Guidance to Local Health Departments For Blue–Green Algae Blooms in Recreational Freshwaters

May 2023

BACKGROUND AND PURPOSE

Blue-green algae, also known as cyanobacteria, occur naturally in lakes and ponds throughout Connecticut. These microscopic organisms are components of the aquatic food chain. In ordinary circumstances, cyanobacteria cause no apparent harm, however warmer water temperatures and high nutrient concentrations may induce a rapid increase in their abundance. This response is commonly called a “bloom” because algal biomass increases to the extent that normally clear water becomes markedly turbid. This tainted water takes on a green, blue-green or reddish-brown colored hue (See Figures 1-3).

Figure 1: Open water view of bloom conditions at Fisher Meadow Pond, Avon CT, in June 2015. View across shoreline and into a cove.

Figure 2: Shoreline view along the Fisher Meadow Pond bloom

Figure 3: View standing at shoreline looking down to water's margin during the Fisher Meadow Pond bloom.

In Connecticut during the summer of 2012, an algae bloom in Lower Bolton Lake raised concerns with the local community and the news media. The response was managed by local health officials with input from stakeholders and State agencies. In anticipation of further algae blooms in subsequent summers, the Connecticut Department of Public Health (CT DPH) and the Connecticut Department of Energy and Environmental Protection (CT DEEP), in collaboration with the Connecticut Association of Directors of Health (CADH), have produced this interim response plan for Connecticut local health officials. This document outlines the rationale for a response and presents a scheme for surveillance and intervention designed to protect the public's health at lakes or ponds used for recreation. The scheme presented is based on precedent from other States. In future years it is likely that this guidance will change subsequent to input from local health officials.

Blue-green algae biomass can contain a mix of toxins, including skin irritants and potent liver toxins. The blue-green algae genera and some of their associated toxins are listed in Table 1. The public health implications of harmful algal blooms (HABs) are indeterminate and continued research on incidence, exposure, and effects is needed. In response, the Center for Disease Control (CDC) conducted a passive surveillance study tracking reports of human and animal morbidity and mortality for the US during the years 2007-2011 (Backer L, 2015). Some results of this study are presented in Table 2. Dermal effects (e.g.; rash, itching, blistering) are the most frequently reported human health effect following direct contact with freshwater blooms. GI/Respiratory effects were also prominent. Where evidence of toxin in lake water was available, GI/Respiratory effects were attributed to microcystin poisoning; though the acute health effects reported are not symptomatic of microcystin toxicity.

An additional recent study found significant trends in two categories (severe and more severe) of gastrointestinal illness in subjects living near three eutrophic lakes in Quebec. The authors of this study found a dose-dependent association between illness (diarrhea, vomiting, nausea and fever, or abdominal cramps and fever) and lake water endotoxin concentration (Lévesque B, 2015). Some results from this study are shown in Table 3. The authors attribute these effects to either gram negative bacteria or cyanobacteria as each include lipopolysaccharides in cell walls. The Lipid A component of this endotoxin induces fever, diarrhea, and possible fatal endotoxic shock. Another, more recent, report demonstrated that LPS from a fresh-water bloom dominated by the common cyanobacteria species (Microcystis aeruginosa) caused inflammatory responses in human blood (Moosová Z, et al., 2019). Illness such as gastroenteritis can exacerbate the effects LPS by increasing its absorption from the gut.

Table 1: Principal groups of cyanobacterial toxins, their acute toxicities, congeners and known producers. (Bláha, Babica, & Maršálek, 2009)

