TAHOE: STATE OF THE LAKE REPORT 2019

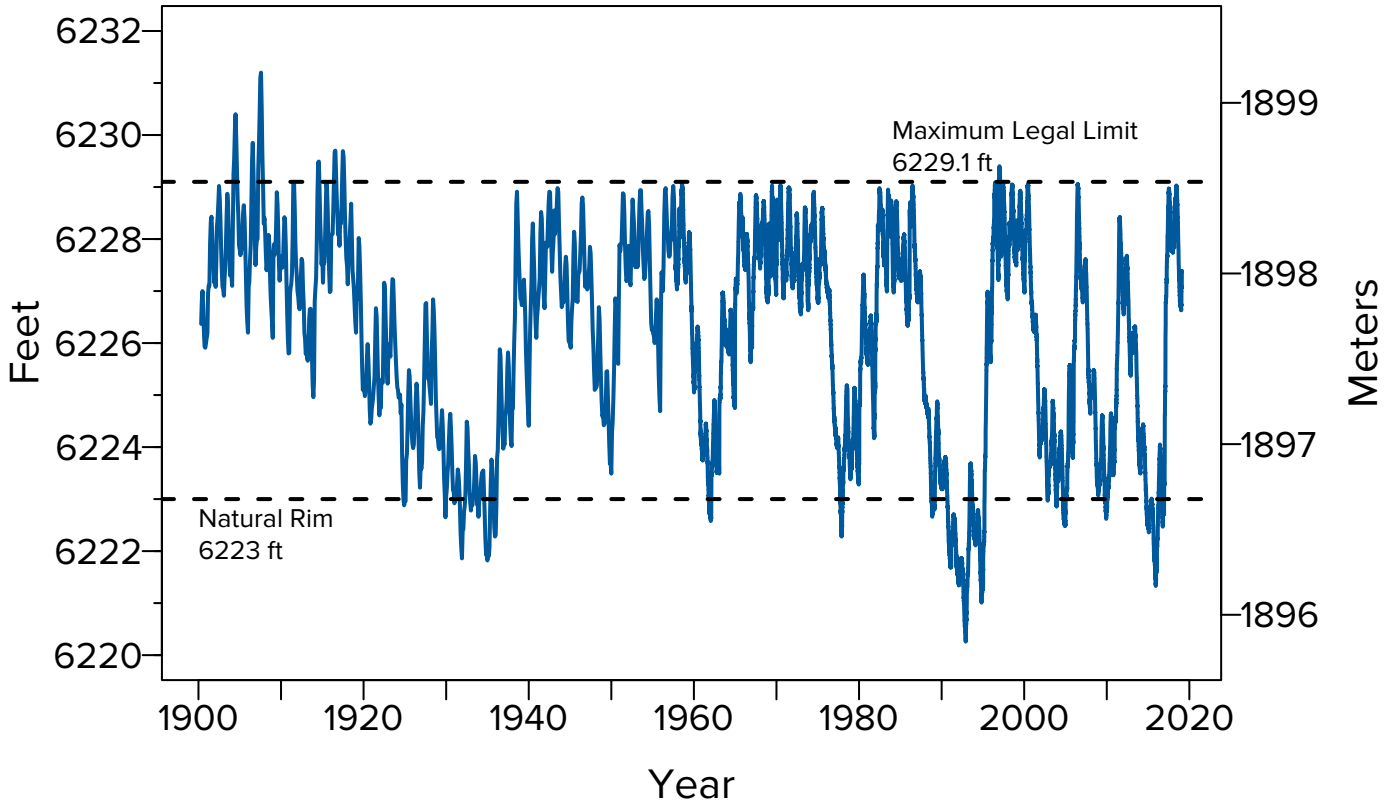
PHYSICAL PROPERTIES

UCDAVIS
Tahoe Environmental
Research Center

Lake surface level

Daily since 1900

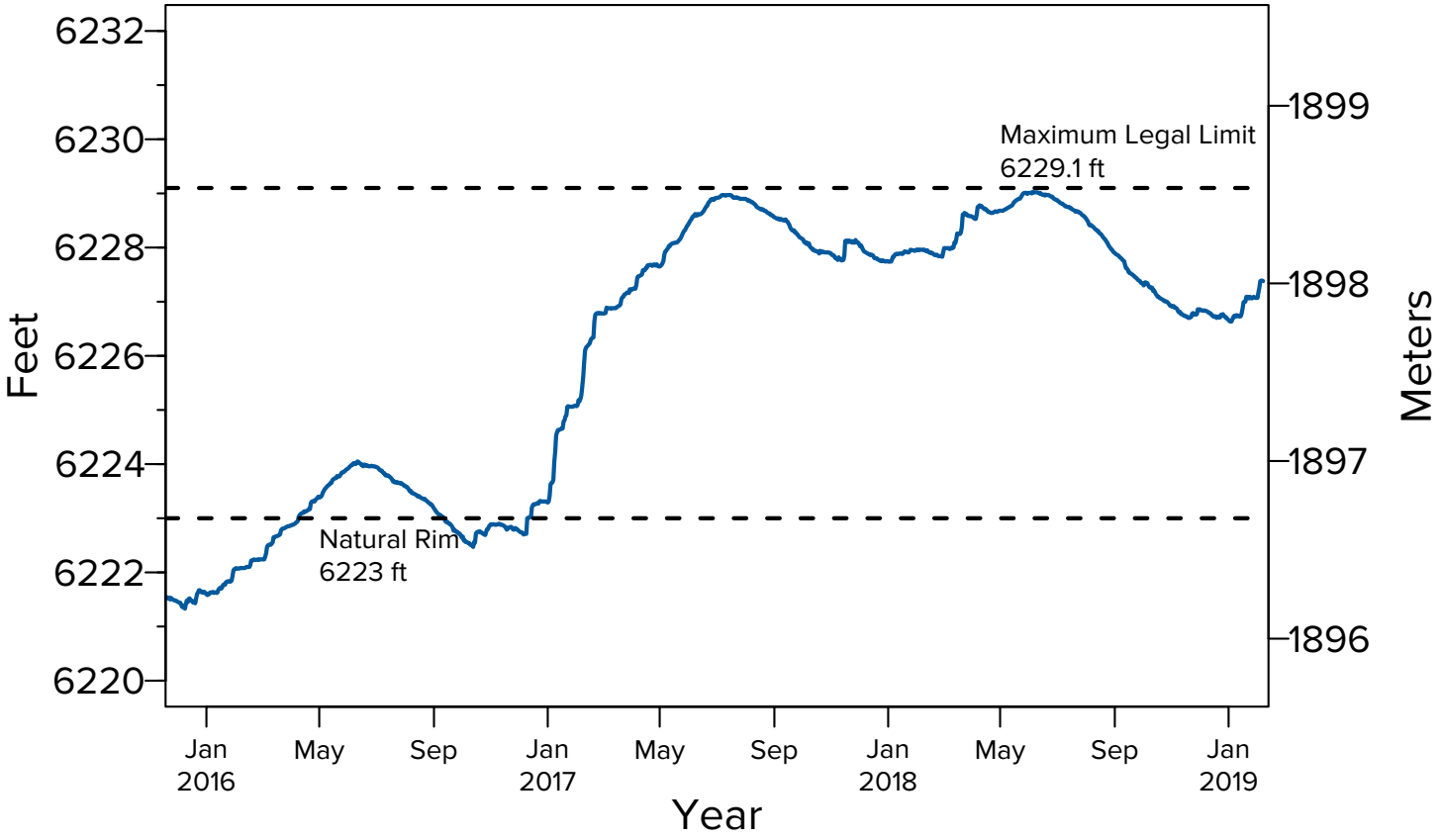
Lake surface level varies throughout the year. Lake level rises due to high stream inflow, groundwater inflow, and precipitation directly onto the lake surface. It falls due to evaporation, in-basin water withdrawals, groundwater outflows, and outflow via the Truckee River at Tahoe City. Overall, lake level fell over 13 inches during 2018. The highest lake level was 6229.03 feet on June 5, and the lowest was 6226.68 feet on December 31. 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.
Data source: US Geological Survey level recorder at Tahoe City.



