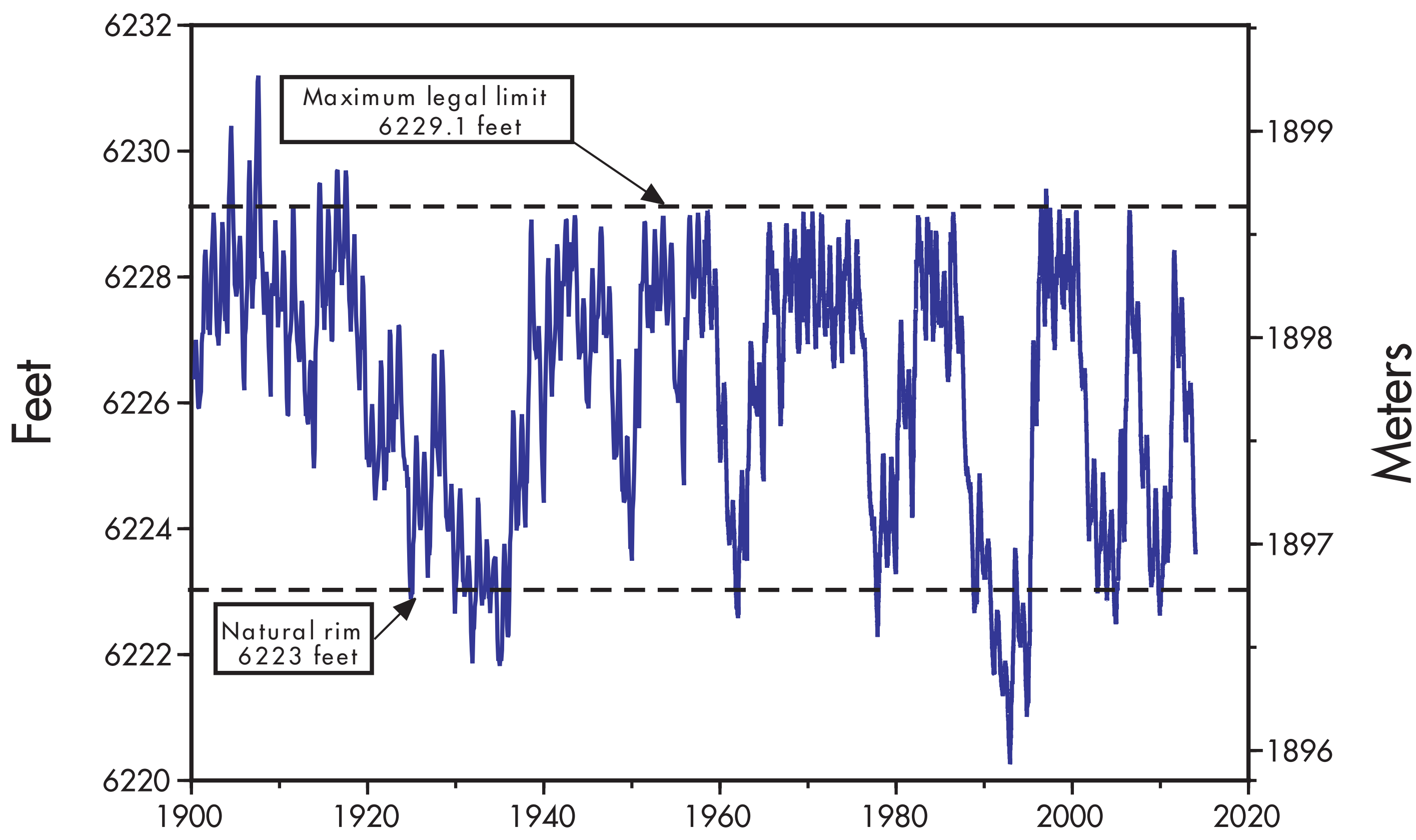
RESEARCH CENTER

PHYSICAL PROPERTIES

Lake surface level

Daily since 1900

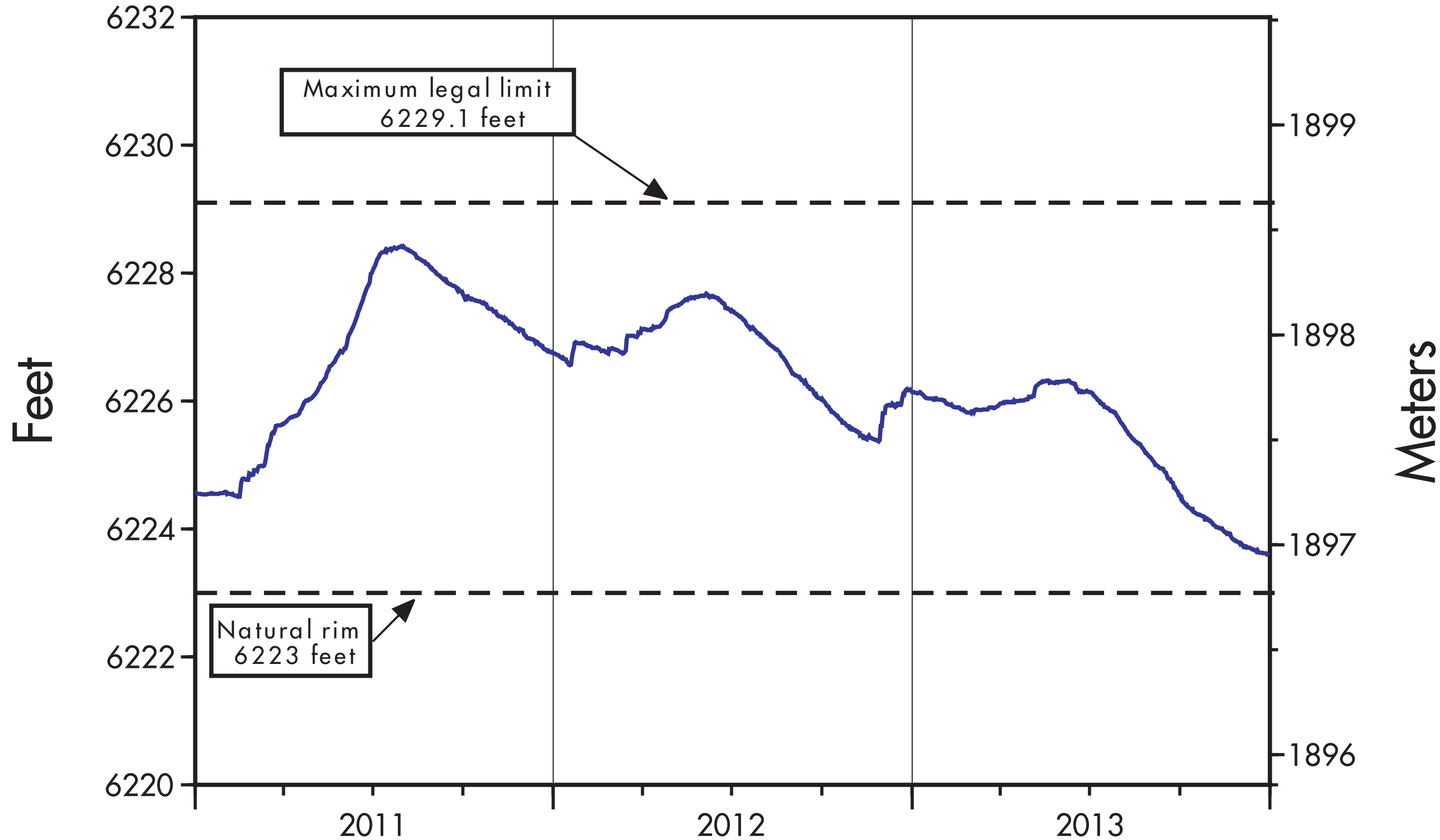
Lake surface level varies throughout the year. It rises due to high stream inflow, groundwater inflow and precipitation directly onto the lake surface. It falls due to evaporation, in-basin water withdrawals, groundwater outflows, and outflow via the Truckee River at Tahoe City. Overall, lake level fell during 2013. The highest lake level was 6226.32 feet on May 18 and again on June 9, and the lowest was 6223.59 feet on December 31. In 2013, the lake level rose by only 6 inches during snowmelt, compared with 3.9 feet in 2011.



Lake surface level, continued

Daily since 2011

Displayed below is the lake surface data from 2011-2013 extracted from the same data on page 8.1. This more detailed presentation of recent lake level data allows us to see the seasonal patterns in greater detail. Data clearly show the lake level only 7 inches above the natural rim at the end of 2013 as well as the timing of highest yearly lake levels in late spring following snowmelt. The effects of the high snowfall in December 2012 on lake level are clearly evident.

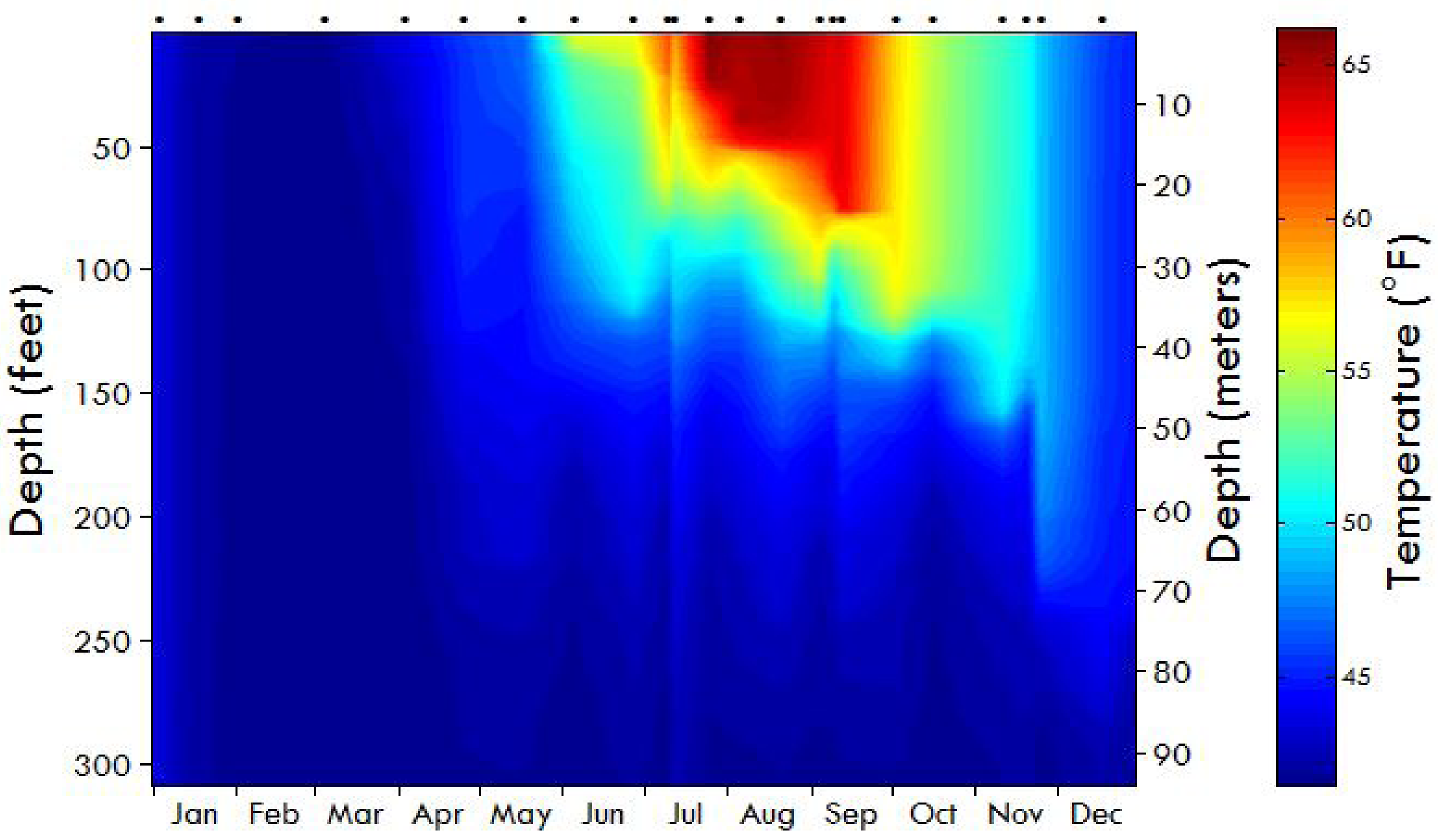


PHYSICAL PROPERTIES

Water temperature distribution

In 2013

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 2013, the lake temperature followed a typical seasonal pattern. In late March, the lake surface was at its coldest. The beginning of the 2013-2014 winter mixing is evident at the end of the plot, with the surface layer both cooling and deepening. By the end of 2013, mixing had proceeded to only 245 feet (74 m), a relatively shallow amount.

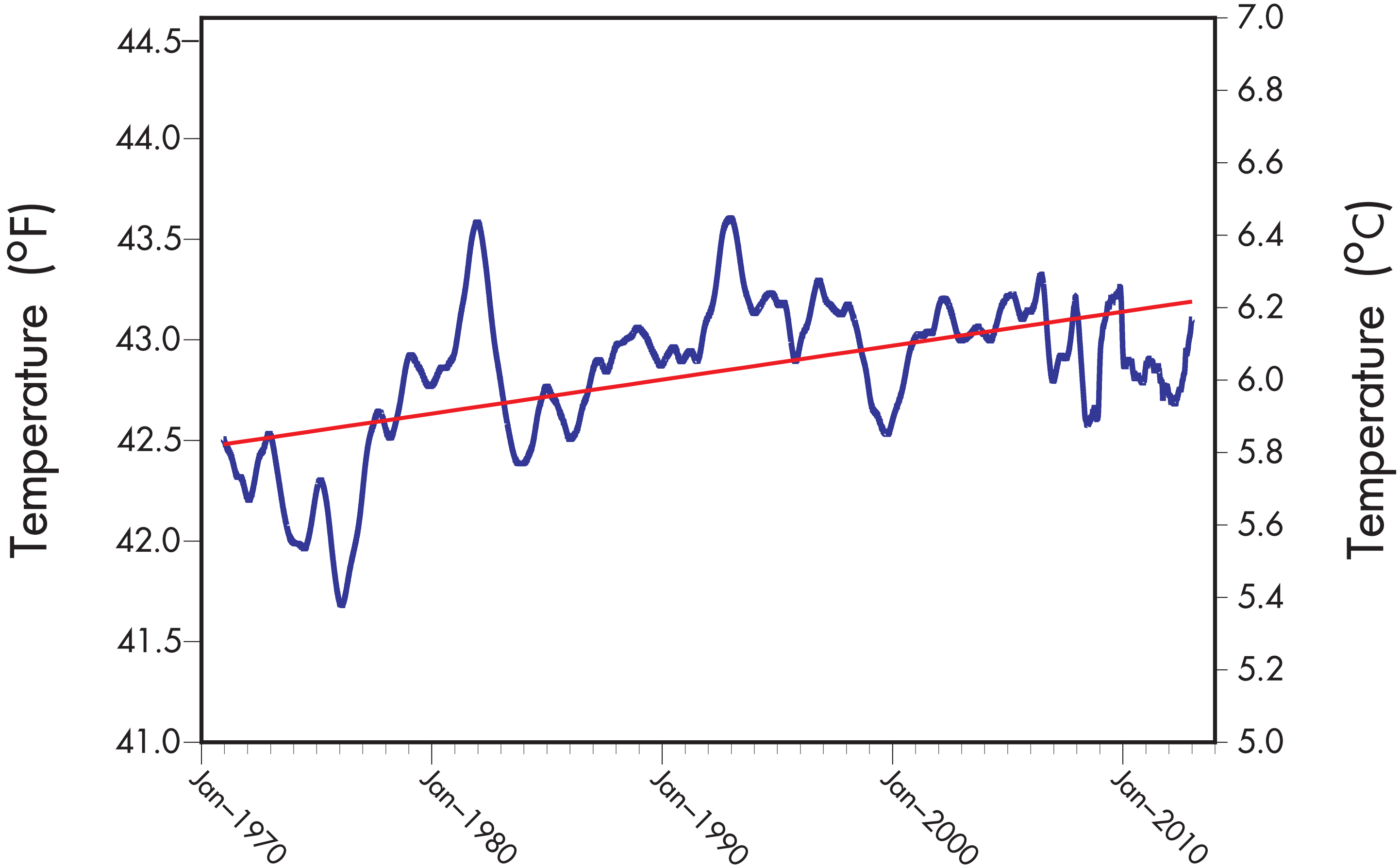


PHYSICAL PROPERTIES

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 annual rate of warming is 0.017 °F (0.0094 °C). The monthly temperature profile data from the lake has been smoothed and seasonal influences removed to best show the long-term trend. Up until the late 1990s the warming rate was considerably greater, but an unusual number of deep mixing years since 1997 have slowed the warming rate.

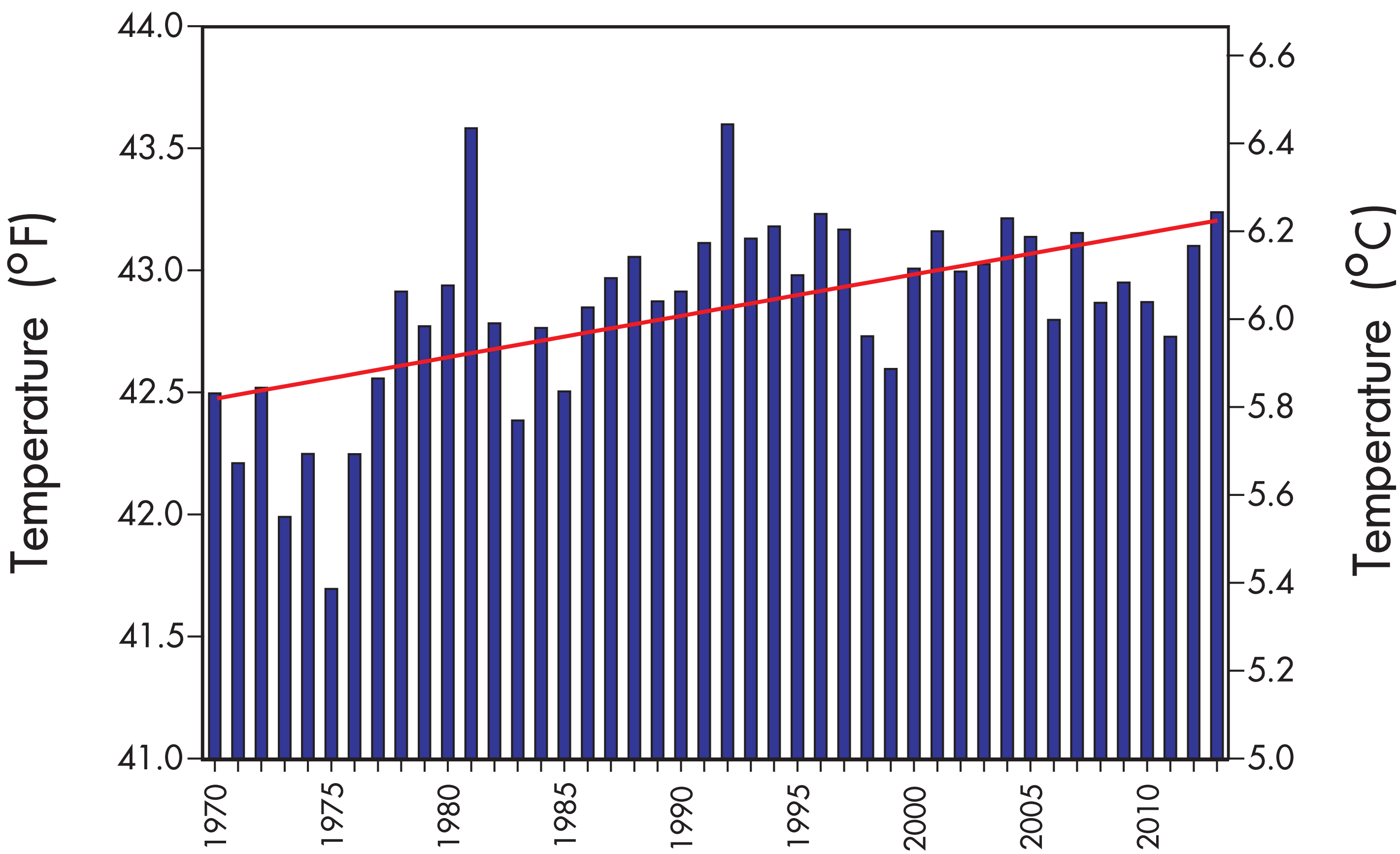


PHYSICAL PROPERTIES

Annual average water temperature

Since 1970

The volume-averaged temperature of the lake for each year since 1970 is shown. In 2013 the volume-averaged temperature increased by 0.14 °F (0.08 °C) over the previous year. The years with the largest decreases in temperature generally correspond to those years in which deep mixing occurred. Years with increases in temperature are often associated with a lack of deep mixing.

