IMPACTS OF CLIMATE CHANGE ON THE BIG VALLEY BAND OF POMO INDIANS

Warming air temperatures, variable precipitation, drought, wildfire, warming lake temperatures, harmful algal blooms, reduction of fish, bird and animals, as well as other stressors are impacting Tribal livelihood, culture, and traditions.

Background

The Big Valley Band of Pomo Indians of the Big Valley Rancheria of California is a self-governing, federally recognized Tribe of Pomo Indians residing on the shores of Clear Lake in Lake County, California (Figures 1 and 2). Their ancestors, the Xa-Ben-Na-Po Band of Pomo Indians, inhabited the Clear Lake area for over 11,800 years (BVR, 2022). In 1851, a treaty was agreed upon with the office of the U.S. President which established a reservation of approximately 72 square miles with extensive lake front property, including much of the Clear Lake basin including Mt. Konocti. However, the U.S. Senate refused to ratify this treaty, along with 17 others. Largely because of the opposition of the Legislature and the Senators from California, the United States Senate refused to ratify the treaties, on July 8, 1852. The United States Senate placed the treaties under an injunction of secrecy which was not removed for over 50 years (Flushman and Barbier 1986). Instead, Congress passed the Land Claims Act of 1851 requiring claims to California lands be presented within two years (Patrick, 2008). Tribes were intentionally never told of this new requirement. Like all Tribes, the Big Valley Band of Pomo leaders failed to meet the statutory deadline, and their Tribe and others became landless. After the US Government took Indian homelands, they gave loans to settlers to buy Indian land (Montez, 2022).

Big Valley, along with other bands of Pomo, were granted small rancherias years later. In 1914, the U.S. Department of the Interior purchased land for the Big Valley Rancheria. In 1936, under the Indian Reorganization Act of 1935, the Tribe became federally recognized, formed its government, and ratified its constitution. Then in 1963 the Tribe was illegally terminated under the California Rancheria Act of 1959. The Tribe was subsequently re-established by court order as a federally recognized Tribal entity in 1983. During that 20-year period approximately half of the original Rancheria land, including Mt. Konocti, had been seized and sold to non-Indians. In 1986 the Big Valley Tribe began the process of reconstituting their rights of self-determination by re-forming their government through the guidance of their 1936 Constitution. The Tribe is also in the process of buying back their homelands (BVR, 2022a).

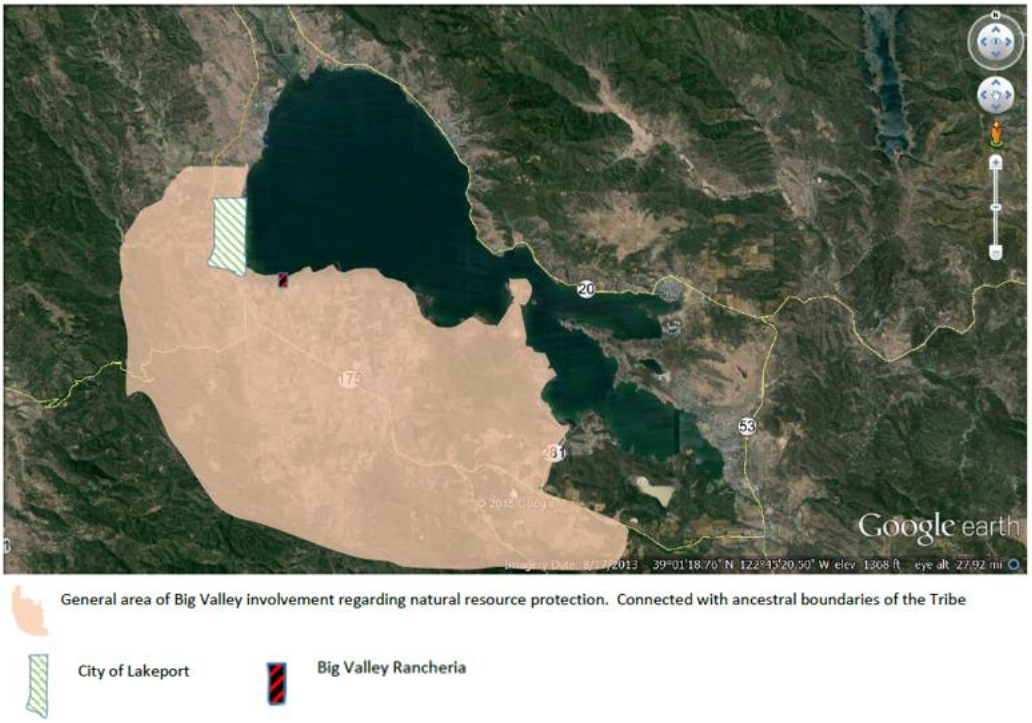
Current Big Valley Tribal membership is approximately 1,300 people. Though the Rancheria sits on 350 acres today, traditional Tribal lands extend much farther. Additionally, Tribal members live all around the lake, and throughout California. Figure 2 shows the Rancheria territory, the City of Lakeport, and the much larger general area in

which Big Valley is involved in natural resource protection. This map helps illustrate that the lands the Tribe uses and cares for extend beyond Rancheria borders. Big Valley Pomo rely heavily on Clear Lake and the resources surrounding it for subsistence and livelihood, as well as for important cultural and spiritual practices.

The waters of Clear Lake itself are of cultural importance to the Big Valley Tribe. The Tribe conducts their Tule Boat Festival and other important cultural and spiritual events on Clear Lake. The Tule Boat Festival is a three-day festival showcasing traditional Pomo boat-making skills. The boats, constructed primarily using materials gathered from shoreline tule plants, are raced by Tribal members. The festival draws Tribes from around the North Coast region and beyond and provides an opportunity for sharing traditional foods. (BVBPI and MRPI, 2021).

Figure 1. Clear Lake basin looking from what is now called Soda Bay

Figure 2. Map showing location of Big Valley Rancheria (red and green area), the City of Lakeport (green-striped area), and the general area in which the Tribe engages in natural resource protection (tan area). The tan area is also closely tied to the Tribe's ancestral boundaries.



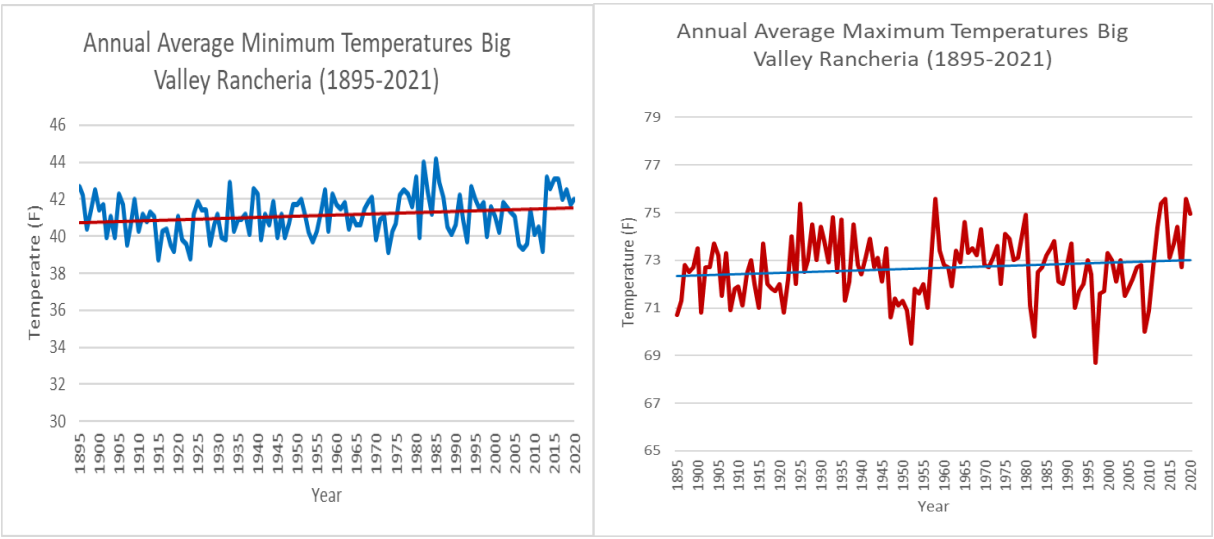
Source: BV EPA, 2014

Air Temperatures

Figure 3 shows that over the past century, maximum temperatures (daytime) and minimum temperatures have increased at the Big Valley Rancheria. However, minimum temperatures, which reflect temperatures at night, are increasing at about 1.2 times the rate of maximum temperatures (0.06°F/decade and 0.05°F/decade, respectively).

Warming air temperatures are linked to numerous impacts on human health and livelihood, as well as ecosystem health and function. Warmer air temperatures change precipitation and runoff patterns, which impact the availability of freshwater. Warming air temperatures lead to changes in species distribution and abundance and the timing of life-cycle events, all of which alter the ecosystem as a whole. Rising temperatures also strain energy demand and infrastructure, increasing the number and length of the Public Safety Power Shutoffs (PSPS) the Tribe has seen. To protect Elders during these PSPS events the Tribe has purchased generators. Increasing air temperatures promote ozone formation leading to adverse health effects such as lung irritation, inflammation, worsening of asthma, and increasing mortality (USEPA, 2021a).