Lake surface level, continued

Daily since 2016

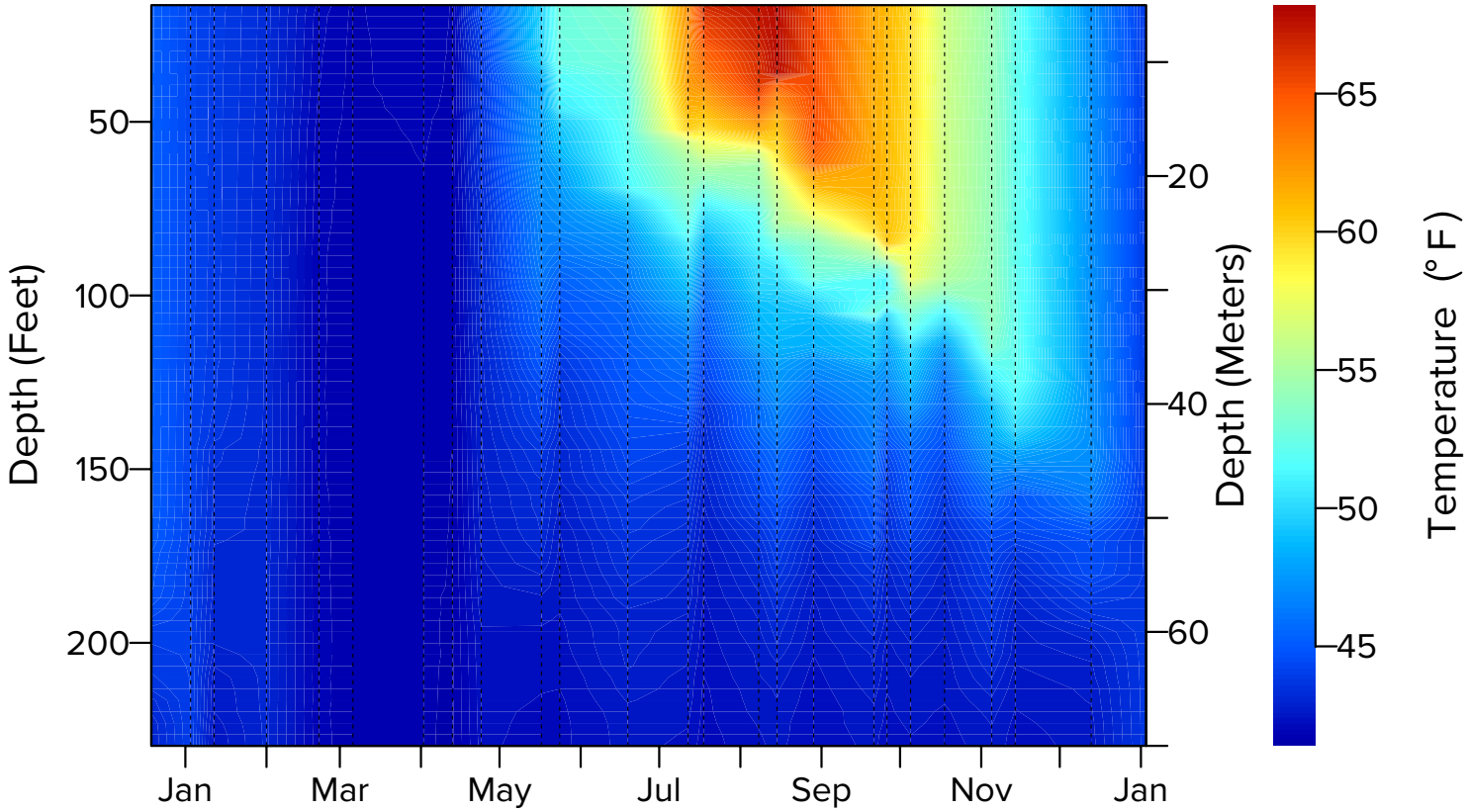
Displayed below is the lake surface data for three years from 2016-2018 extracted from the same data on page 8.1. This more time restricted presentation of recent lake level data allows us to see the annual patterns of rising and falling lake level in greater detail. Data clearly show the lake level falling below the natural rim in 2016 and the rapid rise in lake level that has been maintained in 2017 and 2018.



Water temperature profile

In 2018

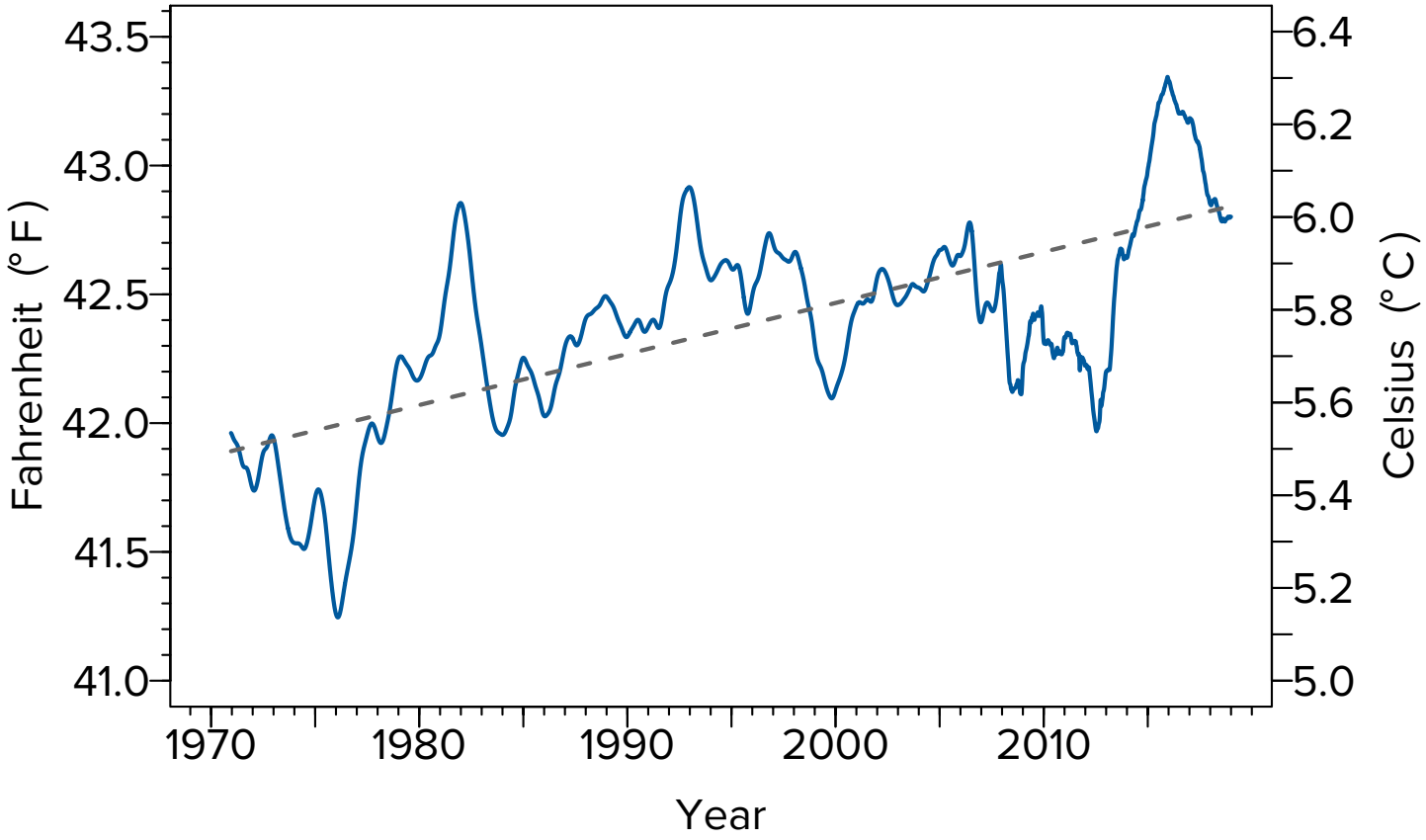
Water temperature profiles are measured in the lake using a Seabird CTD (conductivity, temperature, depth) profiler at the times indicated by the dashed vertical lines. The temperature is accurate to within 0.005 °F. Water temperature distribution is important, as it represents lake density, with warmer, lighter water trapped at the surface during the summer months. Here the temperature in the upper 220 feet (70 m) is displayed as a color contour plot. In 2018, 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 deepening 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

