TAHOE: STATE OF THE LAKE REPORT 2024

BIOLOGY

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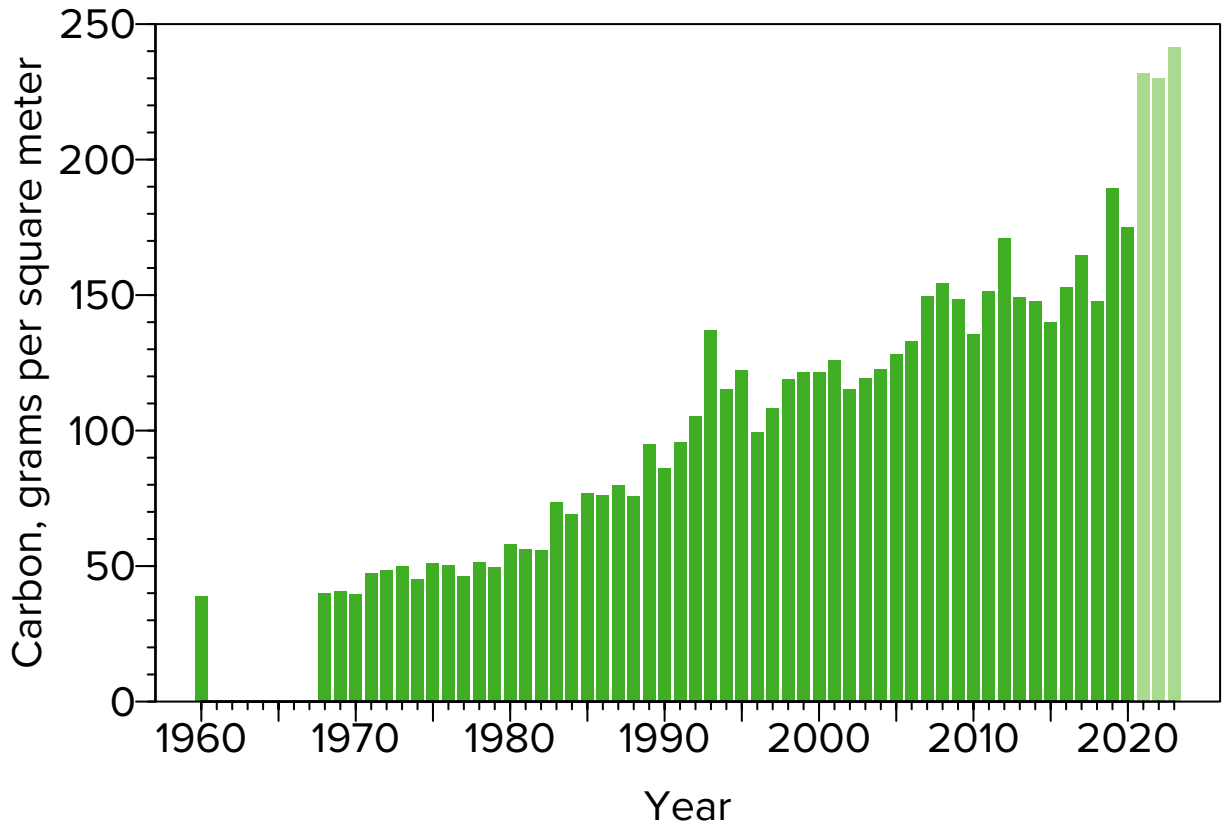
Algae growth (primary productivity)

Yearly since 1959

Primary productivity is a measure of the rate at which algae incorporate inorganic carbon through photosynthesis to produce organic matter or biomass. It was first measured at Lake Tahoe in 1959 and has been measured continuously since 1968. Regulated by a complex interplay of nutrient availability, light levels, temperature, composition and physiological state of algae, and many other factors, the long-term trend shows that primary productivity has increased over time, particularly in the last few years.

The long-term dataset was recently reviewed and corrected data show that over the last 55 years, there was a 480% increase in the annual average primary productivity. Since 2021, there have been extremely high standard deviations indicative of highly fluctuating month-to-month values. In 2023, the annual average primary productivity attained a record high value of 240 mg of carbon per m^2.

Data source: TERC lake monitoring.

