TAHOE: STATE OF THE LAKE REPORT 2020

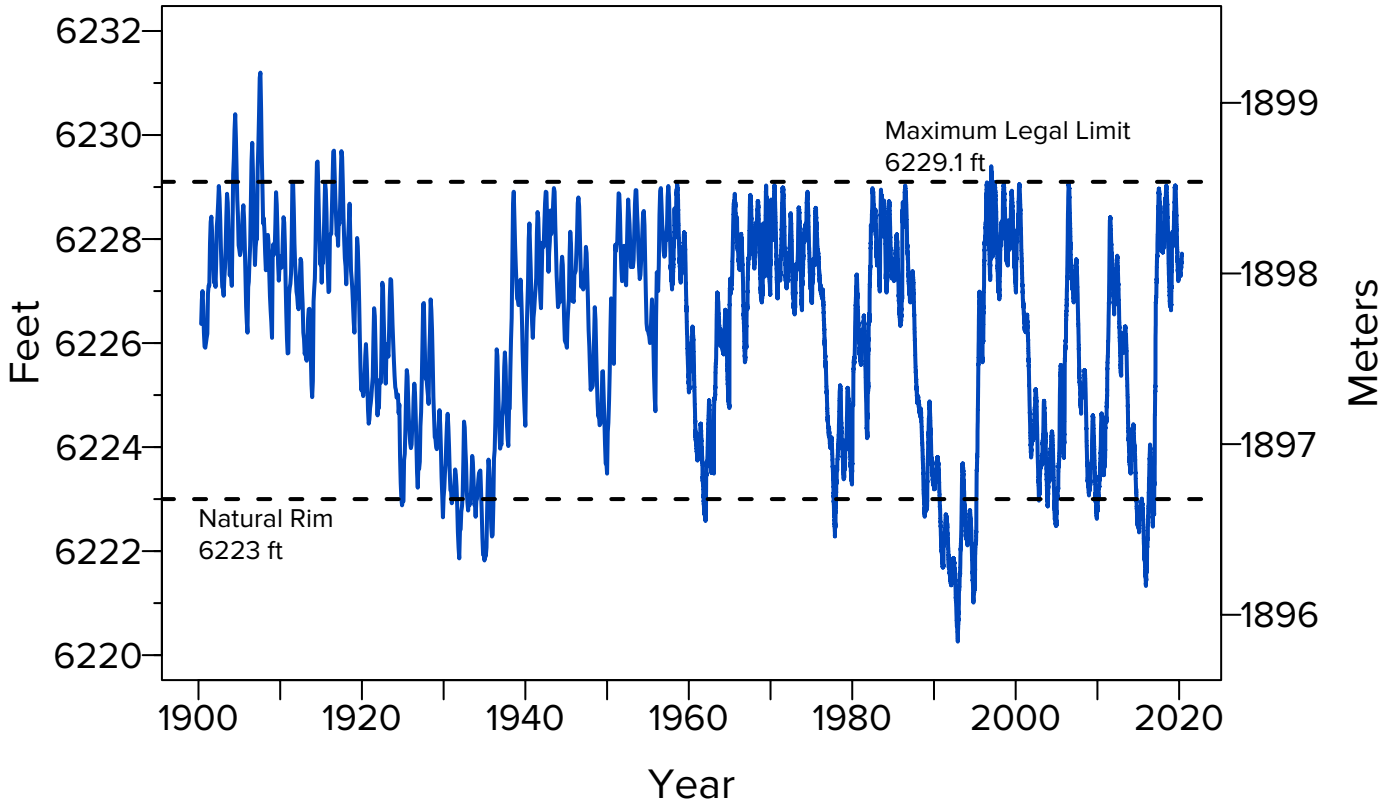
PHYSICAL PROPERTIES

UCDAVIS
Tahoe Environmental
Research Center

Lake surface level

Daily since 1900

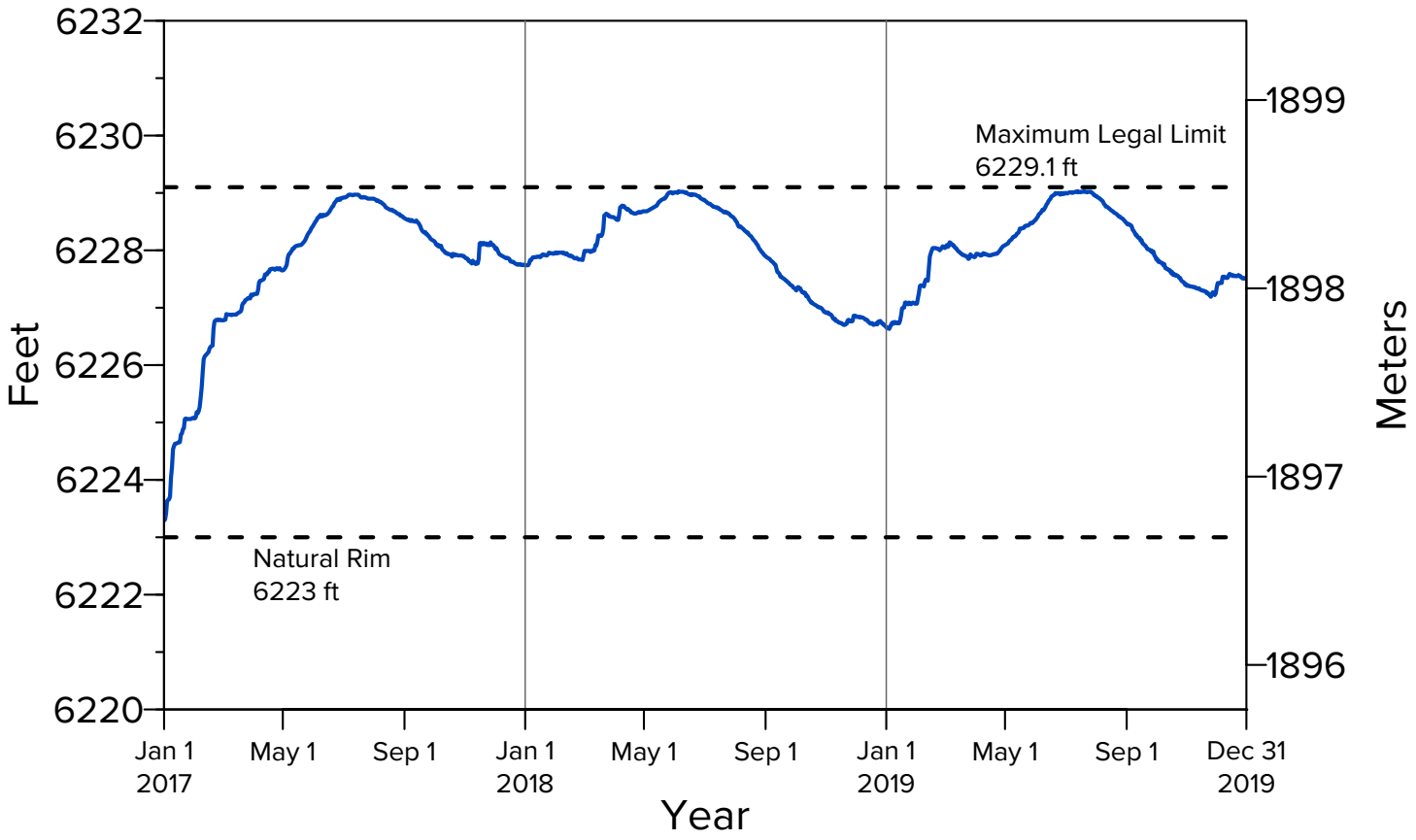
Lake surface level varies throughout the year. Lake level rises due to high stream inflow, groundwater inflow, and precipitation directly onto the lake surface. It falls due to evaporation, in-basin water withdrawals, groundwater outflows, and outflow via the Truckee River at Tahoe City. The highest lake level in 2019 was 6229.03 feet on July 1, and the lowest was 6226.63 feet on January 4. The natural rim of the lake is at an elevation of 6223 feet. Lake Tahoe was above its rim for the entire year. When the lake is below its rim, outflow via the Truckee River ceases. 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 6220.26 feet on November 30, 1992. Data source: U.S. Geological Survey level recorder in Tahoe City.



