TAHOE: STATE OF THE LAKE REPORT 2022

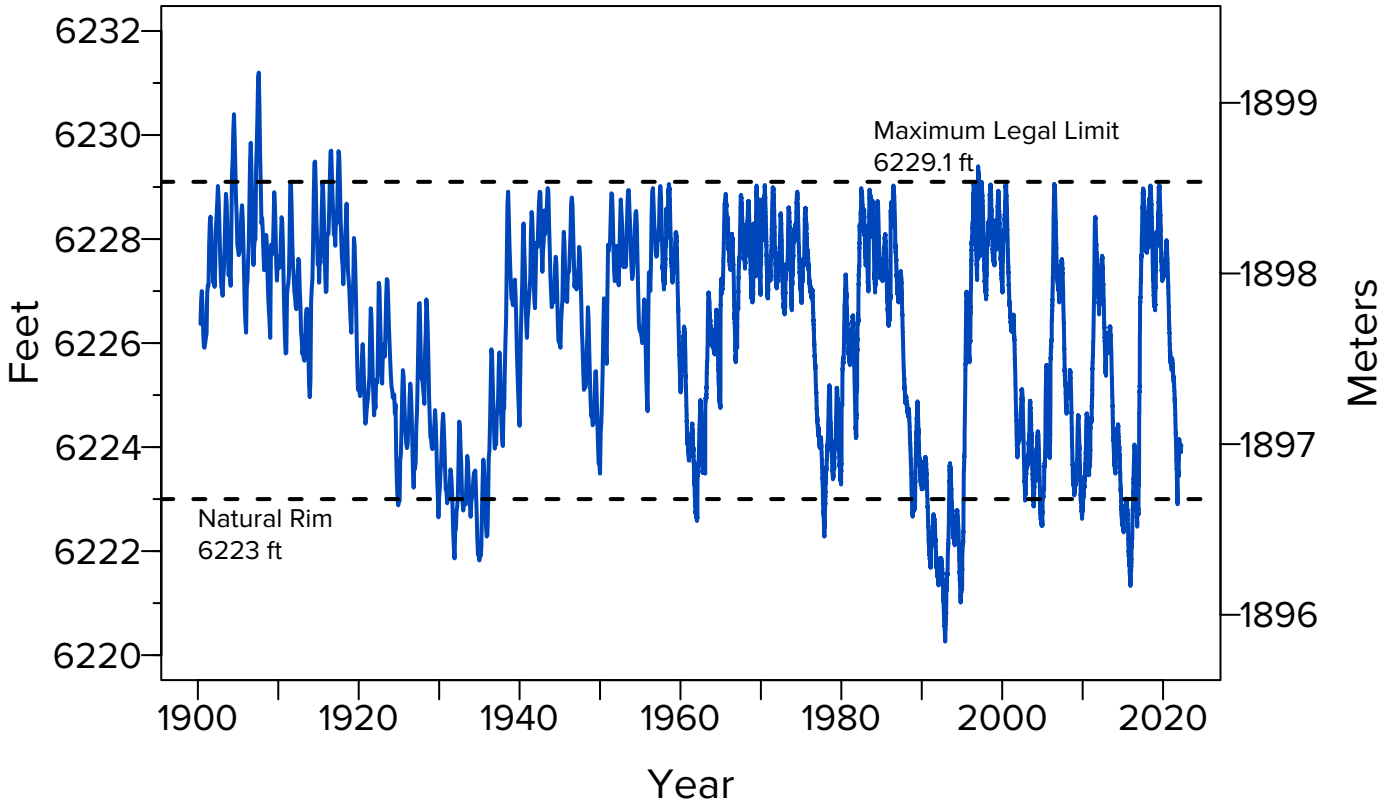
PHYSICAL PROPERTIES

UCDAVIS
Tahoe Environmental
Research Center

Lake surface level

Daily since 1900

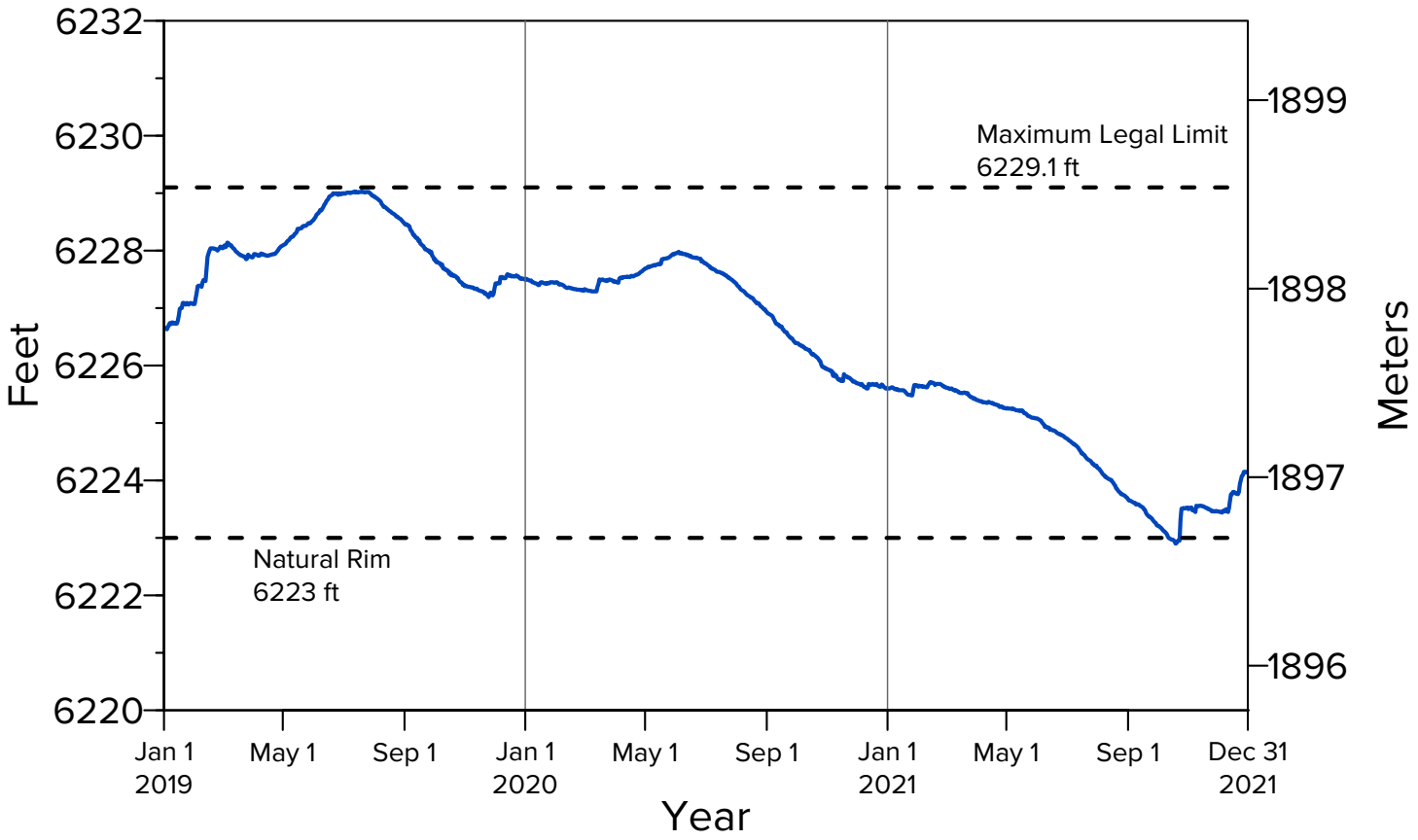
Lake surface level varies throughout the year. Lake levels rise due to high stream inflow, groundwater inflow, and precipitation directly onto the lake surface. It falls due to evaporation, in-basin water withdrawals, groundwater outflows, and outflows via the Truckee River at Tahoe City. In 2021, the highest lake level was 6,225.71 feet on February 13, and the lowest was 6,222.90 feet on October 19. The natural rim of the lake is at an elevation of 6,223 feet. Lake Tahoe fell below its rim on October 13 but rose back above it on October 24. When the lake was below its rim, outflows via the Truckee River ceased. Several episodes of lake level falling below the natural rim are evident in the last 114 years. The frequency of such episodes appears to be increasing. The lowest lake level on record is 6,220.26 feet on November 30, 1992.
Data source: US Geological Survey level recorder in Tahoe City.



