Blue Green Algae Work Group of
the State Water Resources Control Board (SWRCB),
the California Department of Public Health (CDPH), and
Office of Environmental Health and Hazard Assessment (OEHHA)

Cyanobacteria in California Recreational Water Bodies:

Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification

July 2010 Draft

Changes from the prior draft (September 2008), other than some minor editorial changes, are shown as ~~strikeouts~~ for deletions and <u>underlines</u> for additions.

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Introduction

The purpose of this document is to provide guidance to local, state, and tribal regulators to protect people, pets, and livestock from the effects of toxic cyanobacteria in non-marine water bodies in the state of California. This draft will be updated as new information and data become available. Pets and livestock are included in this guidance because of reports of blue-green algae exposure-related harm or death, and because they can serve as sentinels for public health protection.

Specifically, the guidance ~~will~~ provides:

- background information on cyanotoxins and their health effects;
- information on ~~the status of~~ environmental sampling for cyanobacteria and their toxins;
- information to educate the recreating public;
- guidance for providing public notification and warning advisories, ~~and~~
- guidance for posting and lifting advisories of affected water bodies; ~~by the local health officer~~ and
- resources and websites for more detailed information.

This guidance does not address cyanobacteria in drinking water supplies. Public drinking water systems, which are regulated by CDPH, have algae control programs to avoid taste and odor problems associated with surface water supplies. These programs help minimize the development of cyanobacterial blooms. Nevertheless, cyanobacteria will receive more attention from drinking water suppliers, since cyanobacteria, as well as other freshwater algae, and their toxins are included in US EPA's Candidate Contaminant List 2, and in the methods development phase (List 3) of US EPA's unregulated contaminants requiring monitoring. Information on cyanobacterial blooms and drinking water is available at the CDPH website:
http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Bluegreenalgae.aspx

The CDPH website is also updated with pertinent new information regarding cyanobacteria in both drinking water and recreational waters, and has links to its drinking water and environmental management programs.

Background

Cyanobacteria, also known as blue-green algae, are common and naturally occurring in many aquatic systems around the world. When they occur, they generally reflect the overall status of the specific water body, in terms of conditions that can contribute to blooms, including decreased water flow and decreased water mixing, elevated temperature, the presence of excess nutrients, or other conditions. Certain species of cyanobacteria have the ability to produce toxins.

At least 46 species of cyanobacteria have been shown to be toxic to vertebrates (Chorus & Bartram, 1999). Some of the more common genera in California include *Microcystis*, *Anabaena*, *Aphanizomenon*, *Lyngbya, Planktothrix*, *Nostoc* and *Cylindrospermopsis.* All of these genera occur in other parts of the world.

Cyanobacterial blooms have been detected in non-marine water bodies in California, including Los Vaqueros and Mallard Reservoirs, the Sacramento River, the San Joaquin River, the Old River, Crowley Lake, Black Butte Lake, Clear Lake, the South Fork Eel River, Lake Hensley, Lake Isabella, Big Bear Lake, Perris Lake, Lake Elsinore, Canyon Lake, Pinto Lake, Lake Hennessey, Lake Britton, the Klamath River and its reservoirs, and in surface water components of the Metropolitan Water District of Southern California. Cyanobacterial blooms also may occur in Big Lagoon, an estuary, and have occurred in the Salton Sea, an inland salt-water lake. ~~To date the~~ Specific cyanotoxins identified in California include microcystins and anatoxin-a. While cyanobacteria can produce other toxins, the focus of this guidance will be on microcystin and anatoxin-a, the state's most commonly detected cyanotoxins. There may be other toxins that will be added to this draft guidance document in subsequent updates.

Various factors control the quantity of toxins produced by cyanobacteria. If cyanotoxins are produced, they are found within the cell during most of a bloom event. Toxins are released into the water when the cells die or their cellular membranes become more permeable, a process called lysis. The released toxin will dilute and eventually degrade over time. The level of toxins, and risk of exposure to dissolved toxins, may increase immediately following the peak (or collapse) of a bloom. Cyanotoxins have been detected in the water phase as a result of extra-cellular release, even though the producer cells (*i.e.*, cell density) are absent or found in low numbers (Lawton *et al.*, 1994). The potential for human exposure during this period may also increase as water clarity improves and appears more suitable for recreational activities.

Recreational, cultural and subsistence exposure to water bodies containing cyanobacteria and their toxins can cause:

- rashes (pruritic and non-pruritic),
- eye, nose, mouth or throat irritation (including oral blistering),
- allergic reactions (including urticarial rash),
- headache,

- gastrointestinal upset (abdominal pain, nausea, vomiting, diarrhea),
- malaise, and
- other effects.

Reports of fever, dyspnea, and pneumonia have also been associated with recreational exposure to these organisms. For example, British military recruits in the United Kingdom exposed to a bloom of *M. aeruginosa* during an exercise in a reservoir experienced abdominal pain, vomiting, diarrhea, sore throat, blistering of the mouth, and pneumonia (Turner *et al.*, 1990).~~One death in the United States was attributed to swimming in a cyanobacteria contaminated pond~~ High levels of cyanotoxins in drinking water have caused serious illness resulting in hospitalization in some parts of the world.

Pets and other animals are also at risk. Since 2001 ~~it is suspected that the deaths of elevendogs resulted from their~~ authorities suspect eleven dogs have died due to ~~exposure to~~ cyanotoxin exposure from swimming in water bodies with cyanobacterial blooms in Humboldt and Mendocino Counties. Exposure to anatoxin-a also was implicated in the deaths of three dogs after they swam in a creek near Roseburg, Oregon in 2009. However, most mammalian poisonings reported in the scientific literature have been due to livestock drinking microcystin-contaminated water. For example, cattle in Oklahoma, Colorado and Georgia exposed to *Microcystis aeruginosa* experienced generalized weakness, hyperthermia, anorexia, diarrhea, pale mucous membranes, mental derangement, muscle tremors, coma and death within a few days (Frazier *et al.*, 1998, Puschner *et al.*, 1998, Short & Edwards, 1990). Acute liver necrosis was the most common pathological lesion.

Microcystins

Microcystins are the most commonly detected cyanotoxin across the globe (Chorus & Bartram, 1999). Cyanobacteria that are known to produce microcystins include *Microcystis, Planktothrix, Oscillatoria, Nostoc, Anabaena, Anabaenopsis and Hapalosiphon*. Microcystins are cyclic heptapeptides with over 70 known structural variants that have significant influence on the toxicity and physio-chemical properties of the toxin. ~~The most studied and commen variant, is microcystin-LR.~~ , The cyanobacterium *Microcystis* is commonly found in recreational fresh water. The most studied microcystin variant is microcystin-LR.

The mechanism of toxicity of microcystins is the inhibition of protein phosphatases. The inhibition of protein phosphatases can cause programmed cell death that can in turn lead to internal hemorrhaging of the liver. Exposure to microcystins has the potential to cause acute and chronic injury, depending on the dose and duration of exposure. Sub-acute damage to the liver is likely to go unnoticed up to levels that are near severe acute damage (Chorus *et al.*, 2000). Two aspects of chronic damage include progressive injury to the liver and tumor-promoting capacity. The International Agency for Research on Cancer found there was inadequate evidence for carcinogenicity of microcystin-LR or *Microcystis* extracts (WHO, 2006). However like several other liver toxins, microcystins have been shown to promote liver tumors (Falconer & Buckley, 1989). Promoters increase the number of tumors when given after a chemical known to interact with DNA, but not when given alone.

The World Health Organization (WHO) has established a Tolerable Daily Intake (TDI) as well as Guideline Values (GVs) for microcystin toxin in water. These are useful in evaluating potential risk of adverse health impacts from exposure via drinking water as well as recreational water activities.

According to WHO, a TDI is the amount of a potentially harmful substance that can be consumed daily, via ingestion, over a lifetime, with negligible risk of adverse health effects. TDIs are based on scientific data and controlled laboratory studies of observed adverse health impacts. The TDI for microcystin-LR was based on observed acute effects on the liver. The primary study used to develop the microcystin-LR TDI is a 13--week oral ingestion mouse study. Because of lack of data, no long term chronic effects or carcinogenicity potential was used in the development of this TDI. Although TDIs do not account for multiple routes of exposure or cumulative risk due to exposure to multiple toxins, they are highly valuable in assessing the potential risk of adverse health effects from a single toxin. The WHO TDI for microcystin-LR toxin is 0.04 µg/kg body weight.

The GVs have been developed by the WHO to specifically address the probability of adverse effects occurring in individuals exposed to contaminated water during specific water use scenarios. GVs have been developed for drinking water consumption as well as recreational water exposure.

WHO guideline values represent a scientific consensus, based on broad international participation, of the health risk to humans associated with exposure to microbes and chemicals found in water. For recreational water exposure GVs are defined at three primary concentration levels: *mild or low*, *moderate* and *high probability* of risk for adverse health impacts if exposed at a given toxin concentration. GVs are calculated values. They are derived using the TDI for a given chemical along with a person's average body weight and the estimated amount of contaminated water that may be ingested on a daily basis during a given activity. GVs do not take into account health risks that may be attributed to other routes of exposure, such as aerosol inhalation or skin contact. The WHO GV for moderate risk of adverse health effects from recreational exposure to microcystin in water is 20 µg/liter (or a density of approximately 100,000 cyanobacteria cells per milliliter (ml) of water). The WHO GV for high risk is the presence of active algal scums, which can increase cell densities 1000 to 1,000,000 fold. See Table 2, below.

Anatoxin-a

Anatoxin-a is an alkaloid neurotoxin that is produced by some strains of *Anabaena*, *Aphanizomenon, Oscillatoria, Phormidium,* and *Cylindrospermum* (Chorus & Bartram, 1999; Gugger *et al.*, 2005). Anatoxin-a mimics the neurotransmitter acetylcholine, binds to nicotinic acetylcholine receptors but cannot be degraded by the enzyme acetylcholinesterase. The molecular activity of anatoxin-a leads to over stimulation of muscle cells and possibly paralysis followed by asphyxiation (Carmichael, 1997). In addition to anatoxin-a, anatoxin-a(s) and homoanatoxin have been identified from cyanobacteria and vary in their toxicity and mode of action.

The acute~~ly~~ toxic ~~properties~~ effects of anatoxin-a exposure in pets can include ~~are obvious, since it~~s e~~ffects are on the nervous system~~ difficulty breathing, muscle tremors, convulsions, ~~(~~paralysis, and death due to asphyxiation. Such health effects may occur very quickly (*i.e.*, within 30 minutes) after exposure. Available data indicate that limited exposure to anatoxin-a is unlikely to cause chronic toxicity (Fawell *et al.*, 1994). At this time, however, data are insufficient to enable derivation of a TDI, reflecting the lack of human exposure information and results from suitable animal tests.

Exposures Pathways

The primary exposure pathway of concern for exposure to cyanotoxins is through ingestion of water. Dermal irritant or allergic effects are possible from skin contact with lipopolysaccharides found on algal cell surfaces; however the cyanotoxins are not likely to cross the skin barrier and enter the bloodstream. Inhalation and aspiration of toxin is possible, especially through activities where the toxin is aerosolized, such as water skiing, jet skiing or splashing.

Ingestion of water can occur through both incidental and intentional ingestion pathways. Incidental ingestion is more likely in recreational waters, especially in turbid or discolored lakes. The risk of incidental ingestion is particularly high for children playing in near-shore areas since these areas are also where scums tend to accumulate. Exposure levels can be broadly defined as high, moderate and low based on recreational activity (Table 1).

Table 1. Level of recreational activity (modified from (Queensland Health, 2001).

Level of Exposure	Recreational Activity
High	Swimming, diving, water skiing
Moderate	Canoeing, sailing, rowing
Low to none	Fishing, pleasure cruising, picnicking, hiking

Ingestion of untreated water is never a good idea, as it increases risk of exposure to microorganisms such as bacteria, viruses, *Giardia*, and *Cryptosporidium*, as well as cyanobacteria. A possible scenario for the intentional ingestion of recreational water is the use of lake water for drinking or cooking purposes by campers, hikers and backpackers. ~~It is possible that some campers, hikers, or backpackers have the mistaken belief that~~ However, boiling, filtering or treating cyanotoxin-contaminated water with field equipment will not make it potable. Health concerns about ingesting toxins from blue-green algae contaminated water bodies should be addressed in informational materials for this audience and advisory signs posted at trail heads when feasible.

At this time, there is insufficient information to determine the risk of consuming fish caught in waters with toxigenic cyanobacteria. Studies have shown that toxins mainly accumulate in the liver and viscera of fish, although microcystins have been detected in the fillet (Magalhaes *et al.*, 2001, Vasconcelos, 1999, Xie *et al.*, 2005). At a minimum, the fish should be rinsed with potable water and the organs should be removed and discarded prior to cooking fillets. In one study, the muscle, as well as liver, of carnivorous fish contained higher microcystin concentrations than similar tissues from herbivorous fish (Xie et al., 2005). In addition, shellfish have been shown to accumulate cyanotoxins in edible tissue (Vasconcelos, 1999).

Monitoring

General Information

Assessing the human health risk posed by toxic cyanobacteria, or the potential for development of cyanobacterial blooms, and linking this to effective measures to protect public health within available resources, is complex. Currently there are few readily available analytical methods to quantify cyanobacterial toxicity and identify the profile of microcystin variants within a water sample.

An initial step in determining the prevalence of potentially harmful algal blooms in California could include collection of standardized information on visible blue-green algae blooms by local agencies. This information might include:

> Historical records and local knowledge – historical records, if available, and information from the local community can be used to identify presence of water bodies prone to cyanobacterial blooms. Members of the local community can often provide anecdotal examples of human health incidents, pet or livestock mortalities and fish-kills associated with blooms and scums. A lack of historical and local evidence of blooms cannot be taken as assurance that cyanobacterial blooms have not occurred, or will not occur.
>
> Physical data – planktonic cyanobacteria favor certain growing conditions that include surface water temperature above about 18 °C, and persistent thermal stratification with little mixing.
>
> Hydraulic mixing and transport processes -the ratio between the depth of the mixed layer and the depth to which sufficient light for photosynthesis penetrates, along with data on flushing rates in lakes as well as river flow rates are useful because planktonic cyanobacteria do not usually attain high population densities in highly flushed environments with retention times (i.e. the time it takes for the water volume to be exchanged once) of less than 5-10 days, or in the open channels of flowing rivers. Cyanotoxins are water-soluble compounds that can readily move downstream; as such it may be prudent to monitor potential cyanotoxin concentrations downstream from a lake or reservoir where a bloom is occurring or has recently dispersed.
>
> Chemical data -the mass development of cyanobacteria leading to blooms is dependent on the nutrient concentrations (especially phosphorus and nitrogen) in a water body. The relationship between chlorophyll *a* concentrations (as a simple measure of cyanobacterial and planktonic algal biomass) and annual mean phosphorus and nitrogen concentrations ~~provides a valuable (but easily misued)~~

~~basis for~~ may be helpful in assessing the likelihood of planktonic biomass development.

Biological data -monitoring records are useful in contributing to the assessment of the likelihood, onset and persistence of cyanobacterial mass developments.

