TAHOE: STATE OF THE LAKE REPORT 2021

PHYSICAL PROPERTIES

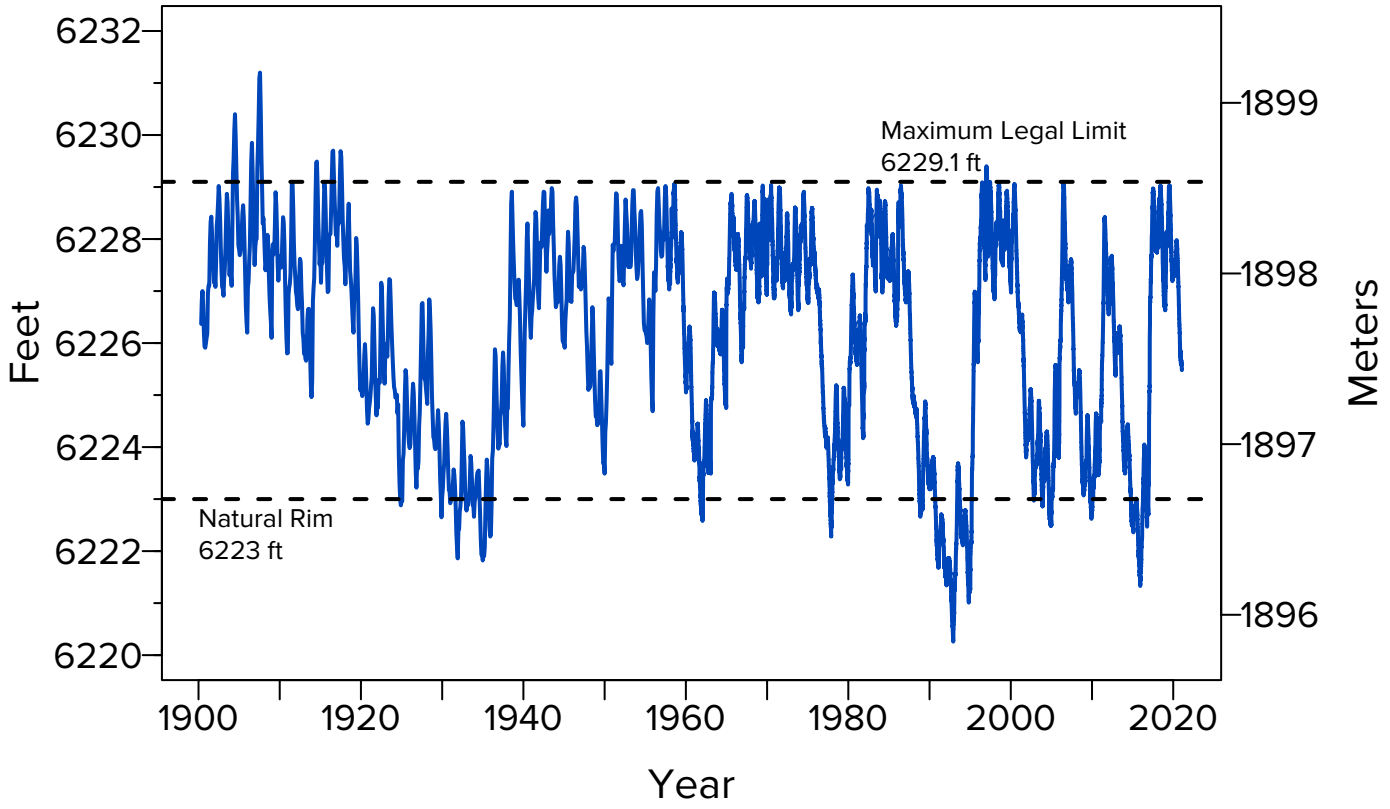
UCDAVIS
Tahoe Environmental
Research Center

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 2020, the highest lake level was 6,227.98 feet on June 4, and the lowest was 6,225.60 feet on December 11. The natural rim of the lake is at an elevation of 6,223 feet. Lake Tahoe was above its rim for the entire year. When the lake is below its rim, outflows via the Truckee River cease. Several episodes of lake level falling below the natural rim are evident in the last 120 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.

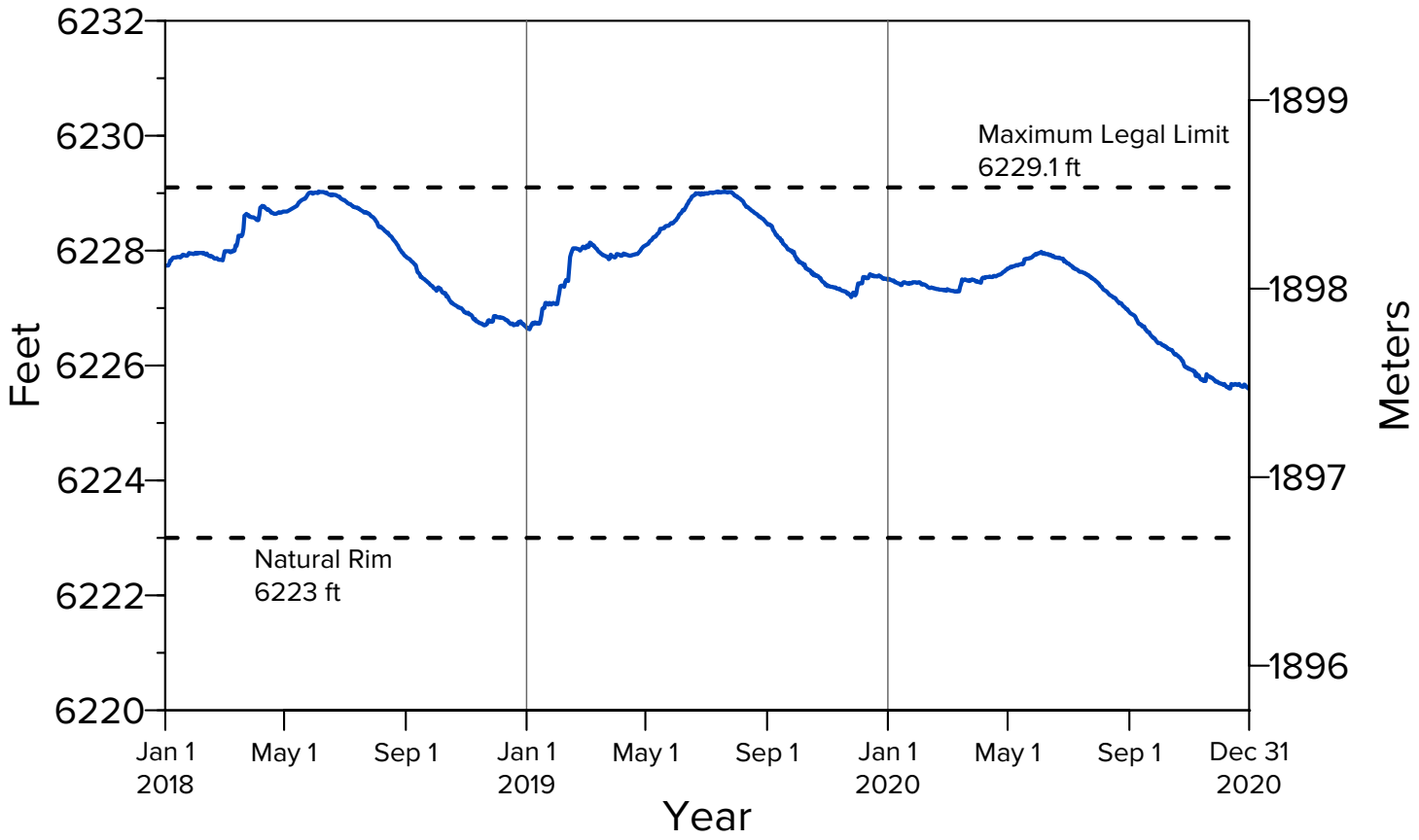
Data source: US Geological Survey level recorder in Tahoe City.