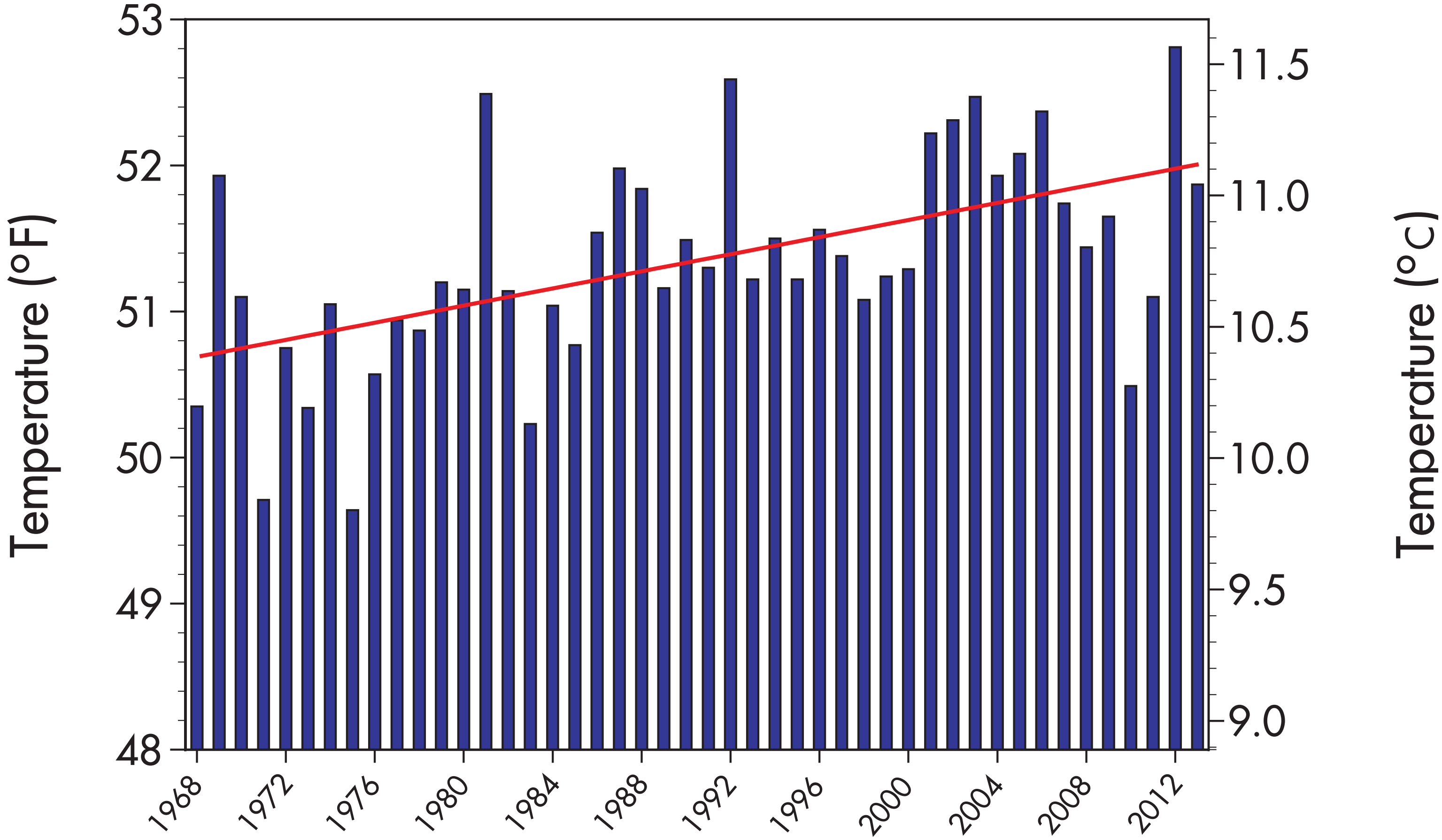


PHYSICAL PROPERTIES

Surface water temperature

Yearly since 1968

Surface water temperatures have been recorded monthly at the mid-lake station since 1968 from our research vessel John LeConte. Despite year-to-year variability, the annual average surface water temperatures show an increasing trend. The average temperature in 1968 was 50.3 °F (10.2 °C). For 2013, the average surface water temperature was 51.9 °F, a decrease of 0.9 °F (0.5 °C) over 2012, the warmest year yet recorded. The overall rate of warming of the lake surface is 0.029 °F (0.016 °C) per year.

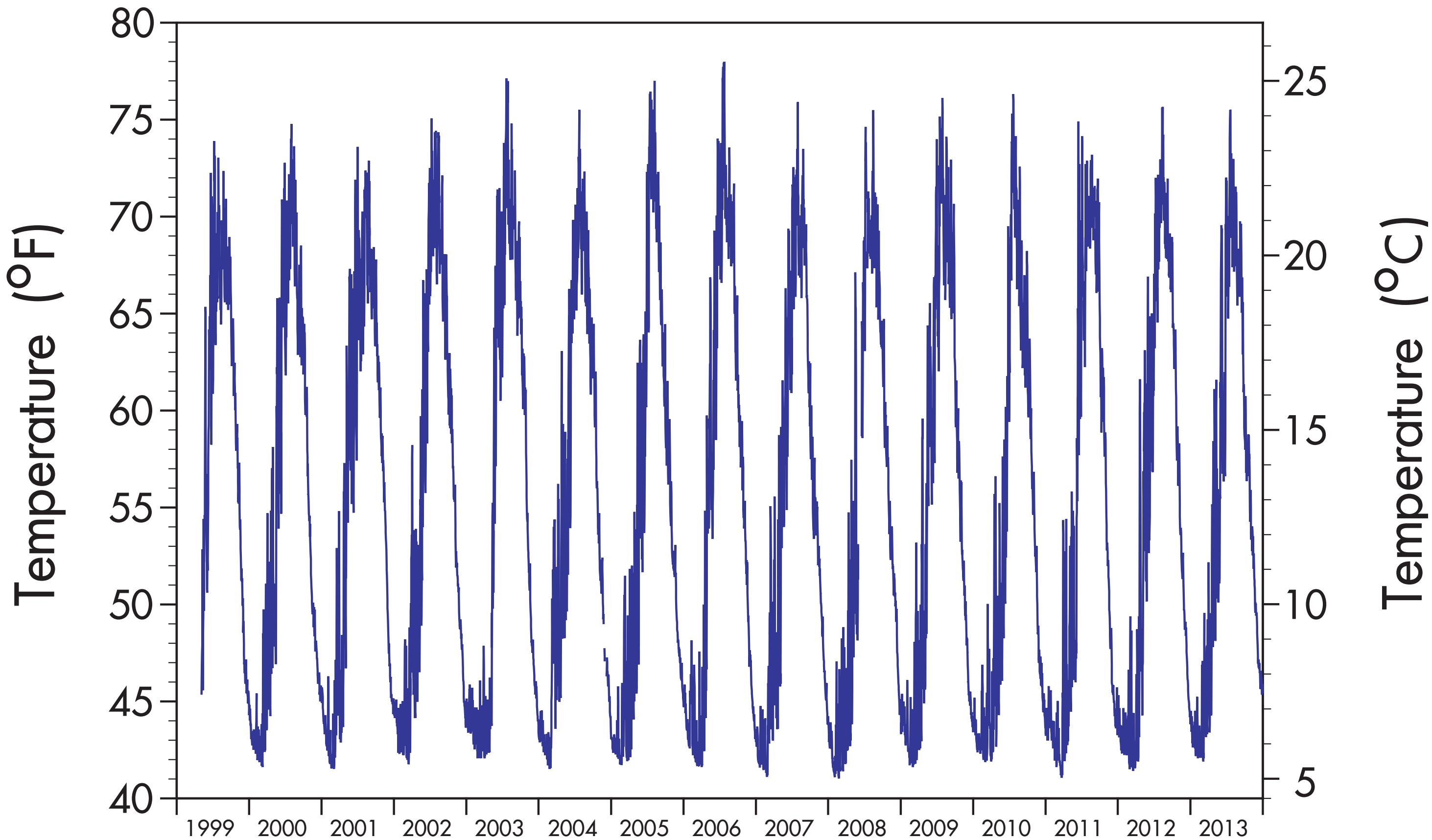


PHYSICAL PROPERTIES

Maximum daily surface water temperature

Surface temperature measured every 2 minutes since 1999

The maximum daily surface water temperature in 2013 was similar to 2012. The highest maximum daily surface water temperature was 74.32 °F, which was recorded at 2pm on July 20, 2013. The lowest maximum daily surface water temperature was 41.41 °F, which was recorded at 6:50am on March 10, 2012. These data are collected in real-time by NASA and UC Davis from 4 buoys located over the deepest parts of the lake.

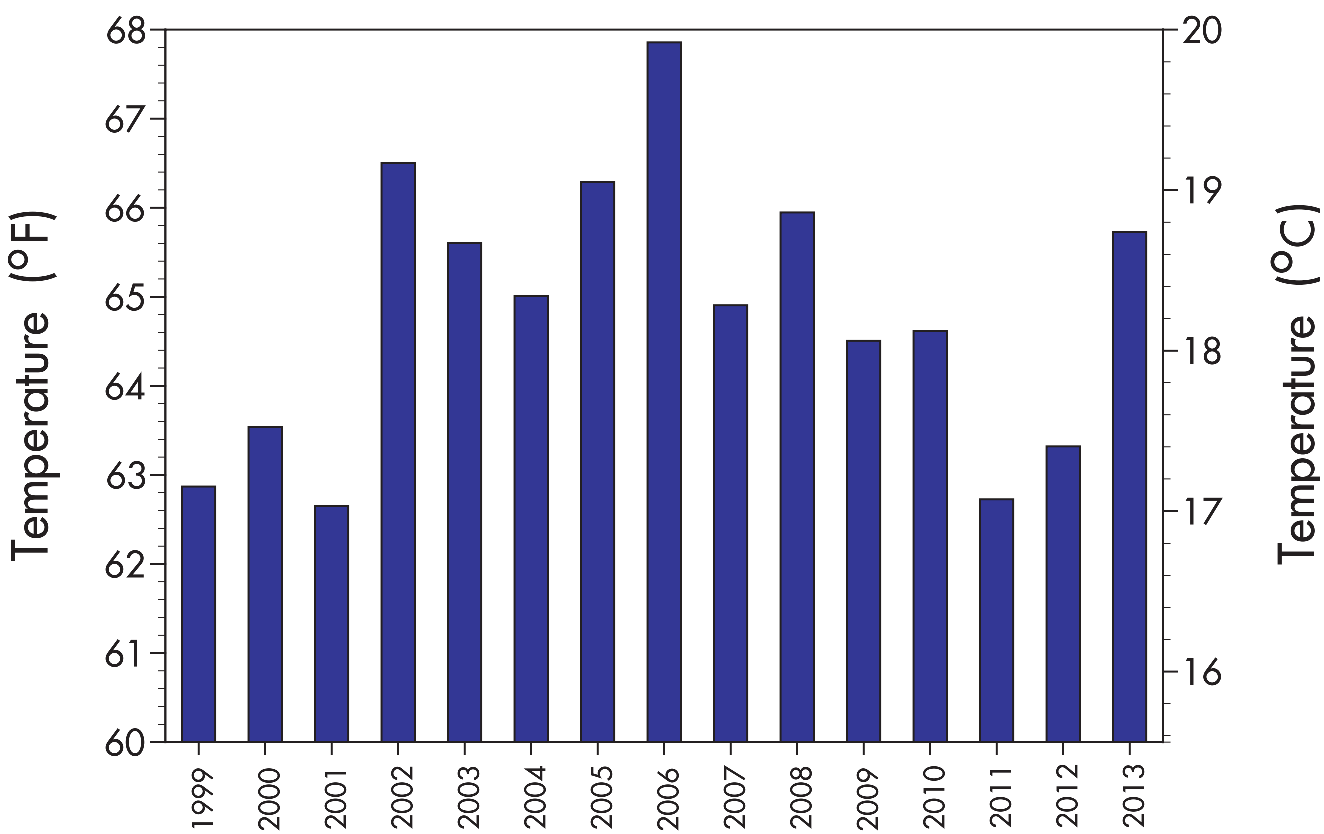


PHYSICAL PROPERTIES

July average surface water temperature

Measured every 2 minutes since 1999

Since 1999, surface water temperature has been recorded every two minutes from four NASA/UC Davis buoys. Shown here are 15 years of average surface water temperatures in the month of July when water temperatures are typically warmest. In 2013, 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.

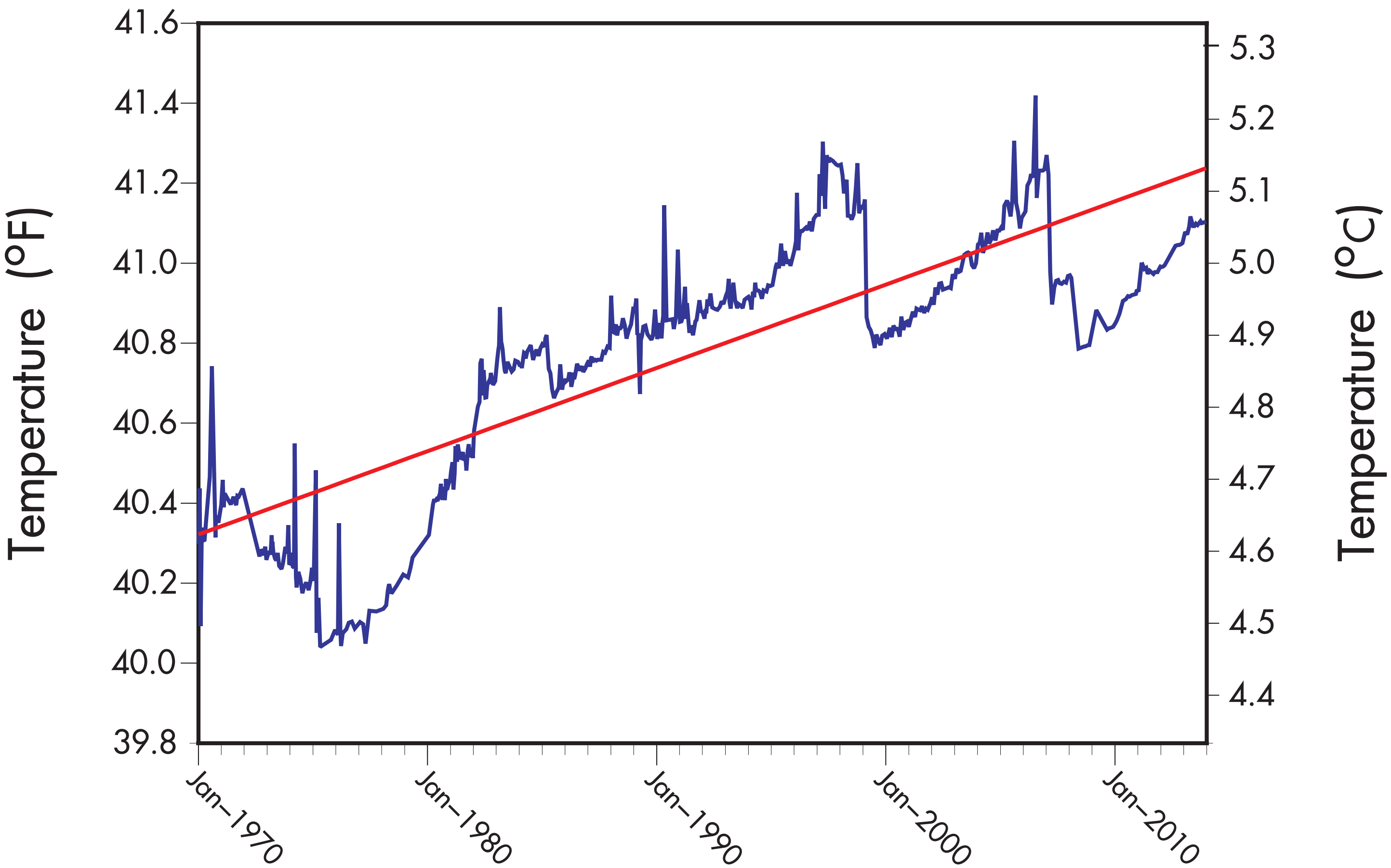


PHYSICAL PROPERTIES

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 (0.6 °C), at an annual rate of 0.021 °F (0.012 °C), a rate of warming slower than the surface water. This increase has not been steady but is punctuated by occasional drops in temperature. These coincide with times when the lake completely mixes 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 motions of internal waves.

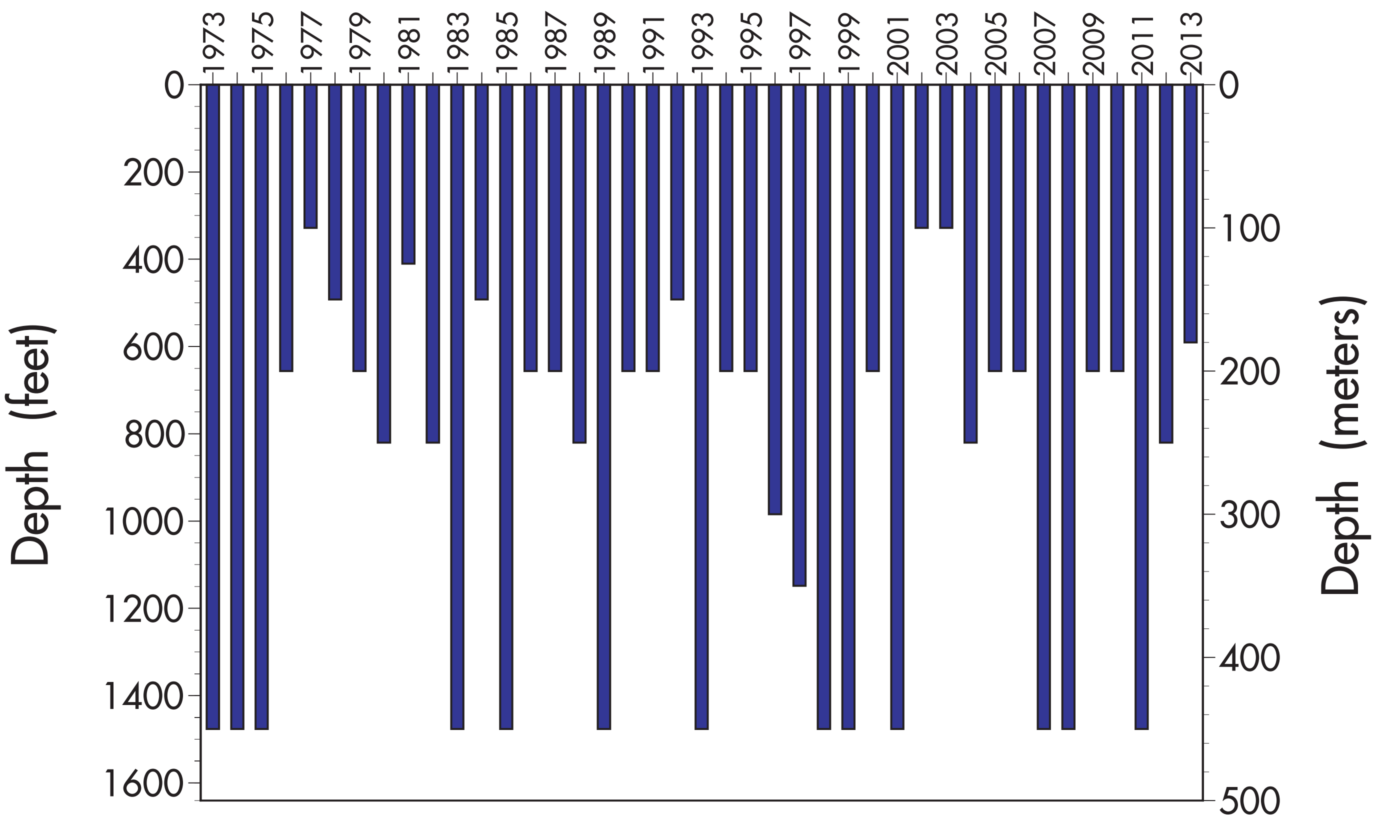


PHYSICAL PROPERTIES

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 helps to determine how deep the lake mixes. Mixing depth has profound impacts on lake ecology and water quality. Deep mixing brings nutrients to the surface, where they promote algal growth. It also moves oxygen to deep waters, promoting aquatic life throughout the water column. The deepest mixing typically occurs between February and March. In 2013, Lake Tahoe mixed to a depth of only 600 feet (180 m). This lack of deep mixing most likely contributed to the warmer surface temperature and the generally higher clarity. Beginning in 2013, the depth of mixing is based on high-resolution temperature profiles rather than nitrate concentration sampled at discrete depths.

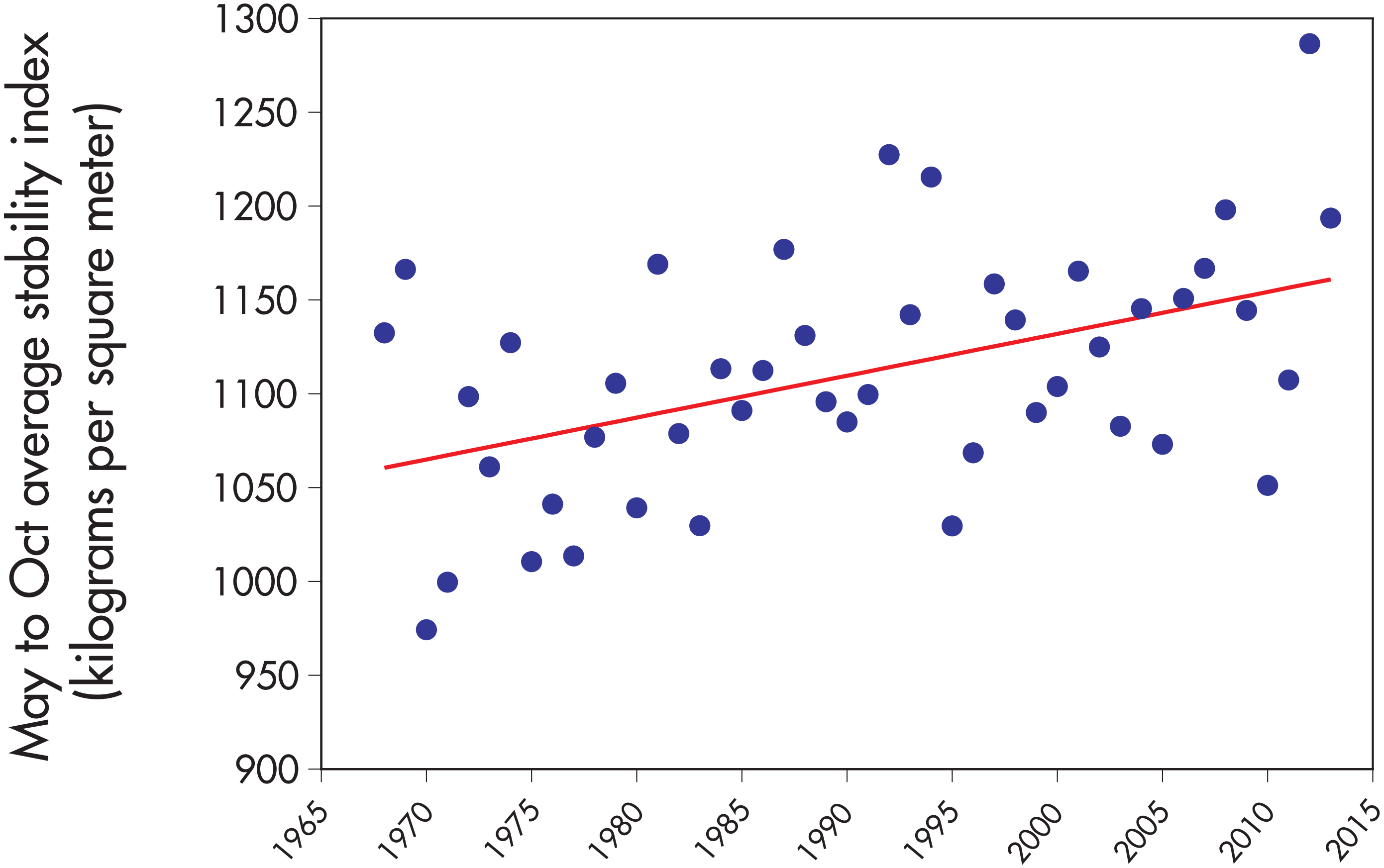


PHYSICAL PROPERTIES

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 water column when its density is stratified. The average stability index for the upper 330 feet (100 m) of Lake Tahoe is plotted 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 by over 10% in the last 45 years.

