# Cyanobacteria: Their Toxins and Their Impacts to Tribal Water Uses

## Being Proactive To Protect Tribal Communities

**Sarah Ryan, Environmental Director**
**Big Valley Band of Pomo Indians**
**2018 California Tribal Water Summit**
**April 4-5, 2018**

# WHAT ARE CYANOBACTERIA?

- Formerly known as “Blue Green Algae”
- Marine or freshwater. Oceans, rivers, lakes and reservoirs.
- Naturally occurring water borne bacteria, produce oxygen. Why our atmosphere has oxygen in it.
- Occur when excess nutrient loads including Phosphorus and Nitrogen.  Dense mats are called “blooms”.
- Some produce toxins – skin, liver and neural that are harmful to health.
- Harmful Algal Blooms is the term given to these mats that produce cyanotoxins.

# CYANOBACTERIA IMPACTS

- As blooms die off, they deplete oxygen, leading to fish kills
- Blooms create questions about safety of being in the water.
- Strong odor, visually unpleasing.
- Bloom proliferation leads to reduced sunlight in water column, impacting plant growth
- Create increased costs for drinking water systems that have to filter for cyanobacteria and treat for their toxins.

# WHAT ARE CYANOTOXINS?

- Exposure occurs when cyanotoxins are ingested through water, blooms, fish.
- Can cause illness and death in animals and humans.
- Can't be detected except through lab analysis, some field kits detect presence.
- Blooms don't always produce cyanotoxins, clear water isn't always cyanotoxin free.
- Require special treatment to be removed from drinking water.
- California has developed recommendations for waterbodies with cyanotoxins.

# CYANOTOXINS' IMPACTS

ANIMAL DEATHS

HOME / SCIENCE / EARTH/ENVIRONMENT

## Clear Lake contaminated by algae in potentially hazardous bloom

7 September 2014, 10:12 am EDT By James Maynard Tech Times

LOCAL NEWS

## Toxin known to kill dogs within 30 minutes found in several California lakes, rivers

## NOAA Fisheries mobilizes to gauge unprecedented West Coast toxic algal bloom

*Offshore survey will measure extent and severity of largest harmful algal bloom in more than a decade*