Figure 3. Annual average daily maximum temperatures (left) and annual average daily minimum temperatures (right) at Big Valley Rancheria.



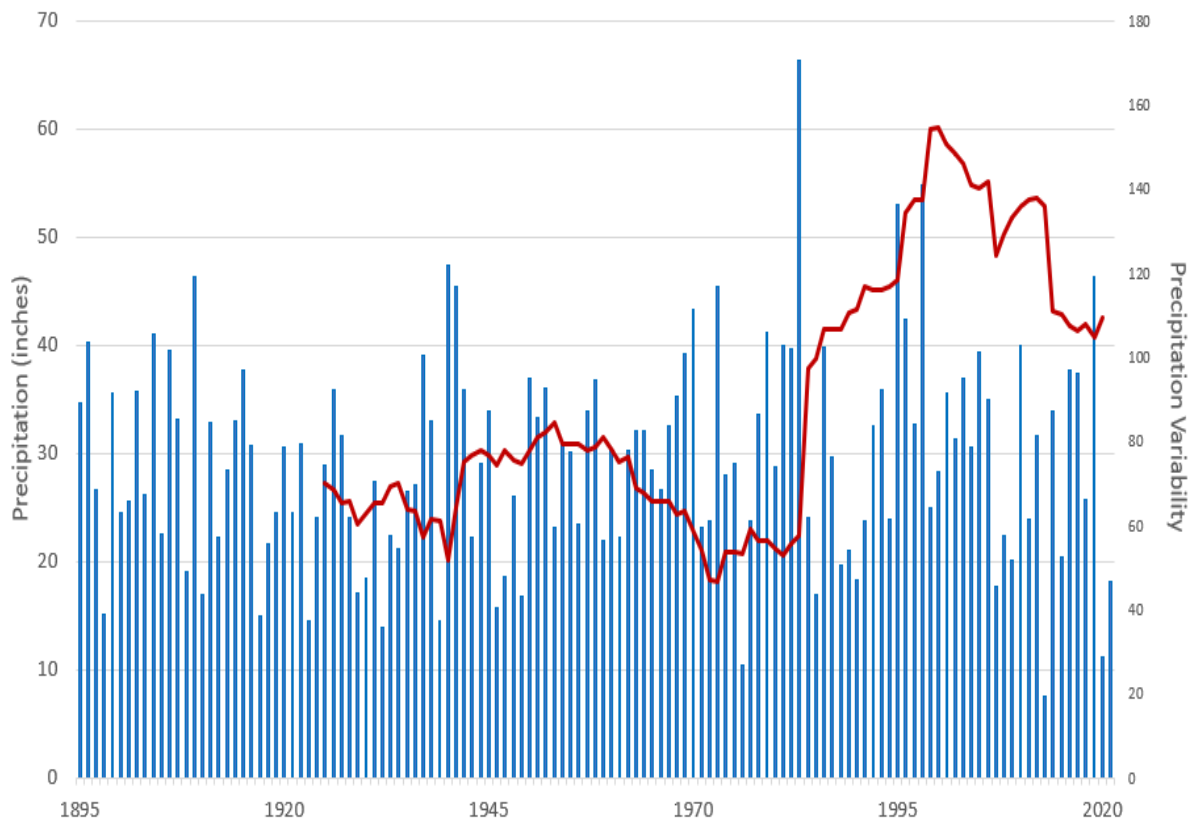
Source: PRISM, 2022

Warmer air temperatures along with a lack of rainfall over time stresses vegetation, creating susceptibility to pests, disease, and death. The increase in dead vegetation then increases wildfire risk for the Tribe. The effects on vegetation also reduce the availability of materials and resources important to the Tribe for various cultural and spiritual uses, such as tules.

Warming temperatures and changing precipitation patterns are associated with increased harmful algal blooms (HABs) in Clear Lake. Additionally, warmer winter temperatures have allowed the invasive water primrose to flourish year-round, leading to further tule loss along the shoreline due to competition (BV EPA, 2014).

Precipitation

Figure 4. Total yearly precipitation at Big Valley Rancheria, 1895-2021



Source: PRISM, 2022

As shown in Figure 4, there is considerable year-to-year variability in the amount of rain at the Big Valley Rancheria, particularly in the last thirty years. Average annual precipitation dropped to its lowest around 2013/2014 and during a period when Lake County experienced extreme drought (Lake County, 2021). The Rancheria has experienced years of extremely high and extremely low rainfall, as well as increasingly unpredictable precipitation patterns throughout the year. High rainfall events cause a sharp increase of surface water flow into Clear Lake, leading to sedimentation and erosion, particularly in shoreline areas where vegetation has been lost. Sediment deposition into the lake impacts water quality (USDA, 1995). Sediments carry contaminants such as trace metals and organic and inorganic compounds which are toxic to plants and animals (BV EPA, 2017a). Sediments are often nutrient-rich, and these excess nutrients cause HABs.

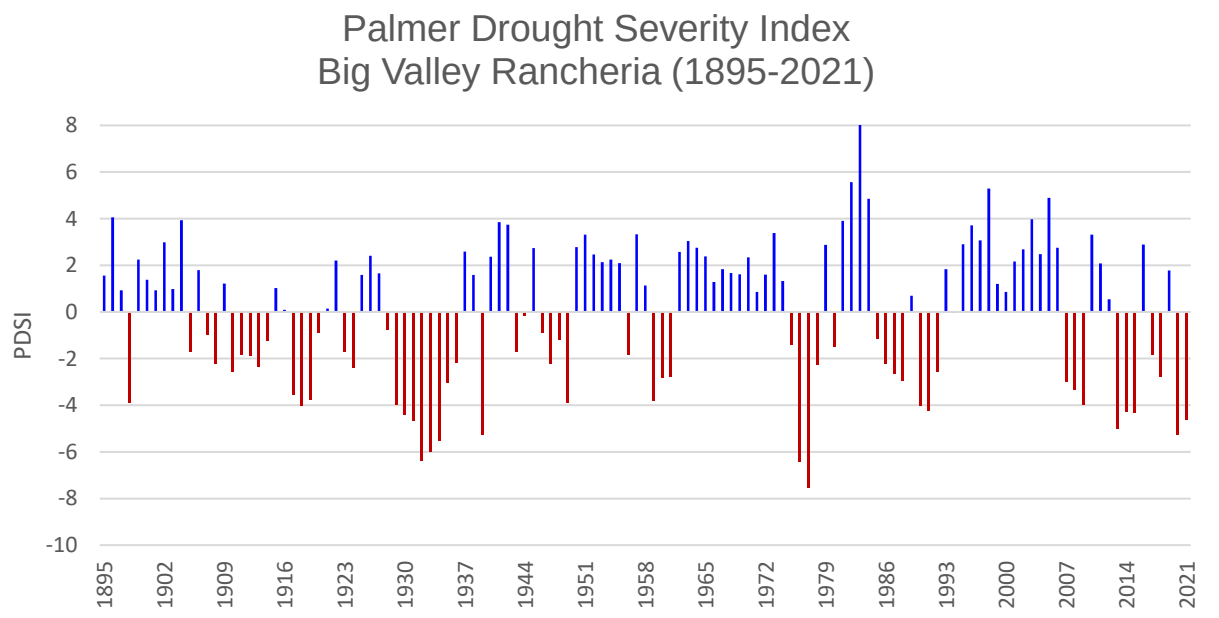
Heavy rains affect infrastructure at Big Valley. The Rancheria needs a better drainage system to prevent flooding which also damages homes. Many Tribal members live in mobile homes, which are particularly susceptible to flooding and seepage. Several members have had to build their own weirs to access their homes during high rainfall. The Tribe has identified increased mold growth after heavy rain events as an impact of

climate change (BVBPI and MRPI, 2021). The marina at the Rancheria has been replanted with vegetation previously lost along the shoreline to combat erosion, but during periods of heavy rain, large sections of shorelines wash away.

Big Valley's Integrated Solid Waste Management Plan addresses climate change impacts such as flooding and resulting landslides the Tribe is seeing as a result of extreme rain events. The Tribe has experienced landslides that blocked roads and damaged Tribal buildings and lands following heavy rainfalls in recent past and the Tribe is working to protect its facilities from future impacts (BV ISWMP, 2015).

Drought

Figure 5. Palmer Drought Severity Index



Source: Abatzoglou et al., 2022

The graph above shows a commonly used measure of drought, the Palmer Drought Severity Index (PDSI), which combines both temperature and precipitation data to provide a measure of relative dryness (drought) on a scale from +10 (wet) to -10 (dry). The lower the number the drier the conditions. In the 80 years between 1895 and 1975 the Big Valley Tribe experienced extreme drought (-4 or below) 7 times, including the state-wide drought that impacted California from 1928-1934 (USGS, 2022). During the 47 years since then Big Valley has experienced extreme drought 9 times. The most recent two years 2020 and 2021 were -5.25 and -4.62 respectively (Abatzoglou et al., 2022).

Drought has impacted Clear Lake resources, lake water quality, and consequently, the people and other species that rely on the lake. Additionally, drought has caused stress to vegetation throughout the Lake County area, notably to native pine trees, making

them more susceptible to pests such as the Pine Bark beetle. Dead trees and other vegetation increase fuel for wildfires. Water scarcity impacts local agriculture, stressing crops such as pears, walnuts, and grapes. Increased reliance on groundwater to support agriculture in areas near the Rancheria reduces the volume of surface water entering streams where Clear Lake Hitch, an endemic and culturally significant fish, spawn (see Lake water temperature section). Many streams and creeks surrounding Clear Lake have dried up during periods of drought (BVBPI and MRPI, 2021).