Lake surface level

Daily since 2019

Displayed below is a subset of lake surface data extracted from the same data as in Fig. 8.1 for the most recent three years from 2019–2021. This more time-restricted presentation of recent lake level data allows us to see the annual patterns of rising and falling lake level in greater detail, particularly as we head towards a return to drought conditions and low lake levels. In 2021, on account of the dry winter, the winter and spring rise in lake level was virtually nonexistent. The mid-October snow in 2021 produced a sudden jump in lake level, but overall from January through December 2021, overall lake level fell 1.5 feet.
Data source: US Geological Survey level recorder in Tahoe City.



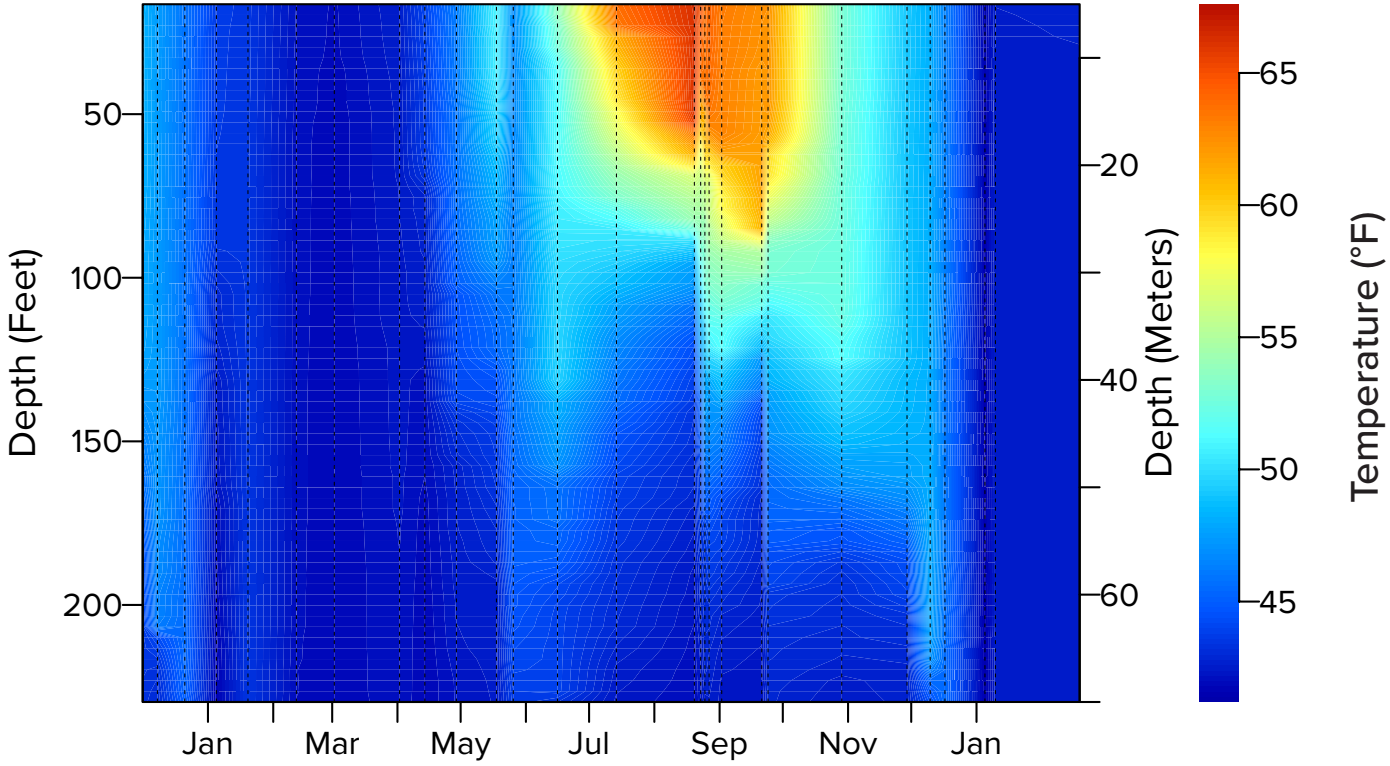
Water temperature profile

In 2021

Water temperature profiles are measured in the lake using a Seabird CTD (conductivity, temperature, depth) profiler on the days indicated by the dashed vertical lines. The intensification of the sampling frequency in August and September was part of the effort to capture the impacts of the extremely smokey conditions being experienced at Lake Tahoe. The temperature is accurate to within 0.005 °F. The vertical distribution of water temperature is a very important lake attribute, as it represents lake density, with warmer, lighter water trapped at the surface during the summer months. Here, the temperature in the upper 230 feet (70 m) is displayed as a color contour plot. In the early part of 2021, the lake temperature followed the typical seasonal pattern. In February and March, the lake surface was at its coldest, while it was at its warmest in August.

In 2021, the upper portions of the lake cooled earlier than in comparison to most years. This was in part due to the blockage of solar radiation by the smoke which engulfed the basin. The continued cooling of the surface water toward the end of the year is part of the normal cycle of winter mixing, a process that is key to bringing oxygen to the deeper parts of the lake.

Data source: TERC lake monitoring.