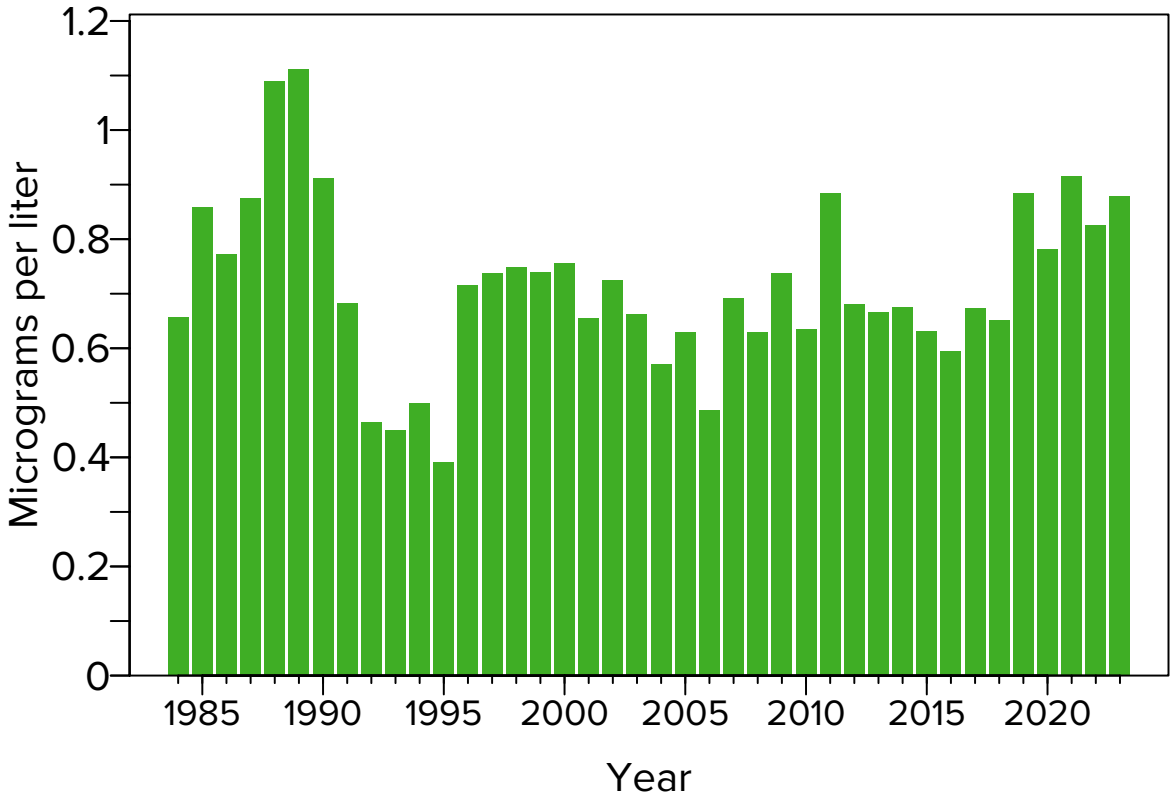


Phytoplankton chlorophyll annually

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. Like land plants, all phytoplankton have chlorophyll-a which is a photosynthetic pigment that allows them to absorb and covert light energy into biomass. Therefore, measurements of the concentration of chlorophyll-a of phytoplankton can be used to estimate the algal biomass in the lake water. Though the value varies annually and at different depths throughout the lake, for the last 26 years the average concentration has shown remarkable consistency and 2023 continued along this pattern. The average annual concentration for the year was 0.88 micrograms per liter, a slight increase from the previous year. For the period of 1984–2023 the average annual chlorophyll-a concentration in Lake Tahoe was 0.72 micrograms per liter.

Data source: TERC lake monitoring.

