TAHOE:
STATE
OF THE
LAKE
REPORT
2014

PHYSICAL
PROPERTIES
Lake surface level varies throughout the year. It 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 during 2013. The highest lake level was 6226.32 feet on May 18 and again on June 9, and the lowest was 6223.59 feet on December 31. In 2013, the lake level rose by only 6 inches during snowmelt, compared with 3.9 feet in 2011.
**Physical Properties**

**Lake surface level, continued**

Daily since 2011

Displayed below is the lake surface data from 2011-2013 extracted from the same data on page 8.1. This more detailed presentation of recent lake level data allows us to see the seasonal patterns in greater detail. Data clearly show the lake level only 7 inches above the natural rim at the end of 2013 as well as the timing of highest yearly lake levels in late spring following snowmelt. The effects of the high snowfall in December 2012 on lake level are clearly evident.
Water temperature profiles are measured in the lake using a Seabird CTD at the times indicated by the dots along the top of the figure. The temperature is accurate to within 0.005 °F. Here the temperature in the upper 330 feet is displayed as a color contour plot. In 2013, the lake temperature followed a typical seasonal pattern. In late March, the lake surface was at its coldest. The beginning of the 2013-2014 winter mixing is evident at the end of the plot, with the surface layer both cooling and deepening. By the end of 2013, mixing had proceeded to only 245 feet (74 m), a relatively shallow amount.
PHYSICAL PROPERTIES

Average water temperature
Since 1970

The trend in the volume-averaged temperature of Lake Tahoe has increased by approximately 0.7 °F since 1970. The annual rate of warming is 0.017 °F (0.0094 °C). The monthly temperature profile data from 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 considerably greater, but an unusual number of deep mixing years since 1997 have slowed the warming rate.
PHYSICAL PROPERTIES

Annual average water temperature
Since 1970

The volume-averaged temperature of the lake for each year since 1970 is shown. In 2013 the volume-averaged temperature increased by 0.14 °F (0.08 °C) over the previous year. The years with the largest decreases in temperature generally correspond to those years in which deep mixing occurred. Years with increases in temperature are often associated with a lack of deep mixing.
Surface water temperatures have been recorded monthly at the mid-lake station since 1968 from our research vessel John LeConte. 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 2013, the average surface water temperature was 51.9 °F, a decrease of 0.9 °F (0.5 °C) over 2012, the warmest year yet recorded. The overall rate of warming of the lake surface is 0.029 °F (0.016 °C) per year.
**PHYSICAL PROPERTIES**

**Maximum daily surface water temperature**

Surface temperature measured every 2 minutes since 1999

The maximum daily surface water temperature in 2013 was similar to 2012. The highest maximum daily surface water temperature was 74.32 °F, which was recorded at 2pm on July 20, 2013. The lowest maximum daily surface water temperature was 41.14 °F, which was recorded at 6:50am on March 10, 2012. These data are collected in real-time by NASA and UC Davis from 4 buoys located over the deepest parts of the lake.
Since 1999, surface water temperature has been recorded every two minutes from four NASA/UC Davis buoys. Shown here are 15 years of average surface water temperatures in the month of July when water temperatures are typically warmest. In 2013, July surface water temperature averaged 63.3 °F, compared with 62.7 °F in 2011. This increase is most likely attributable to the absence of deep lake mixing in 2012, an event that cools the surface layers of the lake. The average for the 14 year period is 64.7 °F.
Deep water temperature
Since 1970

The water temperature at a depth of 1320 feet (400 m) is indicative of conditions in the deeper waters (hypolimnion) of Lake Tahoe. Since 1970 the deep water temperature has increased by approximately 1 °F (0.6 °C), at an annual rate of 0.021 °F (0.012 °C), a rate of warming slower than the surface water. This increase has not been steady but is punctuated by occasional drops in temperature. 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 motions of internal waves.
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 to deep waters, promoting aquatic life throughout the water column. The deepest mixing typically occurs between February and March. In 2013, Lake Tahoe mixed to a depth of only 600 feet (180 m). This lack of deep mixing most likely contributed to the warmer surface temperature and the generally higher clarity. Beginning in 2013, the depth of mixing is based on high-resolution temperature profiles rather than nitrate concentration sampled at discrete depths.
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 45 years.
PHYSICAL PROPERTIES