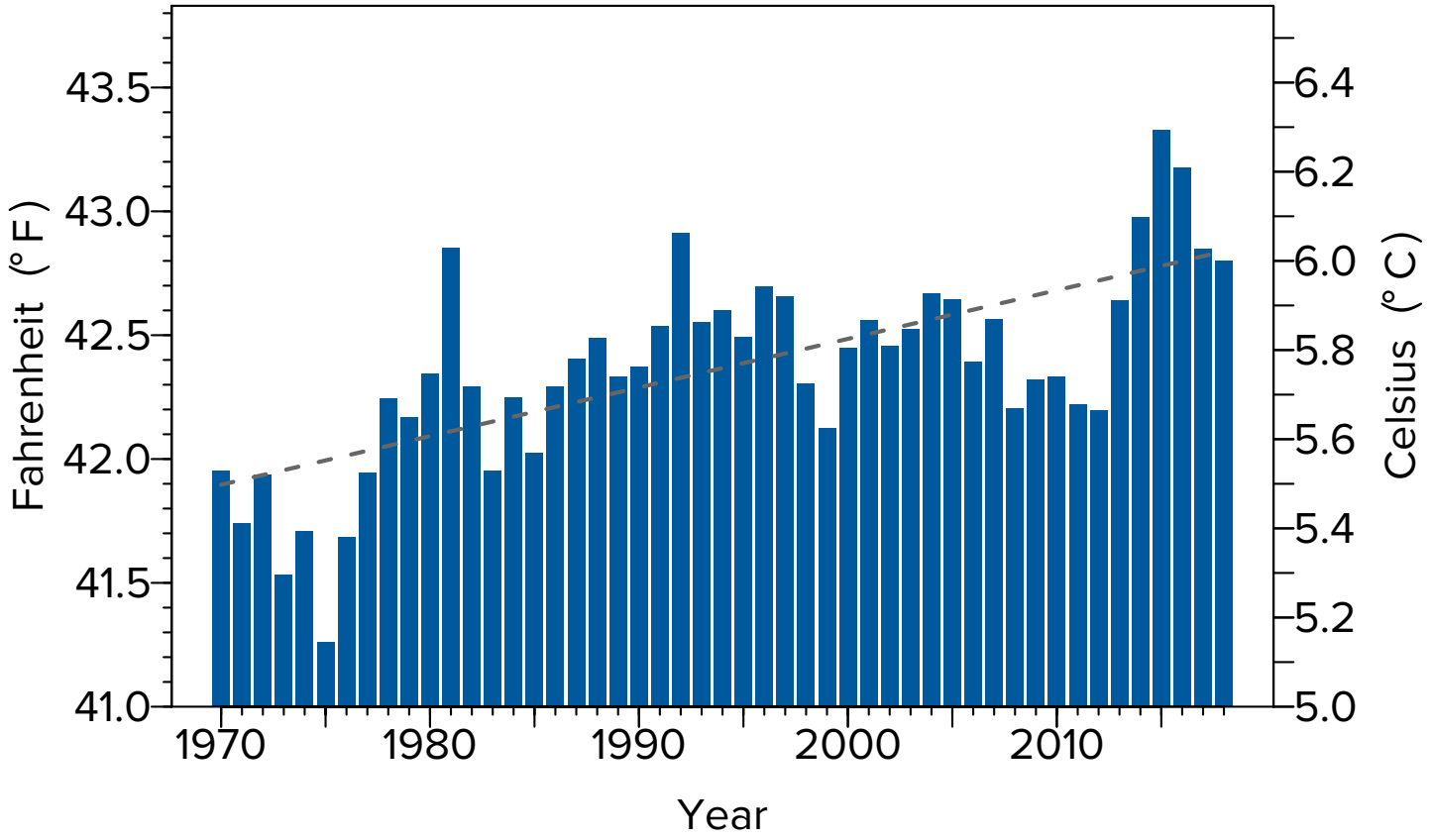
The trend in the volume-averaged temperature of Lake Tahoe (dashed line) has increased by approximately 0.95 °F since 1970. The annual rate of warming is 0.020 °F/year (0.011 °C/year). The monthly temperature profile data from the top to the bottom of the lake has been smoothed and seasonal influences removed to best show the long-term trend. Up until the late 1990s the warming rate was high, but a high number of deep mixing years between 1997 and 2011 caused the lake temperature to cool.



Annual average water temperature

Since 1970

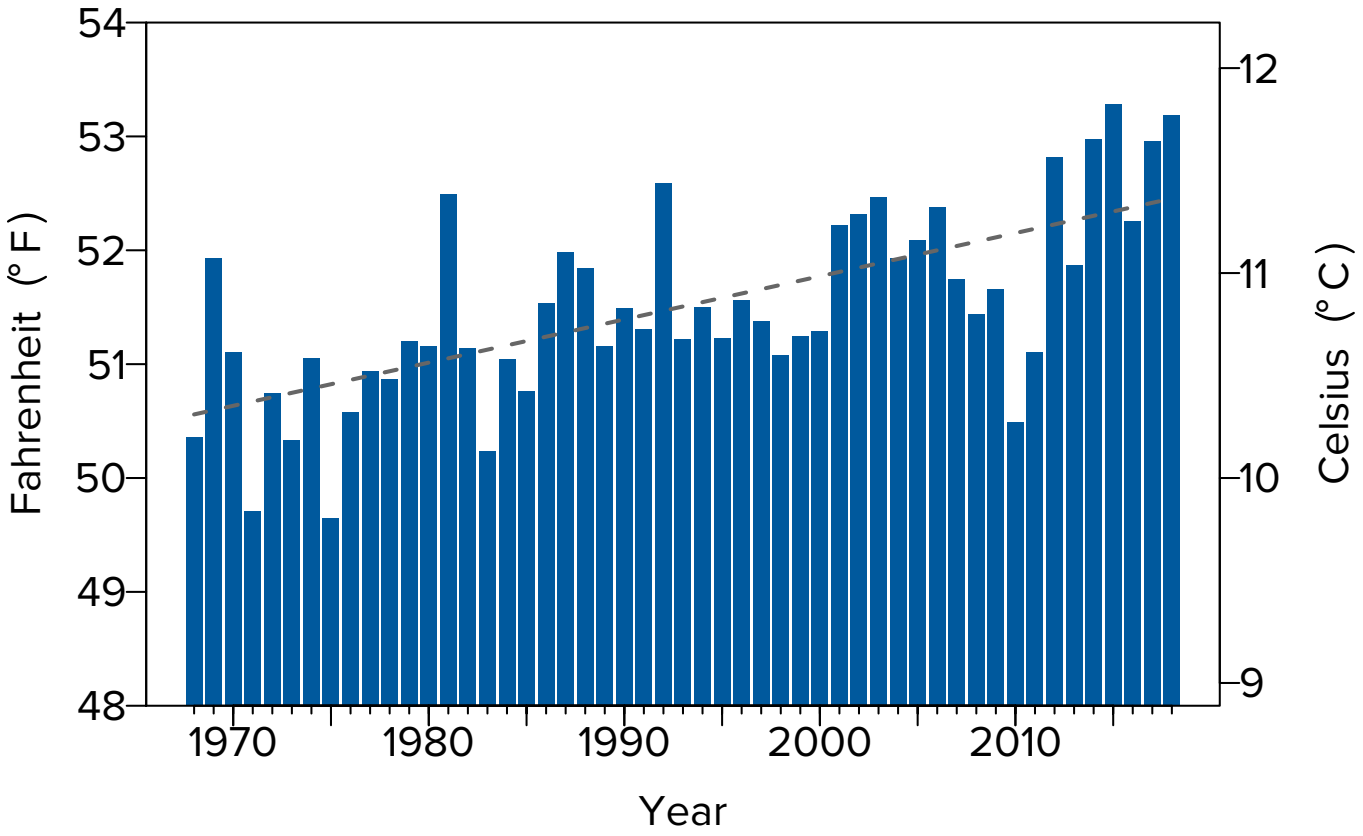
The volume-averaged temperature of the lake for each year since 1970 is shown. In 2018, the volume-averaged temperature decreased by 0.05 °F (0.03 °C) over the previous year. In the last 4 years the lake has cooled slightly from its warmest year in 2015. Since 1970, the trend in annual temperature rise (dashed line) has increased by 0.94 °F.