June 2015

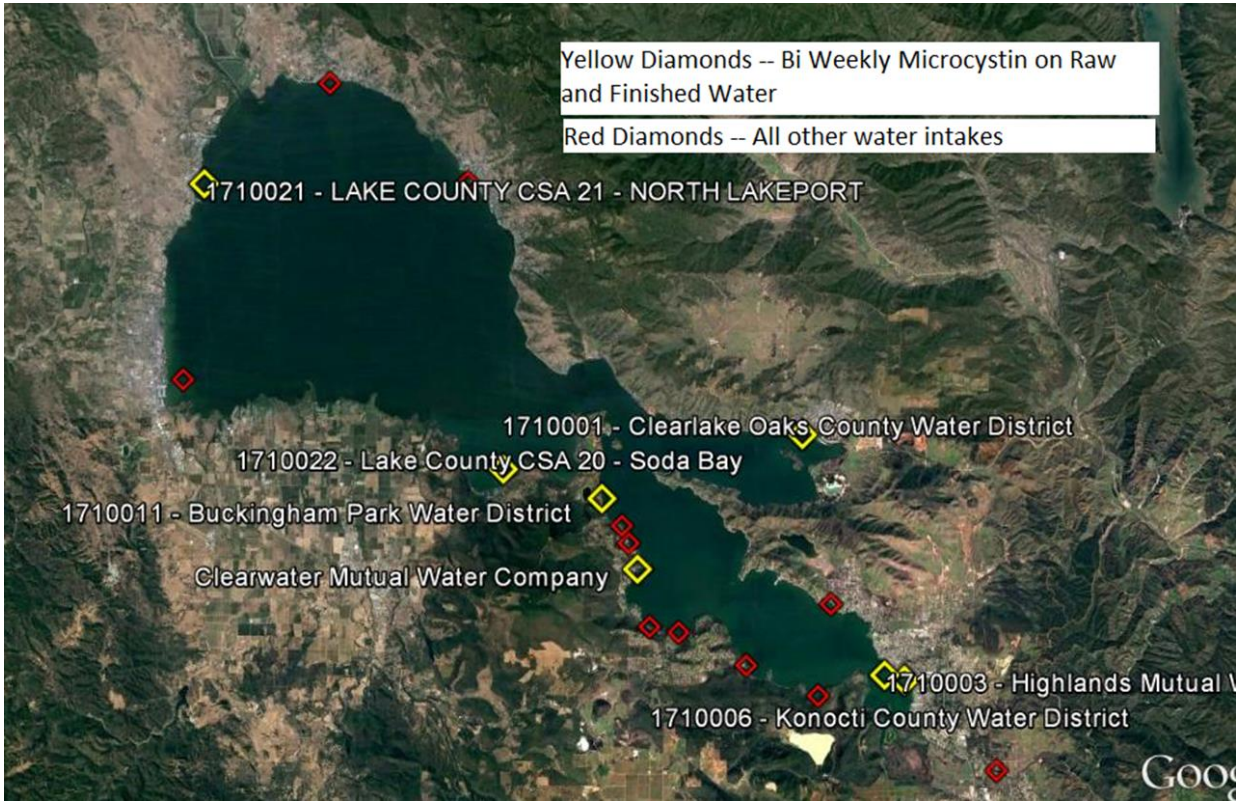
*Contributed by Michael Milstein*

NATIONAL GEOGRAPHIC

## New Diseases, Toxins Harming Marine Life

Dolphins, other marine mammals weakened by pollution, scientists say.

# CYANOTOXINS' IMPACTS



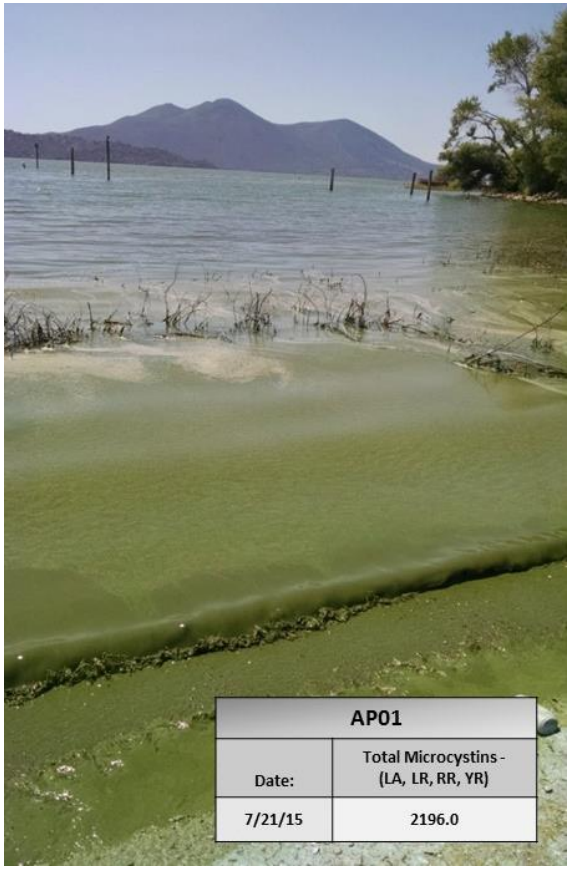

Surface Water Public Water Systems, Clear Lake

## DRINKING WATER

**Clear Lake surface water serves 70% of Lake County residents.**

# CYANOTOXINS' IMPACTS

EXPOSURE



| AP01 | |
|---|---|
| Date: | Total Microcystins - (LA, LR, RR, YR) |
| 7/21/15 | 2196.0 |

# CYANOTOXINS' IMPACTS

## FISH CONSUMPTION

| INVENTORY NAME | SITE ID | DATE COLLECTED (see seasonal color chart at bottom of spreadsheet) | SPECIES NAME *species are categorized by different colors | Microcystin RESULT TISSUE (ng/g) | Microcystin RESULT LIVER (ng/g) |
|---|---|---|---|---|---|
| 83 | M4 | 4/21/2015 | CRAYFISH | 5.94 | |
| 84 | 609 | 4/22/2015 | BLACK CRAPPIE | 4 | 59.75 |
| 85 | 762 | 4/23/2015 | TULE PERCH | 3.02 | 6.18 |
| 86 | 609 | 4/22/2015 | TULE PERCH | 4.56 | ND |
| 87 | AC1 | 3/25/2010 | HITCH | 13.34 ★ | 52.42 |
| 88 | AC1 | 3/25/2010 | HITCH | 16.5 ★ | 10.89 |
| 89 | AC1 | 3/25/2010 | HITCH | 9.08 | 1.65 |
| 90 | AC1 | MAY, 2010 | HITCH | 8.47 | 7.51 |
| 91 | 215 | 5/26/2015 | LM BASS | 1.94 | 8.04 |
| 93 | BVCL6 | 12/12/2017 | MUSSEL | 28.6 ★ | |
| 100 | BVCL6 | 12/12/2017 | MUSSEL | 17.25 ★ | |
| 101 | BVCL6 | 12/12/2017 | MUSSEL | 15.21 ★ | |
| 103 | CP | 12/14/2017 | MUSSEL | 12.73 ★ | |
| 104 | CP | 12/14/2017 | MUSSEL | 19.53 ★ | |
| 105 | CP | 12/14/2017 | MUSSEL | 22.95 ★ | |