Simple visual observation of a water body is an important tool in recognizing blue-green algae. Materials that enable the identification of algal types (e.g., a field guide) provide an early-warning mechanism to help address concerns about blue-green algal blooms.

Characterizing the recreational water body (for example, by a sanitary survey) is also helpful in identifying situations and activities that might affect the overall water quality, not only for blue-green algae, but also for microbiological indicators (e.g., total and fecal coliforms, enterococcus, and *E. coli*) that may be important to consider for healthful recreation.

If a blue-green algal bloom occurs, water sample collection for algal species identification, algal cell enumeration or toxin analysis may be warranted. See Appendix 1 for additional discussion on this issue.

Reporting

Large blooms of blue-green algae, and any known occurrences of toxic cyanobacteria and their toxins (if toxin analysis has been performed) should be reported to local health and environmental health officials, as well as the State and Regional Water Boards. ~~Known occurrences of toxic cyanobacteria should also be reported to the State and Regional Water Boards. To the extent that historical information is available, it should be reported to the State Water Board. The State Water Board will provide a clearinghouse of reported algal blooms and toxic cyanobacteria, on a dedicated webpage that will be updated periodically.~~

The occurrence of large cyanobacterial blooms should also be reported to the county agricultural commissioner if grazing lands are proximal to the affected water body, and to the local offices of the State Department of Fish and Game, as well as U.S. Fish and Wildlife, to address concerns about effects on livestock and wildlife. If the blooms are observed on federal or tribal lands these should also be reported to the appropriate land managing authority (e.g., US Forest Service, Tribal Health Department, etc.)

Posting Information / Issuing Warning Notices and ~~Issuing~~ Advisories

Public Health Information

For water bodies that historically experience cyanobacterial blooms routinely during the summer months, local officials should consider providing general information about cyanobacteria to the public. Informational materials may include signs or brochures available at public access points indicating that visitors should watch for and avoid contact with algal scums. Public service announcements or messages on local government agency websites may also be helpful ways to inform recreational water users. Examples of informational materials are included in Appendix 3.

Warning Notices and Advisories
Local health agencies may post advisories regarding blue-green algal blooms or order closure of recreational waters. Recommended steps in determining whether to post a health advisory may include:

Hazard Identification

- Are there visual indications of a blue-green algal bloom (distinct green or blue-green discoloration or streaks along surface water, or an accumulation of scum in bays or along shorelines)?

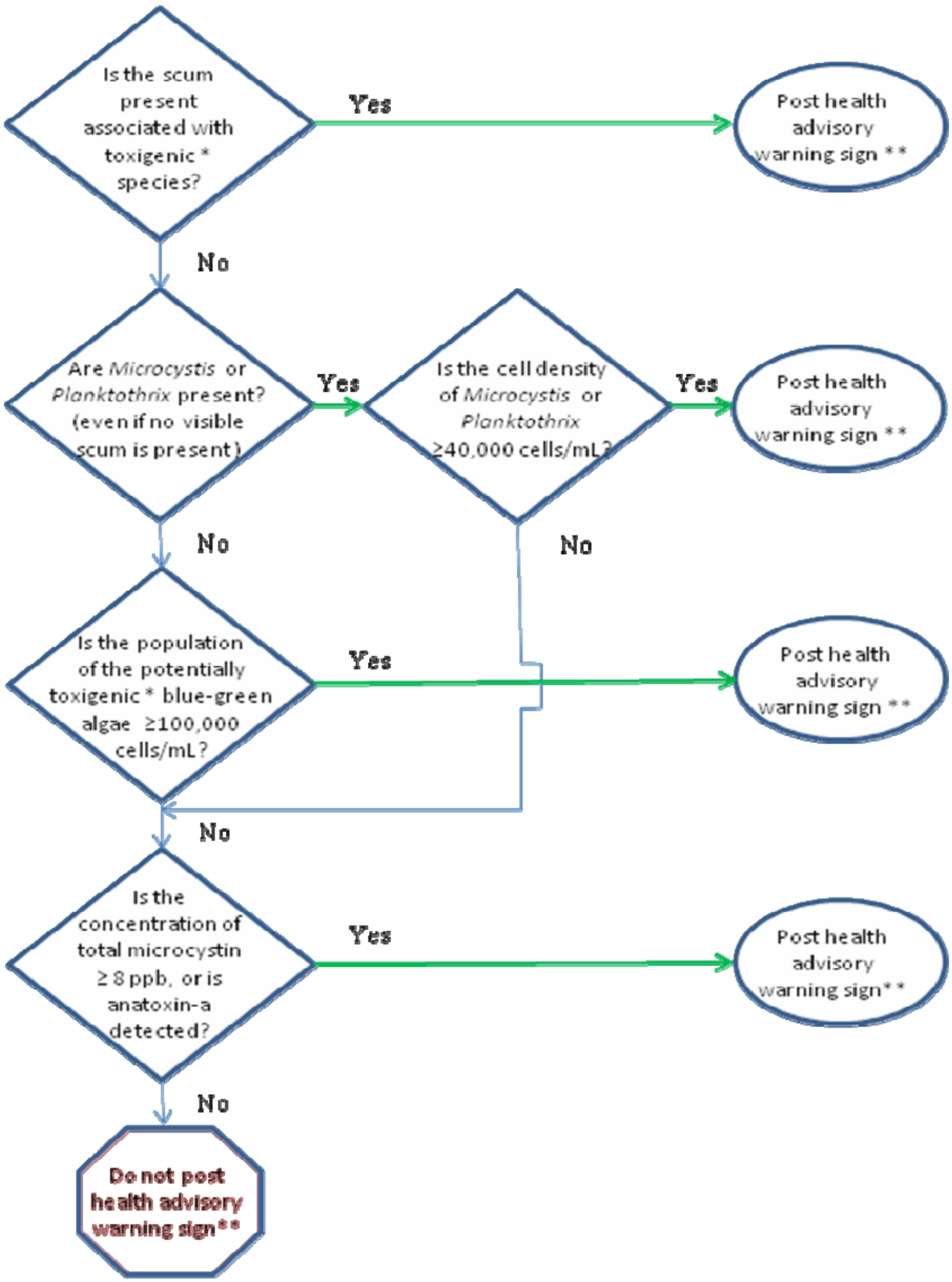
- If water analysis for algae has been done, are toxigenic cyanobacterial species present? If Yes:

  - What species of toxigenic cyanobacteria are present?
  - What is the density of toxigenic species in the water?
  - If water analysis for the cyanobacterial toxin microcystin or anatoxin-a has been done, what is the concentration of total microcystins or anatoxin-a?

Posting Decisions

- If visible scum is present, Post health advisory warning signs and distribute informational brochures. See Appendix 2 for examples of Health Advisory warning signs.
- When sampling for phytoplankton identification and/or cyanobacterial toxin quantification, the following decision tree may be utilized:

Figure 1. – Decision tree for posting health advisory warnings:



* Potentially toxic blue-green algae that have been detected in California include those of the genera *Anabaena, Microcystis*, *Aphanizomenon, Planktothrix, and Gloeotrichia.* *A*dditional blue-green algae that are known to be potentially toxic may be added to this list.

** <u>See Appendix 2 for examples of Health Advisory warning signs</u>

At this time, health impairments from exposure to cyanobacteria in recreational waters cannot be precisely defined or predicted. Recreational exposure to cyanotoxins via direct skin contact, inhalation, or inadvertent ingestion of water can cause rashes, allergies, and gastrointestinal problems for people working or recreating on the water (WHO, 2003). The long-term effects of such exposures or the effects of inhalation of toxins are not well known (Lopez *et al.*, 2007). However, the World Health Organization has developed a series of categories that compare cyanobacterial cell concentrations with the probability of adverse health effects:

As most cyanobacteria produce some combination of cyanotoxins, and as the most commonly found cyanobacteria produce microcystins in particular, the trend in monitoring has often used cyanobacterial cell counts as a proxy for toxin concentrations. This stems from the higher cost for toxin analyses, the small number of laboratories performing the analyses, and the limitations in the research to be able to quantify all of the different cyanotoxins. <u>However</u>, <u>enzyme-linked immunosorbent assay (ELISA)-based testing kits are now available that measure total microcystin concentration in water. These kits provide toxin results more rapidly than is possible for cell count analysis and are likely to become more affordable as this technology matures.</u>

The World Health Organization has used a number of studies to estimate an approximate microcystin concentration that would be expected from a given cell density of *Microcystis aeruginosa*. Their guidelines also state that levels of 4 µg/L and 20 µg/L would be expected at the relatively low and moderate risk levels respectively. The WHO also points out that if another species other than *M. aeruginosa* dominates, the microcystin levels could be quite different. Microcystin levels could be doubled for a bloom of *Planktothrix agardhii* or significantly decreased for blooms of other microcystin-producing genera such as Anabaena. Other studies in the literature indicate that there can be substantial variability in the toxin production by *M. aeruginosa*. Different strains of the same cyanobacterial species can vary in their genetic capacity to produce toxin. Some blooms of *M. aeruginosa* may in fact produce little to no microcystin. Other strains may be neurotoxic, hepatotoxic, or both neuro-and hepatotoxic. This may be related to a variety of genetic and environmental variables that can alter the behavior of *M. aeruginosa* strains, as well as determine when genes for microcystin synthesis are activated (Zurawell *et al.*, 2005). When possible, it is ideal to identify and enumerate the cyanobacteria species, and to also analyze and quantify the presence of microcystins. ~~When this is not possible, cyanobacterial cell counts may be used as an indicator for toxin concentrations as a prudent precaution.~~

Table 2. WHO Guidelines

Guidelines for Algae and Cyanobacteria in Fresh Water (from WHO Guidelines for Safe Recreational Water Environments, Table 8.3, Guidelines for Safe Practice in Managing Recreational Waters, page 150 (WHO, 2003))				
Probability of adverse health effects	Guidance level or situation	How guidance level derived	Health Risks	Typical Actions
Relatively low	20,000 cyanobacterial cells/ml or 10 µg/ chlorophyll-a/liter with dominance of cyanobacteria	From human bathing epidemiological study	Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	Post on-site risk advisory signs Inform relevant authorities
Moderate	100,000 cyanobacterial cells/ml or 50 µg chlorophyll-a/liter with dominance of cyanobacteria	From provisional drinking-water guideline value for microcystin-LR [= 1 µg/L] and data concerning other cyanotoxins	Potential for long-term illness with some cyanobacterial species Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	Watch for scums or conditions conducive to scums Discourage swimming and further investigate hazard Post on-site risk advisory signs
				Inform relevant authorities
High	Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur	Inference from oral animal lethal poisonings Actual human illness case histories	Potential for acute poisoning Potential for long-term illness with some cyanobacterial species Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	Immediate action to control contact with scums; possible prohibition of swimming and other water contact activities Public health follow-up investigation Inform public and relevant authorities
*Actual action taken should be determined in light of extent of use and public health assessment of hazard.				

In 2005, an Oregon statewide interagency cyanobacteria task force recommended issuing advisories at a lower guideline of 40,000 cells/mL if cell populations are dominated by *Microcystis* and *Planktothrix* (Stone & Bress, 2007). This lower guideline is based on the premise that these two genera are more likely to produce microcystin toxin compared to other genera, such as *Anabaena* (Chorus & Bartram, 1999, Codd *et al.*, 2005) and the observation that almost all *Microcystis* strains are toxic (Carmichael, 1995). To derive the guideline of 40,000 cells/ml, a risk assessment approach was employed based on recreational exposure to microcystin toxin to a child (Appendix 7).

No TDI or reference dose has been established for anatoxin-a, prohibiting the quantitative approach that was used for microcystin. However, the Washington State Department of Health tentatively recommended a level of <1 ug/L as a "protective approach for use in the absence of an acute anatoxin-a RfD [reference dose]"(Washington State, 2008). Detection of anatoxin-a at any level should trigger posting of a health advisory warning because of its ephemeral nature and potentially lethal effects.

If a water body is posted because of a large blue-green algae bloom, the signage should address the presence of cyanobacteria in general. This is because it is as yet unclear whether all important cyanotoxins have been identified, and because the health outcomes that may be observed after recreational exposure (particularly irritation of the skin and mucous membranes) are probably related to other components of cyanobacteria, such as allergens and irritants.

Suggested Signage and Information

If the decision is made to post a recreational water body, signage should be large enough to be seen and read by the recreating public. Signs should be placed at access points to the affected water body or other appropriate locations. (See examples of suggested signage, Appendix 2).

When a posting, closure, or other restriction or public notification occurs in a water body that is used as a source of drinking water by a public water system, the local health officer should notify the manager of the public water system.

Other means of public information and education may be appropriate, including signs, brochures, press releases and public service announcements. Examples of informational notices (signs), press releases and brochures are attached in Appendix 3.

Because the symptoms of exposure to cyanobacterial toxins may be similar to those caused by other disorders or diseases, local health officials may want to notify local doctors, hospitals, and veterinarians of the presence of toxic cyanobacteria.

Doctors and veterinarians may not be familiar with the symptoms of cyanotoxin exposure in humans, pets, and livestock. Symptoms of cyanotoxin poisoning may be misdiagnosed without proper information on their acute and chronic effects.

Facts sheets may be sent to local doctors, hospitals, clinics and veterinarians with information about the occurrence and symptoms of toxin exposure. Examples of fact sheets and animal illness response plans are attached in Appendices 4, 5 and 6.

Long-Term Advisory Warnings

In certain situations when chronic blue-green algae blooms occur, as with certain ocean storm drains with chronic microbiological contamination, long-term posting in lieu of monitoring may be a reasonable approach.

Lifting Advisories

Cyanotoxins are found within the cell during most of a bloom event. Toxins may be released into the water when the cells die and lyse. The released toxin will dilute and eventually degrade over time. The risk of exposure to toxins may be greater immediately following the peak of a bloom through extracellular release, even though the producer cells (i.e. cell density) are absent or found in low numbers (Lawton et al., 1994). An additional risk factor is that the water will appear more suitable for recreational activities as clarity increases, thus elevating the potential for exposure during this period.

Stone and Bress (2007) recommend that advisories be lifted two weeks after cell counts fall below ~~recommended thresholds established in the “Posting Warning Notices and Issuing Advisories” section~~ the guideline values in Fig 1 of this guidance ~~and~~ as long as ~~if~~ there is evidence of a declining bloom (i.e., increasing water clarity). If toxin analyses are being conducted, then advisories may be lifted one week after toxin results are below the guideline levels, as long as the bloom continuing to decline. Stone and Bress also suggest that under extreme blooms, e.g., when an illness from cyanobacterial toxins exposure occurs, an official closure of the water body may be appropriate.

If the dominant species of blue-green algae is known to produce anatoxin-a and microcystin, it is recommended that both toxins be tested prior to lifting an advisory.

The advisory should remain in place until a final quantitative sample confirms the decreasing trend of potentially toxigenic blue-green algae and restrictions should remain in place whenever scums are visible. In some situations there may be reason, such as reported illness and/or persistence of the toxin, to prolong the advisory beyond the recommended waiting period.

