TAHOE: STATE OF THE LAKE REPORT 2008

UC DAVIS
TAHOE ENVIRONMENTAL RESEARCH CENTER

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INTRODUCTION

The University of California, Davis, has monitored Lake Tahoe for nearly 40 years, 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 and human activity have affected the lake's clarity, temperature, chemistry and biology. We also present 2007 data.

The data shown here reveal a unique record of trends and patterns -- the result of natural forces and human actions that operate over time scales ranging from days to decades. These patterns tell us that Lake Tahoe is a complex ecosystem, and it behaves in ways we don't always expect.

Our role as scientists is to explore that complexity and to use our advancing knowledge to suggest options for ecosystem restoration and management. Choosing among those options, and implementing them, is the work of those outside the scientific community.

The annual UC Davis *Tahoe: State of the Lake Report* is intended to inform non-scientists about the most important variables that affect lake health.

Until recently, only one indicator of Lake Tahoe's health status was widely available: the annual clarity report (often called the Secchi depth, after the instrument used to collect the clarity data). In the *Tahoe: State of the Lake Report*, the UC Davis Tahoe Environmental Research Center (TERC) publishes many other indicators of the lake's conditions.

This report is not intended to be a scorecard for Lake Tahoe. Rather, it sets the context for understanding what changes are occurring from year to year: How much did the Angora Fire affect Lake Tahoe? Was Lake Tahoe warmer or cooler than the historical record last year? Are algae increasing? 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, students and technicians who have worked at Lake Tahoe throughout the decades. I would, however, like to acknowledge the contributions of Patty Arneson, John Reuter, Amy Horne, Scott Hackley, Brant Allen, Bob Richards, Charles Goldman, Monika Winder, Debbie Hunter, Anne Liston, Tina Hammell, Mark Palmer, Andrea Parra, Heather Segale, Bill Fleenor, Todd Steissberg, Simon Hook, Stephen Andrews, Dan Nover, Bob Coats, George Malyj and Cigdem Alemdar.

Funding for this enormous undertaking comes from a great many sources, spanning federal, state and local agencies, as well as UC Davis itself. While many other water quality variables could be tracked, funding ultimately limits what we measure. Current funding for monitoring and analysis is provided by the Lahontan Regional Water Quality Control Board, the Tahoe Regional Planning Agency, the U.S. Forest Service and the U.S. Geological Survey.

TERC's monitoring is frequently done in collaboration with other research institutions and agencies. In particular we would like to acknowledge the U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the Desert Research Institute (DRI), and the University of Nevada, Reno (UNR).

We hope you find this report helpful. I welcome your comments.

Sincerely,

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EXECUTIVE SUMMARY

The long-term data set collected on the Lake Tahoe ecosystem by the University of California, Davis, is a valuable tool for understanding ecosystem function and change. It has become essential to public agencies tasked with restoring and managing the Tahoe ecosystem, in part because it allows us to monitor progress toward reaching Tahoe's restoration goals.

This annual *Tahoe: State of the Lake Report* presents 2007 data in the context of the long-term record. It includes new data about impacts of the Angora Fire, and the effects of climate change on snowmelt timing, lake water temperature and density stratification. It also shows how much of the pollutants that reduce lake clarity (fine sediment particles, nitrogen and phosphorus) are contributed by different sources.

The UC Davis Tahoe Environmental Research Center has developed sophisticated computer models that help scientists more accurately predict how Lake Tahoe's ecosystem behaves. Long-term data sets are essential to refine the accuracy of those models. In these times of rapid change, reliable predictive models are indispensable tools for Lake Tahoe Basin resource managers.

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

Here are some of the highlights presented in the following pages.

ANGORA FIRE

- During the Angora Fire, atmospheric deposition of nitrogen and phosphorus was 2½ to 7 times normal summer rates, but still represented only 1 to 2 percent of the annual loads from all sources. (Fig. 6.1)
- Atmospheric deposition from the Angora Fire had a negligible impact on lake clarity and algal biomass. (Figs. 6.2 and 6.3)

METEOROLOGY

The Lake Tahoe ecosystem is largely driven by meteorology. In the short term, meteorological conditions are expressed as daily variations in weather. In the long term, they are expressed as normal cyclical variations such as wet and dry cycles, and long-term trends related to global climate change.

Historical record:

- The nightly minimum temperatures recorded at Tahoe City have increased by more than 4 degrees F. since 1910. (Fig. 7.1)
- Days when air temperatures averaged below freezing have decreased by 30 days per year since 1910. (Fig. 7.2)
- Since 1910, the percent of precipitation that fell as snow decreased from 52 percent to 34 percent. (Fig. 7.7)
- Peak snow melt averages 2 ½ weeks earlier than in the early 1960s. (Fig. 7.8)

Previous year[1]:

- 2007 was the 14th driest year on record. Precipitation at Tahoe City was 19.7 inches, two-thirds of the annual average of 31.6 inches. (Fig. 7.5)
- Every month in 2007, except February and September, was drier than the 97-year average. (Fig. 7.6)
- Snow represented 37.6 percent of total precipitation at lake level. (Fig. 7.7)

PHYSICAL PROPERTIES

Lake Tahoe's physical properties are largely a response to external factors, especially meteorology. Physical properties, in turn, determine the environment for all the lake's chemical and biological processes (see next sections).

Historical record:

- Water temperature (volume averaged) rose by more than 1 degree F. in the past 37 years. (Fig 8.3)
- Average surface water temperature rose by more than 1.5 degrees F. in the past 37 years, to 51.9 degrees F. (Fig. 8.4)
- Winter surface water temperatures were the coldest measured in the

(CONTINUED ON NEXT PAGE)

[1] *"Previous year" for some parameters means data collated in terms of the water year, which runs from October 1 through September 30; for other parameters, it means data for the calendar year, January 1 through December 31. Therefore, for this 2008 report, water year data are from Oct. 1, 2006 through Sept. 30, 2007. Calendar year data are from Jan. 1, 2007 through Dec. 31, 2007.*

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 5)

last 10 years, with the lowest maximum surface water temperature of 41.11 degrees F. (Fig. 8.5)

- Density stratification of Lake Tahoe has increased over the last 37 years as surface water warmed due to climate change. (Fig. 8.8)

Previous year:

- In 2007, lake level fell to a low of 6224.7 feet in December. (Fig. 8.2)
- Lake Tahoe mixed all the way to the bottom in March 2007, the first deep mixing since 2001. (Fig. 8.9)

NUTRIENTS AND PARTICLES

Lake Tahoe's clarity is determined especially by fine sediment particles, and also by nutrients. Tahoe's urban areas contribute 72% of fine particles, despite representing only 10% of the land base.

Nutrients affect lake clarity by promoting algae growth. Offshore, algae make the water greenish and less clear. Along the shoreline, algae are a problem because it coats rocks with green slime.

The two nutrients that most affect algal growth are nitrogen and phosphorus. These nutrients are measured at various depths at TERC's mid-lake and western lake stations.

One form of nitrogen—nitrate—enters the lake through stream and urban runoff, groundwater and atmospheric deposition. Phosphorus occurs naturally in Tahoe Basin soils and enters the lake from soil disturbance and erosion, as well as atmospheric deposition.

Historical record:

- Stream inputs of particles, nitrogen and phosphorus are directly linked to the annual amount of precipitation. (Figs. 9.3 to 9.5)
- Atmospheric deposition of nutrients, both in concentration and total loads, are also linked to precipitation. (Figs 9.6 and 9.7)
- Nitrogen concentrations in the lake have remained generally constant for many years. (Fig. 9.8)
- Phosphorus reached a minimum in 1999 and has increased slightly since. (Fig. 9.9)

Previous year:

- The watersheds that contributed the most particles and nutrients to Lake Tahoe were the Upper Truckee River, Blackwood Creek, Trout Creek, Ward Creek and Incline Creek. (Fig. 9.2)

BIOLOGY

The longest data sets for lake biology are on the base of the food web – the algae (or phytoplankton) and the zooplankton (microscopic aquatic animals that graze on algae). Algae and zooplankton influence the lake's food web, clarity and aesthetics.

Historical record:

- Primary productivity, the rate at which algae produce biomass through photosynthesis, has been increasing since 1959. (Fig. 10.1)
- Since 1984, the annual average depth of the deep chlorophyll maximum has declined. (Fig. 10.4)
- Diatoms remain the dominant algal species and provide high quality food for aquatic species. (Fig 10.6)

Previous year:

- Primary productivity in 2007 was the highest on record, five times the 1959 level. (Fig. 10.1)
- The maximum deep chlorophyll depth increased in 2007 to a mean of 180 feet. (Fig. 10.4)
- Periphyton (attached algae) concentrations were above average in 2007. (Fig. 10.9)
- Zooplankton, an important part of the food web, were at a 10-year low in 2007. (Figs. 10.11 to 10.12)

CLARITY

Clarity remains the indicator of greatest interest about Lake Tahoe because it tracks degradation and the community's efforts to restore clarity to historic levels. Secchi depth (the point below the lake surface at which a 10-inch white disk disappears from view) has been measured continuously since 1968, and is the longest continuous measure of Lake Tahoe's water clarity.

In 2007, the Secchi depth was 70.1 feet, an increase of 2.4 feet over 2006. In the last seven years, Secchi depth measurements have been better than predicted by the long-term linear trend. There is statistical support that Lake Tahoe's clarity decline has slowed significantly, and is now best represented by a curve. (Fig. 11.1)

EDUCATION AND OUTREACH

The public can learn about the science behind Lake Tahoe restoration at TERC's Incline Village education center (the Thomas J. Long Foundation Education Center). In 2007, over 6,900 people participated in our education and outreach activities. (Fig. 12.1)

ABOUT LAKE TAHOE AND THE TAHOE BASIN

- Maximum depth: 1,645 feet (501 meters), making it 11th deepest lake in the world, 2nd deepest lake in the USA
- 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 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.
- Average residence time of water in 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: 66,000 (2000 Census)
- Number of visitors: 3,000,000 annually

ABOUT THE UC DAVIS TAHOE ENVIRONMENTAL RESEARCH CENTER (TERC)

The Tahoe Environmental Research Center (formerly the Tahoe Research Group) is a year-round UC Davis program of research, education and outreach in the Tahoe Basin.

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

Our main laboratories and offices are located on the campus of Sierra Nevada College in Incline Village, Nev., 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.

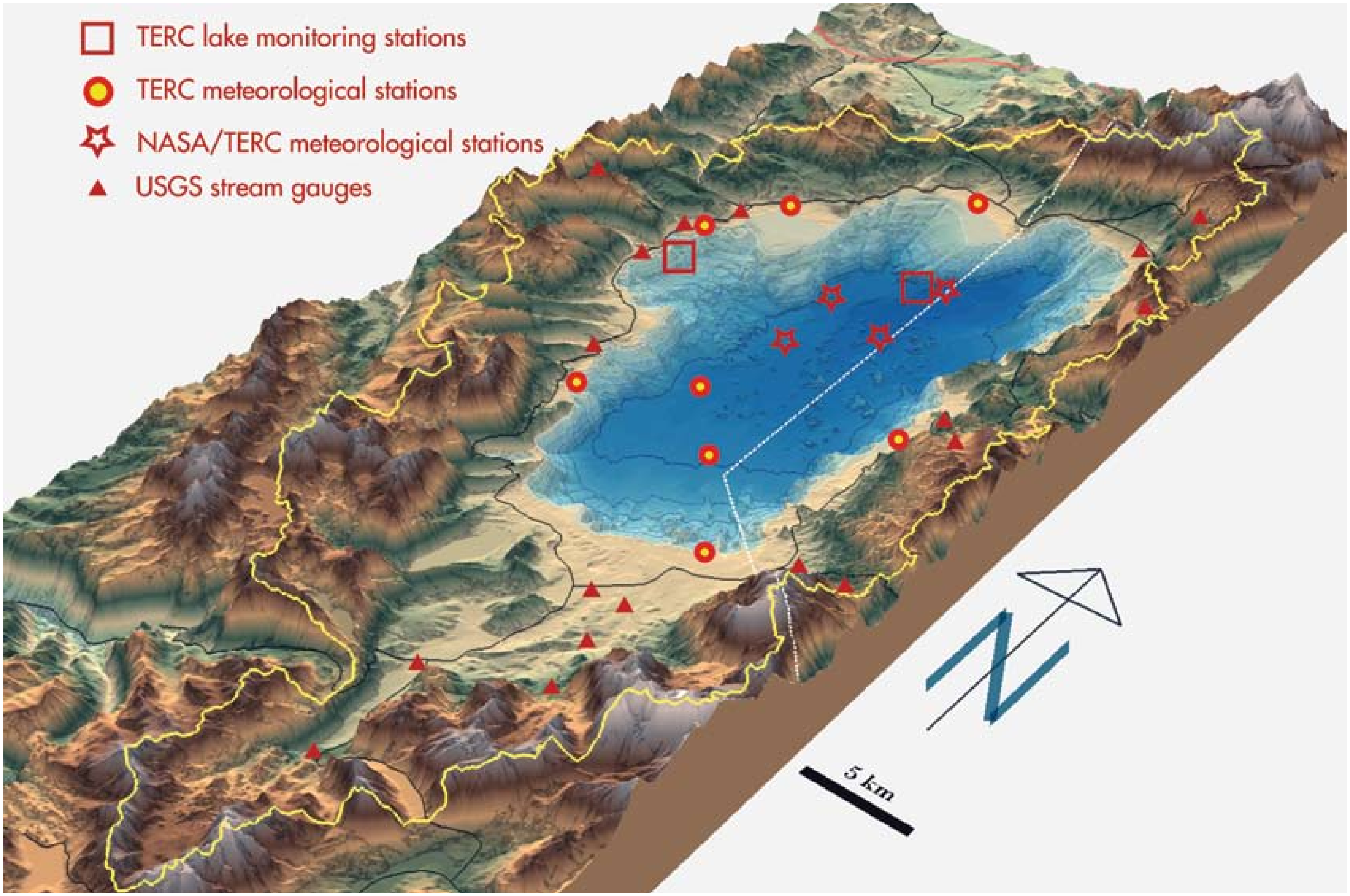
In Tahoe City, Calif., we operate a field station (formerly a state fish hatchery) and the Eriksson Education Center. Tahoe City is also the mooring site for our two research vessels, the John LeConte and the Ted Frantz.

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

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 meteorological data gathered by our network of sensors;
- A list of publications;
- Exhibits and events at the Education Centers; and
- Information about supporting our research and teaching programs.

MAP OF TAHOE BASIN DATA COLLECTION SITES



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ANGORA FIRE

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ANGORA FIRE - LAKE RESPONSE

Atmospheric deposition of nutrients

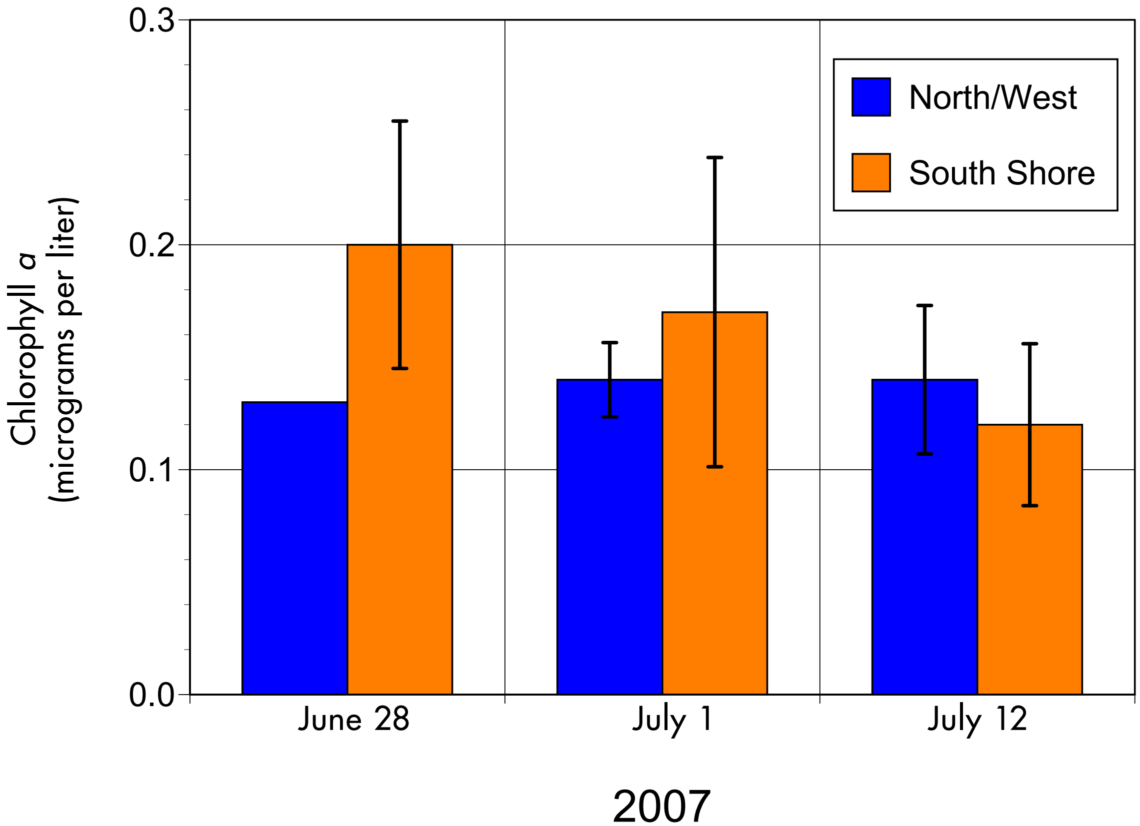
The Angora Fire began on June 24, 2007, and was fully contained within eight days. Nearly 3,100 acres burned in the Upper Truckee River watershed, located in the southwest corner of the Lake Tahoe Basin. Satellite images showed the smoke had significantly cleared within 4 or 5 days. Atmospheric deposition was measured about one mile east of the fire and at the mid-lake buoy in the northern part of the lake. Atmospheric deposition of nitrogen on the lake from the fire was estimated to be 5.0 to 8.4 metric tons; phosphorus deposition was estimated at 0.4 to 0.8 metric tons. (One metric ton = 2,205 pounds.) Although deposition during the fire was 2.5 to 7 times the normal summer rate, it represented only about 1 to 2 percent of the annual load from all sources. Nutrient loads from the streams are not presented here, but no significant runoff occurred during 2007.