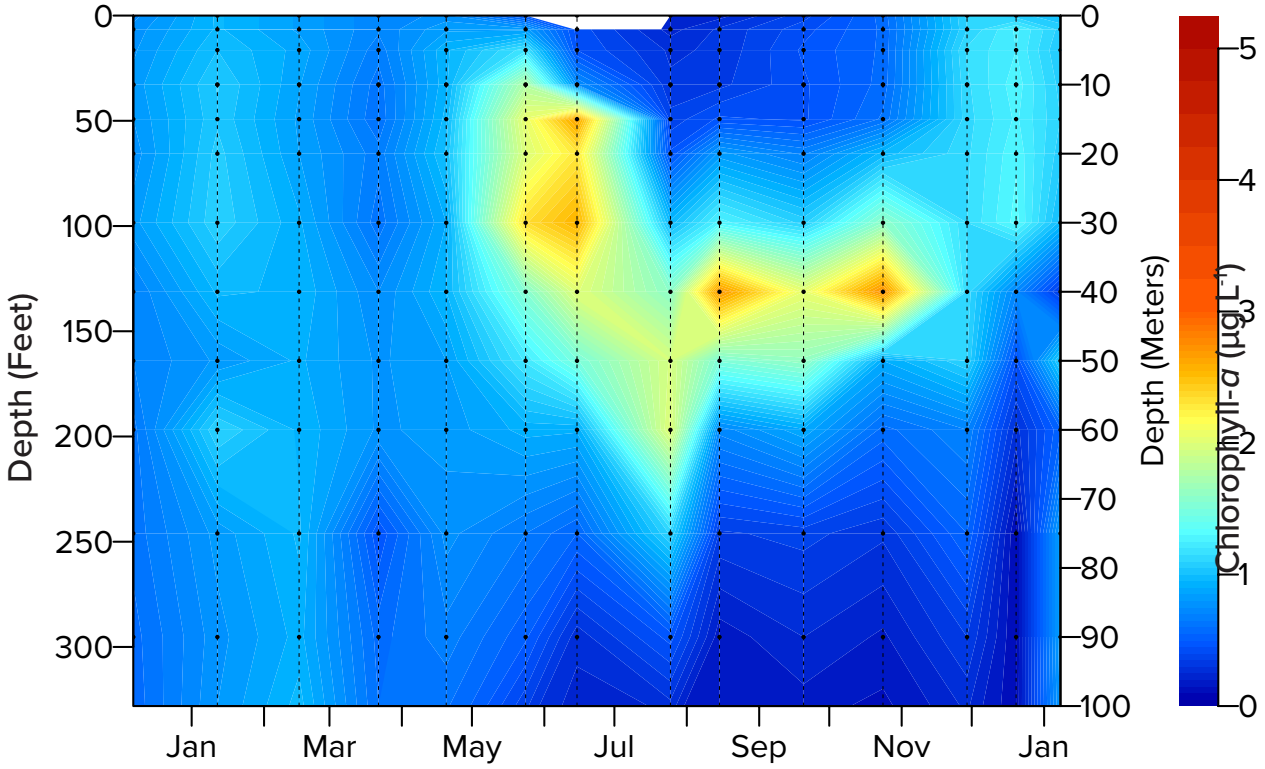


Chlorophyll-*a* spatial distribution

In 2023

The spatial and temporal distribution of chlorophyll-a at the euphotic zone (to a depth of 350 feet.) Below this depth, chlorophyll-a concentrations are near zero due to the absence of light. Lake Tahoe typically has a distinct deep chlorophyll maximum (DCM) in the summer that occupies the range of 150–300 feet (45-90 m) in the water column, well below the thermocline.

In 2023, however, DCM was present in a much shallower range mostly between 30-160 feet (9-49 m) in the water column. The full mixing of the lake and redistribution of nutrients in the water column in March and April may have contributed to the development of a chlorophyll peak at shallow depths during late May and June. During a short period in late-July the warmer surface water extended in depth, and elevated levels of chlorophyll-a were similarly observed reaching 250 feet (76 m). On two occasions, secondary chlorophyll-a peaks occurred after the onset of thermal stratification. Later in December, then again, with the commencement of mixing, the algae were redistributed in the water column.