**Table 12: Sport Fish and Shellfish Action Levels for Consumption (ng/g, ww[1])**

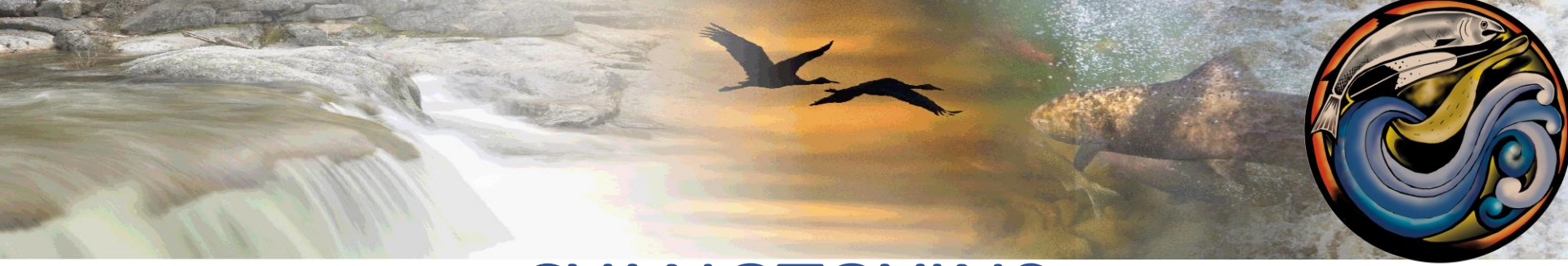
| | Microcystins | Anatoxin-a | Cylindrospermopsin |
|---|---|---|---|
| Sport fish tissue level | ★ 10 | 5000 | 70 |

# CALIFORNIA CYANOTOXIN GUIDELINES

**Action levels for selected scenarios**

| | Microcystins[1] | Anatoxin-a | Cylindro-spermopsin | Media (units) |
|---|---|---|---|---|
| Human recreational uses[2] | 0.8 | 90 | 4 | Water (µg/L) |
| Human fish consumption | 10 | 5000 | 70 | Fish (ng/g) ww[3] |
| Subchronic water intake, dog[4] | 2 | 100 | 10 | Water (µg/L) |
| Subchronic crust and mat intake, dog | 0.01 | 0.3 | 0.04 | Crusts and Mats (mg/kg) dw[5] |
| Acute water intake, dog[6] | 100 | 100 | 200 | Water (µg/L) |
| Acute crust and mat intake, dog | 0.5 | 0.3 | 0.5 | Crusts and Mats (mg/kg) dw[5] |
| Subchronic water intake, cattle[7] | 0.9 | 40 | 5 | Water (µg/L) |
| Subchronic crust and mat intake, cattle[7] | 0.1 | 3 | 0.4 | Crusts and Mats (mg/kg) dw[5] |
| Acute water intake, cattle[7] | 50 | 40 | 60 | Water (µg/L) |
| Acute crust and mat intake, cattle[7] | 5 | 3 | 5 | Crusts and Mats (mg/kg) dw[5] |

