# TAHOE: STATE OF THE LAKE REPORT 2022

# BIOLOGY

UCDAVIS
Tahoe Environmental
Research Center

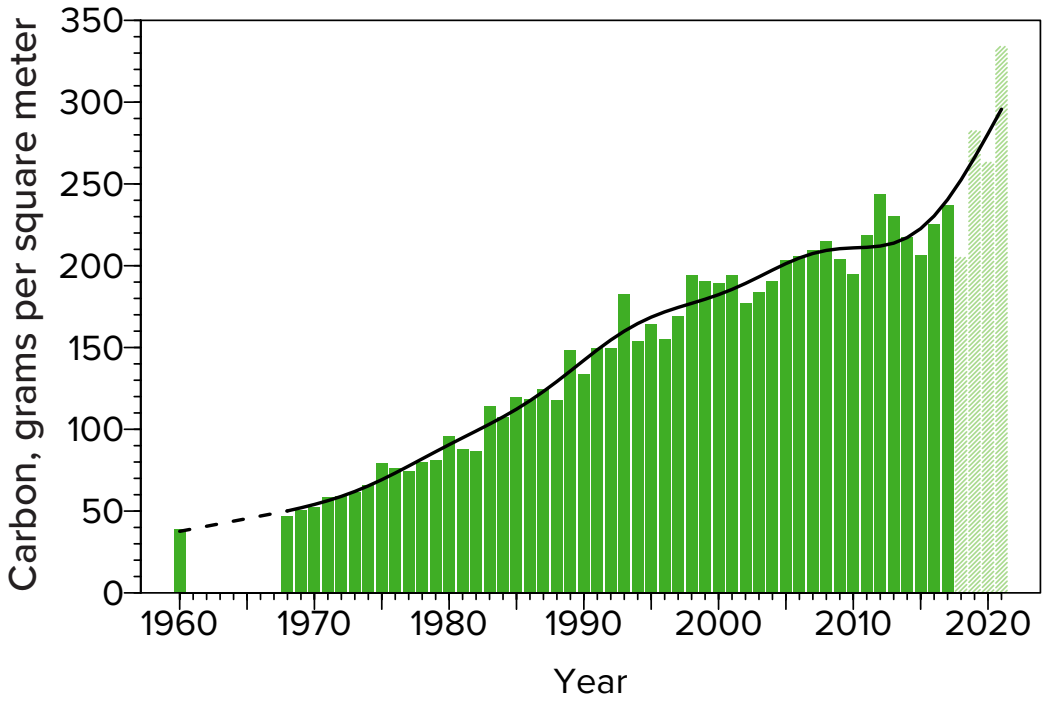
# Algae growth (primary productivity)

**Yearly since 1959**

Primary productivity is a measure of the rate at which algae produce biomass (carbon) through photosynthesis. It was first measured at Lake Tahoe in 1959 and has been continuously measured since 1968. Supported by nutrient loading into the lake, changes in the underwater light environment, and a succession of algal species, the trend shows that primary productivity has increased substantially over time. Data since 2018 are considered "provisional" due to changes in instrumentation and methodology that are under review.

As plotted, the data show that there has been a six-fold increase in primary productivity over the last 50 years. In 2021, primary productivity attained an all-time high annual value of 334 mg of carbon per $m^2$, an increase of 20 percent over the previous highest year in 2019. In 2021, the measured primary productivity was a maximum in April at a depth of 30 m (100 ft). From July through December, the peak productivity was always above 20 m (66 ft). While significant uncertainties remain, the increase in primary productivity in 2021 is believed to be associated with a combination of environmental factors that favored the seasonal dominance of the pennate diatom *Synedra*, the major biomass contributor, and the filamentous cyanobacteria, *Leptolyngbya* sp. which was the most abundant species in this particular year.

Data source: TERC lake monitoring.