Lake surface level

Daily since 2017

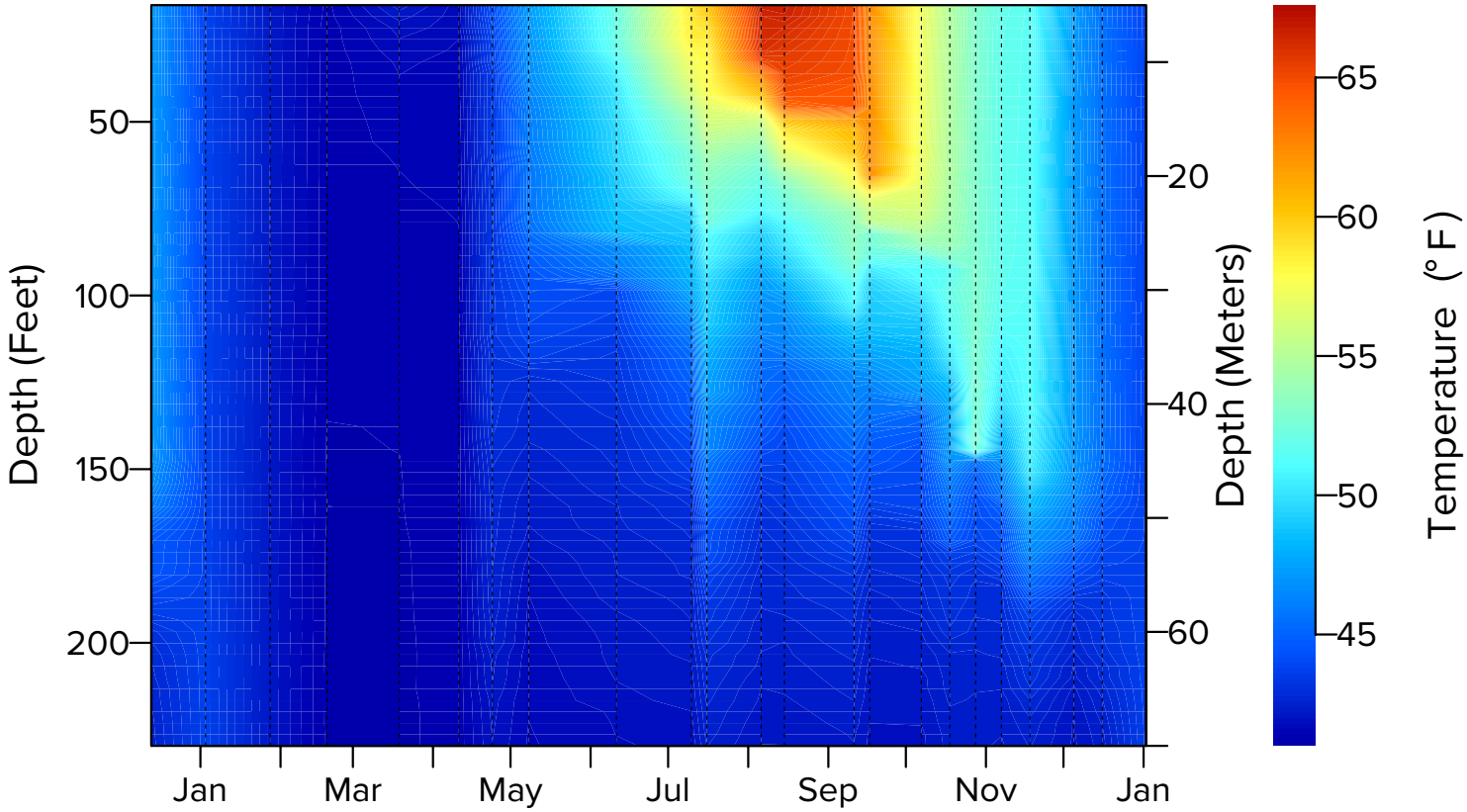
Displayed below is a subset of lake surface data extracted from the same data as in Fig. 8.1 for the most recent three years from 2017-2019. This more time restricted presentation of recent lake level data allows us to see the annual patterns of rising and falling lake level in greater detail. In each of the last three years, Lake Tahoe has come close to its maximum level. Typically, the lake is at its highest level in early summer and reaches its lowest level in early winter. From January through December 2019, lake level rose 10.2 inches.



Water temperature profile

In 2019

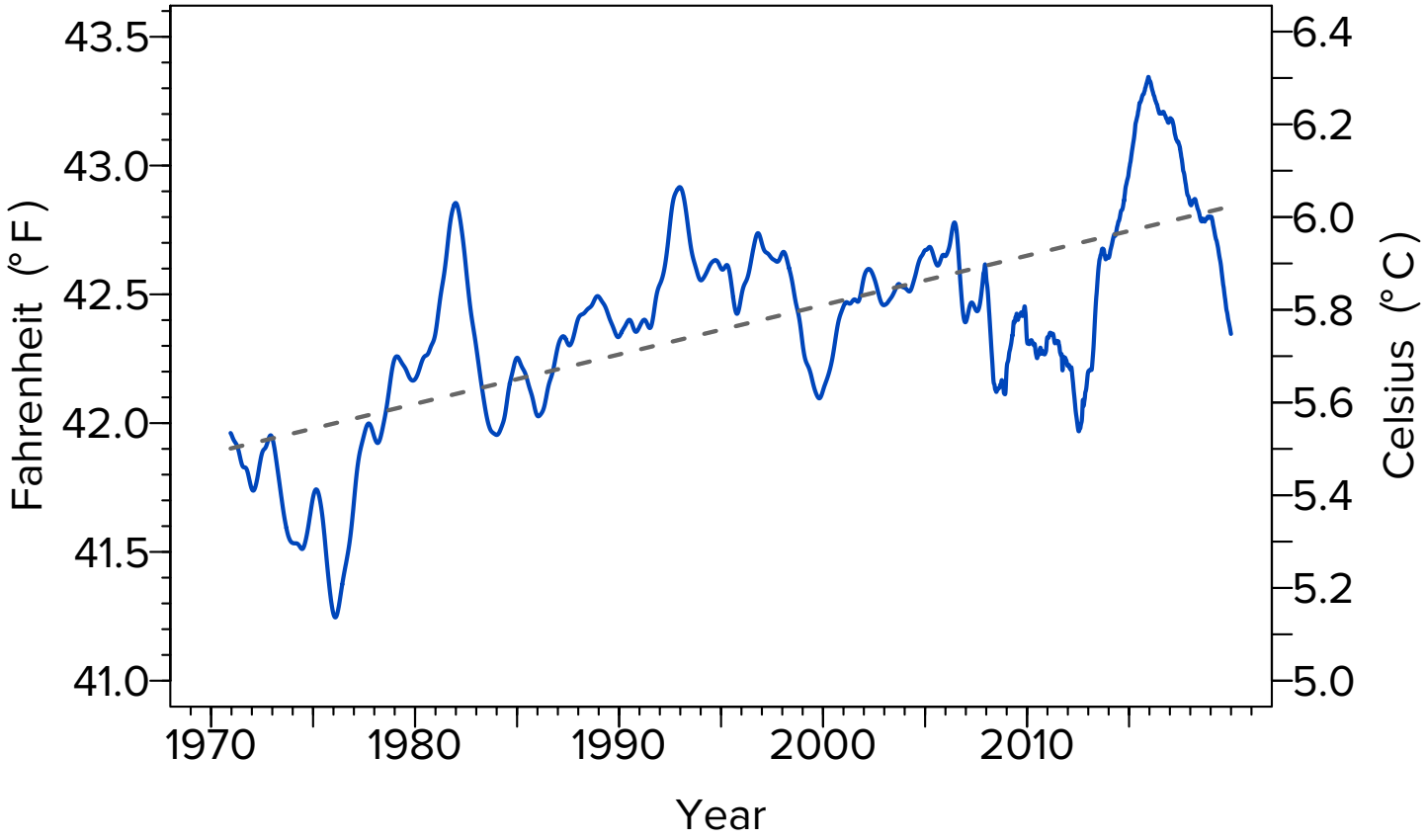
Water temperature profiles are measured in the lake using a Seabird CTD (conductivity, temperature, depth) profiler at the times indicated by the dashed vertical lines. The temperature is accurate to within 0.005 °F. The vertical distribution of water temperature is important, as it represents lake density, 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 2019, the lake temperature followed a typical seasonal pattern. In February-March, the lake surface was at its coldest, while it was at its warmest in August. The thickening of the warm water zone toward the end of the year is the result of winter mixing, a process that is important in bringing oxygen to the deeper parts of the lake.