Toxins (LD50-acute toxicity-ug/kg ip, mouse)	**Structure (number of variants)**	**Activity**	**Toxigenic genera**
Hepatotoxins			
Microcystins (25 to ~ 1000)	Cyclic heptapeptides (71)	Hepatotoxic, protein phosphatase inhibition, membrane integrity and conductance disruption, tumour promoters	*Microcystis, Anabaena, Nostoc, Planktothrix, Anabaenopsis, Hapalosiphon*
Nodularins (30 to 50)	Cyclic pentapeptides (9)	Hepatotoxic, protein phosphatase inhibition, membrane integrity and conductance disruption, tumour promoters, carcinogenic	*Nodularia*
Cylindrospermopsins (200 to 2100)	Guanidine alkaloids (3)	Necrotic injury to liver (also to kidneys, spleen, lungs, intestine), protein synthesis inhibitor, genotoxic	*Cylindrospermopsis, Aphanizomenon, Anabaena, Raphidiopsis, Umezakia*
Neurotoxins			
Anatoxin-a (250)	Tropane-related alkaloids (5)	Postsynaptic, depolarising neuromuscular blockers	*Aphanizomenon, Anabaena, Raphidiopsis, Oscillatoria, Planktothrix, Cylindrospermum*
Anatoxin-a(S) (40)	Guanidine methyl phosphate ester (1)	Acetylcholinesterase inhibitor	*Anabaena*
Saxitoxins (10 to 30)	Carbamate alkaloids (20)	Sodium channel blockers	*Aphanizomenon, Anabaena, Planktothrix, Cylindrospermopsis, Lyngbya*
Dermatotoxins (irritants) and cytotoxins			
Lyngbyatoxin-a (LD50 unknown)	Alkaloid (1)	Inflammatory agent, protein kinase C activator	*Lyngbya, Schizotrix, Oscillatoria*
Aplysiatoxin (LD50 unknown)	Alkaloids (2)	Inflammatory agents, protein kinase C activators	*Lyngbya, Schizotrix, Oscillatoria*
Endotoxins (irritants)			
Lipopolysaccharides (LD50 unknown)	Lipopoly-saccharides	Inflammatory agents, gastrointestinal irritants	All cyanobacteria?

Table 2: Cases of human illnesses following exposure to cyanobacteria or algae blooms at freshwater lakes 2007-2011 (Backer L, 2015).

Acute HAB-Related Health Effect	#Cases
Dermal (rash etc.)	89
GI/Respiratory	55

Table 3: Multivariate models associating lake endotoxin exposure to gastrointestinal effects in nearby residents (Lévesque B, 2015).

Endotoxin in Lake Water	Health Effect	
Contact Tranche	GI1 (moderate) Relative Risk	GI2 (severe) Relative Risk
T1 (<26 endotoxin/ml)	1.37	1.03
T2 (26-48 endotoxin/ml)	1.35	2.06
T3 (> 48 endotoxin/ml)	2.87	3.11

STATUTORY AUTHORITY

The Connecticut General Statutes outlines enforcement authority under Chapter 98, Municipal Powers. Section 7-148 states that municipalities have the power to "control and operate" recreation places, public beaches and beach facilities. They also have the power to "regulate and prohibit swimming or bathing in the public or exposed places within the municipality". The CT Public Health Code does not include a pertinent regulation specific for lakes and ponds, however; section 19a-36-B61 may apply to impoundments.

SIGNIFCANT EXPOSURE PATHWAYS

For those recreating on or near an affected water body, the route of direct exposure to toxins from blue-green algae may be via ingestion, breathing, or contact with skin. Ingestion for this recreational scenario is possible when swimming. For example, EPA's Exposure Factors Handbook (US EPA, 2011) states that boys actively playing ingest 60 ml water in one hour of swimming. It therefore may be necessary to take measures to block the oral and dermal potential exposure pathways by prohibiting swimming during a blue-green algae bloom. As ingestion of relatively large quantities of algae-tainted water can cause serious harm, pet owners should not let their pets swim in an algal bloom. As algae blooms do not occur in groundwater, drinking water wells in the vicinity of the affected lake are not at risk of contamination from potential migration of the algal cells or toxins through groundwater into nearby wells.

Other recreational activities may involve direct exposure and it may be prudent to advise the participating public to avoid direct contact with an algae bloom. These other recreational activities have been compiled and ranked according to relative risk and the published table is reproduced here as Table 4.

Table 4: Generalized list of primary exposure pathways of concern for cyanotoxins during recreational activities (Bress & Stone, 2007).