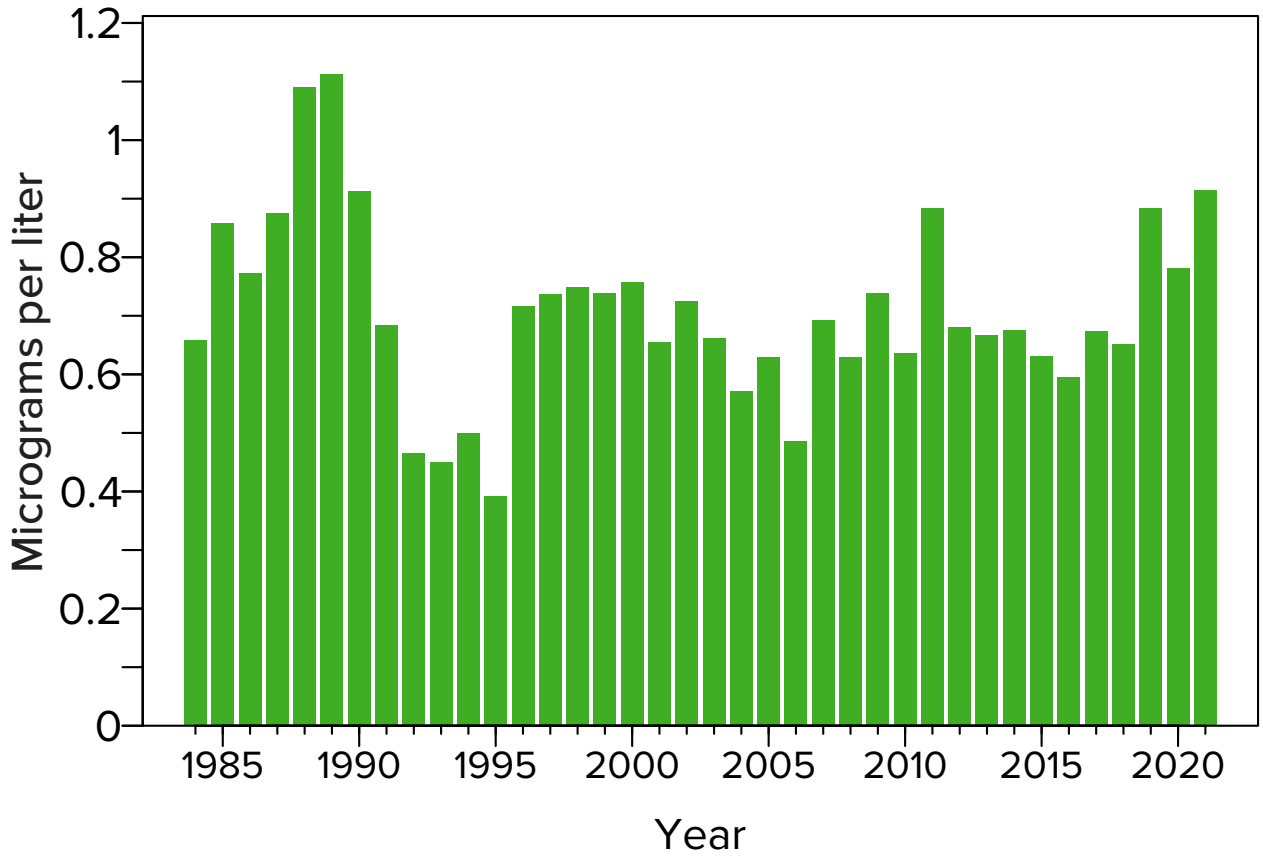


## Phytoplankton chlorophyll

**Yearly since 1984**

Phytoplankton (Algae) are the base of the Lake Tahoe food web and essential for lake health and the well-being of the entire ecosystem. One measure of the amount or biomass of free-floating algae in the water is determined by extracting and measuring the concentration of chlorophyll-*a*, a photosynthetic pigment that allows plants to convert energy from the sun. Though the value varies annually, it has shown remarkable consistency over the last 25 years, and 2021 maintained this pattern. The average annual concentration for 2021 was 0.91 micrograms per liter. For the period of 1984–2021 the average annual chlorophyll-a concentration in Lake Tahoe was 0.71 micrograms per liter.

Data source: TERC lake monitoring.