Average water temperature

Since 1970

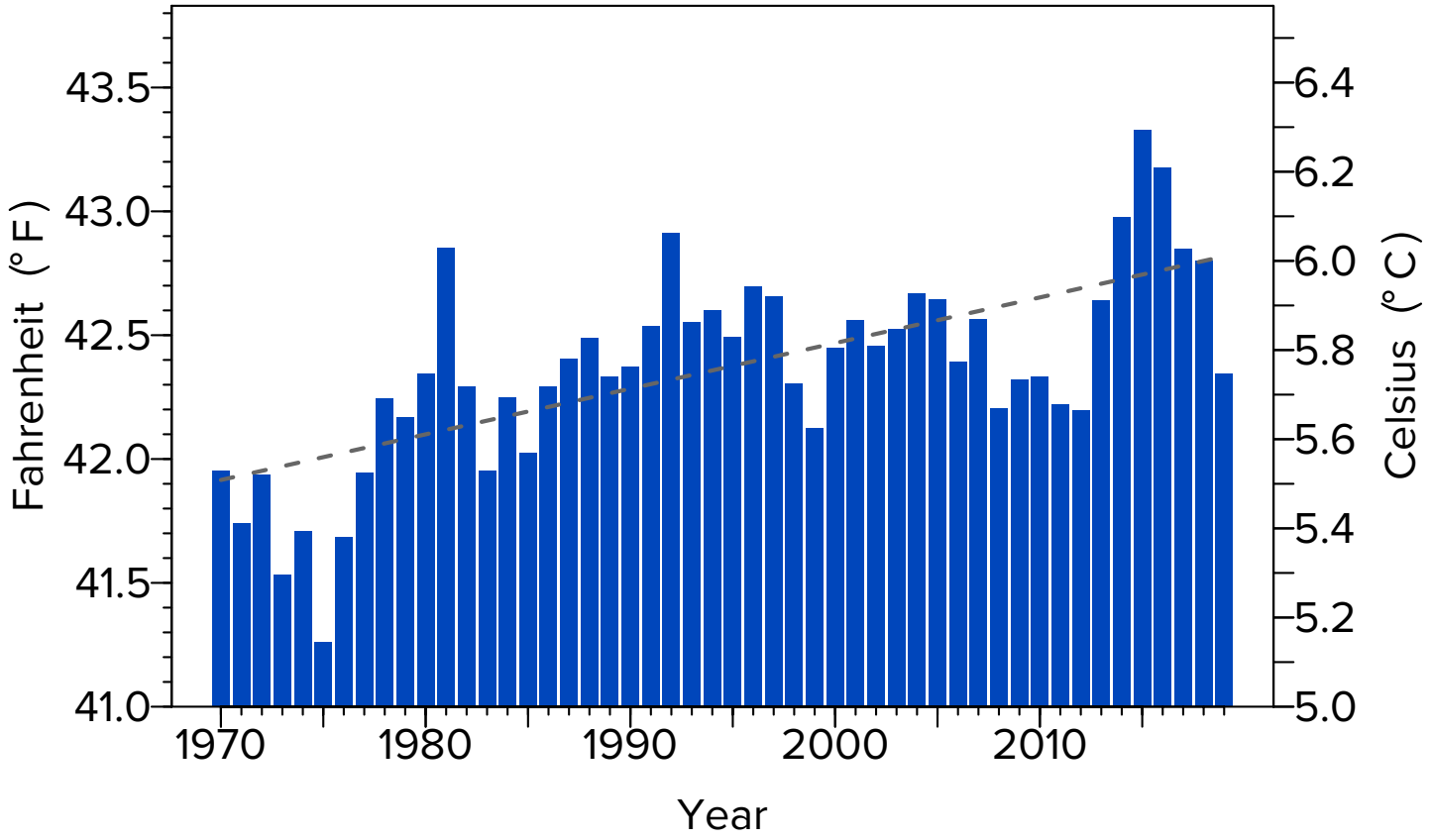
The linear trend in the average temperature of all the water in Lake Tahoe (dashed line) has increased by approximately 0.94 °F since 1970. The annual rate of warming is 0.19 °F/decade (0.011 °C/decade). The monthly temperature profile data from the top to the bottom of the lake has been smoothed and seasonal influences removed to best show the long-term trend. Up until the late 1990s, the warming rate was high. However, a high number of deep mixing years between 1997 and 2011, plus deep mixing in 2019. caused the average lake temperature to cool.



Annual average water temperature

Since 1970

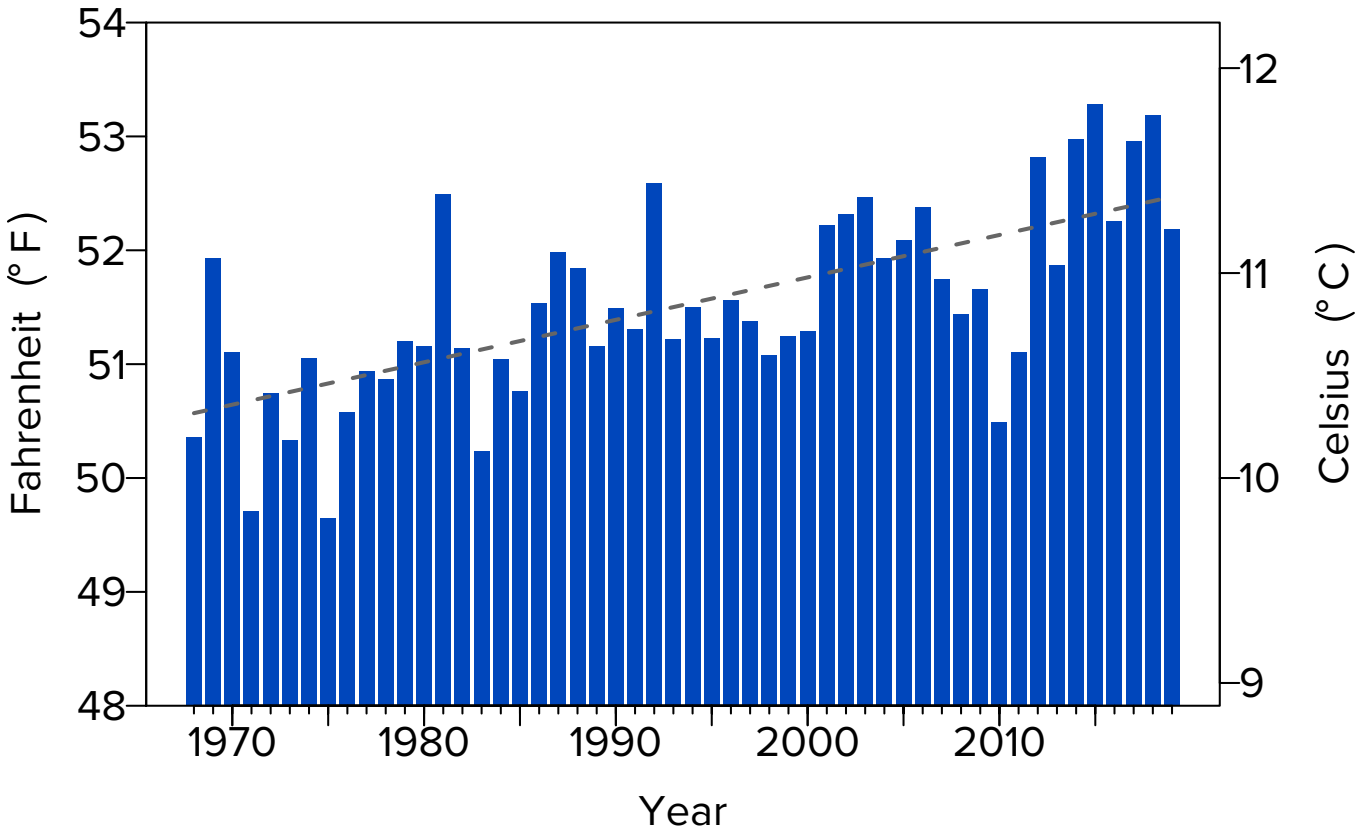
The volume-averaged temperature of the lake for each year since 1970 is shown. In 2019, the volume-averaged temperature decreased by 0.5 °F (0.2 °C) over the previous year. In the last four years, the lake has cooled slightly from its record warmest year in 2015. Since 1970, the trend in annual temperature rise (dashed line) has increased by 0.94 °F.