	Total Nitrogen	Total Phosphorus
Load from Angora Fire	5.0 TO 8.4 METRIC TONS	0.40 TO 0.77 METRIC TONS
Increased deposition rate during fire	2.5 TO 4 TIMES	4 TO 7 TIMES
Contribution to annual atmospheric loading	2 TO 4 %	6 TO 11 %
Contribution to annual loading from all sources	1.2 TO 2.1 %	0.9 TO 1.5 %

ANGORA FIRE - LAKE RESPONSE

Short-term impacts on phytoplankton

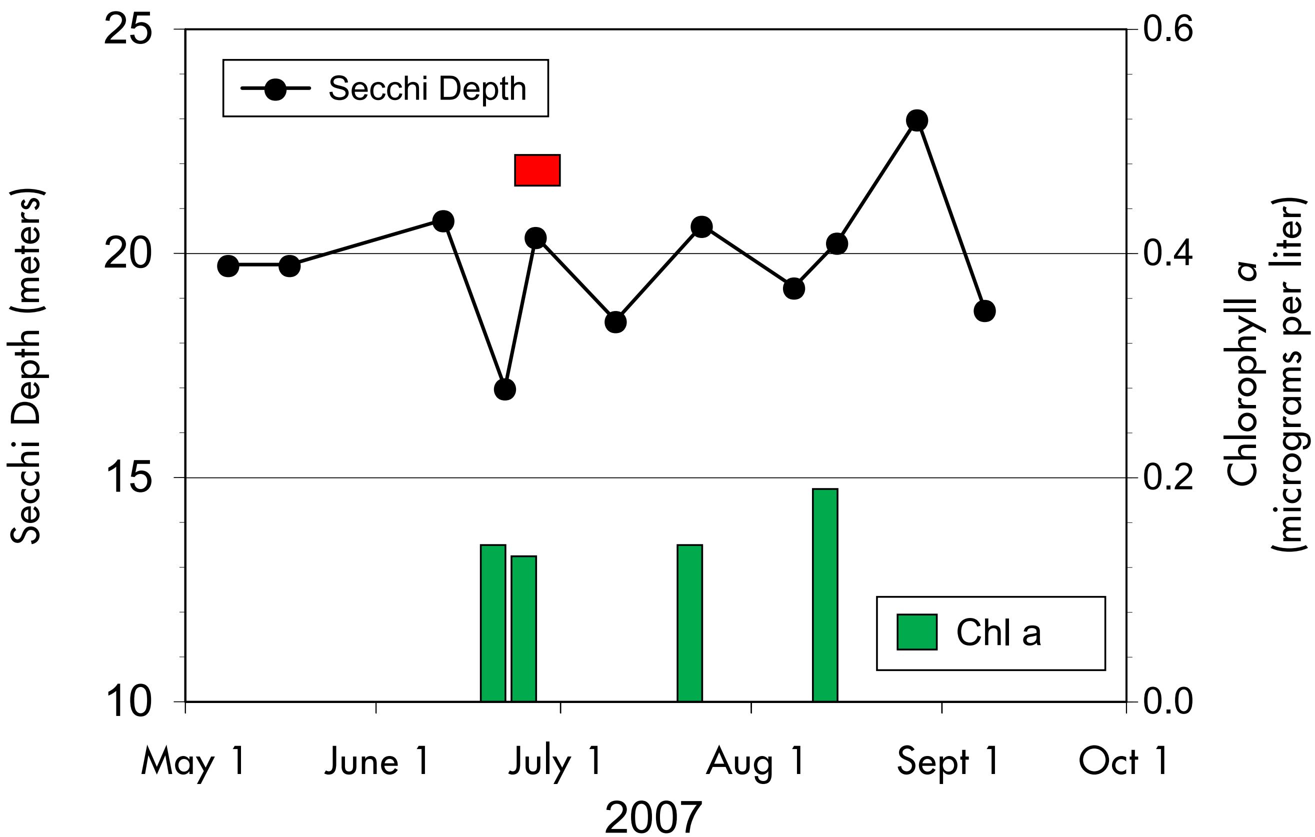
Chlorophyll concentrations in the lake were measured along a depth profile and the average value of the top 33 feet of water was calculated. (Chlorophyll concentrations below 33 feet could be influenced by the deep chlorophyll maximum and therefore were assumed not to be a direct response to the fire.) From 8 to 17 stations were visited on three dates within 2 to 3 weeks after the fire. On June 28th, phytoplankton biomass along the south shore was about 50 percent higher than other sites on the lake. The effect was short-lived however, and phytoplankton biomass was relatively uniform across the lake by July 12th. Chlorophyll concentrations at these shallow depths are extremely low.



ANGORA FIRE - LAKE RESPONSE

Seasonal impacts on phytoplankton

Analysis of routine monitoring data collected at TERC's western lake monitoring station allowed us to evaluate the seasonal impacts of atmospheric deposition from the Angora Fire on lake clarity and algal biomass. Secchi depth was relatively steady for the six-week period from July to mid-August. The low Secchi reading of 17.5 meters was taken two days before the fire, on June 22nd. The red horizontal bar shows when smoke was in the basin. Both Secchi depth and chlorophyll *a* remained stable until late August, indicating that atmospheric deposition from the Angora Fire had a negligible impact on lake clarity and algal biomass. It is highly unlikely that changes after late August were related to the fire.



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METEOROLOGY

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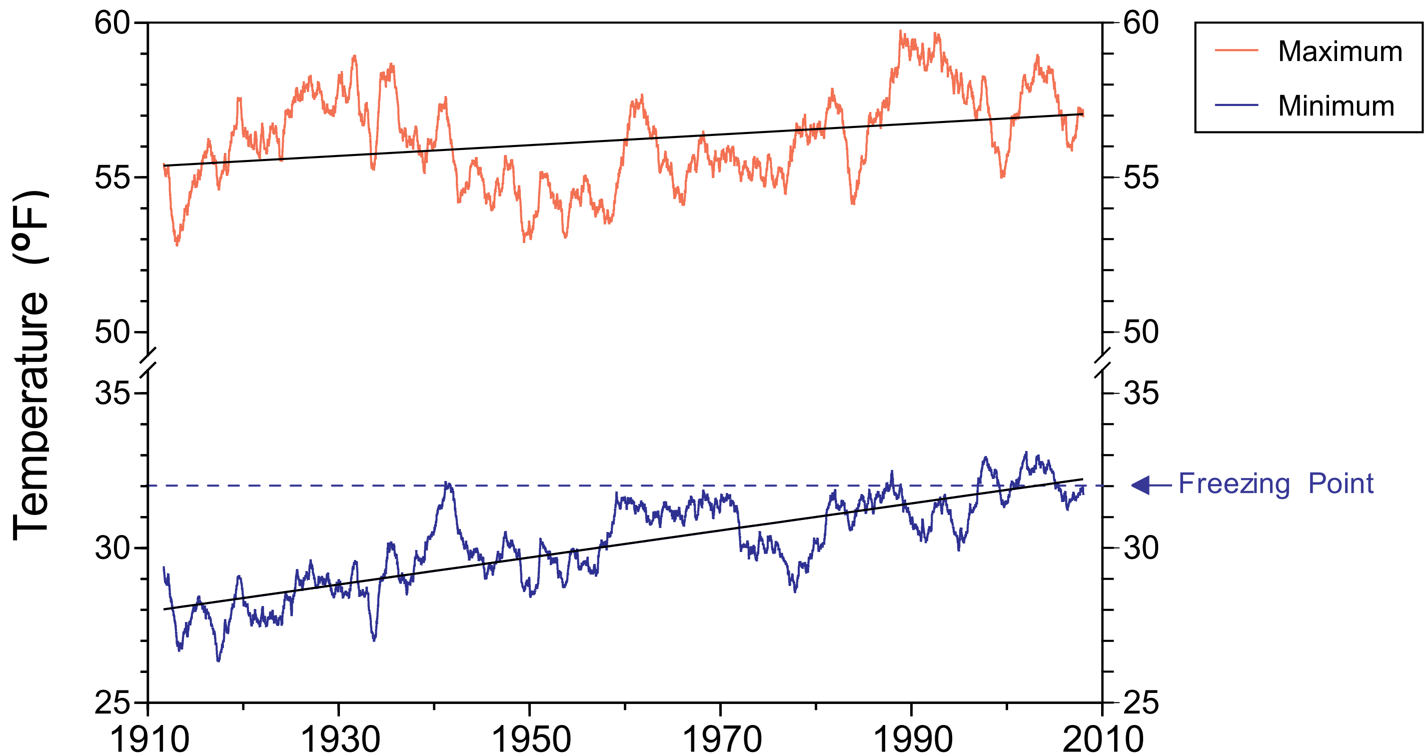
METEOROLOGY

Air temperature

Daily since 1910

Daily air temperatures have increased over the 97 years measured at Tahoe City. Daily minimum temperature has increased by more than 4 degrees F., and daily maximum temperature has risen by less than 2 degrees F. The average 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.

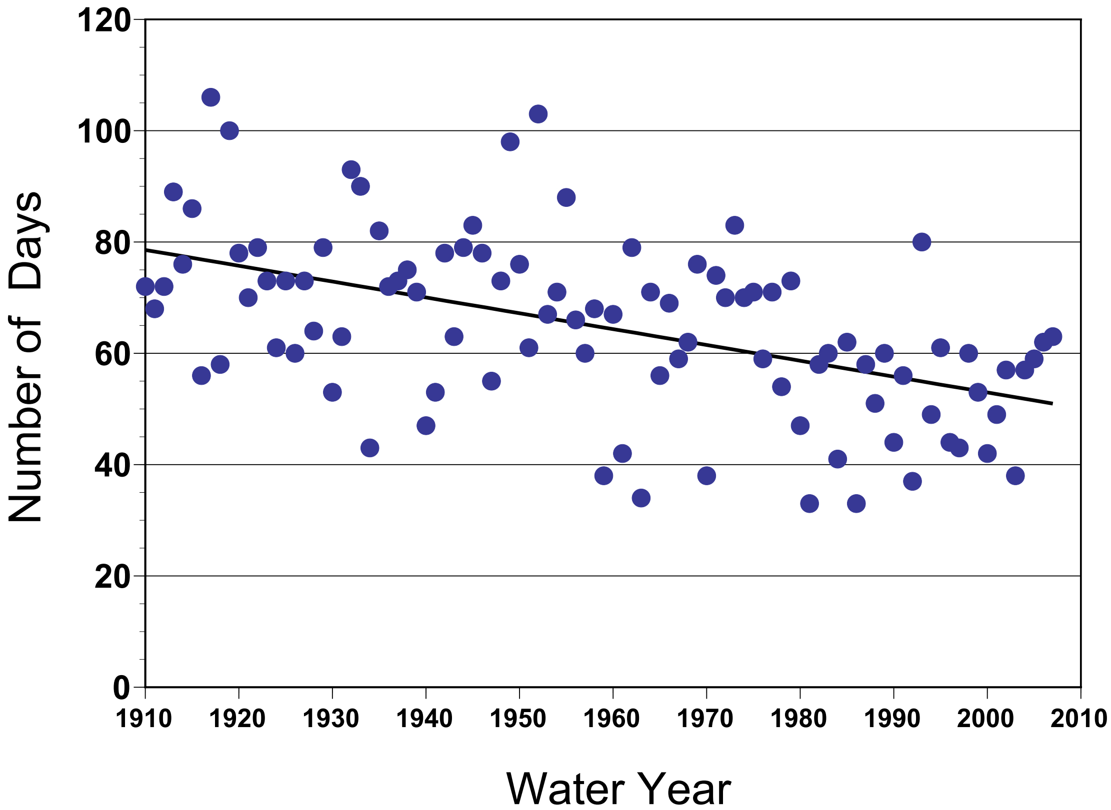


METEOROLOGY

Below-freezing air temperatures

Yearly since 1910

Although year-to-year variability is high, the number of days when temperatures averaged below freezing has declined by about 30 days since 1910. In 2007, the number of freezing days was 63.

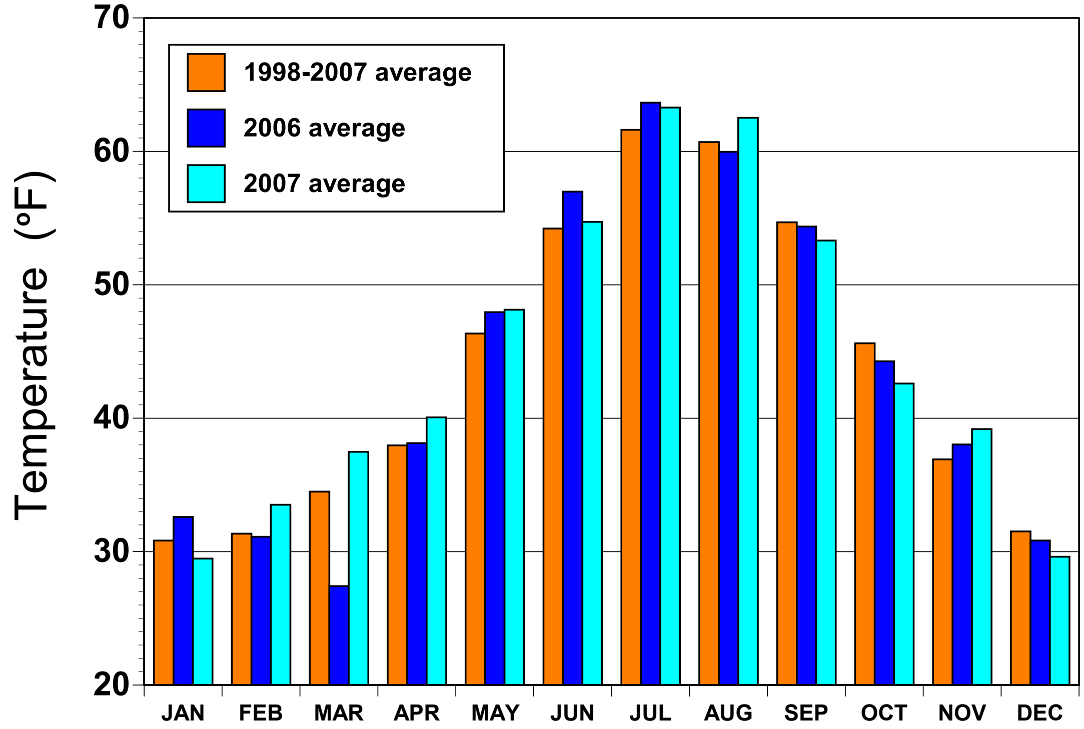


METEOROLOGY

Monthly air temperature

Since 1998

In 2007, February through May were warmer than either the previous year or the ten-year average. The months of January, September, October and December were cooler than the ten-year average.

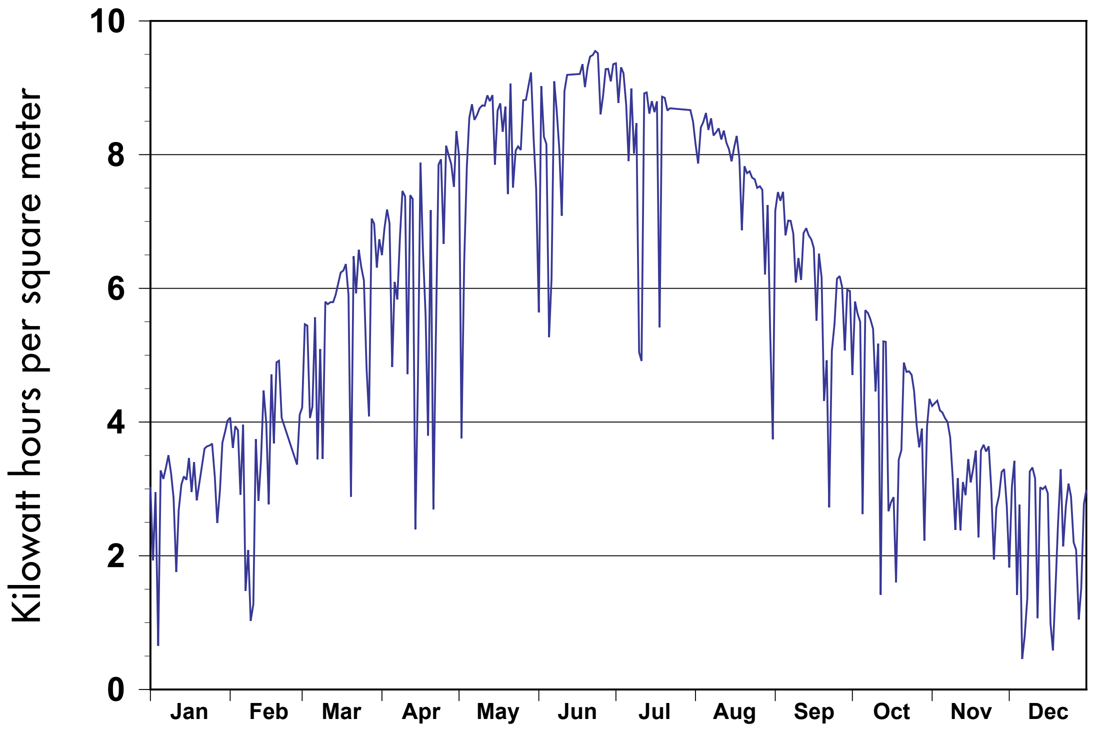


METEOROLOGY

Solar Radiation

Daily in 2007

Solar radiation showed the typical annual pattern of increasing then decreasing, peaking at the summer solstice on June 21 or 22. Dips in daily solar radiation are due to clouds, smoke and other atmospheric constituents. The smoke generated by the Angora Fire in the last week of June greatly affected solar radiation at the south shore, but did not have much effect on solar radiation at the north shore, where this sensor is located.

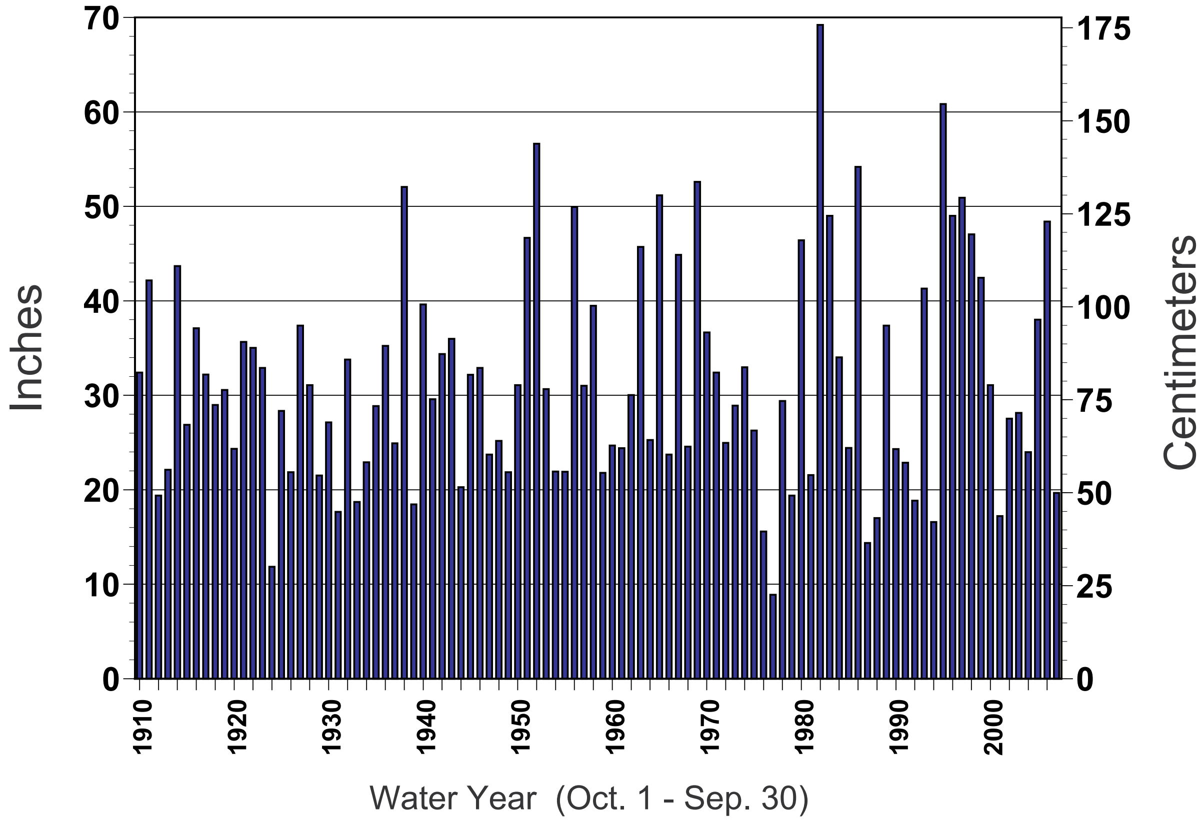


METEOROLOGY

Annual precipitation

Yearly since 1910

From 1910 to 2007, average annual precipitation (water equivalent of rain and snow) was 31.6 inches. The maximum was 69.2 inches in 1982. The minimum was 8.9 inches in 1977. 2007 was the 14th driest year on record, with only 19.7 inches of precipitation. (Precipitation is summed over the Water Year, which extends from October 1 through September 30.)