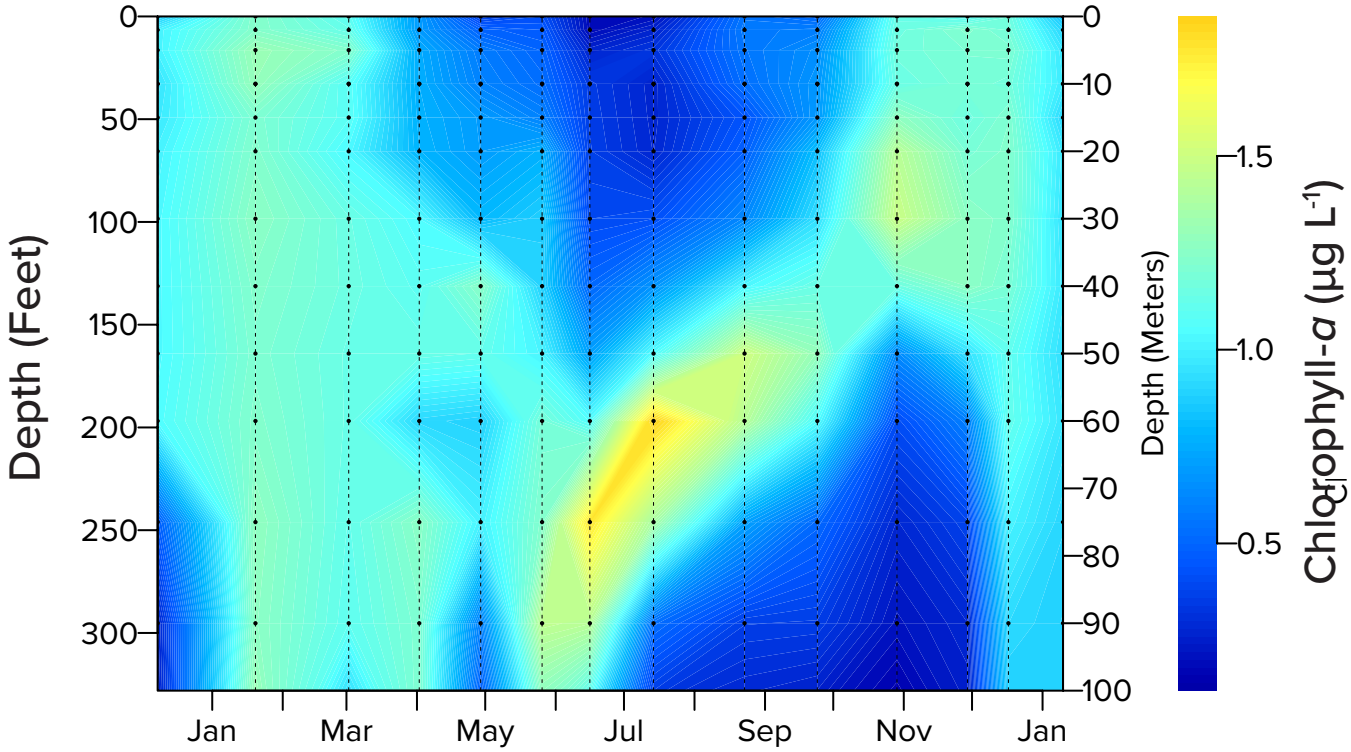


## Chlorophyll-*a* distribution

**In 2021**

The distribution of algae (measured as chlorophyll-*a*) is the result of a combination of light availability, nutrient availability, mixing processes and, to a lesser extent, water temperature. This figure shows color contours of chlorophyll-*a* concentration to a depth of 350 feet. Below this depth chlorophyll-a concentrations are near zero due to the absence of light. Lake Tahoe generally has a "deep chlorophyll maximum" (DCM) in the summer that occupies the range of 150–300 feet in the water column. In that depth range, the light and nutrient conditions are most favorable for algal growth.

In 2021, this pattern changed significantly. The DCM started to form at 250 ft in June and July of 2021, but then progressively became shallower throughout the summer, until fall mixing in late November. This pattern is unlike any previous year. The cause of this change may be due in part to the reduction in sunlight and UV radiation that occurred due to wildfire smoke. Phytoplankton need sunlight to photosynthesize, so such an upward shift is not unexpected. There was also a major change in the relative abundance and species composition, with the emergence of the filamentous cyanobacteria *Leptolyngbya* sp., observed between September and December.