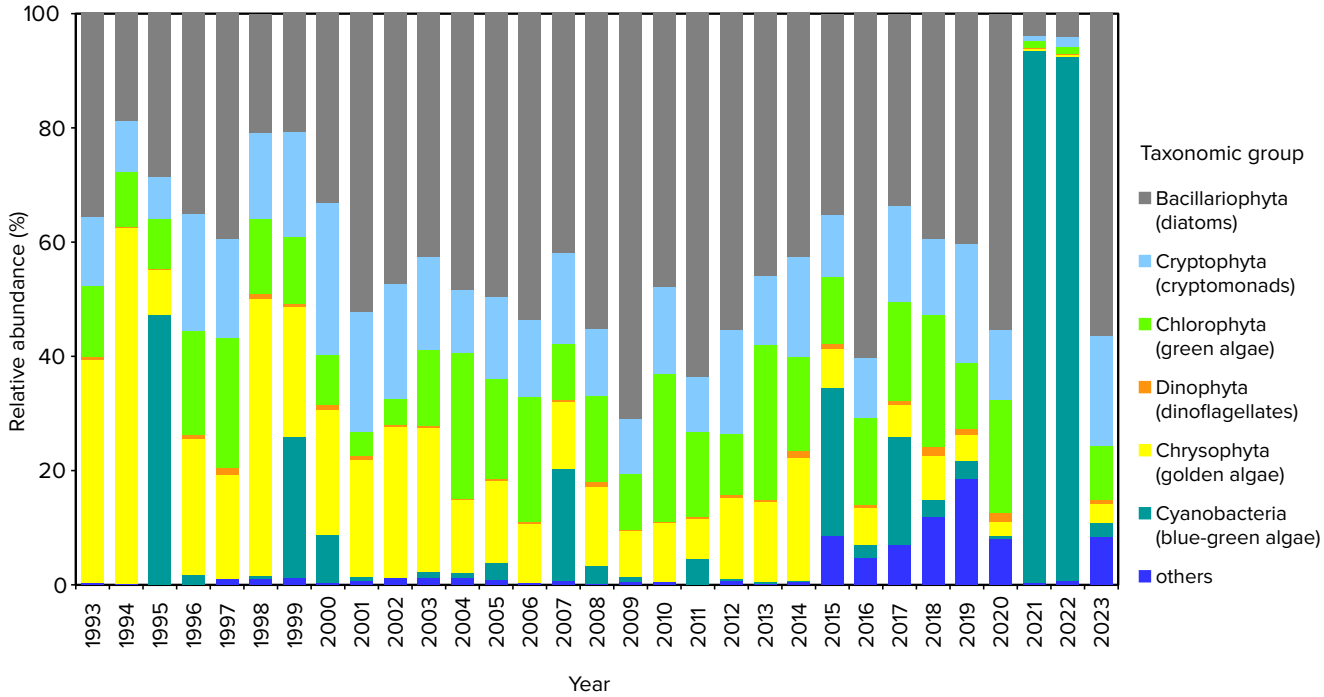


Distribution of algal groups

Yearly since 1993

There are six major taxonomic groups represented in the pelagic phytoplankton from Lake Tahoe. The relative abundance of different groups varies from year to year, but diatoms are generally the most common type of algae. In 2021 and 2022, cyanobacteria dominated the phytoplankton assemblage part of a single, contiguous event resulting from nutrient inputs from the Caldor Fire. In 2023, diatoms comprised approximately 56 percent of the total abundance of algal cells, following a two-year period of major composition change with unusual dominance of cyanobacteria. This shift was likely associated to contiguous event resulting from the Caldor Fire. Cryptomonads, green-algae and golden-algae comprised respectively 19, 9.5 and 3 percent of the total cell counts in 2023, while cyanobacteria accounted for 2.5 percent of total. While the proportion of the major algal groups show a degree of consistency from year-to-year, TERC research has shown that the composition of individual species within the major groups is changing both seasonally and annually in response to climate and changing conditions.

Data source: TERC lake monitoring.

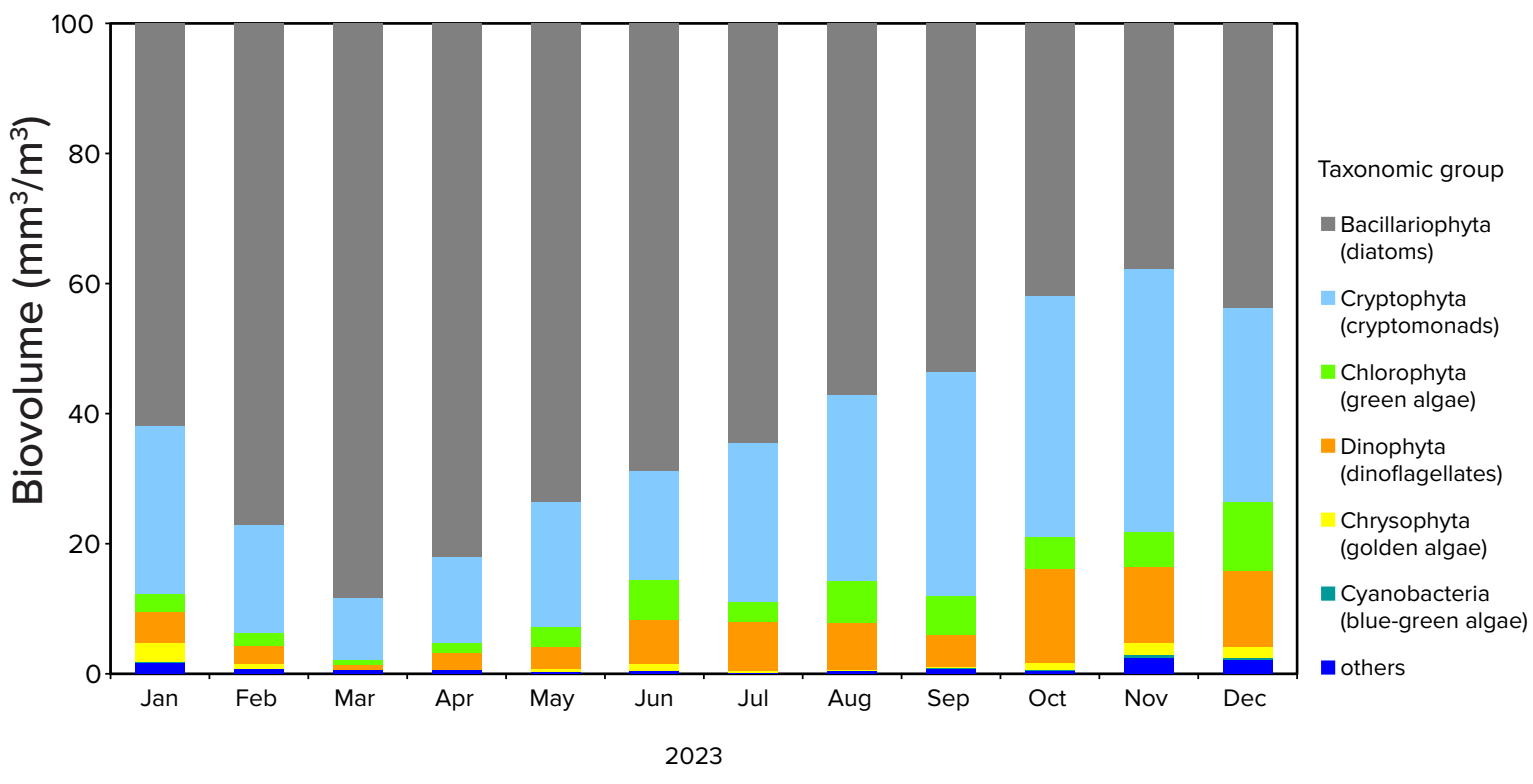


Algal groups as a fraction of total biovolume

Monthly in 2023

The biovolume of algal populations usually vary seasonally as well as year to year. In 2023, the total biovolume was largely dominated by diatoms. The highest biovolume was recorded between March and May with the occurrence of a peak of 320 cubic millimeters per cubic meter in April. This "spring bloom" is a typical occurrence in Lake Tahoe and many other temperate lakes. Annual minima occurred between late-fall and early-winter. While the proportion of the major algal groups have shown a degree of consistency from year-to-year. TERC data show how extreme events can easily disrupt balance of these groups in Lake Tahoe for multiple years before returning to baseline conditions.