-from CA OEHHA, 2012



# CYANOTOXINS

## Cyanobacteria and Known Toxins Chart

| Cyanobacteria Genus | Cyanotoxin Class | | | | | | | | | | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CYL | MC | NOD | ATX | SAX | NEO | LYN | BMAA | DAT | APL | |
| *Anabaenopsis* | | ✓ | | | | | | | | | Lanaras and Cook, 1994; Graham et al., 2010 |
| *Aphanizomenon* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | Graham et al., 2010; Jacoby and Kann, 2007; Pilotto et al., 1997; Vezie et al., 1998; Graham et al., 2008 |
| *Aphanocapsa* | | ✓ | | | | | | | | | Graham et al., 2010 |
| *Calothrix* | | ✓ | | | | | | ✓ | | | Mohamed et al., 2006; Paerl and Otten, 2013 |
| *Coelomoron* | | ✓ | | | | | | | | | Dos S Vieira et al., 2005 |
| *Coelosphaerium* | | ✓ | | | | | | | | | Graham et al., 2010; Jacoby and Kann, 2007 |
| *Cylindrosperm-opsis* | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | Graham et al., 2010; Griffiths and Saker, 2002; Woods and Sterling, 2003; Graham et al., 2008; Paerl and Otten, 2013 |
| *Cylindrospermum* | | ✓ | | ✓ | ✓ | | | | | | Borges et al., 2015; Pandey and Tiwari, 2010; Sivonen et al., 1989 |
| *Dolichospermum (Anabaena)* | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | | | Bruno et al., 1994; Graham et al., 2010; Harada et al., 1991; Jacoby and Kann, 2007; Mohamed et al., 2006; Pilotto et al., 1997; Sivonen et al., 1989; Spoof et al., 2006; Vezie et al., 1998 ;Graham et al., 2008 |
| *Fischerella* | | ✓ | | | | | | | | | Otten and Paerl, 2015 |
| *Geitlerinema* | | ✓ | | | ✓ | | | | | | Aboal et al., 2005; Borges et al., 2015; Myers et al., 2007 |
| *Gloeotrichia* | | ✓ | | | | | | | | | Carey et al., 2007; Graham et al., 2010; Jacoby and Kann, 2007 |
| *Hapalosiphon* | | ✓ | | | | | | | | | Prinsep et al., 1992 |
| *Limnothrix* | | ✓ | | | | | | | | | Graham et al., 2010 |
| | | | | | | | | | | | Berry et al., 2004; Dos S Vieira et al., 2005; Foss et al., |

# CLEAR LAKE CYANOBACTERIA MONITORING PROGRAM

- Began 2014, 2 Tribes wanted more info on blooms, realized they had to do it.
- Big Valley Band of Pomo Indians, Elem Indian Colony already had established water monitoring programs and QAPPs so added this element.
- Initially used EPA Clean Water Act 106 funds to pay for time and lab analysis. Other funding used in the program: CalEPA EJ, BIA Water Resources, GAP, US Fish and Wildlife.

# CONTINUALLY DEVELOPING PROGRAM

**2014**

- Formed Clear Lake Cyanobacteria Task Force, has continued to meet quarterly
- Focused on Microcystin levels at 8 shoreline sites– used Abraxis Algal Toxin strips

**2015**

- 18 shoreline sites
- Cyanobacteria cell identification
- Analyzing for Microcystin, Anatoxin-a, Cylindrospermopsin, Saxitoxin

**2016**

- Began monitoring toxins in drinking water systems
- Using Fluorometer to get chlorophyl-a/phycocyanin levels for TMDL
- Microcystin analysis at every site and every sampling event