The Pine bark beetle has killed large areas of Pinon pine trees which are a food source for the Tribe. Government policies have prevented traditional cultural burning, leading to an increase in large-scale wildfires as well as an increase in invasive species and pests. For example, invasive star thistle and other non-native plants have taken hold, increasing the use of herbicides which also poison native species, further exacerbating the issue. This increases the pesticide/herbicide exposure from dust and runoff from nearby agricultural operations that impact the health of Tribal members.

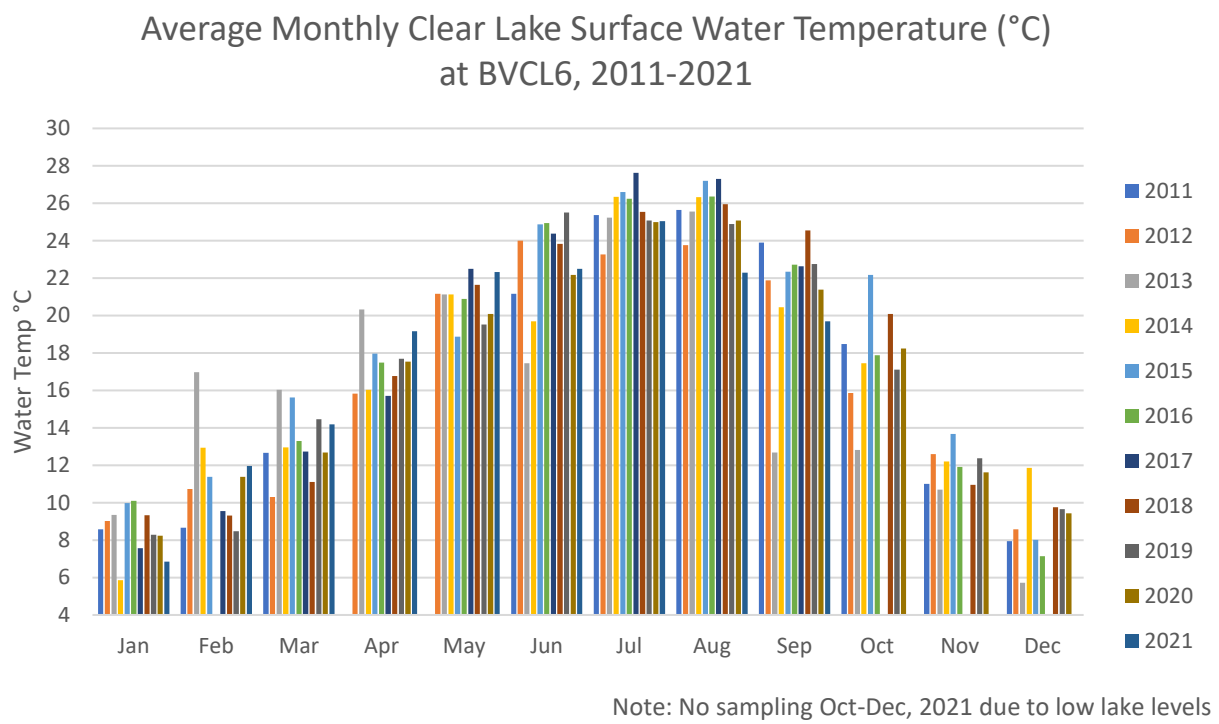
Figure 6. Children playing in a tule boat

During periods of drought, decreased stream flows into Clear Lake reduce dilution, thus concentrating pollutants, leading to increases in microbes and pathogens in the lake, which in turn affects public health. Additionally, drinking water sources are impaired and with 18 water purveyors pulling water from the lake, the increased cost is passed to the Tribal consumer. Partnering with Tracking California, which compiles and analyzes data about public health and the environment, Big Valley tested private drinking water systems on Clear Lake for cyanotoxins, nitrates, coliform bacteria and herbicides, all contaminants of concern for private drinking water systems (BV EPA, 2017b). During the most recent testing between June and October 2021, twenty of the thirty-six homes tested had detectable cyanotoxins and 13 were above the USEPA health advisory level of 0.3 µg/L (micrograms per liter). The highest level sampled was 3.85 µg/L. In November 2021 forty-one homes were tested and cyanotoxins were found in 22 samples; of those 10 were above the USEPA health advisory (Cal-WATCH, 2022). The Tribe is also developing a program to measure groundwater in local wells to have a better understanding of the variations in groundwater storage to ensure sustainability.

Declining lake water levels in Clear Lake due to drought have exposed cultural resources, such as arrowheads. This has exacerbated the problem of non-natives actively searching for these resources to sell. These items are Tribal property and taking them is disrespectful and disturbs the Tribe as a whole. Artifacts found need to be honored and left in place or returned to the Tribes (BVBPI and MRPI, 2021).

Lake water temperature

Figure 7. Monthly average lake surface water temperature by year at sampling site BVCL6 in Clear Lake



Source: BV EPA, 2022b

Figure 8. Location of Big Valley offshore monitoring sites

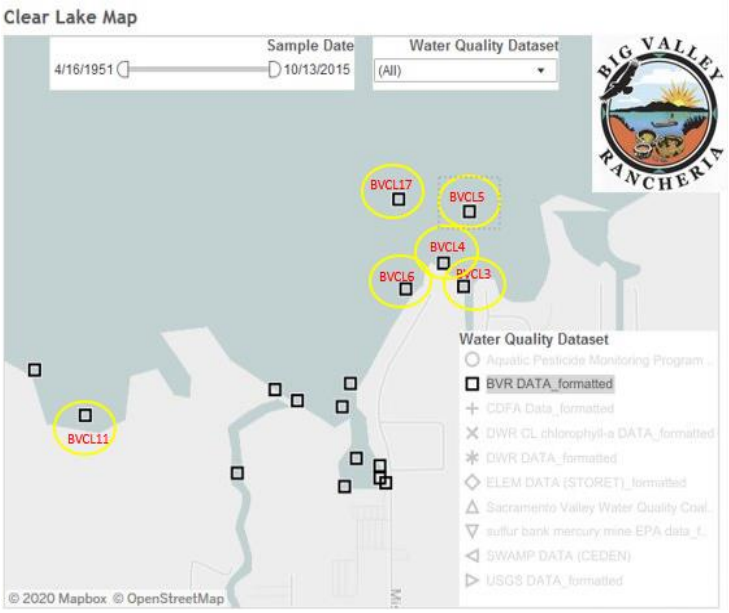


Figure 7 presents annual average lake surface water temperature between 2011 and 2021 at a sampling site (BVCL6), an area of Clear Lake of particular importance to the Tribe. Six total sites offshore of Big Valley Rancheria were selected for analysis (shown circled in yellow in Figure 8). All six sites showed similar results, so only data from BVCL6 is displayed. This site has seen monthly average water temperatures that are highly variable across years, marked by exceptionally warm temperatures in certain years:

for example, notably warm temperatures were observed from February to April in 2013, in December 2014, and in October 2015.

Even seemingly small increases in water temperature can significantly affect key physical and biological processes in lakes. As the lake is impacted, so is the Tribe. Fish and other aquatic species often do best within a certain range of water temperatures. As water temperatures rise, native populations of fish and other species which are important to the Tribe might not thrive, while introduced species that previously would not survive in the lake are absent their natural predators. Balance is key for a healthy lake.

Figure 9. Map showing concerns relating to some creeks that drain into Clear Lake

Source: BVBPI and MRPI, 2021

Changing lake temperatures affects the habitat and distribution of fish. Figure 9 shows creeks feeding into Clear Lake in the Big Valley area (BVBPI and MRPI, 2021). Clear Lake Hitch, a threatened species of "immeasurable ecological and cultural value" (CDFW, 2014) migrate from Clear Lake into tributary streams such as Kelsey Creek and

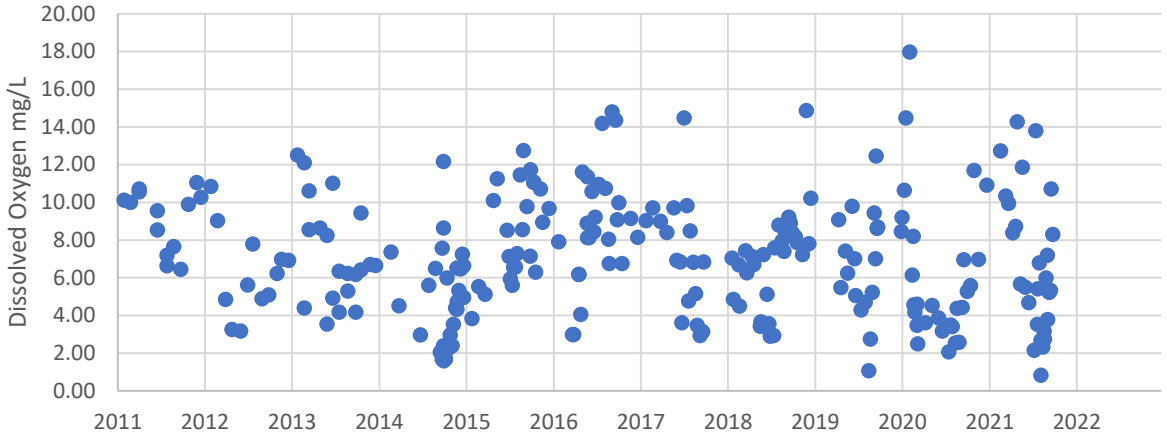
Adobe Creek (indicated with yellow stars on the map) for spawning (Feyrer et al., 2019). In 2014 Hitch were only observed spawning in these two streams.