Lake surface level

Daily since 2018

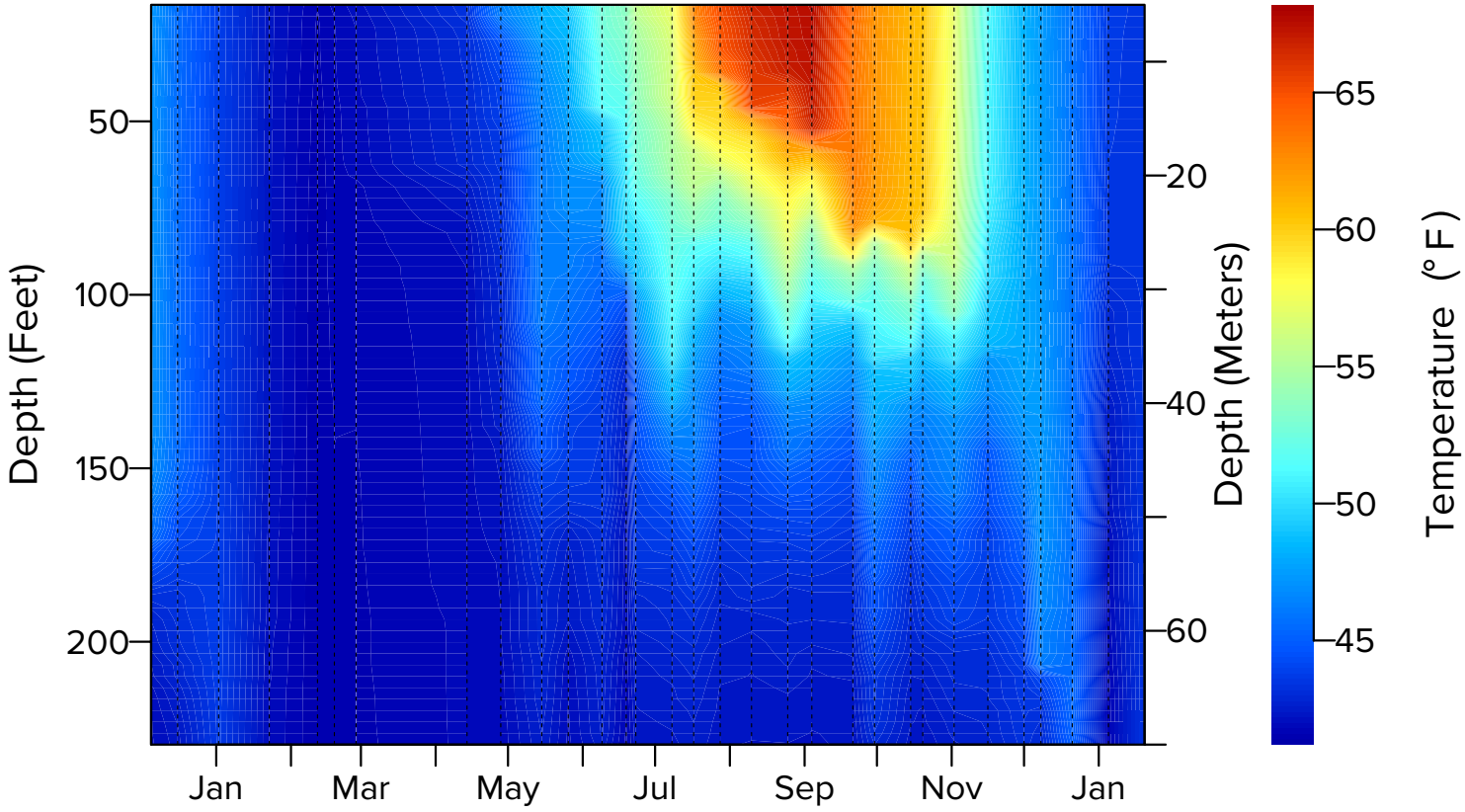
Displayed below is a subset of lake surface data extracted from the same data as in Fig. 8.1 for the most recent three years from 2018–2020. This more time-restricted presentation of recent lake level data allows us to see the annual patterns of rising and falling lake level in greater detail, particularly as we head towards a return to drought conditions and low lake levels. In 2020, on account of a dry winter, the annual rise in lake level was very muted. From January through December 2020, overall lake level fell 1.9 feet. Based on historical water level data, it is likely that Lake Tahoe will fall below its natural rim in October 2021.



Water temperature profile

In 2020

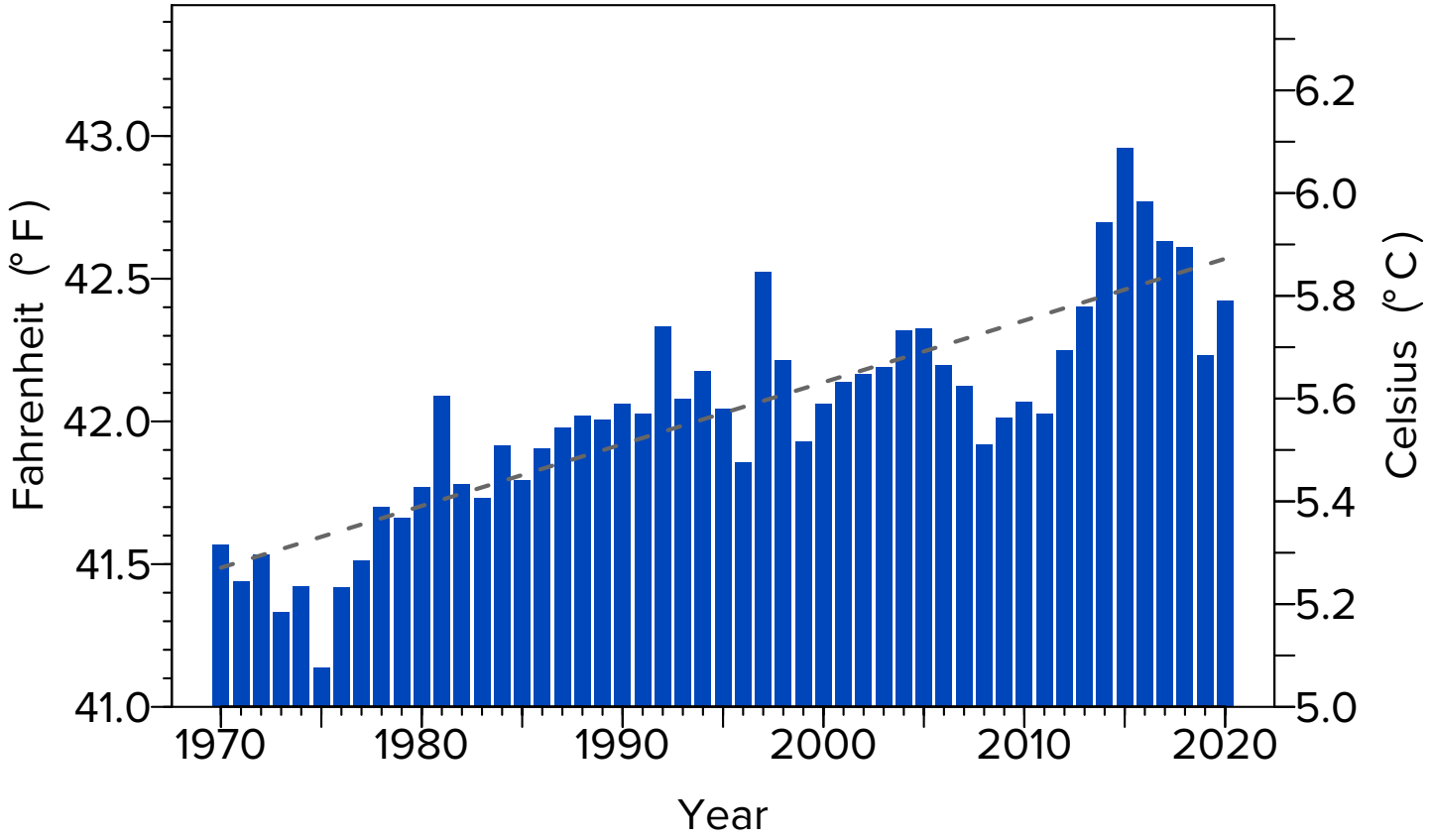
Water temperature profiles are measured in the lake using a Seabird CTD (conductivity, temperature, depth) profiler at the times indicated by the dashed vertical lines. The six-week gap in March and April was due to COVID-19 restrictions. The temperature is accurate to within 0.005 °F. The vertical distribution 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 2020, the lake temperature followed a typical seasonal pattern. In February and March, the lake surface was at its coldest, while it was at its warmest in August and September. The thickening and cooling of the warm water zone toward the end of the year is part of the cycle of winter mixing, a process that is important in bringing oxygen to the deeper parts of the lake.