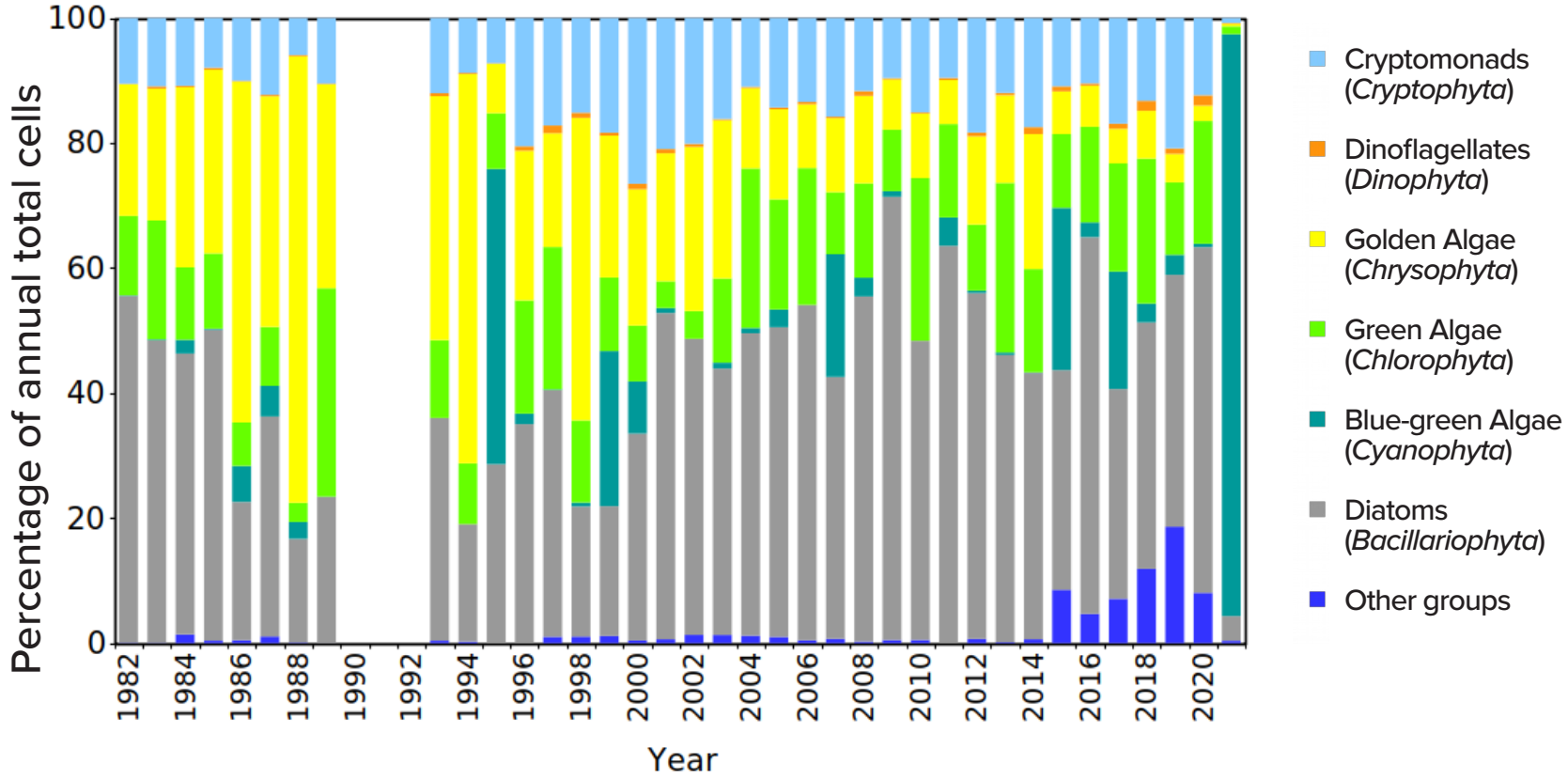


## Annual distribution of algal groups

**Yearly since 1982**

There are six major taxonomic groups represented in the phytoplankton from Lake Tahoe. The total number of algal cells from different groups varies from year to year. Diatoms are generally the most common type of algae. In 2021, there was a major shift in the phytoplankton composition, with an abrupt increase in the abundance of the cyanobacteria *Leptolyngbya* sp. extending from September through the end of the year. This was the only year on record in which a single taxon belonging to the cyanobacteria group dominated the phytoplankton assemblage. *Leptolyngbya* is a simple filamentous genus that in Lake Tahoe includes an extremely narrow species, generally with cells 1–2 microns wide, which makes them important for clarity. Individual filaments display a visible sheath comprising of dozens of individual cells and can be over 200 microns in length.

Data source: TERC lake monitoring. No data in 1990-1992.