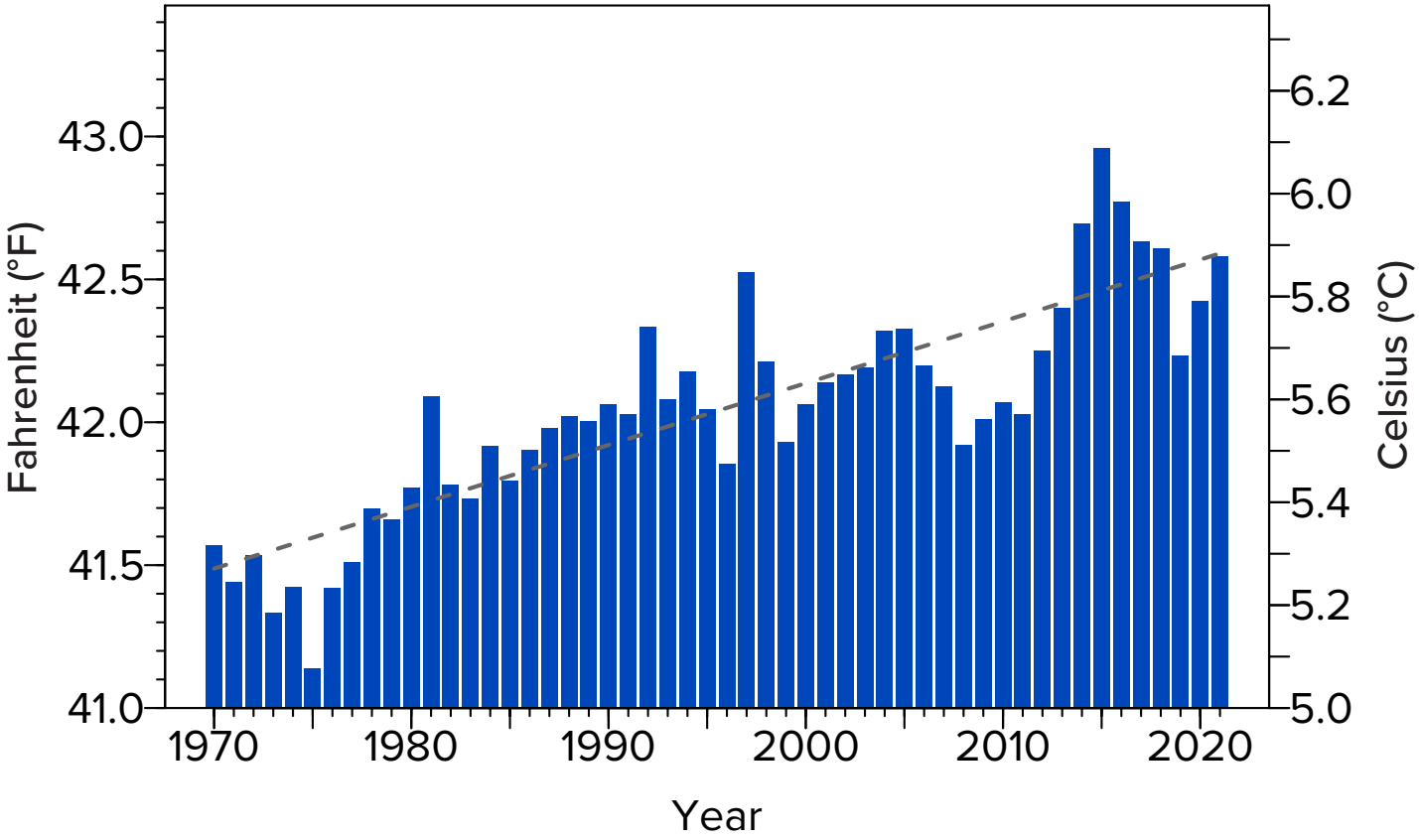


Annual average water temperature

Since 1970

The volume-averaged temperature of the lake for each year since 1970 is shown. The trend line indicates that water temperature has increased by approximately 1.1 °F (0.61 °C) since 1970. The annual rate of warming is 0.22 °F/decade (0.12 °C/decade). The monthly temperature profile data from the top to the bottom of the lake has been smoothed, and any seasonal influences were removed to best show the long-term trend. Up until the late 1990s, the warming rate was high, but there were still a relatively large number of deep mixing years between 1997 and 2011, and additionally, the top to bottom mixing in 2019 caused the average lake temperature to cool. Despite that, the longer-term warming trend appears to be returning with the 2021 average temperature of 42.6 °F (5.9 °C)

Data source: TERC lake monitoring.

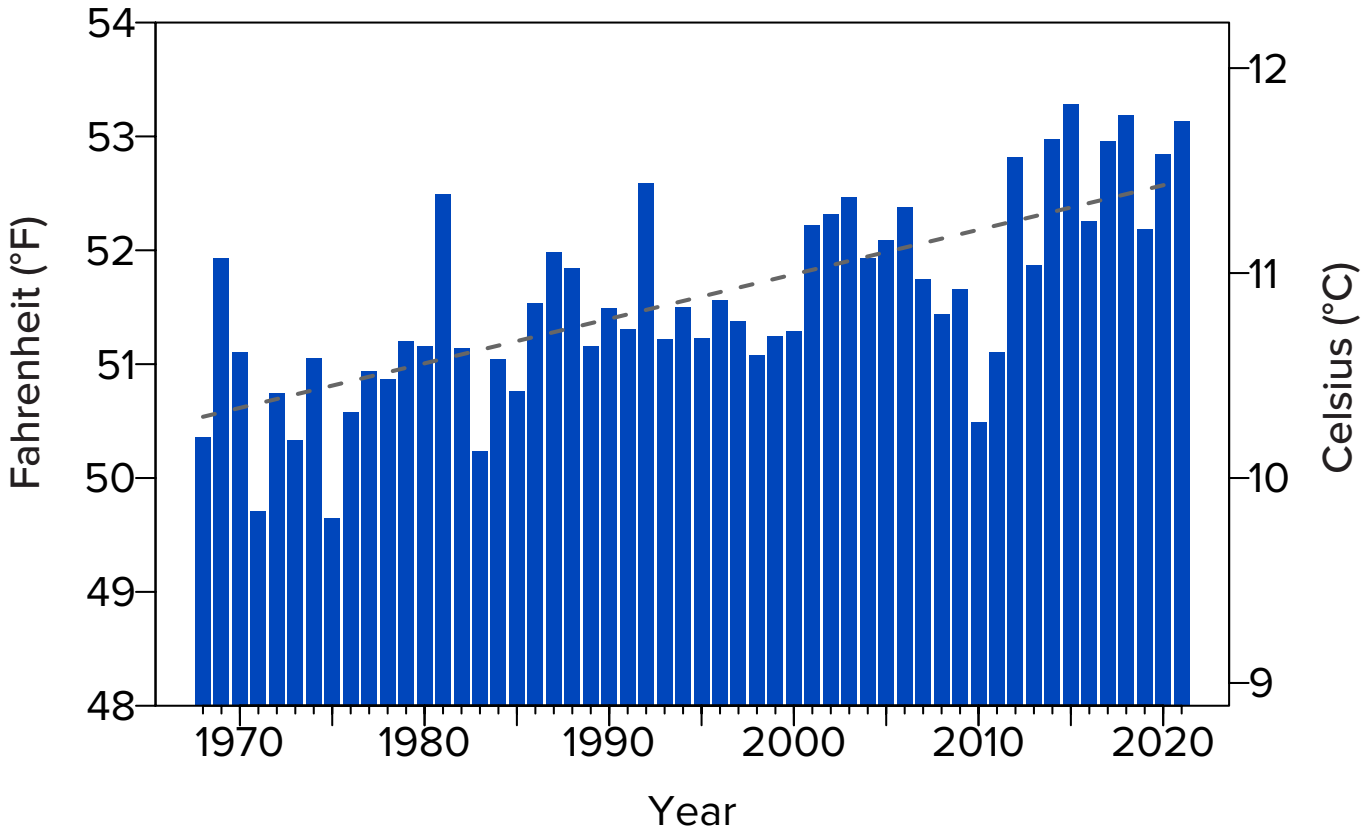


Annual surface water temperature

Yearly since 1968

Surface water temperatures (technically at a depth of 5 feet) have been recorded monthly at the Mid-lake and Index stations from TERC's research vessels since 1968 and from four buoys since 2007. Despite year-to-year and longer cyclical variability, the annual average surface water temperatures show an increasing trend. The average temperature in 1968 was 50.4 °F (10.2 °C). For 2021, the average surface water temperature was 53.1 °F (11.7 °C), making it the third warmest year on record. The overall rate of warming of the lake surface is 0.39 °F (0.22 °C) per decade.

Data source: TERC lake monitoring.