Annual average water temperature

Since 1970

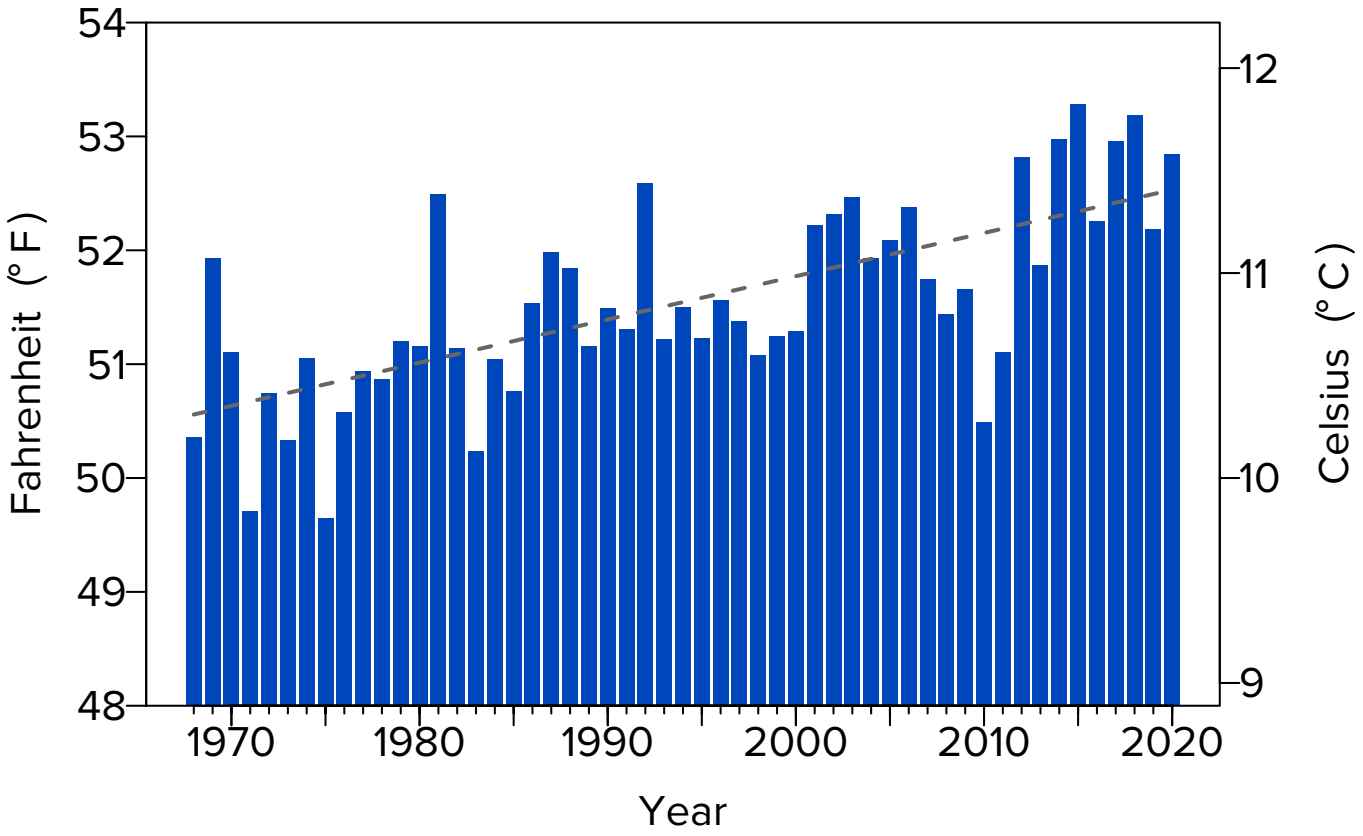
The volume-averaged temperature of the lake for each year since 1970 is shown. The trend line indicates that water temperature has increased by approximately 1.1 °F (0.61°C) since 1970. The annual rate of warming is 0.22 °F/decade (0.12 °C/decade). The monthly temperature profile data from the top to the bottom of the lake has been smoothed, and seasonal influences 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, plus top to bottom mixing in 2019 caused the average lake temperature to cool. However, the longer-term warming trend appears to be returning.