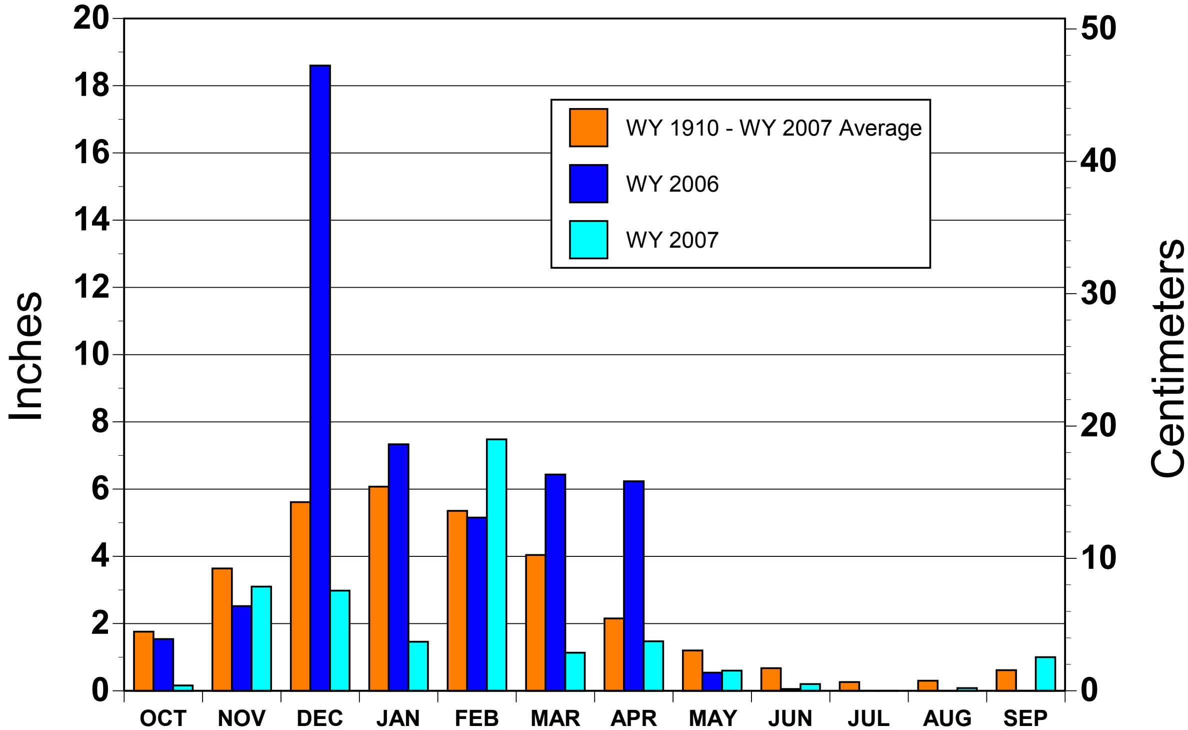


METEOROLOGY

Monthly precipitation

2006, 2007 and 1910 to 2007 Average

2007 was notable as the 14th driest year on record. Annual precipitation barely exceeded the amount received in the month of December 2006. Ten months were drier than the 97-year historical average and February was by far the wettest month. The 2007 Water Year extended from Oct. 1, 2006, through Sept. 30, 2007.

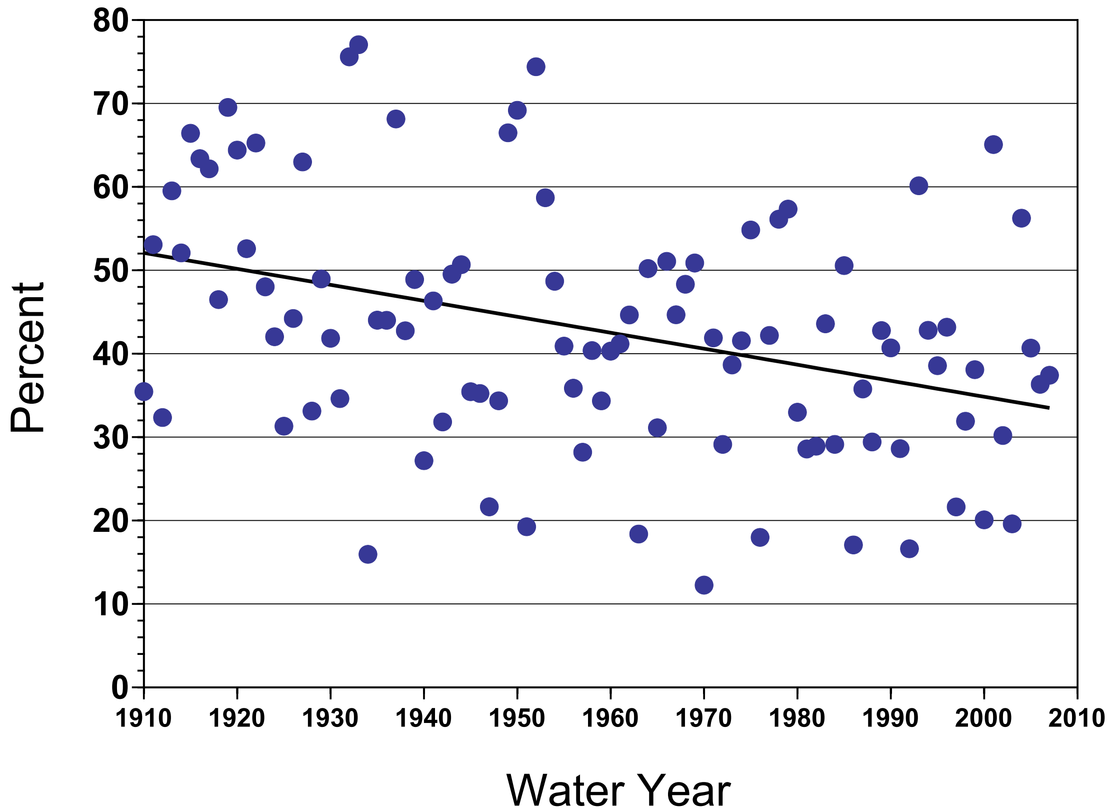


METEOROLOGY

Snow as a fraction of annual precipitation

Yearly since 1910

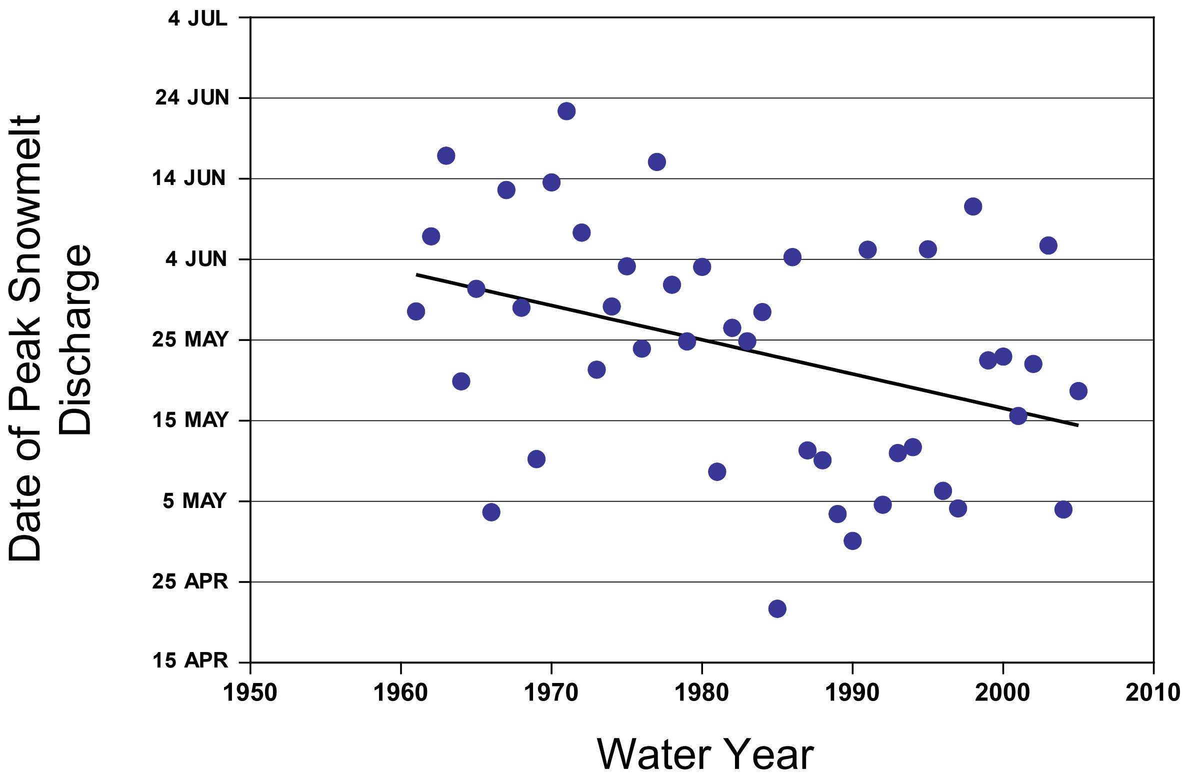
Snow has declined as a fraction of total precipitation, from an average of 52 percent in 1910 to 34 percent in present times. In Tahoe City, snow represented 37.6 percent of 2007 total precipitation. These data assume precipitation falls as snow whenever the average daily air temperature is below freezing. (Precipitation is summed over the Water Year, which extends from October 1 through September 30.)



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 ½ weeks. This shift is statistically significant and is one effect of climate change on Lake Tahoe. Peak snowmelt is defined as the date when daily river flows reach their yearly maximum. Daily river flows increase throughout spring as the snow melts because of rising air temperatures, increasing solar radiation and longer days. The data here are for the Upper Truckee River.



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PHYSICAL PROPERTIES

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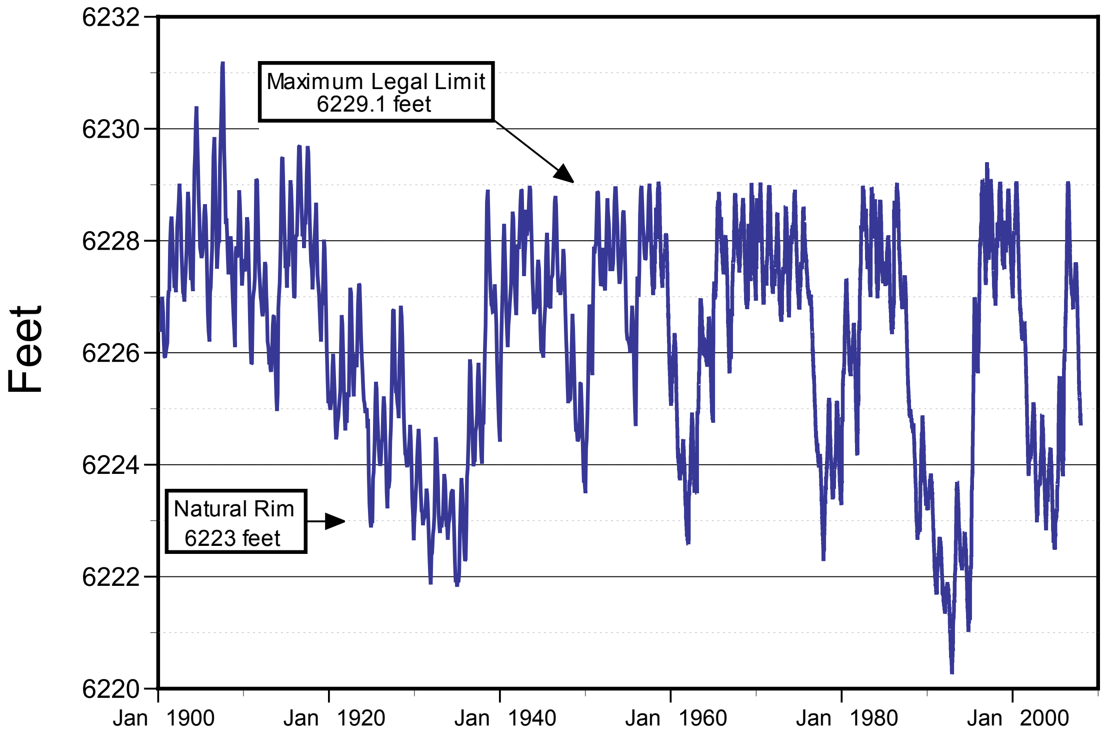
Lake surface level

Daily since 1900

The lowest lake level on record was 6,220.26 feet on Nov. 30, 1992. Since 1900, lake level has varied by more than 10 feet. Lake level typically alternates between several years with values close to the maximum, then several years close to the natural rim. This pattern reflects climate wet and dry cycles in the western US. (Lake surface levels are recorded by the U.S. Geological Survey as height above mean sea level. By law, Lake Tahoe cannot exceed 6,229.1 feet and nor can water be released to the Truckee River when it falls below the natural rim of 6,223 feet.)

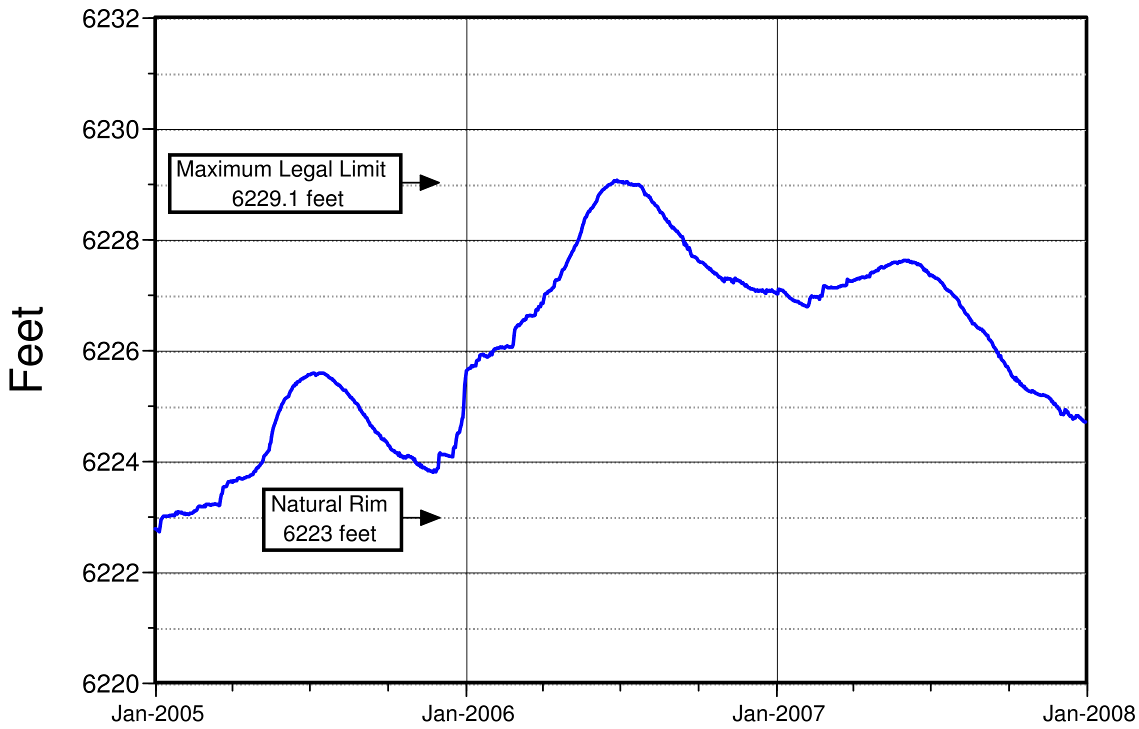


PHYSICAL PROPERTIES

Lake surface level

Daily since 2005

Lake surface level varies throughout the year. It rises due to high stream inflow and precipitation directly onto the lake. It falls due to evaporation and flow out of the Truckee River. In 2007, dry conditions caused lake level to rise by less than one foot during snowmelt, compared with over four feet the previous year. The highest lake level was 6227.6 feet on June 3, and the lowest was 6224.7 feet on December 31.

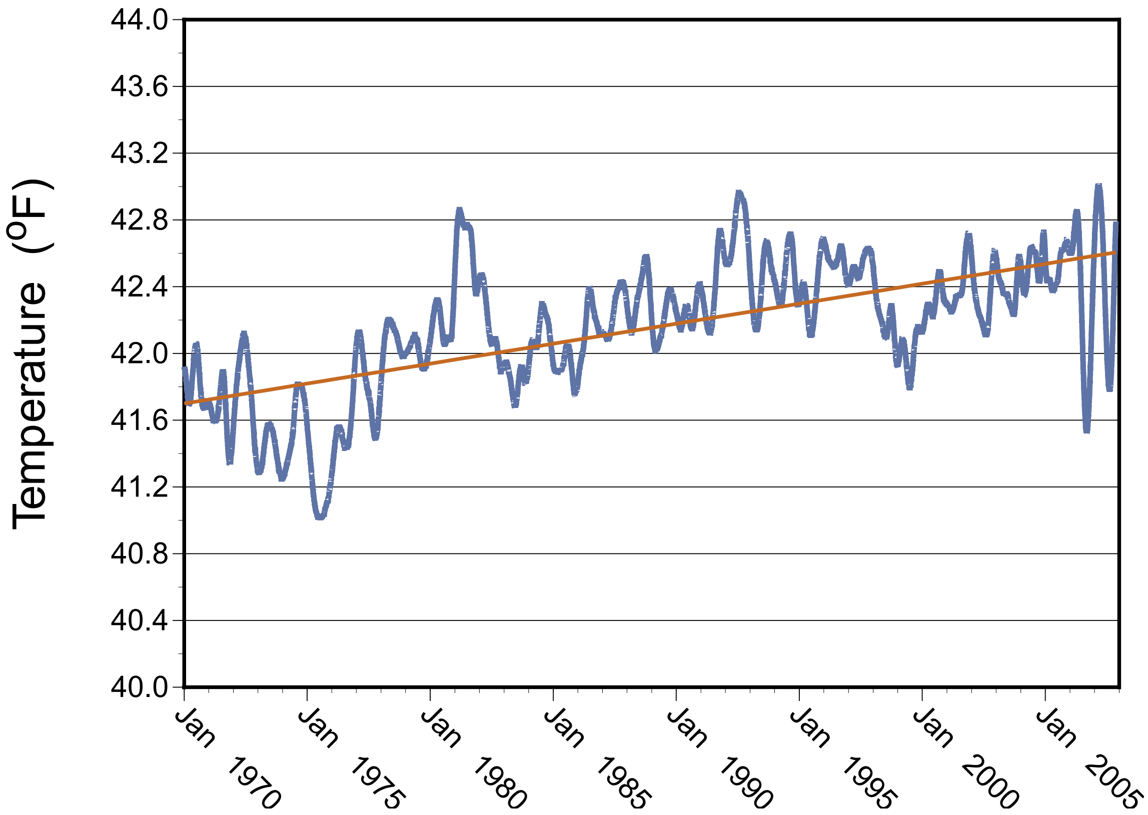


PHYSICAL PROPERTIES

Average water temperature

Since 1970

The volume-averaged temperature of Lake Tahoe has increased nearly a full degree since 1970, from 41.7 degrees F to 42.6 degrees F. (The monthly temperature profile data from the lake has been smoothed and deseasonalized to best show the long-term trend.)

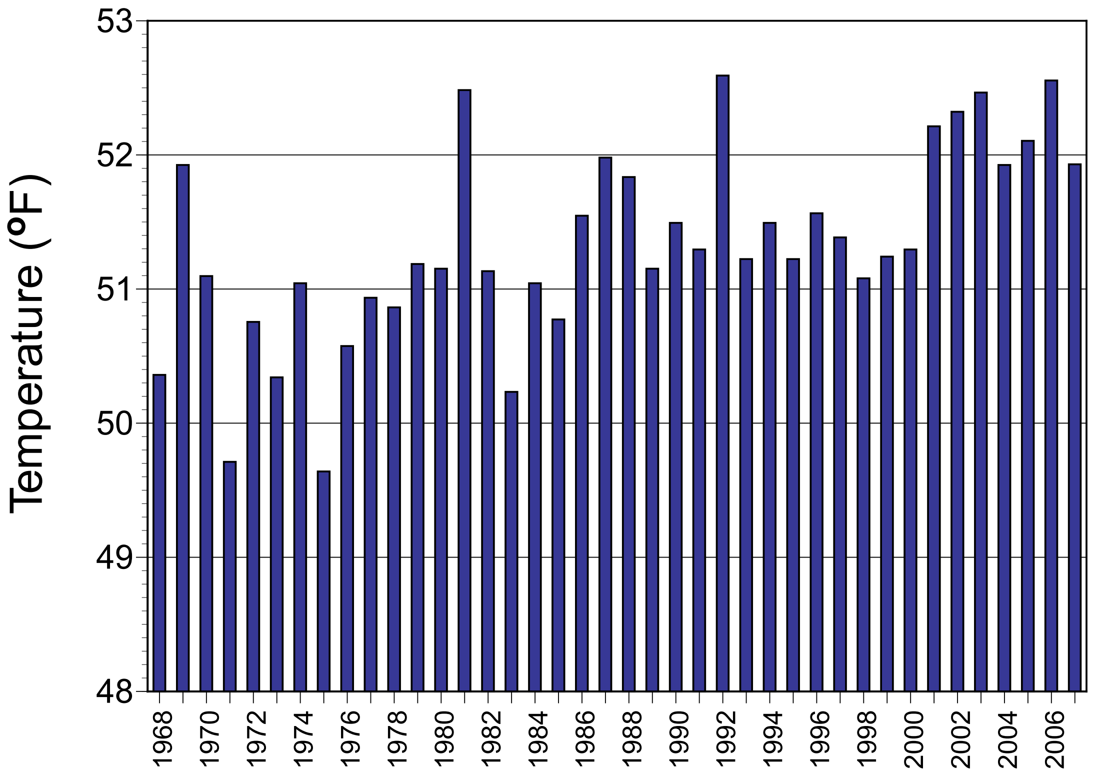


PHYSICAL PROPERTIES

Surface water temperature

Yearly since 1968

Surface water temperatures have been recorded at the mid-lake station since 1968. Despite year-to-year variability, water temperatures show an increasing trend. The average temperature in 1968 was 50.3 degrees F. For 2007, the average surface water temperature was 51.9 degrees F.