This general approach may be useful in determining when to lift warning advisories:

- If posting occurred due to visible scum – wait two weeks (there should be no visible scum recurrence during this time) before lifting the advisory.
- If posting occurred due to exceeding a cell count guideline – wait two weeks after cell count falls below the recommended guideline (there should be no visible scum recurrence during this time) before lifting the advisory.
- If posting occurred due to exceeding a toxin concentration guideline – wait 1 week after the toxin concentration falls below the recommended guideline (there should be no visible scum recurrence during this time) before lifting the advisory.

Authorities

State and Regional Water Boards

The Water Boards are authorized to require others to post health warnings or to post the warnings themselves under appropriate circumstances. Under Water Code section 13304, the Water Boards can issue a Cleanup and Abatement Order directing anyone responsible for discharging wastes that have caused an algae bloom to post health warnings. Posting is a pollution or nuisance "abatement" activity authorized under section 13304. Under Water Code section 13304(b), the Water Boards may do the posting themselves under appropriate circumstances, for example, if there is no readily identifiable responsible party or urgent action is needed.

If the algae bloom is not the result of waste discharges, then the Water Boards can use Water Code section 13225(d) and/or (g) to formally notify the local health officer of the health threat and officially request that the health officer post health warnings. Subsection (d) provides that the Regional Water Boards shall request federal, state, and local agencies to enforce their respective water quality control laws. Subsection (g) directs the Regional Water Boards to report any case of suspected contamination to the State Water Board and the appropriate local health officer. Further, if more assertive action is necessary, the Regional Water Boards can require the local health officer, under Water Code Section 13225(c), to investigate the problem and report back to the Regional Water Boards on the results of the investigation and actions that the health officer will take to protect the public.

The Regional Water Boards can coordinate the posting of health warnings under Water Code section 13225(a). This subsection requires the Regional Water Boards to "[c]oordinate with the state board and other regional boards, as well as other state agencies with responsibility for water quality, with respect to water quality control matters, including the prevention and abatement of water pollution and nuisance."

Under Clean Water Act section 303(d), the Water Boards are required to identify and list water bodies that are impaired due to pollutants and to develop plans to address the impairments. Appropriate measures to address the impairments may include posting for public health protection."

Local Health Departments

Health and Safety Code 101030. The county health officer shall enforce and observe in the unincorporated territory of the county, all of the following:

a) Orders and ordinances of the board of supervisors, pertaining to the public health and sanitary matters.
b) Orders, including quarantine and other regulations, prescribed by the California Department of Health Public Health;
c) Statutes relating to public health.

Health and Safety Code 101040. The county health officer may take any preventive measure that may be necessary to protect and preserve the public health from any public health hazard during any "state of war emergency," "state of emergency," or "local emergency," as defined by Section 8558 of the Government Code, within his or her jurisdiction.

- "Preventive measure" means abatement, correction, removal or any other protective step that may be taken against any public health hazard that is caused by a disaster and affects the public health.

- Funds for these measures may be allowed pursuant to Sections 29127 to 29131, inclusive, and 53021 to 53023, inclusive, of the Government Code and from any other money appropriated by a county board of supervisors or a city governing body to carry out the purposes of this section.

- The county health officer, upon consent of the county board of supervisors or a city governing body, may certify any public health hazard resulting from any disaster condition if certification is required for any federal or state disaster relief program.

California Department of Public Health

California DPH regulates public water systems under the California Safe Drinking Water Act (Health and Safety Code Section 116270, et seq.), and, via primacy, the federal Safe Drinking Water Act. DPH laws and regulations include:

1) Health and Safety Code Sections 100275, 115880, 116075, and 116080 authorize the Department of Public Health to adopt regulations pertaining to beach safety (the latter two are specific for ocean waters and bays).
2) DPH's regulations for ocean beaches and ocean water contact areas for recreational use are published in Title 17 of the California Code of Regulations, in Group 10. Sanitation, Healthfulness and Safety of Ocean Water-Contact Sports Areas. beginning with Section 7952.
3) DPH's regulations for public beaches are in Title 17 of the California Code of Regulations, Group 10.1 Sanitation of Public Beaches, beginning with Section 7972. They provide definitions of terms, and address the provision of water supply, toilets and sanitary facilities, maintenance, refuse handling, campsites and animals.
4) DPH also has general authority in public health matters:

Health and Safety Code Section 131056 states that the department may commence and maintain all proper and necessary actions and proceedings for any or all of the following purposes: (a) To enforce its regulations. (b) To enjoin and abate nuisances dangerous to health. (c) To compel the performance of any act specifically enjoined upon any person, officer, or board, by any law of this state relating to the public health; and (d) To protect and preserve the public health. It may defend all actions and proceedings involving its powers and duties. In all actions and proceedings it shall sue and be sued under the name of the department.

Health and Safety Code Section 131080 states that the department may advise all local health authorities, and, when in its judgment the public health is menaced, it shall control and regulate their action.

Resources for Additional Information

Each county in California (as well as the cities of Berkeley, Long Beach, Pasadena, and Vernon) has a health department led by a Director or Health Officer. Their contact information is available through the directory published by the California Conference of Local Health Officers: http://www.cdph.ca.gov/programs/cclho/Pages/default.aspx

Local telephone book blue government pages also list phone numbers for the local city or county health department.

California Department of Public Health:
http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Bluegreenalgae.aspx

State Water Resources Control Board:
http://www.waterboards.ca.gov/water_issues/programs/bluegreen_algae/

United States Geological Survey:
http://pubs.usgs.gov/sir/2008/5038/

National Center for Disease Control:
http://www.cdc.gov/hab/cyanobacteria/facts.htm

World Health Organization Guidelines for Drinking Water Quality, 3rd Edition:
http://www.who.int/water_sanitation_health/dwq/gdwq3/en/index.html

World Health Organization Guidelines for Safe Recreational Waters, V. 1 – Coastal and Fresh Waters: http://www.who.int/water_sanitation_health/bathing/srwe1-chap8.pdf

World Health Organization's "Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management":
http://www.who.int/water_sanitation_health/resourcesquality/toxicyanbact/en/index.html

Cyanobacteria Image Galleries:

http://www-cyanosite.bio.purdue.edu/images/images.html

http://botit.botany.wisc.edu/images/130/Bacteria/Cyanobacteria/

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Appendix 1 – Monitoring

Assessing the risk posed by toxic cyanobacteria, or the potential for development of Cyanobacterial blooms, and linking this to effective measures for the protection of public health within available resources, is complex. The responses to long-term situations will be different from those where there is an immediate threat.

Public health concerns will probably drive objectives when developing monitoring plans for cyanobacterial blooms. Before data are collected public health officers should develop a plan to communicate those data to the public. Example objectives could include:

- Assessing and responding to public health concerns,
- Assessing potential causes of the bloom and identifying patterns in bloom development,
- Comparing monitoring results with established alert levels, or
- Tracking the effects of management changes,

Monitoring should focus primarily on the protection of human health and secondarily on the health of pets and livestock. Assessing the potential hazard at recreational water bodies can be complicated if numerous access points are present allowing people and animals to enter or move around the water. Blue-green algae concentrations often rapidly change due to wind or other factors. Scums can generally be assumed to present the greatest risk to recreational bathers. Monitoring should include samples that represent worst-case conditions in areas in which people and animals are most likely to contact the water. Analyses of samples that represent areas of the lake without a visible cyanobacterial bloom can also be helpful for risk communication to the public.

An effective design for bloom evaluation and monitoring should collect data that could answer questions such as:

1) Where is the bloom most concentrated? Does that change based on wind direction?
2) What are the dominant species in the bloom?
3) Are the cyanobacterial cells producing toxins? At what concentration?
4) Are toxin concentrations changing with bloom growth and die-off?
5) Are there other associated concerns or patterns – pH, dissolved oxygen (DO), taste and odor problems?

Sampling Frequency and Number of Samples

The location of samples and the number of samples taken depends upon both the specific needs as determined by recreational use and available funding. If funding is limited, sampling may need to be focused on near shore waters in areas where wading and swimming might occur. If resources allow, sampling far from shore may be desired, in order to assess risks to water skiers and other similar the recreating public.

Depending on funding and the reasons for sampling (e.g., resource management, public health protection), samples from within the bloom, from areas at various distances from the bloom, and areas appearing to be without bloom may be appropriate. Samples at various depths may also be desirable depending again on the reasons for sampling. In addition, chemical analysis can complement biological analysis by providing information on the cause of a bloom. Nutrient data to calculate the ratio of nitrogen (N) to phosphorus (P) before and during the bloom may be useful for evaluating whether or not a low N:P ratio (in general, lower than 10:1 molecules) may be one of the causes of the bloom (WHO, 1999, Chap. 2).

Sampling frequency will depend on visible changes in a bloom, public health concerns, the desired schedule for risk communication, project budget, and likely analytical turn-around times.

Sampling Methods

Sample collection

Samples of water containing blue-green algae should be taken using methods specified by the analytical laboratories. Sample collectors should take special precautions when gathering samples as some cyanotoxins may cause skin rashes following dermal exposure.

Algal sampling

Sample collection can be qualitative (a plankton net) or quantitative (a whole water sample of known volume). The online document titled "Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health," located at:
http://www.scotland.gov.uk/library5/environment/bgac-01.asp
contains a guide for sampling blue-green algae. It's called, "Recognition and identification of blue-green algal blooms and methods for sampling Annex E, " and it is located at:
http://www.scotland.gov.uk/library5/environment/bgac-18.asp

Qualitative net sampling provides a sample that is representative of a larger water volume than a specific volume of water sampling.

Sampling for toxins

Water samples should be taken in pre-cleaned glass containers equipped with Teflon-lined screw tops. The volume of sample needed is about 250 milliliters (mL), but collection volume and methods of storing and shipping samples should be discussed with the laboratory performing the analyses.

Analytical Methodologies and Laboratory Access

Blue-Green Algae Speciation Method

There is not a standard method, *per se*, for speciating cyanobacteria. There are, however, accepted methods for quantifying the numbers of each species in a known volume of sample. These require a settling chamber (and approximately 24 hours for the cells in the sample to settle), a standard cell counter like a Sedgwick-Rafter or Palmer-Maloney, and an inverted microscope. Typically a 1-milliliter (mL) sample of the settled mass is placed in the counting cell and all cells are counted and identified to genus and species.

Alternatively, a qualitative approach can be used and is often the most practical for detecting low concentrations of cells, as well as for increasing sample throughput. Qualitative observations could involve a quick field screening of a sample for determining the relative abundance of each species. This process would involve training staff to perform microscopic evaluations in the field or at a local laboratory facility. A time series of qualitative samples can provide the trend data necessary to detect an imminent bloom.

Manuals and guides for blue-green algal speciation are available and can be provided if needed.

Toxin Quantification

There are currently no US EPA approved methods for identifying and quantifying cyanotoxins in recreational or drinking water. However, US EPA has put a high priority on studying these compounds as part of its drinking water unregulated contaminants monitoring requirement (UCMR) program (see (Maizels & Budde, 2004) and http://www.epa.gov/nerl/research/2005/g2-3.html).

Cyanotoxin analysis currently available through commercial laboratories uses either liquid chromatography-mass spectrometry (LC-MS) or enzyme-linked immunosorbent assay (ELISA). The LC-MS specifically identifies individual toxins such as microcystin-LR (the most toxic of approximately 60 different microcystin congeners), while the ELISA method determines multiple types of microcystins. The capital costs of the LCMS are quite high, thus, many otherwise well-equipped water testing laboratories lack the needed instrumentation.

Laboratories

The number of laboratories available for blue-green algae speciation, cell counting, and toxin analysis is quite limited.

These analyses may be quite costly, ranging from $150 for species identification and cell counts, and from $150 to $350 for individual toxin analyses by LC-MS. The ELISA determination of microcystins is less expensive.

Laboratories providing cyanobacterial analysis at the time of publication include the following [this list will be updated as appropriate in future drafts of this document; laboratories capable of these analyses should be encouraged to contact the SWRCB to be included in updates of this list].

Species Identification

http://www.cyanolab.com

Note: Laboratories that contract with wastewater utilities often have this expertise.

Microcystin and Anatoxin Analysis

GreenWater labs (previously Cyanolabs), in Florida. LC-MS for the toxins produced by Cylindrospermopsis and Aphanizomenon and an ELISA method (qualitative and quantitative) for microcystins. Mark Aubel, (386) 328-0882, http://cyanolab.com

California Animal Health & Food Safety Laboratory System, Davis, (530) 752-8700, Tests water and animal stomach contents. http://www.cahfs.ucdavis.edu/index.php

California Department of Fish and Game, Fish and Wildlife Water Pollution Control Laboratory, water and tissue analysis, David B. Crane (916) 358-2859, dcrane@ospr.dfg.ca.gov

US EPA Region 9 Lab, 1337 S. 46th St., Bldg. 201, Richmond, CA 94804 Contact: Andrew Lincoff. EPA lab does ELISA method (qualitative and quantitative) for microcystins, in support of EPA Regionally identified priorities.

Field testing

Research is ongoing for ELISA -based and genetic-based field test kits. There are commercial test kits (ELISA format) that may be suitable for use in local public health laboratories: http://www.envirologix.com/library/et022spec.pdf and http://www.abraxiskits.com/product_algal.htm

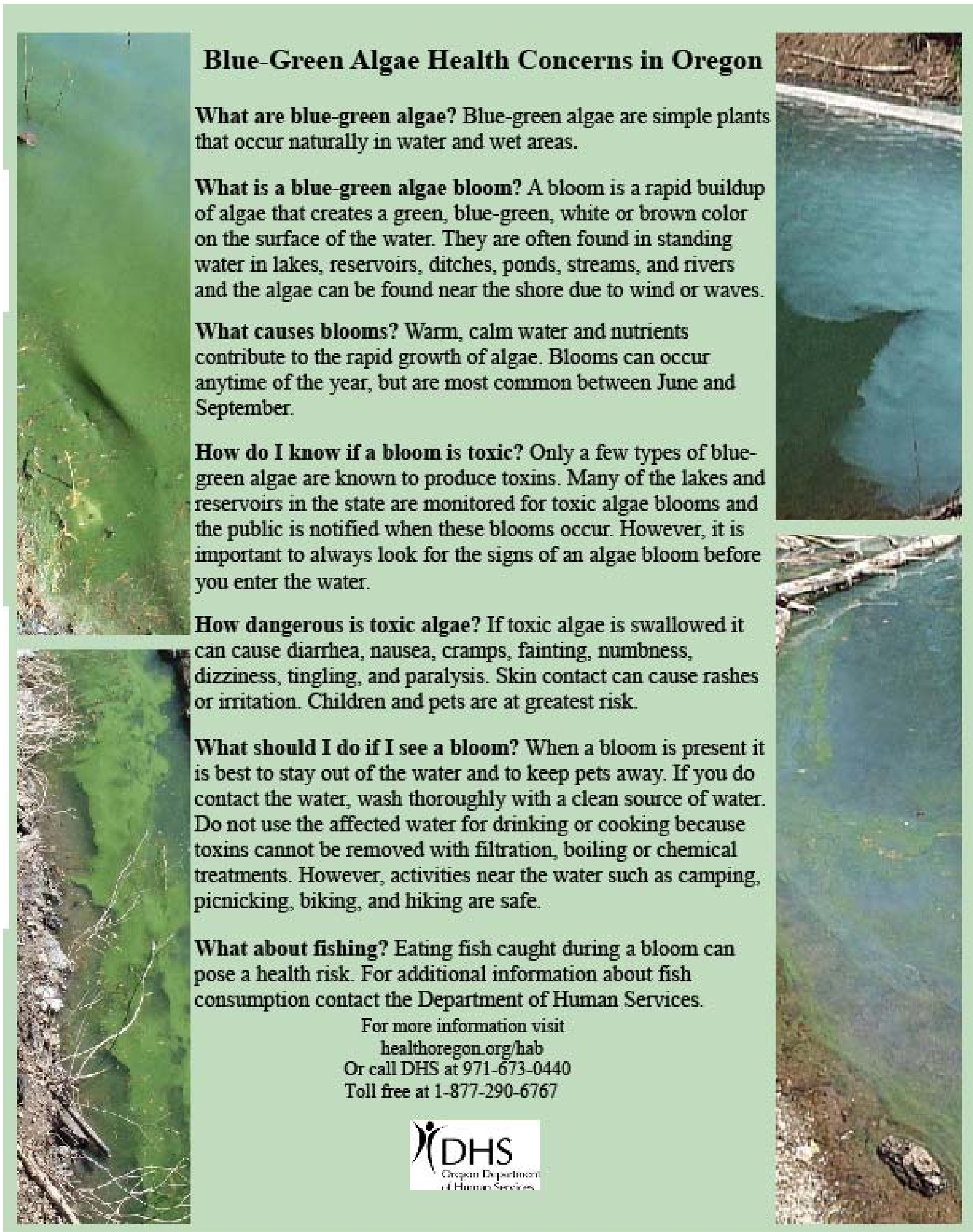
Appendix 2 – Signage

Example of advisory sign from Oregon:

Example of advisory sign from the North Coast RWQCB:

Appendix 3 - Public Brochures and Press Releases

Example of Public Brochure from the Oregon Department of Health:



Blue-Green Algae Health Concerns in Oregon

What are blue-green algae? Blue-green algae are simple plants that occur naturally in water and wet areas.