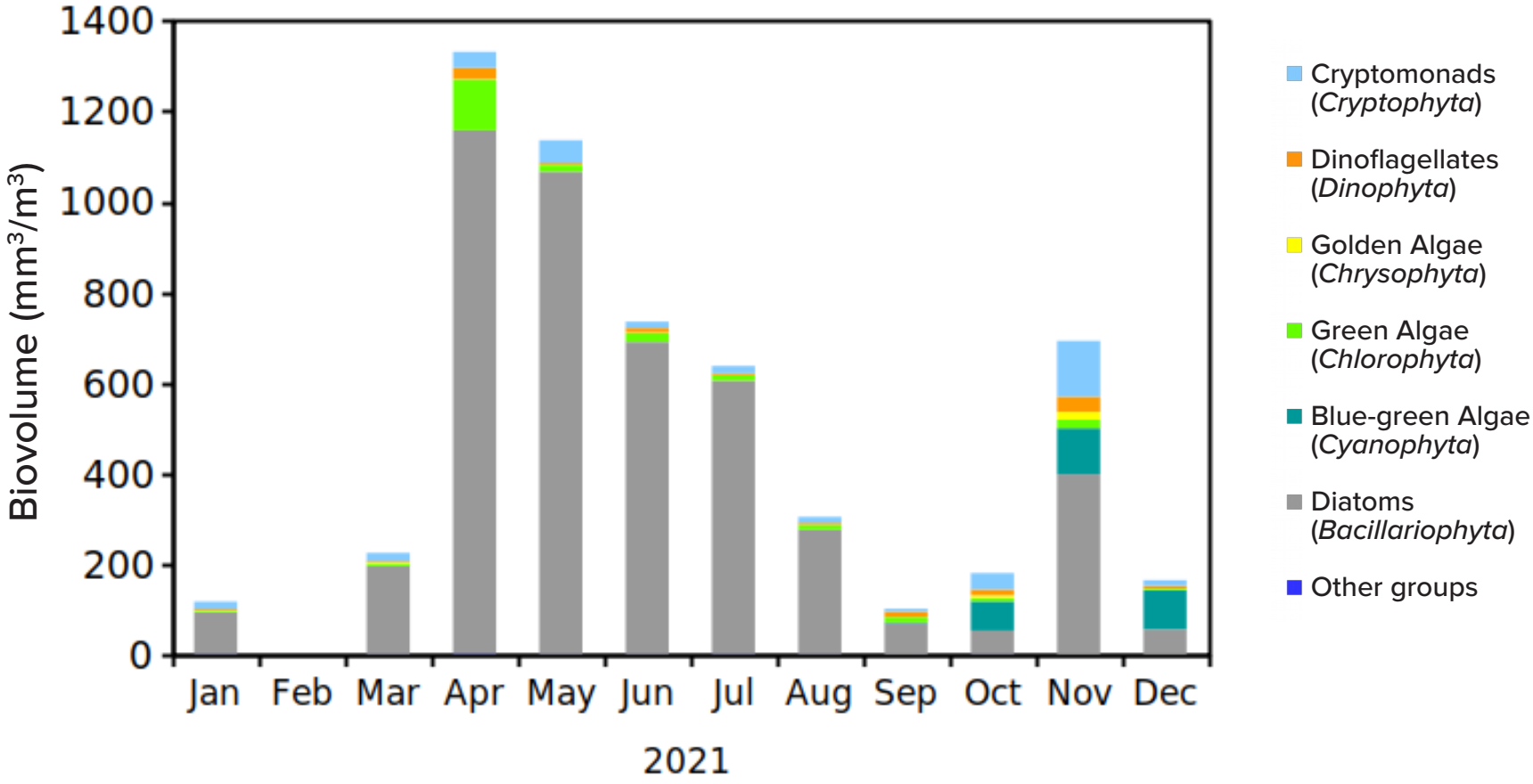


## Algal groups as a fraction of total biovolume

**Monthly in 2021**

The total biovolume of different algal genera vary month to month as well as year to year. In 2021, despite the fact that cyanobacteria dominated algal abundance on the basis of the number of individual cells, diatoms again dominated the biovolume (proportional to the mass) of the phytoplankton community in every month. The peak in the monthly average biovolume occurred in April and May 2021. This "spring bloom" is a typical occurrence in Lake Tahoe and many other lakes. The peak biovolume in 2021 was over 1300 cubic millimeters per cubic meter, six times the usual peak biovolume. There was also a smaller "fall bloom" in November.

Data source: TERC lake monitoring. No data in February.