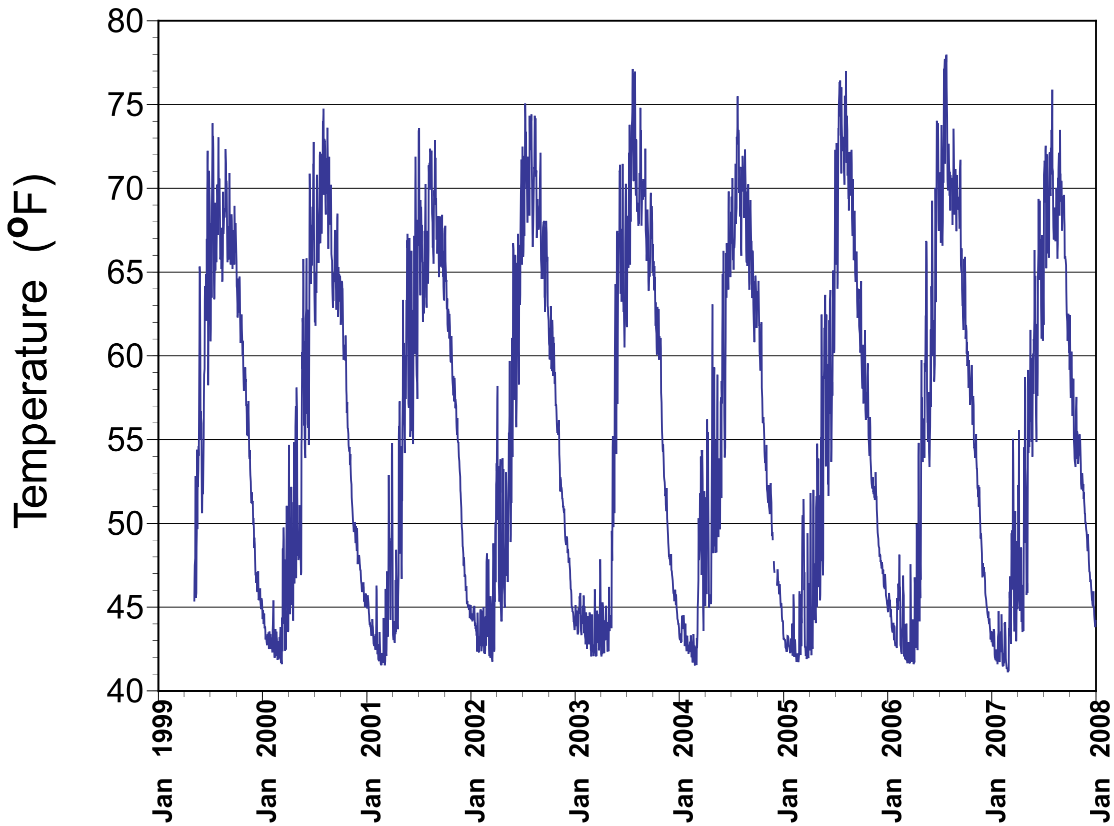


PHYSICAL PROPERTIES

Maximum daily surface water temperature

Every 15 minutes since 1999

Maximum daily surface water temperatures were significantly cooler in 2007, although summer surface water temperatures continue to show a long- term increase. Since May 1999, the highest maximum daily surface temperature was 77.99 degrees F on July 26, 2006. The lowest maximum surface water temperature was 41.11 degrees F on Feb. 26, 2007. In the last decade, the 12 lowest maximum daily surface water temperatures occurred between Feb. 8, 2007 and March 1, 2007.

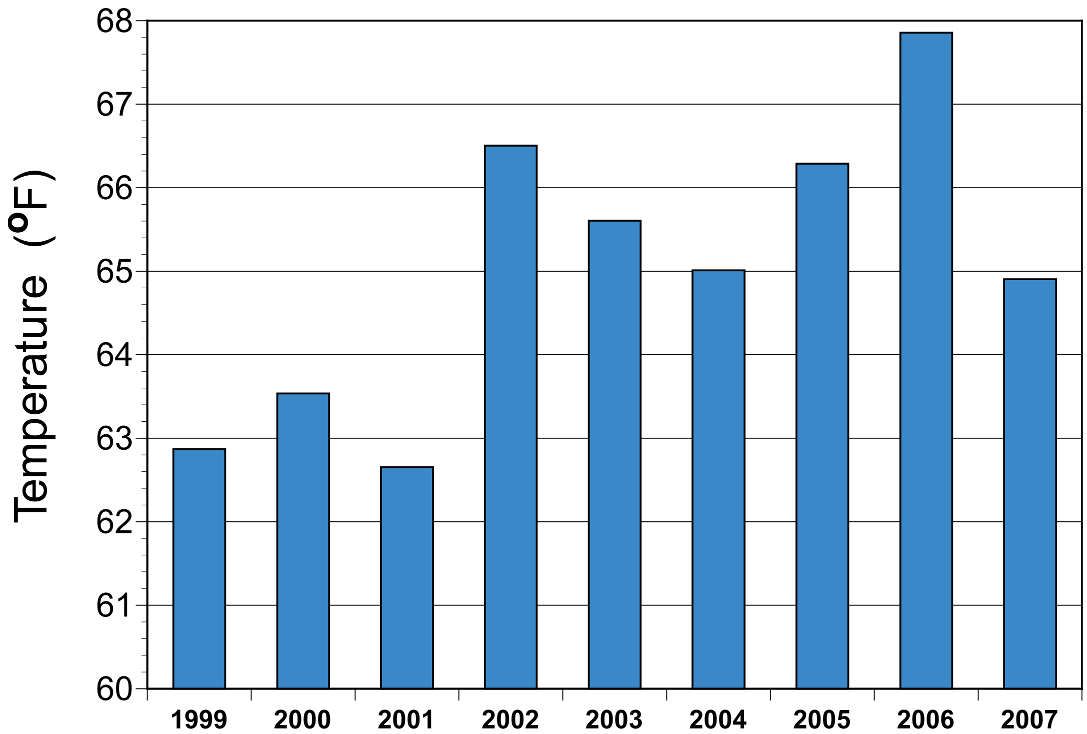


PHYSICAL PROPERTIES

July average surface water temperature

Since 1999

Since 1999, surface water temperature has been recorded every two minutes from four NASA/UC Davis buoys. Shown here are ten years of average surface water temperatures in the month of July when water temperatures are warmest. In 2007, July surface water temperature averaged 64.9 degrees F., 2.9 degrees cooler than in 2006.

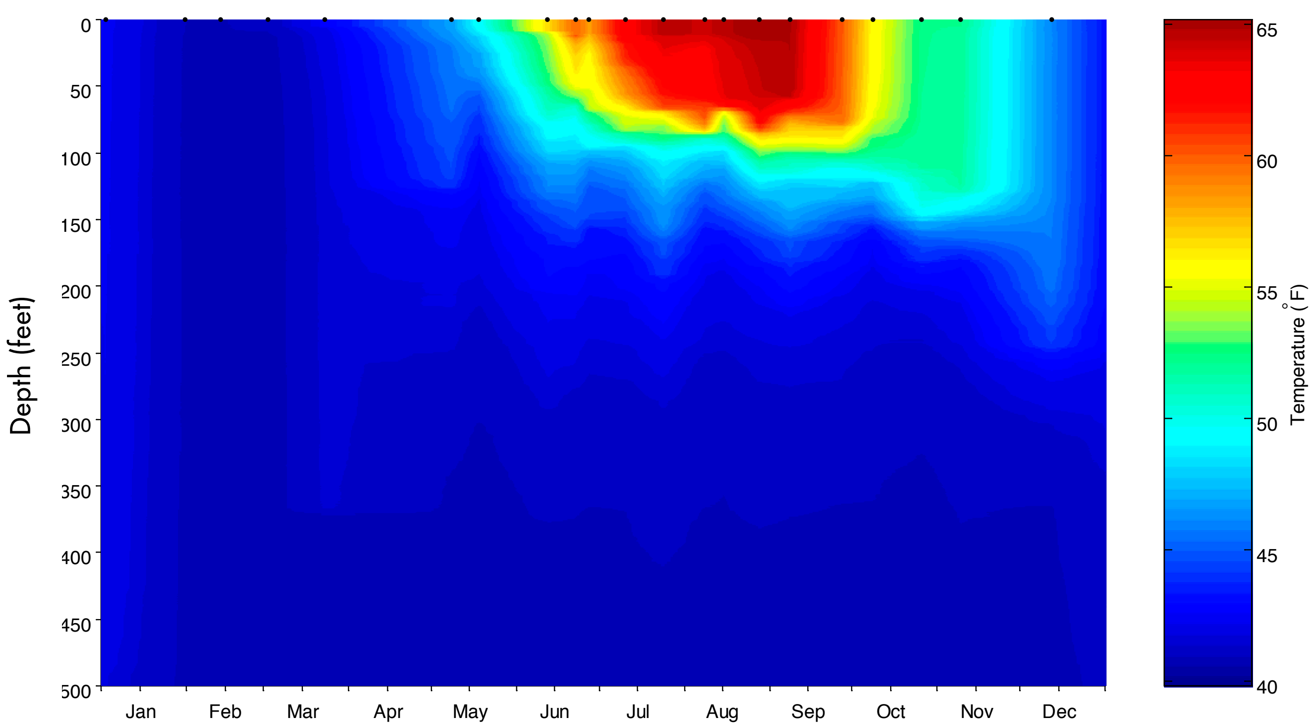


PHYSICAL PROPERTIES

Water temperature profile

In 2007

Water temperatures are measured at six-inch intervals every two to four weeks to produce Lake Tahoe's thermal profile. In 2007, that profile followed a typical seasonal pattern. In early March, the lake was coldest with a uniform temperature throughout its depth. This resulted in a complete mixing from the surface to the bottom (1,645 feet). Thermal stratification began in May and peaked in late August. From September onwards, the surface layer cooled and deepened.

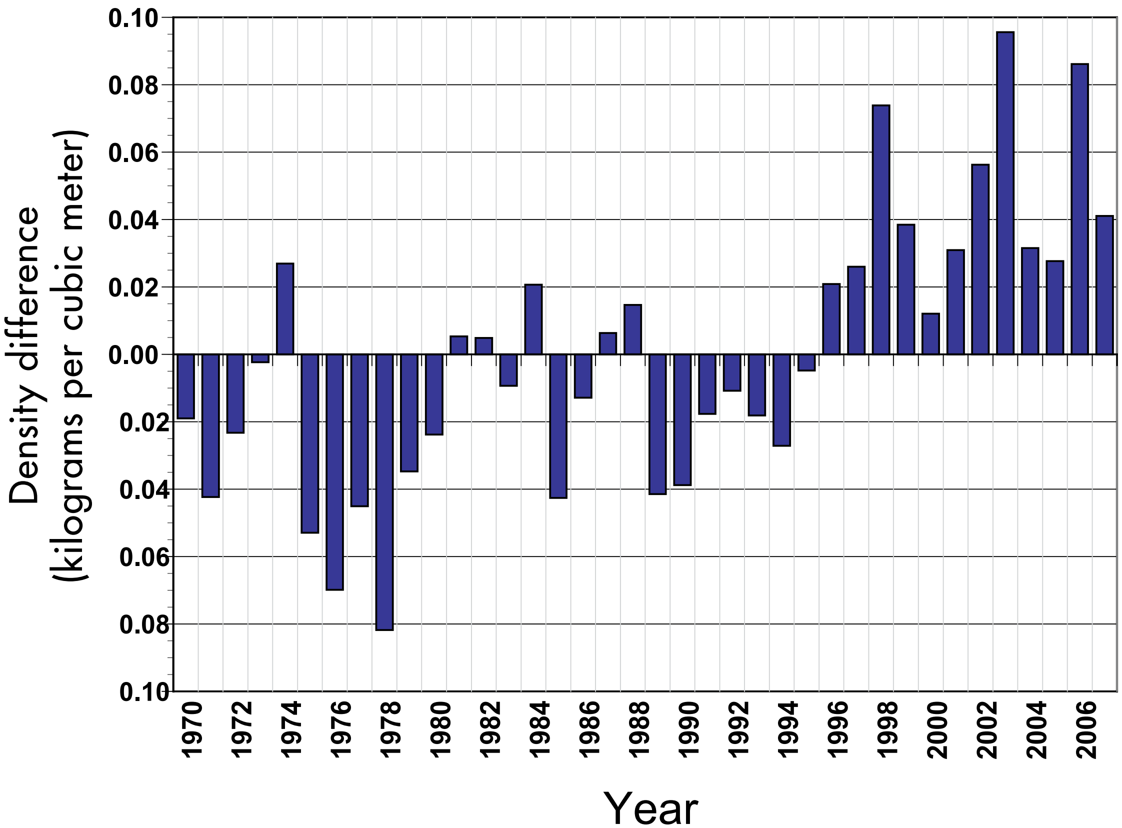


PHYSICAL PROPERTIES

Density stratification

Since 1970

Density stratification in Lake Tahoe has increased since 1970, as shown by the trend below. Each bar represents the annual average density difference between deep (100 to 165 feet) and shallow (0 to 33 feet) water, subtracted from mean density. Density differences increase as Lake Tahoe's surface waters warm, making them less dense or lighter. Increasing density stratification makes deep mixing of the lake occur less frequently.

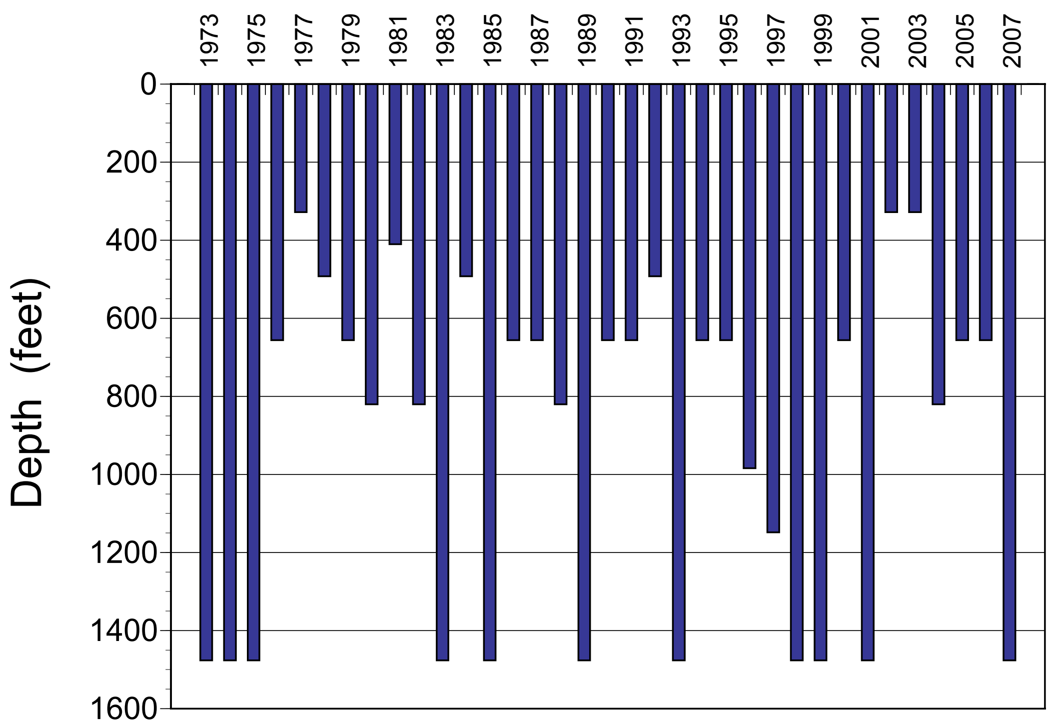


PHYSICAL PROPERTIES

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 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 late February to early March. In 2007, Lake Tahoe mixed all the way to the bottom at the mid-lake station. This was the first complete mix since 2001.



TAHOE: STATE OF THE LAKE REPORT 2008

NUTRIENTS AND PARTICLES

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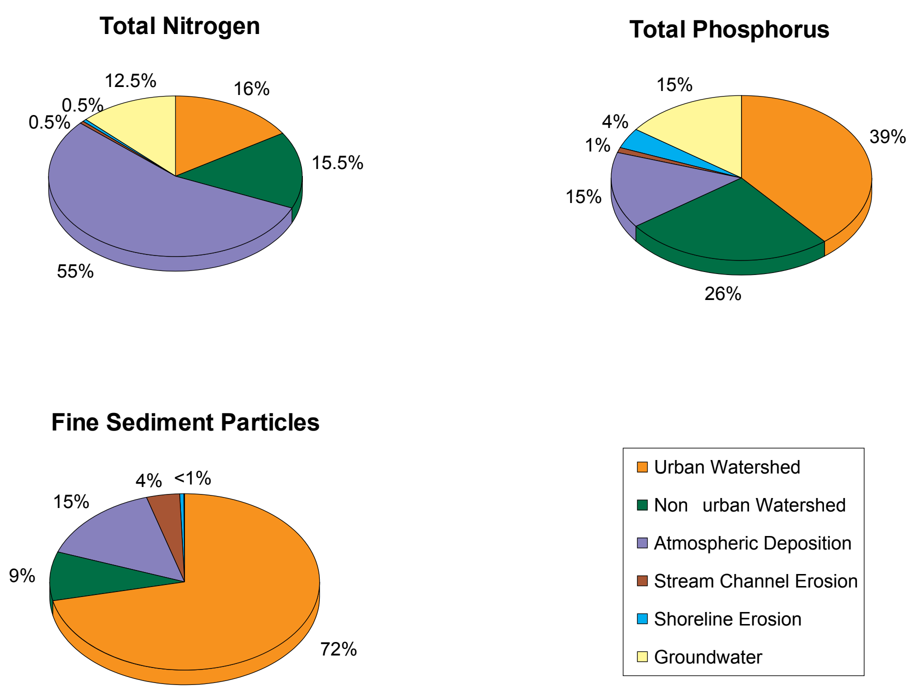
TAHOE ENVIRONMENTAL RESEARCH CENTER

NUTRIENTS AND PARTICLES

Sources of clarity-reducing pollutants

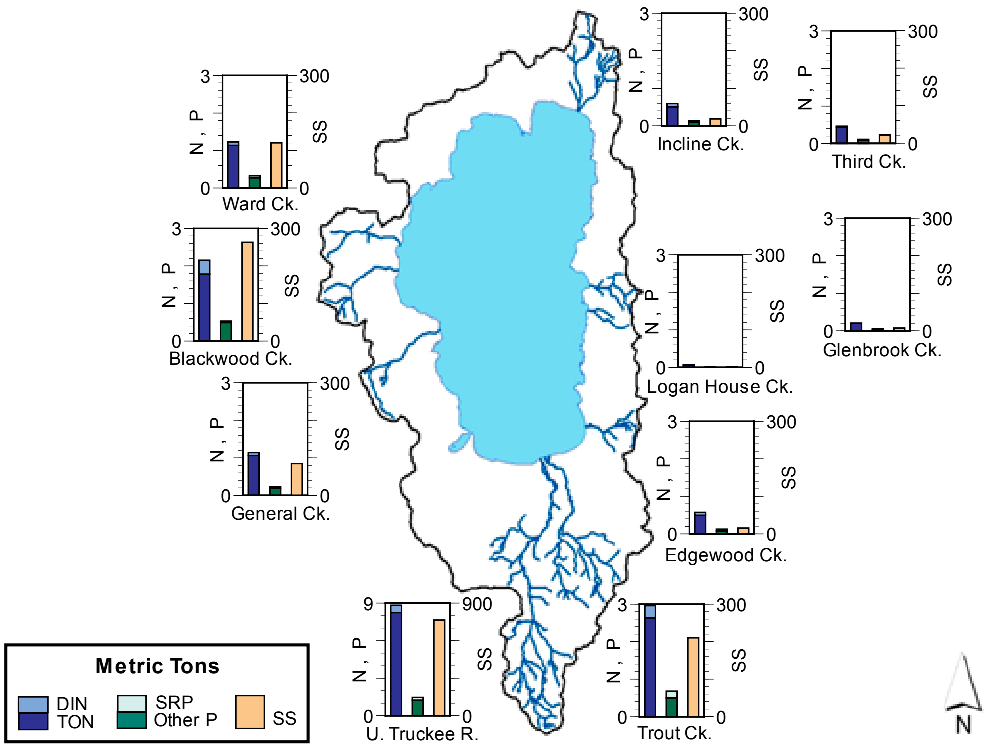
In the last 10 years, research has quantified the primary sources of nutrients (nitrogen and phosphorus) and particulate material that are causing Lake Tahoe to lose clarity. Fine particulates, the major contributor to clarity decline, primarily originate from the urban watershed (72%), even though such watersheds cover only 10% of the Tahoe Basin. For nitrogen, atmospheric deposition is the major source (55%). Phosphorus is primarily introduced by the urban (39%) and non-urban (26%) watersheds. These categories of pollutant sources are forming the basis of plans to restore Lake Tahoe by agencies including the Lahontan Regional Water Quality Control Board, the Nevada Division of Environmental Protection, the California Tahoe Conservancy, and the Tahoe Regional Planning Agency. (Data were generated for the Lake Tahoe TMDL Program.)