What is a blue-green algae bloom? A bloom is a rapid buildup of algae that creates a green, blue-green, white or brown color on the surface of the water. They are often found in standing water in lakes, reservoirs, ditches, ponds, streams, and rivers and the algae can be found near the shore due to wind or waves.

What causes blooms? Warm, calm water and nutrients contribute to the rapid growth of algae. Blooms can occur anytime of the year, but are most common between June and September.

How do I know if a bloom is toxic? Only a few types of blue-green algae are known to produce toxins. Many of the lakes and reservoirs in the state are monitored for toxic algae blooms and the public is notified when these blooms occur. However, it is important to always look for the signs of an algae bloom before you enter the water.

How dangerous is toxic algae? If toxic algae is swallowed it can cause diarrhea, nausea, cramps, fainting, numbness, dizziness, tingling, and paralysis. Skin contact can cause rashes or irritation. Children and pets are at greatest risk.

What should I do if I see a bloom? When a bloom is present it is best to stay out of the water and to keep pets away. If you do contact the water, wash thoroughly with a clean source of water. Do not use the affected water for drinking or cooking because toxins cannot be removed with filtration, boiling or chemical treatments. However, activities near the water such as camping, picnicking, biking, and hiking are safe.

What about fishing? Eating fish caught during a bloom can pose a health risk. For additional information about fish consumption contact the Department of Human Services.

For more information visit
healthoregon.org/hab
Or call DHS at 971-673-0440
Toll free at 1-877-290-6767

DHS
Oregon Department of Human Services

Example of Public Brochure from the Wisconsin Department of Natural Resources

Contact Information

***If you think you are experiencing symptoms** related to exposure or ingestion of blue-green algae, contact your doctor or the Poison Information Hotline at 1-800-222-1222.*

***If your pet displays symptoms** such as seizures, vomiting, or diarrhea after contact with the water, contact your local veterinarian.*

***For more information** about contacting your local health department, check the Department of Health & Family Services website:*

http://www.dhfs.state.wi.us/dph_ops/LocalHealth/

State of Wisconsin
Department of Natural Resources

Watershed Bureau
101 S. Webster St.
Box 7921
Madison, Wisconsin 53707-7921

Telephone 608-267-7694
FAX 608-267-7664

TTY Access via relay – 711

http://dnr.wi.gov

PUB-WT-803 6/04

PRINTED ON RECYCLED PAPER

Blue-Green Algae

GET THE FACTS ABOUT BLOOMS OF BLUE-GREEN ALGAE AND CONTINUE TO ENJOY WISCONSIN WATERS

Wisconsin Department of Natural Resources

Blue-green algae can form "blooms" in lakes, ponds, or rivers.

What are Blue-Green Algae?

Blue-green algae (or cyanobacteria) are common, native algal species found in rivers, lakes, and ponds throughout Wisconsin. These algae can form large "blooms" due to high nutrient levels, (e.g. phosphorous) or when environmental conditions are favorable. These blooms may appear as scum layers or large floating mats and often have a bluish-green color and an unpleasant odor.

Some species of blue-green algae naturally produce toxic substances. Humans and animals may experience illness or other health effects if there is skin contact with algal toxins or if large quantities of the algae are ingested while toxins are being produced. Scientists who study water quality do not have any sampling tools to accurately predict when algal toxins may be present. Due to this uncertainty, common sense is necessary if algal blooms are present.

Symptoms of Contact with Blue-Green Algae

Swimming in water with an algal bloom may cause symptoms such as:

- skin rash
- hives
- runny nose
- irritated eyes
- throat irritation

Swallowing* or *ingesting water with an algal bloom may cause symptoms such as:

- vomiting, diarrhea, or nausea
- headache, throat irritation, or muscle and joint pain
- in severe cases, paralysis, respiratory failure, or death
- seizures or convulsions in your pets

Do not allow pets to drink or swim in algal blooms.

Preventing Exposure to Algal Toxins

- Use common sense to ensure the safety of yourself and your family.
- Avoid contact with scum layers, large mats, or other visible blooms of blue-green algae.
- DO NOT allow pets or children to play in shallow, scummy areas or areas where blooms of algae are present.
- Avoid jet-skiing, windsurfing or water-skiing over mats of algae.
- Do not use raw, untreated water for drinking, cleaning food or washing camping gear.
- Do not attempt to boil contaminated water as this may release more toxins from the algae.
- If you come in contact with a bloom, wash off thoroughly, paying special attention to the swimsuit area.
- If your pet comes in contact with a bloom, wash off your pet's coat to prevent it from ingesting the algae while self-cleaning.

Fact Sheet approved by
Humboldt, Mendocino and Del Norte County Environmental Health Departments:

<u>Blue Green Algae Health Concerns—North Coast Region of California</u>

What are blue green algae? Blue green algae are actually a type of ancient bacteria commonly found in water or wet areas.

What is a blue green algae bloom? When conditions are right, algae can rapidly build up or "bloom" on the surface of reservoirs, rivers, creeks, lagoons, lakes and ponds. The bloom can be green, blue green, white or brown, and may look like a floating layer of scum or paint.

What causes blooms? Warm, slow-moving waters that are rich in nutrients like fertilizer or manure runoff can cause algae growth. Blooms can occur at any time, but are most common in late summer or early fall.

How do I know if a bloom is toxic? Only a few types of blue green algae are known to produce poisons. Most blooms of algae in our region are made up of harmless green algae. North coast counties do not have the resources to test their many water bodies for these toxins. (An exception is the Klamath River, which has been regularly tested for blue green algae toxins by tribal and federal agencies over the summer season for the last few years). Often, the first sign that a bloom is toxic is a dog that has gotten sick after swimming in stagnant water.
Always look for the signs of an algae bloom <u>before</u> you enter the water, or before you let your children or pets enter the water.

How dangerous is toxic algae? If toxic algae touches your skin, or you accidentally inhale or swallow water containing the toxin during recreation, you could get a rash or an allergic reaction, or develop gastrointestinal problems. The long-term effects of these exposures are not well known, but children and pets are at greatest risk. Since 2001, 9 dog deaths following contact with fresh water bodies in Humboldt and Mendocino Counties are suspected to have been caused by blue green algae poisoning. Dogs can be exposed to particularly high levels of toxins by licking blue green algae off their fur after a swim. No documented incidents of human poisoning from blue green algae have been reported in any of the three north coast counties.

What should I do if I see a bloom?

- Stay out of areas where the water has foam, scum, or mats of algae. Keep children and pets out of such areas at all times. If you or your pets swim or wade in water with algae, rinse off with fresh water as soon as possible. Always warn young children not to swallow **any** water, whether or not you see signs of algae.
- Do not drink or cook with this water. Even if you boil or filter it, the toxins can persist.
- Do not let livestock swim in or drink from areas where you see foam, scum, or mats.
- Get medical treatment right away if you think that you, your pet or your livestock might have been poisoned by blue green algae toxins.

What about fishing and other activities? Eating fish caught during a heavy bloom can pose a health risk. Always remove the guts and liver, and rinse fillets in tap water before eating the fish. Other activities near the water such as camping, picnicking, biking and hiking are safe.

Report pet deaths/illnesses following water contact, or unusual numbers of dead or distressed wildlife along the shoreline to:

- Humboldt County – Harriet Hill, REHS, 707-445-6215 or 1-800-963-9241
- Mendocino County – John Morley, REHS, 707-463-4466
- Del Norte County – Peter Esko, REHS, 707-464-3191

Find more information at the CA Department of Heath Public Health's website:
http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Bluegreenalgae.asp

Example of public news release from Siskiyou County Public Health:

News Release

Siskiyou County Public Health

NUMBER: ALG 06-02 DATE: August 3, 2006 FOR RELEASE:
CONTACT: Terry Barber
http://www.co.siskiyou.ca.us/phs

The summer recreation season is upon us. County residents and visitors are visiting our local waterways to enjoy camping, boating, kayaking, and river rafting activities.

The Siskiyou County Public Health Department reminds residents and visitors that Irongate Reservoir, Copco Lake and Lake Shastina are known to have seasonal blooms of blue-green algae (cyanobacteria). Irongate Reservoir and Copco Lake are currently experiencing a bloom. Blooms typically occur between June and October when temperatures rise and water conditions are favorable for algal growth.

Samples from Irongate Reservoir and Copco Lake taken in late July indicate high algae cell counts and visible algal scums along the shoreline. Sampling from previous years indicates that these algae are capable of releasing toxins that are potentially harmful to human health. Related to those blooms, Siskiyou County provided brochures at the affected water bodies and provided public service announcements about potential health concerns.

Blue-green algal blooms are common phenomena that occur world wide. The State of California has embarked upon a process to evaluate the potential health risks associated with blue-green algal toxins, determine appropriate water sampling and monitoring procedures, identify strategies to control toxic blooms, and to better inform the public about health and environmental concerns. Siskiyou County is an active participant in this statewide effort and will continue to keep abreast of information and issues concerning toxic blue-green algal blooms.

While there have been no documented cases of human illness associated with blue-green algae in California, studies around the world show that recreational exposures to toxic blue-green algae might result in eye irritation, allergic skin rash, mouth ulcers, vomiting and diarrhea, and hay-fever like symptoms. There is little information available about the potential human health effects of long-term exposure to blue-green algae.

The presence of blue-green algae in a water body does not necessarily mean toxins are always present. However, identifying the presence of toxins is an expensive and difficult process and one that may involve many days to weeks before results are available. Therefore, it is prudent for recreational users to adhere to the following precautions with regard to blue-green algae blooms in Siskiyou County water bodies:

- Avoid wading and swimming in water containing visible blooms or water containing algal scums or mats.
- Carefully watch children to ensure that their exposure and accidental water ingestion is minimized. Because of their small body size and weight, children who ingest a small amount of water can receive a higher relative exposure to toxic substances than adults who ingest the same amount.

- Do not drink, cook or wash dishes with untreated surface water under any circumstances. In addition to blue green algal toxin concerns, open surface waters can contain harmful bacteria and parasites.
- If you accidentally swallow water from a bloom and experience one or more of the following symptoms you should contact your physician and the Public Health Department:
    - Stomach cramps
    - Vomiting
    - Diarrhea
    - Fever
- Fish caught in these reservoirs may be consumed after removing guts and liver, and rinsing filets in tap water.

In addition, residents and visitors are reminded that domestic animals and livestock can be affected by blue-green algal blooms. There are documented animal poisonings and deaths associated with exposure and consumption of algal toxins. Special care should be taken to ensure that animals do not drink the water or swim through heavy scums or mats. Consumption of algal toxins occurs when animals lick their fur after wading/swimming in blue-green algal blooms.

The public may contact the Siskiyou County Public Health Department for additional information by calling (530) 841-2100. Information is also available by visiting our website: http://www.co.siskiyou.ca.us/phs . For information about the State of California's activities related to blue-green algae blooms, visit these web sites:

- Department of Public Health: http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Bluegreenalgae.aspx
- State Water Resources Control Board: http://www.waterboards.ca.gov/water_issues/programs/bluegreen_algae/index.html

Example of State and Federal Agency Press Release

Multi-agency joint public news releases have been used by participants in the Klamath Blue-Green Algae Work Group. Examples can be obtained from US EPA Region 9, the State Water Resources Control Board, and the North Coast Regional Water Control Board. Please note that these and other agencies have jointly created the content of multi-agency press releases, reaching consensus for the content of press releases. For future press releases on other water bodies, agencies must be contacted to request joint sign-on.

News Release

California Regional Water Quality Control Board
North Coast Region
5550 Skylane Boulevard, Suite A
Santa Rosa, CA 95403
http://www.waterboards.ca.gov/northcoast

For Immediate Release Thursday, July 31, 2008
Contact: Luis Rivera (707) 570-3769.

U.S. EPA, State and tribes, warn against Klamath River blue-green algae. Contact with blue-green algae can cause eye irritation, skin rash. Caution urged when consuming fish.

San Francisco – Due to its potential health risks, federal, state, and tribal agencies are urging swimmers, boaters and recreational users to avoid contact with blue-green algae now blooming in Iron Gate and Copco Reservoirs on the Klamath River in Northern California.

The U.S. Environmental Protection Agency and California agencies including the North Coast Regional Water Quality Control Board, the Office of Environmental Health Hazard Assessment (OEHHA), Department of Public Health, and the Yurok and Karuk Tribes urge residents and recreational water users of the Klamath River to use caution or avoid getting in the water near these blooms, especially during the upcoming summer months. “As blue-green algae can pose health risks, especially to children and pets, we urge people to be careful where they swim when visiting the reservoirs” said Alexis Strauss, the EPA’s Water Division director for the Pacific Southwest region. “We recommend that people and their pets avoid contact with the blooms, and particularly avoid swallowing or inhaling water spray in an algal bloom area."

The algal blooms look like green, blue-green, white or brown foam, scum or mats floating on the water. Recreational exposure to toxic blue-green algae can cause eye irritation, allergic skin rash, mouth ulcer, vomiting, diarrhea, and cold and flu-like symptoms. .