While there is no water quality standard for cool water temperature ranges in Clear Lake, there is a standard that the lake has no more than a 5˚F difference from receiving stream temperatures (BV EPA, 2017b). A temperature differential greater than 5˚F leads to negative impacts on fish which are important to the Tribal diet. Warming waters are associated with lower levels of dissolved oxygen (DO) in the water, which poses risks to aquatic species. Precipitation also impacts the level of DO in the waters of Clear Lake. DO is the most important health indicator of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals. Oxygen from the atmosphere and photosynthesis dissolves into the upper level of all bodies of water. The amount of DO in a water body decreases with depth, rising water temperatures, and the oxidation of organic matter and pollutants. Erosion and sedimentation caused by high precipitation events carry organic, oxygen-consuming pollutants into Clear Lake leading to a reduction in DO. Sediments also carry nutrients that promote HABs. Low levels of precipitation, and lower surface flow into Clear Lake reduce dilution and increase the concentration of organic pollutants in Clear Lake, also leading to a decrease in DO.

Data collected by multiple agencies over the last several years on Clear Lake show extended periods of time throughout the lake where DO was suppressed, leading to fish kills that have been investigated by California Department of Fish and Wildlife who have confirmed that low DO was the cause (BV EPA, 2017a). The Upper Arm of Clear Lake, where the Tribe and monitoring station BVCL6 is located has shown lower DO and increasing frequencies of hypoxia since 2000 (UCD, 2010).

Big Valley Rancheria has developed a set of water quality objectives that for DO are outlined by three beneficial uses: (1) warm freshwater habitat - uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates; (2) cold freshwater habitat - uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates; and (3) warm spawning, reproduction and/or early development – uses of water that support high quality aquatic habitats for reproduction and early development of fish (BV EPA, 2017a). These water quality objectives dictate that DO concentrations in Clear Lake should not fall below 5.0 mg/L for warm habitat and 7.0 mg/L for both cold habitat and warm spawning habitat. Figure 10 shows DO levels at site BVCL6 over the past 10 years. During that time DO dropped to extremely low levels (below 2.0 mg/L) 6 times, below 5.0 mg/L 71 times, and to below 7.0 mg/L 128 times.

Figure 10. Dissolved Oxygen (DO) mg/L at Clear Lake Sampling Site BVCL6, 2011-2021



Source: BV EPA, 2022b

Culturally important species

Climate change has impacted species of cultural significance to the Big Valley Band of Pomo Indians. The Tribe is seeing fewer, quail, otters, turtles and other animals that are important to the Tribe. These species have diminished due to the cascading impacts of climate change on their habitat (BV EPA, 2022a). Additionally, the Tribe has observed fewer flicker and red-wing blackbird species. These are important birds because the Tribe uses the feathers in regalia and other important cultural activities. With the loss of these birds, the passing on of skills, vocabulary, and ceremony to younger generations is impacted. This constitutes a larger loss than just having to change which feathers the Tribe uses for regalia; it constitutes a loss of culture and an important part of Tribal identity and long-standing traditions (BVBPI andMRPI, 2021). Twenty eight percent of the native aquatic fish species in Clear Lake have become extinct in the last century (UCDNAR, 2022).

The Asian clam (*Corbicula fluminea*) was historically invasive to this area but over time became a staple food source for the Tribe and others living around Clear Lake. Tribal members have observed changes in the size and availability of Asian clams in Clear Lake. Asian clams are short-lived filter feeders, consuming large quantities of phytoplankton (Sousa *et al.*, 2008). As such they are susceptible to contaminants such as mercury and cyanotoxins, which pose serious health risks to people who consume Asian clams.

One native species of concern is the Clear Lake Hitch (pictured below), a large minnow, 14-16 inches long found only in Clear Lake and its tributaries. Hitch typically live 6-7 years. Unlike salmon that die after spawning, Hitch normally return to Clear Lake at the end of their spawning season. Hitch were formally listed as a threatened species under

Figure 11. Clear Lake Hitch

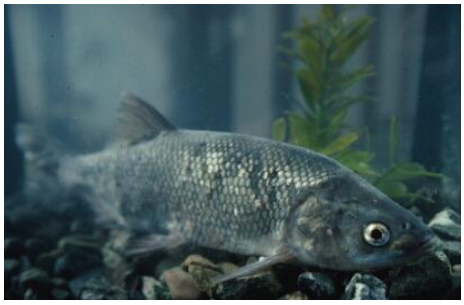


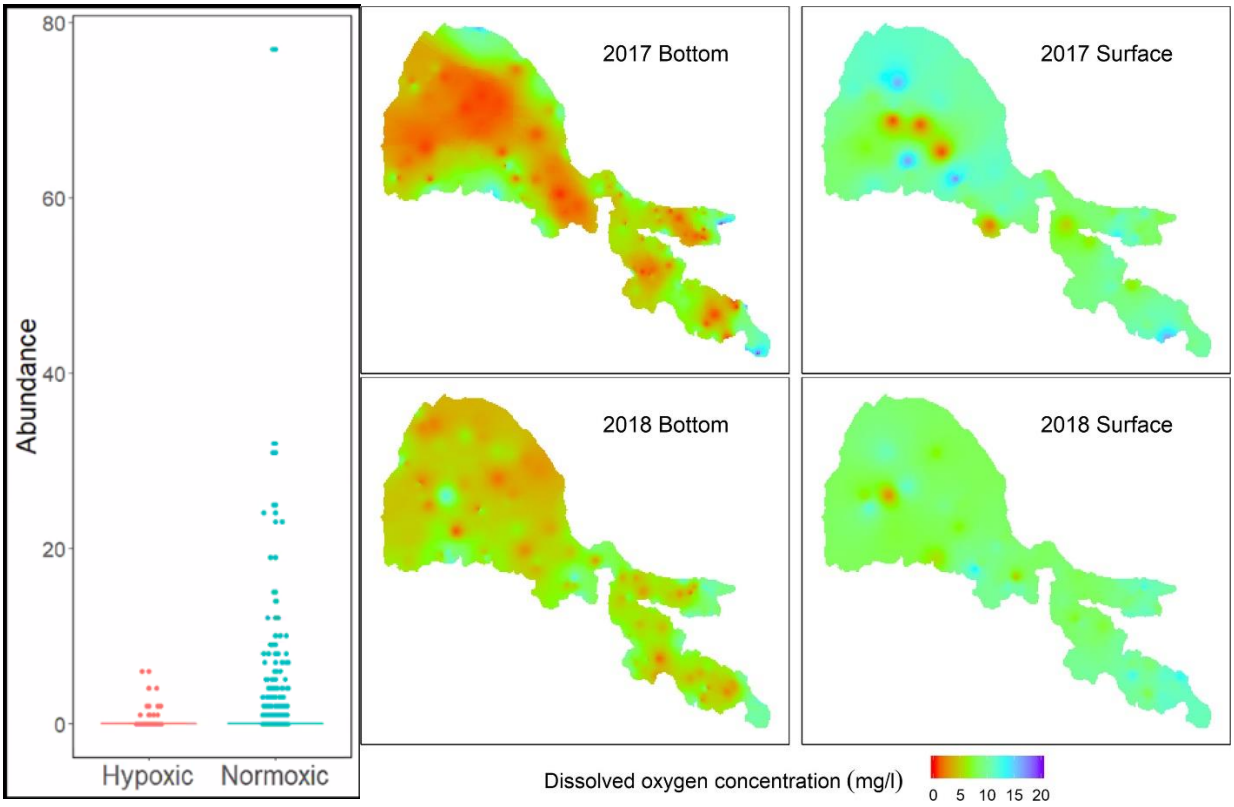
Photo by Richard Macedo
CA Department of Fish and Game

California's state Endangered Species Act in 2014 due to significant decline in numbers of Hitch, and the fish's disappearance from most former spawning streams. Clear Lake Hitch have been impacted by reduced stream flows from drought and decreased precipitation, loss and degradation of spawning habitat, water pumping, barriers to fish migration (such as dams), pollution, and competition from invasive fish (Center for Biological Diversity, 2017, Feyrer, 2022).

Elders of the Big Valley Tribe have seen Hitch numbers decline in their lifetime. In the 1960s and 1970s, Hitch were so numerous that they made the water appear to boil in area creeks and streams (BVBPI and MRPI, 2021). Hitch now spawn regularly in only two streams, Adobe Creek and Kelsey Creek. One Big Valley Elder reported that while Hitch used to be plentiful in Kelsey Creek, which runs behind his home, he has not seen Hitch in the creek since 2010. He also noticed that the spawning season has shortened. Traditionally Hitch would spawn for about 6 weeks and now the spawning season seems to be about three weeks. Another Elder explained that the Hitch were dried and kept for use throughout the winter and was a valuable trade item with Coastal Pomo Tribes for resources such as seaweed, clam shells and abalone. Hitch were also a major food source for ceremonies (BVR, 2013). The Clear Lake Hitch are a culturally and biologically important fish. The loss of this fish impacts the community, the history, and the culture of the Pomo people. Restoring their habitat and numbers will also improve the health of Clear Lake overall as they are also an important food source for numerous birds, fish and other wildlife.