Annual surface water temperature

Yearly since 1968

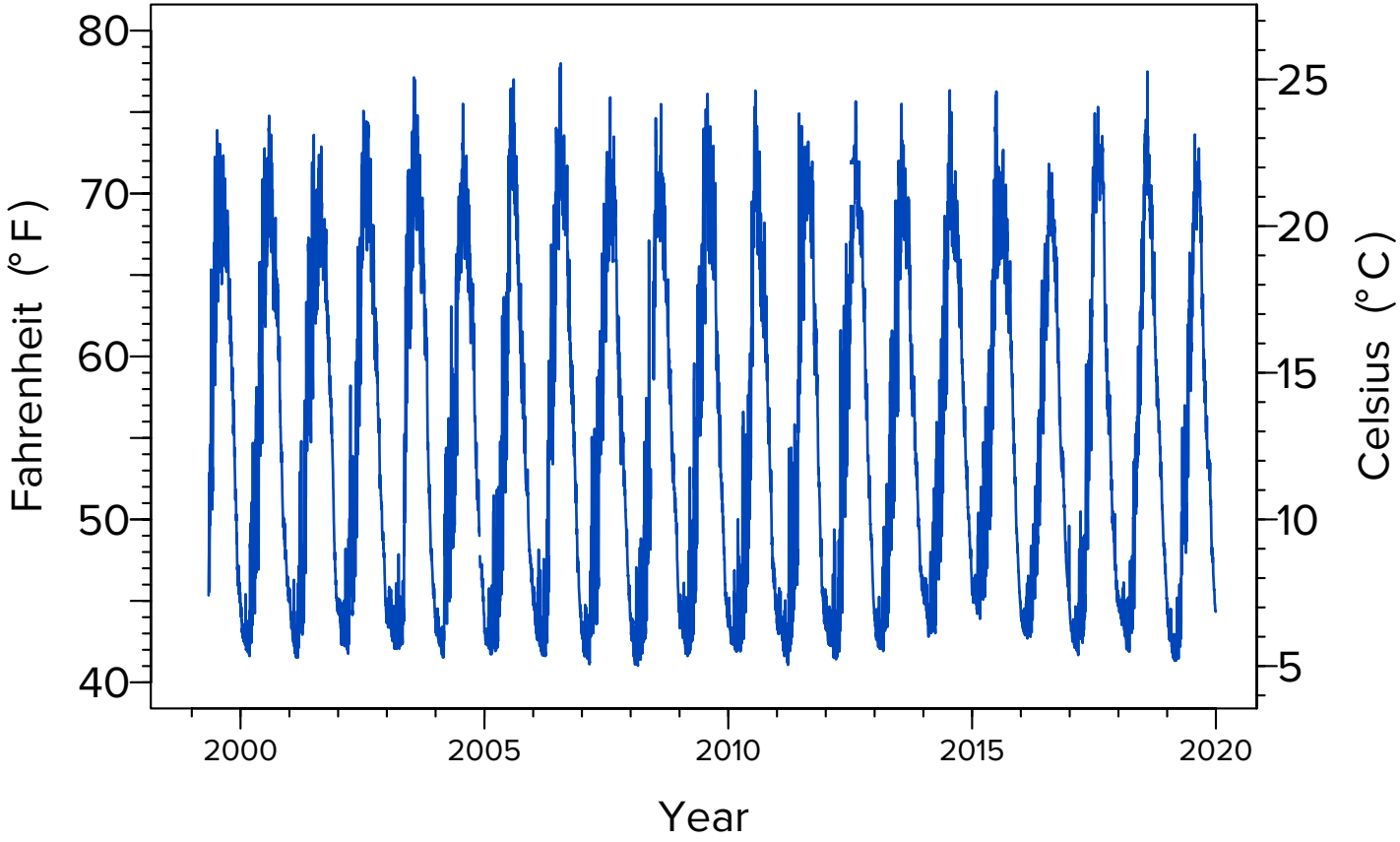
Surface water temperatures have been recorded monthly at the Mid-lake and Index stations since 1968 from the R/V John LeConte and the R/V Bob Richards. Despite year-to-year variability, the annual average surface water temperatures show an increasing trend. The average temperature in 1968 was 50.4 °F (10.2 °C). For 2019, the average surface water temperature was 52.2 °F (11.2 °C), slightly cooler than 2018. The overall rate of warming of the lake surface is 0.37 °F (0.21 °C) per decade.