“This is a situation that anyone who comes into contact with water at Copco or Iron Gate should be aware of. Vacationers and the public should adjust their activities accordingly”, said Catherine Kuhlman, Executive Officer, North Coast Regional Water Board. Algal toxins were detected in fish from Copco and Iron Gate reservoirs, however, the risk posed to human health by consuming fish is still being determined by OEHHA. "Until then, people should avoid eating fish caught in the reservoirs where the bloom exists. The precautions that we are recommending are reasonably simple and based on common sense."

The Statewide Guidance on Harmful Algal Blooms recommends the following:

- Avoid wading and swimming in water containing visible blooms or water containing algal scums or mats;
- If no algal scums or mats are visible, you should still carefully watch young children and warn them not to swallow the water;
- Do not drink, cook or wash dishes with untreated surface water under any circumstances;
- People should avoid eating fish from Copco and Iron Gate which previously tested positive for an algal toxin as the risk to human health is being evaluated by public health authorities.
- Take care that pets and livestock do not drink the water or swim through heavy scums or mats, nor lick their fur after going in the water;
- Get medical treatment right away if you think that you, your pet, or livestock might have been poisoned by blue-green algae toxins. Be sure to alert the medical professional to the possible contact with blue-green algae.

With proper precautions to avoid water contact and when fishing from the reservoirs, people can still visit Iron Gate and Copco reservoirs and the river areas and enjoy camping, hiking, biking, canoeing, picnicking or other recreational activities excluding direct contact with the algal bloom scum.

For more information, please visit:
World Health Organization Guidelines for Drinking Water Quality, 3rd Edition:
www.who.int/water_sanitation_health/dwq/gdwq3/en/index.html
California Department of Public Health:
http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Bluegreenalgae.aspx
State Water Resources Control Board
http://www.waterboards.ca.gov/water_issues/programs/bluegreen_algae/
National Center for Disease Control:
http://www.cdc.gov/hab/cyanobacteria/facts.htm
Siskiyou County Public Health Department: http://www.co.siskiyou.ca.us/phs/
(530) 841-2100
County of Humboldt, Department of Health and Human Services, Public Health Branch
http://co.humboldt.ca.us/health/envhealth/
(707) 445-6215
Yurok Tribe Real Time Water Quality and BGA Data
http://exchange.yuroktribe.nsn.us/lrgsclient/stations/stations.html
State Water Resources Control Board Office of Public Affairs Phone: 916.341.5254
Fax: 916.341.5252 Email: info@waterboards.ca.gov

Appendix 4 - Information for Physicians

The Centers for Disease Control and Prevention's Harmful Algal Blooms website at: **www.cdc.gov/hab/cyanobacteria/about.htm** includes a short section on health effects and CDC's efforts to support research on human health effects from recreational water exposure to cyanobacteria.

CDC's cyanobacterial fact sheet:
http://www.cdc.gov/hab/cyanobacteria/pdfs/about.pdf

Appendix 5 - Sample Fact Sheet for Veterinarians

Blue Green Algae (BGA) -Detailed Fact Sheet
For Distribution to Animal Health Workers Prepared by: Harriet Hill, Humboldt County Division of Environmental Health, revised June 2006

INTRODUCTION

The blue green algae (BGA), now considered to be a type of bacteria called cyanobacteria, are an ancient family of photosynthetic organisms. The fossil record shows that BGA has existed for around 3.5 billion years. It is thought to be one of the first organisms able to carry out photosynthesis. BGA also are noted for their ability to "fix" gaseous nitrogen, and some produce deadly toxins as secondary metabolites. BGA can produce nervous system poisons (neurotoxins), liver poisons (hepatotoxins), or compounds that cause allergic responses (lipopolysaccharide endotoxins). BGA neurotoxins can kill animals within minutes by paralyzing the respiratory muscles, while the hepatotoxins can cause death within hours by causing blood to pool in the liver. The same BGA species can be toxic or nontoxic at different times.

Since the summer of 2001, 9 dog deaths following contact with water bodies in Humboldt and Mendocino Counties may have been caused by BGA poisoning, prompting the preparation of this fact sheet for animal health workers and other interested parties.

BGA BLOOMS

BGA periodically "blooms," that is, creates floating mats, forming what is commonly known as "pond scum." These blooms can be green, blue-green, white or brown. The occurrence of BGA toxins in the freshwater environment is unpredictable. Blooms may persist for up to seven days but the resulting toxins may last for weeks. BGA move up and down within the water column and thus may not always float to the surface. Currents and surface winds can push them toward the land, causing poison-filled cells to accumulate in a thick layer near the leeward shore. Low flow river conditions in the summer and fall may result in large build-ups of BGA. When algae cells die or are damaged, toxins may be released at levels harmful to humans, pets and livestock if they ingest water or algae.

Blooms are most likely to form when three conditions converge:

- the wind is quiet or mild
- the water is warm but not hot (60 to 86 degrees F, 18 – 25 ºC))
- the water harbors an abundance of the nutrients nitrogen and phosphorus (i.e., from agricultural or urban runoff, or failing sewage disposal systems).

EFFECTS OF BGA ON ANIMALS

There are numerous reports of thirsty domestic animals and wildlife consuming fresh water contaminated with toxic BGA and dying within hours from neurotoxicity or hepatotoxicity, or developing sublethal chronic liver disease. Canine deaths from BGA exposure include dogs dying from neurotoxic exposure in lakes in Scotland, from drinking BGA-contaminated lake water in Saskatchewan, Canada, and from contact with a lake in Idaho. Reported neurological symptoms included stumbling and falling, followed by an inability to rise, elevated heart rate, foaming at the mouth, howling, tremors, loss of bowel control, eyes rolling back into the head, and seizures.

The amount of BGA-tainted water needed to kill an animal depends on many factors but typically the volume ranges from a few ounces to several gallons. Thirsty animals are often undeterred by the foul smell and taste of contaminated water. Additionally, dogs can consume large quantities of BGA by licking their fur after swimming in a bloom.

Recent Dog Deaths Following Contact With Big Lagoon and South Fork Eel River

From July through October 2001, 5 dogs died after swimming in Big Lagoon, mostly in the northeastern boat launch area known as the “Yacht Club.” Symptoms included severe gastrointestinal distress, such as vomiting, bleeding, diarrhea and dehydration, and elevated liver enzyme levels. A pathology report found massive liver damage in one of the dogs. Two other dogs became ill after swimming in the lagoon and showed heightened liver enzyme levels. The onset of symptoms was within twelve hours and deaths occurred 2 to 4 days later. One dog had been covered in green slime after swimming in the lagoon. Water samples taken from Big Lagoon in November of 2001 (11/9/01), approximately one month after the last dog death on 10/7/01, were tested for microcystins, and found to be negative for this BGA hepatotoxin. Since 2001, no dog illnesses or deaths that could be attributed to BGA were reported from Big Lagoon. The deaths in 2001 may have been associated with the following factors: 1) heavy nutrient loading because the lagoon did not breach to the ocean during the winter, and 2) unusually warm weather.

In the summer of 2002, 3 dog deaths were reported after contact with the South Fork of the Eel River. Near Standish-Hickey State Park in Mendocino County, 2 dogs died within a few minutes of swimming in the river, and another dog died after swimming near Tooby Park in Garberville in Humboldt County. The vet who saw the dogs from Standish-Hickey stated that the animals had seizures within 5-10 minutes of exposure to the water, and were dead within 15 minutes (Horvath, 2003).

A water sample taken a few days later in this area by Mendocino County Environmental Health Division (MEH) was found to contain *Anabaena* and *Lyngbya,* two toxin-producing BGA genera. A separate water sample was sent to the California Animal Health and Food Safety Laboratory System (CAHFS) who collaborated with the University of North Carolina (UNC) on the algae identification. The only toxin-producing BGA found by the UNC scientists in the sample was *Planktothrix. Planktothrix* and *Lyngbya* sometimes produce neurotoxins, including what are known as “paralytic shellfish toxins,” while *Anabaena* may produce another neurotoxin called anatoxin.

CAHFS first analyzed the dogs' stomach samples for commonly encountered neurotoxins not associated with BGA, such as strychnine, metaldehyde and zinc phosphide: none were present. They then collaborated with Wright State University to analyze the stomach contents for BGA neurotoxins. The contents contained green plant-like material, and low concentrations of paralytic shellfish toxins. Most notably, the stomach contents contained very high concentrations of anatoxin-a, even though the water sample that CAHFS obtained did not include the BGA genera that produce this toxin. However, MEH staff had identified *Anabaena*, a genus that produces this toxin, in their water sample, and it is possible Anabaena was present only in one of the water samples, while the toxin was present in both. BGA and their toxins move with winds and currents, and a species of BGA could turn up in one water sample, but not another, depending on the time and location of sampling.

Therefore, based on analyses of the stomach contents of the dead animals, and the water sample collected from the river, CAHFS believes that the dogs were most likely poisoned by anatoxin-a, a neurotoxin produced by BGA (Puschner, 2003). This conclusion was supported by a recent survey of the South Fork Eel River by Denbo (2003), who observed *Anabaena* during the summer of 2003 on the river near the Humboldt/Mendocino County line.

In 2004, a dog that died in July shortly after swimming in the South Fork Eel River in Mendocino County near Indian Creek (Piercy) may have ingested BGA toxins; however, the dog was buried before this could be confirmed.

Guidelines for Veterinarians on Water and Necropsy Sample Collection:

Evidence of an algae bloom and/or a case history of sudden illness or death after water contact should raise suspicion of BGA poisoning. This may be supported if wild species (e.g., mice, muskrats, birds, snakes or fish) have also died in the vicinity. If BGA is suspected, samples should be taken as soon as possible, in the same location where an animal fell ill after swimming. **Any questions regarding sample collection from water sources or affected animals should be directed to the California Animal Health and Food Safety Laboratory (CAHFS), Toxicology Laboratory in Davis at 530-752-6322.** Samples should be collected as follows:

- Collect water samples in plastic water sample bottles or other plastic bottles. Collect samples in duplicates (freeze one sample, and refrigerate the other sample)
- Collect at least one liter of water for each sample.
- Send samples to the CAHFS Toxicology Laboratory, Davis on cold packs (call first).
- Undiluted, refrigerated samples can be examined microscopically using low power magnification. Microscopic examination may provide evidence that potentially toxic genera are present, not that harmful levels of toxins exist. On the other hand, the absence of visible algae does not exclude poisoning, especially if heavy rain or wind suddenly dispersed blooms.
- Specimens from affected animals: In general, the best samples for accurate diagnostic work are: vomitus, gastric lavage fluid, stomach content, liver, urine, and serum. Veterinarians can call the CAHFS Toxicology Laboratory in Davis for case-related consultations.

CONTACTS AND INFORMATION

Report algal blooms, pet deaths/illnesses following water contact and/or unusual numbers of any dead animals (including cattle) around water bodies to the appropriate County Environmental Health Division: Humboldt County – **Harriet Hill, REHS, 707-445-6215 or 1-800-963-9241** Mendocino County – **David Koppel, REHS, 707-463-4466**

For information on animal health contact the **State Animal Health Branch: 530225-2140**

For information on specimen collection, laboratory testing and animal diseases contact the CAHFS Toxicology Laboratory – **Drs. Birgit Puschner or Robert Poppenga, 530-752-6322**

See also the following web sites for details on drinking water and human health issues.

Department of Health Public Health:
http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Bluegreenalgae.aspx

State Water Resources Control Board:
http://www.waterboards.ca.gov/water_issues/programs/bluegreen_algae/

National Center for Disease Control:
www.cdc.gov/hab/cyanobacteria

Appendix 6 - Sample Response Plans for Suspected BGA Animal Death or Illness

<u>Suspected BGA Animal Death or Illness Response Plan</u>
Resource for veterinarians and local or state agencies

It is possible that animals may become sick or die after exposure to the cyanotoxins sometimes present in freshwater ponds, lakes and other bodies of freshwater. Our understanding of the impacts of the blooms could be improved by documenting such incidents. This brief response plan to share with agencies and local veterinarians was created to assist them in responding quickly to take advantage of the short time when animal specimens can be collected. This is not meant as information for the general public.

Who might report an incident:
Ranch and farm workers Residents Recreational lake users, campers Veterinarians Government agency staff Water system management staff and employees.

What to look for:
Dead or dying animals in the vicinity of the reservoirs during bloom season. They may have green dried scum on their fur/feathers/skin indicating their contact with the water. The animals may be wild (mice, muskrats, birds, snakes, deer, etc.) or domestic (dogs, cattle, etc.)

Who to notify:

What kind of samples and where to send them:

<u>Live ill animal:</u> Samples of stomach contents (for instance, after vomiting) and feces are the most useful for diagnostic evaluation.

<u>Dead animal:</u> Samples of contents from the stomach and/or the small or large intestines are useful. Although measurement of microcystin in the liver itself has not yet been validated, a liver sample should also be collected from animals where BGA is a suspected cause of death.

All samples for toxicology evaluation must be frozen, and no chemical preservatives should be added. Samples should then be sent on ice as soon as possible or within 3 days after the animal's death to the California Animal Health and Food Safety Toxicology Laboratory. Call in advance to notify the laboratory of any shipments. Dead animals should have a post-mortem examination (i.e. a necropsy should be performed) conducted by the attending veterinarian, and tissues should collected for pathological evaluation at that time.

Contact: Dr. Birgit Puschner or Dr. Robert Poppenga at 530-752-6322 **Ship to:** California Animal Health and Food Safety Laboratory, CAHFS, U.C. Davis, West Health Sciences Drive, Davis, CA 95616

Appendix 7 - Risk Assessment for Deriving Quantitative Guidance for Blooms Dominated by Microcystis or Planktothrix (from the Oregon Department of Human Services, Environmental Toxicology Program, 2005)

A focused risk assessment was conducted to characterize the risk associated with swimming in waters that are dominated by *Microcystis* or *Planktothrix* cyanobacteria.