Clear Lake Hitch avoid areas with low levels of DO. A survey done by the USGS in 2017 and 2018 identified abundance-habitat relationships for juvenile and adult Hitch. Results of this study showed that DO concentration was the most important habitat feature measured. The figure below, right, shows DO concentrations in Clear Lake in 2017 and 2018. The graph on the left shows the number of Hitch detected and if they were found in low DO (hypoxic) or normal DO (normoxic) areas.

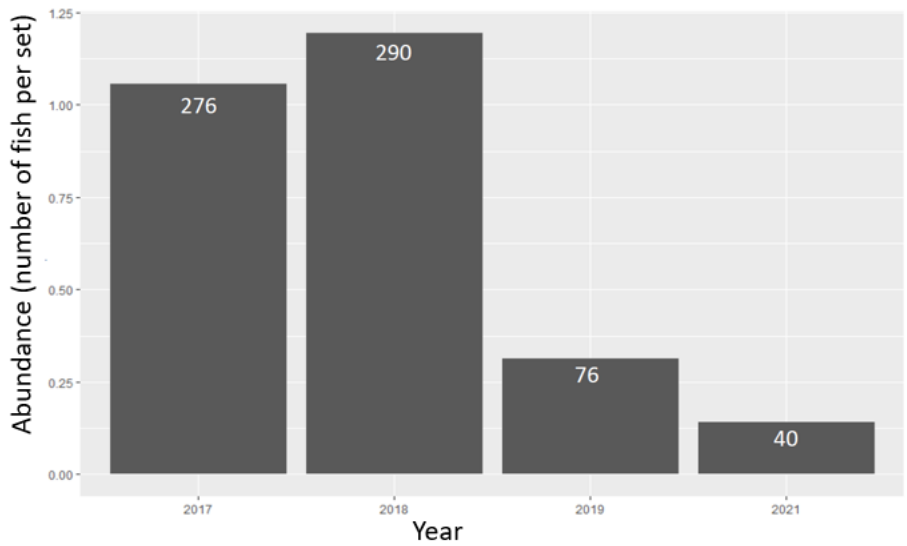
Figure 12. Abundance of Clear Lake Hitch in normal and low DO areas in Clear Lake 2017-2018 (left panel); the spatial distribution of DO concentrations in waters at the surface and lake bottom in 2017 and 2018 (maps on the right)



Source: Feyrer et al, 2020

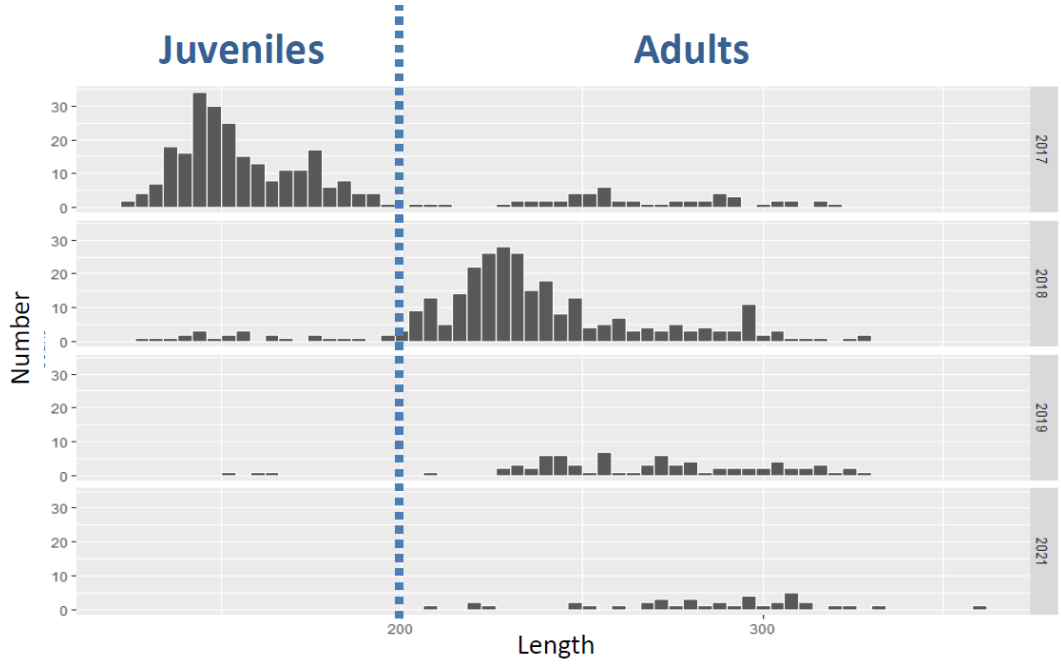
Monitoring of the Hitch in Clear Lake, (Figures 13 and 14) shows a troubling pattern, not only are fewer Hitch in Clear Lake, but the number of juveniles, are declining.

Figure 13. Hitch abundance in Clear Lake 2017-2021



Source: Feyrer, 2022

Figure 14. Numbers of adult and juvenile Hitch in Clear Lake 2017-2021



Source: Feyrer, 2022

Clear Lake Hitch have been forced to adapt to a very brief period of suitable stream conditions for their annual spawning run, as water diversions and a changing climate have caused streams to prematurely dry. Hitch typically spawn in the Spring during periods when creek and groundwater levels are now lower as a result of drought,

agricultural irrigation, and the use of pumped water for frost protection. These low water levels are also impacting overall Hitch numbers. Increased drought and rapid climate change due to warming temperatures will likely accelerate this trend, causing further spawning failures. The spawning runs from 2013 to 2015 had an annual average of fewer than 1,000 spawning fish in the entire Clear Lake basin. Since 2013 the average number of spawning fish in the last two tributaries, Kelsey Creek and Adobe Creek, has been under 1,700 fish annually (Center for Biological Diversity, 2021). Spawning, the process of releasing the eggs and milt, is only part of the success or failure of the Hitch to thrive. The fry must also hatch and survive long enough to travel back to Clear Lake and then live long enough to reproduce for the fish numbers to begin to rebound (Feyrer, 2022).

Figure 15. Hitch spawning at Bell Hill Road Crossing on Adobe Creek.

Photo by Richard Macedo
CA Department of Fish and Game

Figure 16. Clear Lake Hitch rescue by Tribal staff and CDFW

Big Valley, the nearby Robinson Rancheria and Habematolel Pomo of Upper Lake have been working together to study and protect Clear Lake Hitch since 2005. In 2015 Big Valley Rancheria received an award from the Bureau of Indian Affairs (BIA) to conduct a Water Resource Climate Adaptation Plan on Adobe Creek for the Recovery of Hitch (*Lavinia exilicauda*) in Clear Lake (Bureau of Indian Affairs, 2015). Clear Lake area Tribes are also working with non-tribal agencies to help with Hitch recovery efforts, but to date these efforts have no regulatory authority, and as a result may not effectively restore Hitch populations.

Fish consumption by Big Valley Tribal members is often higher than among recreational anglers. A person who eats fish occasionally from sport fishing or commercial fish sources will also consume fish from multiple sources, thereby limiting exposure to contaminants found in a specific location. Tribal members eat large quantities of fish from Clear Lake during ceremonies or as a regular food source. Additionally, the Tribe consumes fish caught in different areas of the lake than recreational anglers.

Tribal Elders have observed a large reduction in the abundance of other native fish species which Tribal members eat, such as blackfish, sculpin, and sunfish.

Tules, an important plant for the Tribe, are used to build boats, for weaving, in traditional ceremonies, as a food source, and for various household uses, are also at risk from a changing climate and area development. Roughly 85% of the shoreline tules have been lost already (BVBPI and MRPI, 2021).

Tules have been impacted by drought and warming temperatures which stresses tules, making them more likely to be impacted by pests, disease, and invasive species. One such invasive species is water primrose, which has taken over where many tules used to grow along Clear Lake's shoreline. Tules help buffer against wind and water, allowing the establishment of other types of plants and reducing erosion. Tules have roots at or under the waterline and play an important filtration role in Clear Lake's ecosystem. These tule wetlands filter out much of the nutrient load and other chemicals found in storm water runoff before they enter the lake. Tules also provide habitat, food, and nesting materials for terrestrial and aquatic species.

> *"The Tule is part of our Traditional Tribal history, it was used for ceremony inside the Roundhouse as a ground cover and mat for the people to sit upon, The Big Head Dancers wore skirts made of Tule for our regalia, clothing for our women were made of Tule, Tule Mats were used as sleeping mats in our Hut made of a willow frame and a covering with Tules, men made a Tule Shirt worn in colder weather, we ate the Tule Roots for food, The health of the Tribe and the health of the Tules are interrelated. It is important to bring notice to and make others aware of the problems we are seeing in the quality of our lake waters and how it is affecting our cultural practices, our subsistence fishing, birds and loss of plant life (Tules) on the shores of our rancheria."*
> *~Ron Montez, Tribal Elder and Tribal Historic Preservation Officer*

The use of plants such as tule, sedge, dogbane, and willow does not just benefit the user, but the ecosystem as a whole. Stands of plants are tended and groomed to make them more useful for basketry and other uses and that grooming helps strengthen riverbanks and reduces soil erosion. The plant bases go from short and knotty, to straight, long and strong. This grooming also promotes access for riparian animals who can more easily access the water in well-tended areas (Pearce, 2022).