NUTRIENTS AND PARTICLES

Pollutant loads from 10 watersheds

The Lake Tahoe Interagency Monitoring Program (LTIMP) has measured nutrient and sediment input from 10 of the 63 watershed streams, which account for half of all stream flow into the lake. Most of the suspended sediment is from the Upper Truckee River, Trout Creek, Ward Creek and Blackwood Creek. About 30 percent of the phosphorus comes from the Upper Truckee River, Trout Creek, Ward Creek and Blackwood Creek. The LTIMP stream water quality program is managed by the U.S. Geological Survey in Carson City, Nev.; UC Davis TERC, and the Tahoe Regional Planning Agency.

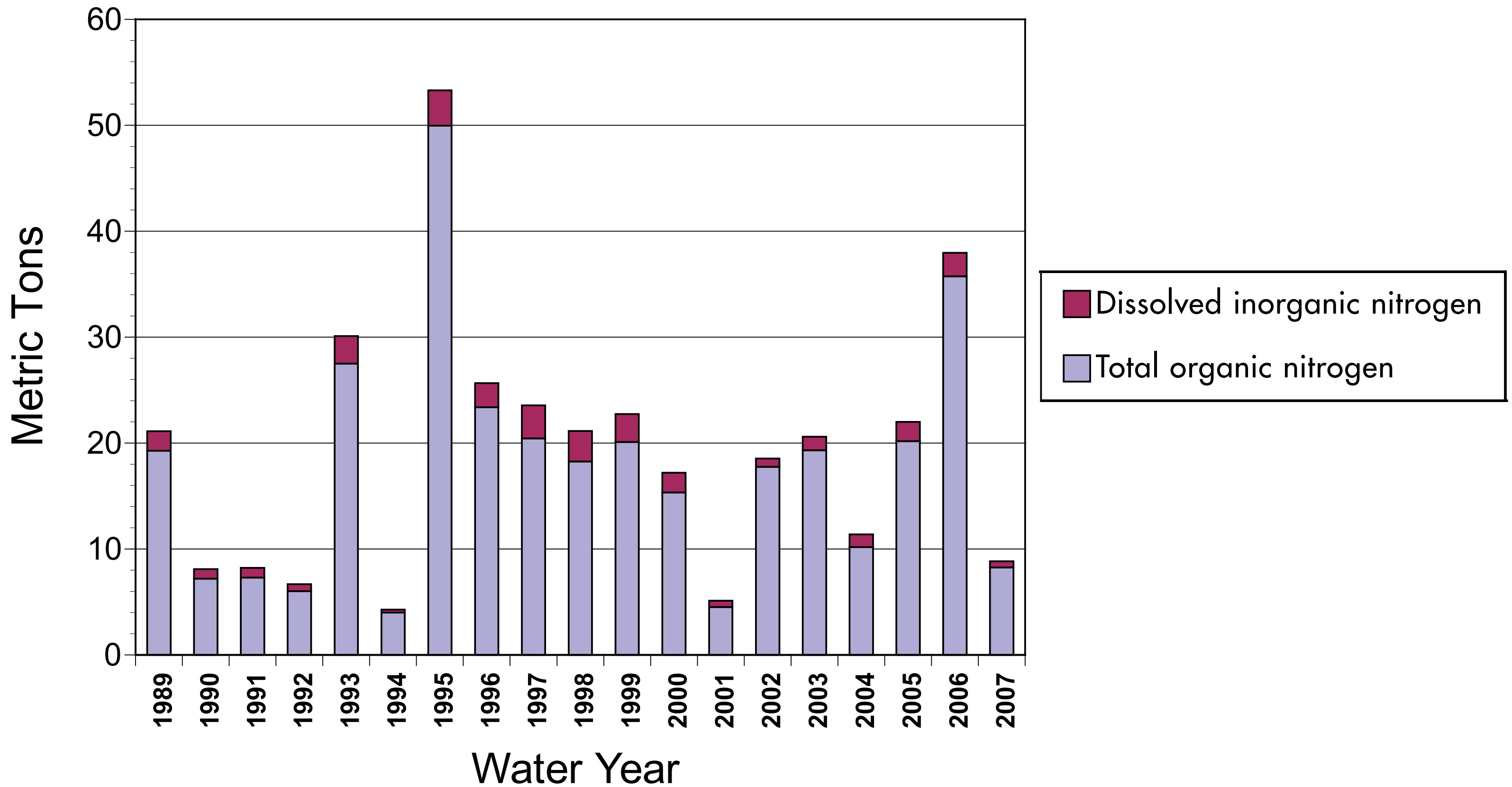


NUTRIENTS AND PARTICLES

Nitrogen contribution by Upper Truckee River

Since 1989

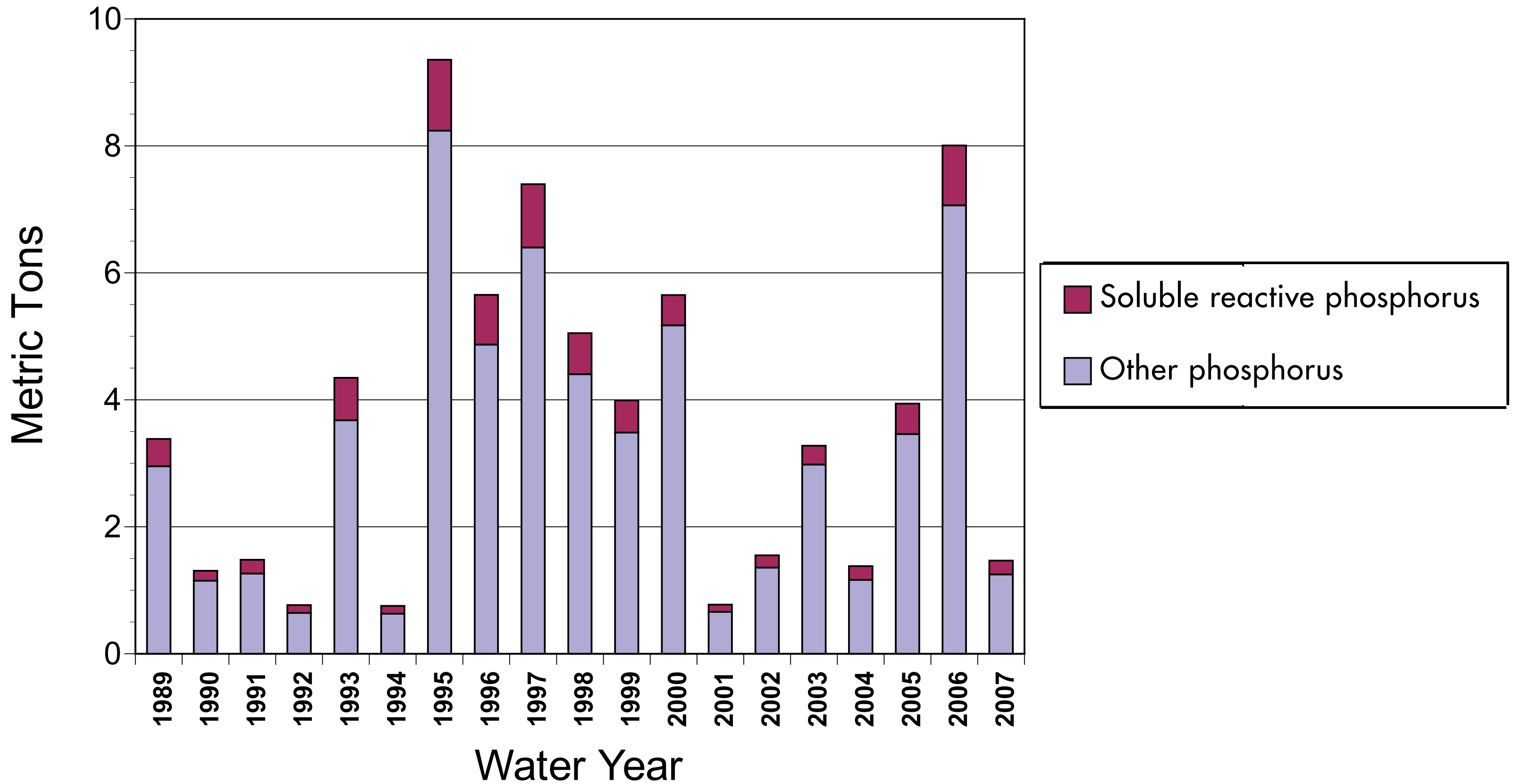
Nitrogen concentration is important because it, along with phosphorus, promotes algal growth. (Fig. 9.1 shows the sources of Lake Tahoe's pollutants.) The Upper Truckee River is the largest of the 63 streams that flow into Lake Tahoe, contributing about 25 percent of the inflowing water. The river's contribution of dissolved inorganic nitrogen (nitrate and ammonium) and total organic nitrogen 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. Low rainfall in 2007 resulted in a low nitrogen load. (One metric ton = 2,205 pounds.)



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. Low rainfall in 2007 resulted in a low phosphorus load. (Total phosphorus is the sum of SRP and other phosphorus, which includes organic phosphorus and phosphorus attached to particles.) (One metric ton = 2,205 pounds.)

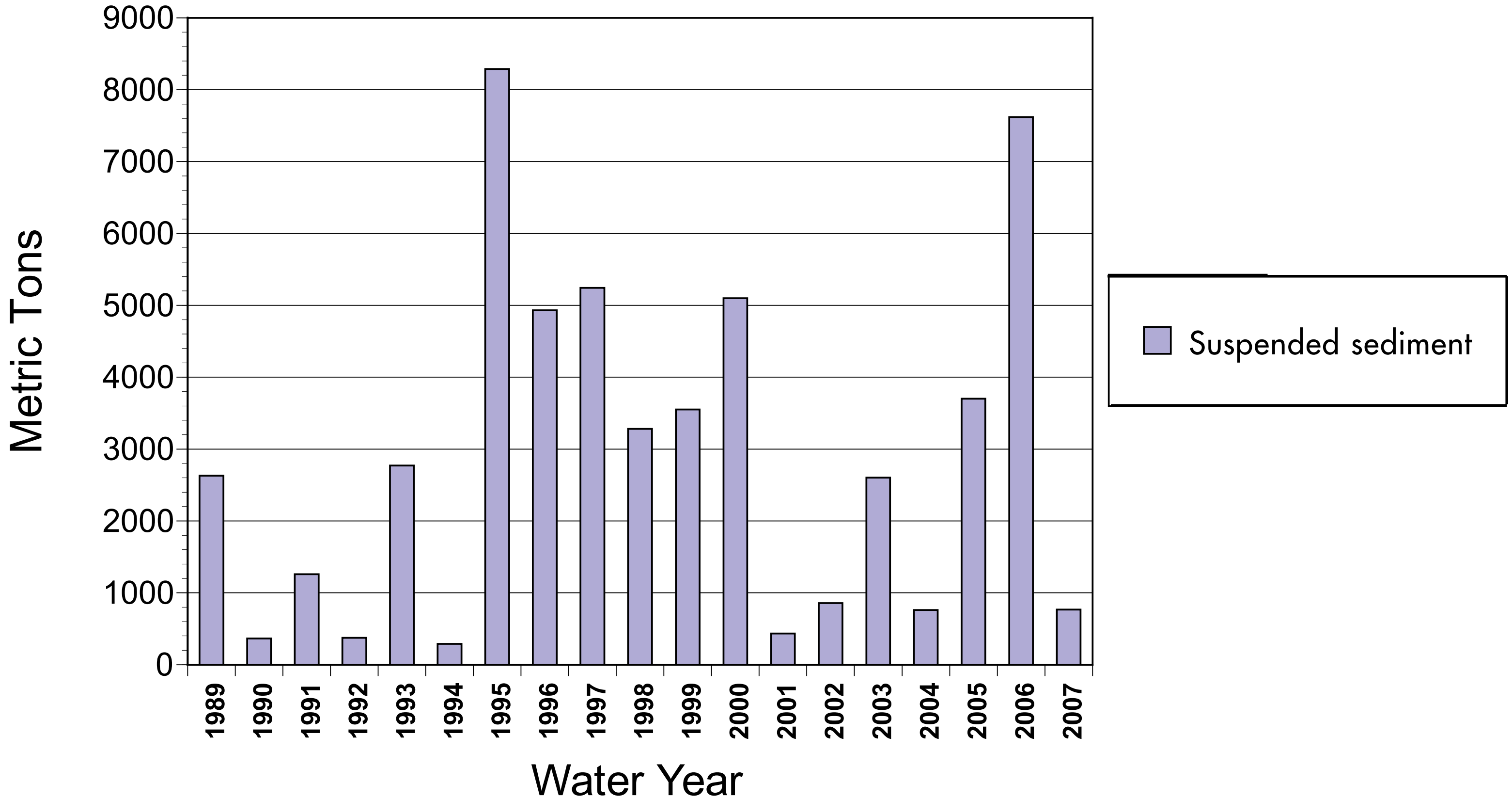


NUTRIENTS AND PARTICLES

Suspended sediment contribution by Upper Truckee River

Yearly since 1989

The load of suspended sediment delivered to the lake by the Upper Truckee is tied directly to precipitation and stream flow. Low rainfall in 2007 resulted in a low suspended sediment load. 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). (One metric ton = 2,205 pounds.)



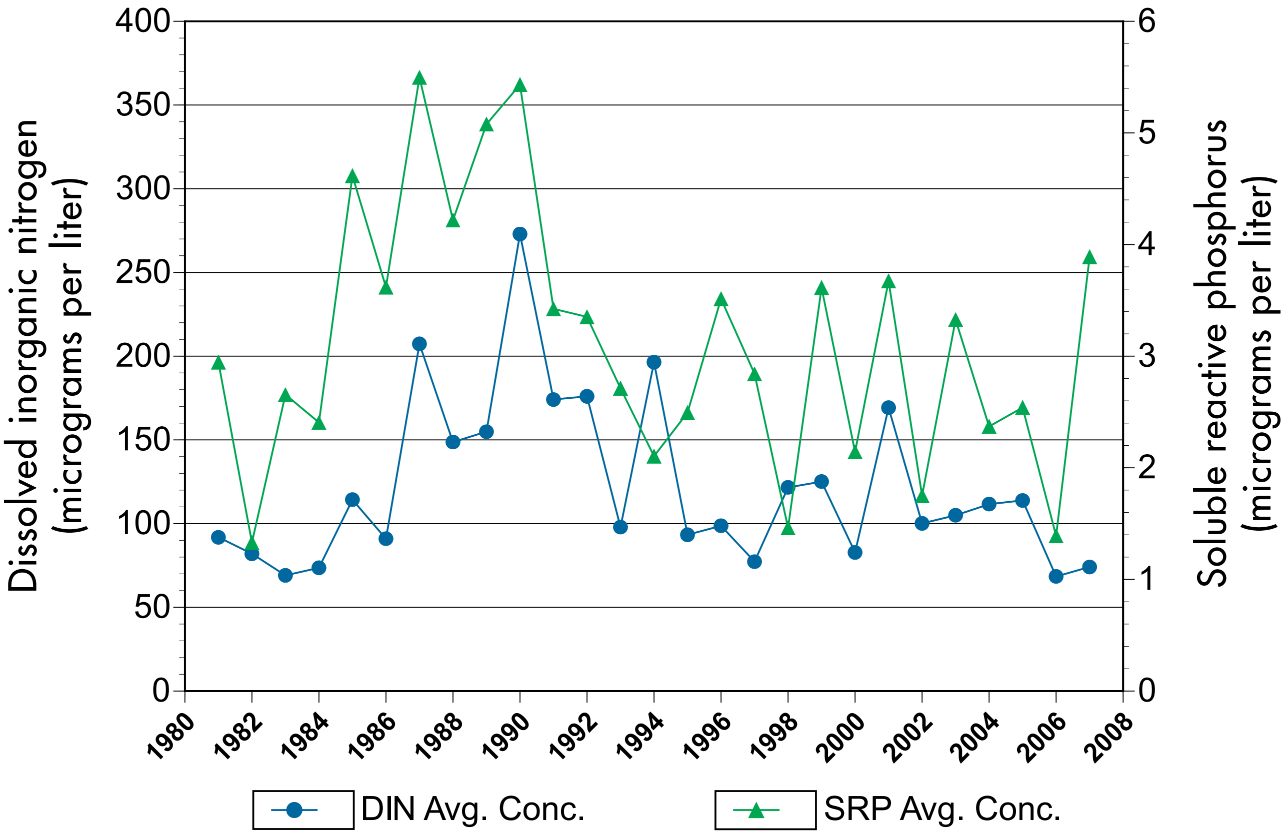
NUTRIENTS AND PARTICLES

Nutrient concentrations in rain and snow

Yearly since 1981

Nutrients in rainwater and snow (called wet deposition) contribute significant amounts of especially nitrogen, but also phosphorus, to Lake Tahoe. Nutrients in precipitation have been measured near Ward Creek since 1981, but show no consistent trend.

Annual concentrations in precipitation of dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) vary from year to year. In 2007, concentrations of DIN in precipitation were relatively low, but were above average for SRP.