The equation and parameters are described below:

$$\text{Concentration of toxin } (\mu g/L) = \frac{TDI \times BW}{IR}$$

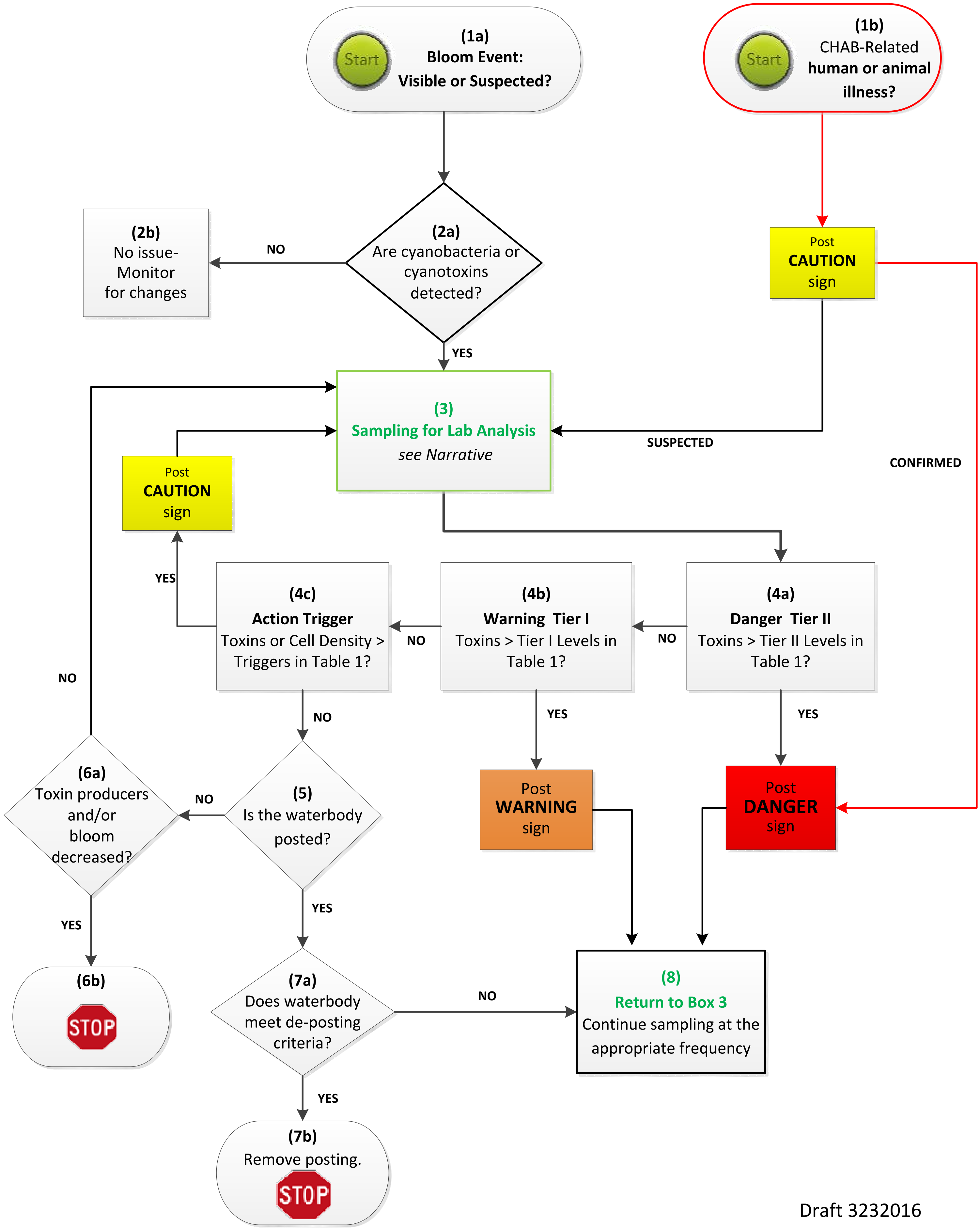
Where,
TDI (tolerable daily intake) = 0.04 µg/kg/day
BW (body weight) = 20 kg
IR (ingestion rate) = 0.1 L

The TDI was developed by the World Health Organization based on repeated oral administration of microcystin-LR in mice and effects on the liver (Fawell and James, 1994). A body weight (BW) of 20 kg was used to represent a child. An ingestion rate (IR) was based on EPA guidance for incidental ingestion of surface waters, in which 0.05 L is accidentally ingested per one-hour event (Dang, 1996). For this guidance, it was assumed that a child would swim for up to two hours in a single day.

Using the parameters described above, the equation results in 8 µg/L of microcystin toxin. According to World Health Organization guidance, 8 µg/L would correspond to approximately 40,000 cells/mL if *Microcystis* were the dominant species (Chorus & Bartrum, 1999). *Planktothrix* was included in the additional guidance, since it has the potential to contain higher endocellular microcystin compared with *Microcystis* (Codd et al., 2005).

Figure 1. Decision Tree for Posting and De-posting Health Advisories for CyanoHABs

Proposed changes to consider for Voluntary CHAB Guidance



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Narrative for Figure 1 - Decision Tree for Posting and De-posting Health Advisories for CyanoHABs

Box 1a. Bloom Event: Visible or Suspected

- **If a bloom event is suspected proceed to Box 2a**

If there are visible signs of a harmful algal bloom, or a bloom may reasonably be suspected based on the indicators listed or past history, proceed to Box 2a.

The following are indicators of potential harmful algal blooms:

Visual suggestion -
Any of the following:

- water that is usually clear becomes bright green, opaque, or other discoloration
- water may appear soupy
- water may have planktonic (plankton-like) growth
- surface scum or algal mats on the water surface or on the shoreline
- benthic algal mats may accumulate on river/stream substrate
- foul odors

Suspected blooms may be compared with images shown in *Appendix X* or on the websites located at *(website)*;

OR

Measurable chemical factors –
An increase or change in pH or nutrient loading (increased levels of nitrogen and phosphorus compounds) may signal development of a bloom;

OR

Satellite imaging –
Positive detection of cyanobacteria pigments, via satellite imaging, will result in notifications that trigger field verification and possible sampling. A statewide program for notification will be available in the near future for waterbodies greater than 250 acres. For more information on satellite imaging visit (www.xxSWAMPsatelliteHABimagingxx);

OR

Historic evidence -
In some waterbodies with reoccurring blooms, cyanobacteria have been monitored for a sufficient time to identify trends. Blooms tend to occur under certain conditions that may be used as indicators to alert managers to potential blooms. These condition indicators are typically waterbody specific, therefore, they need to be

developed for each waterbody rather than developing a single set of indicators for statewide use.

Condition indicators may include:

- water reaching or exceeding a certain temperature
- water flow falling below a certain level
- decreasing depth of sunlight penetration/increased water opacity
- time of year associated with longer periods of sunlight (blooms may tend to begin and end around the same time each year in a particular waterbody).

Routine monitoring during the bloom season is essential to fully characterize the potential risks to public health and water quality. While full characterization of a bloom may not always be feasible, it is important to monitor during the bloom season, as the dominant cyanobacteria can turnover and a new bloom, involving different cyanobacteria, may develop. Historical information can also be used to help predict which toxins are likely to be produced during the bloom season; thus, reducing monitoring cost and event response time.

Box 1b. CHAB-Related Human or Animal Illness.

- **If suspected post CAUTION sign immediately and proceed to Box (3)**
- **If confirmed post DANGER sign immediately and proceed to Box (8)**

SUSPECTED:

Suspected acute human Illness [(1)]

Any of the following symptoms **AND** symptom onset within 48 hours of exposure to a waterbody with a suspected or confirmed algal bloom **AND** no other obvious cause of illness:

- sore throat or congestion
- coughing, wheezing, or difficulty breathing
- red, or itchy skin, or a rash
- skin blisters or hives
- earache or irritated eyes
- diarrhea or vomiting
- agitation
- headache
- abdominal pain

Human exposure to cyanotoxins most commonly occurs through ingestion or skin contact with contaminated water. Inhalation of spray or mist coming off water with high toxin concentrations may also contribute to exposure during activities such as water-or jet-skiing. Children are considered more susceptible to effects from toxins than adults.

CAUTION signs should be posted immediately.

Collect water and algal mat samples immediately, including benthic mats in river systems. Samples should be collected and stored as appropriate for the lab identified for analysis. Contact with the lab prior to sampling is recommended.

NOTE: People with symptoms should contact their health care provider.

Suspected acute animal illness [(2)]

Any of the following symptoms **AND** symptom onset within 48 hours of exposure to a waterbody with a suspected or confirmed algal bloom **AND** no other obvious cause of illness:

- vomiting and/or diarrhea
- lethargy or general weakness
- abnormal liver function test results
- difficulty breathing
- foaming at the mouth
- muscle twitching that may lead to convulsions
- death

Pet and livestock exposure to cyanotoxins is typically through drinking water with sufficiently high concentrations of toxins, or ingestion of scum or drying mats along the shoreline. Dogs may ingest additional toxins or scum when they lick their fur after getting wet.

CAUTION signs should be posted immediately.

Collect water and algal mat samples immediately, including benthic mats in river systems. Samples should be collected and stored as recommended by the lab that will be conducting the analysis. Contact with the lab prior to sampling is recommended.

In the case of an animal death, ask the attending veterinarian to collect animal tissues (specifically the stomach contents, liver, and brain) for testing as soon as possible, prior to animal preservation or disposal. Stomach contents from an ill or dead animal are the most important samples for determining cyanotoxin exposure.

CONFIRMED:

Once a human illness, or animal illness or death, has been confirmed as being due to cyanotoxin exposure a **DANGER** sign should be posted immediately, and regular sampling and analysis of the water and scums, mats, or benthic algae should begin.

Confirmed acute human Illness
Meets criteria for *SUSPECTED CASE* **AND** there is laboratory documentation of at least one HAB toxin in the water **AND** professional judgment based on medical review by a health care provider.

DANGER signs should be posted immediately.

Confirmed acute animal illness or death
Meets criteria for *SUSPECTED CASE* **AND** there is laboratory documentation of HAB toxin(s) in stomach contents or in water and/or algal mats.

DANGER signs should be posted immediately.

NOTE: Dogs exposed to anatoxin-a may die within 20-30 minutes following onset of symptoms.

If humans or animals show symptoms of cyanotoxin exposure after contact with water, or with scums or mats of algae, they should receive immediate medical attention. The water and area where the contact has occurred should be sampled immediately to determine if cyanobacteria or cyanotoxins are present. Hospitals and veterinary clinics can be alerted to look for signs of cyanotoxin exposure in other patients, especially if these facilities are located near water where cyanobacteria may be present. Hospitals and veterinary clinics should be encouraged to report any suspected or confirmed cases of cyanotoxin exposure to the local health department and regional water board. (http://www.waterboards.ca.gov/waterboards_map.shtml).

Box 2a. Are cyanobacteria or cyanotoxins detected?

- **If No: Proceed to Box (2b), and continue routine monitoring for indicators**
- **If Yes: Proceed to Box (3)**

Box 2a provides an opportunity for initial screening using tools that do not require formal laboratory analysis. In some cases this is not a necessary step for making a management decision.

Are cyanobacteria detected?
There are a number of methods available for initial determination of cyanobacteria presence including:

- Visual screening for cyanobacteria using field or office-based microscopes, Smartphone tools (http://cellscope.berkeley.edu/), FlowCam (http://www.fluidimaging.com/)
- Field sensor or bench top fluorimeter measurements of phycocyanin pigments
- Stick test and jar tests (http://www.kdheks.gov/algae-illness/download/Jar_Test.pdf)

There are websites where photos of algal blooms and microscope images can be seen to compare to local conditions. These may help rule out non-harmful algal blooms and narrow down the type of bloom a waterbody is having. The USGS Field and Laboratory Guide can be helpful in some areas. https://pubs.er.usgs.gov/publication/ofr20151164

Are cyanotoxins detected?

The presence of some cyanotoxins may be confirmed quickly through the use of field test kits. Currently field test kits are available for measuring microcystins in water. Field test kits for measuring anatoxin-a and cylindrospermopsin will be available in 2016.

It is recommended that these kits be used for determining presence or absence of cyanotoxins. To detect intracellular toxins, a lysing step must be included (e.g. lysing chemical, freeze-thaw method) to release toxins from cells prior to testing with the kit.

NOTE: field test kits may not detect toxins from surface scum, algal mats, or benthic algal mats. These mats need to be sampled for identification and formal laboratory analysis.

If cyanobacteria or cyanotoxins are not detected, water managers should continue routine visual monitoring for indicators of cyanobacteria and cyanotoxins as described in Box 1a. If there is reason to believe there are toxins present that field methods did not detect, sampling for laboratory analysis should be considered.

If cyanobacteria or cyanotoxins are detected, sampling for laboratory analysis should begin immediately (proceed to Box 3).

Box 2b. No Detection - Monitor for changes.

If initial screening tools do not detect cyanobacteria or cyanotoxins, the bloom may be green algae or another nuisance. Green algae do not produce toxins, so the voluntary guidance will not cover these situations.

Continued routine visual monitoring for indicators of cyanobacteria and cyanotoxins is recommended as described in Box 1a.

Box 3. Sampling

If it is determined through field testing, bloom indicators, human illness, or animal illness or death that a harmful algal bloom is occurring in the waterbody, field sampling for formal laboratory analysis is strongly recommended.

Communication with the laboratory prior to sampling is strongly recommended to ensure appropriate sample collection, storage, shipping conditions, and other considerations.

NOTE: CAUTION signs should be posted while waiting for lab results.

Sample data received from the laboratory should be compared with the toxin and cell density triggers in Table 1 to determine if **ANY** toxin triggers (Primary Triggers) or Secondary Triggers have been exceeded. Primary Triggers are identified for toxin concentrations; Secondary Triggers are given for cell density of potentially toxin producing cells, and some site specific indicators of cyanobacteria, including visual monitoring. Exceedance of secondary triggers can result in an Action Trigger (see Box 4c).

Sampling Design Considerations

Monitoring should focus primarily on the protection of human health, and secondarily on the health of pets and livestock. Scums and mats often contain the highest levels of toxin; therefore these substances should be considered during sample collection. For human recreational safety, samples should be from areas of high use.

In rivers, and other flowing water, samples should be focused along shorelines where recreational users and animals are entering the water, backwater areas where algae and toxins may accumulate, and upstream and downstream of the area of concern.

Detailed guidance on sampling design is found in Appendix 1 of the 2010 Voluntary Guidance document.

Sampling frequency, location, and number of samples are vital elements to consider when designing a monitoring plan to characterize a bloom. It is recommended that sampling be conducted, at minimum, once a week. During favorable bloom conditions researchers have observed significant fluctuations of cyanobacteria and toxins over a 24 hour period; therefore, more frequent monitoring may be required to capture growth or changes. Although bloom characterization may be important, especially in waterbodies without a history of HABs, the cost of monitoring and turnaround time of laboratory testing should be taken into consideration.

NOTE: Sample frequency should increase if the bloom increases, visually changes, and/or scums/mats form, especially if initial toxin levels were at the Action Trigger or Tier I.

Primary Triggers

To obtain data needed for comparison to the primary triggers, monitoring should include the following sample types:

- *Cyanobacteria toxin analysis - to detect and quantify the concentration of cyanotoxins in water*
- **optional* cell identification - to identify the cyanobacteria present in water samples and if potential toxin producers are present*

The primary triggers are based on toxin concentrations measured in water, if **ANY** toxin exceeds the primary triggers, action is required. Measurements of water may include a combination of water, scum, and mats. The toxins addressed in this guidance, which are commonly detected statewide, include total microcystins, anatoxin-a, and cylindrospermopsin. Total microcystins(3) refers to the measurement of more than one variant of microcystin, at minimum the following microcystin (MC) variants should be analyzed: MC-LR, MC-LA, MC-RR, and MC-YR (can be analyzed by either ELISA or LC-MS). Cyanobacteria toxins predominantly collect within cells and the toxins are released upon cell death and damage. To measure the total toxin in water samples, a cell lysing step should be conducted by the lab prior to toxin analysis.