# CONTINUALLY DEVELOPING PROGRAM

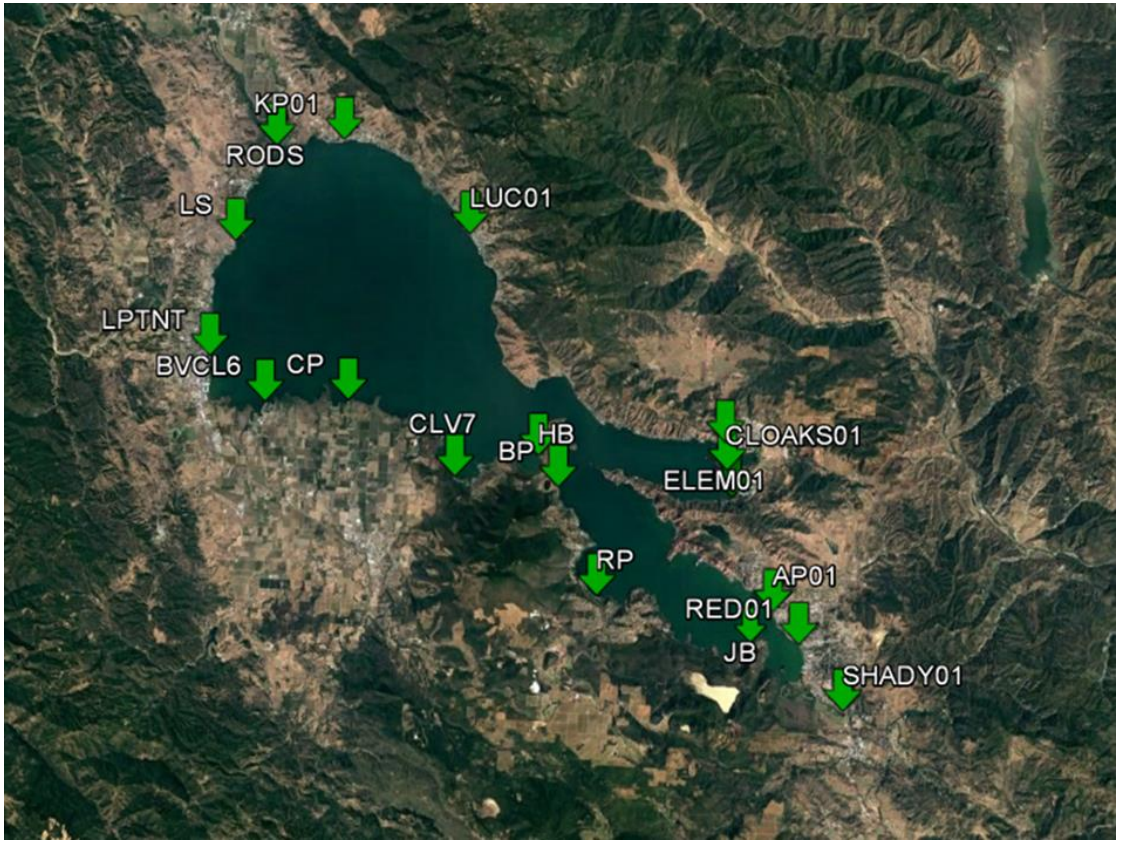
**2017**

- Expanded sites to a few creeks and other waterbodies in Lake County
- Began sending samples for qPCR analysis (quantifying toxin producing genes)

**2018**

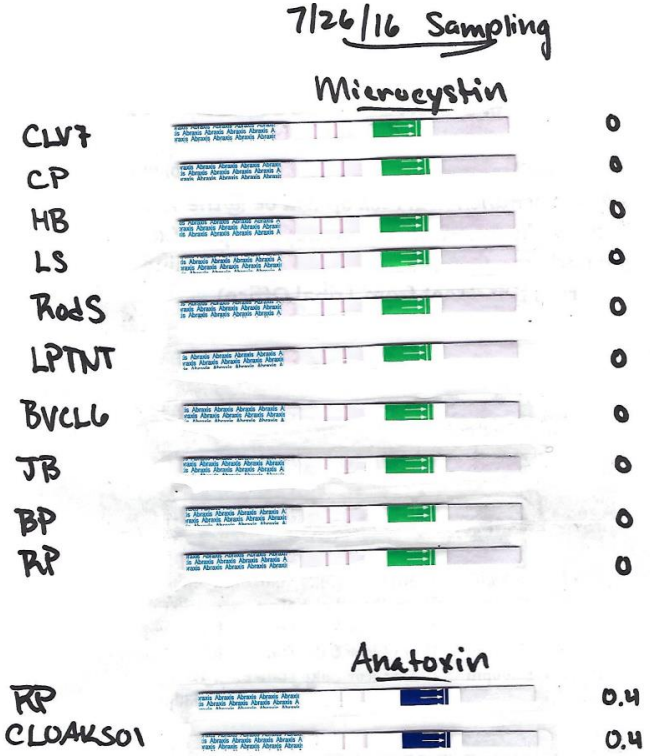
- Analysis of fish and shellfish for Microcystin
- Began collaboration with CA DWR to get water samples from interior of lake