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 lengthened, albeit with considerable year-to-year variation. Overall the stratification season has lengthened by approximately three weeks. See section 6.5 for more information on this trend.
PHYSICAL PROPERTIES

Beginning of the stratification season
Since 1968

The length of time that Lake Tahoe is stratified has lengthened since 1968 by approximately three weeks. The commencement of stratification appears to occur earlier in the year by approximately three days on average. The commencement of the stratification season is typically in late May or early June.
The length of time that Lake Tahoe is stratified has lengthened since 1968 by approximately three weeks. The end of stratification appears to have been extended by approximately 18 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 ends in early December. This has important implications for lake mixing and water quality.
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Peak stratification value
Since 1968

The maximum value that the stability index obtains for each year has been plotted. As can be seen, the strength of the stratification has not changed significantly since 1968. However, as the previous figures indicate, the lake now remains density stratified for a longer period of time.

![Graph showing peak stratification season](image-url)
Mean daily streamflow of Upper Truckee River vs. Truckee River
Water Year 2013

The largest inflowing stream to Lake Tahoe is the Upper Truckee River, which has a natural annual hydrograph typical of a snow-fed stream. The small peaks in the hydrograph represent rain events or short warm periods in winter or spring. The extended seasonal increase (March-June) represents the snowmelt. In 2013 there were two peaks. The first in December had a higher peak streamflow (365 cubic feet per second), but overall a lesser volume of water compared with the spring snowmelt in May (287 cubic feet per second). The peaks were considerably smaller than in 2012 (678 cubic feet per second).

The Truckee River is the only outflow from Lake Tahoe. It is a regulated flow, with release quantity controlled by the Federal water master. As a result, the hydrograph has extended times of near-constant outflow. The release rates are set according to downstream demands for water and concerns for flooding. The maximum discharge in 2013 was 388 cubic feet per second (similar to the previous year), and the peak temperature of the discharge was 72.5 °F (22.5 °C) on July 21. Streamflow data are collected by the US Geological Survey under the Lake Tahoe Interagency Monitoring Program (LTIMP).
Flow into Lake Tahoe (e.g. Upper Truckee River) and discharge out of Lake Tahoe (Truckee River at Tahoe City) have shown considerable variation since 1980. The large peaks in discharge from the lake correspond to years when precipitation (and therefore total inflow) was the greatest, e.g. 1982-1983, 1986, 1995-1999. Similarly, the drought-like conditions in the early 1990s and the low precipitation years in the beginning of the 2000s also stand out. Since many of the pollutants of concern for Lake Tahoe's clarity enter along with surface flow, year-to-year changes in clarity are influenced by precipitation and runoff. The average Upper Truckee annual inflow volume since 1981 is 3.05 billion cubic feet, while the average annual outflow through the Truckee River is 7.23 billion cubic feet. In 2013 discharges into and out of the lake were well below the long-term averages. The Upper Truckee River inflow volume was 1.95 billion cubic feet. The Truckee River discharge was 5.40 billion cubic feet.
Water temperature of the Truckee River as it departs Lake Tahoe in the summer months (July-September) is measured by the US Geological Survey. Data gaps prevent a complete pattern, but the measurements suggest that a 4-5 °F (2.2-2.8 °C) rise in the average temperature may have occurred since 1993. Average air temperatures from Lake Tahoe for the same period also suggest a temperature rise but at a lower rate. Elevated river temperatures can negatively impact downstream fish spawning.
**PHYSICAL PROPERTIES**

**Truckee River Summer Discharge and Lake Elevation**

*Since 1980*

Flow rate of the Truckee River as it departs Lake Tahoe in the summer months (July-September) and lake level for the same period is measured by the US Geological Survey. Here the relationship between these two variables is evident, with mean daily river discharge typically showing a one – two year lag from the lake elevation. Gage height is measured relative to a datum of 6,220 feet. Release of water from Lake Tahoe is controlled by the Federal Water Master.