Annual surface water temperature

Yearly since 1968

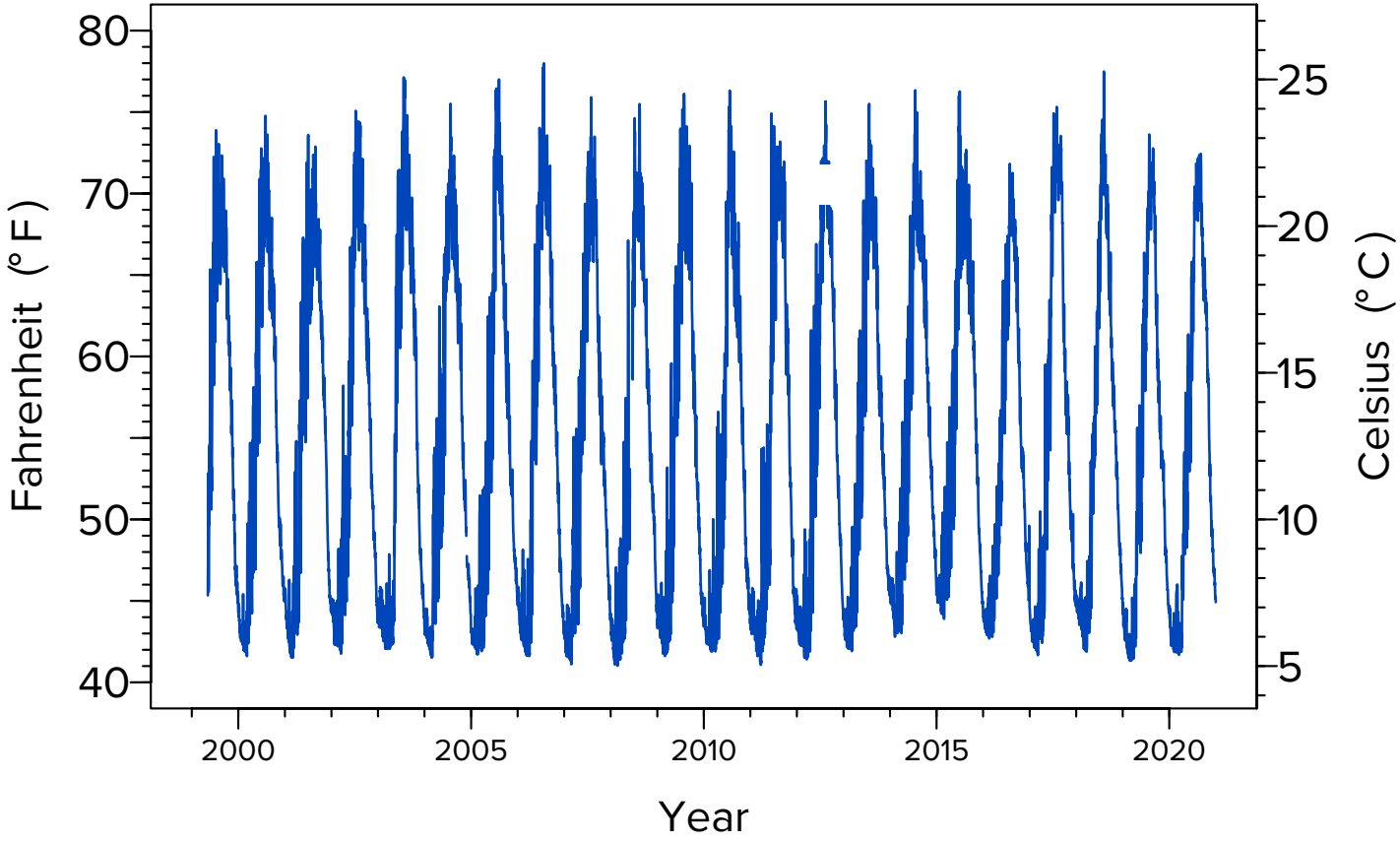
Surface water temperatures have been recorded monthly at the Mid-lake and Index stations from TERC's research vessels since 1968. Despite year-to-year variability, the annual average surface water temperatures show an increasing trend. The average temperature in 1968 was 50.4 °F (10.2 °C). For 2020, the average surface water temperature was 52.8 °F (11.6 °C), warmer than in 2019. The overall rate of warming of the lake surface is 0.38 °F (0.21 °C) per decade.



Maximum daily surface water temperature

Surface temperature measured since 1999 every 2 minutes

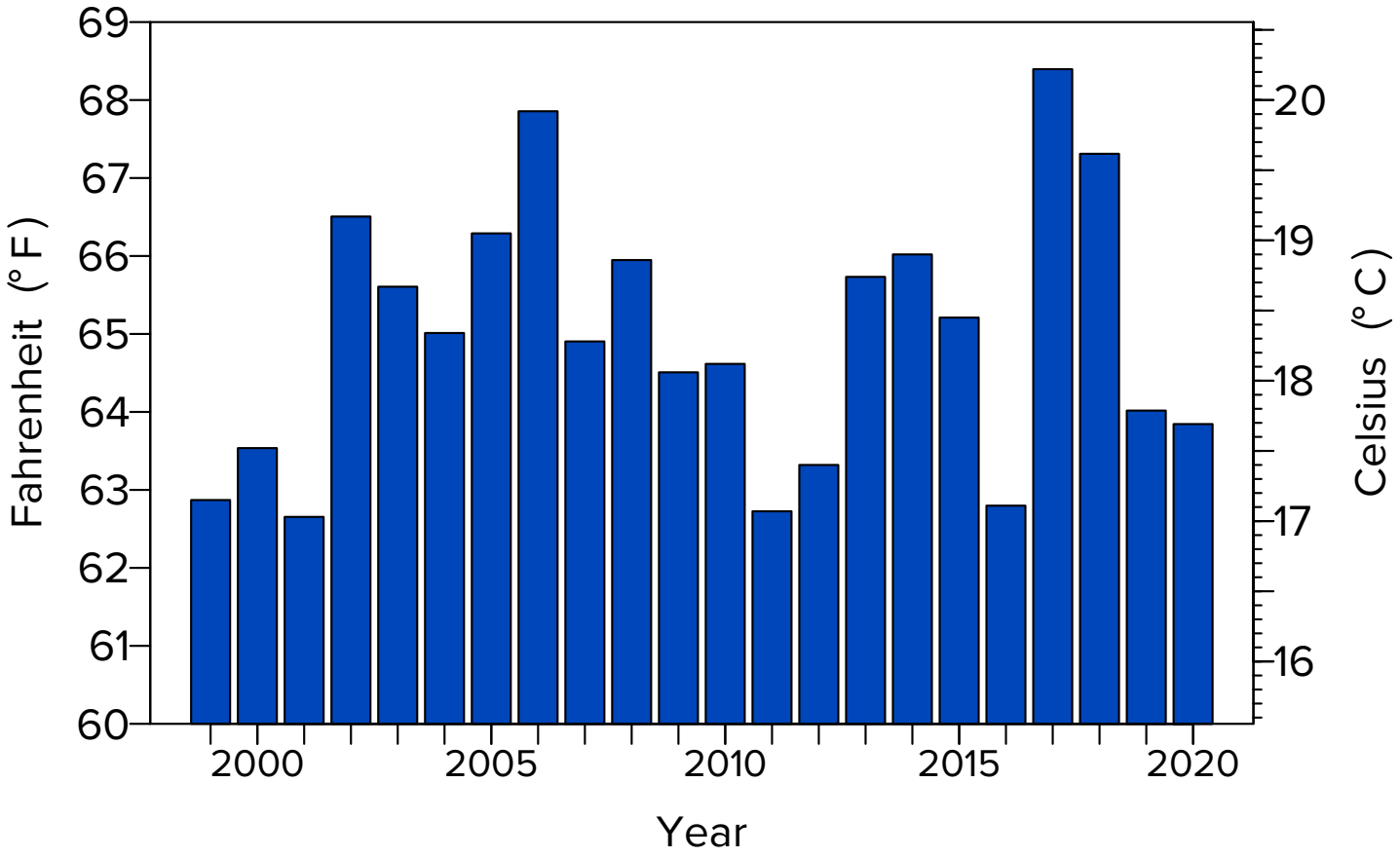
The maximum daily surface water temperature of summer 2020 was one of the coolest since continuous data collection commenced in 1999. The highest maximum daily surface water temperature (summer) was 72.4 °F (22.5 °C), recorded on September 5, 2020. These low summer temperatures may have been influenced by the wildfire smoke that blanketed the region. The lowest maximum daily surface water temperature (winter) was 41.7 °F (5.4 °C), which was recorded on March 17, 2020. This was relatively warm, owing in part to the absence of deep mixing. These data are collected in real-time by NASA-JPL and UC Davis from four buoys located over the deepest portions of the lake.