Manzanita, a culturally important plant, produces berries that are eaten raw, used to sweeten other foods, or ground for flour; its bark and flowers are used to make a medicinal tea (Pearce, 2021). Manzanita is now seen as a fire risk by some and has been cleared by non-tribal members for fire mitigation and to clear land for vineyards. Removal of manzanita constitutes a loss of traditional food and medicine, as well as a loss of habitat and food for other species.

Angelica root is another culturally important medicinal plant that has been impacted by drought and erosion from flooding. The Tribe has tried to harvest Angelica from areas where it may no longer thrive and propagate it in areas where it grows better or is more accessible to the Tribe. Basketry materials such as willow, redbud, and dogbane have also been impacted by the changing climate. Traditional gathering areas have been reduced due to vegetation changes, wildfire, and the privatization of lands (BVBPI and MRPI, 2021). As the Tribe has seen a reduction in culturally important plants, they have seen a rise in invasives such as star thistle, Scotch, French and Spanish broom (BVBPI and MRPI, 2021).

Harmful Algal Blooms

Harmful algal blooms (HABs) are colonies of algae and/or cyanobacteria that grow out of control, threatening fisheries, aquatic ecosystems, public health and economies. HABs produce toxins that contaminate waterbodies used for recreation or drinking water sources, and the shellfish, fish and wildlife living within them. Even without producing toxins, HABs damage aquatic environments by suffocating fish, blocking sunlight, or depleting oxygen in the water (COST, 2016; WHO, 1999).

Climate change affects the factors that drive HAB formation (US EPA, 2017a). Warmer water temperatures, drought conditions, increased carbon dioxide and alternating periods of storms and drought are all known to promote HAB formation (Lehman et al., 2017; Power et al., 2015). Anthropogenic inputs of nutrients like phosphorus and nitrogen also promote HAB formation.

Tribal members and locals around Clear Lake report that HABs have become much more prevalent over the last few decades. HABs are regularly observed in Clear Lake; these blooms damage the environment and produce levels of cyanotoxins that are harmful to humans. The main cyanotoxin produced in Clear Lake is microcystin, which has been known to kill pets and other animals, and cause skin, gastrointestinal and liver impacts in humans. Tribal members are exposed to microcystin through interactions with the water such as swimming, cultural ceremonies, the consumption of aquatic organisms, and drinking water.

HABs on Clear Lake produce very high levels of microcystin and the lake is often posted with recreational advisories from April through October. The California Cyanobacteria Harmful Algal Bloom (CCHAB) Network has adopted tiered cyanotoxin trigger levels for posting recreational waters. For microcystin these advisory levels are 0.8 micrograms per liter (µg/L) (Caution - keep away from visible algae), 6 µg/L (Warning – no swimming) and 20 µg/L (Danger – do not contact the water or eat aquatic organisms). All advisory levels warn people to keep their pets and small children away from the water and shoreline and to avoid shellfish and wash fish filets before cooking them. The Big Valley Band of Pomo Indians and the Elem Indian Colony have been actively involved in sampling and monitoring their waters. Results of the monitoring for 2014-2021 are shown in Table 1 below.

Table 1. Highest Concentrations of Microcystins in Clear Lake Waters

	Highest Level of Microcystins (µg/L)							
Arm of Clear Lake	2014	2015	2016	2017	2018	2019	2020	2021
Upper Arm	878***	Trace	0.3	4*	13**	0.3	1,146***	5,910***
Oaks Arm	16,920***	278***	0.7	46***	4,800***	0.9*	79***	1,449***
Lower Arm	769***	10,162***	0.3	1*	230***	150***	902***	160,377***

Notes:
**Above CCHAB Caution Trigger Level of 0.8 ug/L*
***Above CCHAB Warning Trigger Level of 6 ug/L*
****Above CCHAB Danger Trigger Level of 20 ug/L*
Source: BV EPA, 2022b

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 be prevented 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 (BV EPA, 2022b). Figure 17 illustrates the potential routes of exposure to HABs based on Tribal uses and practices involving Clear Lake.

HABs create sludge that clogs drinking water intakes in Clear Lake (Figure 18). This leads to higher operating and electrical costs due to filters needing to be flushed more frequently. It also increases the cost due to the need for sludge disposal. When microcystin is present in raw water, water treatment plants must make sure this toxin is kept out of the finished drinking water. In Clear Lake more carbon filters have been required to remove the cyanobacteria and toxins, which also increases costs.

Figure 17. Tribal Cultural Use Conceptual Freshwater Harmful Algal Bloom (FHAB) Impact Pathway

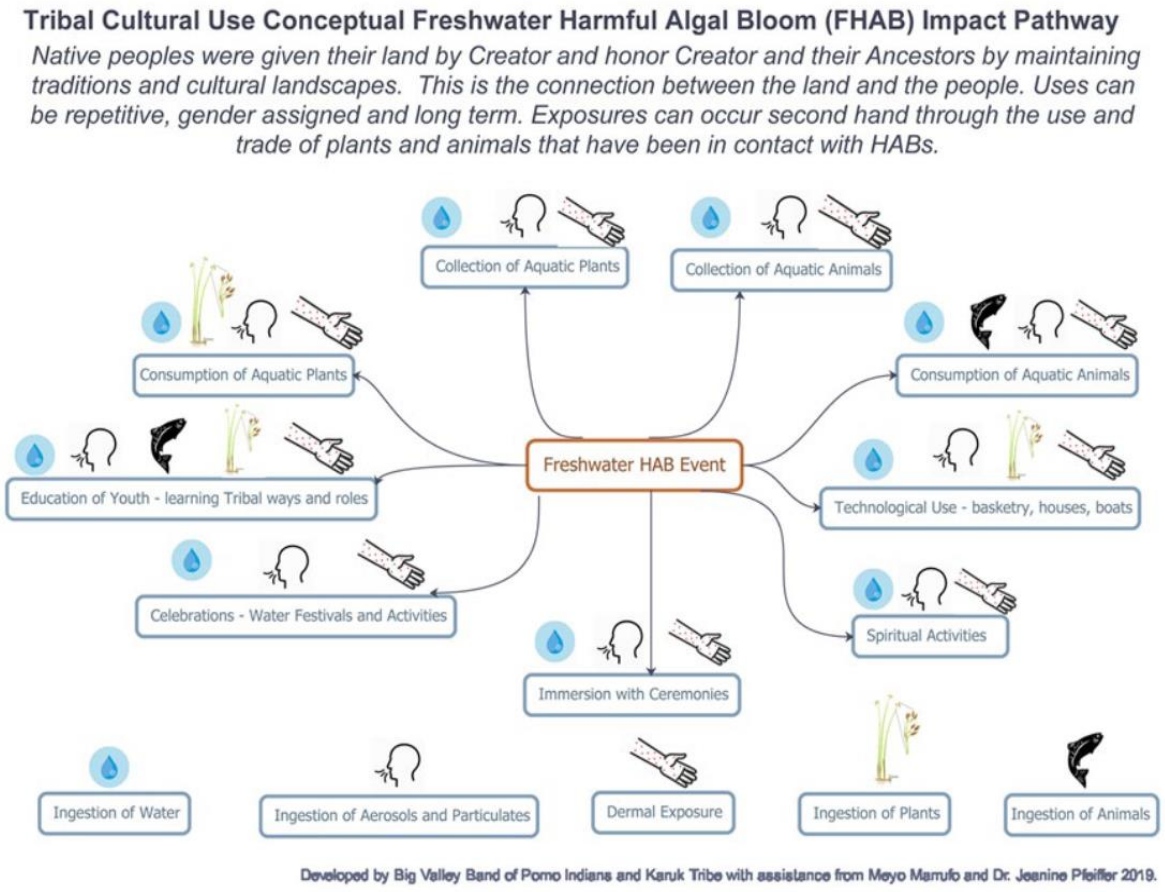


Figure 18. HABs at Clear Lake, September 2021

Photo credit: Justin Sullivan / Getty Images

A 2015 CalEPA Environmental Justice grant funded the Big Valley Rancheria to measure microcystin in Tribally important fish from Clear Lake. Fish and shellfish from ten species were collected over several years. Analysis of 91 fish tissue and 32 fish liver samples found detectable amounts of microcystin. Summaries of the average microcystin toxin levels per fish species are shown in Table 2.

Table 2. Microcystin (MC) concentrations in fish from Clear Lake (2010 – 2018).

Species	Tissue MC ng/g Avg (Count)	Liver MC ng/g Avg (Count)
Black crappie	4 (8)	19† (5)
Blackfish	7 (1)	83† (1)
Blue gill	ND (2)	7 (2)
Carp	14† (2)	34† (2)
Catfish	2 (6)	10† (6)
Hitch	10† (8)	16† (7)
Largemouth bass	2 (7)	6 (2)
Tule perch	6 (10)	35† (8)
Crayfish	4 (23)	
Mussel	10† (26)	

Source: WRCB, 2022

† Concentration is at or above OEHHA's state-wide Action Level for microcystin in fish consumed by humans (10 ng/g).