# CLEAR LAKE CYANOTOXIN MONITORING LOCATIONS



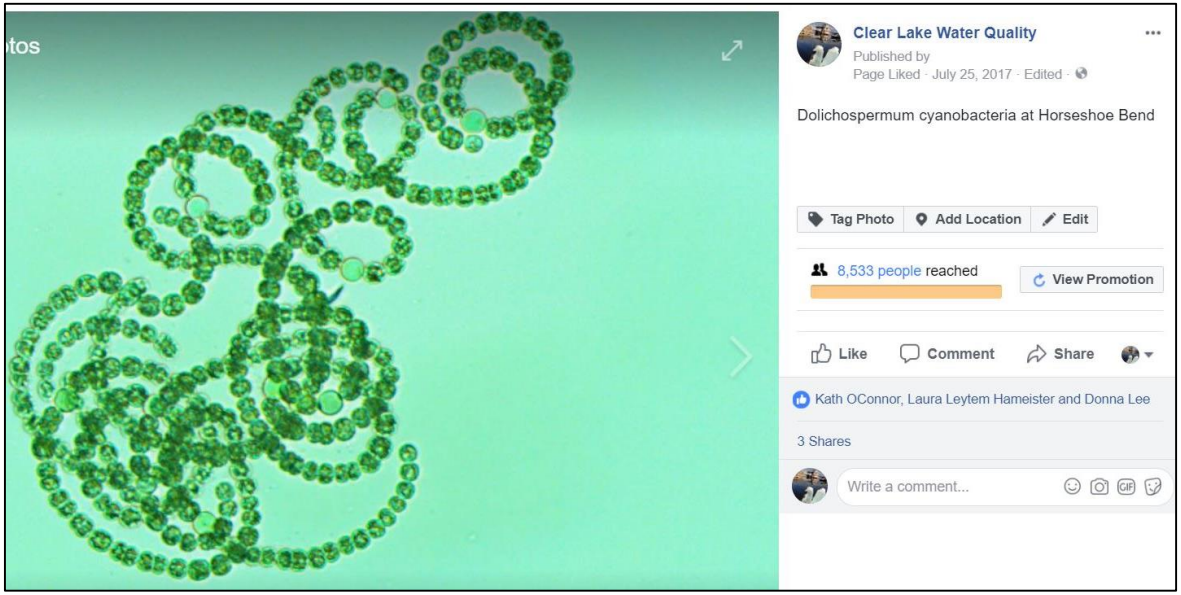

- Choose locations that are Tribally important
- Do monitoring to coincide with important Tribal uses of the water
- Inform other Tribes and the public about the results

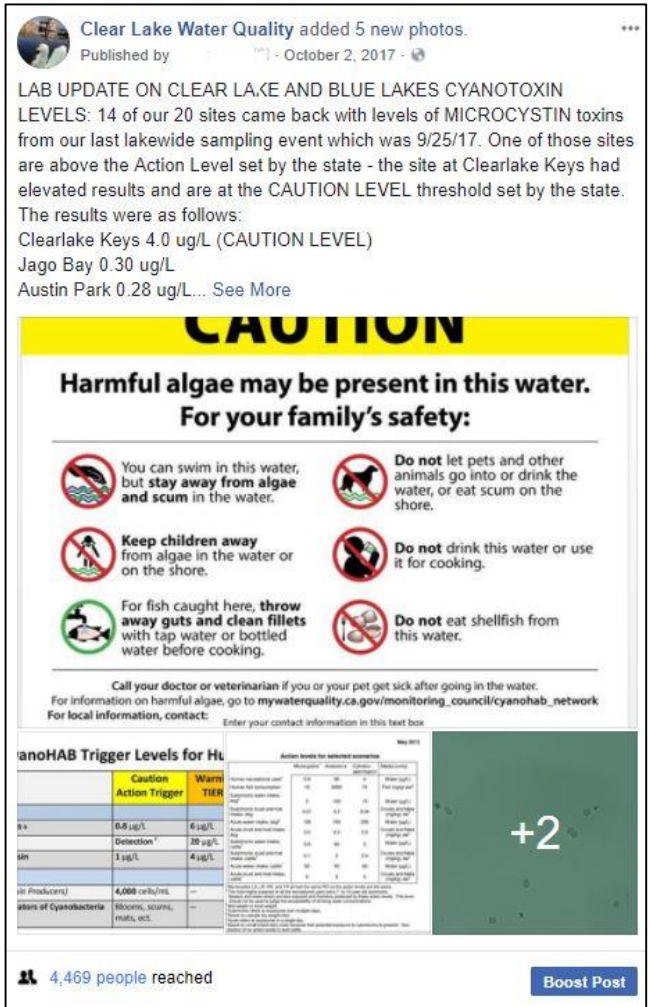
# PROCESSING THE WATER SAMPLES




Testing for presence of microcystin with Abraxis recreational test strips (measures to 10ppb)

# EDUCATING THE PUBLIC



Big Valley Band of Pomo Indians

# UPDATE ADVISORY, BIG VALLEY MEMBERS
## FRIDAY JULY 14, 2017, 4:30PM:
## CYANOBACTERIA (BLUE GREEN ALGAE) BLOOM AT THE POINT CONTINUES.

Dolichospermum, Big Valley Point

BIG VALLEY EPA HAS IDENTIFIED CYANOBACTERIA ALONG BIG VALLEY'S SHORELINE AND AT OTHER LOCATIONS ON CLEAR LAKE. LAB TESTING OF BIG VALLEY'S SHORELINE SHOWED LOW DETECT FOR 1 TOXIN - Microcystin, AT 0.21 ug/L. The state has set a level of 0.8 ug/L, to be protective of kids swimming. The lab results at the Point are below the level of concern.

TAKE CAUTION IF YOU ENTER THE LAKE. UNLESS YOU CAN KEEP YOURSELF AND CHILDREN FROM SWALLOWING LAKE WATER WHILE PLAYING, IT IS BEST TO STAY OUT OF THE LAKE AT THIS TIME. DO NOT SWALLOW LAKE WATER OR ALLOW CHILDREN TO SWALLOW ANY LAKE WATER. KEEP DOGS FROM THE LAKE BECAUSE THEY WILL LICK THEIR FUR AND CONSUME ANY TOXINS THAT MIGHT BE PRESENT.