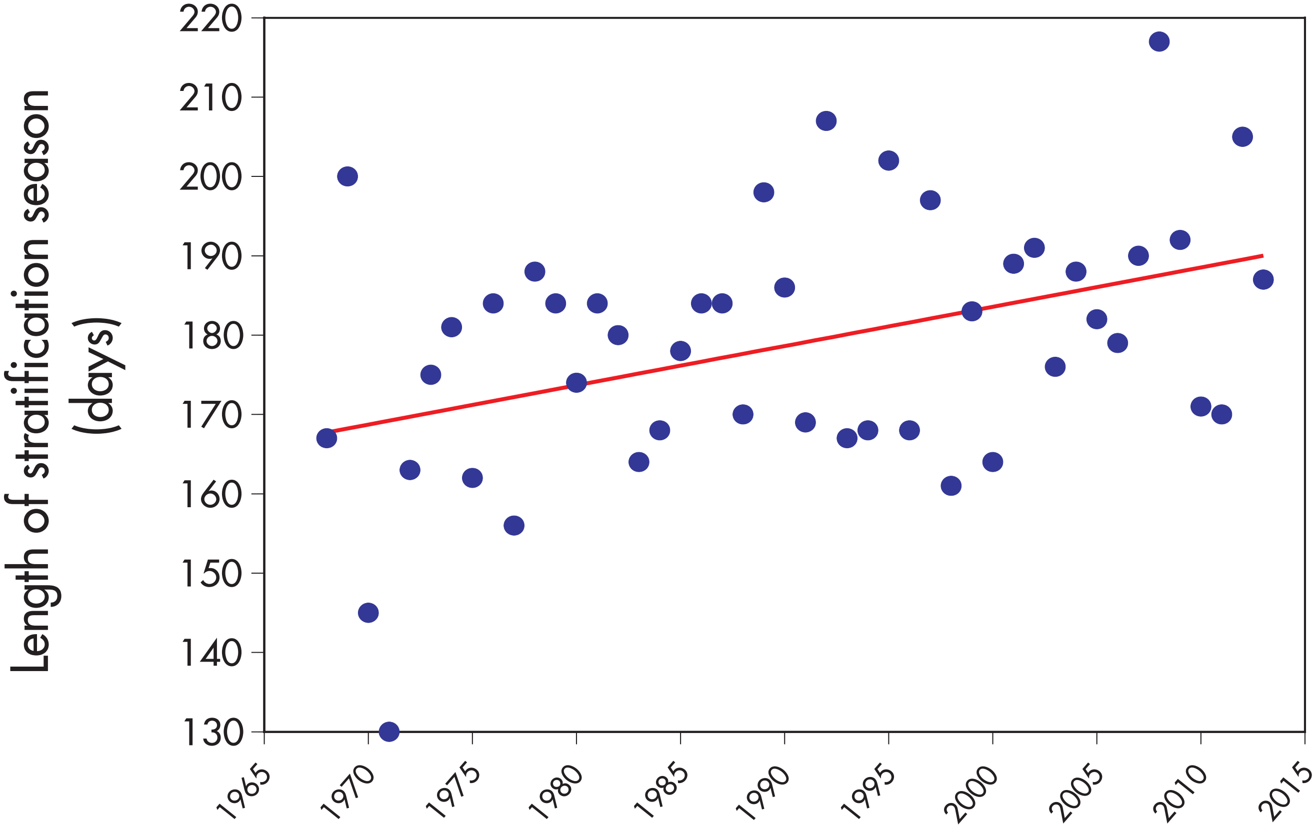


PHYSICAL PROPERTIES

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. See section 6.5 for more information on this trend.

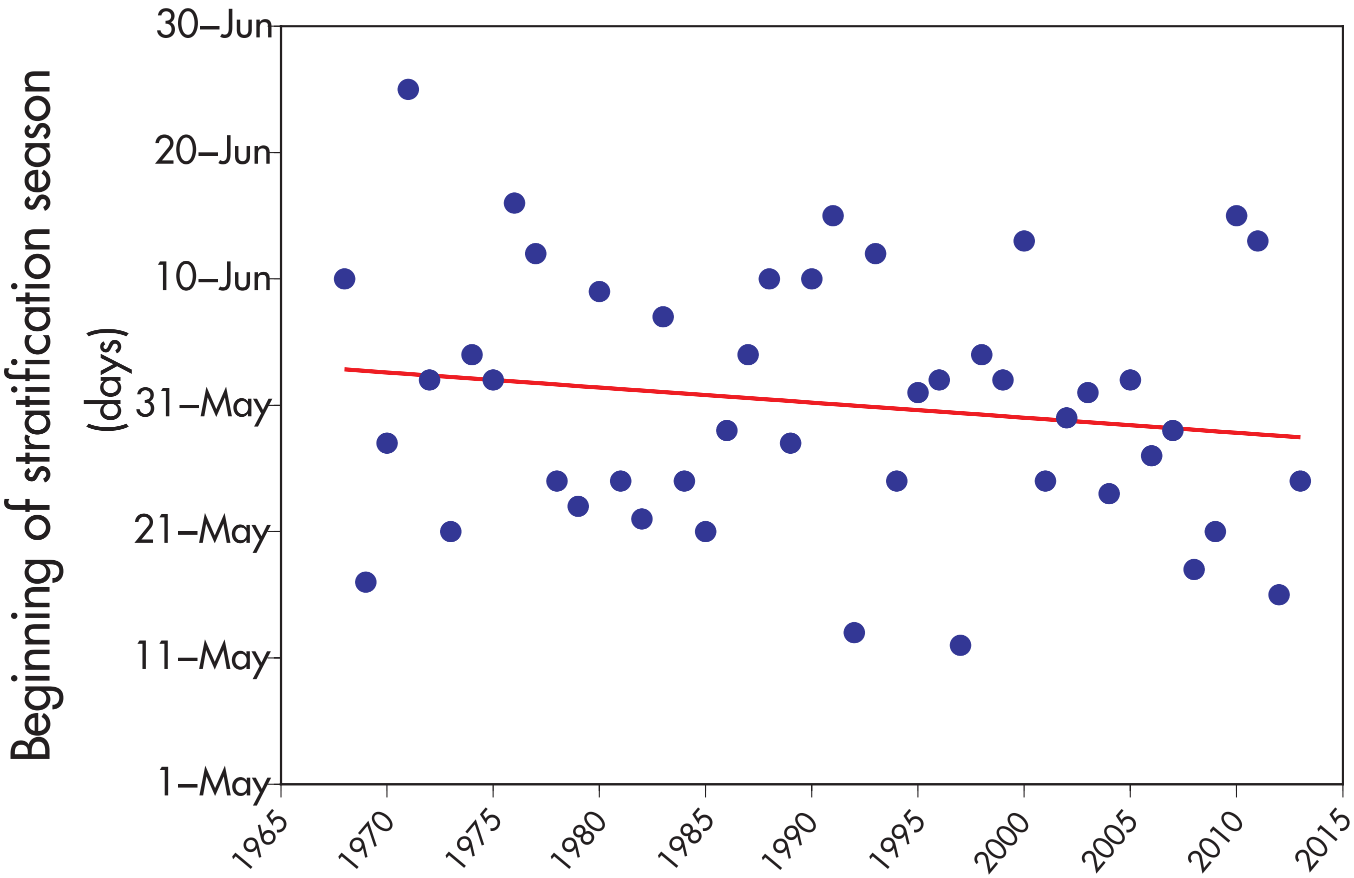


PHYSICAL PROPERTIES

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. The commencement of the stratification season is typically in late May or early June.

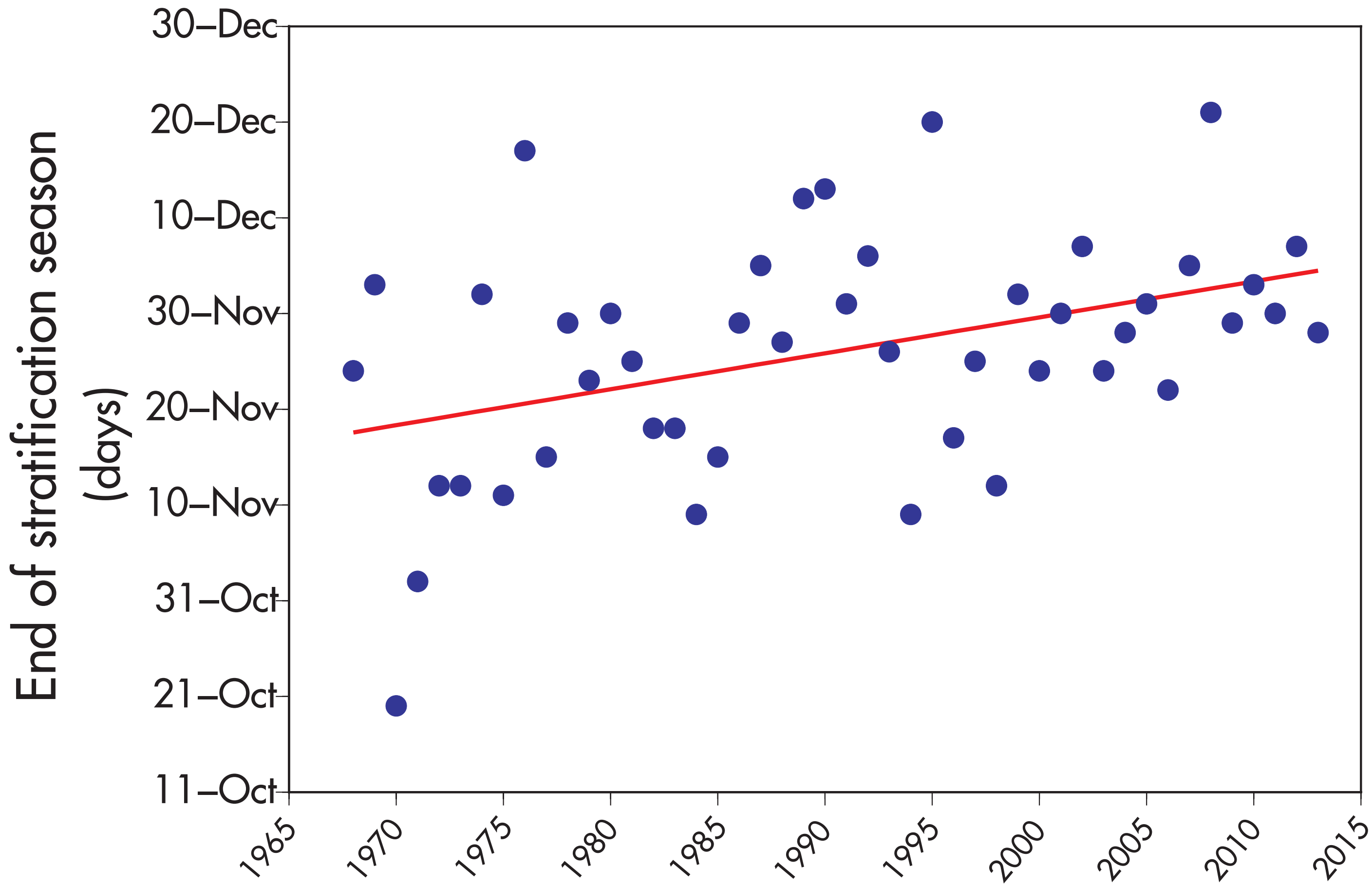


PHYSICAL PROPERTIES

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. In the late 1960's stratification ended in mid-November. Now it ends in early December. This has important implications for lake mixing and water quality.

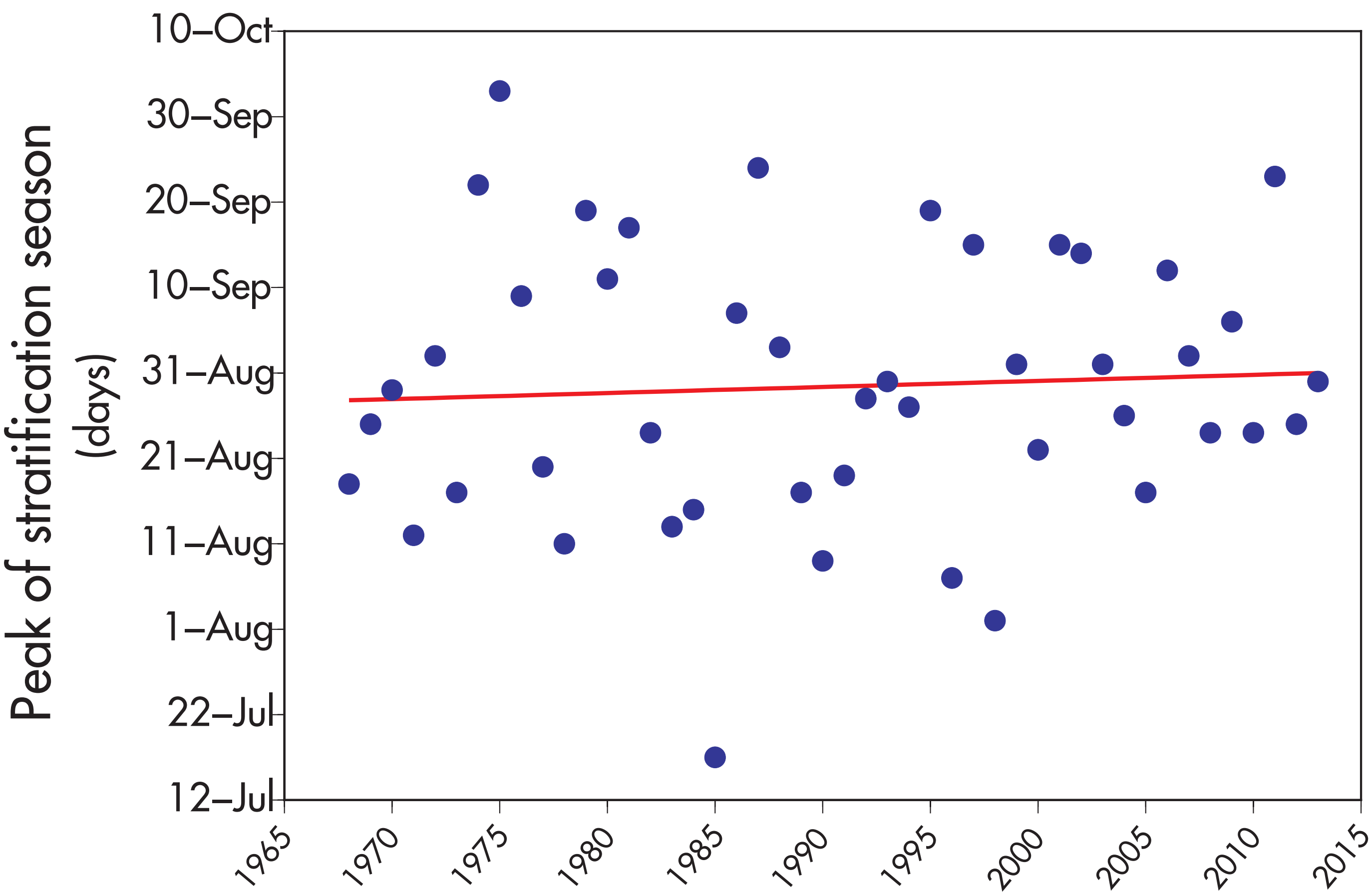


PHYSICAL PROPERTIES

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 lake now remains density stratified for a longer period of time.



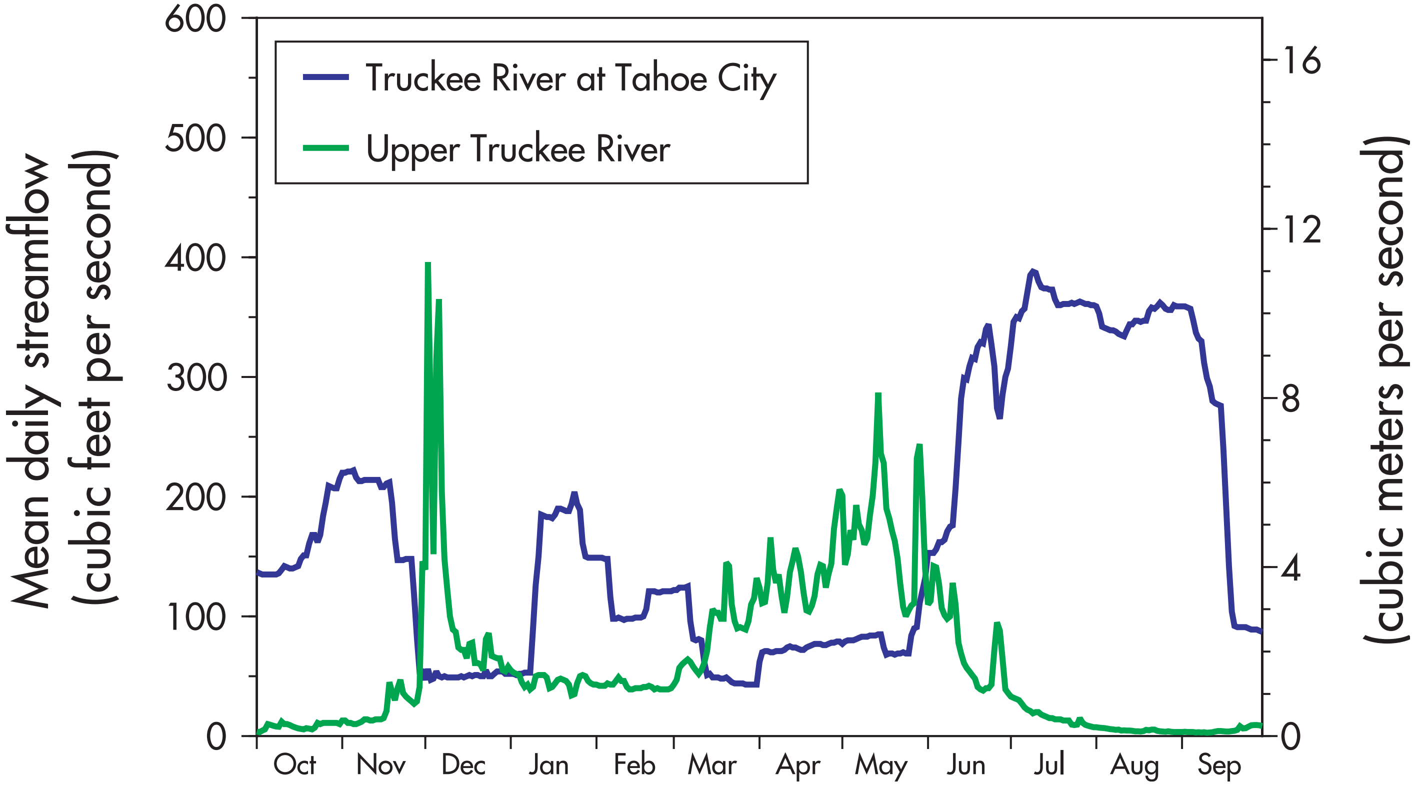
PHYSICAL PROPERTIES

Mean daily streamflow of Upper Truckee River vs. Truckee River

Water Year 2013

The largest inflowing stream to Lake Tahoe is the Upper Truckee River, which has a natural annual hydrograph typical of a snow-fed stream. The small peaks in the hydrograph represent rain events or short warm periods in winter or spring. The extended seasonal increase (March-June) represents the snowmelt. In 2013 there were two peaks. The first in December had a higher peak streamflow (365 cubic feet per second), but overall a lesser volume of water compared with the spring snowmelt in May (287 cubic feet per second). The peaks were considerably smaller than in 2012 (678 cubic feet per second).

The Truckee River is the only outflow from Lake Tahoe. It is a regulated flow, with release quantity controlled by the Federal water master. As a result, the hydrograph has extended times of near-constant outflow. The release rates are set according to downstream demands for water and concerns for flooding. The maximum discharge in 2013 was 388 cubic feet per second (similar to the previous year), and the peak temperature of the discharge was 72.5 °F (22.5 °C) on July 21. Streamflow data are collected by the US Geological Survey under the Lake Tahoe Interagency Monitoring Program (LTIMP).