The Action Level for fish consumption recommended by CalEPA's Office of Environmental Health Hazard Assessment (OEHHA) based on total microcystin in fish and shellfish is 10 nanograms per gram (ng/g) and is calculated for a 70 kg person eating at the sport fish and shellfish consumption rate of one 8-ounce meal per week (Butler et al, 2012). Many Tribal members eat fish and shellfish at a higher weekly consumption rate.-Based on a higher consumption rate and a similar risk level, the recommended maximum level for total microcystin would be lower than 10 ng/g. OEHHA is working with the Big Valley Band of Pomo Indians' Environmental Protection Department to calculate Action Levels for Tribal members.

The occurrence of HABs causes great economic losses. A study from 25 years ago estimated that HABs resulted in $7 – 10 million in lost tourist revenue annually in Lake County (Goldstein and Tolsdorf, 1994). Clear Lake is a large-mouth bass fishing destination and other water activities, such as water skiing, jet skiing, and swimming are popular at the lake. Economic loses today are likely much greater.

To mitigate HABs and fish kills on Clear Lake, Big Valley Environmental Protection Department, with the assistance of a Bay Area Council California Resilience Challenge grant, has acquired and installed two Tribally-managed water quality data loggers. This monitoring program for HABs and fish kills creates a real-time, open-access Clear Lake water quality data monitoring portal, to analyze and address aquatic species die-offs impacting Tribal beneficial uses (BV EPA, 2021).

Additionally, the Big Valley Band of Pomo Indians is partnering with Tracking California to carry out the California Water: Assessment of Toxins for Community Health Project, or Cal-WATCH. The project is working to increase the ability to reliably track and prevent harmful algal bloom illness statewide, with a special emphasis on Clear Lake.

Alongside the climate change impacts causing HABs at Clear Lake, is the closed Sulphur Bank Mine, a flooded open pit mercury mine 23 acres long and 90 feet deep located 750 feet from Clear Lake. The site is filled with a combination of contaminated mine waste and natural geothermal water that seeps mercury into the lake. While the mine closed in 1957 it was not declared a Superfund site until 1991 (USEPA, 2017b). OEHHA has established fish advisories for Clear Lake based on high levels of mercury in fish (OEHHA 2018).

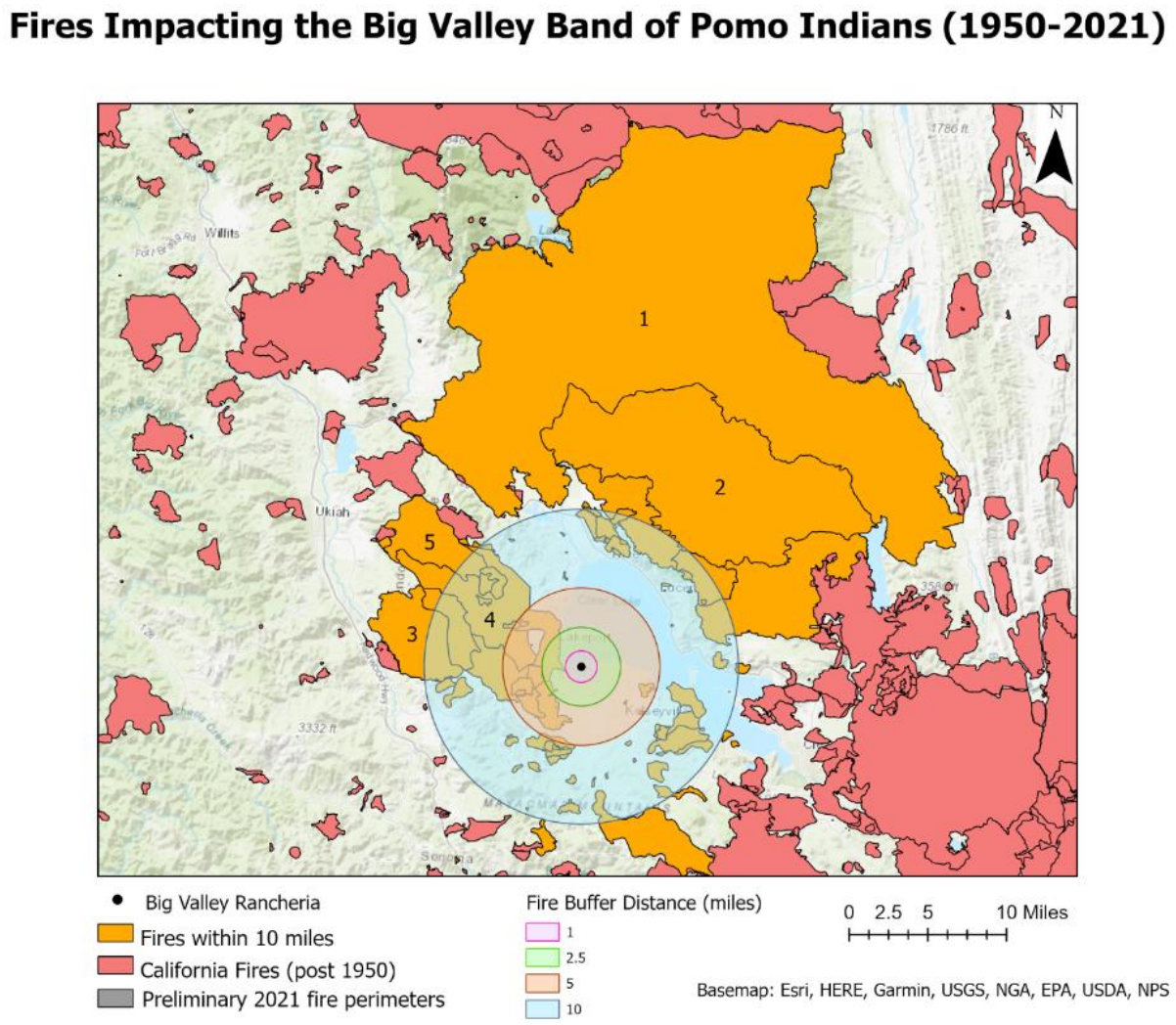
In 2015, Big Valley's EPA measured the mercury levels in several species of fish in different locations around the lake. Mercury levels measured in certain fish in 2015 were found to exceed fish tissue goals established by the Water Board (WRCB, 2015).

In February of 2021, the USEPA updated the local community on the Sulphur Bank Mine's Superfund Site's status. The USEPA estimated that they were within four years of beginning the main clean-up project, which will be broken up into two phases: consolidation and capping. Initially, the plan involves moving smaller piles of mining waste onto large piles to shrink the area that needs to be removed before installing a

heavy cap to act as a barrier over the site. The cap will then be covered with clean soil so that plants begin to grow and rehabilitate the area (USEPA, 2021b).

Wildfires

Figure 19. Fires within 10 miles of the Big Valley Rancheria.



Source: CalFire, 2022

Figure 19 shows California wildfires around the Big Valley Rancheria from 1950 through 2021. In 2018 the Ranch and River fires began during the Tribe's annual Tule Boat Festival, and eventually merged into the 459,123-acre Mendocino Complex Fire (#1 on the map), California's largest wildfire on record at the time.

The Big Valley EPA Director recounted *"People were having trouble breathing on the rancheria. We have a lot of people with asthma and respiratory illnesses. We went to the local stores and tried to get some air purifiers, but everybody was sold out. A neighboring Tribe, the Middletown Rancheria of Pomo Indians, helped Big Valley acquire seventy air purifiers."*

Wildfires are a natural function of California's ecosystems and are important for shaping ecosystem structure. Human influences and policies, however, have worked to prevent natural wildfires and cultural burning practices. Combined with drought, this has led to an increase in the intensity, duration, and frequency of large-scale wildfires which destroy habitat, human infrastructure and livelihood, and harm human health.

Historically the Pomo would have conducted cultural burns, low intensity burns on designated parcels which, under the right conditions, reduce the risk of wildfire by consuming dead wood and other fire fuels on forest floors (Miller et al., 2020).

While cultural burning is gaining respect and use, current levels of agency-prescribed burns and tribal cultural burns are too low to make a significant impact on millions of acres left untended for a century and a half. As a result, Tribal members today encounter a surge of catastrophic wildfires their great-grandparents never experienced. Wildfires pose unique and heightened challenges to Tribes, given their relationships to the land. Further, non-Native government officials often the lack an understanding of tribal customs and priorities (Pfeiffer, 2021).

Figure 20. Mount Konocti in clouds.

Climate change has created shifting conditions for species and created new opportunities for invasive species in what were previously unfavorable climatic regions. Human activities are responsible for habitat and biodiversity loss, land use changes, anthropogenic climate change, forest management and the loss of cultural burning. The resulting droughts, fires, flooding, increases in HABs and other climate threats are impacting our Tribe.