Surface water temperature

Yearly since 1968

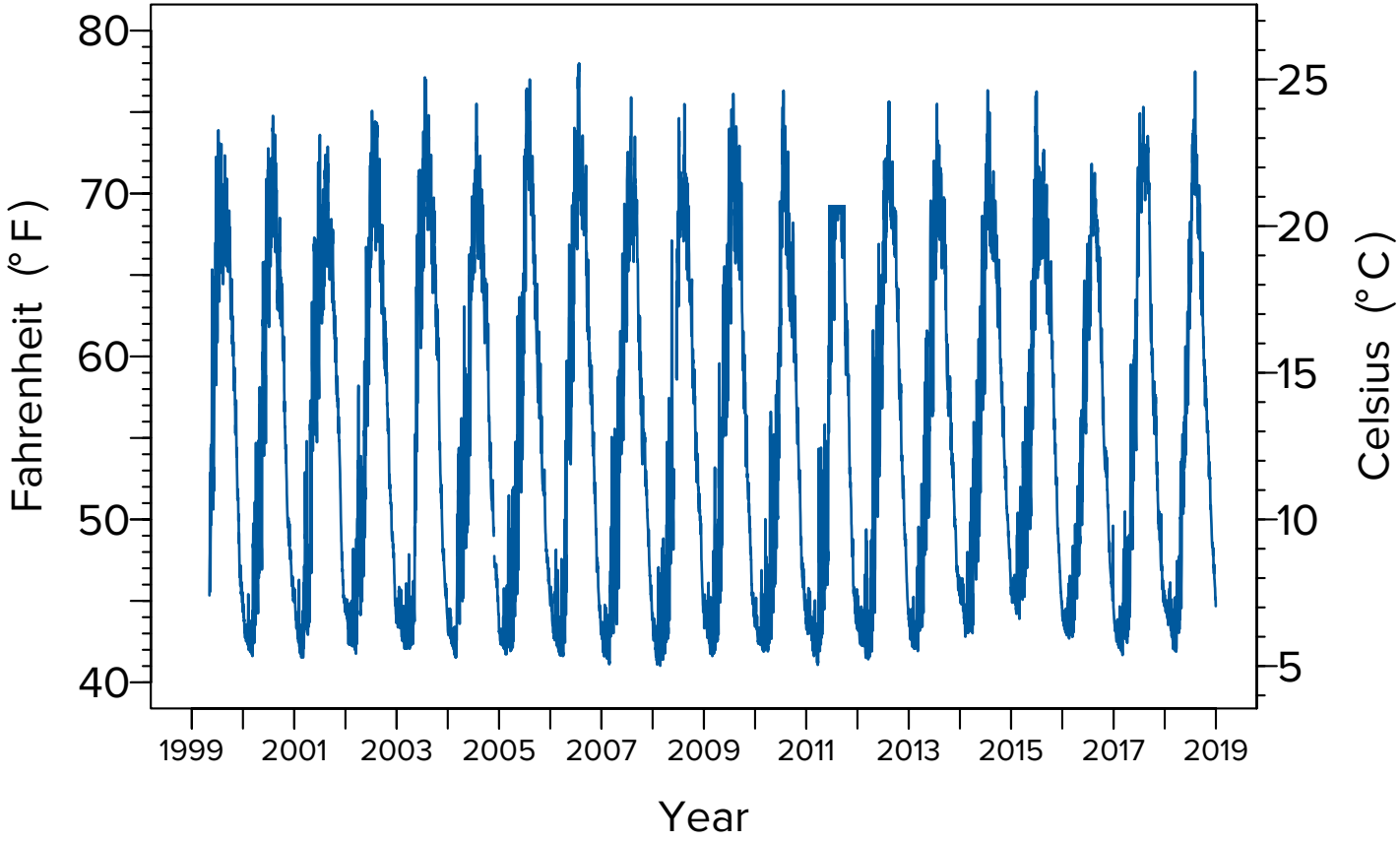
Surface water temperatures have been recorded monthly at the Mid-lake and Index stations since 1968 from the R/V John LeConte and the R/V Bob Richards. Despite year-to-year variability, the annual average surface water temperatures show an increasing trend. The average temperature in 1968 was 50.3 °F (10.2 °C). For 2018, the average surface water temperature was 53.19 °F (11.8 °C). This is the second warmest surface temperature year recorded since 1968. The overall rate of warming of the lake surface is 0.038 °F (0.021 °C) per year.