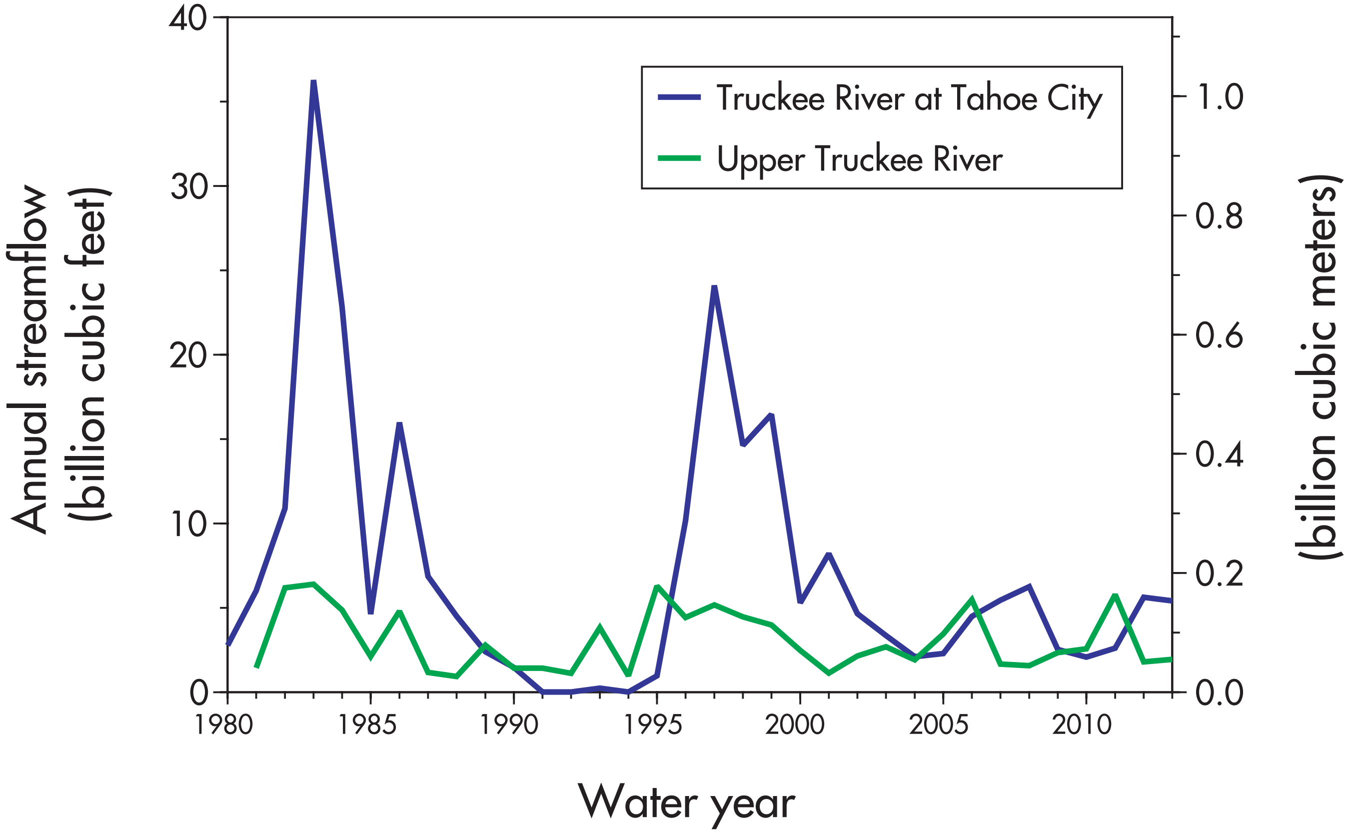


PHYSICAL PROPERTIES

Annual Discharge Volume for Upper Truckee River and Truckee River

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. The average Upper Truckee annual inflow volume since 1981 is 3.05 billion cubic feet, while the average annual outflow through the Truckee River is 7.23 billion cubic feet. In 2013 discharges into and out of the lake were well below the long-term averages. The Upper Truckee River inflow volume was 1.95 billion cubic feet. The Truckee River discharge was 5.40 billion cubic feet.

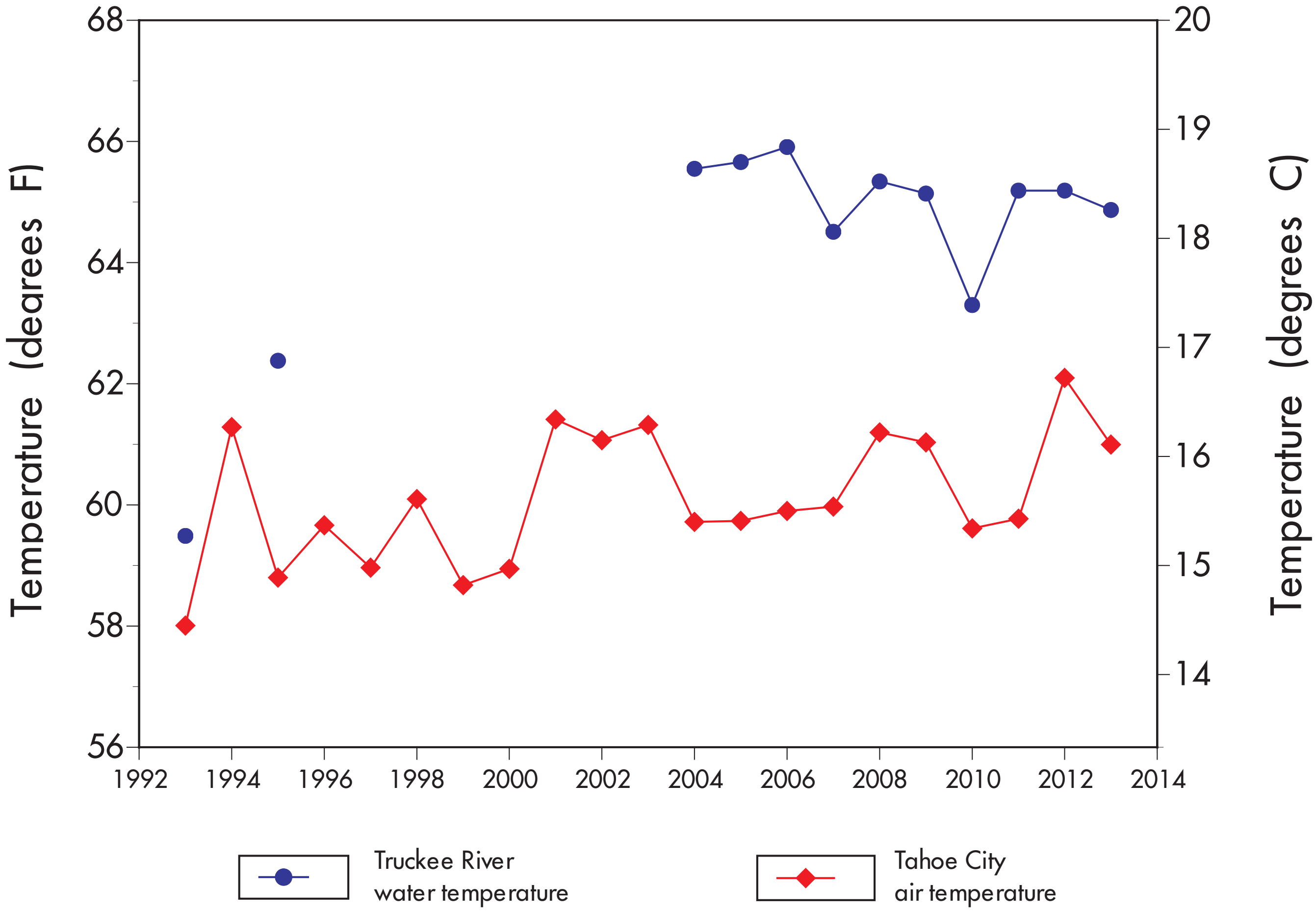


PHYSICAL PROPERTIES

Truckee River July-September 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 (2.2-2.8 °C) rise in the average temperature may have occurred since 1993. Average air temperatures from Lake Tahoe for the same period also suggest a temperature rise but at a lower rate. Elevated river temperatures can negatively impact downstream fish spawning.



PHYSICAL PROPERTIES

Truckee River Summer Discharge and Lake Elevation

Since 1980

Flow rate of the Truckee River as it departs Lake Tahoe in the summer months (July-September) and lake level for the same period 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 – two year lag from the 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.

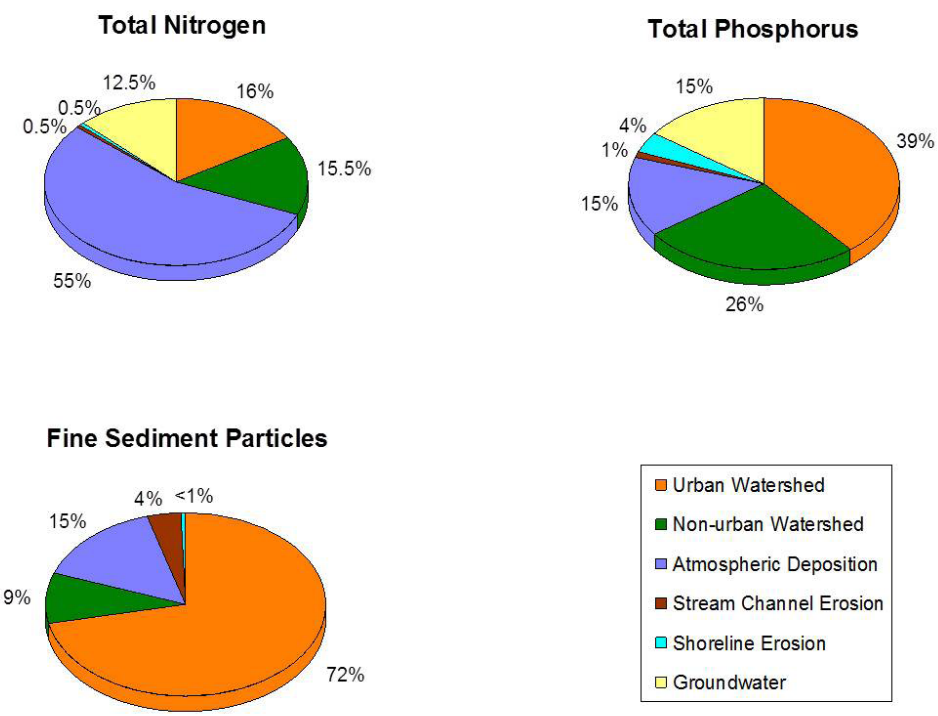
TAHOE: STATE OF THE LAKE REPORT 2014

NUTRIENTS AND PARTICLES

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. One of the major contributors to clarity decline are extremely fine particles that 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 appeared in previous years' State of the Lake Reports.)



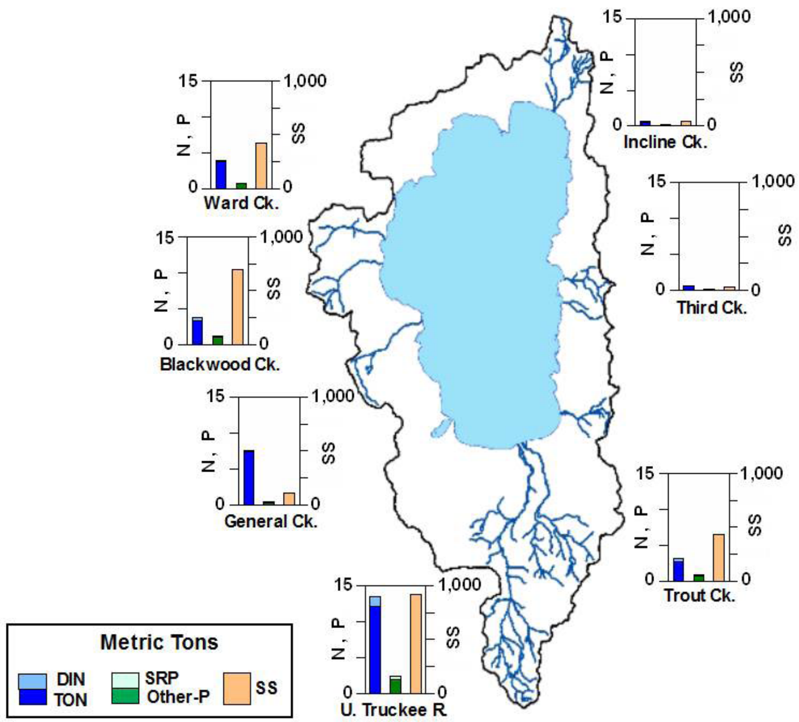
NUTRIENTS AND PARTICLES

Pollutant loads from seven watersheds

In 2013

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 2013 and 2012, compared with 2011. This was largely due to the drier years that the basin experienced.

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.



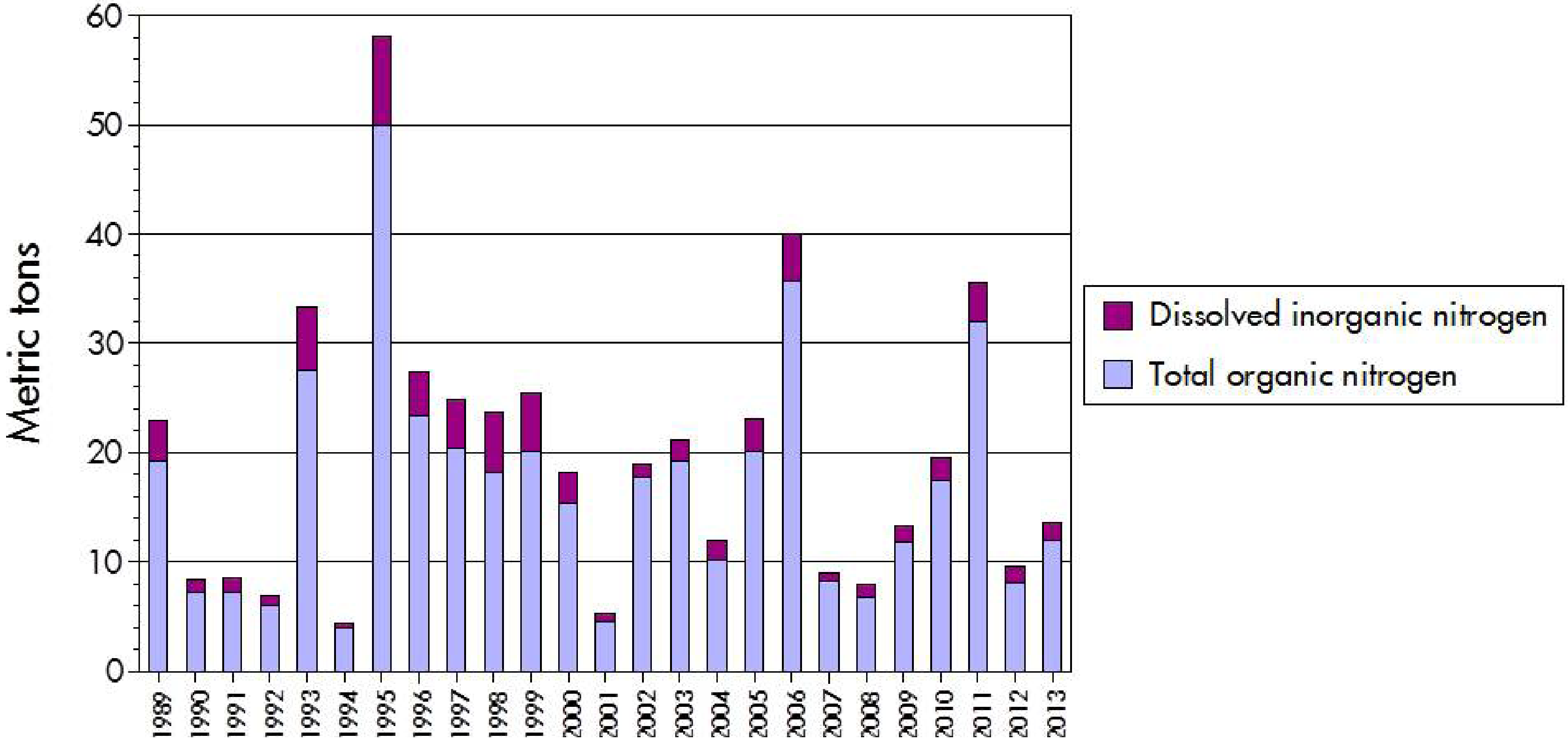
N = Nitrogen
P = Phosphorus
DIN = Dissolved Inorganic Nitrogen
SRP = Soluble Reactive Phosphorus
TON = Total Organic Nitrogen
SS = Suspended Sediment

NUTRIENTS AND PARTICLES

Nitrogen contribution by Upper Truckee River

Yearly since 1989

Nitrogen (N) is important because it, along with phosphorus (P), stimulates algal growth. 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 2013 had 25.19 inches of precipitation and 2012 had 22.48 inches of precipitation. (One metric ton = 2,205 pounds.)

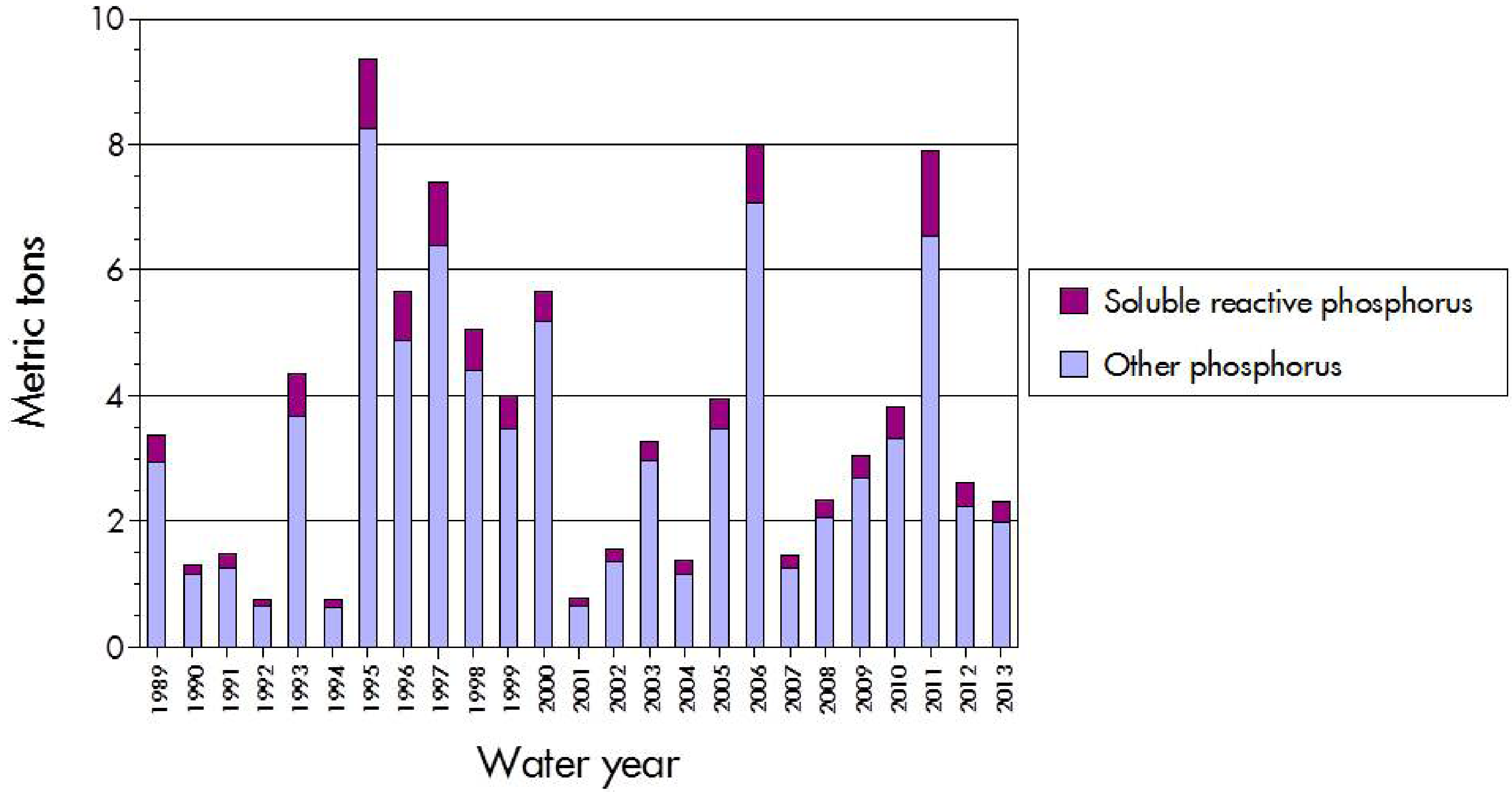


NUTRIENTS AND PARTICLES

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, the year-to-year variation in load largely reflects the changes in precipitation. Below average precipitation in 2013 resulted in a factor of four reduction of the phosphorus load over 2011. 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.)

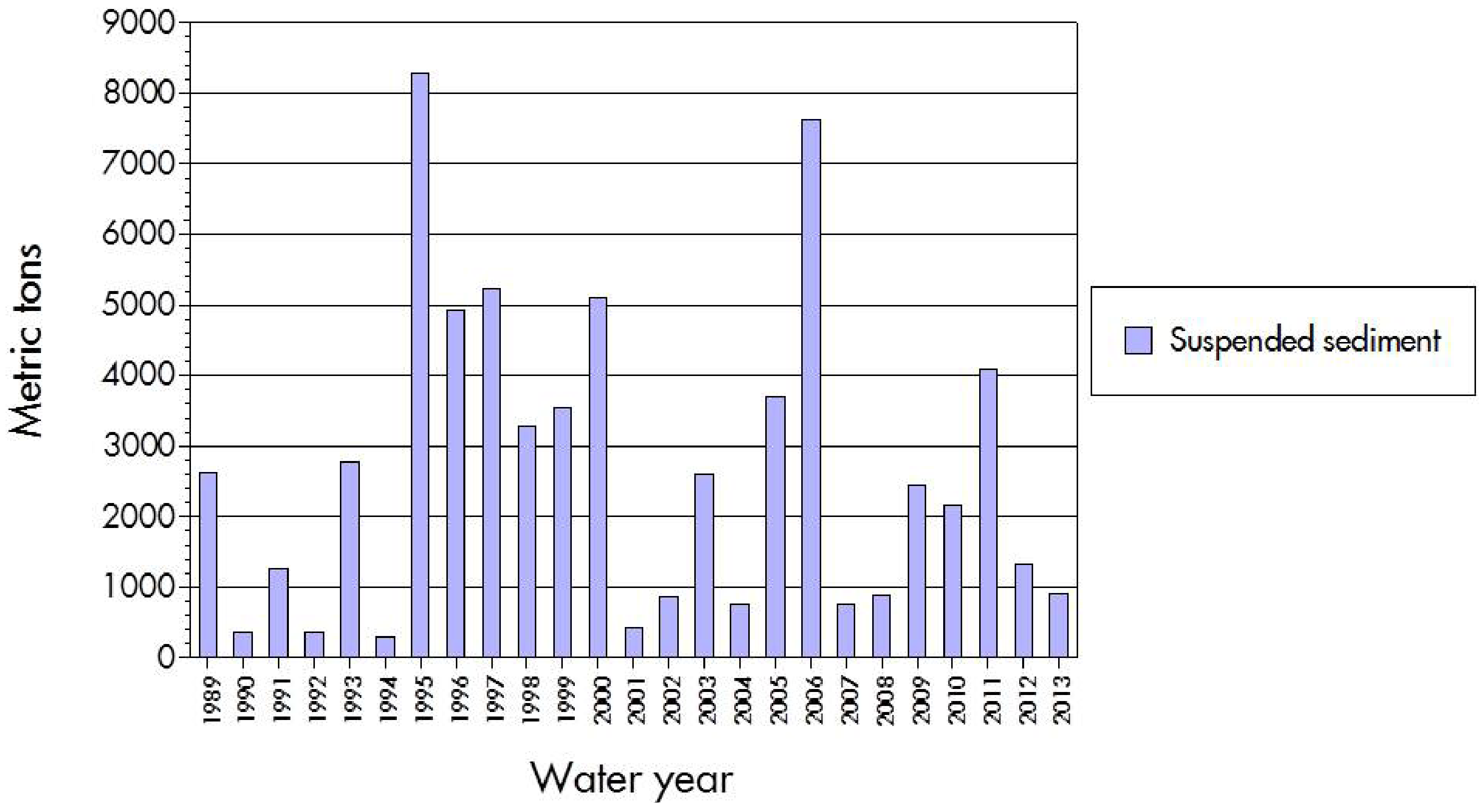


NUTRIENTS AND PARTICLES

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 2013 resulted in a factor of four decrease of the suspended sediment load compared with 2011. 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, as well as restoration of habitat for plants and wildlife.