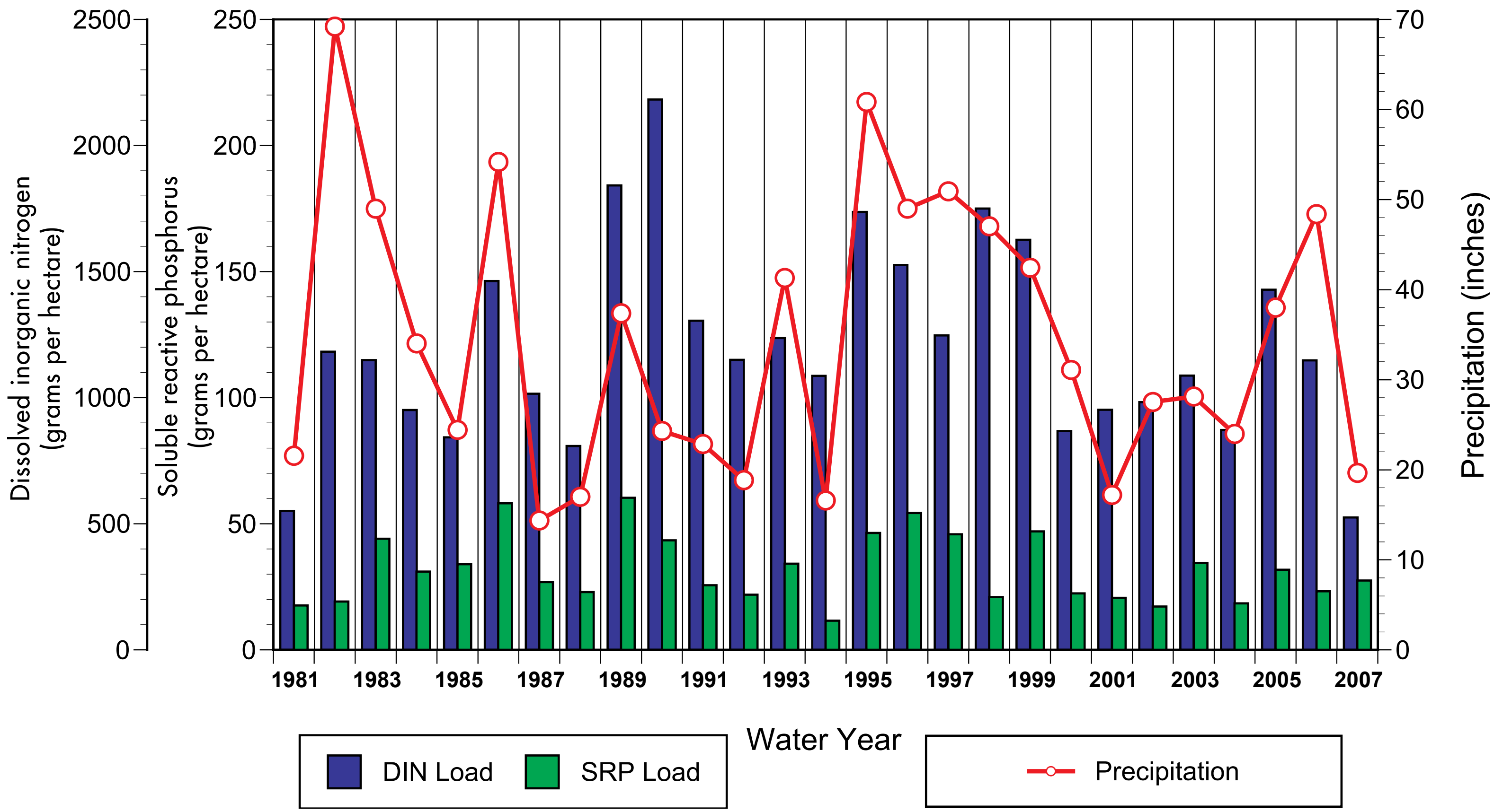


NUTRIENTS AND PARTICLES

Nutrient loads in rain and snow

Since 1981

The annual load for wet deposition is calculated by multiplying the concentration of dissolved inorganic nitrogen 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 2007, the phosphorus load was near the historical average while the nitrogen load was the lowest on record.

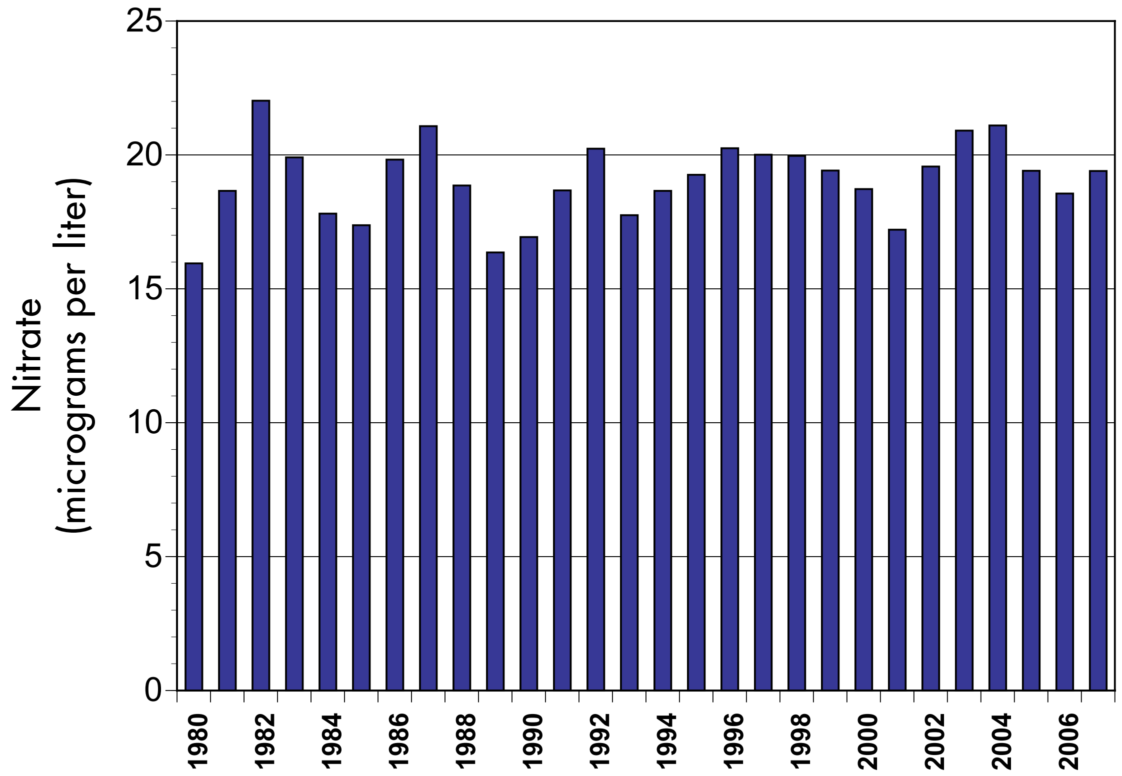


NUTRIENTS AND PARTICLES

Lake nitrate concentration

Yearly since 1980

Since 1980, the lake nitrate concentration has remained relatively constant, ranging between 16 and 22 micrograms per liter. In 2007, the volume-weighted annual average concentration of nitrate was 19.2 micrograms per liter (or parts per billion).

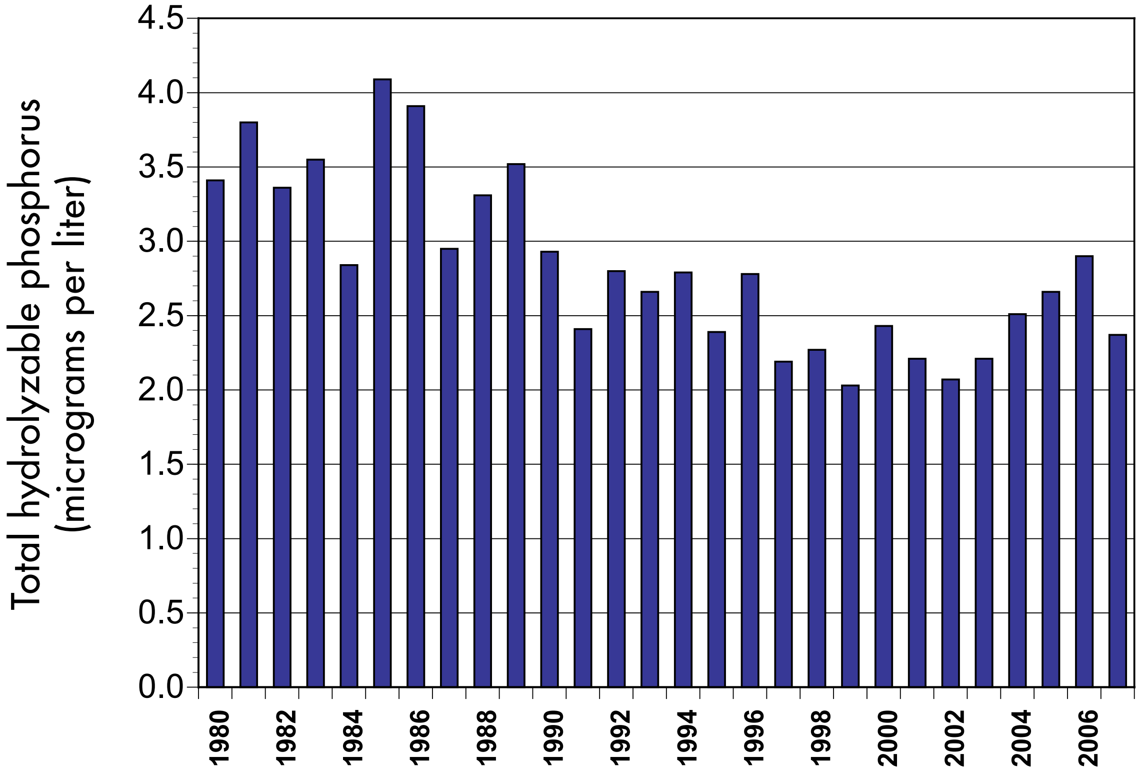


NUTRIENTS AND PARTICLES

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. Since 1980, THP has tended to decline. In 2007, the volume-weighted annual average concentration of THP was 2.35 micrograms per liter (or parts per billion).



TAHOE: STATE OF THE LAKE REPORT 2008

BIOLOGY

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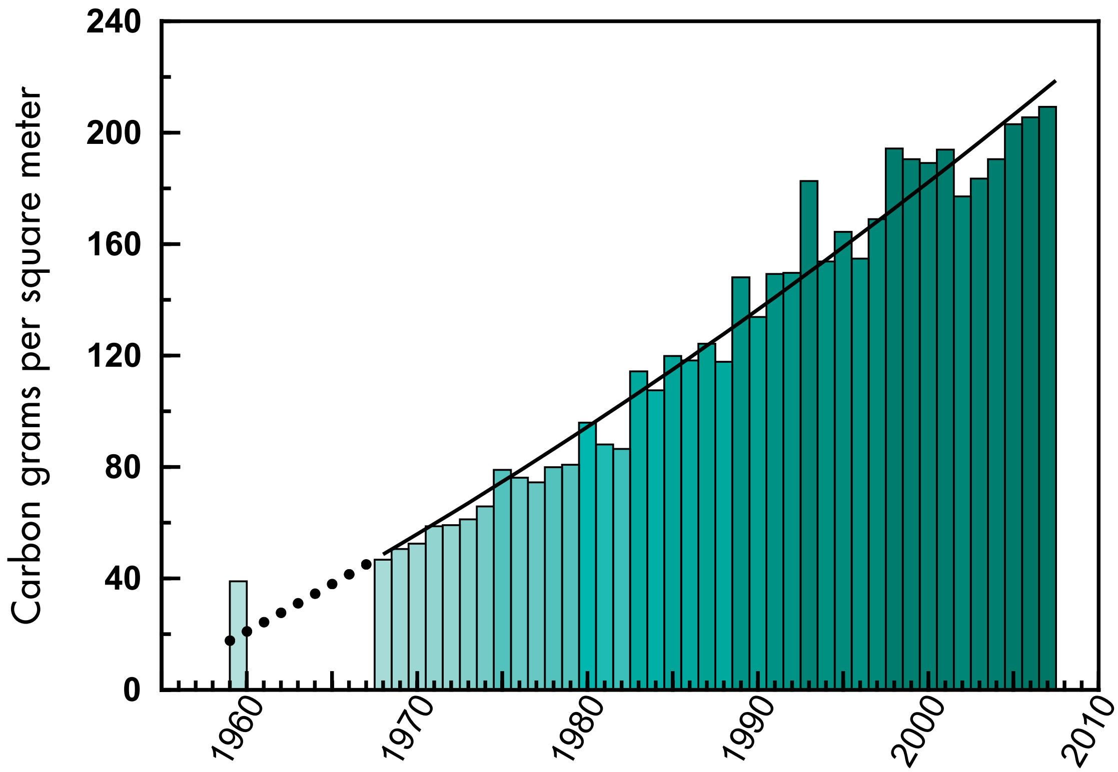
BIOLOGY

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 steadily increased over that time, probably promoted by changes in the lake's nutrient load, light environment and algae species. In 2007, primary productivity was 209.3 grams of carbon per square meter.

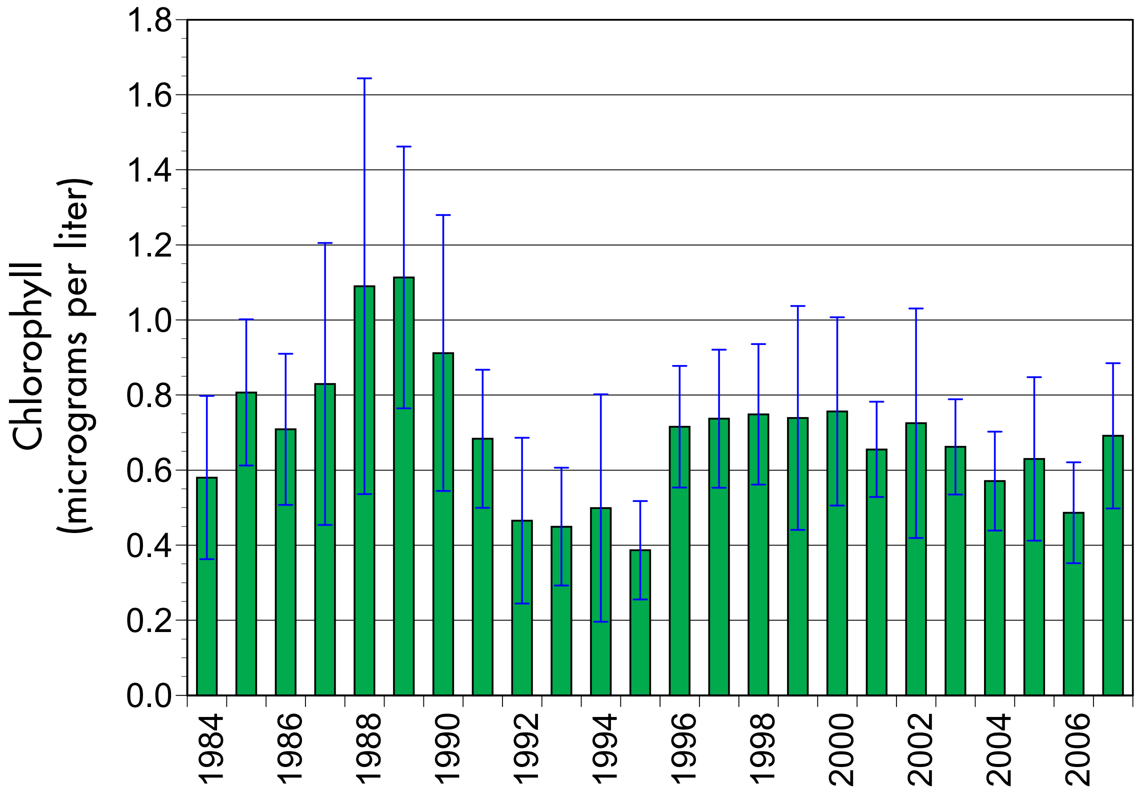


BIOLOGY

Algae abundance

Yearly since 1984

The amount of free-floating algae (phytoplankton) in the water is determined by measuring the concentration of chlorophyll *a*. Though algae abundance varies annually, it does not show a long-term increase. Since measurements began in 1984, the annual average has been 0.69 micrograms of chlorophyll *a* per liter of water (or 0.69 parts per billion). The annual average value for 2007 was 0.69 micrograms per liter, the same as the long-term average.

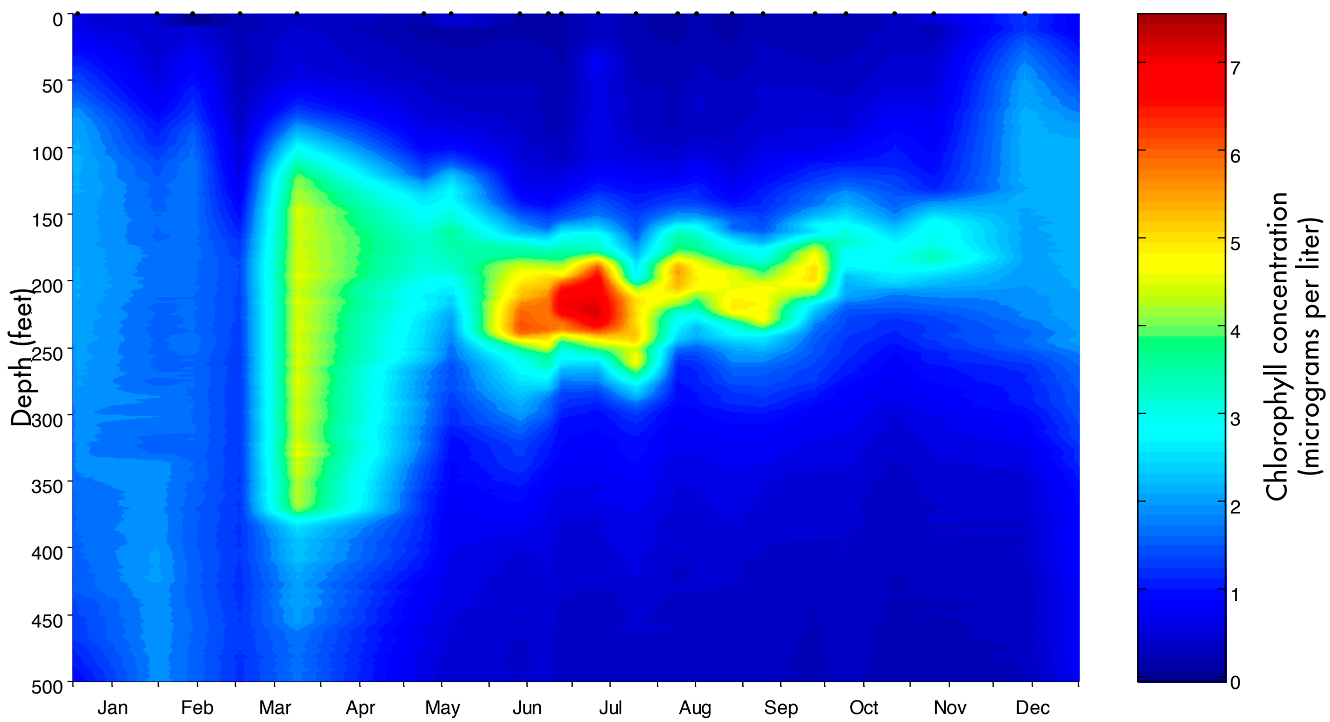


BIOLOGY

Algae concentration by depth

In 2007

The highest concentrations of algae (as measured by chlorophyll *a* concentration) occur in summer between the 100 and 200-foot depths. This discrete layer, known as the deep chlorophyll maximum, forms in spring and persists until winter mixing redistributes algae. This layer is below the Secchi depth (Figs. 11.1 and 11.2), and does not influence lake clarity until winter mixing relocates chlorophyll into the range of the Secchi disk (50 to 80 feet).

