

7.3 Cyanobacterial Harmful Algal Blooms (Freshwater and Estuarine)

Cyanobacterial harmful algal blooms (CyanoHABs) occur when cyanobacteria – nonpathogenic, photosynthetic bacteria commonly found in freshwater and estuarine environments – can quickly multiply under favorable conditions. Some can produce toxins (cyanotoxins) that may pose risks to water quality, ecosystems, and public health when exposure occurs. In California, CyanoHABs mainly occur in freshwater recreational waters, including lakes, reservoirs, rivers and streams, and estuaries. Globally, they are expanding in occurrence, distribution, intensity, and toxicity because of a combination of climate change and anthropogenic eutrophication (the overabundance of nutrients in a waterbody due to the actions of people) (Ho et al. 2019; Paerl and Barnard, 2020; Taranu et al., 2015). In California, reports of CyanoHABs have been increasing over the past 40 years based on periodic and anecdotal data (SWRCB, 2021). Ongoing observational data between 2016 and 2020 also show that reports of CyanoHABs are increasing spatially and temporally throughout the state, occurring in freshwater bodies ranging from high elevations to the coast and sometimes lasting from 6 to 12 months. In 2022, California received 684 voluntary freshwater harmful algal bloom (FHAB) incident reports – the majority of which are cyanobacterial blooms in freshwater systems – through the statewide online reporting system, up from 190 reports in 2018 (SWRCB, 2024).



Tribal Connection 7.3.1.

The culture and health of the Big Valley Band of Pomo Indians is inextricable from the health of their homelands around the shores of Clear Lake, which is one of the most HAB-impacted freshwater bodies in the state. In the *Impacts of Climate Change on the Big Valley Band of Pomo Indians*, the author writes, “Tribal members and locals around Clear Lake report that HABs have become much more prevalent over the last few decades. [...]. HABs on Clear Lake produce very high levels of microcystin and the Lake is often posted with recreational advisories from April through October. [...]. When advisories are posted at Clear Lake, Tribal Members can’t safely participate in Tribal activities that require them to be in the lake. Important tribal activities that are prevented by trigger level advisories include spiritual activities, water immersion for ceremonies, using plants for ceremonies and basketry, and the collection and consumption of fish and other aquatic organisms. Tribal members are also prevented [by Lake conditions] from swimming or playing in the water, which is important for heat relief. In 2021, cyanotoxin was monitored from April through December. During that time there was never a period in which the whole lake was safe for contact” (Big Valley Band of Pomo Indians, 2026). Big Valley has monitored cyanobacteria and cyanotoxins in the Lake since 2014 and is a leading contributor to the California Cyanobacteria and Harmful Algal Bloom Network.

Climate change drivers of CyanoHABs include increasing water temperatures, changing precipitation rates, rising occurrences of extreme storm events, and increasing carbon dioxide levels (Paerl et al., 2016; Paerl and Paul 2012; Paerl et al., 2018; Preece et al., 2025). Increasing temperatures may cause CyanoHABs to grow faster, to appear in places that were previously unsuitable to them, at new times of the year, and for longer durations (Suikkanen et al., 2013). Increasing temperatures also contribute to water stratification and anoxic conditions at the sediment-water interface that allow for phosphorous re-mobilization, which can increase the likelihood of CyanoHABs. Increased precipitation significantly increases the external loading of nutrients from land into surface waters, which can promote the growth and duration of CyanoHABs (IPCC,



2022; Preece et al., 2025). In shallow waterbodies, increased precipitation can also elevate the flux of legacy nutrients stored in the sediment to the surface (Paerl and Barnard, 2020). Extreme storms can promote CyanoHABs through strong winds that mix the water column, which causes sediment resuspension and the release of legacy nutrients (Wells et al., 2015). Decreased levels of precipitation can slow the flow of rivers and streams, leading to hydrologically stagnant waters and limited flushing flows for benthic CyanoHAB mats (Quiblier et al. 2013), which promote the occurrence of CyanoHABs (Paerl, 2008). Another climate driver of CyanoHABs is the increasing level of dissolved carbon dioxide in waterbodies. Elevated carbon dioxide levels can increase the growth rates of cyanobacteria, and subsequent responses may include reduced competitiveness of toxic strains relative to non-toxic strains as well as shifts in phytoplankton community composition, potentially altering bloom frequency, duration, and cyanotoxin production (Ma and Wang, 2021; Raven et al., 2020; Verspagen et al., 2014; Visser et al., 2016).

In addition to increasing event frequency and duration, CyanoHABs in California pose ongoing impacts to aquatic ecosystems and the species that interact with them. The Interagency HAB-related Illness Workgroup has reported CyanoHAB-related impacts to fish and/or wildlife annually since 2018, along with human and domestic animal illnesses ([Freshwater HAB-related Illness Tracking in California - OEHHA](#)). People may be exposed to cyanotoxins through drinking contaminated water or recreating in waterbodies with an active CyanoHAB event. People may also be exposed to fish or shellfish harvested from CyanoHAB-impacted waters. In California, the number of public health advisories at recreational waterbodies has doubled since 2016; however, this trend is largely attributed to expanded monitoring, reporting, and response efforts under the Freshwater Harmful Algal Bloom (FHAB) Program (since 2018), rather than a clear increase in underlying HAB occurrence (SWRCB, 2021).

While climate change likely increases the risk and severity of CyanoHABs in California, more data are needed to better understand the relative contribution of climate change compared with direct anthropogenic drivers, such as nutrient enrichment. Planktonic CyanoHABs are also strongly associated with anthropogenic eutrophication, including external nutrient loading from agricultural land use, animal wastes, sewage, and



industrial and household use of products containing phosphorus and nitrogen (Le Moal et al., 2019). Nutrients from these sources enter waterbodies through runoff, storm drains, wastewater, and other direct discharges. Excess nutrients from external loading and re-mobilization of internal sources can lead to enhanced growth of cyanobacteria, phytoplankton, and aquatic vegetation. Anthropogenic eutrophication is increasing due to land use changes, urbanization, and industrial activities, and its influence on planktonic CyanoHABs is difficult to distinguish from climate change (Wells et al., 2021).

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Shannon Murphy and Rebecca Stanton
Office of Environmental Health Hazard Assessment

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