Level of Potential Exposure	Recreational Activity	Primary Exposure Pathway of Concern
High	Swimming/wading	Ingestion
	Diving	Ingestion
	Water skiing/wake boarding	Ingestion/inhalation
	Wind surfing	Ingestion/inhalation
	Jet skiing	Ingestion/inhalation
Moderate	**Fish consumption ***	Ingestion
	Canoeing	Inhalation/skin
	Rowing	Inhalation/skin
	Sailing	Inhalation/skin
	Kayaking	Inhalation/skin
	Motor boating	Inhalation
Low/none	Catch and Release fishing	Skin

*Fish living in waters affected by a blue-green algae bloom may accumulate algal toxins in their muscle tissue and internal organs. However the health risk posed by consumption of such fish is uncertain. Toxin levels are usually higher in internal organs than in the muscle tissue. General precautionary advice to anglers to reduce exposure includes:

- Avoid fishing in areas with visible algae blooms due to potential incidental contact with the water.
- Eat fish from water bodies with blue-green algae blooms in moderation (1-2 meals per week.)
- Remove skin and internal organs before cooking. Wash fillets before cooking or freezing

More guidance for safe fish preparation and consumption can be obtained from the State of Oregon's Health Authority (Link to Oregon's guidance for fishing).

PART 1: SURVEILLANCE AND BLUE-GREEN ALGAE BLOOM CATEGORIZATION

The initial method for surveillance is visual and based on a categorization scheme developed and implemented by the State of Vermont. (Vermont Department of Health, 2008). As is outlined in the Vermont document, the purpose of visual surveillance is to assess bloom development at a beach site. If there is no evidence of a blue-green algae bloom, the site is ranked as Category 1. Observations suggestive or indicative of an algae bloom are classified, respectively, as Category 2 or Category 3. The Vermont guidance is summarized in Table 5. Refer also to the Vermont guidance document for representative photos. (VT guidance for communities)

Table 5: Summary of the Vermont visual classification scheme:

Category	***Description***
One	Visible material is not likely cyanobacteria or water is generally clear.
Two	Cyanobacteria present in low numbers. There are visible small accumulations but water is generally clear.
Three	Cyanobacteria present in high numbers. Scums may or may not be present. Water is discolored throughout. Large areas affected. Color assists to rule out sediment and other algae.

Surveillance is most needed in mid to late summer when algae bloom events are most likely. Reports or complaints from the public or staff require confirmation. Confirmation can be facilitated by consulting someone with prior field experience. Options for consultation include DEEP staff or a professional Limnologist. If such help is not available, health officials in Connecticut should consult the resources available from other State's web sites or the contacts listed in the Additional Resources section of this document. Digital photos of the bloom can provide documentation that could help determine the appropriate course of action.

Laboratory identification and quantification is a reasonable alternative if confirmation cannot be obtained via a visual assessment. If algae bloom species are quantified, then refer to threshold values listed in Table 6. A list of available laboratories is included in Appendix A and from MA DEP (Cyanobacteria and/or Cyanotoxins Contract Services List | Mass.gov). [1] Health officials should know that the DPH Laboratory does not offer testing for cyanobacteria or the associated toxins.

PART 2: INTERVENTIONS

This section outlines intervention strategies for the observational phase and the evaluation phase of a blue-green algae bloom.

A) Guidance for Declaring an algae bloom Advisory

When issuing and advisory take note of all access points. Depending on the size of the bloom relative to the lake, and the location of the access point relative to the bloom, some access locations may not be impacted.

[1] We do not endorse or certify any of the laboratories listed. This appendix is included as a convenience to readers of this document.

A reasonable protocol may be as follows:

1) Visit the site of a reported bloom.
2) If justifiable (Category 2), notify State Agencies
3) Continue regular field observations. (See example field observation form in Appendix.)
4) If conditions deteriorate to Category 3, post[2] the swimming area.
5) When visual conditions improve, take a water sample for microscopic analysis.
6) Wait approximately one week and sample again.
7) A: If justifiable, terminate the posting. (Section B, below.)
   B: Otherwise wait approximately one more week and sample again.
8) Repeat step 7 until termination or the end of the summer recreational season.