Data source: TERC lake monitoring.



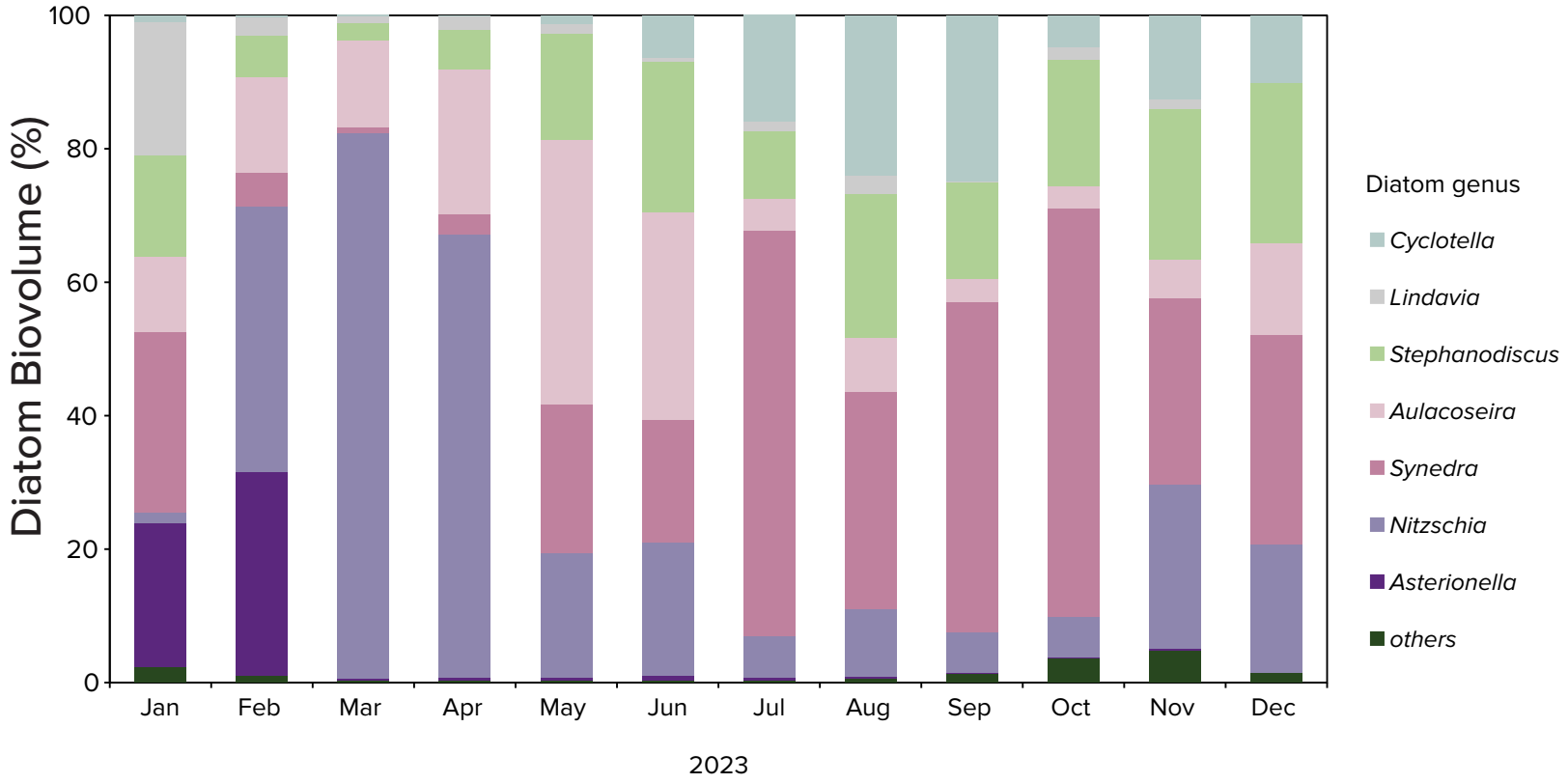
Abundance of dominant diatom species

Monthly in 2023

Since 1982, diatoms have been the dominant algal group at Lake Tahoe for all but a few years. Diatoms are unique among algae in that they have a rigid cell wall made of silica, called a frustule. The relative abundance of dominant diatoms in terms of depth-integrated biovolume at Lake Tahoe in 2023 are shown below.

There were large variations in the relative composition with the succession of seven major genera throughout the year. The genera *Asterionella*, *Lindavia*, *Stephanodiscus*, *Synedra*, *Nitzschia*, and *Aulacoseira* are all relatively large diatoms, while Cyclotella is in a smaller size range. It is worth noting that in terms of cell counts, larger forms may be less abundant than smaller ones, but their biovolume may have higher contribution to the total biomass.