**RESULTS FROM OTHER SITES ON THE LAKE:**

| | |
|---|---|
| Soda Bay Cove | 3.5 ug/L |
| Sulphur Bank | |
| Mercury Mine | 2.4 ug/L |
| Buckingham | 1.3 ug/L |
| Richmond Park | 1.2 ug/L |
| Elem shoreline | 0.38 ug/L |
| Horseshoe Bend | 0.35 ug/L |
| Keeling Park | 0.34 ug/L |
| Austin Park | 0.27 ug/L |
| Clearlake Oaks | 0.22 ug/L |
| Big Valley shoreline | 0.21 ug/L |
| Redbud Park | 0.11 ug/L |
| Jago Bay | No Detect |
| Lakeside County Park | No Detect |
| Lakeport 5th Street Ramp | No Detect |
| Rodman Slough | No Detect |
| Lucerne Alpine Park | No Detect |
| Cache Creek | No Detect |
| Upper Blue Lakes | No Detect |
| Lower Blue Lakes | No Detect |

THIS ADVISORY IS IN EFFECT UNTIL FURTHER NOTICE. NEXT SAMPLING DATE IS JULY 17, 2017 AND WE WILL PROVIDE RESULTS SOON AFTER. IF YOU HAVE ANY QUESTIONS, PLEASE CONTACT ENVIRONMENTAL DIRECTOR SARAH RYAN AT 707-340-4040.

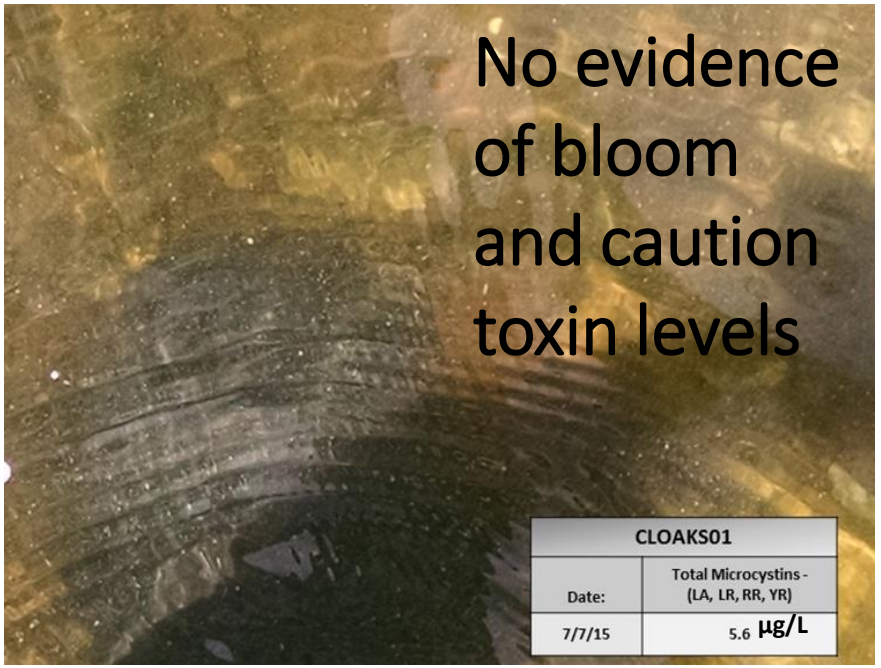
4 SITES ABOVE LEVEL OF CONCERN ARE HIGHLIGHTED BLUE. BIG VALLEY SHORELINE AT THE POINT HIGHLIGHTED YELLOW BELOW LEVEL OF CONCERN BUT TOXINS ARE PRESENT

Additional information can be found at www.mywaterquality.ca.gov

**ONE OF SEVERAL ADVISORIES PUT OUT BY TRIBES ON CLEAR LAKE IN 2017**

# RESEARCH


| SBMMEL01 | |
|---|---|
| Dates | Total Microcystins (EPA) |
| 7/12/2016 | 0.67 µg/L |




| CLOAKS01 | |
|---|---|
| Date: | Total Microcystins - (LA, LR, RR, YR) |
| 7/7/15 | 5.6 µg/L |