Characterization of a bloom involves identification of the dominant cyanobacteria to determine if there are potential toxin producers and if so, which types of toxins may be produced. Water samples can be examined by field or laboratory methods to identify the cells. This characterization can help direct laboratory testing for the most relevant toxins, thereby reducing the cost of analysis.

<u>Secondary Triggers</u>

Data may be obtained from the following parameters to compare to secondary triggers:

- *Cell density - to quantify the dominant cyanobacteria population*
- *Visual observation - to observe formation of blooms, scums, or mats*

There is research being done in several areas that may provide additional cost-effective secondary trigger parameters in the future. These include:

- *Satellite imagery - data or notification indicating formation of a bloom*
- *Cyanotoxin gene analysis - to detect cell genetic material capable of toxin production*

The secondary triggers are only developed for the “action trigger” level (box 4c). If data collected from these parameters meets the secondary trigger level, monitoring and posting of the waterbody is recommended.

NOTE: The Surface Water Ambient Monitoring Program(4) (SWAMP) has established a Statewide Freshwater HABs Program, including an Assessment and Support Strategy for fresh water HABs. An integral component of this program is the development of guidance documents for statewide event response. The guidance documents will include the following subjects:

- Standard operating procedures for sample collection

- Health and safety guidelines for sample collection
- Standard laboratory analysis methodology
- Decision frameworks for sampling and analysis
- Quality assurance objectives
- List of qualified labs and types of analyses they perform

These documents will be available on the SWAMP website under the highlights button labeled FHABs.

Box 4a. Danger Tier II. Have <u>ANY</u> Tier II toxin triggers been exceeded?

- **If No: Proceed to Box (4b)**
  - If Tier II triggers in Table 1 have **NOT** been exceeded, proceed to Box 4b and compare toxin levels with those in Table 1 for Tier I.
- **If Yes: Post DANGER signs immediately and proceed to Box (8)**
  - If Tier II triggers have been exceeded for **ANY** toxin, post the recommended **DANGER** signs in areas where the public is likely to recreate on the water or to encounter the signs and proceed to Box 8.

There is a heightened risk of adverse effects in people, pets, and livestock at these cyanotoxin concentrations. The public should be warned against contact with the water, including water spray from activities like jet skiing. Pets and livestock have very high risks of serious illness or death at these toxin concentrations because they consume more algal material compared to humans.

If conditions begin to change sampling should resume to determine when it is appropriate to move from Tier II to Tier I warning signs. Be aware that cyanotoxin levels may spike again, so even if cyanotoxin levels are decreasing, it is recommended that the decision tree be followed until de-posting criteria (Box 7a) are met in order to insure public safety and animal welfare.

Appendix A describes the basis of the Tier II Trigger levels for each toxin.

Box 4b. Warning Tier I. Have <u>ANY</u> Tier I toxin triggers been exceeded? (but not Tier II)

- **If No: Proceed to Box (4c)**
  - If Tier I triggers in Table 1 have **NOT** been exceeded, proceed to Box 4c and compare toxin levels with those in Table 1 for Action Trigger Levels.
- **If Yes: Post WARNING signs and proceed to Box (8)**
  - If Tier I triggers in Table 1 have been exceeded for **ANY** toxin, post the recommended **WARNING** signs where the public is likely to recreate on the water or to encounter the signs and proceed to Box 8.

There is cause to be concerned about exposure to cyanotoxin concentrations at this level. Prolonged contact with water can lead to an itching rash or other skin issues. Activities that lead to the ingestion of water, like swimming, can be dangerous to people and pets. Pets and livestock need to be kept out of the water and away from the shoreline; they tend to consume scum at the shoreline and drying algal mats that wash up on shore. These materials may have exceptionally high concentrations of cyanotoxins and can be lethal to pets and livestock.

Appendix A describes the basis of the Tier I Trigger level for each toxin.

Box 4c. Caution Action Trigger. Have ANY Primary or Secondary Action Triggers been exceeded? (but not Tier I)

- **If No: Proceed to Box (5)**
  - If the Action Triggers in Table 1 have **NOT** been exceeded, proceed to Box 5.
- **If Yes: Post CAUTION sign and proceed to Box (3)**
  - If Action Trigger for **ANY** toxin, or Secondary Trigger, has been exceeded, it is recommended that **CAUTION** signs be posted where the public is likely to recreate on the water or to encounter the signs and proceed to Box 3.

The presence of cyanotoxins above the primary action triggers indicates the need for concern for public health and animal welfare around the waterbody. The waterbody should be monitored for the possibility of increasing toxin concentrations. Cyanotoxin concentrations can change quickly during a bloom event.

Appendix A describes the basis of the Primary Action Trigger for each toxin.

NOTE: There is a heightened risk to dogs and livestock when the trigger level has been exceeded in a waterbody. Many pet and livestock deaths have been attributed to cyanotoxins in recreational waters in California. Deaths have occurred when toxin levels in water are below human thresholds for concern. This is likely due to increased exposure because animals are known to consume algal materials containing high toxin levels (e.g., dried mats, etc.). Dogs and livestock should be kept out of the water and away from the shoreline when action triggers are exceeded.

Secondary Action Triggers may lead to an affirmative response for Box 4c in the absence of toxin measurements. Secondary Action Triggers should not be used to rule out the presence of a harmful bloom because cyanotoxins may be present when cyanobacteria cell densities are low, or when visual cues of a bloom are absent. Use of the Secondary Action Triggers should be used at the discretion of local water or public health managers and may be based on past experience with blooms in a particular waterbody.

Appendix B describes the basis for the Secondary Action Triggers. *[Appendix B has not been drafted yet.]*

Box 5. Is the waterbody posted?

- **If No: Proceed to Box (6a)**
  - If the factors indicating the need for sampling (Box 1a) are not still a concern, sampling may be discontinued. It is recommended that routine visual monitoring be continued.
- **If Yes: Proceed to Box (7a)**
  - If the factors indicating the need for sampling (Box 1a) are still a concern and the waterbody does not meet de-posting criteria, return to Box 3 and continue sampling**.**

It is recommended that toxin levels be below action trigger levels for a minimum of two weeks before considering de-posting, or posting at a lower level.

Box 6a. Toxin producing species, bloom, and favorable conditions decreased?

- **If No: Return to Box (3)**
  - If the bloom visually appears to be persisting or increasing, the concentration of potential toxin producing cells increases, or toxin levels are increasing, return to Box 3 and continue monitoring visually and sampling.
- **If Yes: Proceed to Box (6b)**
  - If the bloom appears to be decreasing and favorable conditions are decreasing, it is recommended to proceed to Box 6b.

A waterbody specific trend analysis may be helpful to determine which conditions signal that bloom events are ending.

Use caution when observing a bloom that appears to be decreasing; particularly for waterbodies undergoing their first recognized algal blooms and have limited historical data and observations to understand trends. When a bloom appears to be decreasing but conditions continue that are favorable for blooms (e.g. long days, low flows, high water temperatures, high nutrient concentrations), it is recommended that visual monitoring and sampling on a regular basis be continued until the favorable conditions decrease. During favorable conditions, a new bloom can quickly replace the previous bloom. Researchers have observed that cyanobacteria populations can fluctuate significantly within a 24 hour period so monitoring is needed to capture re-growth or growth of new blooms.

Box 6b. End of Decision Tree.

If a cyanobacteria bloom has significantly declined and conditions indicate that the bloom is at an end, managers may suspend sampling. Routine monitoring of the waterbody should continue, especially if conditions return that are favorable for blooms.

Box 7a. Does the Waterbody Meet the De-posting Criteria?

- **If Yes: Proceed to Box (7b)** and continue routine visual monitoring
- **If No: Proceed to Box (8)** and continue visual monitoring and sampling

De-posting criteria are intended to protect against the risk of exposure to toxins when water may appear suitable for recreational activities, but toxins may still be present and/or blooms may again increase.

Postings should remain in place until the following criteria are met:

- Quantitative samples confirm that all cyanotoxins are below Primary Action Triggers (see Table 1) **AND** declining bloom conditions (see Box 1a) continue for a minimum of two weeks.
- If posting was based on a Secondary Trigger, then either the secondary trigger OR primary triggers should no longer be exceeded (cell densities of toxin producers are below 4,000 cells/mL and no scums are visible).
- All evidence indicates the bloom is ending and favorable conditions are decreasing.

NOTE: In some instances, blooms may still be active when seasonal changes begin and continued sampling is no longer safe, such as sustained near-freezing temperatures, heavy rains, or snowfall. Professional judgment should be used to inform decisions to remove postings under these circumstances, considering potential for exposure by children, pets, or livestock, and potential for returning warmer weather and bloom resurgence.

Box 7b. Remove Posting

When the waterbody meets the de-posting criteria per Box 7a, all **CAUTION**, **WARNING**, and **DANGER** signs should be removed. Signs left up when cyanotoxins are no longer an immediate concern may result in the public disregarding signs when an immediate danger is present.

Box 8. Return to Box 3

If toxin trigger levels in Table 1 have been exceeded for **ANY** toxin during monitoring, post the appropriate **CAUTION**, **WARNING**, or **DANGER** signs immediately. Return to Box 3 to continue sampling at an appropriate frequency (see Appendix 1) to monitor for changes in cyanotoxin levels necessary to protect public health.

After the waterbody is posted with appropriate signs, return to Box 3 and follow a sampling plan designed for monitoring a toxic bloom. It may not be necessary to continue sampling for toxins as long as conditions do not change, based on observation, and the signs remain in place to ensure that people are sufficiently warned to stay out of the water.

SIGNS

Signs, such as those shown in Appendix [X], should be posted in prominent water access points to alert the public to the dangers of exposure, especially for children, pets, and livestock.

Signs should be highly visible, and made of sufficiently durable materials to remain highly visible throughout the duration of the bloom. Laminated signs can be put up rapidly, but are not durable to weather and vandalism; if used, they should be checked daily and replaced as needed. More permanent signage (e.g., metal) is recommended. In areas where cyanotoxins are annually present in the water, it may be appropriate to install permanent signs that can be easily modified to reflect current conditions (blank, caution, warning, or danger).

Additionally, signage alerting the public to the ongoing issue and providing additional information about cyanobacteria and risks related to cyanotoxins may be warranted; informational signs should be significantly different from **CAUTION**, **WARNING**, and **DANGER** signs so that they are not confused.

Footnotes & References

(1) Human case definitions in this document use criteria slightly modified* from the Ohio Department of Health's *Blue-Green Algae/Cyanobacteria Harmful Algal Bloom (HABs) Physician Reference*, cited on 10-15-2015, available at: http://www.odh.ohio.gov/~/media/ODH/ASSETS/Files/eh/HABs/habproviderreference.ashx. The Ohio document references the Center for Disease Control and Prevention (CDC) *Proposed Case Definition for Algal Toxin-related Diseases* as the source of their case definitions.

* Ohio/CDC lists three categories of cases: suspect, probable and confirmed; while this guidance document captures illnesses in two categories: suspect and confirmed.

(2) Animal case definitions in this document use criteria developed for CDC's Harmful Algal Bloom Illness Surveillance System (HABISS). For further details see Backer LC et al *Canine Cyanotoxin Poisonings in the United States (1920's-2012: Review of Suspected and Confirmed Cases from Three Data Sources; Toxicon, 2013, Full text available online at* stacks.cdc.gov/view/cdc/21319/cdc_21319_DS1.pdf

(3) Welker, M. and von Dohren, H. Cyanobacterial Peptides—Nature's Own Combinatorial Biosynthesis. FEMS Microbiology Reviews, 2006, 30, 530-563.

*Microcystins are a class of toxins synthesized by some cyanobacteria. Approximately 90 variants of the microcystin compound have been discovered. Laboratory analytical capabilities are limited to testing a fraction of the discovered variants. Communication with the laboratory is recommended to learn about their available testing methods.

(4) The Surface Water Ambient Monitoring Program (SWAMP) is conducted by the State Water Resources Control Board and Regional Water Quality Control Boards.

Table 1. CyanoHAB Trigger Levels for Human Health

	Caution Action Trigger	Warning TIER I	Danger TIER II
Primary Triggers [a]			
Total Microcystins [b]	**0.8** µg/L	**6** µg/L	**20** µg/L
Anatoxin-a	**Detection** [c]	**20** µg/L	**90** µg/L
Cylindrospermopsin	**1** µg/L	**4** µg/L	**17** µg/L
Secondary Triggers			
Cell Density *(Toxin Producers)*	**4,000** cells/mL	**--**	**--**
Site Specific Indicators of Cyanobacteria	Blooms, scums, mats, ect.	**--**	**--**

[a] The primary triggers are met when ANY toxin exceeds criteria.

[b] Microcystins refers to the sum of all measured microcystin variants. (See Box 3)

[c] Must use an analytical method that detects ≤ 1µg/L Anatoxin-a.

Appendix to the CCHAB Preliminary Changes to the Statewide Voluntary Guidance on CyanoHABs in Recreational Waters, January 2016.

Appendix A. Description of cyanotoxin triggers in recreational waters.

This appendix describes the basis for the concentration levels selected to trigger the actions in the decision tree. The voluntary guidance relies on the science presented in OEHHA's risk assessment for microcystin, anatoxin-a and cylindrospermopsin (OEHHA 2012). Risk management decisions were used to integrate and expand the OEHHA action levels into a tiered response framework. Under this framework, increasing concentrations of cyanotoxins in recreational waters will prompt increasing public health warnings to users of the waterbody. Some of the triggers are not based on OEHHA's risk assessment but consider other important information such as animal poisoning reports and successful approaches used in other areas.

Development of this framework was a collaborative effort within CCHAB. Risk management decisions involve balancing the risk of low-level toxin exposures with the risks of closing waterbodies to the public, including economic, social and health impacts. Policy issues are also considered in risk management. The approach described here is designed to be feasible, useful and protective of public health.

Table A.1. CyanoHAB Triggers for Recreational Water.

	Toxin (µg/L)		
	Caution Trigger Level	Warning Tier I	Danger Tier II
Microcystins[1]	0.8	6	20
Anatoxin-a	Detect[2]	20	90
Cylindrospermopsin	1	4	17

[1]Microcystins refers to the sum of all measured microcystin variants.

[2]Must use an analytical method that detects <1 µg/L anatoxin-a.

Microcystin

The trigger level of 0.8 µg/L microcystin prompts increased monitoring and the placement of a caution sign stating that people should stay away from scum and pets and livestock should be kept away from the water and scum. The trigger level is based on the Office of Environmental Health Hazard Assessment's (OEHHA) action level of 0.8 µg/L (OEHHA 2012). The action level represents a concentration in recreational water that is not expected to lead to adverse health effects. This is based on the best available science and very health-protective assumptions. OEHHA's action level is based on the short-term Heinze 1999 study in rats, which reported a Lowest Observable

Adverse Effect Level (LOAEL) of 50 µg/kg-d. The endpoint was moderate liver pathology. The next highest dose (150 µg/kg-d) showed moderate to severe liver pathology. OEHHA calculated a 95% lower confidence limit of the Benchmark Dose (BMDL) of 6.4 µg/kg-d to represent the dose of microcystin that serves as the point of departure to estimate a safe dose for humans. An Uncertainty Factor (UF) of 1000 was applied to the BMDL, resulting in a Reference Dose (RfD) of 6×10^{-3} µg/kg-d, which estimates the dose of microcystin that is not expected to produce any adverse liver effects in humans. The UF of 1000 is the product of the following individual uncertainty factors: 10 for extrapolating from rat to human (assumes that humans could be 10 times more sensitive to microcystin than rats), 10 for the different sensitivities in humans (assumes the most sensitive person could be 10 times more susceptible to microcystin than the average person) and 10 for an incomplete toxicological database. The exposure scenario is a child swimming in recreational waters for 5 hours per day (30.25 kg child ingesting 0.05 L water per hour, or 0.25 L per day). OEHHA's risk assessment reflects a conservative, health-based approach and is described in detail in OEHHA (2012).