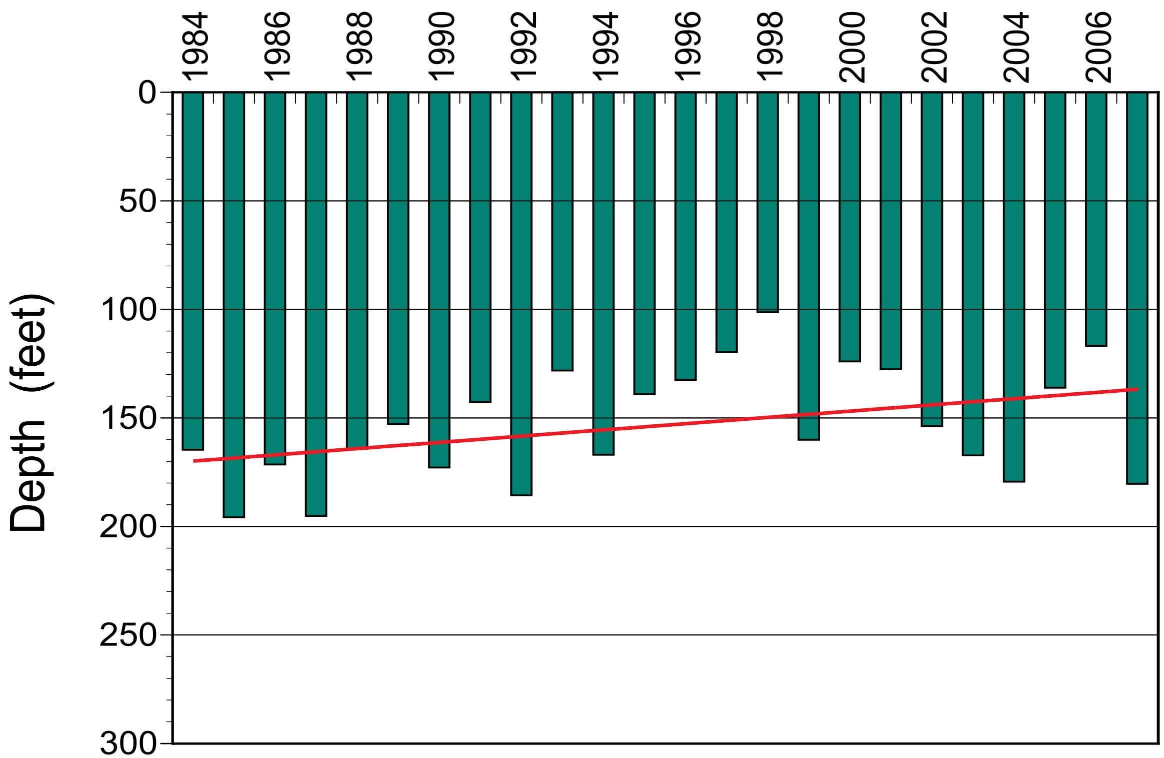


BIOLOGY

Depth of chlorophyll maximum

Yearly since 1984

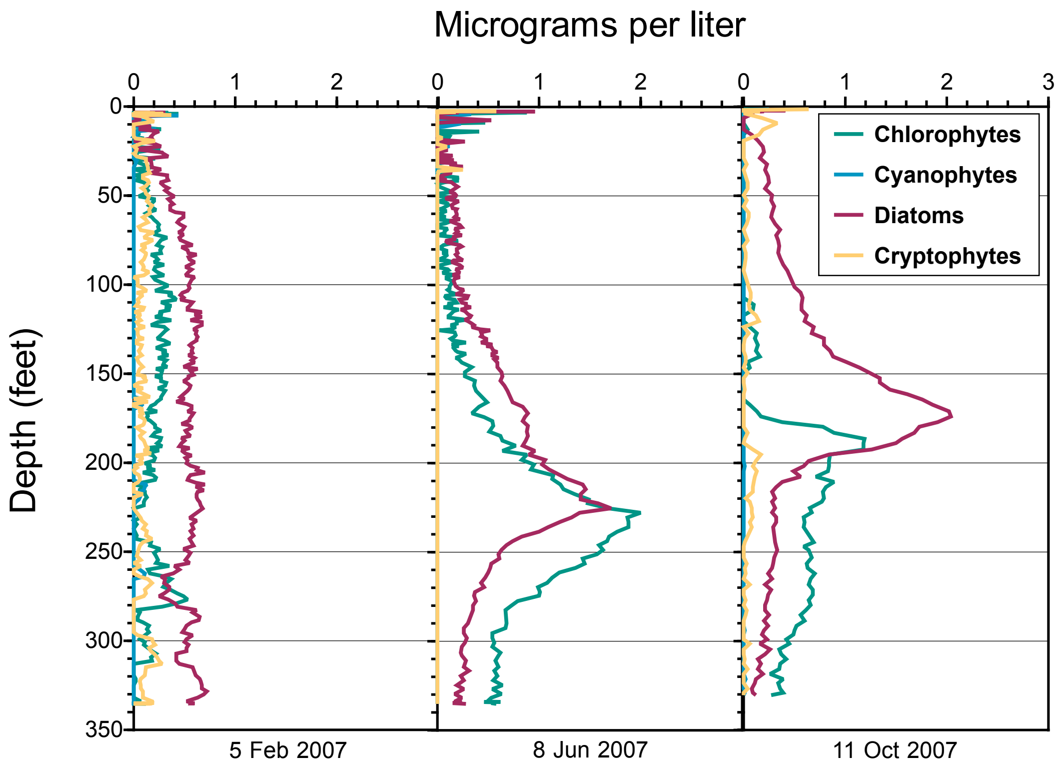
The depth at which the deep chlorophyll maximum occurs varies from year to year. In 2007, the deep chlorophyll maximum was about 180 feet, considerably deeper than the last two years. The deep chlorophyll maximum depth has generally been getting shallower over time, a trend believed to be linked to the decline in water clarity.



Algae group distribution by depth

Three days in 2007

Different algae groups grow at various depths below the lake surface, depending on what light and nutrients they need. Distributions of different algae taxonomic groups vary seasonally, as shown by these three profiles. In winter, algal groups were evenly distributed in the water column. In summer and fall, diatoms and green algae (chlorophytes) dominated the phytoplankton community, and the deep chlorophyll maximum was clearly present. Cryptophytes and cyanophytes were far lower in concentration and tended to favor shallow depths. By mid-October, both the diatoms and green algae were higher in the water, with diatoms clearly dominant.

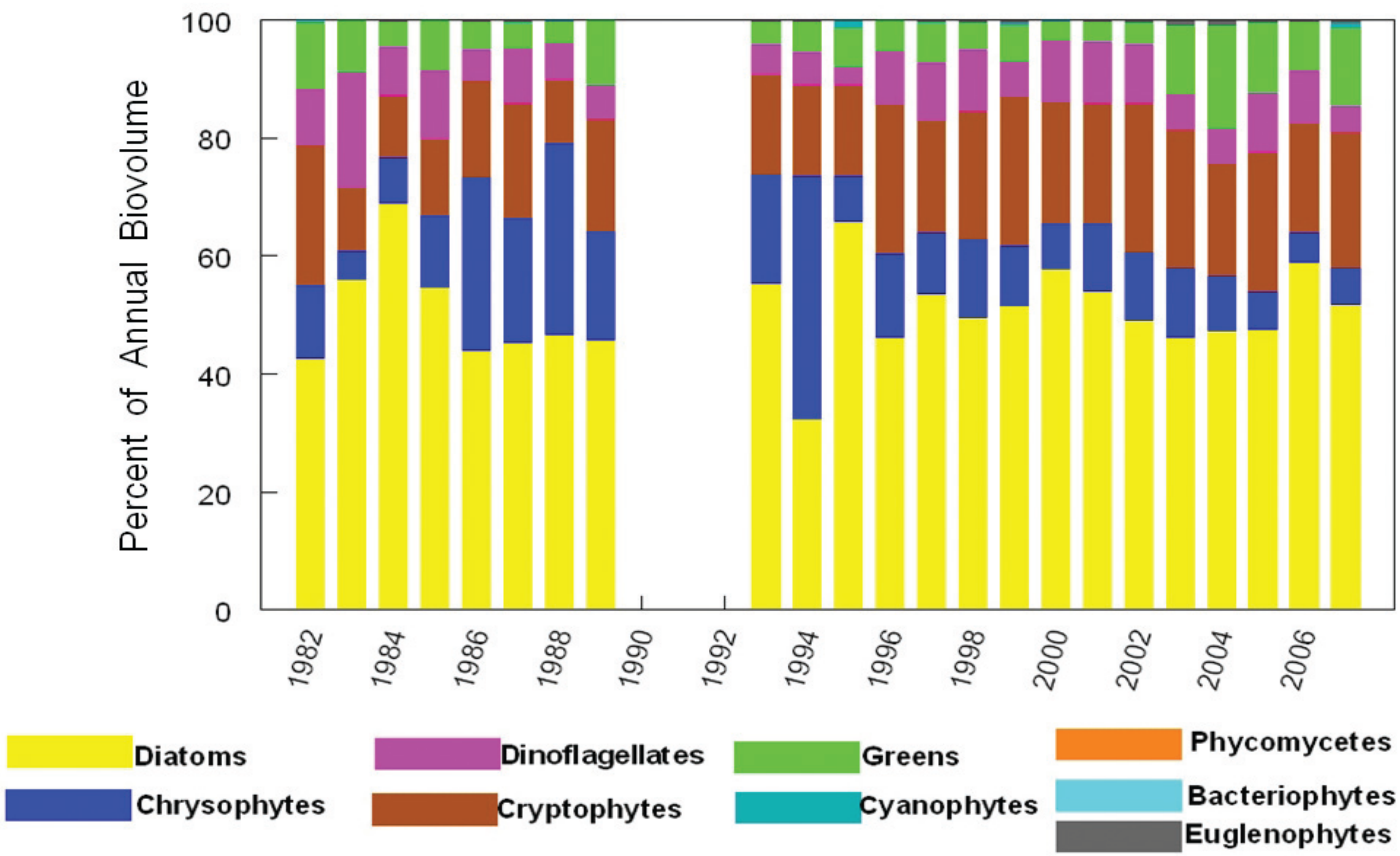


BIOLOGY

Algae groups as a fraction of total population

Yearly since 1982

The population, or biovolume, 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 biovolume each year. Chrysophytes and cryptophytes are next, comprising 10 to 30 percent of the total. Since 2003, the chlorophytes, or green algae, have increased in abundance.



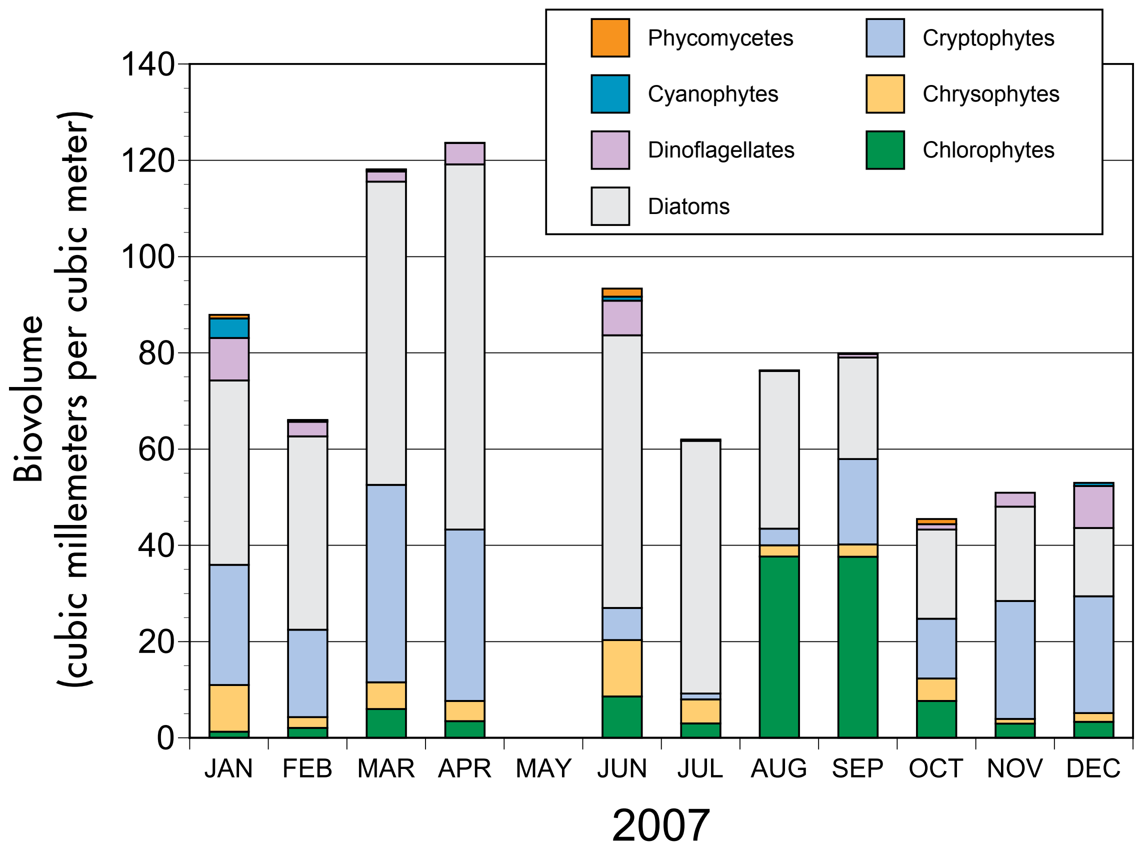
BIOLOGY

Algae groups as a fraction of total population

Monthly in 2007

Algae populations vary month to month, as well as year to year. In 2007, diatoms dominated the phytoplankton community from January through July.

The chlorophytes peaked in August and September, when they also dominated the biovolume.

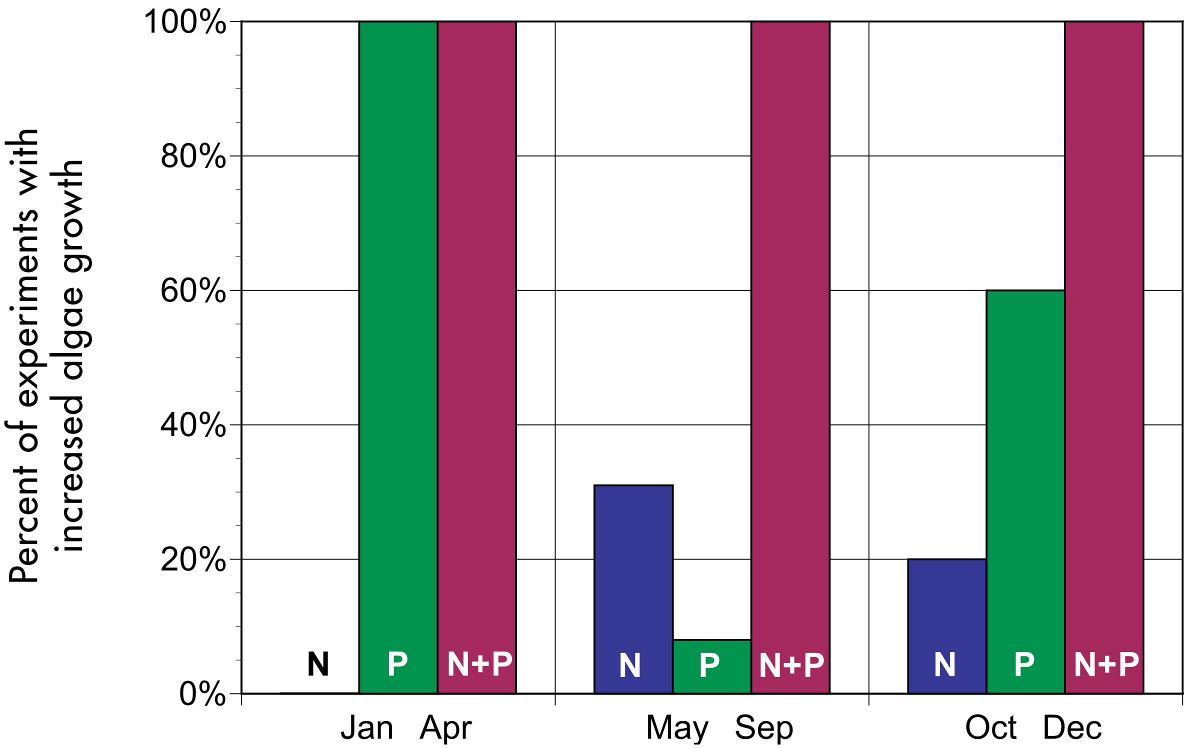


BIOLOGY

Nutrient limitation of algal growth

In 2007

Bioassays determine the nutrient status of phytoplankton by adding nutrients to lake water samples and then measuring increased algae growth. These tests document both seasonal and long-term changes in nutrient limitation. Between January and April in 2007, algae were exclusively limited by phosphorus. From May to September, nitrogen was more limiting, but the lake was co-limited, as shown by the greater response to adding both nutrients. Phosphorus was again limiting from October to December, but co-limitation was also present. These results highlight the role of nutrients in controlling algal growth. They also underscore the synergistic effects of adding both nutrients together.

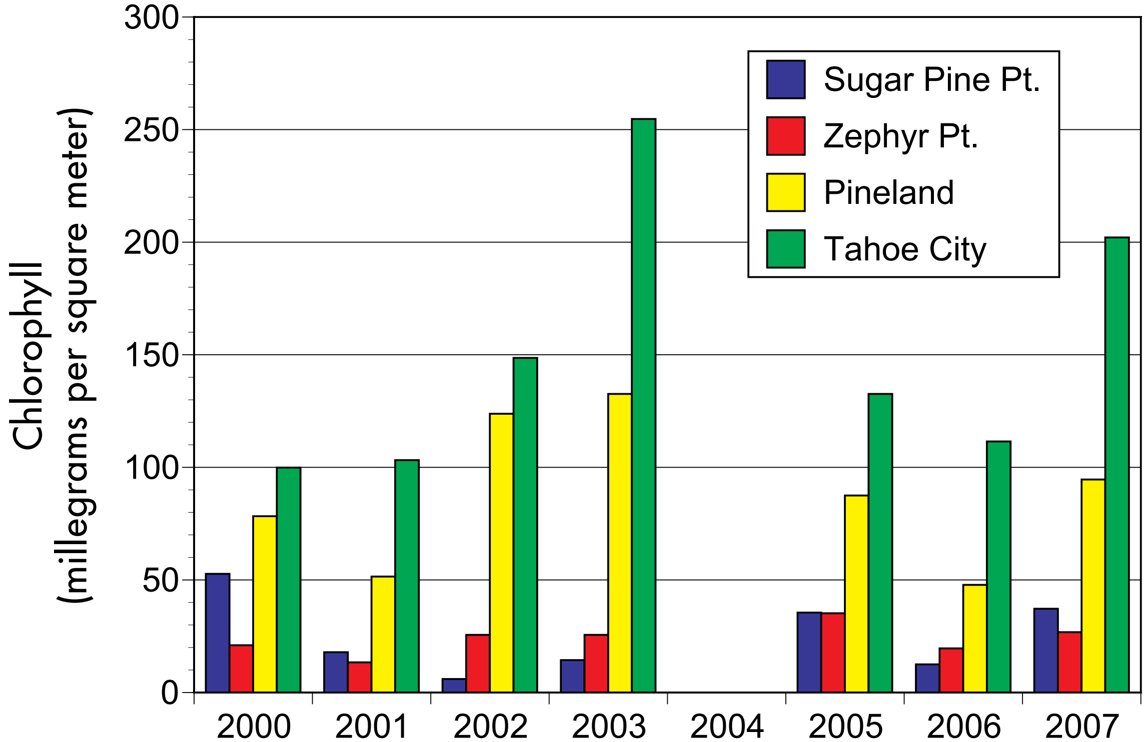


BIOLOGY

Shoreline algae populations

Yearly since 2000

Periphyton, or attached algae, makes rocks around the shoreline of Lake Tahoe green and slimy. Periphyton is measured eight times each year, and this graph shows the maximum biomass measured at four sites. In 2007, concentrations were above average. The two sites with the most periphyton (Tahoe City and Pineland) are closest to urban areas.

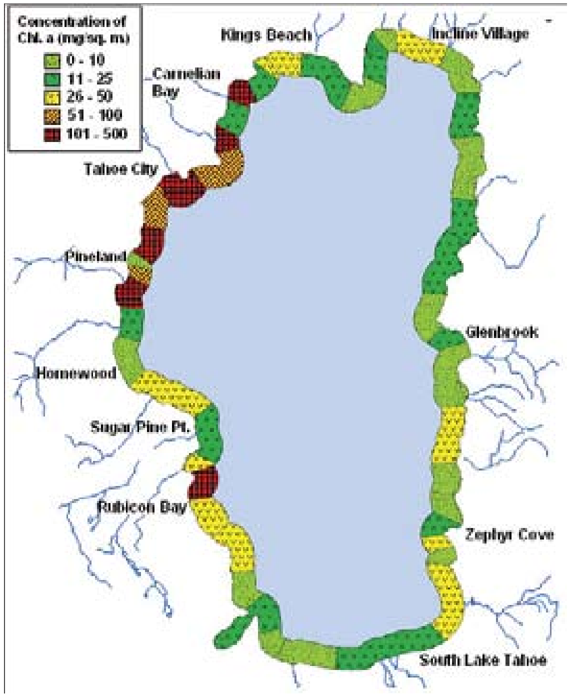


BIOLOGY

Shoreline algae distribution

In 2007

Periphyton biomass was surveyed around the lake during the spring of 2007, when it was at its annual maximum. Nearly 50 locations were surveyed by snorkel in 1.5 feet of water. Periphyton concentrations were highest along the northwest shore. (The width of the color band does not represent the distribution.)