Human Health

The health of the Big Valley Band of Pomo Indians cannot be separated from the health of their environment. Increasing temperatures, increasingly variable rainfall, wildfires and exposure to smoke, pesticides, mold, the loss of important plant and animal species, and exposure to mine waste from the nearby Sulphur Bank Mine Superfund site all impact the health of the Tribe. Exposure to cyanotoxins is a human health concern for the Big Valley Tribe. Tribal members have always used the lake for food, drinking water, ceremony, and recreation (Figure 21). Thus, potential exposures to HABs that produce cyanotoxins include unique pathways that do not apply to non-tribal individuals (Figure 17). Cultural activities that require the use of the lake have had to be postponed or moved due to a lack of tule and other ceremonial material and poor lake water quality. Poor water quality limits Tribal members' access to the lake, an important cultural resource as well as threatens access to safe and clean drinking water.

Climate change has exacerbated food insecurity and the nutrition of the Tribe. There are fewer native wildlife species on which the Tribe has relied on for food such as Indian potato, clover, acorn, pine nuts, edible mushrooms such as chicken of the woods (*Laetiporus sulphureus*), Clear Lake Hitch, clams, prickly sculpin, crayfish, and tules.

Figure 21. Scenes from Big Valley. Left, child at Tule Boat Festival. Center, HABs impacts at Clear Lake. Right, a child fishing in the tules

Summary

The Big Valley Band of Pomo Indians has been living alongside Clear Lake and managing their ecosystem since time immemorial. Big Valley Tribal members, like other Tribes have similar challenges as non-tribal members. Temperatures are warming, rain is less predictable, the environment is stressed. The Tribe is working to restore the balance in their environment. Pomo Tribal members have historically been careful about the balance of consumption and restoration of the environment. The Big Valley Tribe is working both internally and with outside agencies to help to restore a balance and provide a more sustainable and certain environment for future generations.

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References

Abatzoglou, JT, McEvoy DJ, and Redmond, KT in press, The West Wide Drought Tracker: Drought Monitoring at Fine Spatial Scales, Bulletin of the American Meteorological Society. Retrieved January 12, 2022

BVBPI and MRPI (2021). Big Valley Band of Pomo Indians and Middletown Rancheria of Pomo Indians. Summary of the Lake, Sonoma, and Mendocino County Tribal Listening Session hosted by the Big Valley Band of Pomo Indians, the Middletown Rancheria of Pomo Indians, and the Office of Environmental Health Hazard Assessment

BV EPA (2014). Big Valley EPA. Points for Discussion on Climate Change and Impacts on Tribal Resources and Summary of questions from Tule Boat Festival 2014

BV EPA (2017a). Big Valley EPA. Clear Lake Water Quality and Beneficial Use Objectives.

BV EPA (2017b). Big Valley EPA. Triennial Review Comments submitted September 2017.

BV EPA (2021). Big Valley EPA. Big Valley Rancheria Interim Report to the Bay Area Council California.

BV EPA (2022a). Big Valley EPA. Sarah Ryan, Big Valley Band of Pomo Indians of California Environmental Protection Department, Director. Culturally important species impacted by climate change. Email communication with OEHHA.

BV EPA (2022b). Big Valley EPA. Clear Lake Water Quality Dashboard. Accessed January 11, 2022

BV ISWMP (2015). Big Valley Integrated Solid Waste Management Plan. Integrated Solid Waste Management Plan for the Big Valley Rancheria.

BVR (2013). Big Valley Rancheria. Hitch Interview Notes. Shared with the permission of Big Valley Rancheria Environmental Protection Department.

BVR (2022). Big Valley Rancheria 'About Us': Accessed January 04, 2022

BIA (2015). Bureau of Indian Affairs. Bureau of Indian Affairs 2015 Award Summary released September 28, 2015.

Butler N, Carlisle J, and Linville R (2012). Toxicological summary and suggested action levels to reduce potential adverse health effects of six cyanotoxins. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento.

CalFire (2022). Preliminary wildfire data for 2021.

CDFW (2014). California Department of Fish and Wildlife. Report to the Fish and Game Commission, A Status Review of Clear Lake Hitch (*Lavinia exilicauda chi*). May 2014.

COST (2016). California Ocean Science Trust. Frequently Asked Questions: Harmful Algal Blooms and California Fisheries, Developed in Response to the 2015-2016 Domoic Acid Event. California Ocean Science Trust. Oakland, CA.

Cal-WATCH (2022). Cal-WATCH Drinking Water Testing for Cyanobacteria and Cyanotoxin. Presentation by Sarah Ryan, Big Valley Environmental Protection Agency and Susan Paulukonis, Tracking California, January 19, 2022.

Center for Biological Diversity (2013). Vanishing Clear Lake Fish Becomes Candidate for California Endangered Species Act Protection [Press release].

Center for Biological Diversity (2021). Lawsuit Seeks Protection for Northern California's Clear Lake Hitch [Press release]

Feyrer F (2019). Observations of the spawning ecology of the imperiled Clear Lake Hitch

Feyrer F (2022). Presentation at Water Quality Wednesday, Lake County Water Resources Department. January 12, 2022. With permission of the author.

Feyrer F, Young M, Patton O, Ayers D (2020). Dissolved oxygen controls summer habitat of Clear Lake Hitch (*Lavinia exilicauda chi*), an imperilled potamodromous cyprinid. *Ecol Freshw Fish*. 2020; **29**: 188–196.

Feyrer F, Young M, Whitman G, Johnson R (2019). Strontium isotopes reveal ephemeral streams used for spawning and rearing by an imperiled potamodromous cyprinid Clear Lake Hitch. *Marine and Freshwater Research.*

Flushman B and Barbieri J (1986). Aboriginal Title: The Special Case of California, 17 Pac. L. J. 391.

Goldstein JJ, Tolsdorf TN (1994). An economic analysis of potential water quality improvement in Clear Lake: benefits and costs of sediment control, including a geological assessment of potential sediment control levels: Clear Lake Basin, Lake County, California. U.S. Department of Agriculture, Washington, DC.

Lake County (2021). Water Conservation. Accessed 01/04/2022

Lazaro W, Bravo D, da Silva AC and Guimaraes J (2019). Cyanobacteria as Regulators of Methylmercury Production in Periphyton. *Science of the Total Environment*, vol. 668, 2019, pp. 723-729.

Lehman PW, Kurobe T, Lesmeister S, Baxa D and Teh SJ (2017). Impacts of the 2014 severe drought on the Microcystis bloom in San Francisco Estuary. *Harmful Algae* **63**: 94-108

Miller RK, Field CB and Mach KJ (2020). Barriers and enablers for prescribed burns for wildfire management in California. *Nat Sustain* **3:** 101–109 (2020).

Montez R (2022). Ron Montez, Tribal Historic Preservation Officer (THPO). Email communication between the Big Valley Band of Pomo Indians THPO and Laurie Monserrat, OEHHA, on the subject of Tribal history.

OEHHA (2018). Office of Environmental Health Hazard Assessment. Fish Advisory for Clear Lake.

OEHHA (2022). Office of Environmental Health Hazard Assessment. CalEnviroScreen Version 4.0. Accessed January 13, 2022

Parameter-elevation Regressions on Independent Slopes Model (PRISM, 2022). Data for Big Valley Rancheria 39.0202N/122.8867W. Accessed January 13, 2022

Patrick KC (2008). The Pomo of Lake County. ISBN 978-0-7385-5604-8 Arcadia Publishing, Charleston, South Carolina.

Pearce C (2021). Magical Manzanita. Workshop held at the Grace Hudson Museum July 23, 2021.

Pearce C (2022). Keeping Native Habitats Healthy. Accessed January 11, 2022

Pfeiffer J (2021). California Tribes Support Each Other and Seek Inclusion in State Wildfire Response. Accessed January 4, 2022

Power ME, Bouma-Gregson K, Higgins P, Carlson S (2015). The Thirsty Eel: Summer and Winter Flow Thresholds that Tilt the Eel River of Northwestern California from Salmon-Supporting to Cyanobacterially Degraded States. *Copeia* 103(1): 200-211.

Sousa R, Antunes C, and Guilhermino L (2008). Ecology of the invasive Asian clam *Corbicula fluminea* (Müller, 1774) in aquatic ecosystems: an overview. *International Journal of Limnology* 44(2):85-94.

USDA (1995). United States Department of Agriculture. Effects of Sediment on the Aquatic Environment. Accessed January 04, 2022

USEPA (2017a). United States Environmental Protection Agency. Nutrient Pollution: Climate Change and Harmful Algal Blooms. United States Environmental Protection Agency.

USEPA (2017b). United States Environmental Protection Agency. Sulphur Bank Mercury Mine Clearlake Oaks, CA Cleanup activities.

USEPA (2021a). United States Environmental Protection Agency. Health Effects of Ozone Pollution. Accessed January 04, 2022

USEPA (2021b). United States Environmental Protection Agency. 2021 Sulphur Bank Superfund Site Cleanup Update.

UCD (2010). University of California at Davis. Clear Lake Historical Data Analysis.

UCDNAR (2022). University of California, Division of Agriculture and Natural Resources. Clear Lake Aquatic Website. Accessed January 28, 2022

WRCB (2015). Water Resources Control Board. Fish sampling results for Clear Lake.

WRCB (2022). Water Resources Control Board. California Environmental Data Exchange Network. Accessed January 08, 2022.

WHO (1999). World Health Organization. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring and management. London and New York, Routledge.