# RESEARCH

## Collecting Chlorophyll-a and Phycocyanin Measurements for the Nutrient TMDL

| Cyanotoxin Monitoring Sites | | Cell ID | Field Results | | | Lab Results (in pp |
|---|---|---|---|---|---|---|
| Site ID | Dates | Dominant Genus | Chlorophyll-a (µg/L) | Phycocyanin (µg/L) | phyco/chloro-a ratio | Total Microcystins (EPA) |
| BVCL6 | 6/14/2016 | anabaenopsis | 26.45 | 10.97 | 0.4 | ND |
| | 8/23/2016 | anabaena | 65.2 | 118.6 | 1.8 | 0.11 |
| CLV7 | 6/27/2016 | anabaena | 35.22 | 627 | 17.8 | 0.34 |
| | 8/23/2016 | anabaena (v. small | 84.53 | 100.51 | 1.2 | ND |
| LPTNT | 6/14/2016 | anabaenopsis | 15.74 | 7.97 | 0.5 | ND |
| | 8/23/2016 | anabaena | 249.8 | 277.55 | 1.1 | ND |
| RODS | 6/14/2016 | anabaena | 39.77 | 16.32 | 0.4 | ND |
| | 8/23/2016 | - | 99.4 | 95.2 | | |

- **Lowest (green cells) and highest (red cells) phycocyanin measurement per site in 2016**
- **Ratio of phycocyanin to chlorophyll-a. 59% of time when ratio is below 1.0, toxin level is No Detect**

# ANALYZING FOR MICROCYSTIN IN DRINKING WATER

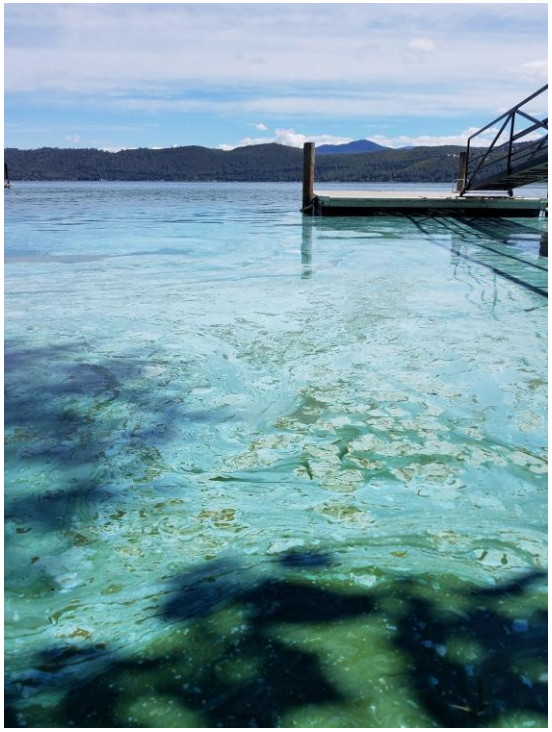
| | RAW WATER | | | | FINISH WATER | | |
|---|---|---|---|---|---|---|---|
| | ROUND 1 6/27/2016 | ROUND 2 7/11/2016 | ROUND 3 7/25/2016 | ROUND 4 8/8/2016 | ROUND 1 6/27/2016 | ROUND 2 7/11/2016 | ROUND 3 7/25/2016 |
| 20 - Soda Bay | 0.16 | 0.18 | 0.18 | <0.1 | <0.1 | <0.1 | 0.14 |
| ounty Water District | 0.73 | 0.38 | 0.26 | <0.1 | 0.18 | <0.1 | 0.16 |
| 21 - North Lakeport | 0.33 | 0.21 | 0.19 | <0.1 | <0.1 | <0.1 | 0.15 |
| : Water District | 0.12 | 0.27 | 0.24 | <0.1 | 0.2 | <0.1 | 0.18 |
| al Water Company | | 0.3 | 0.21 | <0.1 | | <0.1 | <0.1 |
| l Water Company | 0.38 | 0.27 | 0.19 | <0.1 | 0.16 | <0.1 | 0.14 |
| Vater District | | 0.16 | 0.28 | <0.1 | | | 0.17 |

# NON POINT SOURCE MANAGEMENT

**REDUCES NUTRIENTS AND IMPROVES WATER CHEMISTRY TO CONTROL BLOOMS**


# SUMMARY

- Be proactive to protect your waters if you suspect blooms
- Both USEPA and the CA State Water Resources Control Board have programs and funding that can help develop monitoring programs
- Tribes in Northern and Central California have strong monitoring programs, reach out for assistance
- Conduct research, collaborate, educate the public, take action on watershed management and help create policy to protect your waters



**Recreation, Tribal traditional uses, fisheries, drinking water impacts**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