Maximum daily surface water temperature

Surface temperature measured since 1999 every 2 minutes

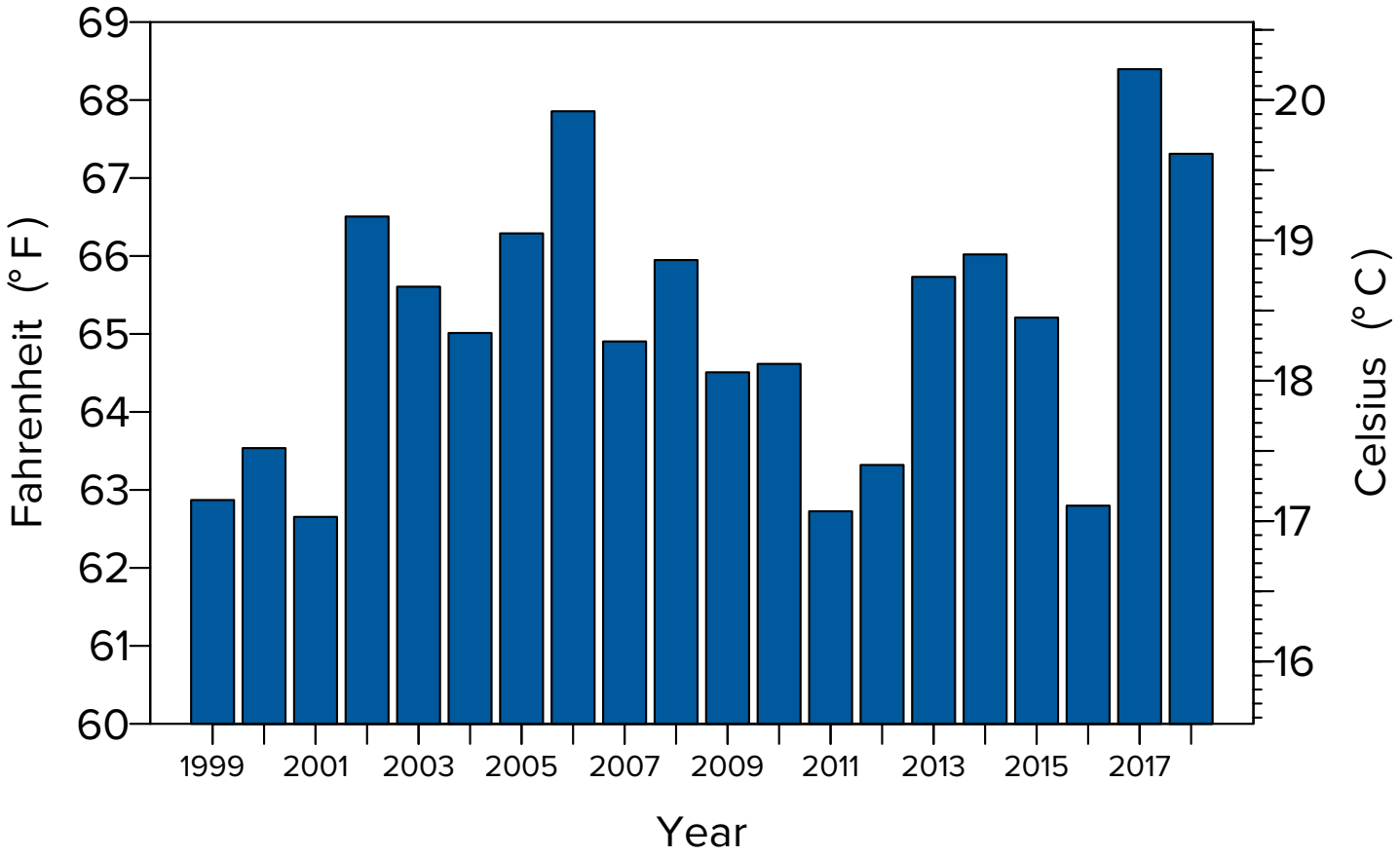
The maximum daily summer surface water temperature in 2018 was one of the highest observed since continuous (every 2 min.) data collection commenced in 1999. The highest maximum daily surface water temperature (summer) was 77.5 °F, which was recorded on August 6, 2018. The lowest maximum daily surface water temperature (winter) was 41.9 °F, which was recorded on March 16, 2018. These data are collected in real-time by NASA-JPL and UC Davis from 4 buoys located over the deepest parts of the lake.



July average surface water temperature

Measured since 1999 every 2 minutes

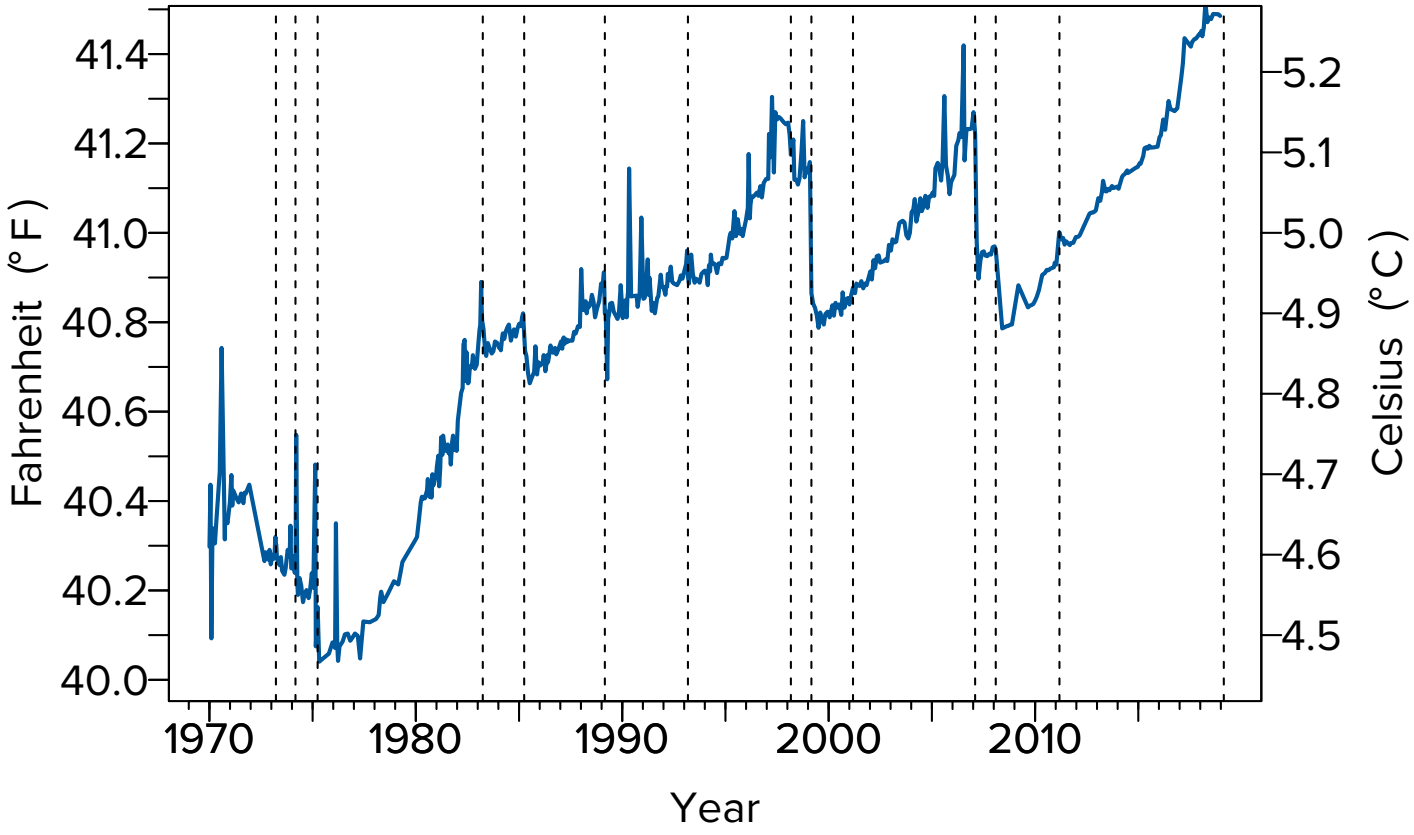
Since 1999, surface water temperature has been recorded every two minutes from four NASA/UC Davis buoys. Shown here are 18 years of average surface water temperatures in the month of July when water temperatures are typically warmest. In 2018, July surface water temperature averaged 67.3 °F, the third warmest July on record. The warmest July temperatures were 67.9 °F in 2006. The average July surface water temperature for the 18-year period is 65.1 °F.