Data source: TERC lake monitoring.



Mysis population

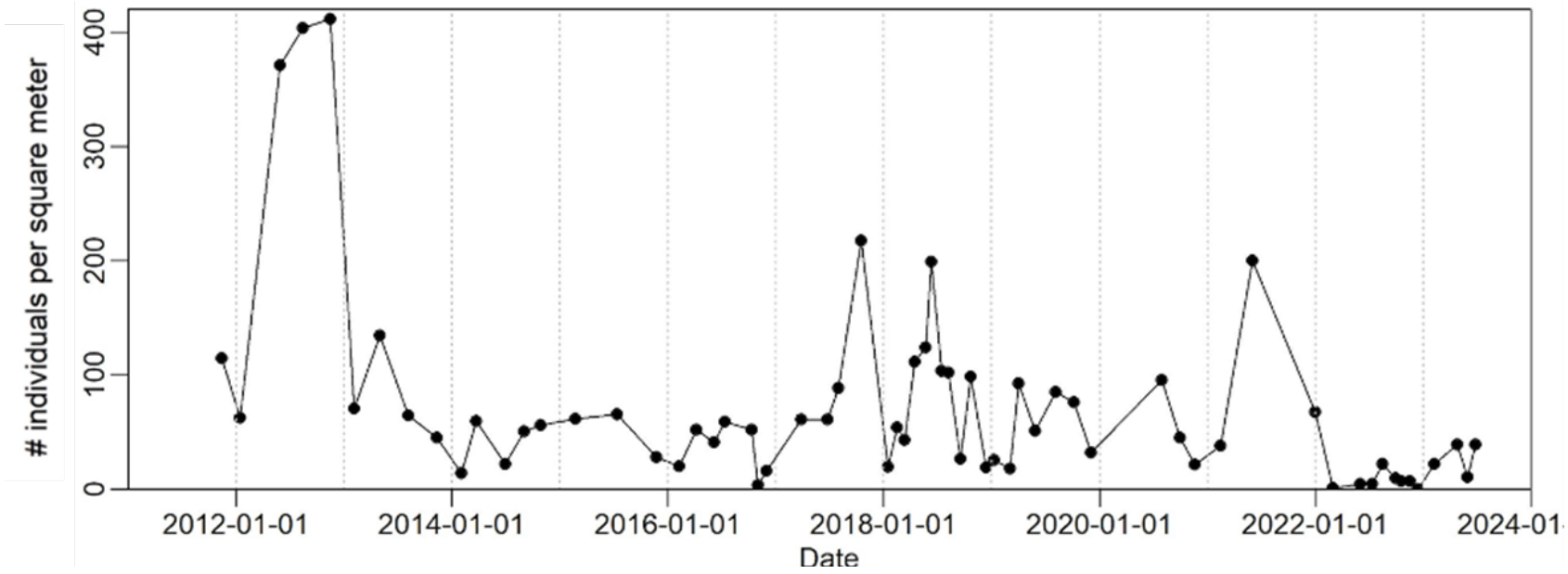
Since 2012

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 cladocerans (*Daphnia* and *Bosmina*) and 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.

In the 1980s, research on *Mysis* essentially stopped. However, since 2012, TERC has recommenced regular surveys of Lake Tahoe and Emerald Bay. 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 considerable variability. It is estimated that a *Mysis* population of 27 individuals per square meter represents the threshold at which cladocerans can reestablish. In early 2022, *Mysis* numbers fell below that threshold and remained low through the end of the year. In 2023, the *Mysis* population in Lake Tahoe has started to recover.

Data source: TERC lake monitoring.