Managers should be aware of the risk to dogs and livestock when the microcystin trigger level is exceeded. Animals have been poisoned by microcystin at recreational waters in California. Exposure in dogs and livestock is unpredictable because they may consume scum at the shoreline and drying algal mats that wash up on shore. They are also exposed by cleaning cyanotoxin-containing material from their coats after being in the water. These materials may have much higher concentrations of microcystin compared to water levels. Dogs and livestock should be kept out of the water and away from the shoreline when the microcystin trigger level is exceeded.

The Tier I level of 6 µg/L microcystin in recreational waters would prompt the placement of a warning sign stating that swimming is not recommended and that pets and livestock should be kept away from the water. The Tier I level is based on OEHHA's calculated BMDL from the Heinze (1999) study (6.4 µg/kg-d; OEHHA 2012), a UF of 300 and a lower exposure rate. The cumulative UF of 300 includes the following factors: 10 for extrapolating from rodent data to humans, 10 for the differing sensitivities within the human population and 3 for an incomplete toxicological database. Using a UF of 3 for an incomplete toxicological database is a common approach in human health risk assessment and is often used by OEHHA (OEHHA 2008). Applying the cumulative UF of 300 to the BMDL of 6.4 µg/kg-d results in an RfD of 2×10^{-2} µg/kg-d. The exposure scenario is a child swimming in recreational waters for 2 hours per day (30.25 kg child ingesting 0.05 L water per hour, or 0.1 L per day). The Tier I level represents a health-based and conservative approach.

The OEHHA action level is conservative and its use as a posting trigger could lead to constant public warnings on waterbodies, which could obscure the need for caution when toxin concentrations increase. Policy and economic issues are also considered in risk management. Local authorities must weigh very low risks of toxic exposures with the high risks of closing waterbodies to the public, including economic, social and health impacts. The approach described here provides a highly useful tiered response to public health protection from microcystin exposure in recreational waters. The Tier I trigger is in the general range of OEHHA's microcystin subchronic action levels for water intake by dogs and livestock (OEHHA 2012). However, because these animals often consume scum and mats containing concentrated toxins, the action trigger level should be used for the protection of dogs and livestock from microcystin poisoning.

The Tier II level of 20 μg/L microcystin would prompt the placement of a sign stating that there is a present danger and that people, pets and livestock should stay out of the water and away from water spray. This level is based on risk management objectives rather than a purely health-based conservative approach. California water bodies support some of the highest microcystin levels in the world, with microcystins measured in the tens of thousands μg/L during bloom seasons in some areas. This guidance provides the Tier II "danger" level to convey the higher risk of critical liver impacts associated with higher microcystin levels in California waters. The concentration of 20 μg/L microcystin has been suggested as a warning level by the World Health Organization (WHO; WHO 1999). WHO's warning level is based on an earlier subchronic mouse study by Fawell et al. (1994; 1999a). Although OEHHA (2012) and USEPA (2015) found the later study by Heinze (1999; described above) to be a stronger study for the basis of health advisories, the Fawell study was acknowledged as a good study by both agencies. The WHO's warning level of 20 μg/L has been employed internationally for over a decade. There have been limited reports of human illness associated with recreational exposure to cyanobacterial bloom waters. Most of the reported human cases have involved rashes and gastrointestinal symptoms (Backer et al., 2015). The California Tier II level of 20 μg/L is intended as a severe warning level and is prompted by the historical, intermittent occurrences of very high microcystin levels in California waters.

Table A.2. Basis of suggested triggers for microcystin in Table A.1.

Basis of Trigger	Trigger (µg/L)	POD (µg/kg-d)	Total UF	RfD (µg/kg-d)	IR (L/d)	BW (kg)	Study
OEHHA's Action Level	0.8	6.4[b]	1000	6×10^{-3}	0.25	30.25	Heinze 1999
Modified OEHHA Action Level[a]	6	6.4[b]	300[c]	2×10^{-2}	0.1	30.25	Heinze 1999
Risk Management: *WHO Warning Level*	20	--	--	--	--	--	--

[a] OEHHA's BMDL with UF = 300 and lower exposure.

[b] Calculated BMDL from Heinze (1999) data.

[c] The UF is lower because a factor of 3 was used to account for limited database.

POD = Point of Departure, the study dose representing the lower end of the observed range of adverse effects.

IR = Ingestion Rate, how much water is assumed to be ingested by members of the target population

BW = Body Weight, average for the target population being considered

Anatoxin-a

The trigger level for anatoxin-a is identified as any detection of the toxin in recreational waters. The chemical analysis must be able to detect anatoxin-a at levels below 1 µg/L in order for the trigger level to be useful. Concentrations above the trigger level will prompt increased monitoring and the placement of a caution sign stating that people should stay away from scum and pets and livestock should be kept away from the water and scum. The guidance for the trigger level is based on the precautionary approach in risk management. With this approach, known vulnerabilities may be addressed despite the absence of sufficient scientific evidence of risk. Anatoxin-a is a potent and very fast-acting neurotoxin. The toxin is responsible for numerous domestic animal and wildlife deaths. The trigger level is a precautionary measure, intended to prompt local managers to continue monitoring anatoxin-a concentrations to detect any increase. The anatoxin-a trigger level is also intended to protect dogs and livestock from acute poisoning as described below.

There is a heightened danger to dogs and livestock whenever anatoxin-a is present in a waterbody. Dogs and livestock may be particularly susceptible to acute lethality from anatoxin-a. Animal poisonings have been observed when anatoxin-a was present at low levels in California waterbodies. Animals can be exposed to high anatoxin-a concentrations by consuming scum at the shoreline and drying algal mats that wash up on shore. They are also exposed by cleaning cyanotoxin-containing material from their coats after being in the water. These materials may have high anatoxin-a concentrations even though the toxin levels are low in the water. Dogs and livestock should be kept out of the water and away from the shoreline when anatoxin-a is present.

The Tier I level of 20 μg/L anatoxin-a in recreational waters would prompt the placement of a warning sign stating that swimming is not recommended and that pets and livestock should be kept away from the water. The Tier I level is based on Oregon's recreational guideline for anatoxin-a, which incorporates a conservative approach (Farrer et al., 2015). The Oregon Health Authority (OHA) based their guideline on the short-term oral study in mice by Fawell et al., (1999b). The mice were examined for a wide range of toxicological endpoints both during and at the end of the study. There was no statistically significantly difference between the control group and any of the dosed groups for any of these endpoints. However there were two unexplained deaths in the study -- one each in the mid- and high-dose groups. Anatoxin-a was not suspected in these deaths but it was not possible to rule it out. Therefore OHA set the lowest dose, 100 μg/kg-d, as the No-Observed Adverse Effect level (NOAEL; Farrer et al., 2015). A UF of 1000 was applied to the NOAEL, resulting in an RfD of 0.1 μg/kg-d. The UF of 1000 is the product of the following individual uncertainty factors: 10 for extrapolating from rodent to human, 10 for the differing sensitivities within the human population and 10 for an incomplete toxicological database. The exposure scenario was a child swimming in recreational waters for 2 hours per day (20 kg child ingesting 0.05 L water per hour, or 0.1 L per day). OHA's risk assessment reflects a conservative, health-based approach using the best available science.

The OHA guideline was chosen as the Tier I trigger as a precautionary approach in the risk management of anatoxin-a. This concentration level is considered precautionary because it is more restrictive than the health-based OEHHA Action Level of 90 μg/L, described below. The Tier I level may be updated as more information becomes available. **As noted above, dogs and livestock are susceptible to acute anatoxin-a poisoning at water concentrations that are below the Tier I level due to high exposures in animals.** The action trigger level should be used for the protection of dogs and livestock from anatoxin-a poisoning.

The Tier II level of 90 μg/L anatoxin-a would prompt the placement of a sign stating that there is a present danger and that people, pets and livestock should stay out of the water and away from water spray. The Tier II level is based on OEHHA's action level for human exposure to anatoxin-a in recreational waters (OEHHA 2012). OEHHA's action level was also based on the short-term oral study in mice by Fawell et al., (1999b). As described above, there was no statistically significant difference between the control group and any of the dosed groups for a wide array of endpoints. OEHHA did not consider the two unexplained mortalities described above to be treatment related. The mice in this study were exposed daily through oral gavage, which is a somewhat stressful technique that can lead to unintended mortalities. OEHHA identified the highest dose, 2,500 µg/kg-d, as the NOAEL (OEHHA 2012). A UF of 1000 was applied to the NOAEL, resulting in an RfD of 2.5 µg/kg-d. The UF of 1000 is the product of the following individual uncertainty factors: 10 for extrapolating from rodent to human, 10 for the differing sensitivities within the human population and 10 for an incomplete toxicological database. The exposure scenario included a child swimming in recreational waters for 5 hours per day (30.25 kg child ingesting 0.05 L water per hour, or 0.25 L per day). OEHHA also considered exposures through inhalation and skin contact (OEHHA 2012). OEHHA's risk assessment reflects a conservative, health-based approach using the best available science.

Table A.3. Basis of suggested triggers for anatoxin-a in Table A.1.

Basis of Trigger	Trigger (µg/L)	POD (µg/kg-d)	Total UF	RfD (µg/kg-d)	IR (L/d)	BW (kg)	Study
Risk Management: *Precautionary Approach*	Detect	--	--	--	--	--	--
Risk Management: *OHA's Guideline*	20	100	1000	0.1	0.1	20	Fawell et al., 1999b
OEHHA's Action Level[a]	90	2,500	1000	2.5	0.25	30.25	Fawell et al., 1999b

[a] OEHHA's action level for anatoxin-a is not solely based on oral exposure (i.e., ingestion rate; IR). The action level also includes dermal and inhalation exposures. See OEHHA 2012 for details on the incorporation of dermal and inhalation exposures into the 90 µg/L action level.

POD = Point of Departure, the study dose representing the lower end of the observed range of adverse effects.

IR = Ingestion Rate, how much water is assumed to be ingested by members of the target population

BW = Body Weight, average for the target population being considered

Cylindrospermopsin

The trigger level of 1 µg/L cylindrospermopsin prompts increased monitoring and the placement of a caution sign stating that people should stay away from scum, and pets and livestock should be kept away from the water and scum. The trigger level is based on a precautionary approach to the risk management of cylindrospermopsin. This toxin has been linked to a widespread outbreak of critical illness in humans following oral exposure (Byth 1980; Griffiths and Saker 2003). The details of the exposure concentrations are unknown but the outbreak supports the use of caution in managing risk associated with cylindrospermopsin. Additionally, less toxicological information is available for this cyanotoxin compared to microcystin. The trigger level concentration (1 µg/L) is intended to alert water managers to the possibility of toxic bloom formation.

Managers should be aware of the risk to dogs and livestock when the cylindrospermopsin trigger level is exceeded. Exposure in animals is unpredictable because they often consume material that can be very high in cylindrospermopsin (scums, mats, cyanobacteria stuck on their coats). We are not aware of any animal poisonings associated with exposure to cylindrospermopsin in California recreational waters. However, as a precaution, dogs and livestock should be kept out of the water and away from the shoreline when the cylindrospermopsin trigger level is exceeded.

The Tier I level of 4 µg/L cylindrospermopsin in recreational waters would prompt the placement of a warning sign stating that swimming is not recommended and that pets and livestock should be kept away from the water. The Tier I level is based on OEHHA's action level for human exposure to cylindrospermopsin in recreational waters (OEHHA 2012). OEHHA's action level is based on the subchronic study in mice by Humpage and Falconer (2003). OEHHA calculated a BMDL of 33 µg/kg-d. The endpoint was increased kidney weight, indicating mild impaired kidney function. A UF of 1000 was applied to the BMDL, resulting in an RfD of 3.3×10^{-2} µg/kg-d. The UF of 1000 is the product of the following individual uncertainty factors: 10 for extrapolating from rat to human, 10 for the differing sensitivities within the human population and 10 for an incomplete toxicological database. The exposure scenario is a child swimming in recreational waters for 5 hours per day (30.25 kg child ingesting 0.05 L water per hour, or 0.25 L per day). OEHHA's risk assessment reflects a conservative, health-based approach. The Tier I level is below OEHHA's cylindrospermopsin subchronic action levels for water intake by dogs and livestock. However, because these animals often consume scum and mats containing concentrated toxins, the action trigger level should be used for the protection of dogs and livestock from cylindrospermopsin poisoning.

The Tier II level of 17 µg/L cylindrospermopsin would prompt the placement of a sign stating that there is a present danger and that people, pets and livestock should stay out of the water and away from water spray. The Tier II level is based on OEHHA's BMDL from the Humpage and Falconer (2003) study described above. However, a lower UF for limited toxicological database is used (6) than was used in the OEHHA action level (10). The cumulative UF of 600 was applied to the BMDL (33 µg/kg-d; Humpage and Falconer 2003), resulting in an RfD of 5.5×10^{-2} µg/kg-d. The UF of 600 is the product of the following individual uncertainty factors: 10 for extrapolating from rodent data to humans, 10 for the differing sensitivities within the human population and 6 for an incomplete toxicological database. The exposure scenario is a child swimming in recreational waters for 2 hours per day (30.25 kg child ingesting 0.05 L water per hour, or 0.1 L per day). The Tier II level is health-based and conservative.

Note that a higher cumulative UF (600) was used to modify the OEHHA action level for cylindrospermopsin compared to that used to modify the OEHHA action level for microcystin (UF=300). This is because more data is available for microcystin compared to cylindrospermopsin. The UF specific to a limited database was 6 for the modified cylindrospermopsin level and 3 for the modified microcystin level.

Table A.4. Basis of suggested triggers for cylindrospermopsin in Table A.1.

Basis of Trigger	Trigger (µg/L)	POD (µg/kg-d)	Total UF	RfD (µg/kg-d)	IR (L/d)	BW (kg)	Study
Risk Management: *Precautionary Approach*	1	--	--	--	--	--	--
OEHHA's Action Level	4	33	1000	3.3E-02	0.25	30.25	Humpage and Falconer (2003)
Modified OEHHA Action Level[a]	17	33	600[b]	5.5E-02	0.1	30.25	Humpage and Falconer (2003)

[a] UF is lowered from 1000 to 600.

[b] The UF is lower because a factor of 6 was used to account for limited database.

POD = Point of Departure, the study dose representing the lower end of the observed range of adverse effects.

IR = Ingestion Rate, how much water is assumed to be ingested by members of the target population

BW = Body Weight, average for the target population being considered

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