Deep water temperature

Monthly since 1970

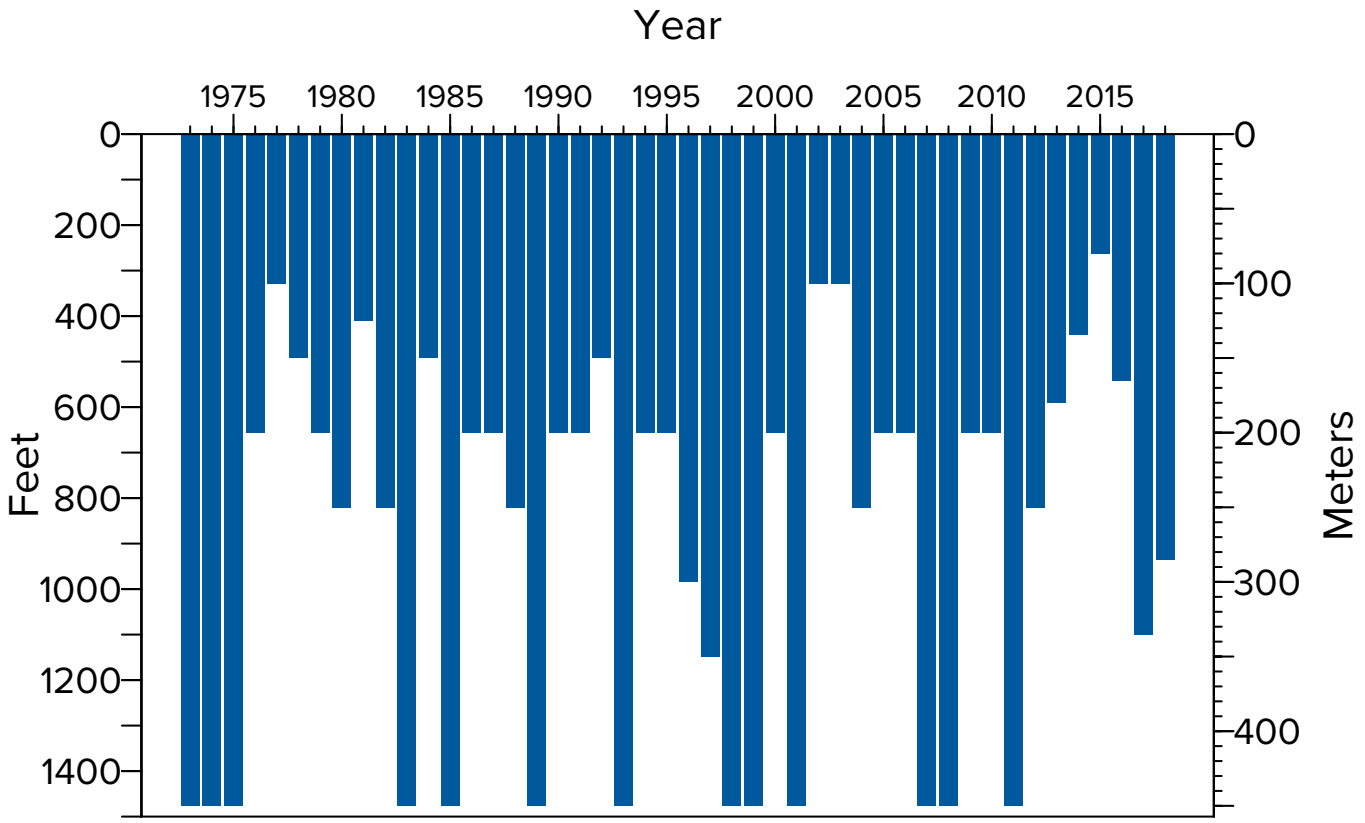
The water temperature at a depth of 1,320 feet (400 m) is indicative of conditions in the deeper waters (hypolimnion) of Lake Tahoe. Since 1970, the deep water temperature has increased by 1.19 °F (0.66 °C), at an annual rate of 0.025 °F/yr (0.014 °C/yr), a rate of warming that is less than that of the surface water. This increase has not been steady but is punctuated by occasional drops in temperature (highlighted with dashed vertical lines). 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 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 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 downward to deep waters, promoting aquatic life throughout the water column. The deepest mixing typically occurs between February and March. In 2018, Lake Tahoe mixed to a depth of 935 feet (285 m). This lack of deep mixing most likely contributed to the warm surface temperatures, the continuing buildup of nitrate in the lake. Beginning in 2013, the determination of the depth of mixing has been based on high-resolution temperature profiles rather than nitrate concentration sampled at discrete depths.

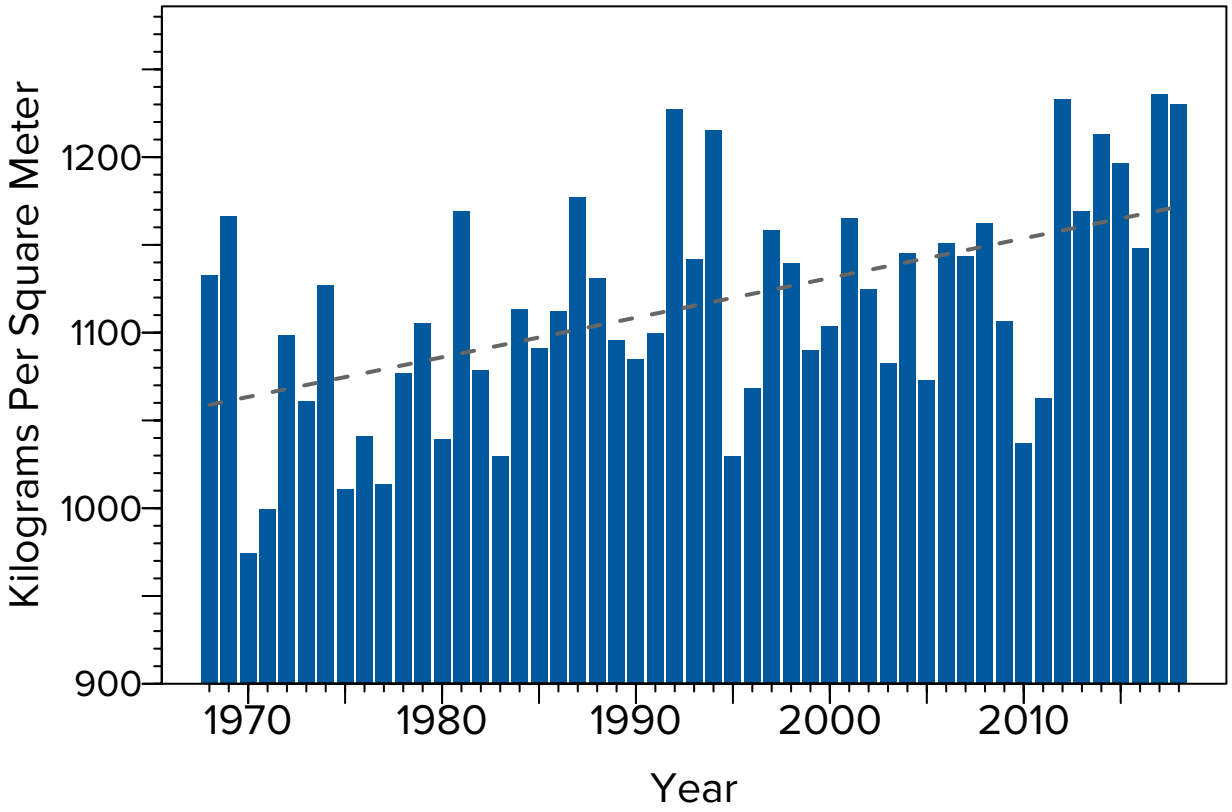


Lake stability

Since 1968

When the lake has a vertical distribution of temperature, it has a corresponding 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 50 years.