July average surface water temperature

Measured since 1999 every 2 minutes

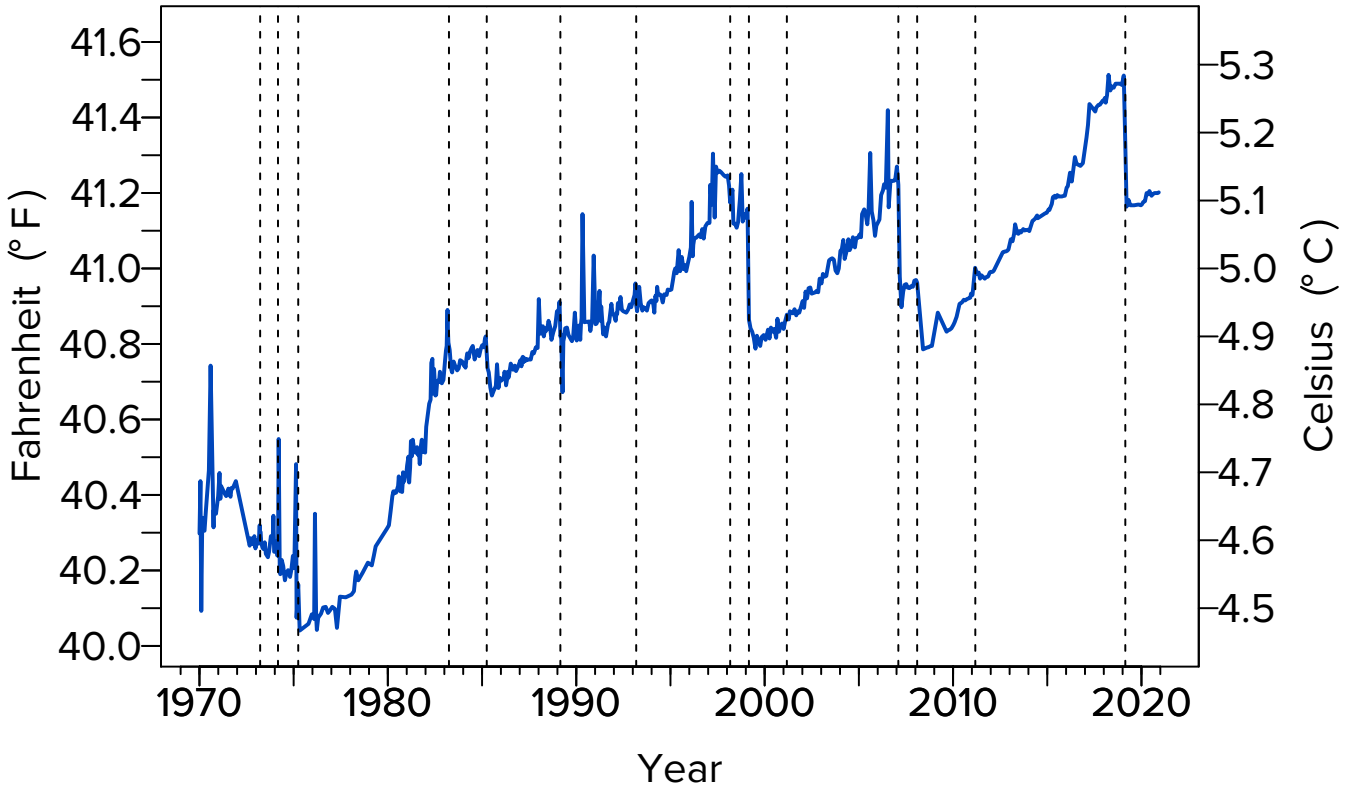
Surface water temperature has been continuously recorded since 1999 from four NASA/UC Davis buoys over the deepest portions of the lake. Shown here are 22 years of average surface water temperatures in the month of July when water temperatures are typically warm and the greatest number of people are swimming in the lake. In 2020, July surface water temperature averaged 63.8 °F. This was 1.2 °F below the average of 65.0 °F for the entire 22-year period of record. The warmest July temperature was 68.4 °F in 2017.



Deep water temperature

Monthly since 1970

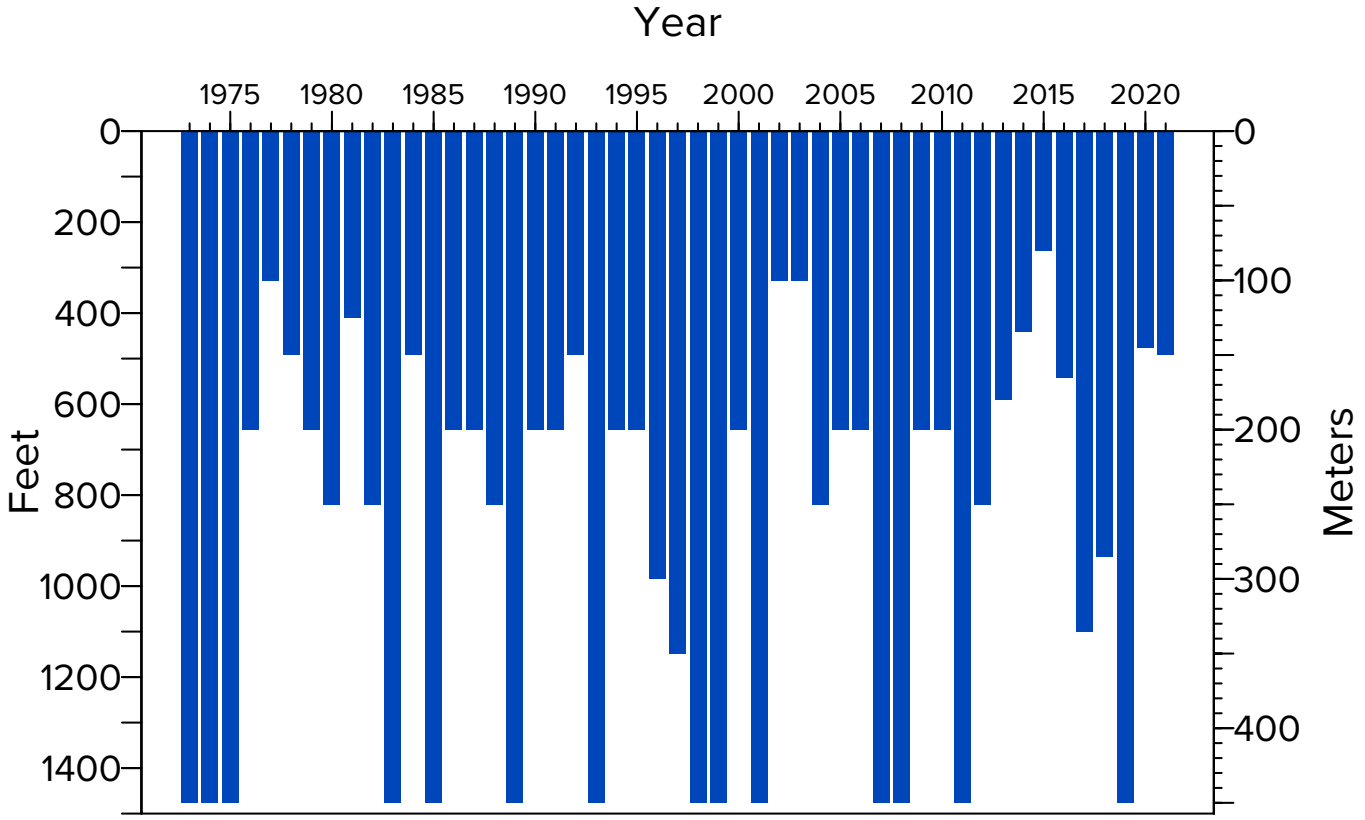
The water temperature at a depth of 1,320 feet (400 m) is indicative of conditions in the deeper waters (hypolimnion) of Lake Tahoe. The deep-water temperatures show a complex pattern of warming and sudden cooling. Warming, due to geothermal heat input, occurs when the lake does not mix deeply. During deep mixing events (shown by the dashed lines), the temperature can drop "precipitously" over a short period of time, although these drops are generally less than 0.3 °F. Generally, bottom temperatures are warming. In 2020, there was no deep mixing (see Fig. 8.9) and deep water temperatures rose slightly. Between the last two deep mixing events in 2011 and 2019, the rate of deep water warming was 0.07 °F/yr. 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.