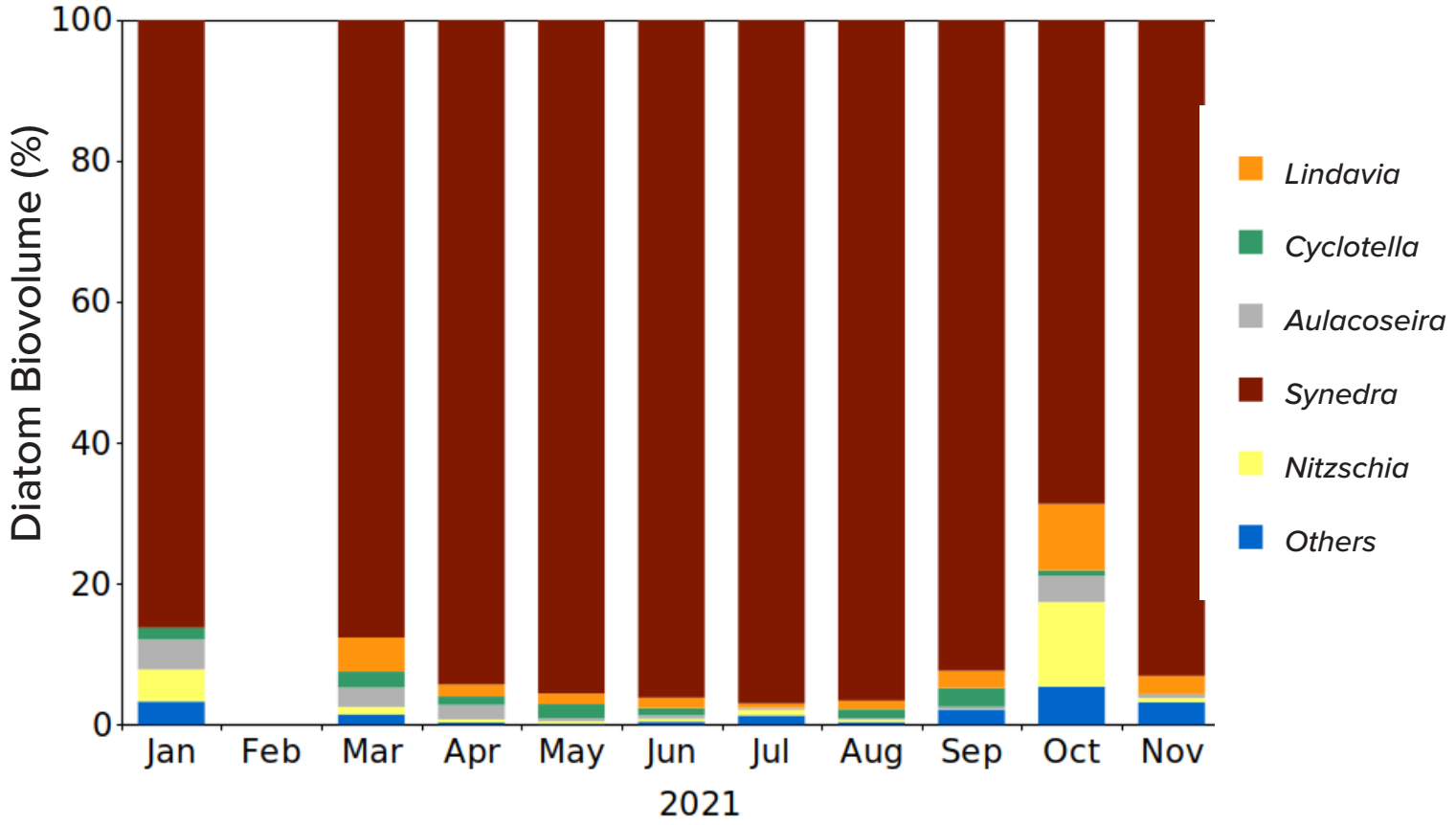
## Abundance of dominant diatom species

**Monthly in 2021**

Since regularly monitoring commenced in 1982, diatoms have been the dominant algal group at Lake Tahoe for all but a few years. Diatoms are unique in that they contain a cell wall made of silica, called a frustule. The dominant diatoms at Lake Tahoe in 2021 are shown below.

Normally there are large variations in the relative composition by month. In 2021, *Synedra* was dominant in terms of biovolume, forming over 80 percent of the diatom biovolume during every month except October. Although *Cyclotella* was a relatively low fraction of the percentage of biovolume of diatoms in 2021, this was a year in which the total algal biovolume was exceptionally high.

Data source: TERC lake monitoring. No data in February.