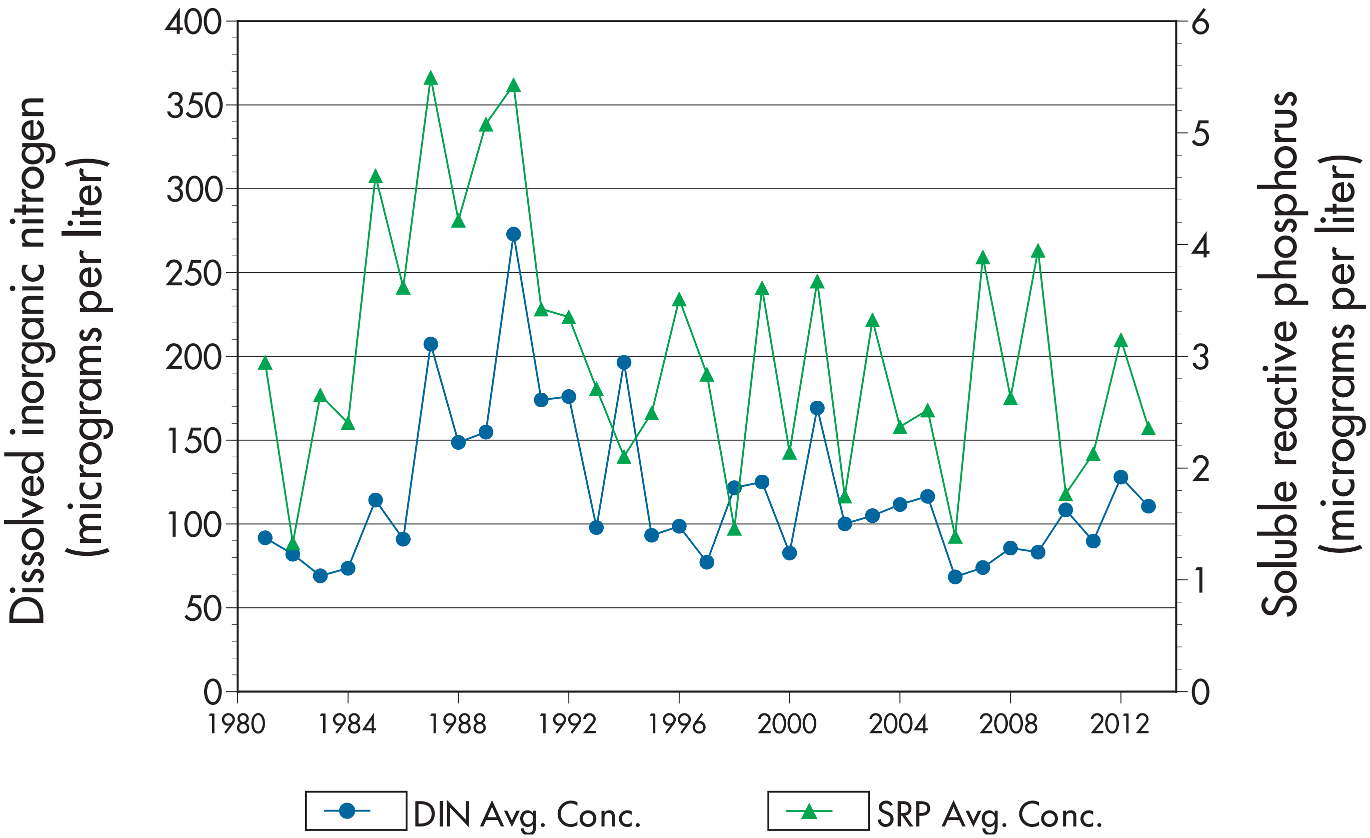


NUTRIENTS AND PARTICLES

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 since peaking in the late 1980's. Annual concentrations in precipitation of dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) vary from year to year. In 2013, concentrations of DIN and SRP decreased from the previous year. The ratio of N:P concentration in precipitation is on average 42:1 (±16). As this is the concentration in precipitation, it is not necessaarily affected by the relatively dry conditions of 2013.

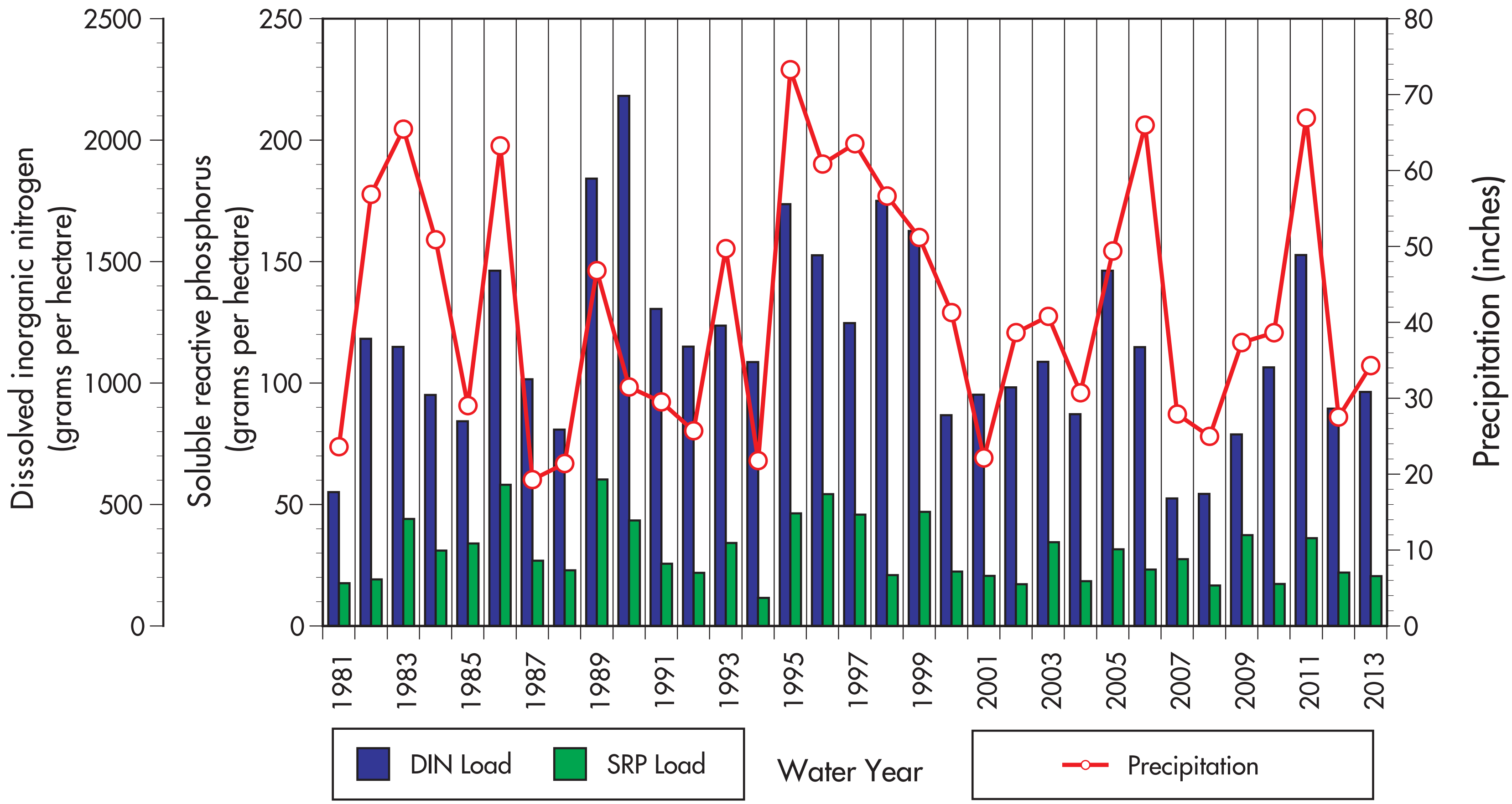


NUTRIENTS AND PARTICLES

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 2013, the nitrogen and phosphorus loads were within the range seen in previous years.

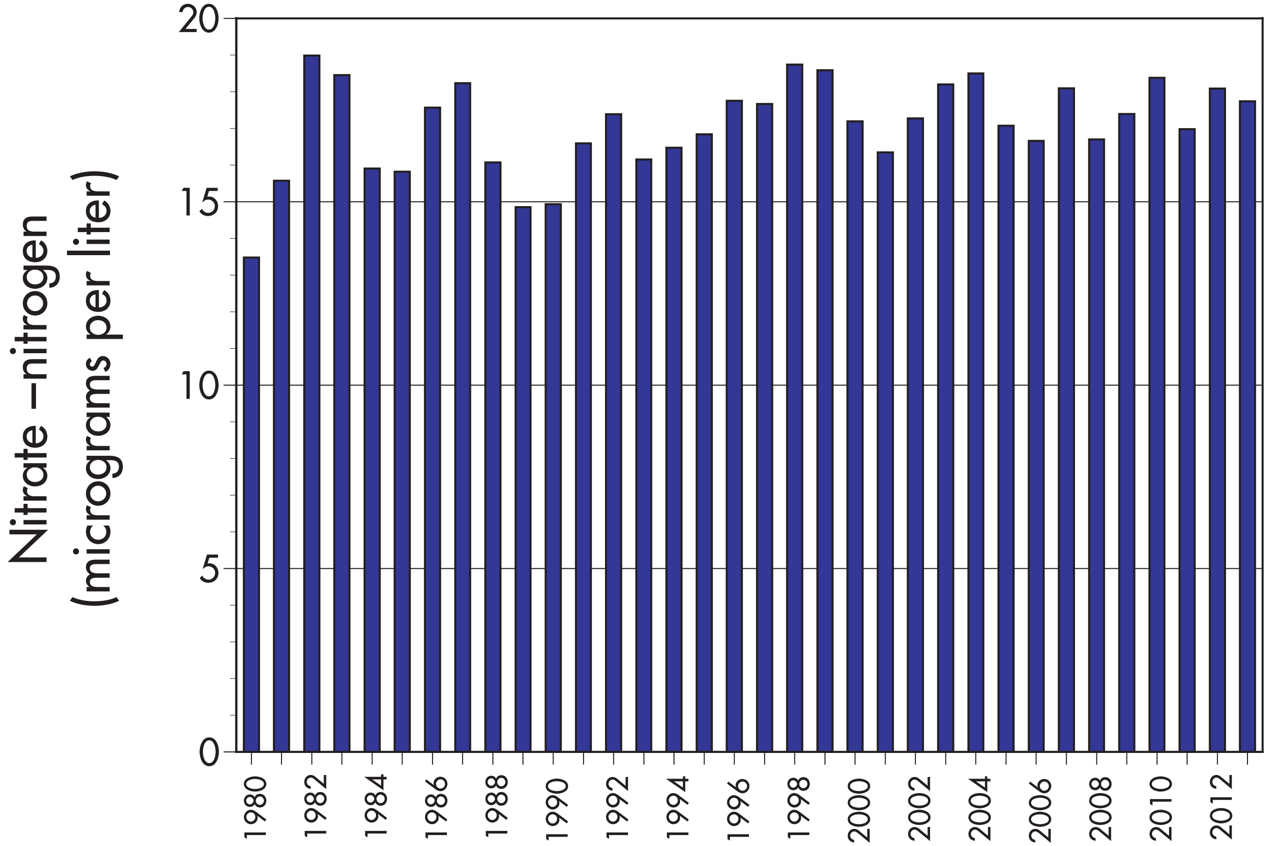


NUTRIENTS AND PARTICLES

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 2013, the volume-weighted annual average concentration of nitrate-nitrogen was 17.7 micrograms per liter. Water samples are taken from the R/V John LeConte at the MLTP (mid-lake) station at 13 depths from the surface to 450 m. The nutrient analysis is performed at the TERC laboratory in Incline Village, Nevada.

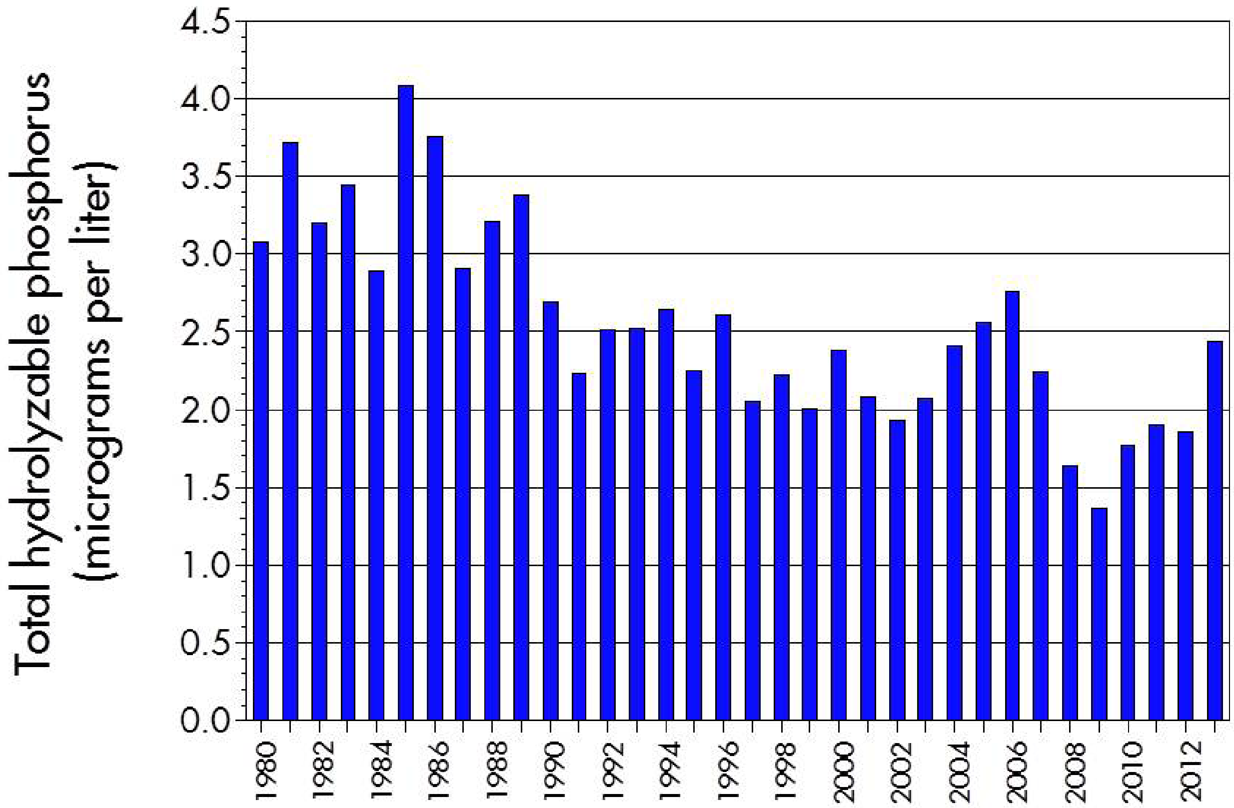


NUTRIENTS AND PARTICLES

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 that 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 2013, the volume-weighted annual average concentration of THP was approximately 2.4 micrograms per liter, an increase over the previous year. Water samples are taken from the R/V John LeConte at the MLTP (mid-lake) station at 13 depths from the surface to 450 m. The nutrient analysis is performed at the TERC laboratory.



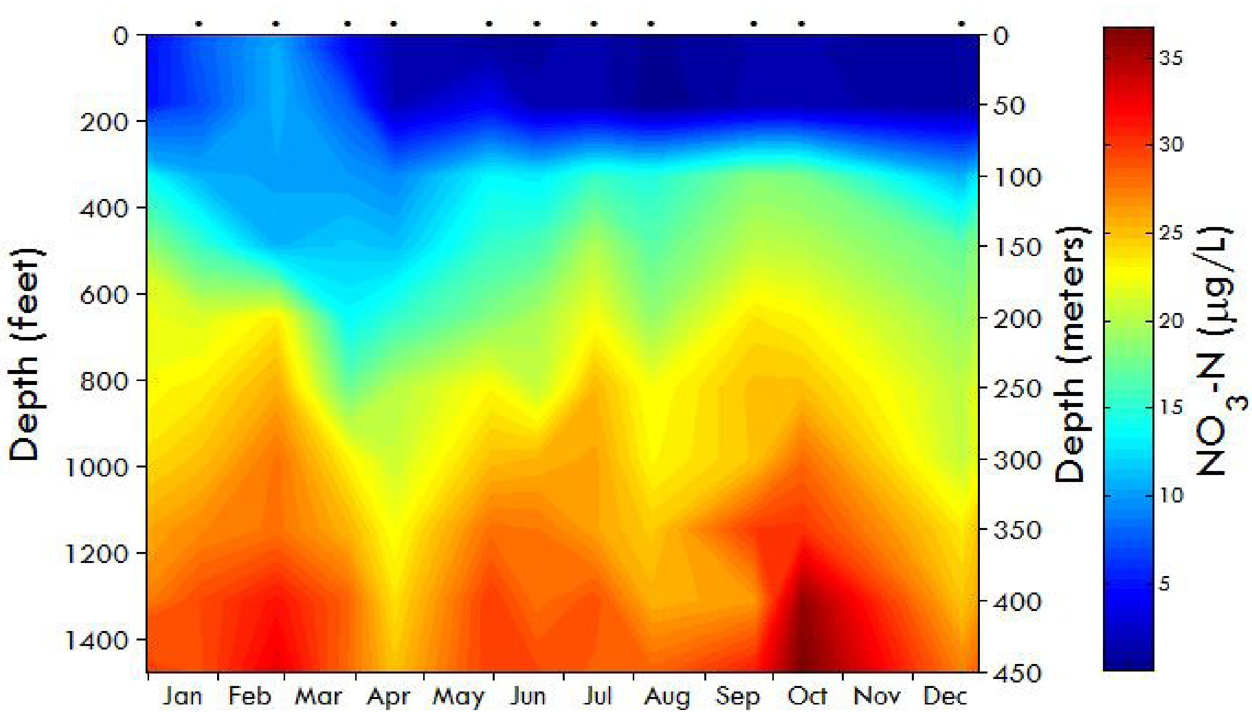
NUTRIENTS AND PARTICLES

Nitrate Distribution

In 2013

Water samples are collected approximately every month (on dates indicated by dots at the top of the figure) at 13 depths at the middle of the lake, and analyzed in the TERC lab for nutrient concentrations. Here the nitrate concentration is shown in the form of color contours.

Most evident in this figure is the vertical distribution of nitrate. Concentrations below a depth of about 400 feet are generally high. The surface waters, where there is sunlight to enable algae to grow usually has low concentrations of nitrate. Although most of the nitrate enters at the surface through atmospheric deposition, it is rapidly used up by the algae. As algae eventually sink and decompose, the nitrate they consumed eventually reappears deep in the lake. At these depths, however, there is insufficient light for algae to grow and to assimilate the nutrients. When deep lake mixing occurs, the deep nitrate can be brought back to the surface. This process is evident in February-March. An increase in nitrate at the surface (light blue color) is being produced by the mixing of water down to 590 feet. 2013 was a year with very shallow mixing, and so most of the nitrate remained trapped in the deep water.



NUTRIENTS AND PARTICLES

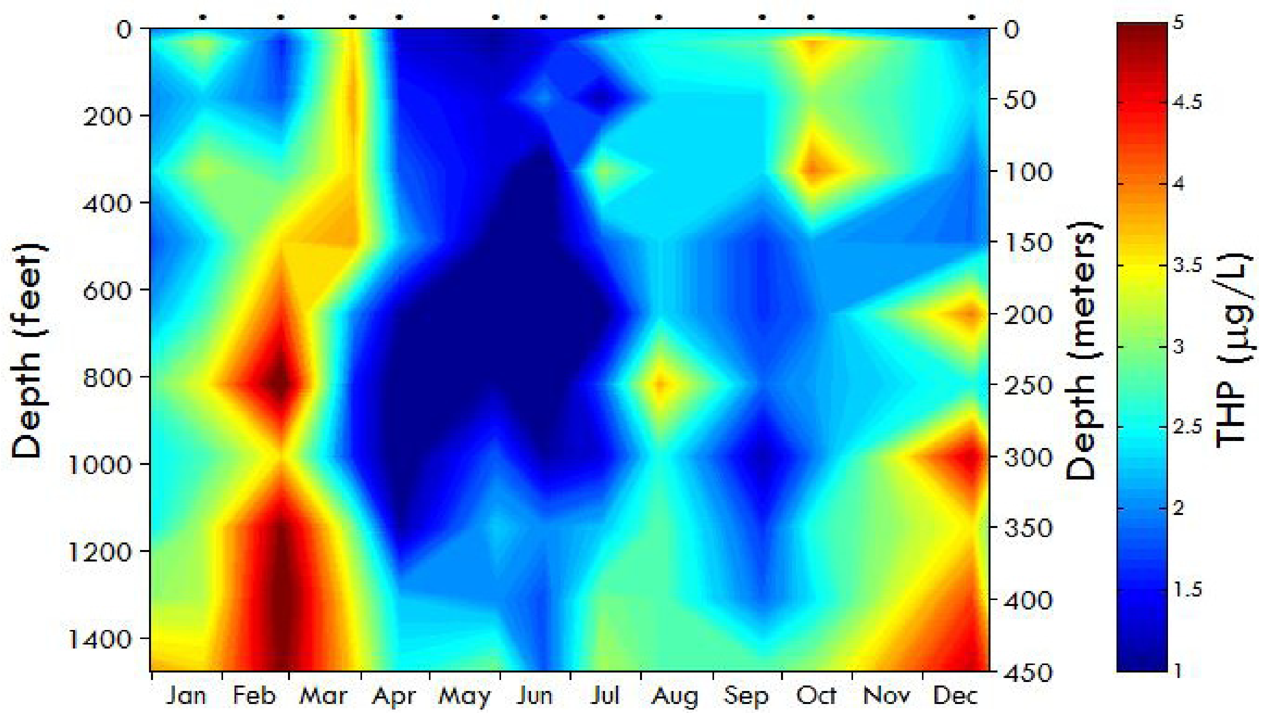
Phosphorus Distribution

In 2013

Water samples are collected approximately monthly (on dates indicated by dots at the top of the figure) at 13 depths at the middle of the lake, and analyzed in the TERC lab for nutrient concentrations. Here the total hydrolyzable phosphorus (THP) concentration (the fraction of the phosphorus that can be most readily used by algae) is shown in the form of color contours.