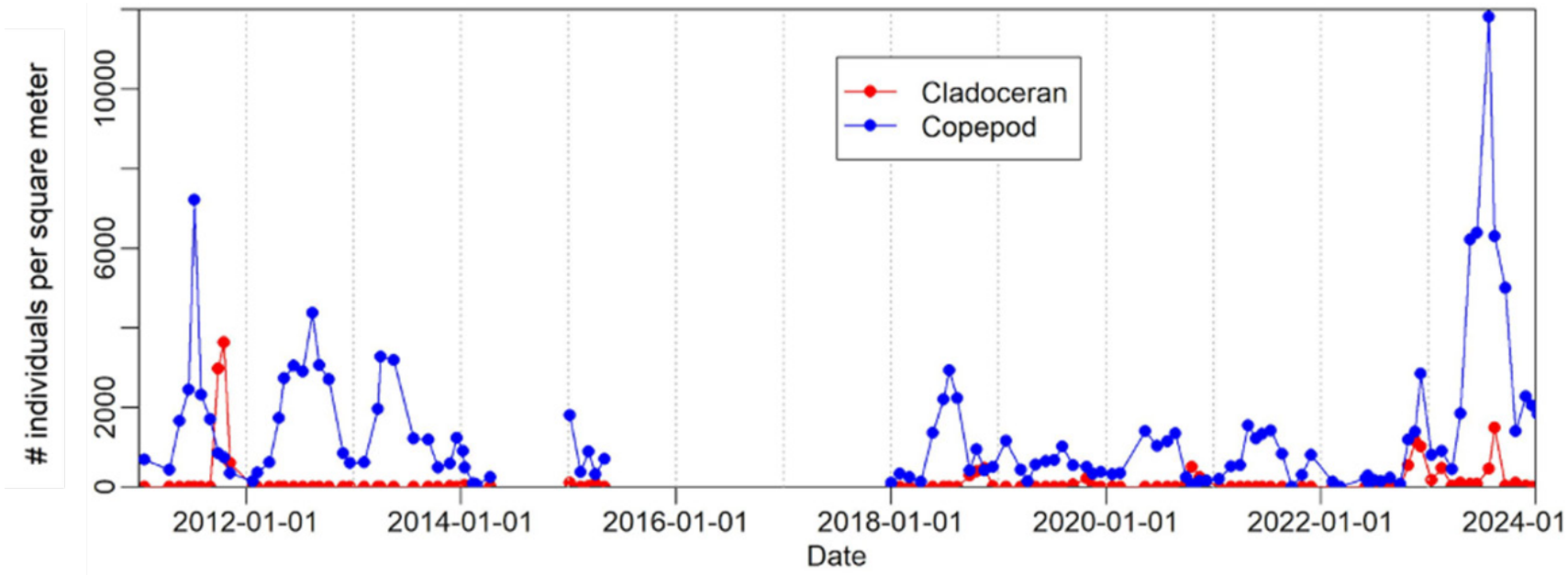
Zooplankton populations

Since 2012

The zooplankton populations in Lake Tahoe have been monitored episodically since the 1960s, but due to a lack of funding there are many data gaps. Since 2012, TERC has sought to re-establish monitoring. The data shown below are from the LTP site, where zooplankton were collected with replicate vertical trawls from a depth of 330 feet to the surface during the middle of the day.

The figure shows the abundance of three groups of zooplankton — cladocerans (*Daphnia* and *Bosmina)* and copepods (*Epischura* and *Diaptomus*). The cladocerans are typically at very low values, a feature that first occurred after the introduction of *Mysis* shrimp in the 1960s. Notably at the end of the record, in September 2022, their numbers increase. The copepods are generally variable, but in late 2021 their numbers collapsed possibly due to a fungal infection.

Data source: TERC lake monitoring.