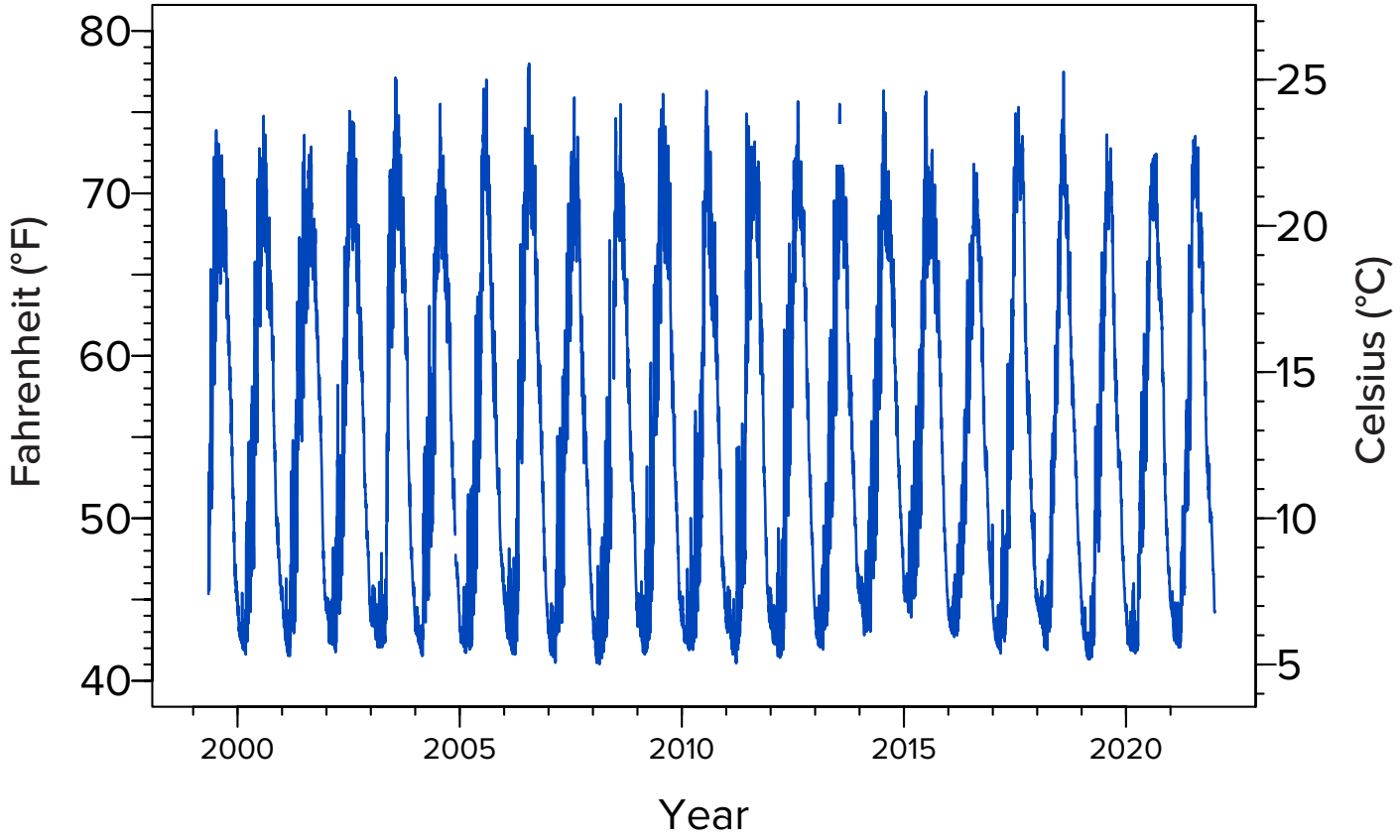


Maximum daily surface water temperature

Surface temperature measured since 1999 every 2 minutes

The maximum daily surface water temperature follows a logarithmic pattern, with the temperature being in equilibrium with the air temperature and other meteorological variables. The highest maximum daily surface water temperature (summer) was 73.5 °F (23.1 °C), recorded on July 24, 2021. The lowest maximum daily surface water temperature (winter) was 42.0 °F (5.6 °C), which was recorded on March 10, 2021. This was relatively warm, due in part to the absence of deep mixing.

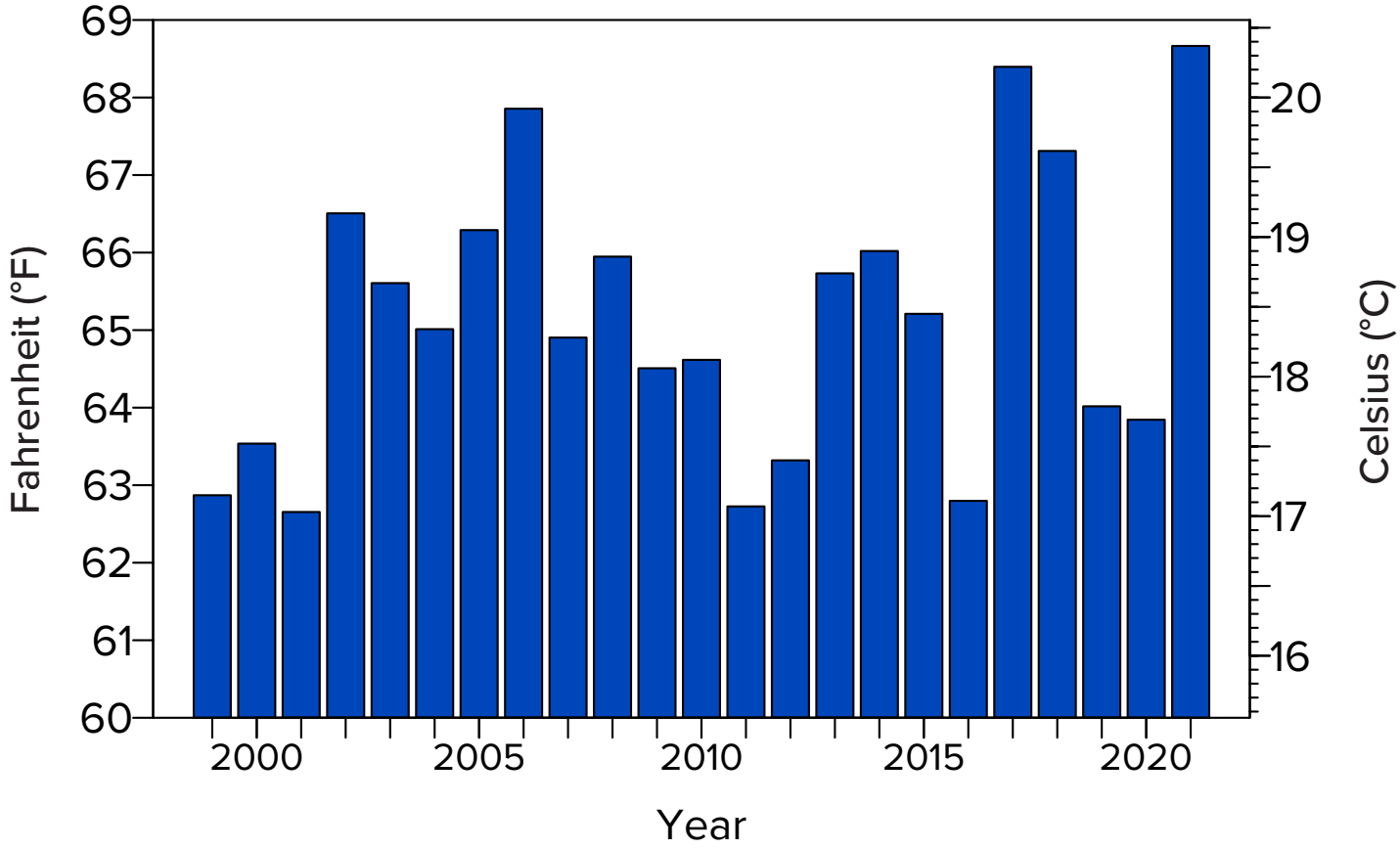
These data are collected from thermistors at a depth of 5 feet (1.5 m) that are attached to four buoys located over the deepest portions of the lake. The highest daily value from among the four buoys is considered as the daily maximum.