Table 6: Suggested interventions based on field observations or cell count data: Examples of appropriate signage are shown in Appendix C.

Observations	***Notifications***	***Further monitoring***	***Public Posting***
Visual Rank Category 1	Not needed	No change	Not needed
Visual Rank Category 2, or blue-green algae cells >20k/ml and < 100k	Notify CT DPH, CT DEEP	Increase regular visual surveillance until conditions change.	Consider cautionary postings at public access points. (See Appendix C, Example B)
Visual Rank Category 3, or blue-green algae cells > 100k/ml	Update/inform CT DPH & CT DEEP and expand risk communication efforts. (See Risk Communication section.)	Collect samples for analysis and/or increase frequency of visual assessment.	POSTED BEACH CLOSURE: If public has beach access, alert water users that a blue-green algae bloom is present. (See Appendix C, Example A) POSTED ADVISORY: At other impacted access points. (See Appendix C, Example B)

[2] Includes closing the swimming area and placing cautionary signage at other public access points. Sample signage is presented in the appendix.

B) <u>Guidance for Terminating an algae bloom Advisory</u>

Though an algae bloom will wane with time, the health concerns will linger until evidence can confirm that the threat has dissipated. While some States criteria for removing restrictions are based on visual observations over time, most others use a combination of visual observation and environmental laboratory data to validate their visual assessment and to address questions about possible health effects. Laboratory data however has practical limitations due to the logistics of sampling, the extra expense, and long or variable turnaround time. Health officials will thus need to weigh the advantages and disadvantages of collecting environmental laboratory data.

Local officials should confer with CT DPH and/or DEEP on the decision to terminate an advisory. The recommended protocol for termination may be based on visual observations over time, or a combination of this taken in concert with laboratory data. The laboratory data approach can be either cell counts or a combination of cell counts and microcystin toxin testing. Yet, as not all blue-green algae blooms produce microcystins, toxin data, alone, is not useful for termination. Obtaining confirmatory toxin data from a waning blue-green algae bloom may however be justified on grounds that microcystins, can increase as the cells die (Oberholster PJ, 2004).

Health officials may thus justify lifting a blue-green algae bloom posting if observations meet either or both of the following two criteria:

- Visual assessment remains at the Category 1 condition for successive and representative observational rounds
- Cell count results of the water column indicate that blue-green algal cell abundance has markedly decreased over successive and representative sampling rounds and is below 70,000 cells per ml.

As the situation requires, health officials may consider additional confirmation through microcystin testing of the water column. The toxin concentration in the water column should be below a threshold. Based on US EPA's recreational criterion, CT DPH recommends a toxin threshold of 8 ug/l microcystin (US EPA, 2019).[3] Health officials however should be aware that cyanotoxin production by cyanobacteria is highly variable and strongly influenced by the environmental conditions, and that the propensity for toxin production can differ between strains and clones of the same species, or between and among blooms. This lack of understanding and the potential for a false-negative assessment of putative harm (See research results presented in Tables 2 & 3) highlight the inadequacy of implementing an intervention strategy based solely on microcystin surveillance data to these recreational exposures.

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[3] This document also includes a criterion value for Cylindrospermopsin (15 ug/l). EPA developed these criteria using their standard methodology for risk assessment. Accordingly, the criteria represent a reasonable estimate of a safe exposure. They are thus not thresholds for toxicity.

RISK COMMUNICATION

Effective public notification and risk communication are important attributes during and immediately after a blue-green algae bloom. Posting closure signs at swimming areas and advisory signs at other access points used for public recreation is the primary intervention. The examples of signage presented in Appendix C may serve as a model for this. If signs are posted at a public access point, then they should be removed no later than the end of October. Further interventions include notifying lake associations and posting information for public access via the internet or local newspapers via a press release. Include information as to how the public can contact the CT DEEP for the most up-to-date information on the status of the blue-green algae bloom. In some communities it may also be important to notify local Veterinarians and Physicians and keep them updated on the status of the blue-green algae bloom.