Maximum daily surface water temperature

Surface temperature measured since 1999 every 2 minutes

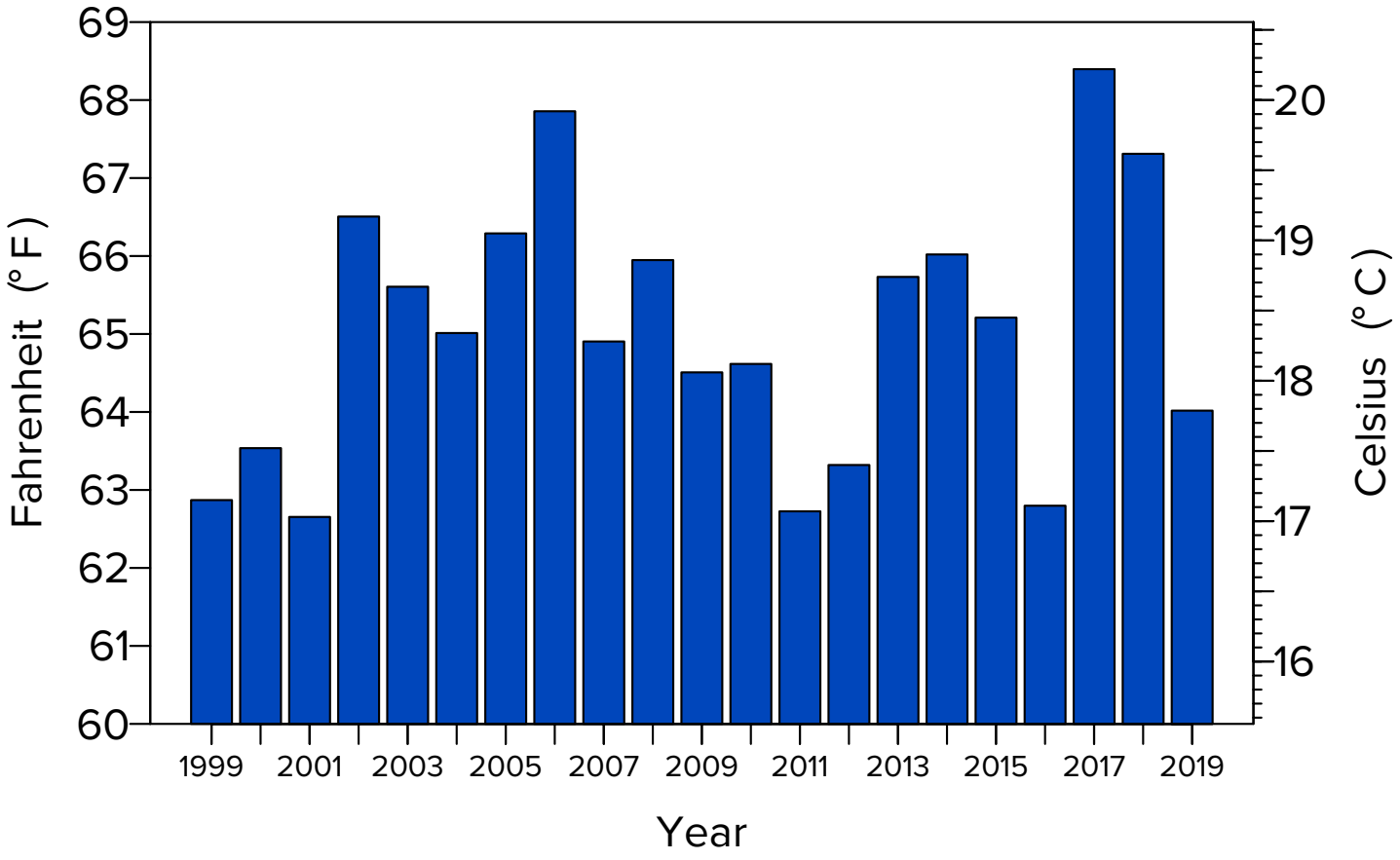
The maximum daily summer surface water temperature in 2019 was the second coolest since continuous data collection commenced in 1999. The highest maximum daily surface water temperature (summer) was 73.6 °F (23.1 °C), recorded on July 28, 2019, 3.9 °F cooler than the previous year. The lowest maximum daily surface water temperature (winter) was 41.3 °F (5.18 °C), which was recorded on February 26, 2019. These data are collected in real-time by NASA-JPL and UC Davis from four buoys located over the deepest parts of the lake.



July average surface water temperature

Measured since 1999 every 2 minutes

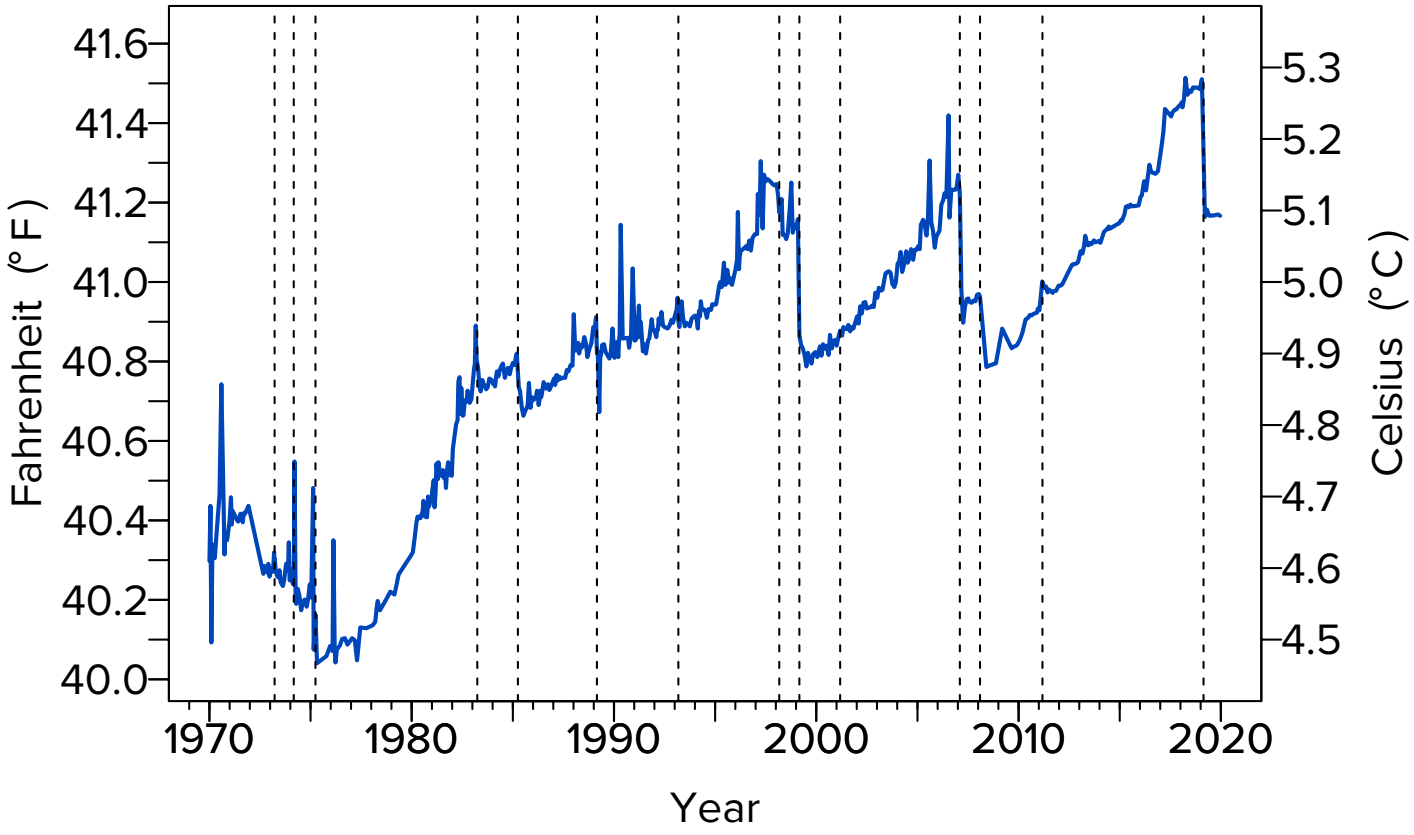
Surface water temperature has been continuously recorded since 1999 from four NASA/UC Davis buoys in the center of the lake. Shown here are 21 years of average surface water temperatures in the month of July when water temperatures are typically warmest and when the greatest number of people are swimming in the lake. In 2019, July surface water temperature averaged 64.0 °F, one degree below the average for the period of record. The warmest July temperatures were 68.4 °F in 2017. The average July surface water temperature for the 21-year period is 65.0 °F.