July average surface water temperature

Measured since 1999 every 2 minutes

Surface water temperature has been continuously recorded since 1999 from four NASA/UC Davis buoys in the center of the lake. Shown here are 23 years of average surface water temperatures in the month of July when water temperatures are typically at their warmest and the greatest number of people are recreating on the lake. In 2021, July surface water temperature averaged 68.7 °F (20.4 °C), the highest value ever recorded. This was 3.5 °F (1.9 °C) above the average of 65.2 °F (18.4 °C) for the 23-year period of record. These data are collected from thermistors at a depth of 5 feet (1.5 m) that are attached to four buoys located over the deepest portions of the lake



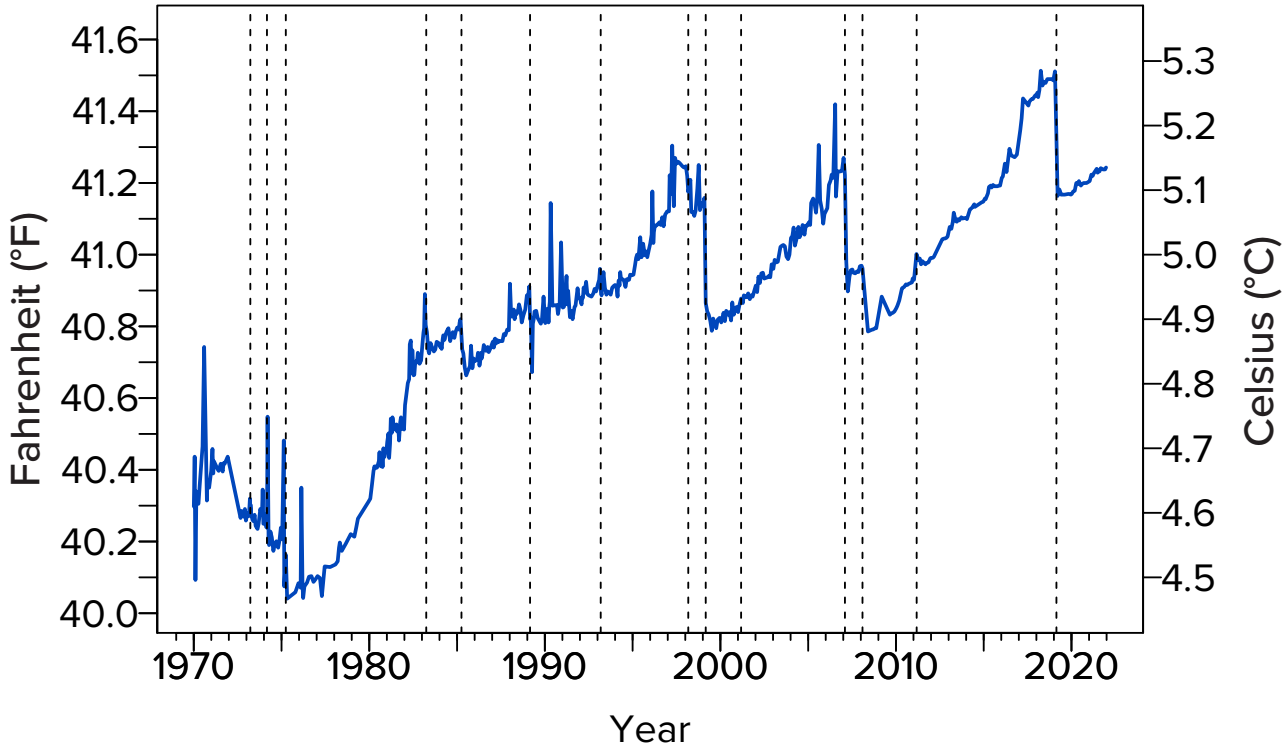
Deep water temperature

Monthly since 1970

The water temperature at a depth of 1,320 feet (400 m) is indicative of conditions in the deeper waters (hypolimnion) of Lake Tahoe. The deep-water temperatures show a complex pattern of warming and sudden cooling. During deep mixing events (shown by the dashed vertical lines), the temperature can drop precipitously over a short period of time, although these drops are generally less than 0.3 °F. The mechanisms behind the heating of the bottom water when deep mixing does not occur is an area of current research. Generally, bottom temperatures are warming.

In 2021, there was no deep mixing (see Fig. 8.9) and water temperatures rose slightly. Between the last two deep mixing events in 2011 and 2019, the rate of water warming was 0.07 °F/year. During the deep mixing of 2019, the water temperature fell over 0.3 °F in just a few weeks. Complete vertical mixing is an event that allows a huge amount of heat to escape from the lake. The short spikes of temperature increase during the warming phases are temporary effects caused by the motions of internal waves and other lake motions in the hypolimnion.

Data source: TERC lake monitoring.