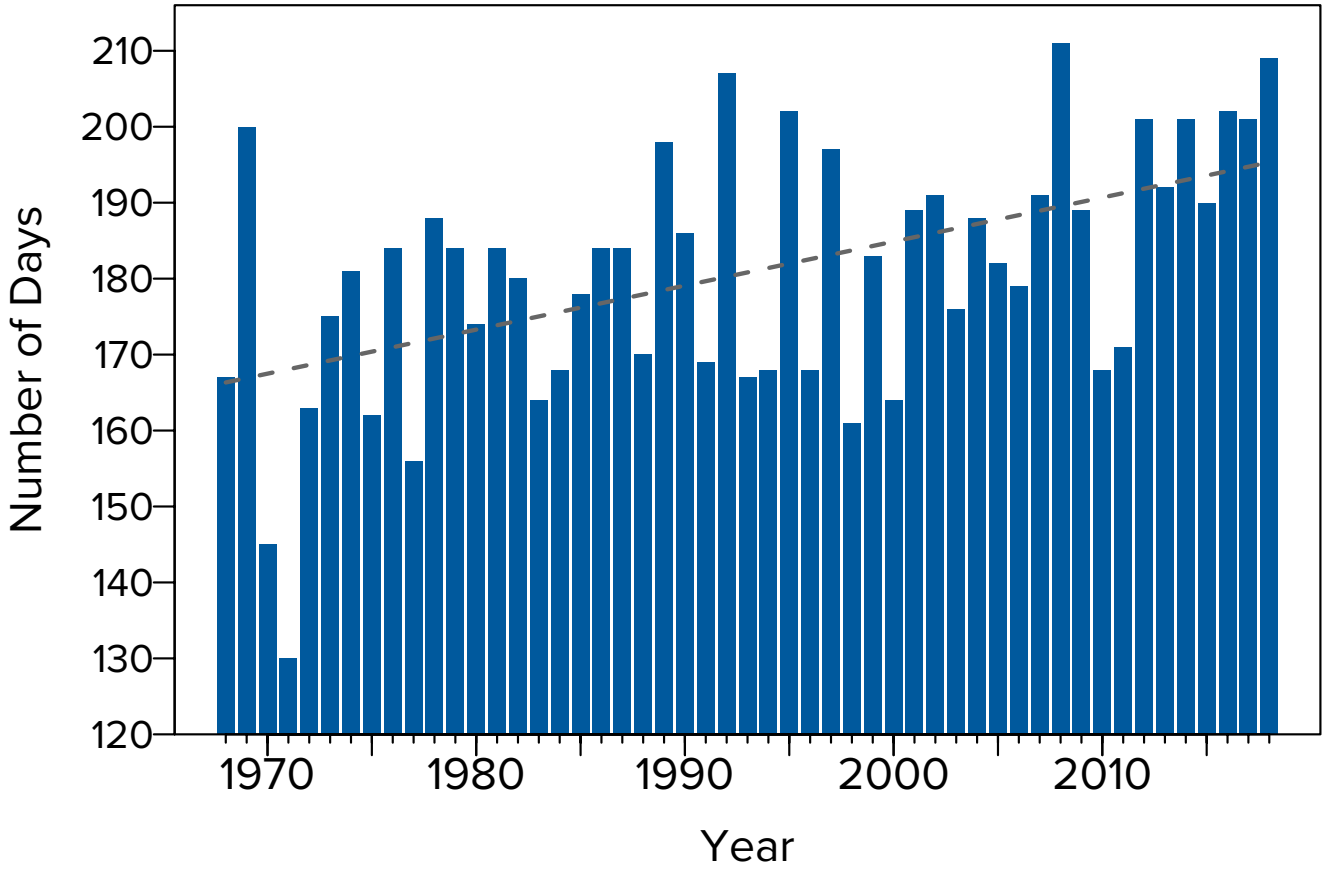
In 2017 and 2018, the stability of the lake was at close to the highest vales on record.



Stratified season length

Since 1968

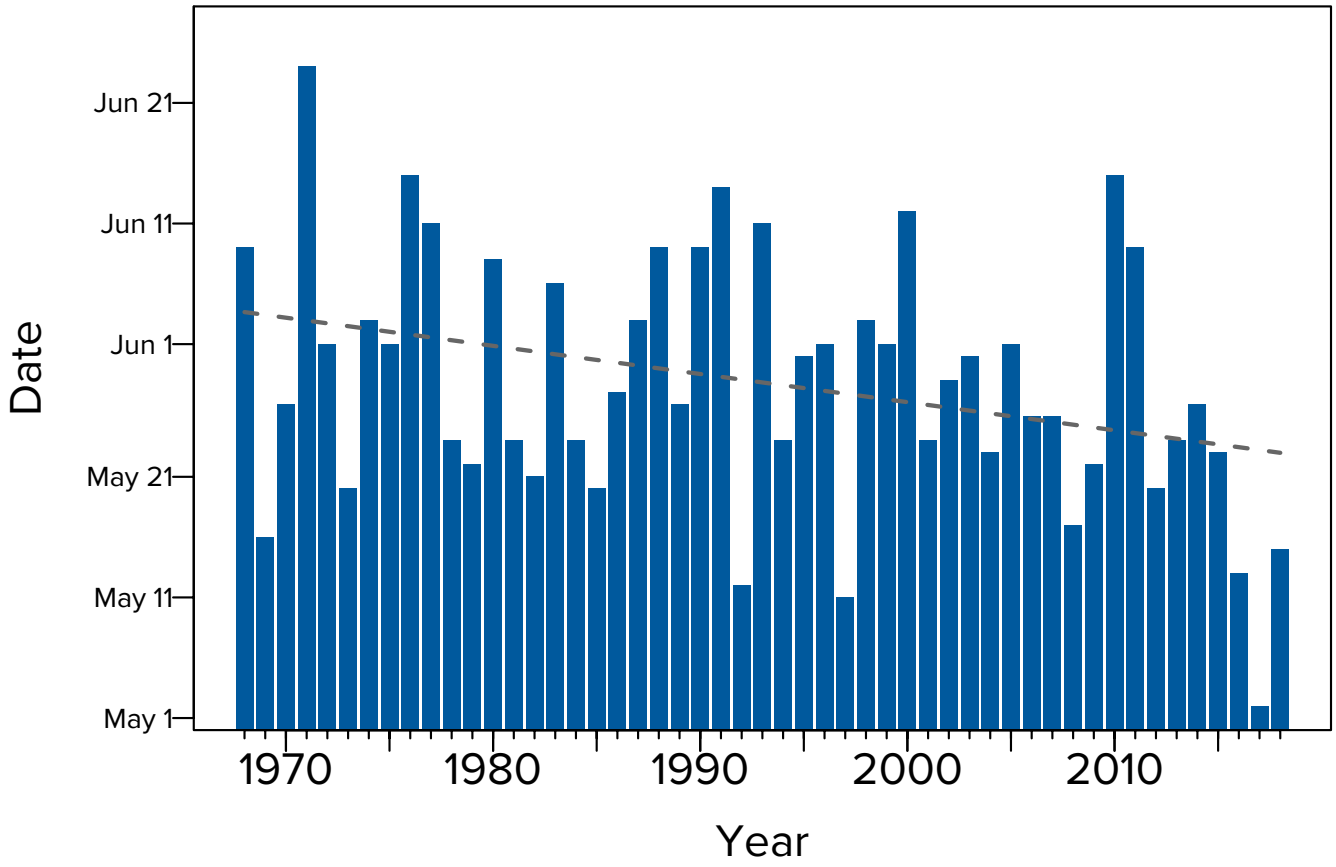
The stability index, a measure of the energy required to fully mix the lake, can be evaluated for every day of the year. We define the stratification season as the length of time when the stratification index exceeds a value of 600 kilograms per square meter. Since 1968, the length of the stratification season has increased, albeit with considerable year-to-year variation. Overall, the stratification season has lengthened by 29 days. In 2018, the length of the stratified season was 209 days.