Unlike the nitrate distribution, there is relatively little vertical distribution of THP. Phosphorus mainly enters the lake in association with fine particles. Because of the low snowmelt volumes and the cold conditions, when snowmelt occurred in March much of the phosphorus was carried with the flow deep into the lake. The phosphorus that remained in the surface was quickly consumed and by April concentrations were extremely low.

Unlike nitrate, which can remain dissolved in the water column, THP is strongly adsorbed to particles, so when algae settle and decompose, the THP is quickly adsorbed to particles which can then settle quickly in the deep water.



NUTRIENTS AND PARTICLES

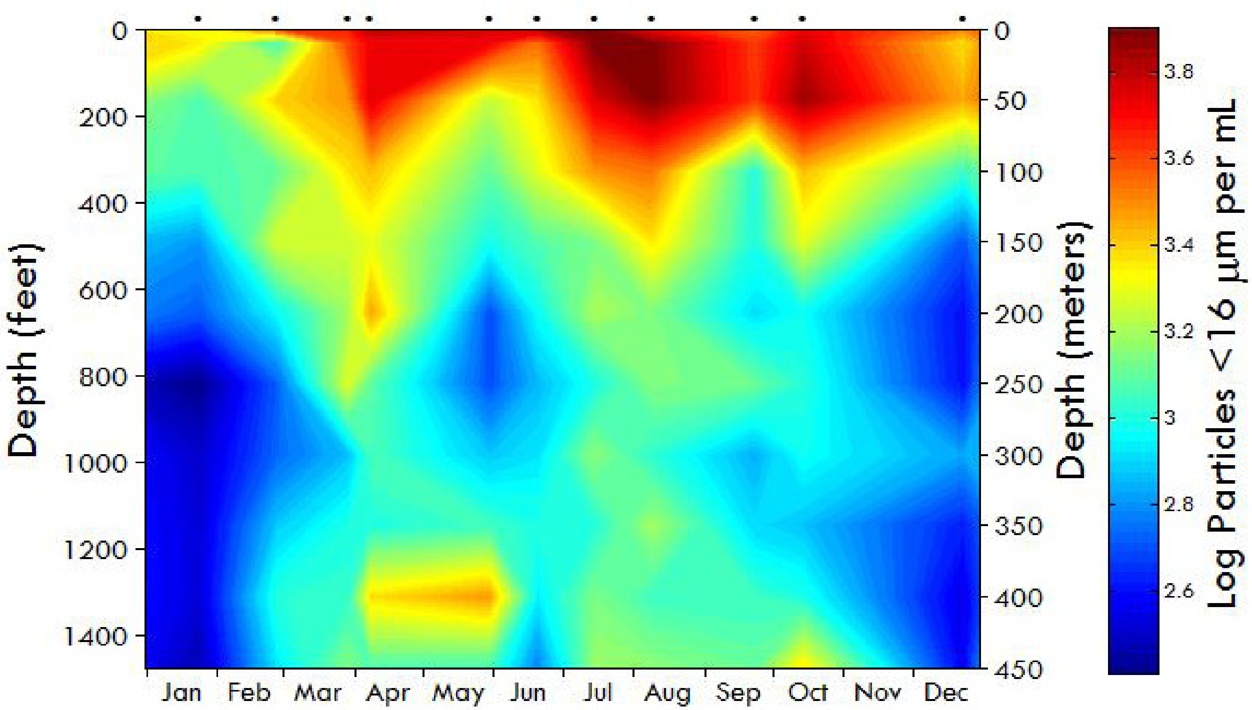
Fine Particle Distribution

In 2013

Water samples are collected approximately monthly (on dates indicated by dots at the top of the figure) at 13 depths at the middle of the lake, and analyzed in the TERC lab for the concentration of fine particles in 15 different bin sizes. Here the distribution of the finest particles (0.5 to 8 microns) are shown in the form of color contours.

Clearly evident in the figure is that the highest concentrations of fine particles (red tones) are concentrated in the upper part of the lake. In the early part of the year (winter), when clarity is generally highest, surface concentration of particles is the lowest. A reduction in surface particle concentration is also evident in December. In winter there is also the lowest concentrations of fine particles in the deep water. This is due to them aggregating and settling out.

The high concentration values at a depth of about 1300 feet in April and May is believed to be due to some of the very cold snowmelt water plunging to the deep part of the lake on account of its high density.



TAHOE: STATE OF THE LAKE REPORT 2014

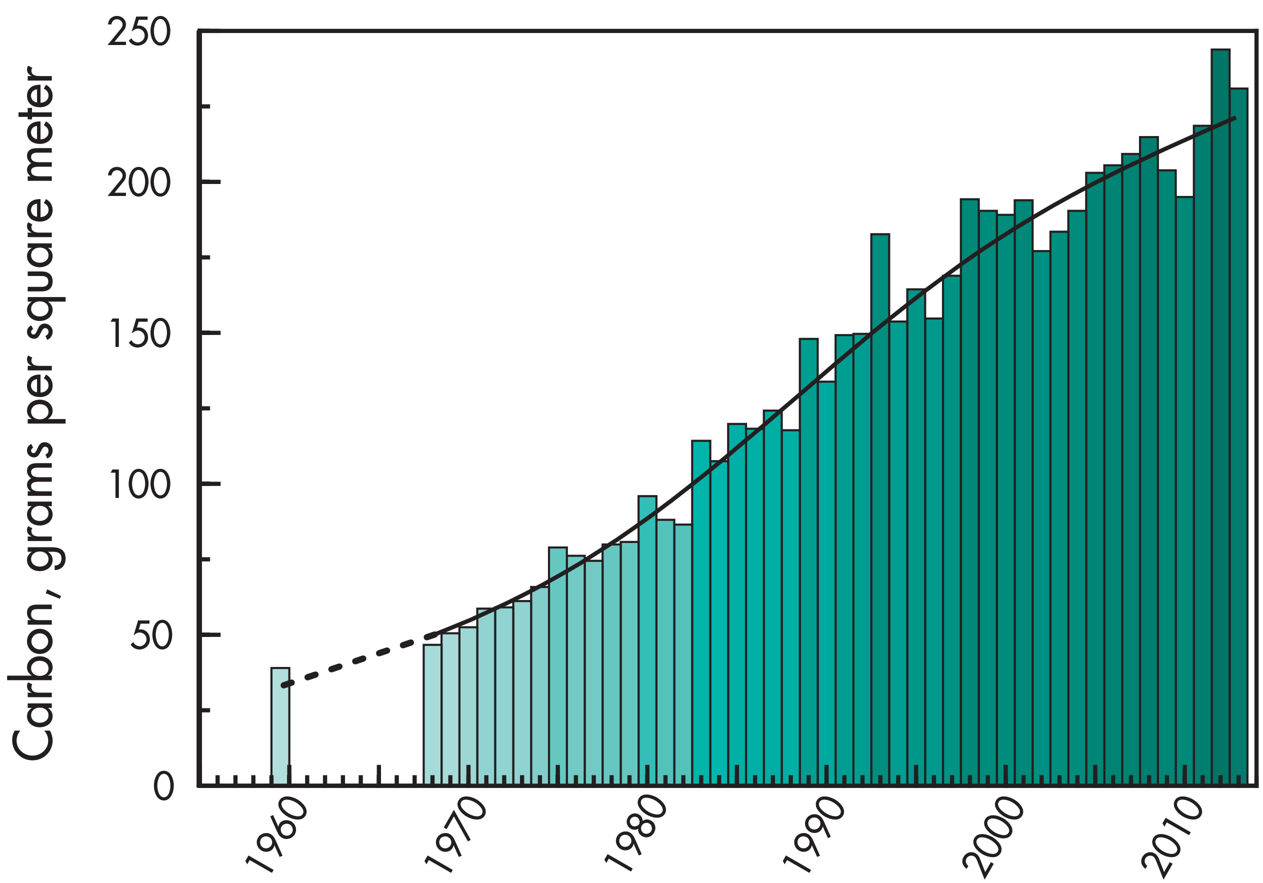
BIOLOGY

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. Supported by nutrient loading into the lake, changes in the underwater light environment and a succession of algal species, the trend shows primary productivity has generally increased over time. In 2013 we saw a slight decrease in primary productivity to 230.9 grams of carbon per square meter, but this was still the second highest volume on record.

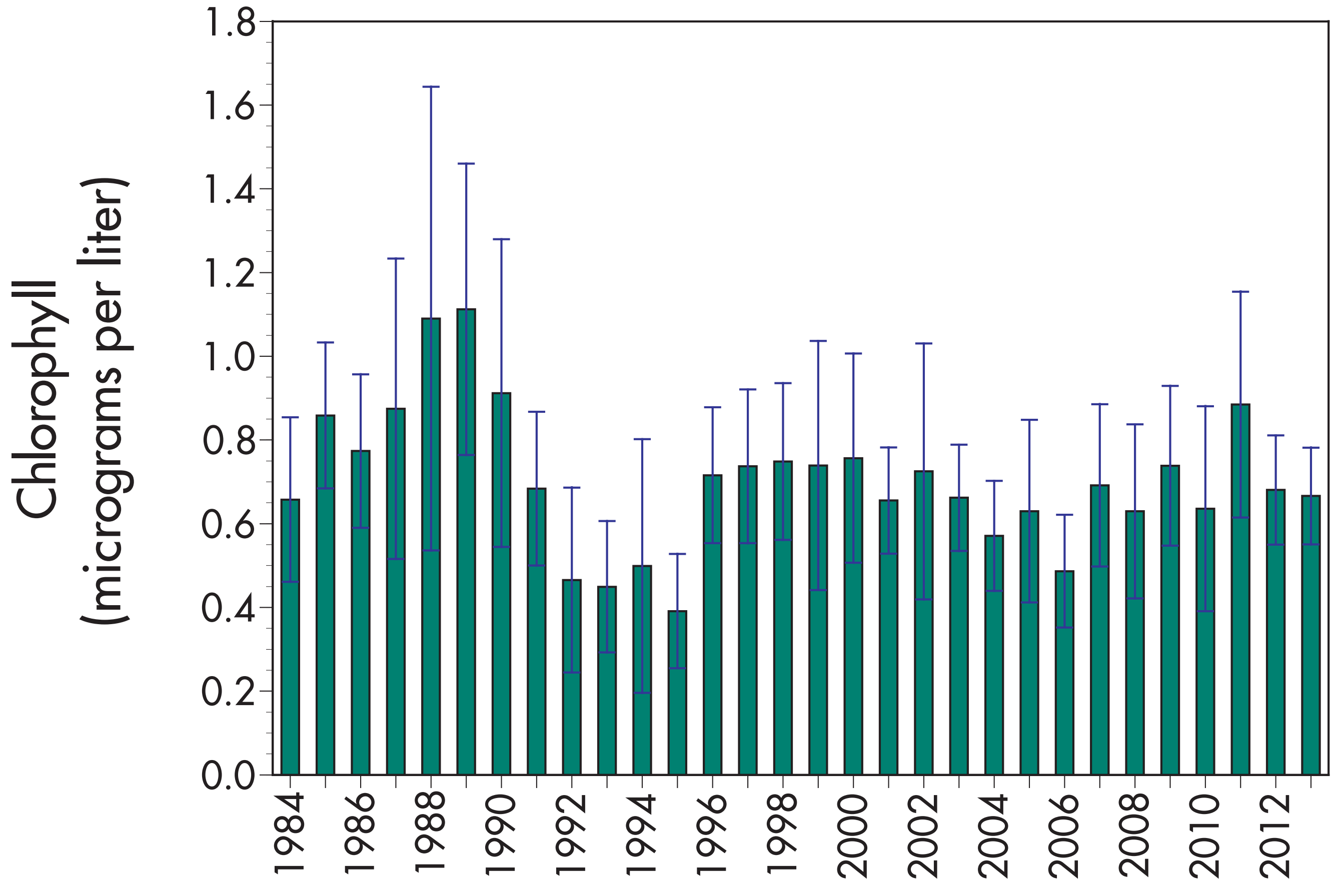


BIOLOGY

Algae abundance

Yearly since 1984

Algae (phytoplankton) are the base of the Lake Tahoe food web, and essential for lake health and the well-being of the entire ecosystem. The amount or biomass of free-floating algae in the water is determined by extracting and measuring the concentration of chlorophyll-*a*, a photosynthetic pigment that allows plants to absorb energy from the sun. Though the value varies annually, it has not shown a significant increase since measurements began in 1984. The annual average value for 2013 was 0.67 micrograms per liter. The average annual chlorophyll-*a* level in Lake Tahoe has remained relatively uniform since 1996. For the period of 1984-2013 the average value was 0.70 micrograms per liter.



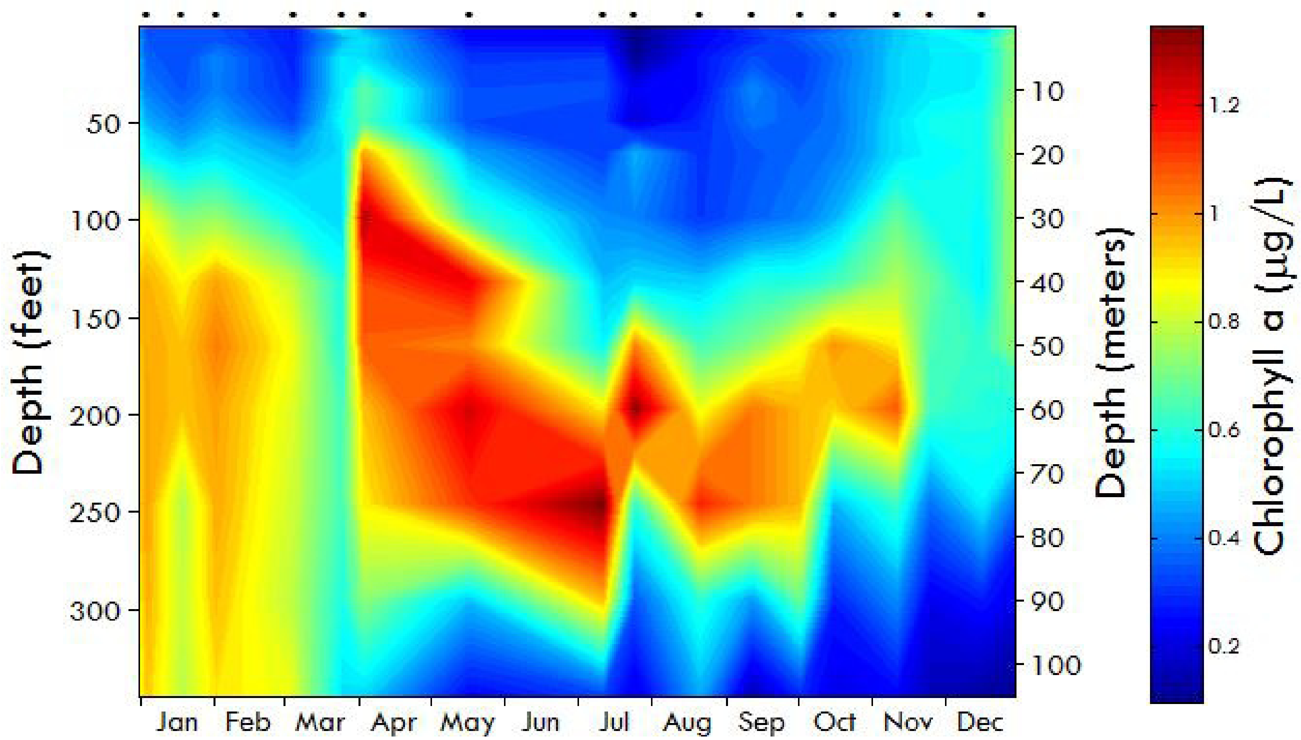
BIOLOGY

Chlorophyll-*a* distribution

In 2013

The distribution of algae (measured as chlorophyll–*a*) is the result of a combination of light availability, nutrient availability, mixing processes and to a lesser extent water temperature. This figure shows color contours of chlorophyll-*a* concentration down to a depth of 350 feet. Below this depth concentrations are near zero due to the absence of light.

Lake Tahoe has a "deep chlorophyll maximum", that is in the range of 100-200 ft. At that depth the light and nutrient conditions are most favorable for algal growth. In the early part of the year, the algae were distributed over a greater depth range because of the deep mixing processes that were occurring. With the onset of thermal stratification, the algae were confined to a discrete band. Throughout the year concentrations decreased as nutrients were depleted. In December, the commencement of deep mixing again redistributed the algae over a broader depth range. This period when algae are lifted into the surface water usually coincides with a decrease in water clarity.

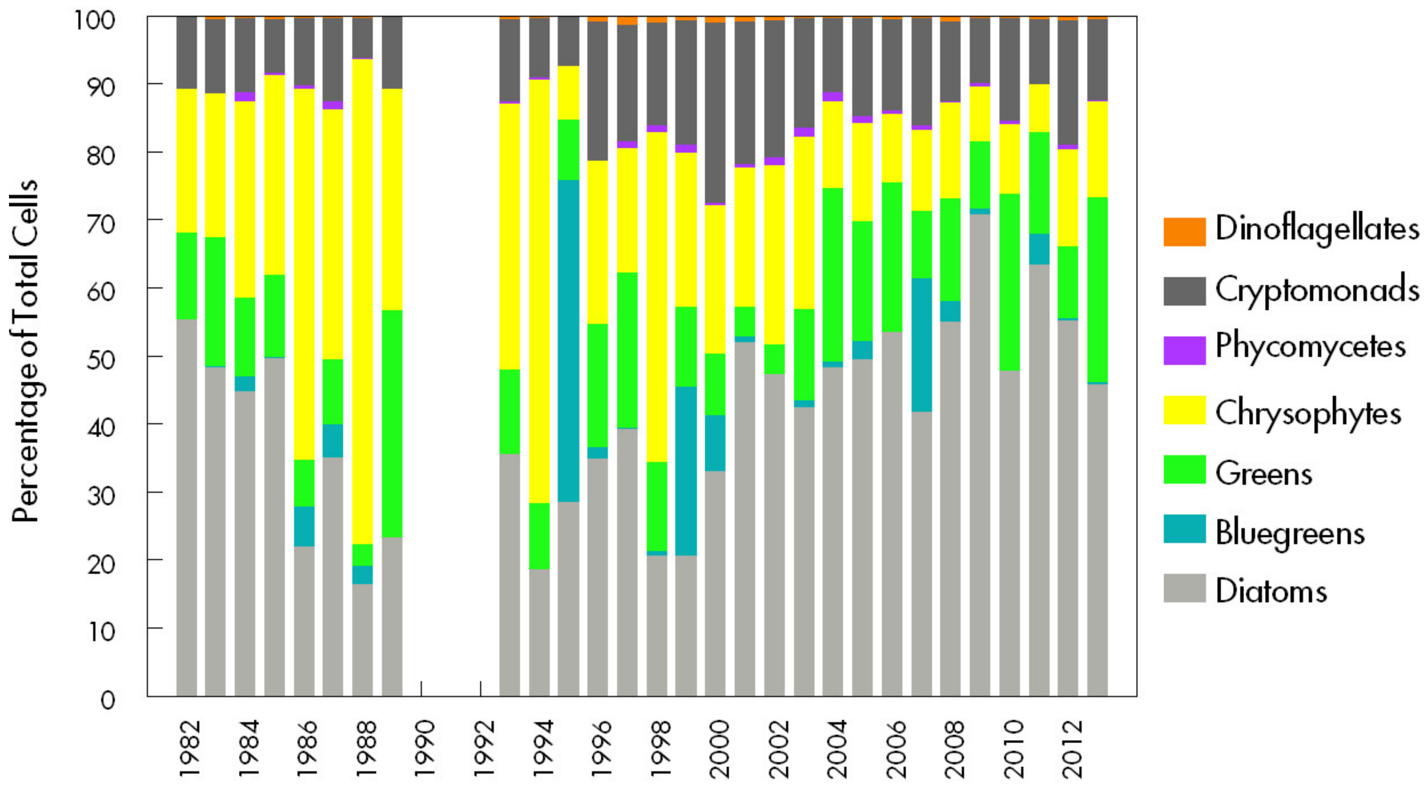


BIOLOGY

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, cryptophytes and green algae 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 conditions.