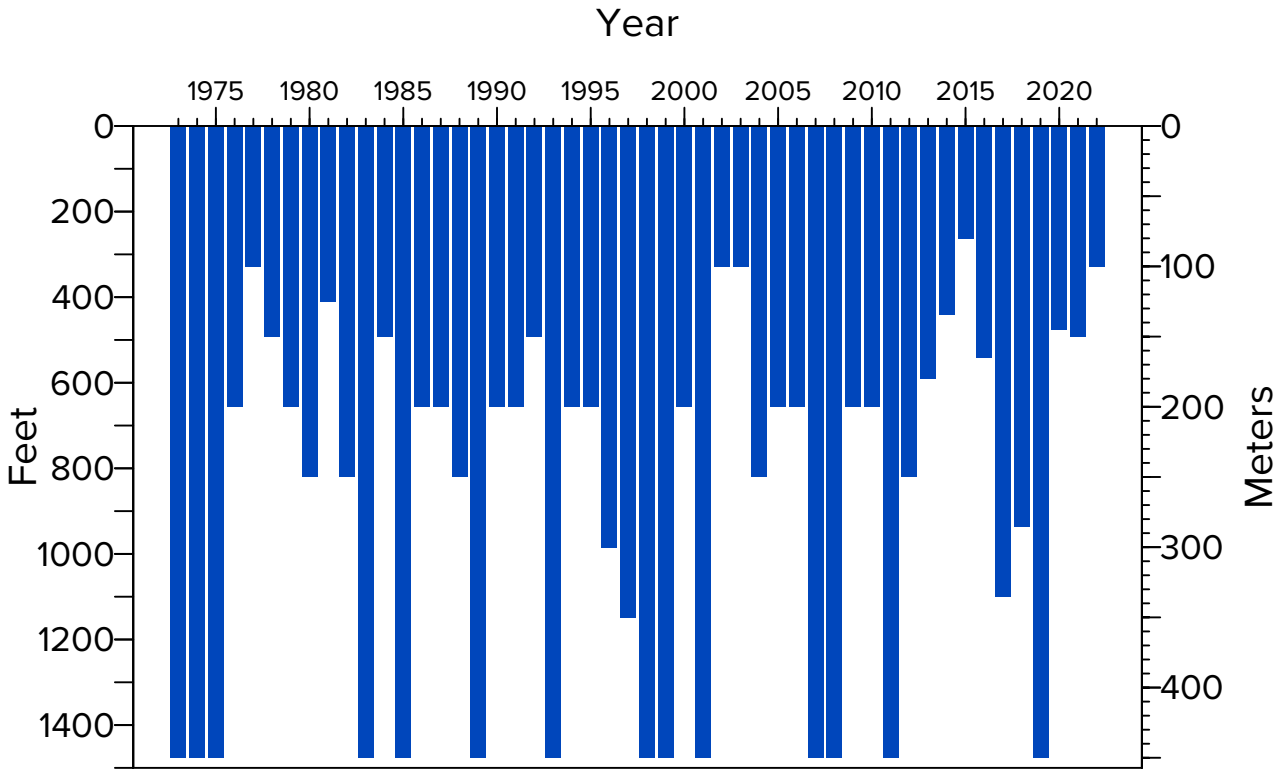
Depth of mixing

Yearly since 1973

The water of Lake Tahoe vertically mixes each winter as surface waters cool and sink downward. In a lake as deep as Tahoe, the intense cooling of winter helps to determine how deep the lake mixes vertically. Mixing depth has profound impacts on lake ecology and water quality. Deep mixing brings nutrients to the surface, that promote algal growth. It also carries oxygen downward to deep waters, promoting aquatic life throughout the water column. The deepest mixing typically occurs between February and March. On March 17, 2021, Lake Tahoe was observed to have mixed to a maximum depth of 492 feet (150 m). This relatively shallow mixing likely contributed to the warmer surface temperatures experienced during winter. On February 18, 2022, Lake Tahoe was observed to have mixed to a maximum depth of only 328 feet (100 m), the second lowest value on record.

Since 2013, the depth of mixing has been determined with more accurate high-resolution temperature profiles rather than nitrate concentration sampled at discrete depths. Continuous temperature measurements off Glenbrook provided additional confirmation.

Data source: TERC lake monitoring.

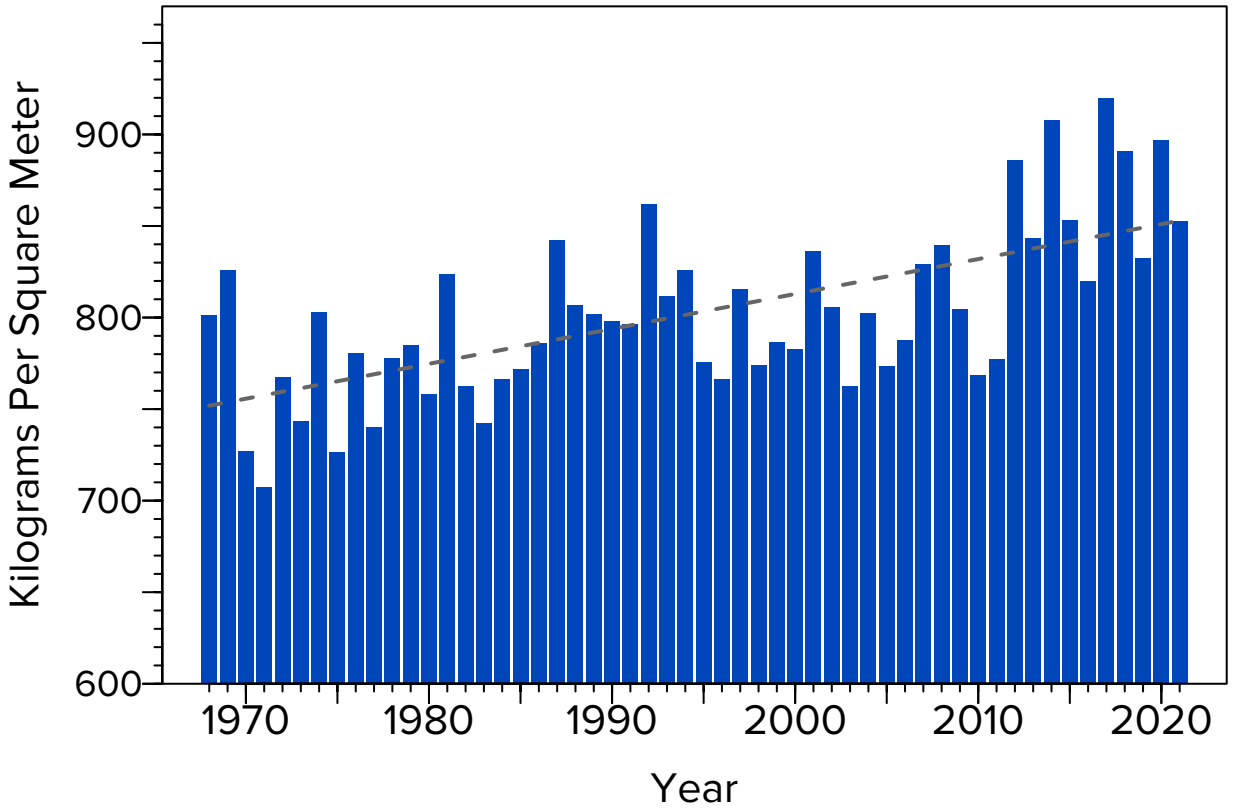


Lake stability index

Since 1968

When the lake has a vertical distribution of temperature, it has a corresponding distribution of density. Warm and lighter (less dense) water stay suspended at the surface above the colder and denser water below. As the temperature difference between top and bottom increases, the lake is said to become more stable. Increasing stability poses a potential threat to all lakes. The stability index is a measure of the energy required to fully mix the water column when it is density 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- to 20-day intervals. There has been an overall increase in lake stability by 13.4 percent in the last 53 years.

Data source: TERC lake monitoring.