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 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, where they 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 February 6, 2020, Lake Tahoe was observed to have mixed to a depth of 476 feet (145 m). This relatively shallow mixing likely contributed to the warmer surface temperatures experienced during winter. On March 17, 2021, Lake Tahoe was observed to have mixed to a maximum depth of 492 feet (150 m). Since 2013, the depth of mixing has been determined with high-resolution temperature profiles rather than nitrate concentration sampled at discrete depths. Continuous temperature measurements off Glenbrook provided additional confirmation.

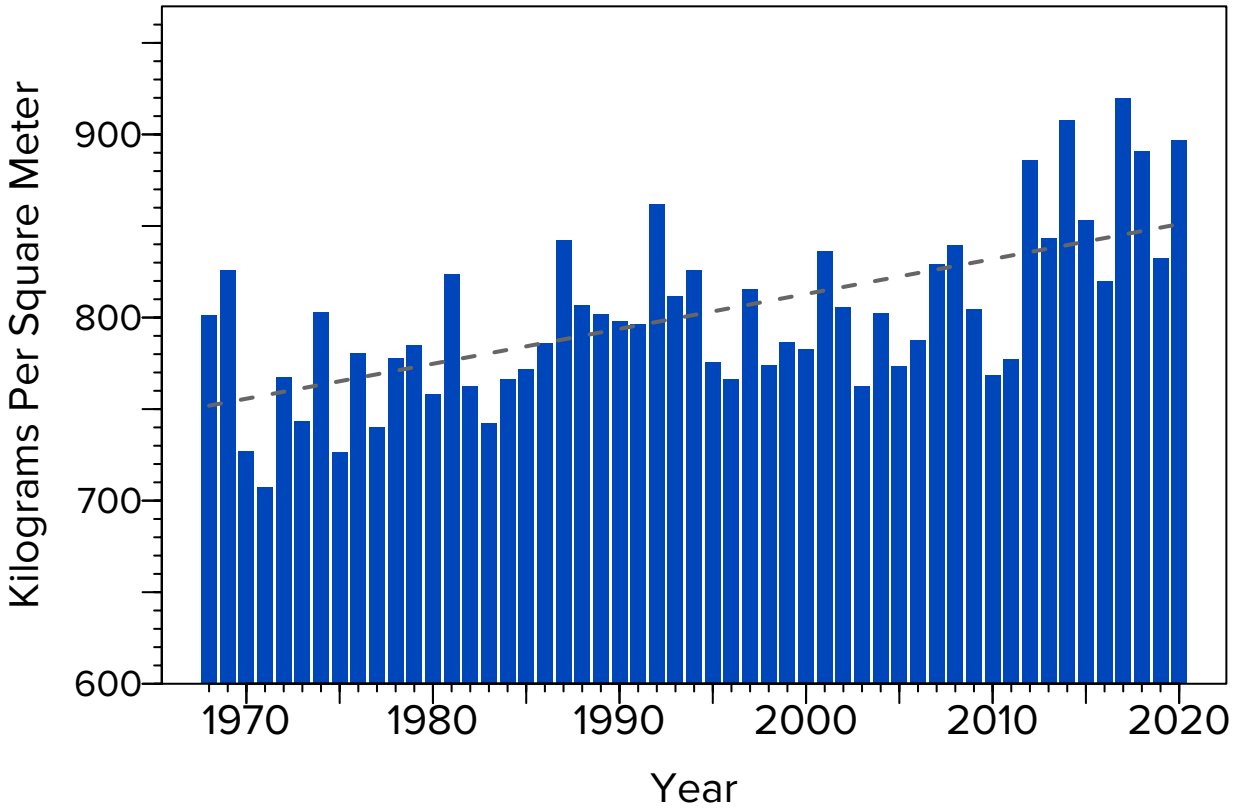


Lake stability index

Since 1968

When the lake has a vertical distribution of temperature, it has a corresponding distribution of density, with warm and lighter water at the surface and colder, denser water below. As the temperature difference 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 10–20 day intervals. There has been an overall increase in lake stability by over 13% in the last 52 years.