SUMMARY

Blue-green algal blooms can be unsafe and local health officials can mitigate the hazard by the surveillance and intervention approaches outlined above. The approaches do not include treatment, but involve implementing strategies that will decrease the extent of the public's exposure.

The approaches recommended in this guidance for monitoring and characterization of blue-green algae bloom events includes visual observation (as is used in Vermont) in conjunction with a measure of blue-green algal cell abundance. If an algal bloom event is evident, then municipalities have the authority to close an impacted beach and/or issue a warning at other access points where recreational activities may involve contact with tainted water.

Blue-green algae blooms wane over time and there is thus the need to ascertain the point in time where an advisory should be removed (i.e.; terminated). The recommendations for termination of an advisory or closure are either based on visual observations over time, or a combination of visual and laboratory data. There are advantages and disadvantages to using environmental data, and the local health official will need to decide which strategy is most appropriate for the situation.

REFERENCES

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US EPA. (2011). *Exposure Factors Handbook.*

US EPA. (2019). *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin.* EPA 822-R-19-001.

Vermont Department of Health. (2008). *Cyanobacteria (Blue-green Algae) Guidance for Vermont Communities.* http://healthvermont.gov/enviro/bg_algae/documents/BGA_guide.pdf.

World Health Organization. (1999). *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management.* Geneva: E & FN Spon.

ADDITIONAL RESOURCES

For health questions - contact
CTDPH
David Kallander, Ph.D.
Toxicologist
860-936-1125
david.kallander@ct.gov

To report a blue-green algae bloom – contact
CT DEEP
deep.algalblooms@ct.gov

INTERNET LINKS

CDC fact sheet on algal blooms for veterinarians

VT guidance for communities

Cyanobacterial Harmful Algal Blooms (CyanoHABs) & Water | Mass.gov

Massachusetts DPH Protect Your Pets From HABs

New York State DOH Information Bulletin

EPA's Cyanobacteria Monitoring Collaborative

Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities (USGS)

ITRC's Strategies for Preventing and Managing Harmful Cyanobacterial Blooms

CDC's One Health Harmful Algal Bloom Surveillance System (OHHABS)

Cyanobacteria and/or Cyanotoxins Contract Services List | Mass.gov

APPENDIX A:

CT-BASED LABORATORIES FOR BLUE-GREEN ALGAE TESTING

This list is a supplement to the MA DEP list. (Cyanobacteria and/or Cyanotoxins Contract Services List | Mass.gov) We do not endorse or certify any of the laboratories listed.

Northeast Aquatic Research, LLC (https://northeastaquaticresearch.net)
(860) 456-3179
northeastaquaticresearch@gmail.com

- Water quality monitoring
- Cyanobacteria Identification
- Cell Counts & Toxin Analysis

Call for pricing.

Northeast Laboratories, Inc. (www.nelabsct.com)
129 Mill Street
Berlin, CT 06037
Tel: (860) 828-9787 (Ext. 103 for Alan Johnson) or Toll free in state: (800) 826-0105 and out of state: (800) 654-1230
Fax: (860)829-1050
Email General: nelabsct@aol.com
Email Alan Johnson: alan@nelabsct.com
Services: Algae/Cyanobacteria Cell Counts & Identification (to genus, not to species), cyanotoxins (Microcystins, Nodularin, Cylindrospermopsin – ELISA, and Abraxis screening dip sticks, potentially also looking at LC-MS for Microcystins)
Pricing: Depends significantly on turnaround time (if things need to be rushed).

