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 underlines 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)?

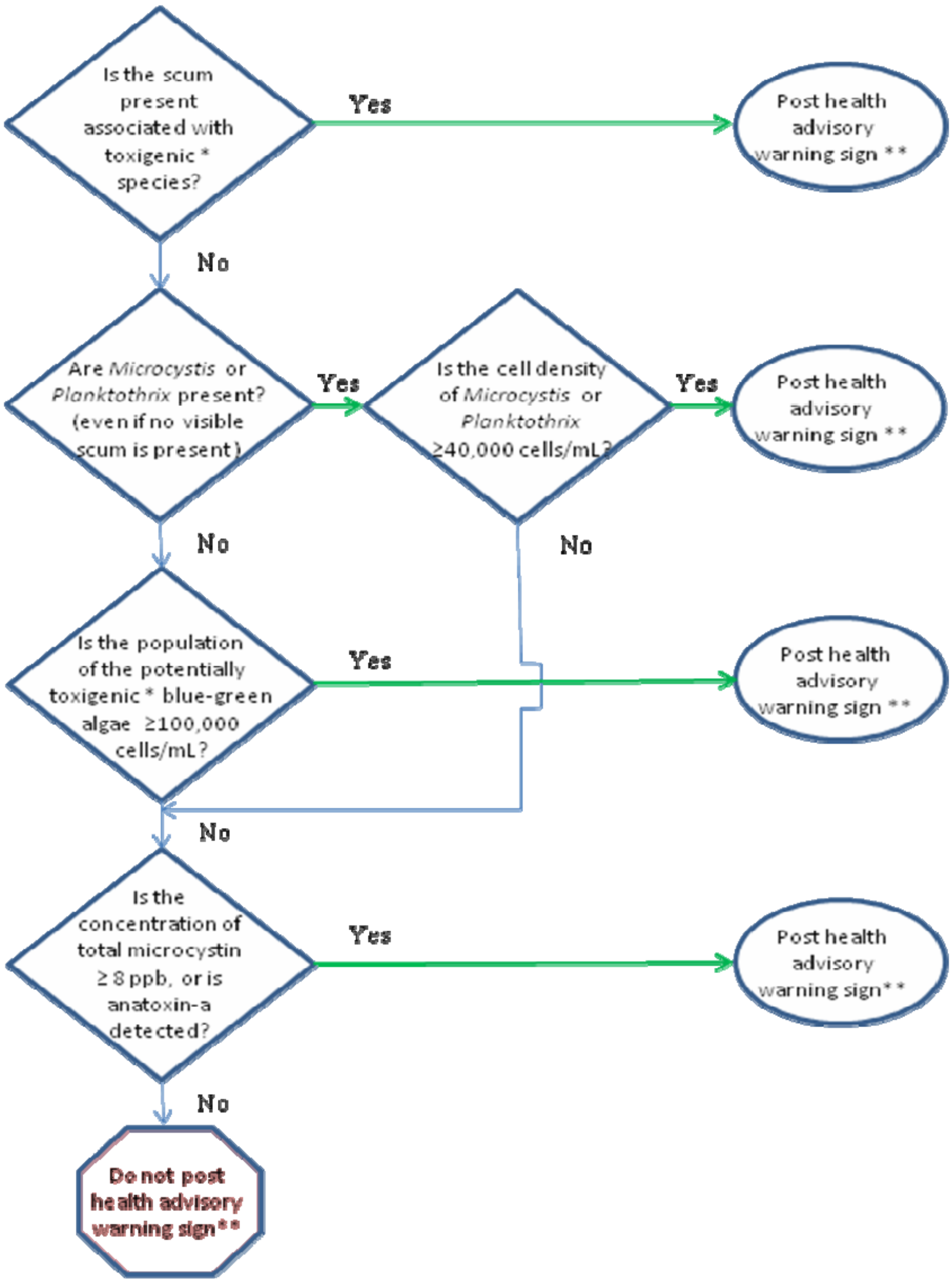
- If water analysis for algae has been done, are toxigenic cyanobacterial species present? If Yes:

    - 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.* Additional 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

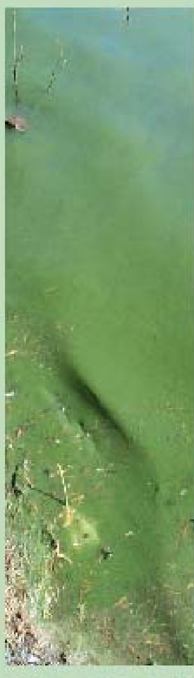
Appendix 2 – Signage

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.

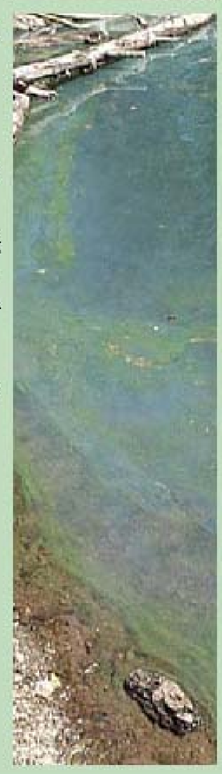
How dangerous is toxic algae? If toxic algae is swallowed it can cause diarrhea, nausea, cramps, fainting, numbness, dizziness, tingling, and paralysis. Skin contact can cause rashes or irritation. Children and pets are at greatest risk.

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

The Wisconsin Department of Natural Resources provides equal opportunity in its employment programs, services, and functions under an Affirmative Action Plan. If you have any questions, please write to the Equal Opportunity Office, U.S. Department of the Interior, Washington, D.C., 20240.

This publication is available in alternative format (large print, Braille, audio tape, etc.) upon request. Please call (608) 264-6127 for more information.

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:

Blue Green Algae Health Concerns—North Coast Region of California

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

Suspected BGA Animal Death or Illness Response Plan
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:

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

Dead animal: 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).