Deep water temperature

Monthly since 1970

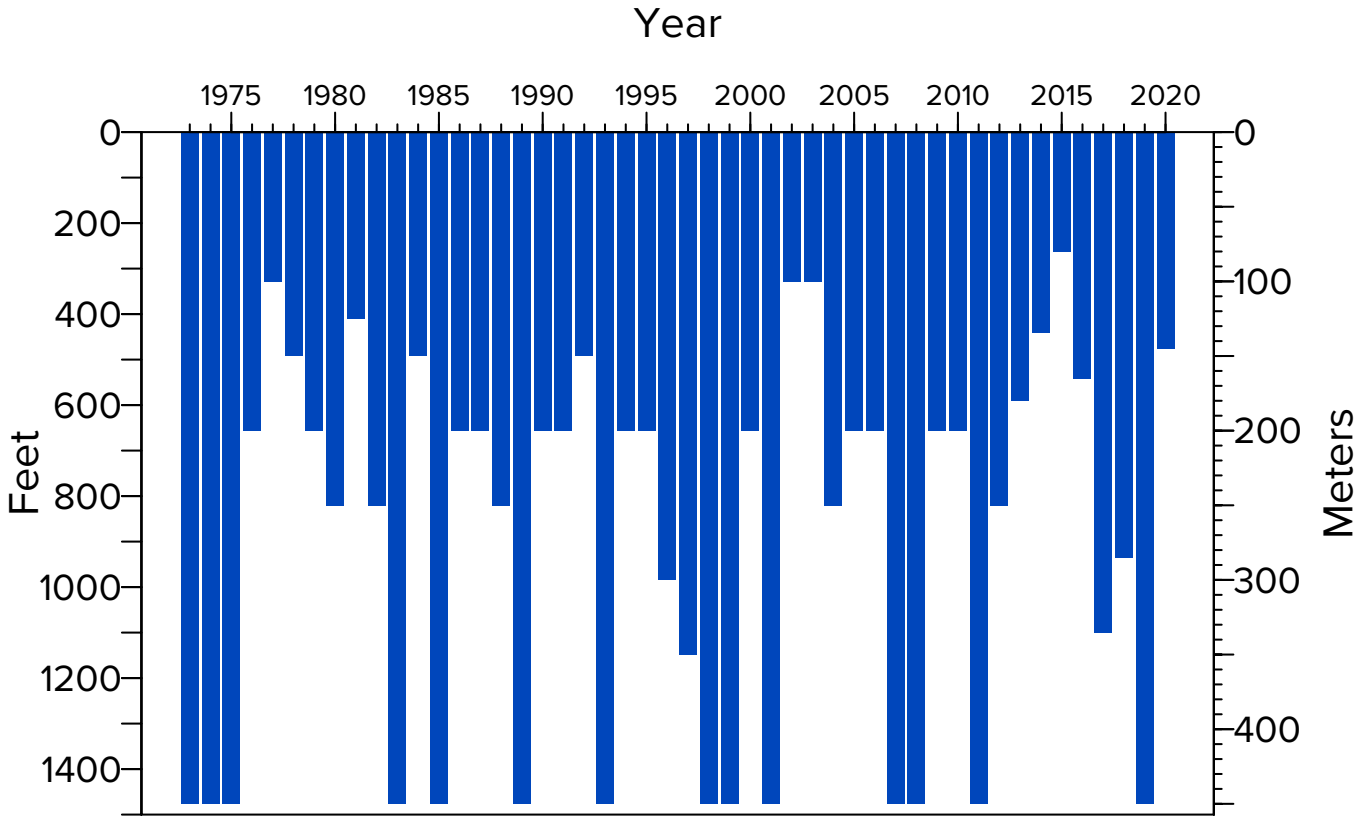
The water temperature at a depth of 1,320 feet (400 m) is indicative of conditions in the deeper waters (hypolimnion) of Lake Tahoe. The deep-water temperatures show a complex pattern of warming and sudden cooling. Warming occurs when the lake does not mix deeply. During deep mixing events (shown by the dashed lines), the temperature can drop precipitously over a short period of time. Generally, bottom temperatures are rising. Between the last two deep mixing events in 2011 and 2019, the rate of warming of the deep water 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 are temporary effects caused by the motions of internal waves.



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 22, 2019, Lake Tahoe was observed to have mixed to a depth of 1476 feet (450 m), effectively from top to bottom. This deep mixing likely contributed to the cooler surface temperatures experienced in the following summer. Beginning in 2013, the depth of mixing has been determined with high-resolution temperature profiles rather than nitrate concentration sampled at discrete depths.

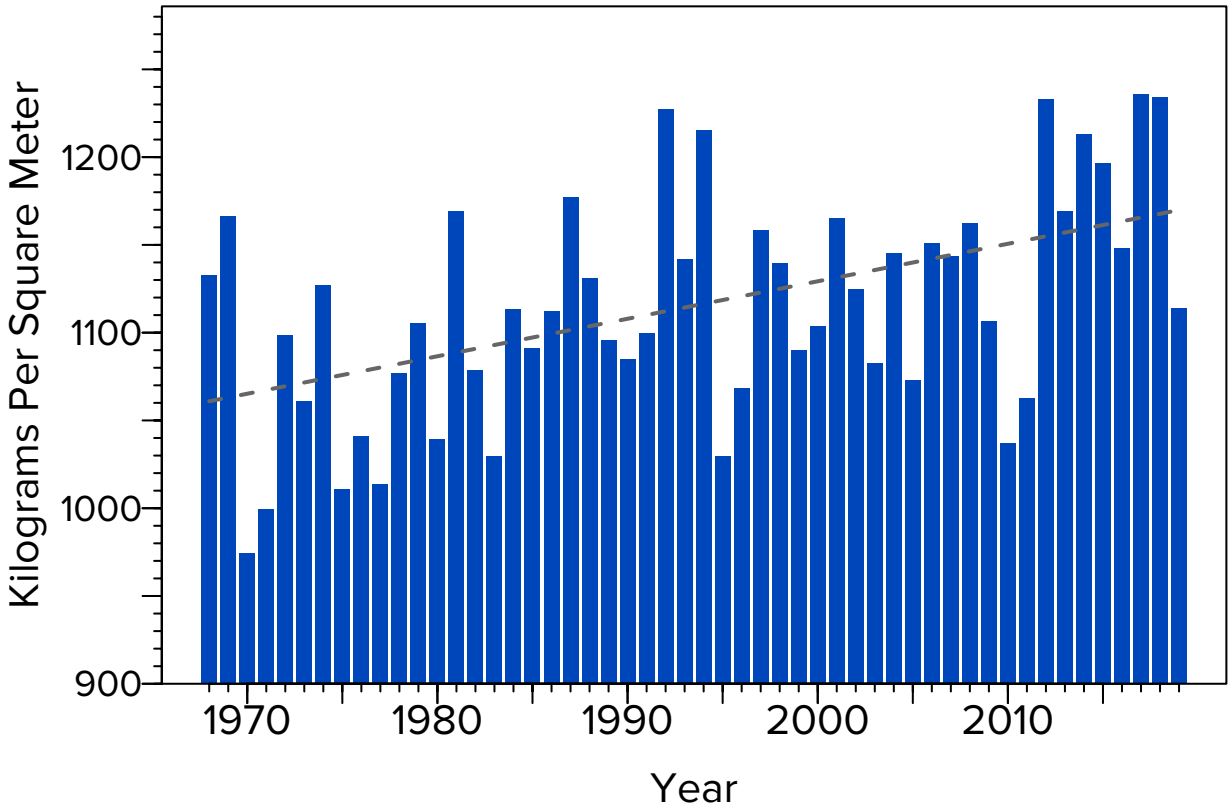


Lake stability

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 at depth. 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 10 percent in the last 51 years.