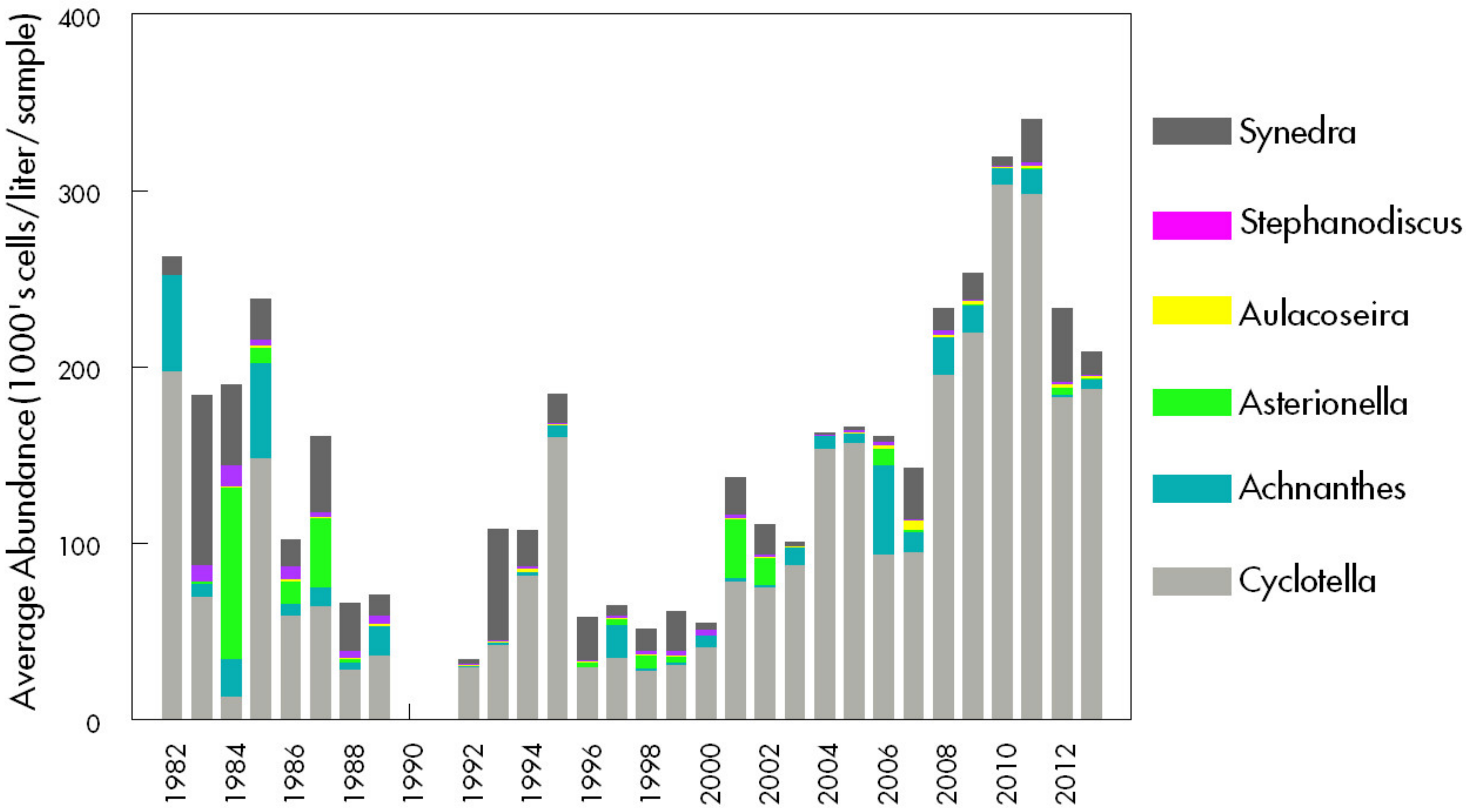


BIOLOGY

Abundance of dominant diatom species

Yearly since 1982

Diatoms have been the dominant algal group at Lake Tahoe for all but a few years since 1982. Diatoms are unique in that they are enclosed within a cell wall made of silica called a frustule. Here the dominant diatom species at Lake Tahoe between 1982 and 2013 are shown. Huge inter-annual variations are evident, both in the overall abundance and in the relative composition. Generally *Cyclotella gordonensis* is the dominant diatom species in Lake Tahoe.

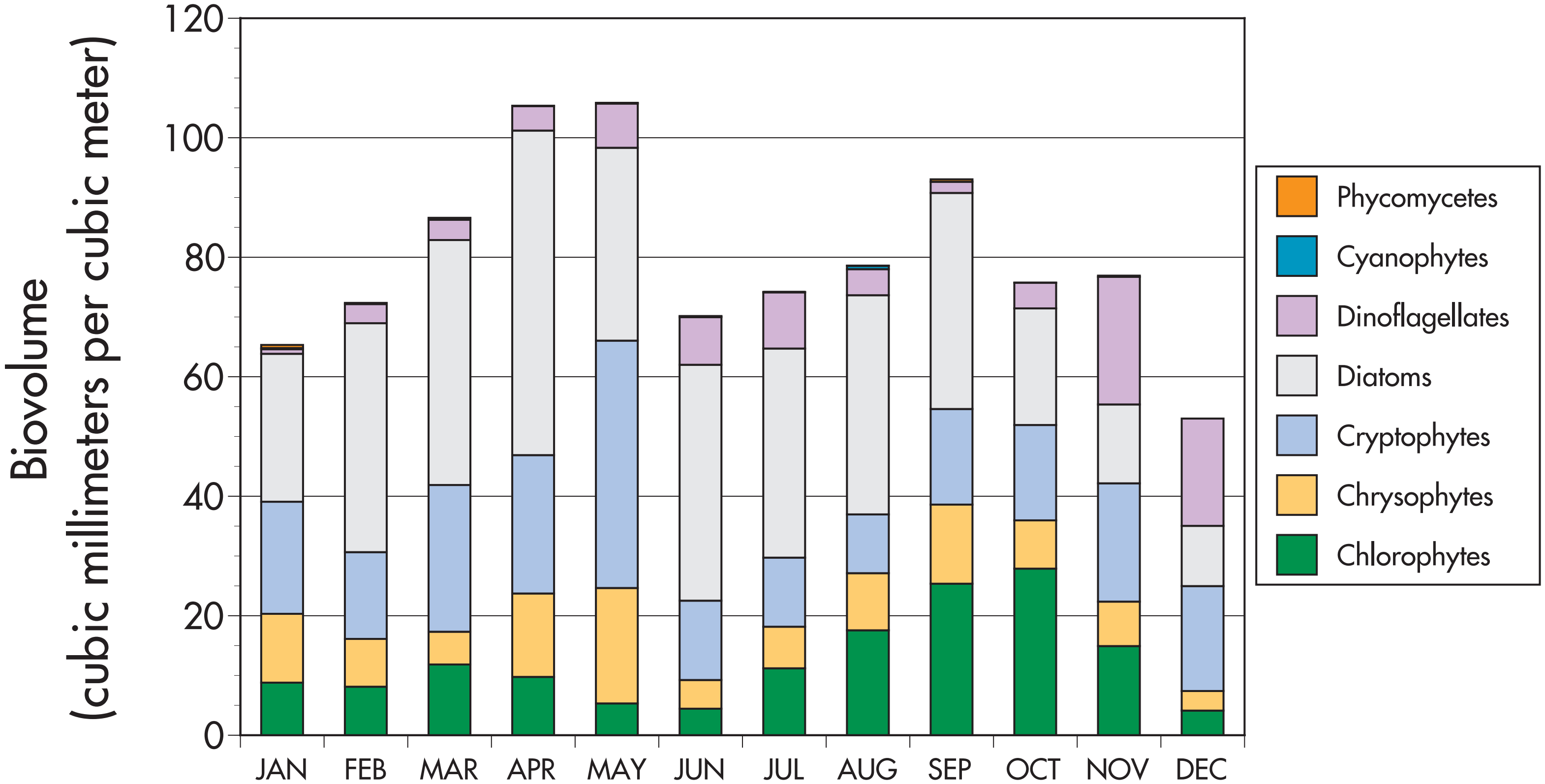


BIOLOGY

Algal groups as a fraction of total population

Monthly in 2013

Algae populations vary month to month, as well as year to year. In 2013, diatoms again dominated the phytoplankton community, especially in the first six months of the year. Diatom concentrations peaked in April and May (the "spring bloom"). Even at the peak of the bloom, algal cells occupied only one ten-millionth of the water in the lake. The peak biovolume in 2013 (105 cubic millimeters per cubic meter) was 35% lower than the peak in 2012. If all the algae in Lake Tahoe were spread out on a football field, they would fill it to a height of 9.2 feet (2.8 m).

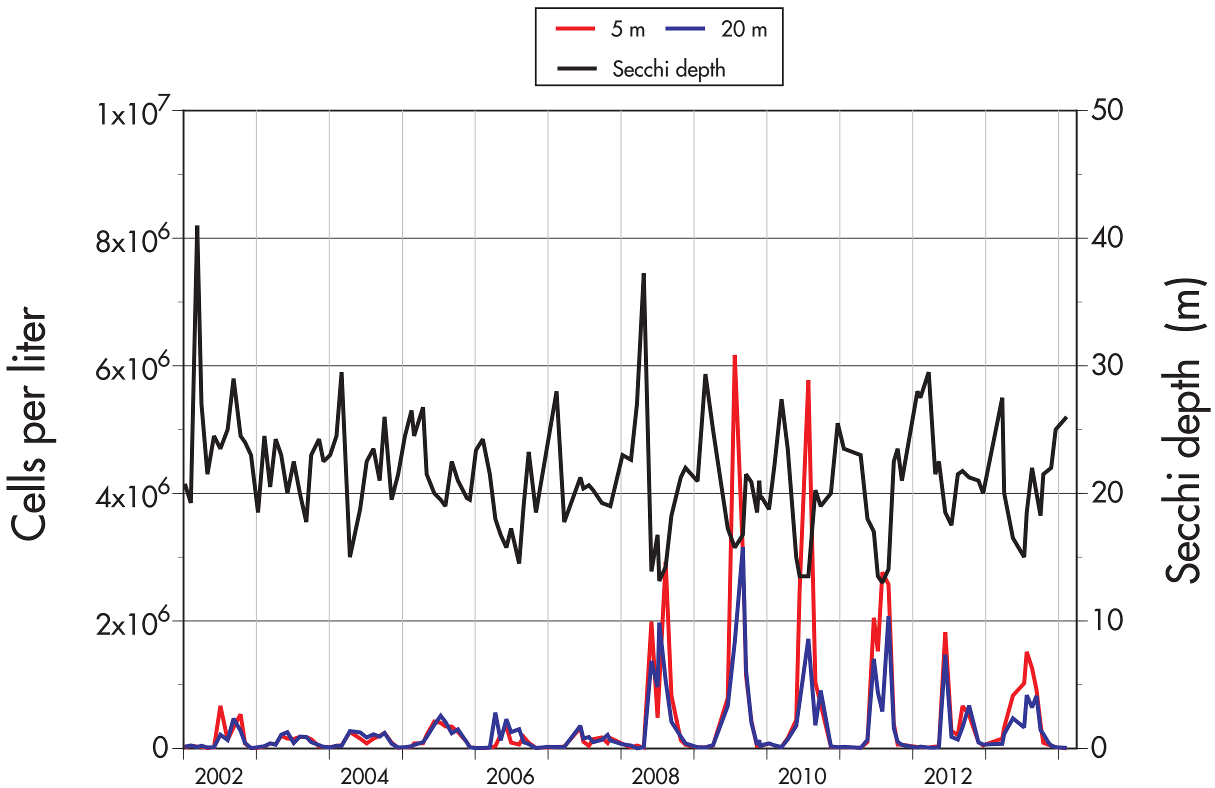


BIOLOGY

Predominance of *Cyclotella sp.*

From 2002 through 2013

In 2008, one species of algae, *Cyclotella gordonensis*, 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 zone. 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 2013 the concentration of *Cyclotella* cells continued to decrease, and summer clarity was relatively high for the second year running. The blue and red 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.

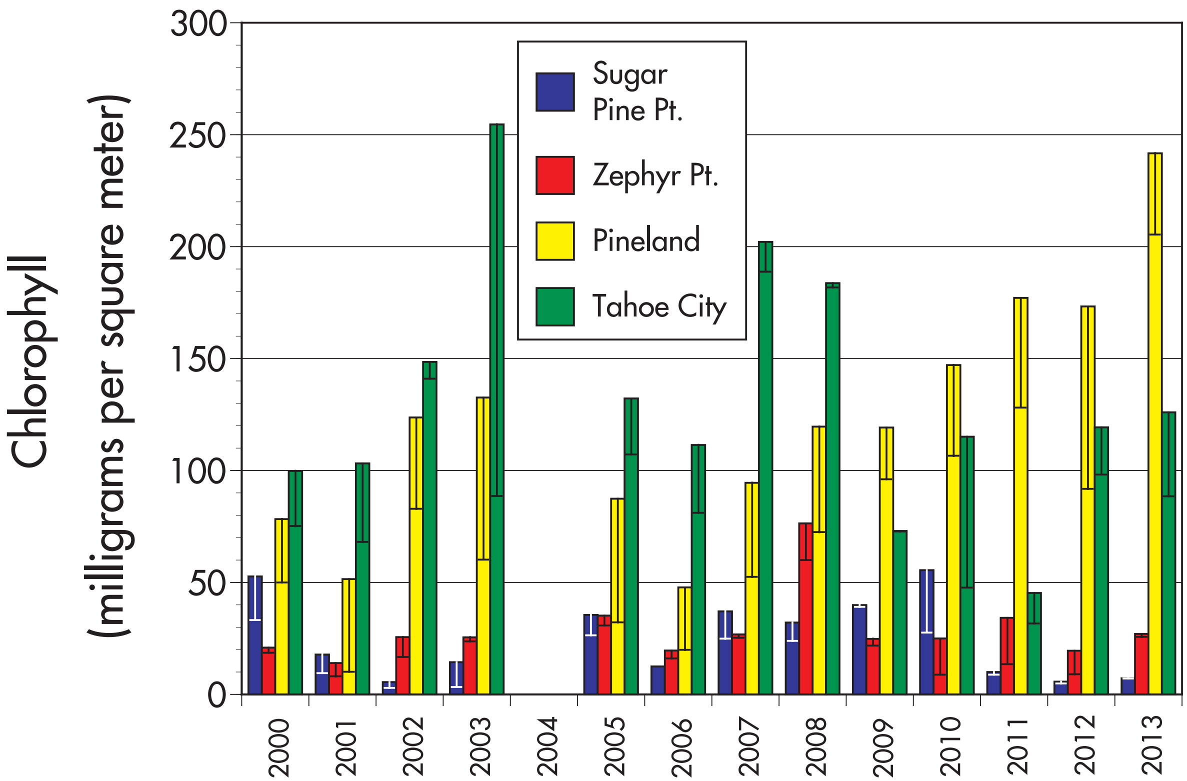


BIOLOGY

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 sites. In 2013, concentrations at Sugar Pine Pt. (no urban influence) were below the long-term average. Tahoe City (heavily urbanized) and Zephyr Pt. were close to the long-term average. The site with the most periphyton (Pineland) is close to an urban area, and was at the highest level ever recorded. While monitoring periphyton is an important indicator of near-shore health, it is clear that greater attention to the mechanisms of periphyton growth is required if a decrease in attached algae is the desired end goal.



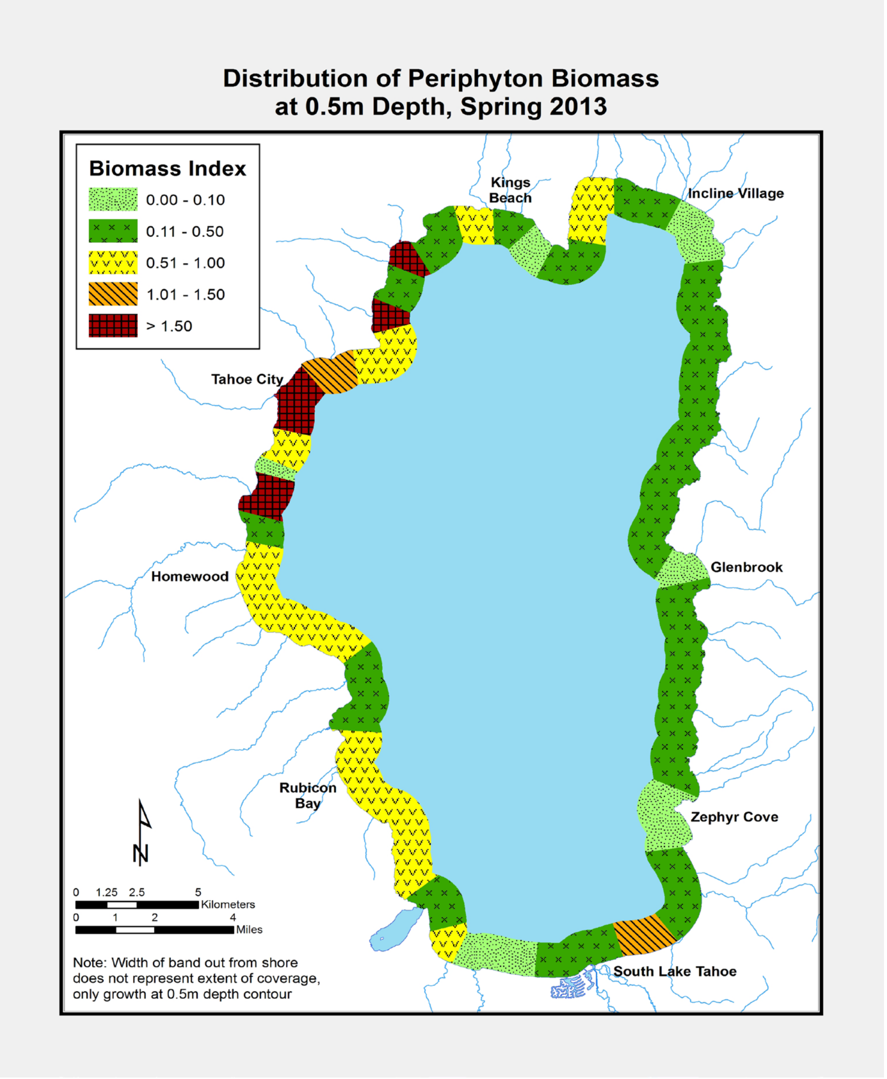
BIOLOGY

Shoreline algae distribution

In 2013

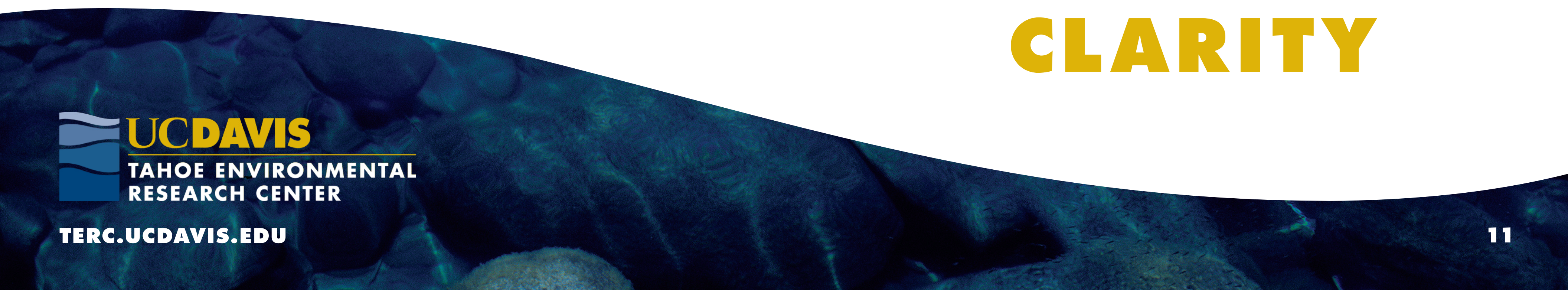
Periphyton biomass was surveyed around the lake during the spring of 2013, when it was at its annual maximum. Nearly 45 locations were inspected by snorkel survey in 1.5 feet (0.5 m) of water. A Periphyton Biomass Index (PBI) is used as an indicator to reflect what the casual observer would visually detect looking into the lake from the shoreline. The PBI is defined as the fraction of the local bottom area covered by periphyton multiplied by the average length of the algal filaments (cm). Zones of elevated PBI are evident, particularly along the north and west shores of Lake Tahoe, although elevated levels of periphyton are also observed in South Lake Tahoe. Overall conditions in 2013 were slightly improved compared to 2012.

Note: The width of the colored band does not represent the actual dimension of the onshore-offshore distribution. Similarly its length does not represent the precise longitudinal extent.



TAHOE: STATE OF THE LAKE REPORT 2014

CLARITY



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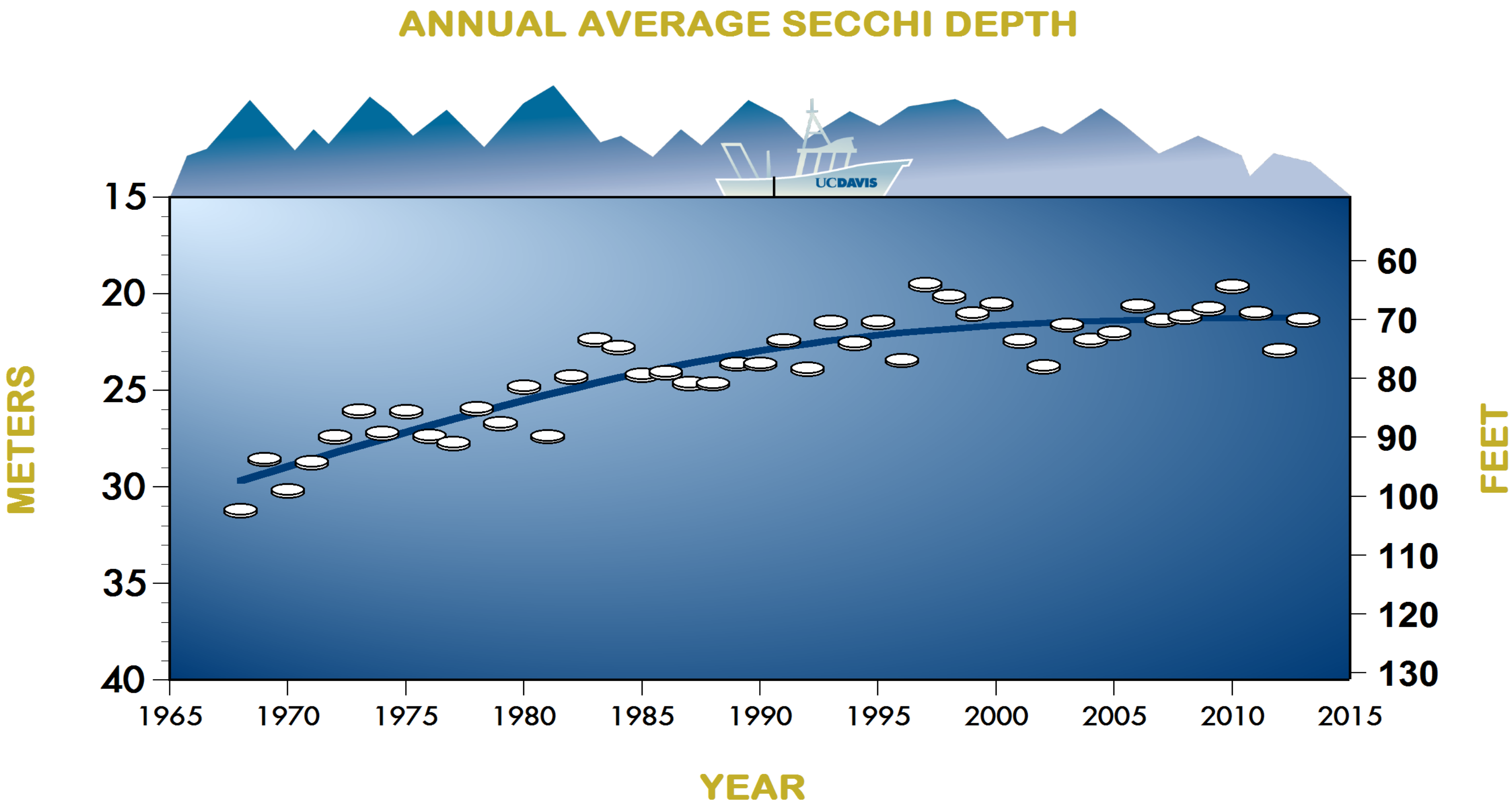
CLARITY

Annual average Secchi depth

Yearly since 1968

In 2013 the annual average Secchi depth was 70.1 feet (21.4 m), a decrease of 5 feet over the previous year, but still well above the lowest value recorded in 1997 of 64.1 feet (19.5 m). The annual average clarity in the past decade has been better than the prior decade. From 2004-2013 the average clarity was 70.0 feet (21.3 m). The clarity level is the average of 25 individual readings taken throughout the year. The highest individual value recorded in 2013 was 90.2 feet (27.5 m) on March 25, and the lowest was 49.2 feet (15.0 m) on July 12. It is important to understand the causes behind clarity change and to evaluate past actions and future investments.