Beginning of the stratification season

Since 1968

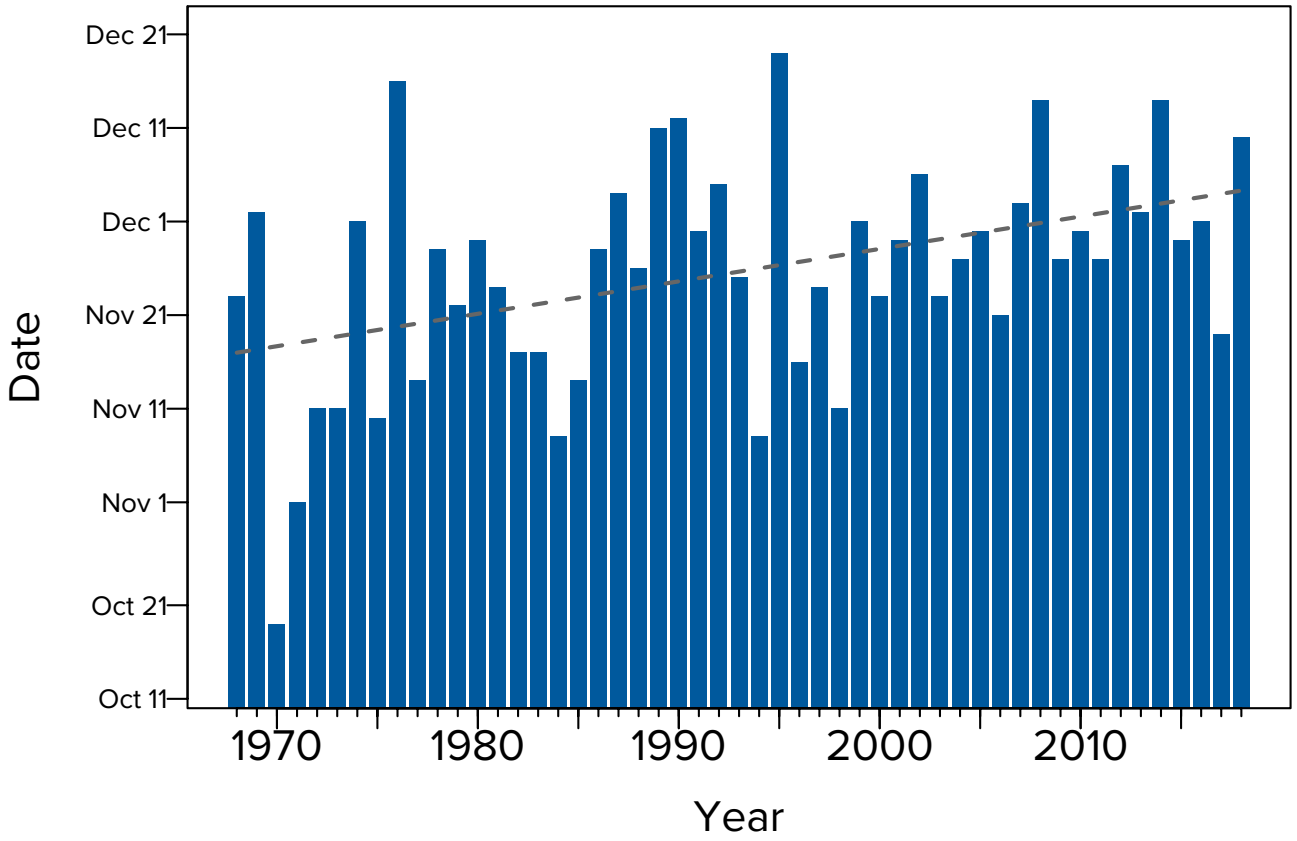
The amount of time that Lake Tahoe is stratified has been lengthening since 1968. One reason for this is the increasingly early arrival of spring as evidenced by the earlier commencement of stratification. Stratification occurs approximately 12 days earlier than it did in 1968. The commencement of the stratification season is typically in late May or early June. In 2018, stratification began on Day 135 (May 15).



End of stratification season

Since 1968

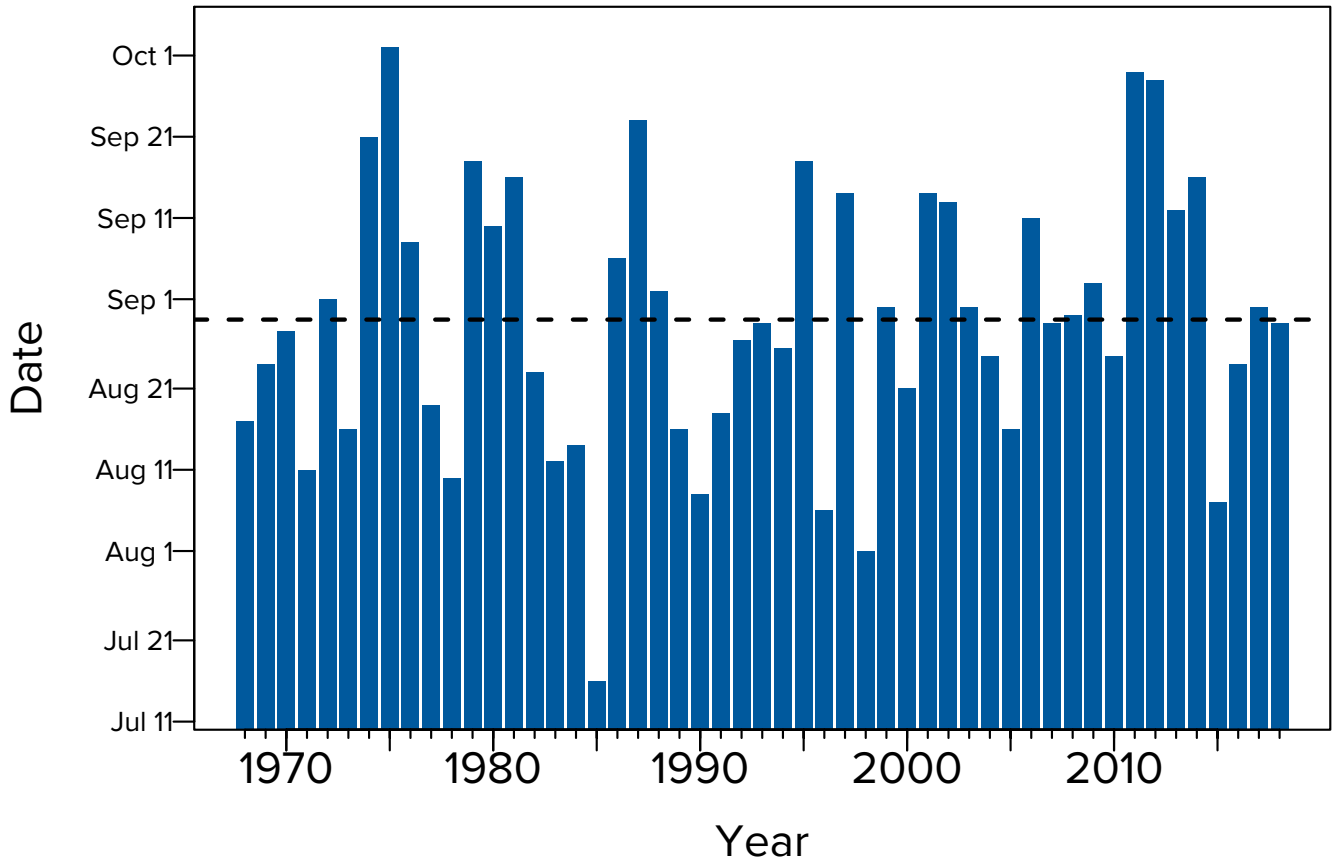
The amount of time that Lake Tahoe is stratified has lengthened since 1968 by almost a month. The end of stratification appears to have been extended by approximately 17 days on average. In other words, the fall season for the lake has been considerably extended. In the late 1960's stratification ended in mid-November. Now it often ends in December. In 2018, stratification ended on Day 334 (December 10) This has 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 only a slight advancement in when the peak occurs. In 2018, the peak occurred on August 29.



Onset of snowmelt pulse

Yearly since 1961

Although the date on which snowmelt commences varies from year to year, since 1961 it has shifted earlier an average of almost 18 days. The snowmelt pulse is calculated for five streams – the Upper Truckee River, Trout Creek, Ward Creek, Blackwood Creek and Third Creek, and the results averaged This shift is statistically significant and is one effect of climate change at Lake Tahoe. In 2018, the average peak snowmelt occurred on March 23. The onset of the pulse is calculated as the day when flow exceeds the mean flow for the period Jan. 1 to Jul 15. In the past, we used the peak of the stream hydrograph to estimate this property.