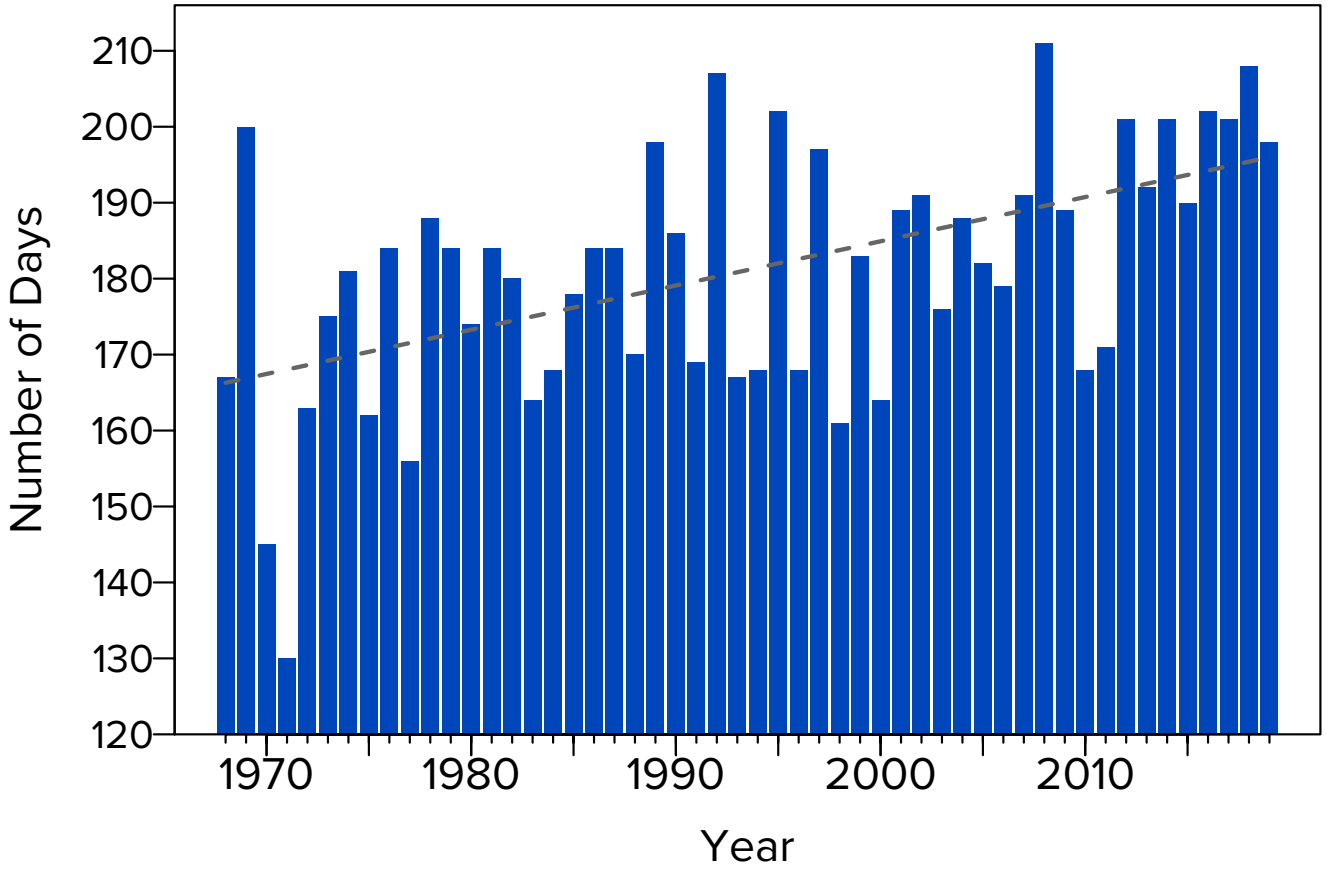
In 2019, the stability of the lake fell below the long-term trend-line, in part due to the cooler surface temperatures.



Stratified season length

Since 1968

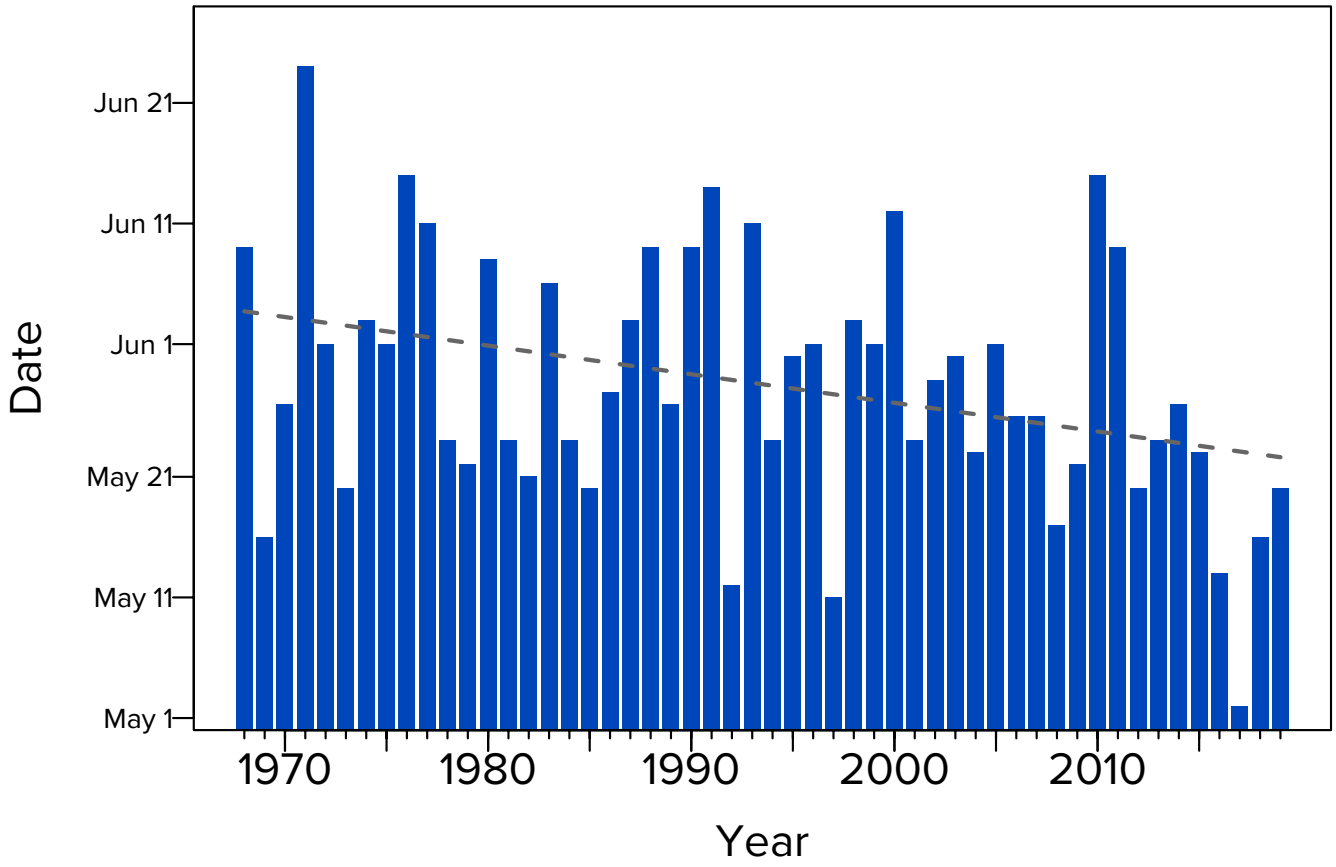
The stability index, a measure of the energy required to mix the lake, can be evaluated for every day of the year. We define the stratification season as the length of time when the stratification index exceeds a value of 600 kilograms per square meter. Since 1968, the length of the stratification season has increased, albeit with considerable year-to-year variation. Overall, the stratification season has lengthened by 30 days since 1968. In 2019, the length of the stratified season was 198 days.