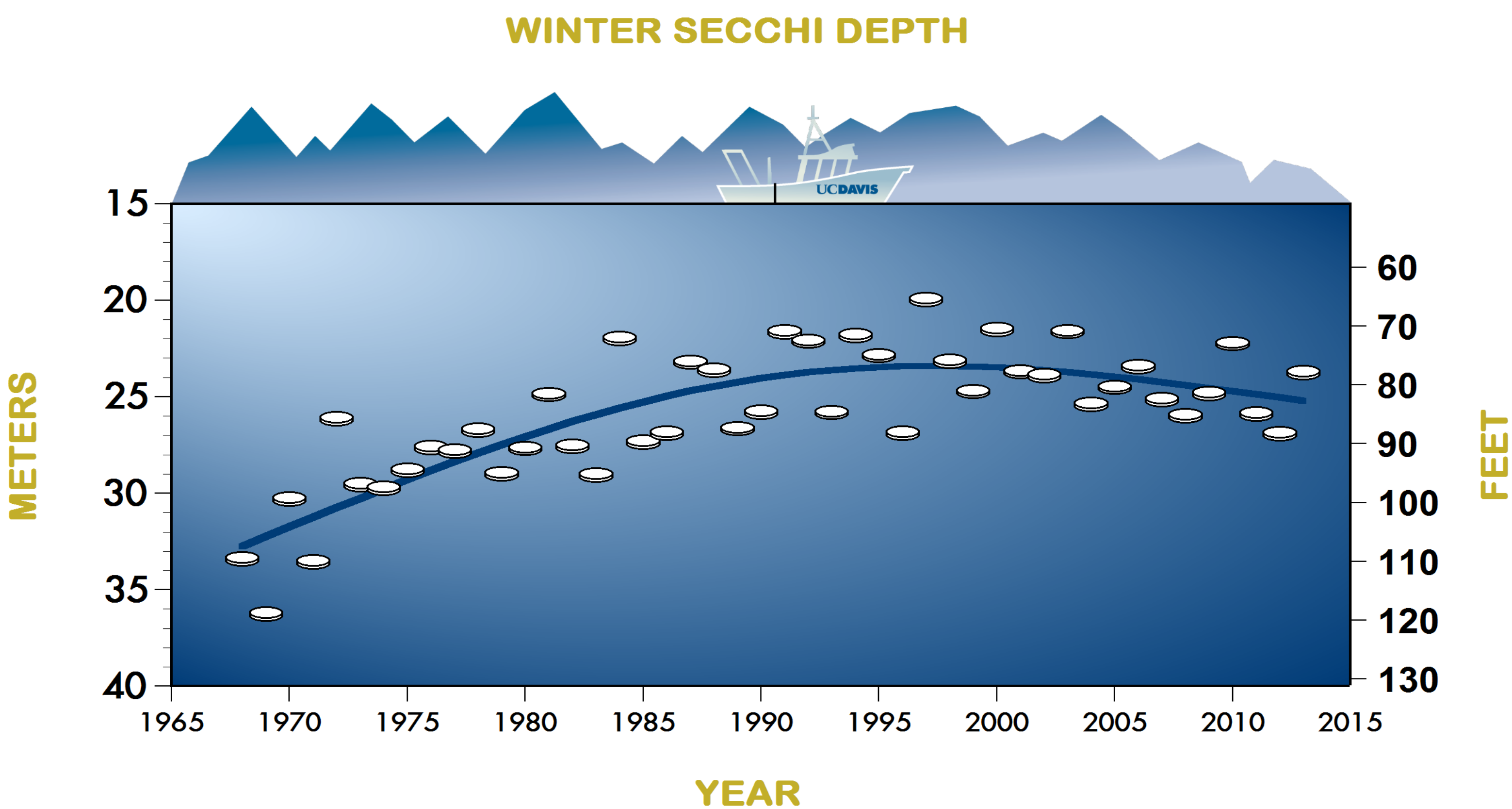


CLARITY

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 2013, although 10 feet less than the previous year, the winter clarity was 77.9 feet (23.7 m). This is well above the lowest reading, seen in 1997. Large stream inflows in winter of 2012/2013 were mainly responsible for the decrease. The reasons behind the overall improvement in winter clarity are not fully understood, but are possibly tied to reductions in the quantity of fine particles from urban stormwater.

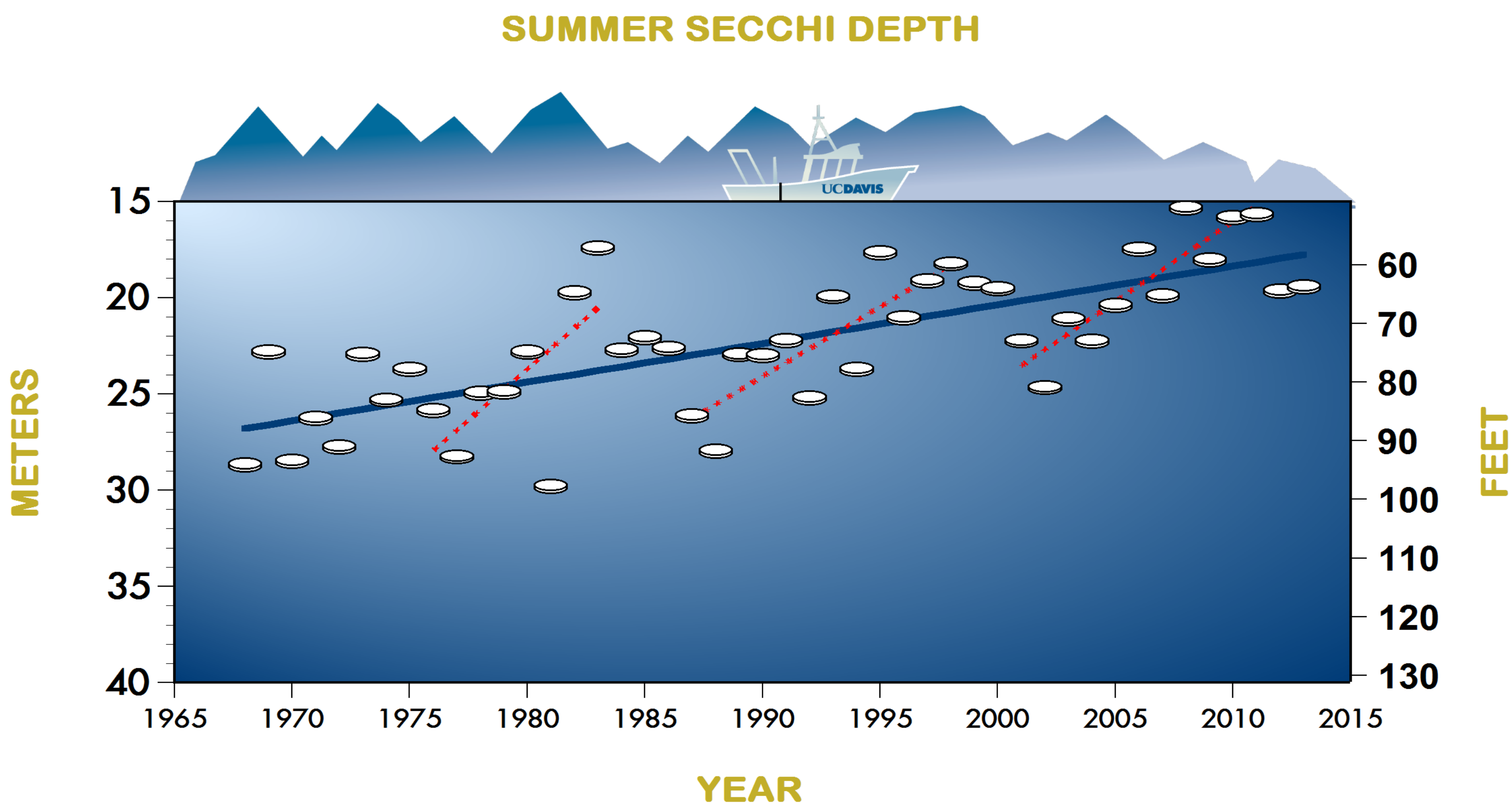


CLARITY

Summer Secchi depth

Yearly since 1968

Summer (June-September) clarity in Lake Tahoe in 2013 was 63.8 feet (19.4 m), almost identical to the value from 2012. This coincided with a decline in the concentration of small algal cells in 2013. Despite this improvement, the summer trend is dominated by a consistent long-term degradation 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

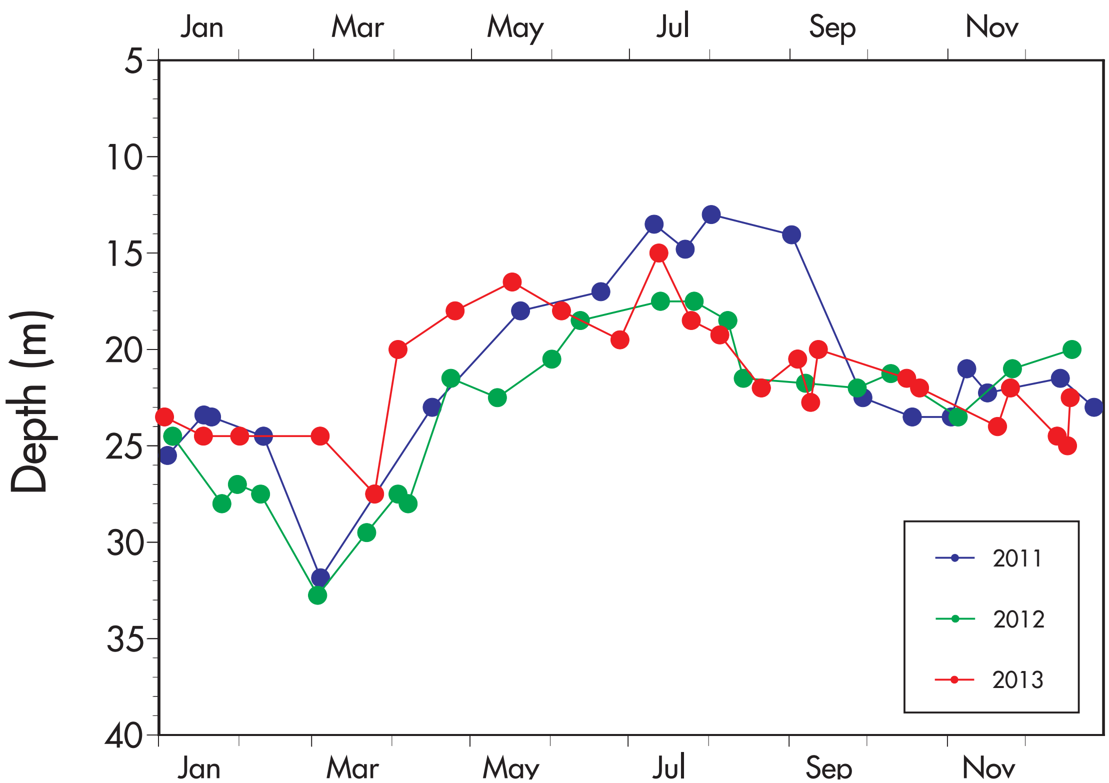
Individual Secchi depths

2011, 2012, 2013

Here the individual Secchi depth readings from the Index station on the west side of the lake for 2011,2012 and 2013 are plotted. For all three years it is evident that there is a distinct seasonality – Secchi depth is generally higher in the fall and winter months, and lowest in the spring and summer. The maximum Secchi depth often occurs around the time of deepest mixing (March). All three years reflected these trends.

2013 was the poorest year for clarity in the winter months. This is believed to be due to high precipitation in the previous December and the subsequent melt-off during the dry months that followed. Summer conditions, however, were very good owing to the small volume of spring snowmelt and the shallow depth of mixing in March.

Secchi values can be seen to sometimes vary considerably over short time intervals. This is evident in early September and early December in 2013. Such short-term variability is common in lakes. In this case the sudden changes are likely due to wind-driven upwellings.

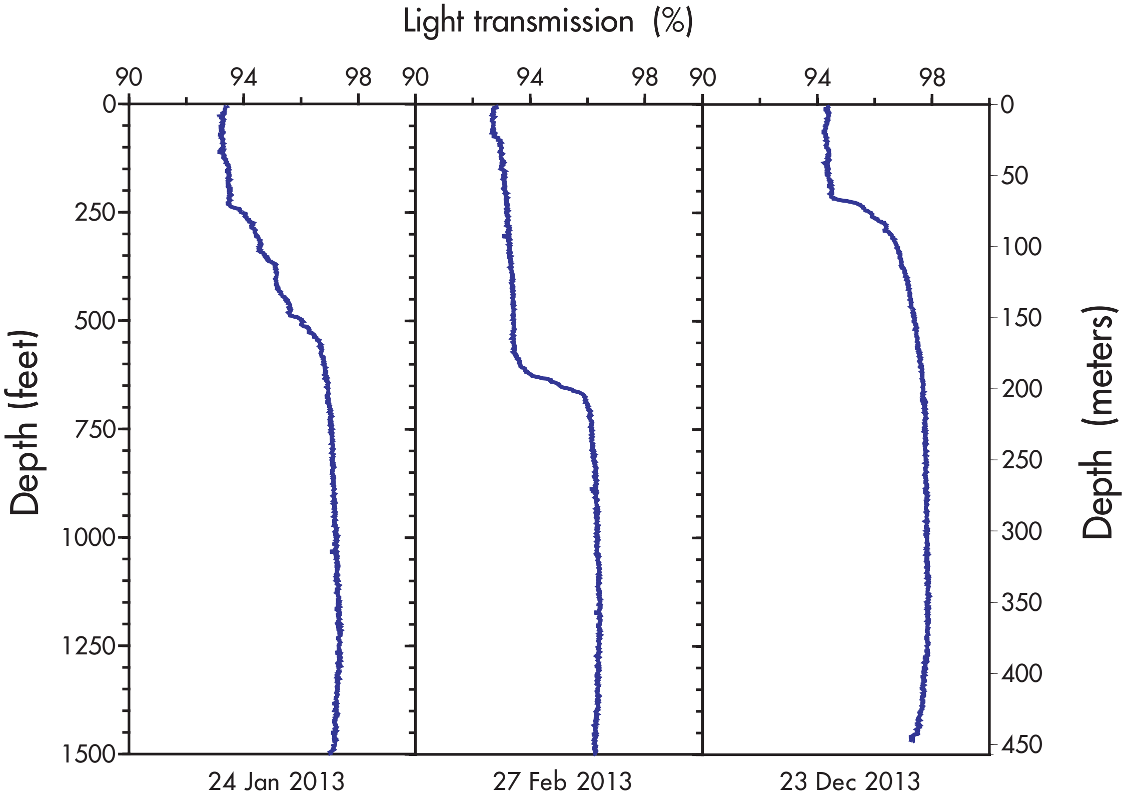


CLARITY

Light transmission

In 2013

A light transmissometer emits a specific wavelength of light and measures the percentage of that light transmitted over a 10 inch path. Clearer water results in a higher percentage of light transmission. Here, the light transmission measured at every depth in the lake is shown at three times in 2013. The "steps" in transmission at 200 feet, 240 feet, and 550 feet in the profiles indicates the depth of active lake mixing on those dates. It is also evident that the lowest light transmission is in the surface layers where between 93 and 94 percent of light is transmitted. The highest light transmission is in the very deepest parts of the lake where as much as 97 percent of the light can be transmitted. The reason for the improvement in deep water is that fine particles aggregate into larger particles that rapidly settle out in the deep water. Large particles do not scatter light as much as fine particles. The vertical trend in light transmission correspond very well with the distribution of fine particles in Figure 9.12.



TAHOE: STATE OF THE LAKE REPORT 2014

EDUCATION AND OUTREACH

EDUCATION AND OUTREACH

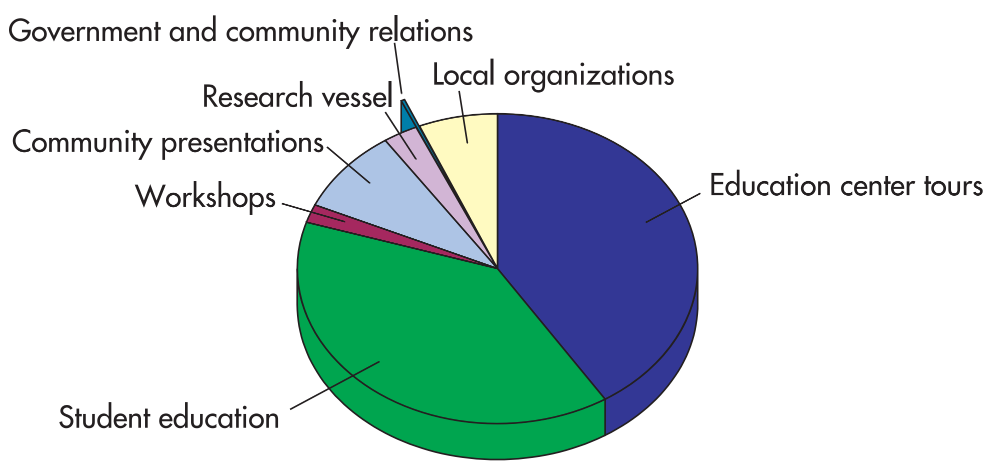
TERC education and outreach

In 2013

Part of TERC's mission is education and outreach. Our public, K-12, teacher professional development, and volunteer programs are designed to spark the imagination and curiosity of our visitors and participants and to sow the seeds of stewardship of our vital, yet fragile, freshwater ecosystems.

During 2013, TERC recorded 12,105 individual visitor contacts. The majority represented student field trips and visitors to the Tahoe Science Center (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 environmental science education in the Tahoe basin. In 2013, these included AmeriCorps, COSMOS, North Tahoe Environmental Education Coalition, Sierra Nevada College, Sierra Watershed Education Partnerships (SWEP), South Tahoe Environmental Education Coalition, UC Davis Young Scholars, and many others.



TOTAL NUMBER OF CONTACTS: 12,105

EDUCATION AND OUTREACH

TERC educational exhibits

In 2013

New activities such as "Why is Tahoe Blue?" and "Measuring Clarity", the new interactive iPad application "Healthy and Unhealthy Lakes", and the game "Race to Save Lake Tahoe" provide Tahoe Science Center visitors with hands-on science focused on Lake Tahoe research and stewardship.

A new 3-D movie "Let's Go Jump in the Lake", funded by the National Science Foundation, will take viewers under the water to look at different organisms that live in the lake and the physical processes that moves them around. Due for completion in fall 2014, the movie will view Lake Tahoe at different time intervals. These range from a snapshot of a singular moment, the daily routine, and the dramatic change that occurs through the seasons.

"Why is Tahoe Blue?" and "Measuring Clarity" were developed to provide more hands-on activities for science center visitors.

Student evaluators test out the new "Race to Save Lake Tahoe" stewardship board game during exhibit development.

Coming soon: "Let's Go Jump in the Lake" 3-D movie is still under development.

EDUCATION AND OUTREACH

TERC educational programs

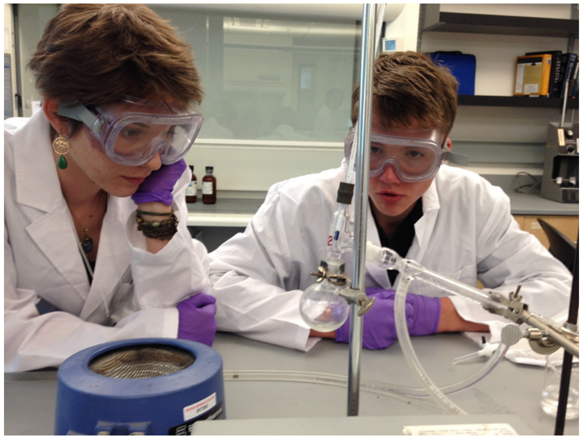
In 2013

In addition to providing education center tours for the general public, the TERC Education Team provides high quality informal science education to more than 4,400 third- through eleventh-grade students by hosting over 80 field trips each year.

Other K-12 educational programs include Trout in the Classroom, coordinated in partnership with Sierra Watershed Education Partnerships, which is 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 annual Youth Science Institute from January through May. Through this afterschool program 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, ecology, and biology, including a new aquatic food web modeling activity.

AmeriCorps member Kristen Reichardt watches as Lahontan cutthroat trout eggs hatch and the small alevins begin swimming.



Youth Science Institute participants from high schools around the region conduct multiple science activities over the 16-week afterschool program.

EDUCATION AND OUTREACH

TERC educational programs, continued

In 2013

Each year we train new volunteer docents at our annual June Docent Training. Volunteer docents become local experts and lead tours at our two science centers. Volunteers also participate in garden work each year to make the Tahoe City Field Station's 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 and plant phenology.

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 2013

TERC hosts monthly lectures throughout the year on various environmental issues, new scientific research and related regional topics of interest. Recent topics have included, “The Art of the Anthropocene”, “What’s in Your Extra Virgin Olive Oil?”, “Music, Memory and the Brain”, and “Lake Tahoe: Climate Change and a Worldwide Crisis for Inland Waters”.

Special events hosted annually include Project WET training workshops (February), Science Expo (March), Green Thumb Tuesdays (July - August), Summer Teacher Institute (July), Children’s Environmental Science Day (August), and Earth Science Day (October).

The annual Science Expo held each March brings in more than 1,000 third-, fourth- and fifth-grade students for hands-on science activities that cover a different theme every year. In 2014 the theme was “Earth and Space”. Next year the theme will be Life Sciences.

Public lectures are held monthly at the Incline Village location and Green Thumb Workshops are held at the Tahoe City Field Station throughout the summer. Sponsors help make these events free to the community.

Children’s Environmental Science Day is held annually each August with hands-on science activities designed for kids ages six and up. Scientists and management agencies from all across the Tahoe basin participate to make this a community event that builds knowledge and develops partnerships.