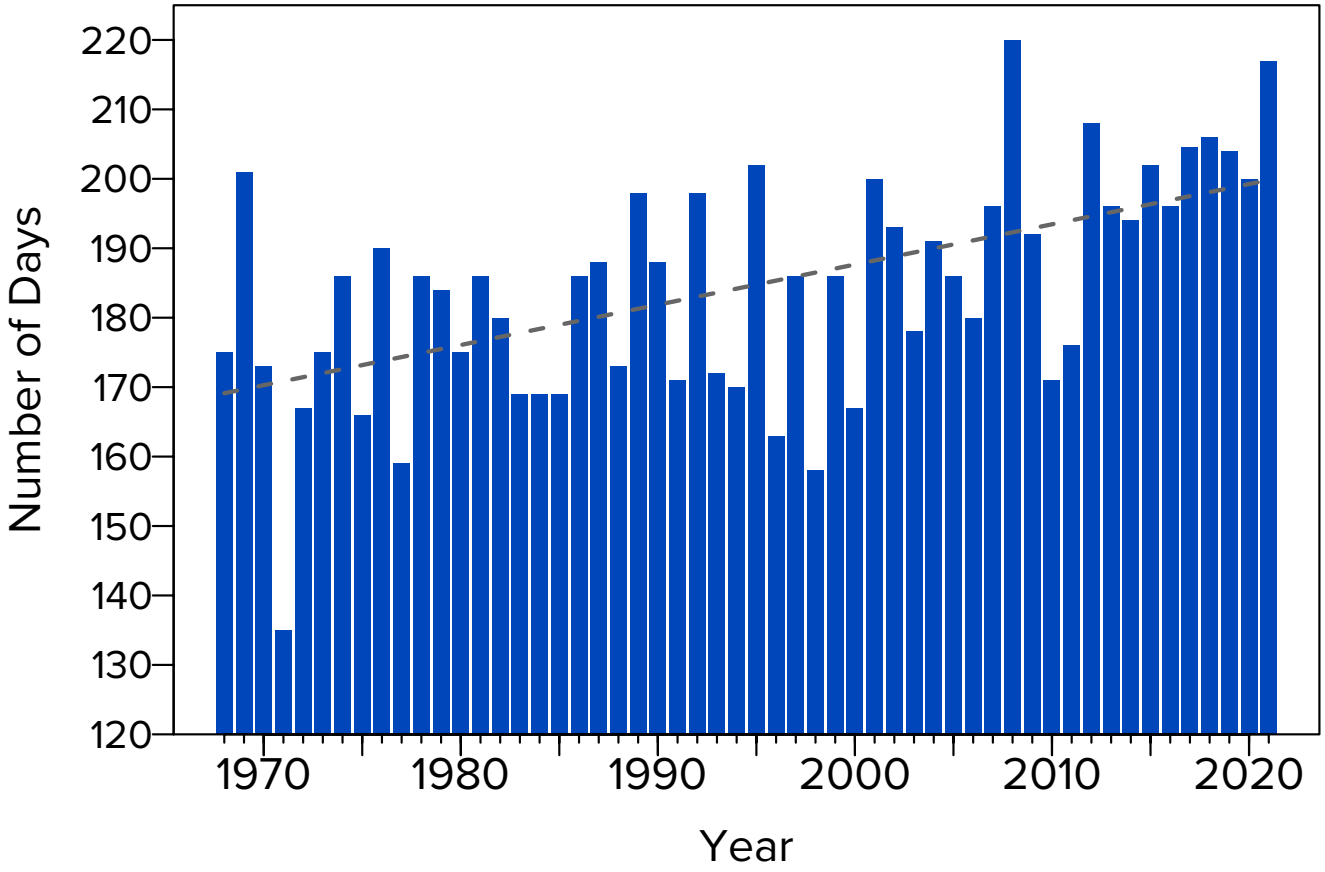


Stratified season length

Since 1968

The stability index, a measure of the energy required to mix the lake, can be evaluated for every day of the year. We define the stratification season as the number of days when the stratification index exceeds a value of 600 kilograms per square meter. Since 1968, the length of the stratification season has increased by 31 days, albeit with considerable year-to-year variation. In 2021, the length of the stratified season was 217 days, the second longest period on record.

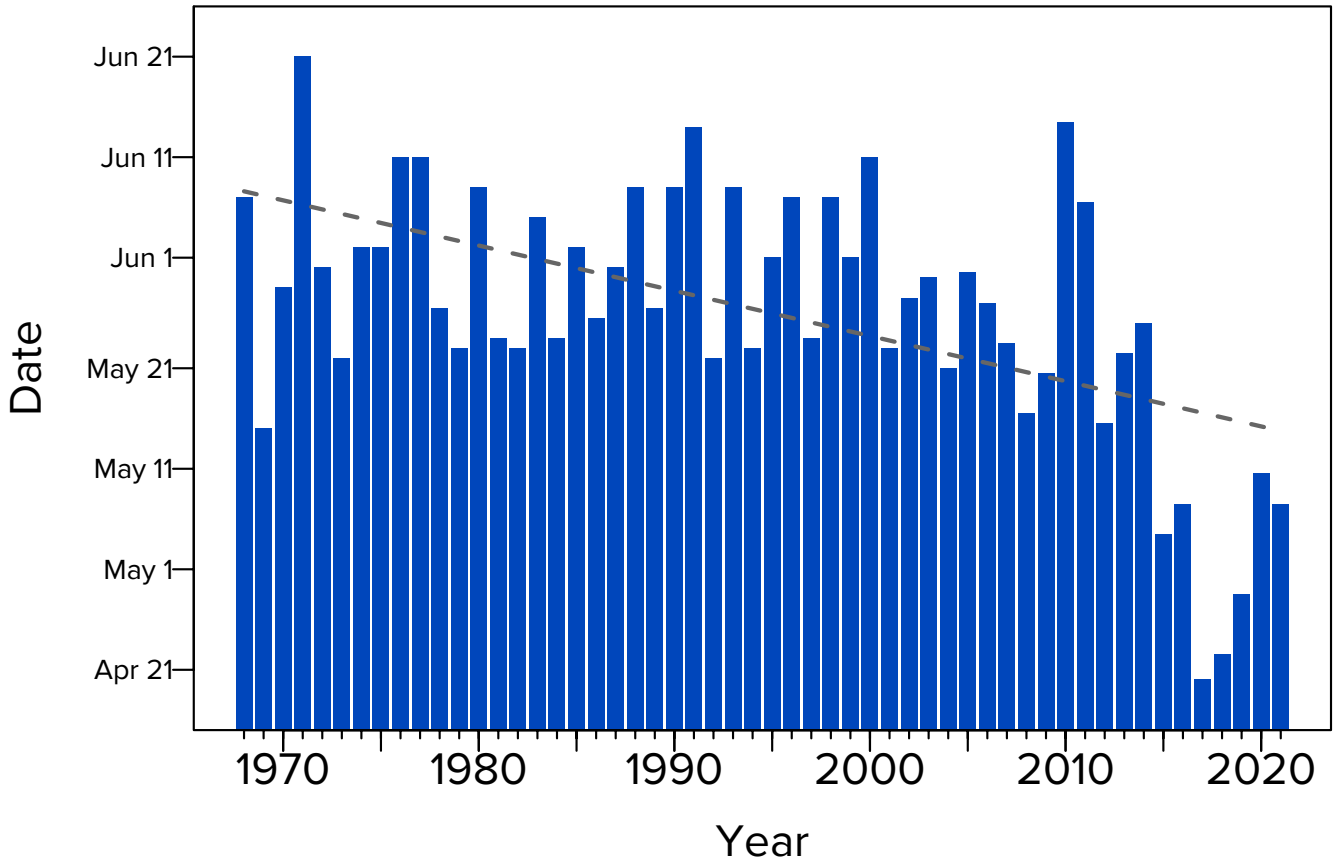
Data source: TERC lake monitoring.



Beginning of the stratification season

Since 1968

The amount of time that Lake Tahoe is stratified has been lengthening since 1968. One reason for this is the increasingly early arrival of spring as evidenced by the earlier commencement of stratification. Stratification occurs approximately 24 days earlier than it did in 1968. The commencement of the stratification season is typically in May or early June. In 2021, stratification began on May 7 (Day 128).
Data source: TERC lake monitoring.