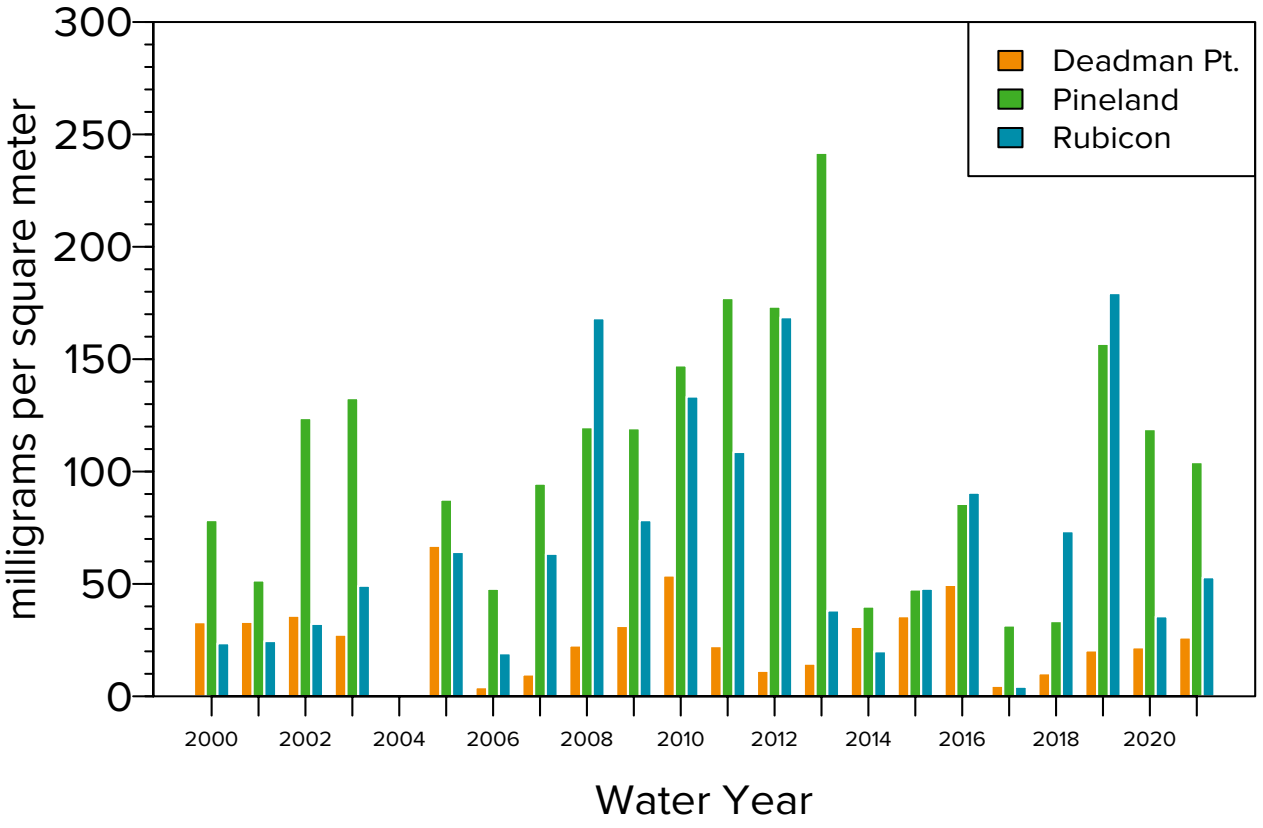


## Peak shoreline algae concentrations

**Yearly since 2000**

Periphyton, or attached algae, makes rocks around the shoreline of Lake Tahoe green and slimy, or they sometimes form a very plush white carpet after being sun-bleached. This graph shows the maximum biomass measured at 1.5 feet (0.5 m) below the surface at three sites from January to June. In 2021, concentrations at the Deadman Pt. and Pineland sites were very close to their long-term average, while Rubicon was 26 percent lower than the long-term average. Monitoring periphyton is an important indicator of near-shore health. In the last four years, TERC has been using whole-lake aerial to better represent the spatial extent of periphyton blooms. See Figure 6.11 for more details.

Data source: TERC lake monitoring. No data in 2004.