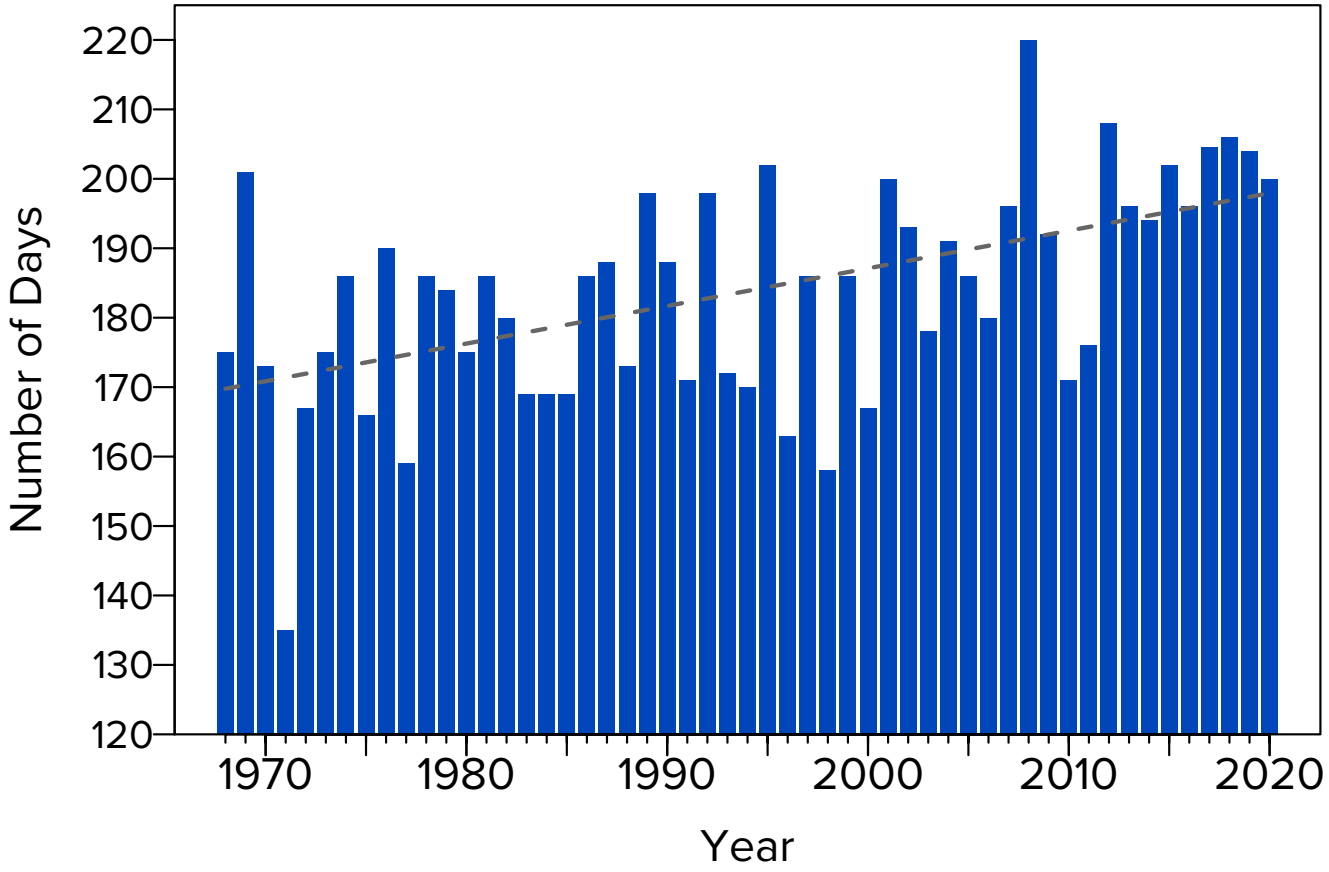
In 2020, the stability index was the third highest ever recorded.



Stratified season length

Since 1968

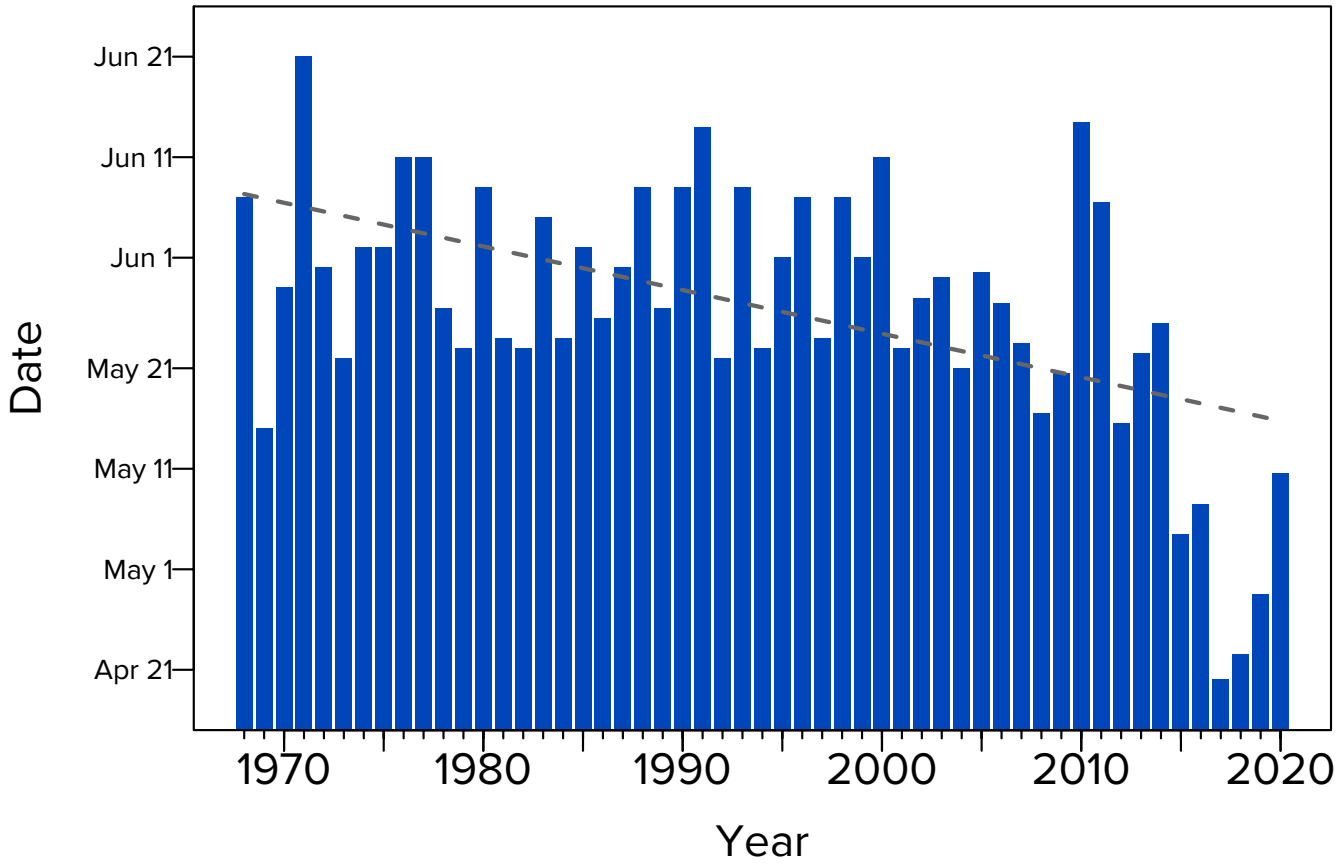
The stability index is a measure of the energy required to mix the lake and can be evaluated for every day of the year. We define the stratification season as the number of days when the stratification index exceeds a value of 600 kilograms per square meter. Since 1968, the length of the stratification season has increased, albeit with considerable year-to-year variation. Overall, the stratification season has lengthened by 28 days since 1968. In 2020, the length of the stratified season was 200 days.