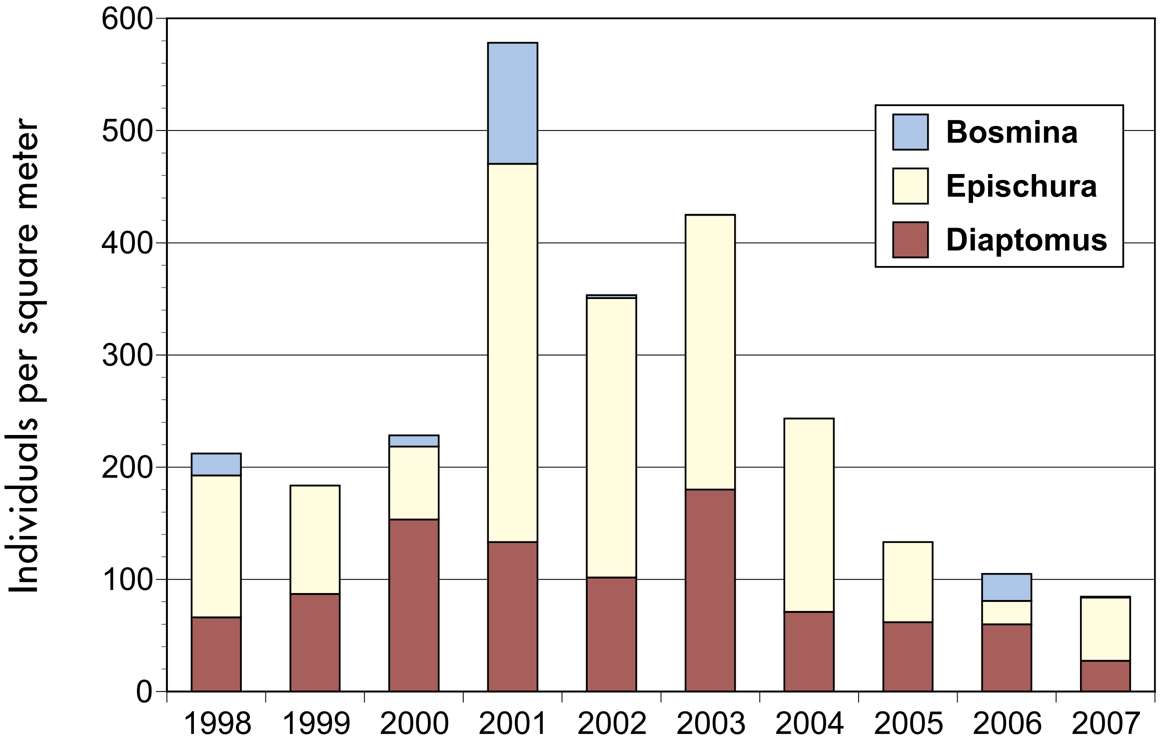


BIOLOGY

Zooplankton population by genus

Yearly since 1998

Zooplankton (microscopic aquatic animals that graze on algae) populations vary from year to year. Since mysid shrimp were introduced to Lake Tahoe, zooplankton have been dominated by *Epischura* and *Diaptomus*. In some years, *Bosmina* are also present, typically in small numbers. In 2007, zooplankton biovolume, an important component of the aquatic food web, was the lowest since 1998.

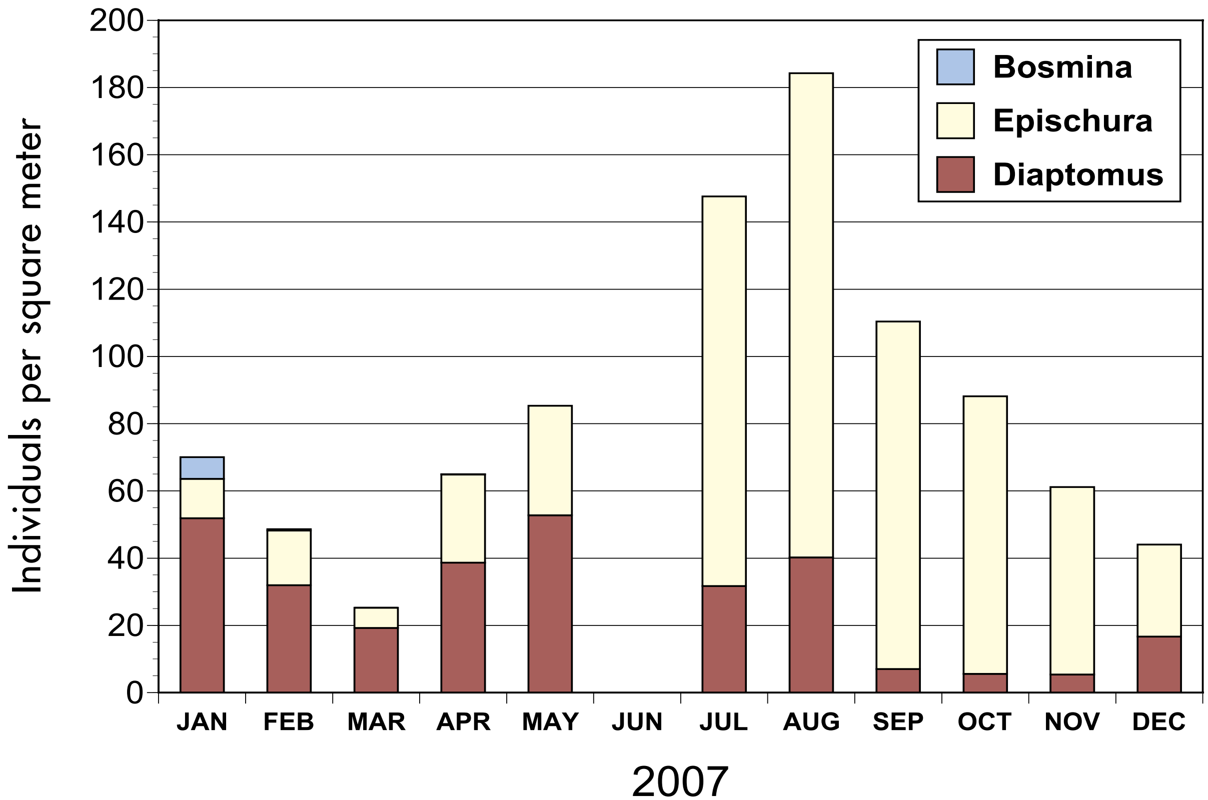


BIOLOGY

Zooplankton population by genus

Monthly in 2007

Diaptomus was the dominant zooplankton during the winter and spring of 2007, as in most years. *Epischura* was dominant in summer. *Bosmina* was present at low concentrations in January, a remnant of greater numbers recorded between October and December of 2006.



TAHOE: STATE OF THE LAKE REPORT 2008

CLARITY

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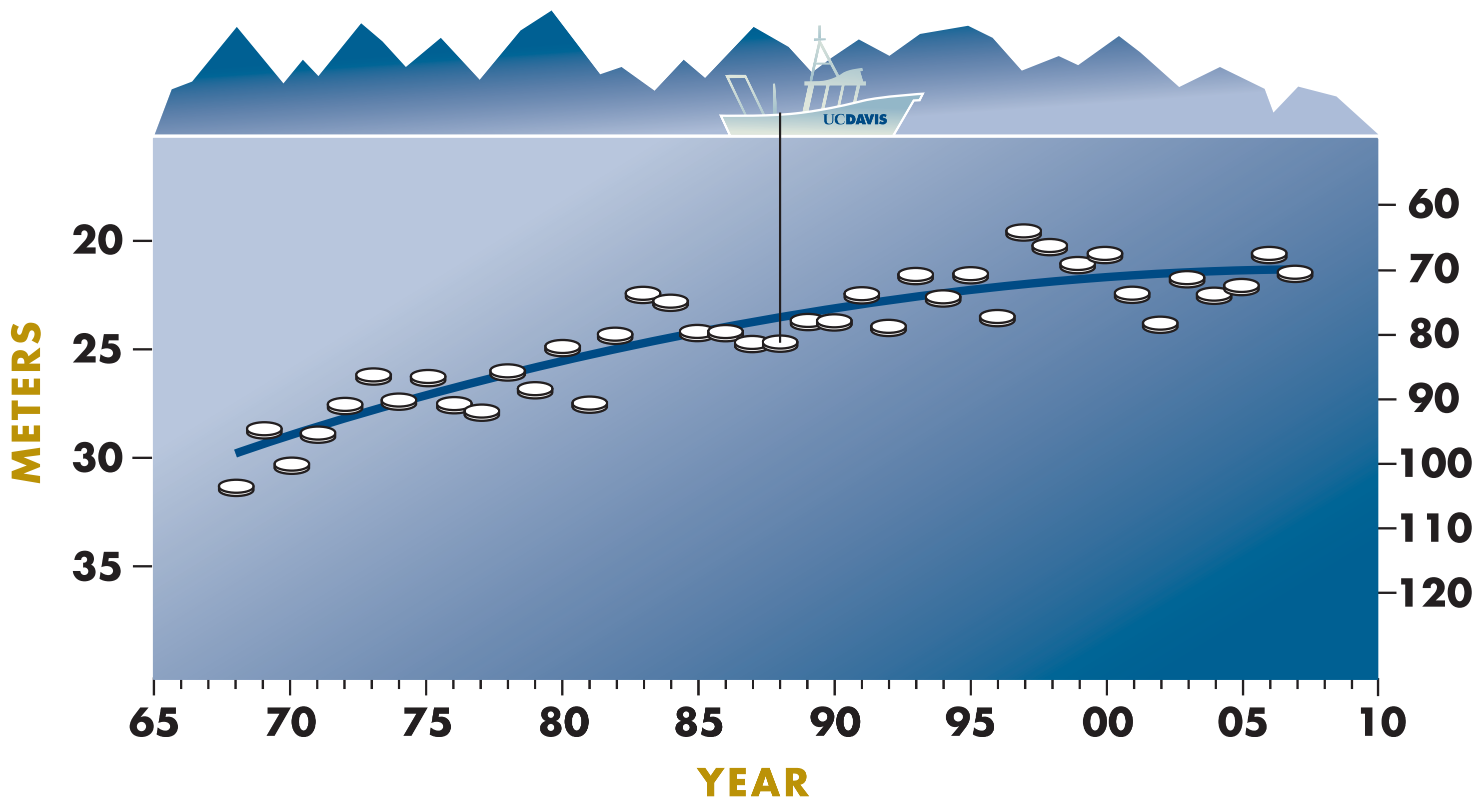
CLARITY

Annual average Secchi depth

Yearly since 1968

Secchi depth (the point below the lake surface at which a 10-inch white disk disappears from view) is the longest continuous measurement of Lake Tahoe clarity. The annual Secchi depth is the average of 20 to 25 readings made throughout the year. While lake clarity has improved for brief periods since 1968, the overall long-term trend has been decline. In the last seven years, Secchi depth measurements have been better than predicted by the long-term linear trend. Statistical analysis suggests that the decline in Lake Tahoe's clarity has slowed significantly, and is now better represented by the curve below than a straight line. In 2007, the Secchi depth was 70.1 feet, 2.4 feet deeper than last year.

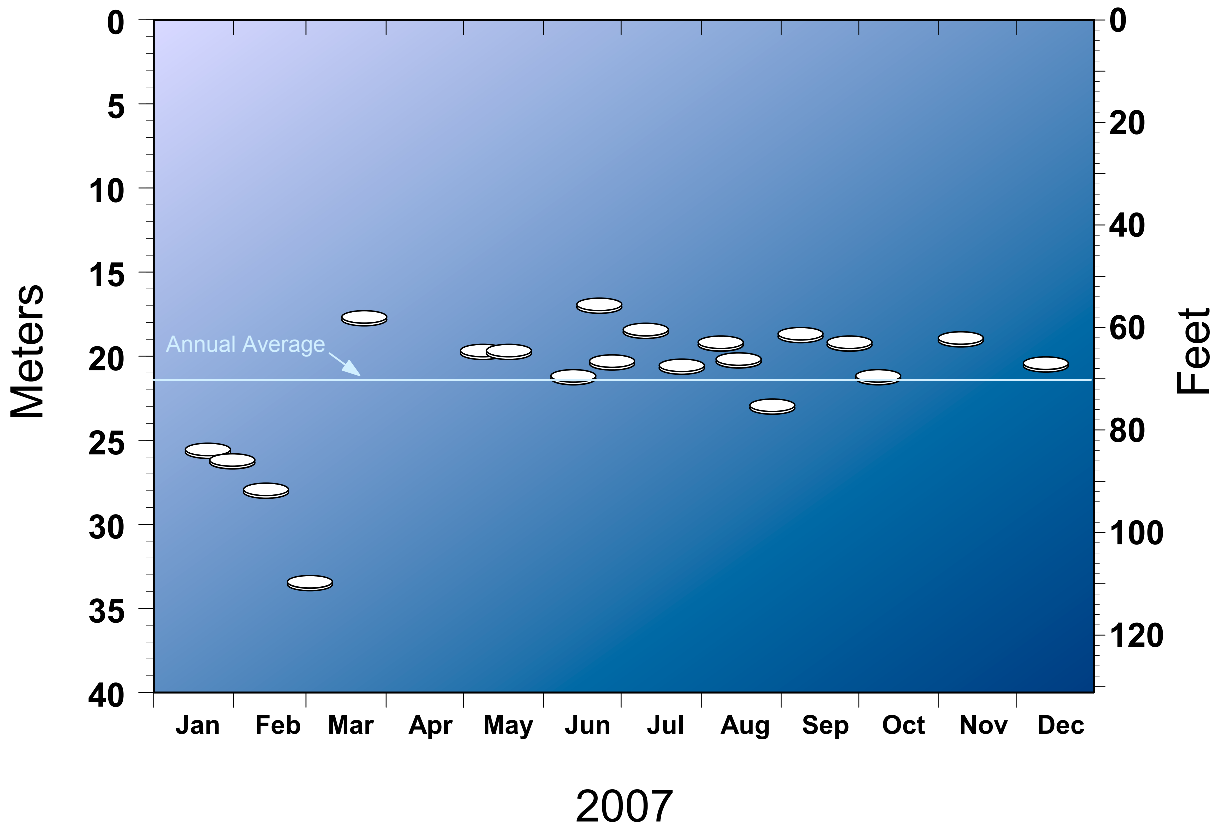


CLARITY

Secchi depth measurements

In 2007

The deepest Secchi depth readings (the clearest water) typically occur in winter and spring. In 2007, the deepest reading was 109.9 feet on March 2nd.

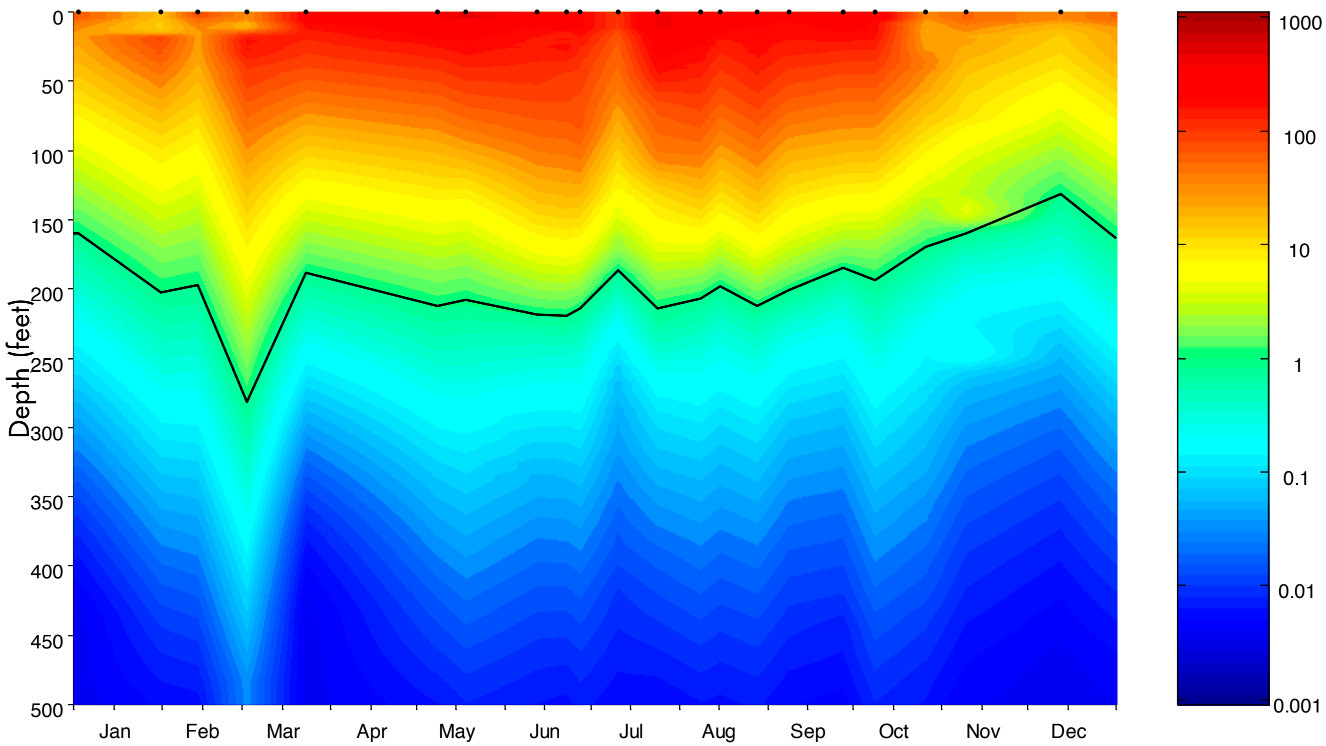


CLARITY

Penetration of photosynthetically active radiation

In 2007

Photosynthetically active radiation (PAR) is that part of solar radiation used for photosynthesis. The black line below shows the depth at which PAR is 1% of its level on the lake surface, known as the euphotic depth. PAR penetration varies throughout the year, but is usually deepest in the summer when the sun is highest in the sky. In 2007, euphotic depth suddenly increased in early March, corresponding to the onset of deep mixing when clear bottom water is brought to the surface (Fig. 8.9). This year, the maximum Secchi depth reading was 109.9 feet on March 2nd.



TAHOE: STATE OF THE LAKE REPORT 2008

EDUCATION AND OUTREACH

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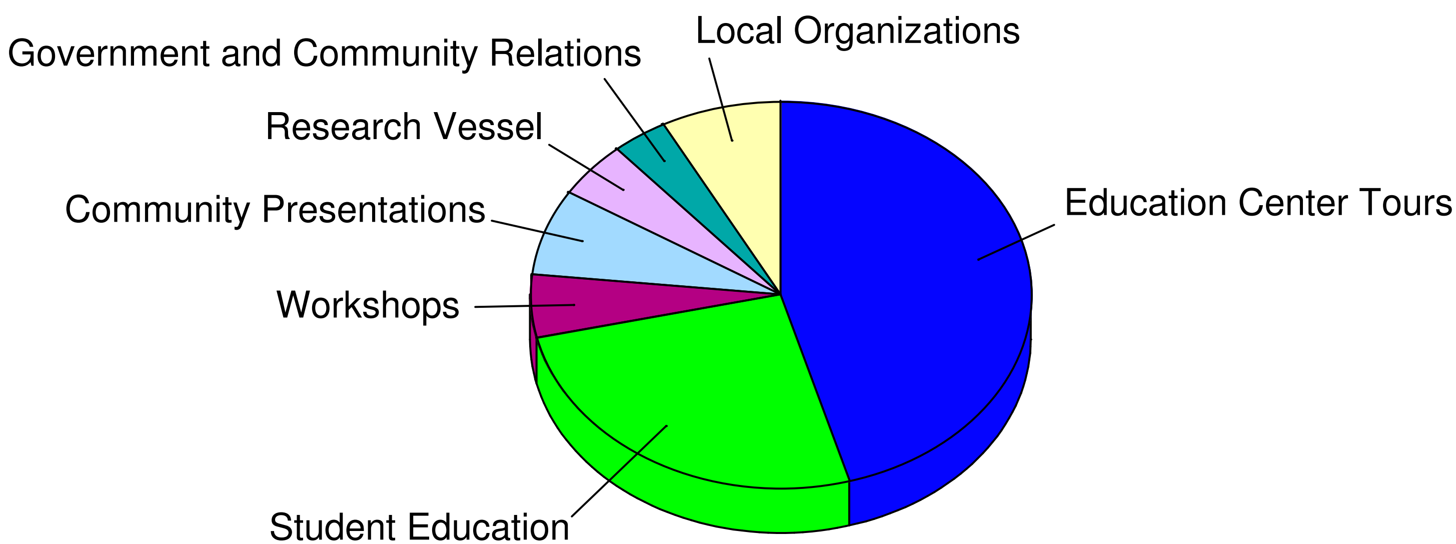
OUTREACH AND EDUCATION

TERC outreach

In 2007

Part of TERC's mission is education and outreach. During 2007, TERC recorded over 6,900 individual visitor contacts. The majority represented visitors to the Thomas J. Long Foundation Education Center at Incline Village. In addition, TERC hosts monthly public lectures, makes presentations to local organizations and takes a limited number of visitors out on our research vessels.



TOTAL NUMBER OF CONTACTS: 6,905