## Shoreline algae distribution

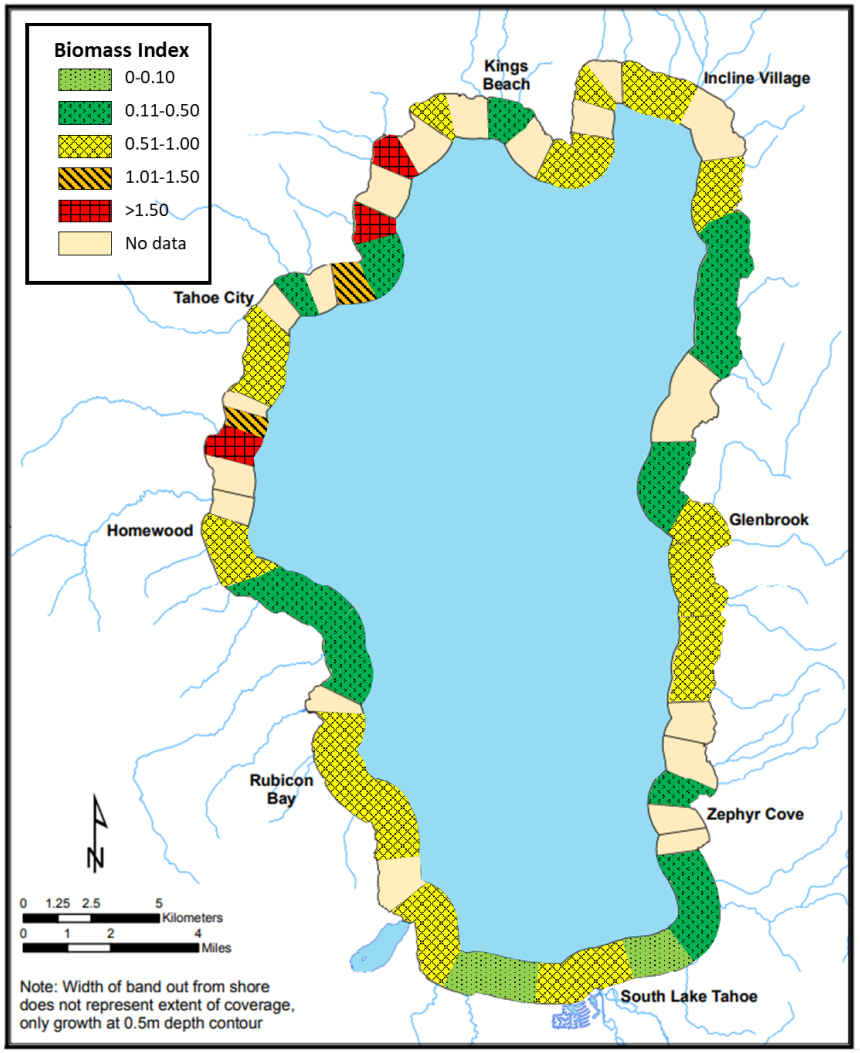
**In 2021**

Periphyton biomass was surveyed around the lake over a three-week period during the spring of 2021, when it was estimated to be at its annual maximum. Over 50 locations were inspected by snorkel survey in 1.5 feet (0.5 m) of water. A Periphyton Biomass Index (PBI) is used as an indicator to assess levels of periphyton. The PBI is defined as the fraction of the local bottom area covered by periphyton multiplied by the average length (cm) of the algal filaments. There were fewer sites with a high PBI in 2021 than the previous year. The majority of the high PBI sites were on the California side. Compared to previous years, this is considered a near-average year. Most of the east shore had relatively low growth. This is in part a reflection of the high wave activity that causes the periphyton to slough, as well as generally lower amounts of precipitation and runoff along the east shore.

Data source: TERC lake monitoring.

*Note: The width of the colored band does not represent the actual dimension of the onshore-offshore distribution. Similarly, its length does not represent the precise longitudinal extent.*

**Distribution of Periphyton Biomass at 0.5m Depth, Spring 2021**



## *Mysis* population

**Since 2012**

*Mysis* shrimp were introduced to Lake Tahoe in the 1960s in an attempt to improve the size of game fish in the lake. The intended result did not occur and instead the *Mysis* upset the existing lake food web. Within four years of their introduction, they had decimated the populations of the native *Daphnia* and *Bosmina*. Since that time, these zooplankton are rarely observed. *Daphnia* and *Bosmina* were once an important food source for native minnows, which in turn provided food for kokanee salmon and rainbow trout.

Research on *Mysis* essentially stopped in the 1980s. Since 2012, regular surveys have recommenced in Lake Tahoe and in Emerald Bay, albeit at a minimal scale, funded by philanthropic gifts. Because *Mysis* migrate to the lake bottom during the day, sampling occurs at night. The sampling net is pulled vertically in Lake Tahoe at 3-month intervals from three sites: South Shore Deep (200 m), LTP Index (100 m) and MLTP (200 m). Since early 2022, sampling has increased to monthly intervals

The *Mysis* densities (number of individuals collected divided by the net opening area) in Lake Tahoe show large variability. The red dashed line at 27 individuals per $m^2$ represents the *Mysis* population level below which *Daphnia* and *Bosmina* can reestablish. During 2021, values were slightly above that threshold. In 2022, however, the numbers have fallen far below that threshold and are currently in single digits. As *Mysis* in Lake Tahoe generally exhibit three to four year classes, the absence of all classes suggest that it may take several years for the Mysis population to rebuild. It is expected that *Daphnia* and *Bosmina* will return in 2023, potentially bringing a significant increase in lake clarity.