Beginning of the stratification season

Since 1968

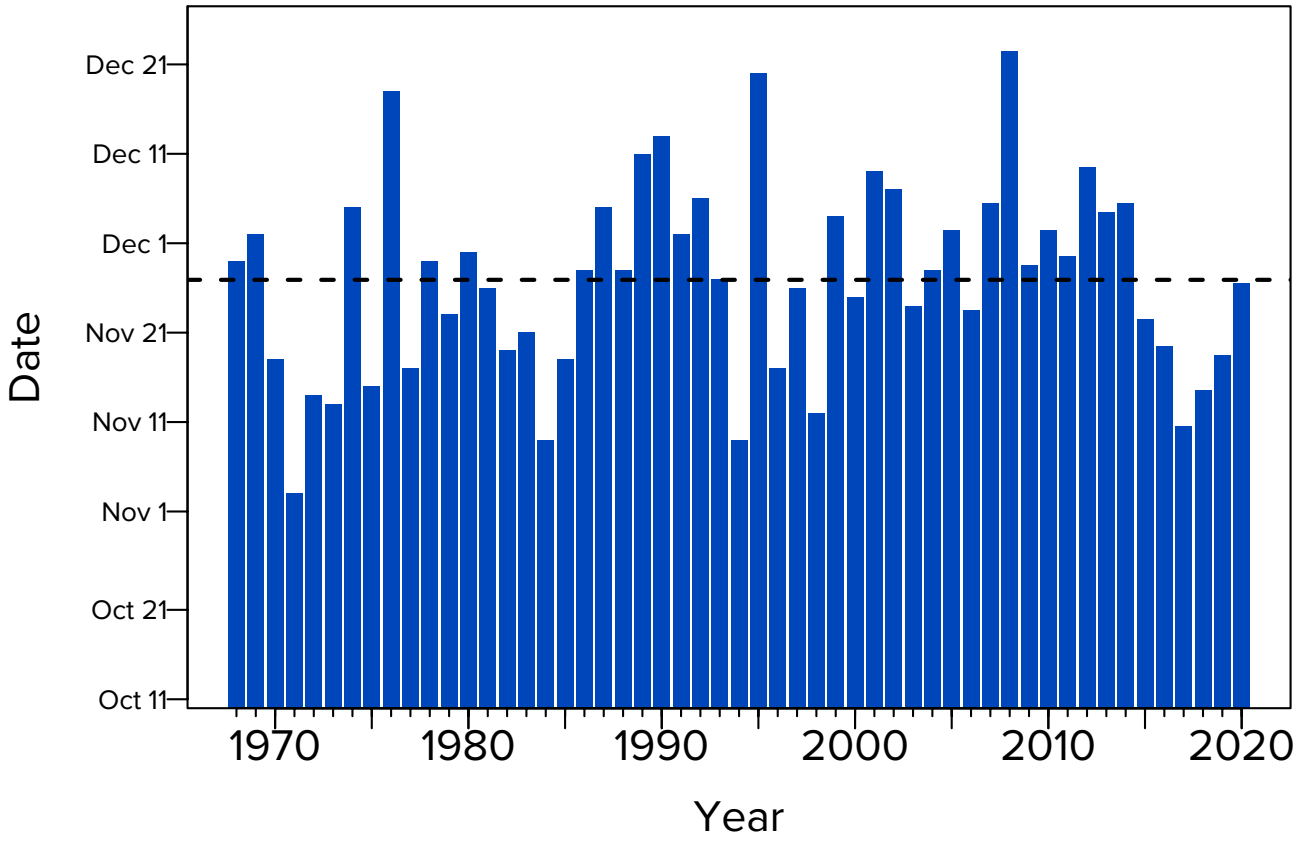
The amount of time that Lake Tahoe is stratified has been lengthening since 1968. One reason for this is the increasingly early arrival of spring as evidenced by the earlier commencement of stratification. Stratification occurs approximately 22 days earlier than it did in 1968. The commencement of the stratification season is typically in late May or early June. In 2020, stratification began on May 9 (Day 129).



End of stratification season

Since 1968

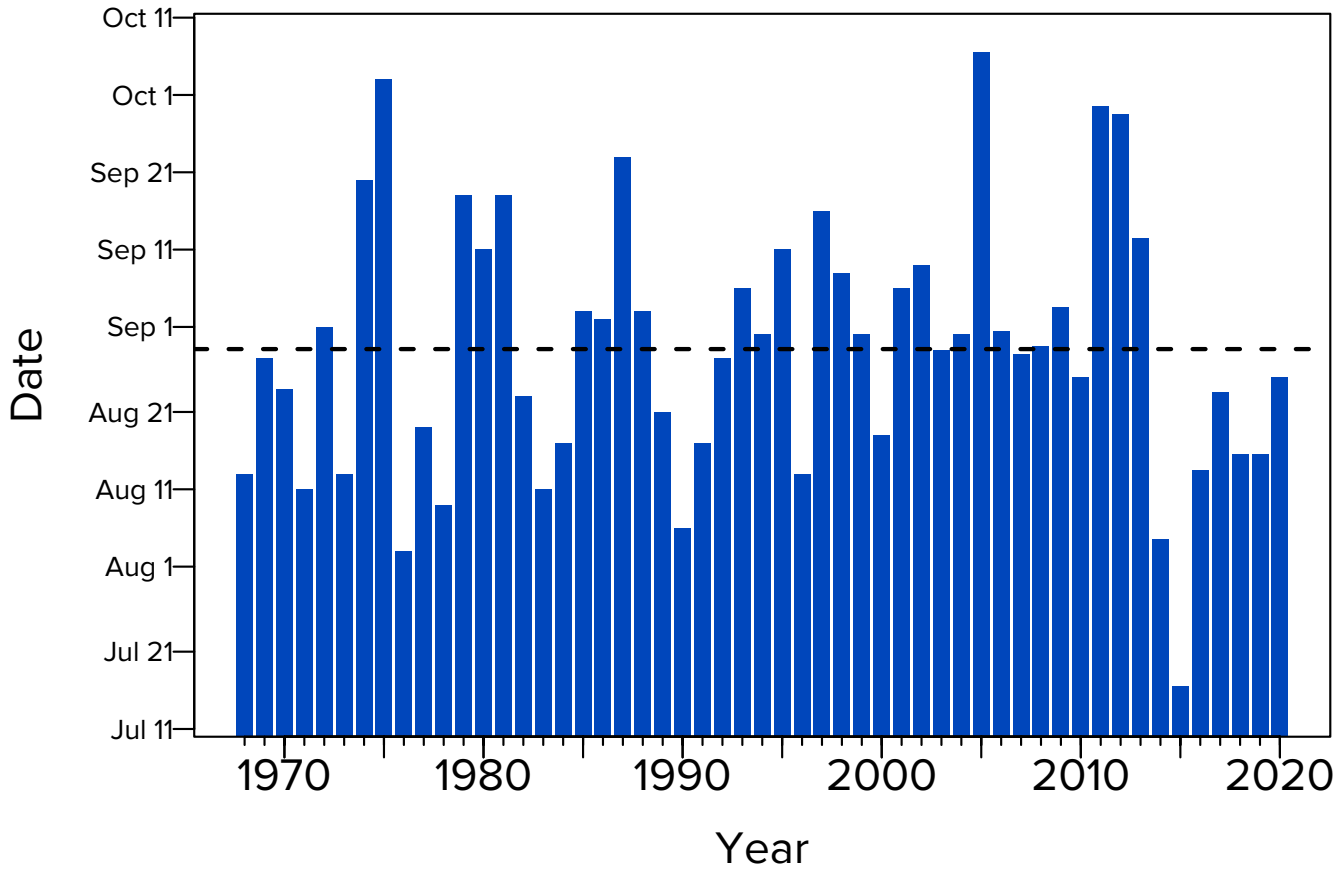
The amount of time that Lake Tahoe is stratified has lengthened by almost a month since 1968. The end of the stratification season has been extended, but not as much as the onset of stratification has been advanced (Fig. 8.12). Over the 52-year record, the end of stratification has been extended by approximately six days. This can have important implications for lake mixing and water quality, such as the buildup of nitrate at the bottom portions of the lake.



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 little has changed in when the peak occurs. In 2020, the peak occurred on August 29, which is close to the long-term average (dashed line).



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 an average of over 16 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 2020, the onset occurred on April 11, slightly later than the long-term average. 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, we used the peak of the stream hydrograph to estimate this property.