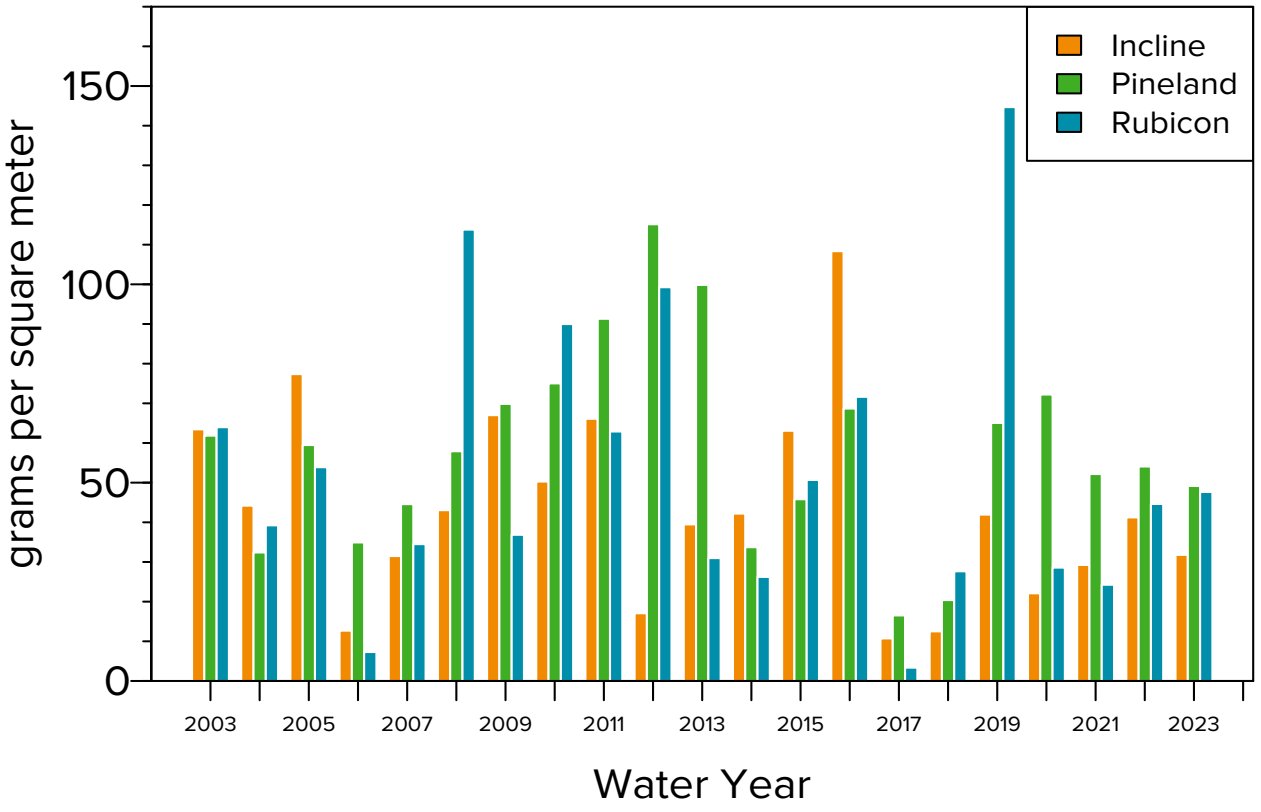
Peak shoreline algae concentrations

Yearly since 2003

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 2023, concentrations at the Incline, Pineland, and Rubicon sites were all below their long-term average.

This data is a part of the newest whole-lake aerial approach to better represent the spatial extent of periphyton blooms. This site-specific measuring does not capture the critically important spatial extent of periphyton blooms but does maintain a long-term record for comparison with the much larger dataset currently being collected.

Data source: TERC lake monitoring.



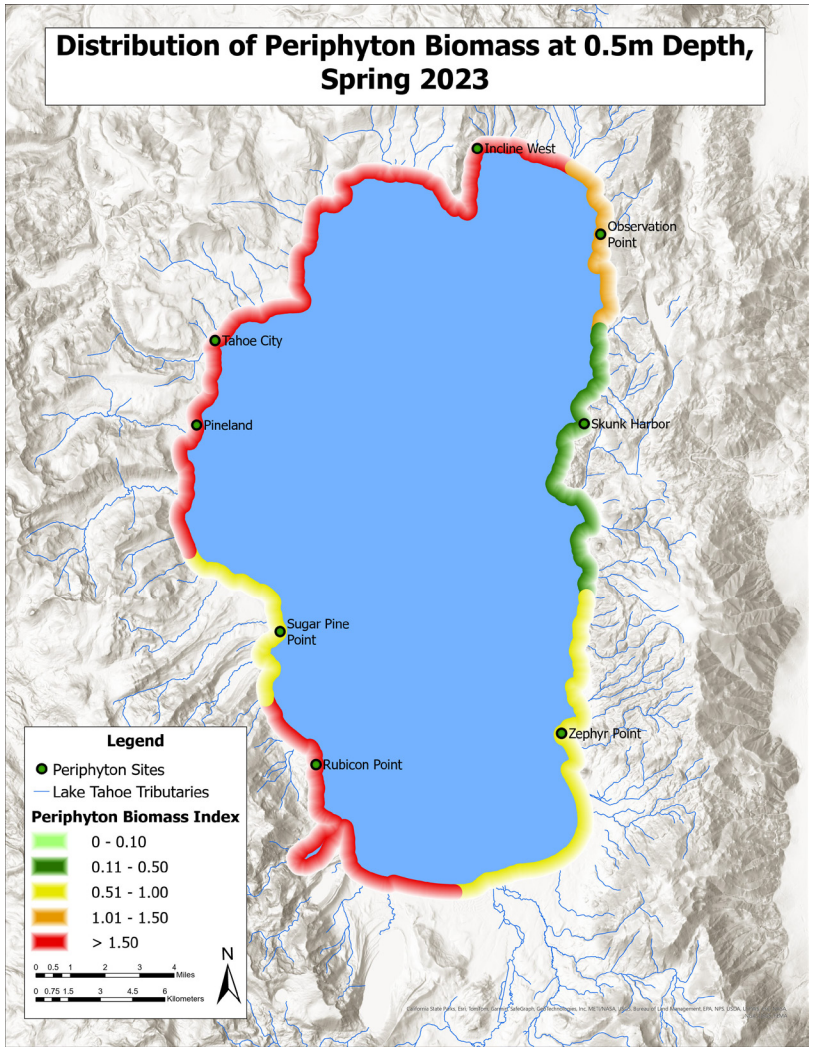
Shoreline algae distribution

In 2023

Periphyton biomass was surveyed in 1.5 feet (0.5 m) of water around the lake over a three-week period during the spring when periphyton is usually at its annual maximum. In 2023, periphyton growth peaked in April. A Periphyton Biomass Index (PBI) is used as an indicator to assess the amount of periphyton algae growth. The PBI is used to indicate the amount of periphyton growth, the higher the ranking, the more algal growth. TERC monitors eight periphyton sites, strategically located around the nearshore of Tahoe. At each site, divers take in-situ PBI measurements and cover approximately 200m of shoreline. The measurements are averaged to provide one PBI measure per site. This PBI ranking is then extrapolated to the length of shoreline adjacent to each site, providing an estimate of periphyton growth around the entire nearshore. While divers are unable to take measurements continuously around the entire 72-mile shoreline of Lake Tahoe, these interpolated rankings are a good estimate of algae growth, but there may be areas of variability within each section of shoreline. The goal of this monitoring is to track periphyton growth both spatially and temporally throughout the 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.