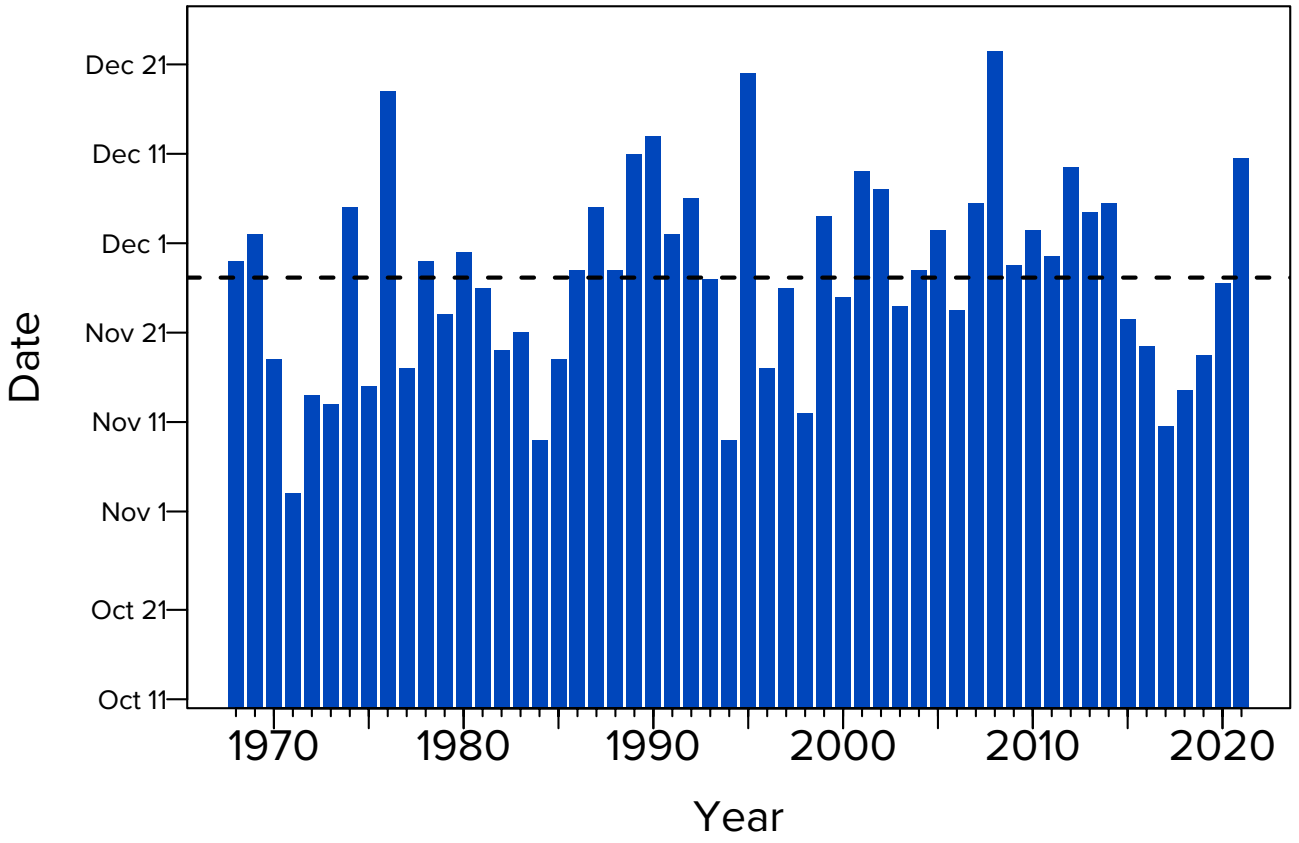


End of stratification season

Since 1968

The amount of time that Lake Tahoe is stratified has lengthened by a month since 1968. The end of the stratification season has been extended, but not as much as the onset of stratification (See Fig. 8.12). Over the 53-year record, the end of stratification has been extended by approximately one week. This can have important implications for lake mixing and water quality, such as the buildup of nitrate at the bottom of the lake. The dashed black line indicates the long-term average end of stratification date.

Data source: TERC lake monitoring.

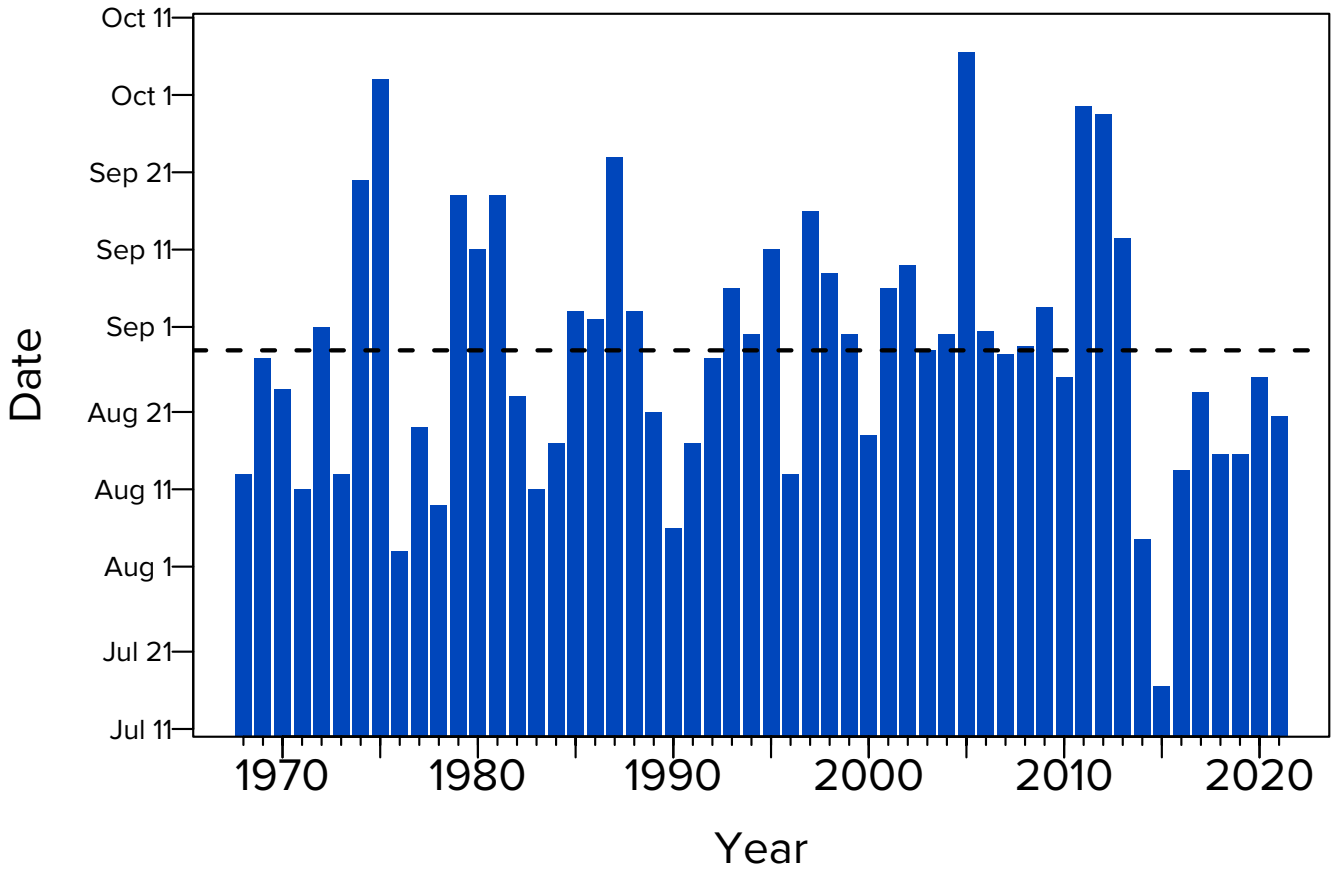


Peak of stratification season

Since 1968

The day of the year when lake stratification reaches its maximum value has been plotted. There is considerable year-to-year variation, but over time there has been no statistically significant change in when the peak occurs. In 2021, the peak occurred on August 20.

Data source: TERC lake monitoring.



Onset of snowmelt pulse

Yearly since 1961

Although the date on which the onset of snowmelt commences varies from year to year, since 1961 it has shifted earlier by an average of over 17 days. The snowmelt pulse is calculated and averaged for five streams—the Upper Truckee River, Trout Creek, Ward Creek, Blackwood Creek, and Third Creek. This shift is statistically significant and is one effect of climate change at Lake Tahoe. In 2021, the date of the onset of snowmelt was March 30 which, according to the regression line, was earlier by 17 days than it was in 1961. The onset of the pulse is calculated as the day when flow exceeds the mean flow for the period January 1 to July 15. In the past, the peak of the stream hydrograph was used to estimate this metric.

Data source: U.S. Geological Survey stream monitoring.