Beginning of the stratification season

Since 1968

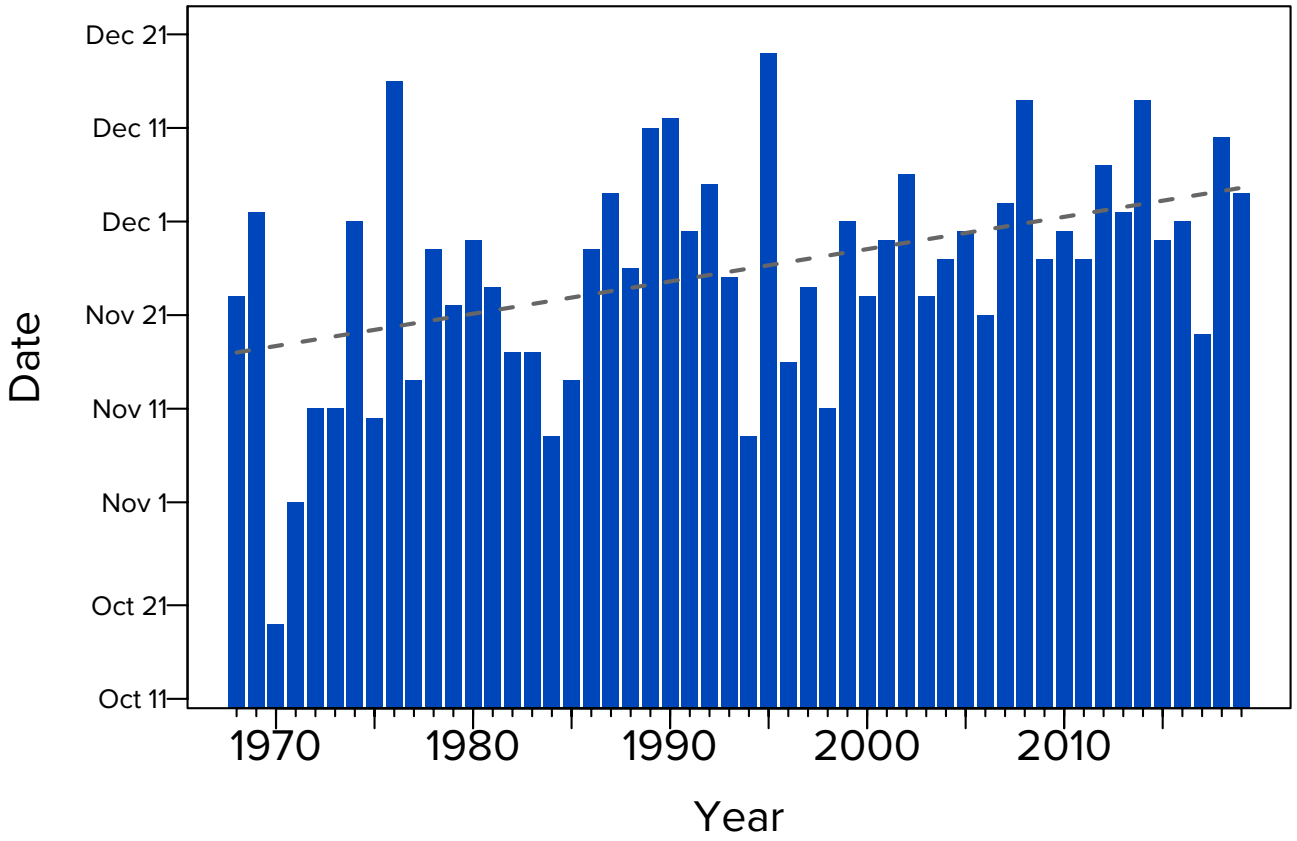
The amount of time that Lake Tahoe is stratified has been lengthening since 1968. One reason for this is the increasingly early arrival of spring as evidenced by the earlier commencement of stratification. Stratification occurs approximately 12 days earlier than it did in 1968. The commencement of the stratification season is typically in late May or early June. In 2019, stratification began on May 20 (Day 140).



End of stratification season

Since 1968

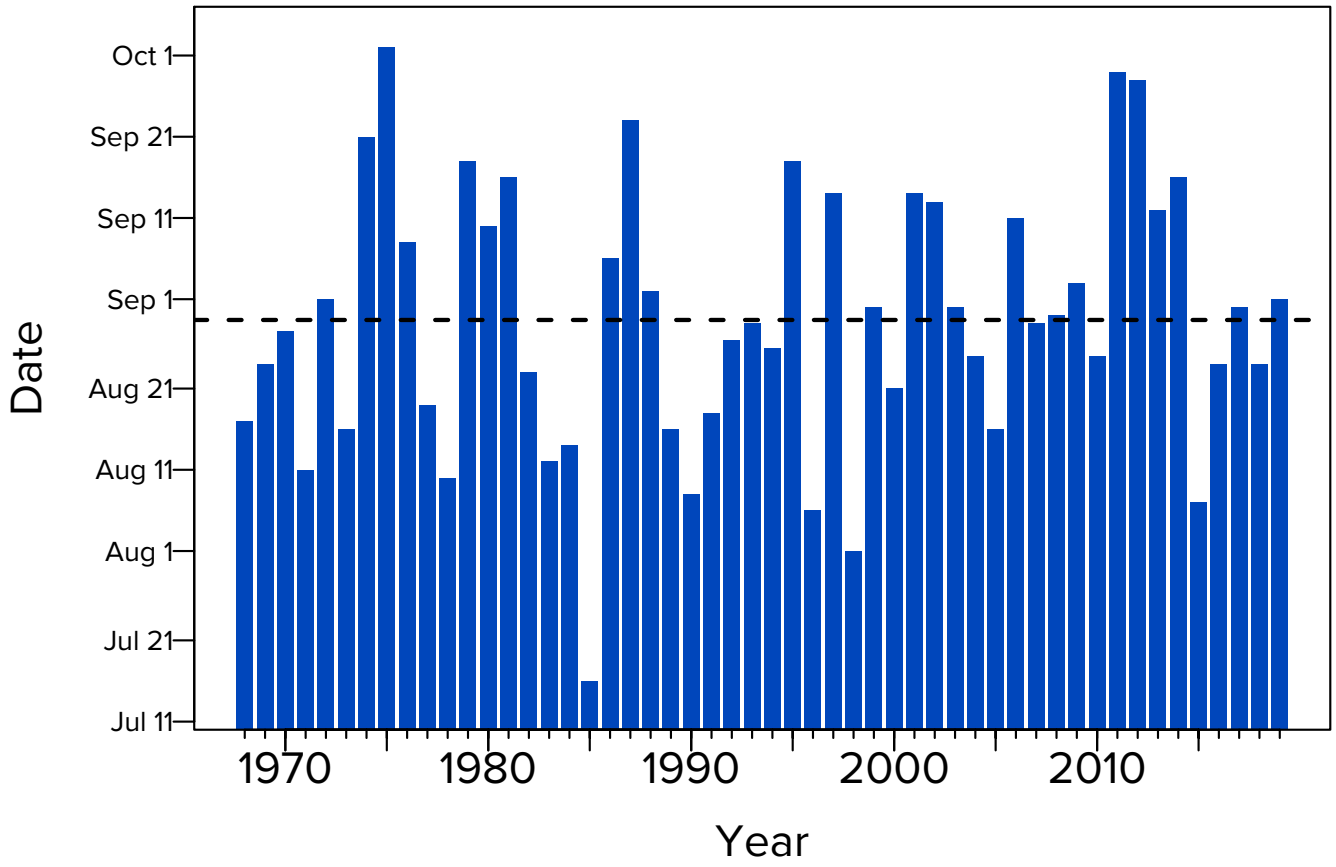
The amount of time that Lake Tahoe is stratified has lengthened by a month since 1968. The end of stratification appears to have been extended by 18 days on average. In other words, the fall season for the lake has been extended. In the late 1960s, stratification ended in mid-November. Now it often ends in December. In 2019, stratification ended on December 4 (Day 338). This can have important implications for lake mixing and water quality, such as the buildup of nitrate at the bottom 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 there has been little change in when the peak occurs. In 2019, the peak occurred on September 19, very close to the long-term average (dashed line).



Onset of snowmelt pulse

Yearly since 1961

Although the date on which onset of the snowmelt commences varies from year to year, since 1961 it has shifted earlier an average of almost 18 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 2019, the onset occurred on April 8, slightly later than the long-term average. In the 34 years since 1985, the onset of the snowmelt peak has occurred earlier than the long-term average on 20 occasions. 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.