- Cell Counts (including identification) – $45-80
- Semi-quantitative screening (Abraxis) – $50
- ELISA – $75-80
- Chlorophyll a – $60

UConn Center for Environmental Science and Engineering
(http://www.cese.uconn.edu/analyt_serv.html)
3107 Horsebarn Hill Road; U-4210
Storrs, CT 06269
Phone: (860) 486-2668
Email: christopher.perkins@uconn.edu

Services: Toxin analysis (ELISA and UPL/MS/MS)
Pricing:

- UPLC/MS/MS for microcystins (-RR, -YR, -LR, and -LA) and anatoxin-a in water – $139 for CT state agencies and municipalities, otherwise $182
    - Analysis for these compounds in filters – $151 for CT state agencies and municipalities, otherwise $199
- Total microcystin in water – $81 for CT state agencies and municipalities, otherwise $107

APPENDIX B:

Section A: Connecticut DEEP Proposed Cyanobacteria Sampling Methodology

Monitoring for blue-green algae should be directed at areas of highest concentrations and risk to public health. These areas are typically along the shoreline of lakes and ponds and often can include bathing beaches that are already the responsibility of State, local and other responsible entities. Contact DEEP for advice if samples are to be obtained from deep water.

A description of the proposed shoreline sampling approach is outlined below. The detailed sampling protocol should be obtained from the chosen analytical laboratory.

Sampling at the Shoreline

- Sampler should be using waders and long sleeved rubber gloves
- Clearly mark sampling containers with required information (site #, date, time, etc.)
- Wade to an approximate depth of three feet
- Invert sample bottle(s) to collect a sample at approximately 18 inches below the surface
- Decant water for required air space and/or pour into additional containers (if necessary), cap bottles
- Visual observations – look to see if bottom is visible, if a scum on water's surface is present
- Fill out chain of custody, including visual observations
- Store samples in a cooler with ice until delivery to lab(s)

Sampling the Shoreline from a Dock, Wall, or Boat

- Sampler should be using long sleeved rubber gloves
- Clearly mark sampling containers with required information (site #, date, time, etc.)
- Choose a location that is approximately three feet deep (if possible)
- Lean over to collect sample (if possible), or use a pole sampling device to collect sample
- Invert sample bottle(s) to collect a sample at approximately 18 inches below the surface
- Decant water for required air space and/or pour into additional containers (if necessary), cap bottles
- Visual observations – look to see if bottom is visible, if a scum on water's surface is present
- Use a Secchi disk with calibrated line to determine transparency and total depth
- Fill out chain of custody, including visual observations
- Store samples in a cooler with ice until delivery to lab(s)

Logistical Issues

1. Long holding times may result in higher counts.
2. Shoreline concentrations tend to be highest in the afternoon.
3. Blue-green algae blooms may be highly localized and vary in location in a lake. One shoreline may be experiencing a bloom while another shoreline can be clear of a bloom.
4. Blue-green algae cells and toxins concentrations can differ considerably on a daily basis. Repeat sampling may be necessary.
5. Blue-green algae cells can be high and toxin levels can be low from the same sample.
6. Blue-green algae cells can be low and toxin levels can be high from the same sample.

Section B: Example Field Observation Sheet

Date of Observation: ___________________________
Time:______________________________
Name of Waterbody:______________________________________Town:______________________
Description of Location:____
____
Take and Send Digital Photos to DPH/DEEP

Visual Assessment:
Water Clarity (check all that apply):

- ❒ Clear
- ❒ Cloudy
- ❒ Hazy

Water Color (check all that apply):

- ❒ Green
- ❒ Brown
- ❒ Milky white
- ❒ Blue-green
- ❒ Red
- ❒ Clear

Visible Bloom (circle one): ❒Yes ❒ No ❒ Don't know
Visible Scum (circle one): ❒Yes ❒ No ❒ Don't know

Observations:
Are there people swimming? ❒Yes ❒ No ❒ Don't know
Are there people boating and jet skiing? ❒Yes ❒ No ❒ Don't know
Are there people with dog recreating in the area? ❒Yes ❒ No ❒ Don't know

Reporters Name:_________________________________

Phone Number:__________________________________

Section C: Postings for beaches and other public access points

Example A: Posting for a Municipal Beach Closure

Example B: Cautionary (Category 2) Posting

DOCUMENT END