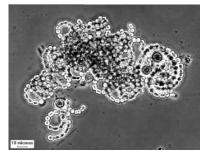


Harmful Algal Blooms: Environment and Public Health Issues









James Hyde, Research Scientist, BWSP, NYDSOH

Southeast New York Stormwater Conference Wednesday, October 17 --- 201820182018

Today's Talk

- HABs 101
- NYS HABs program
- HABs and Health
 - Overview
 - Health Surveillance
 - Recreational Water
 - Drinking Water





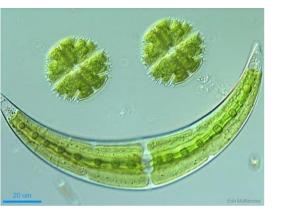
HABs 101

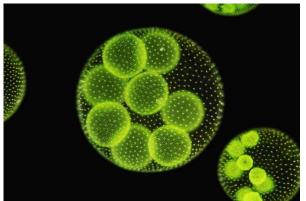




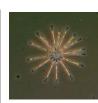
What are Algae?

- Single-celled plants
- Possess chlorophyll
- Conduct photosynthesis.

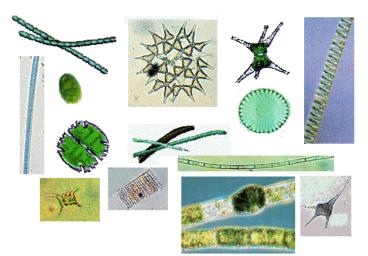












Seasonal Changes in Algae Phytoplankton

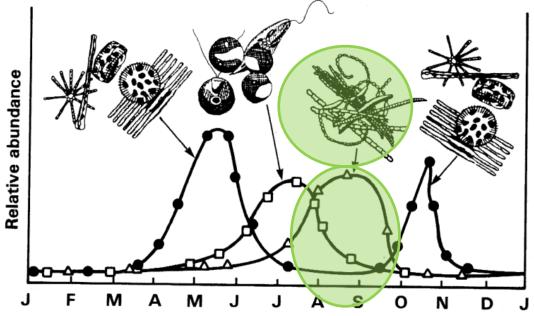


Figure 5. Seasonal Succession of Phytoplankton (Olem and Flock, 1990)
Diatoms tend to dominate in spring and fall, with greens and blue-greens dominant during summer, but many variations are possible.

Department of Health

Images from: http://www-cyanosite.bio.purdue.edu/index.html

Some Potentially Toxic Cyanobacteria

Anabaena



Aphanizomenon



Microcystis



Planktothrix (Oscillatoria)



Cylindrospermopsis



Many others...

Harmful- ugly, messy & potentially toxic

Algae- actually cyanobacteria that look and act very much like algae

Blooms- dense biomass accumulations fueled by nutrients (mainly phosphorus) and warm calm weather



Recognizing HABs

- PROBABLY HABs
- Floating on surface of the water
- Streaks, clumps, pea soup or spilled paint appearance
- Bright green (or bluegreen, brown, whiteish, or purple)

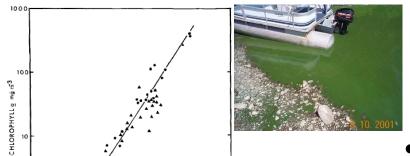


Recognizing HABs

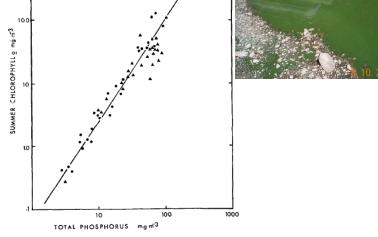
- NOT HABs
- Filamentous algae
- Floating plants (watermeal and duckweed)
- Discolored water
- Blooms of other types of algae



Nutrients, eutrophication & HABs





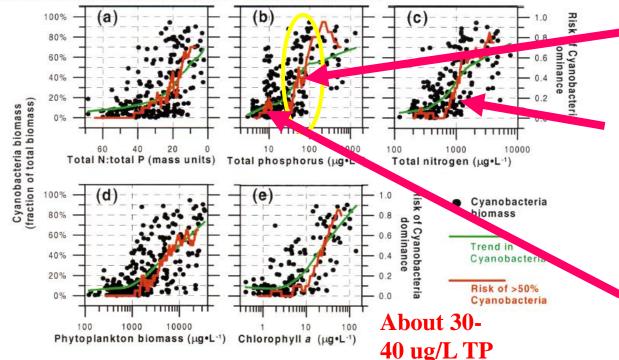


 Total Phosphorus vs Chlorophyll- Dillon and Rigler. 1974, Limnology and Oceanography Vol. 19, Issue 5, Pg 767

Does this hold for cyanobacteria and/or HAB toxins?



Fig. 1. The relative abundance of Cyanobacteria in the plankton of north temperate zone lakes. Dots represent the observations collected using the sources and methods indicated in the legend of Table 1. Solid lines are average LOWESS trend lines (f = 0.3, number of steps = 2) in the fraction of Cyanobacteria in the plankton (green) and the risk of plankton dominated (>50%) by Cyanobacteria (red). The risk values (see text) thus represent the fraction of world lakes with similar values of total N:total P, total P, total N, chlorophyll, or biomass that have phytoplankton composed of >50% Cyanobacteria biomass.

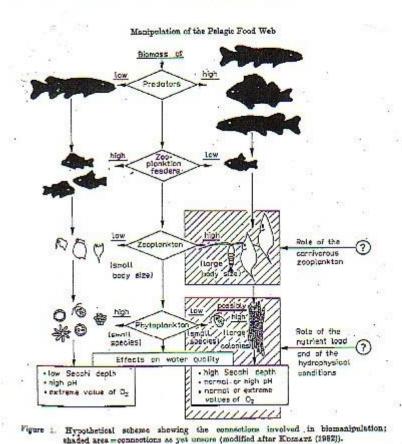


Downing et al. 2001. Predicting Cyanobacteria dominance in lakes. Can. J. Fish. Aquat. Sci. **58**: 1905–1908

- Big increase at 20-30 ug/L TP
- Nitrogen also important(e.g. N:P ratio)
- -Blooms also possible at low nutrients (e.g. Finger Lakes)



Following is a facsimile reproduction from Benndorf et al. (1984) and depicts a hypothetical scheme showing the connections involved in biomanipulation; shaded area connections not yet clear (modified after Kossatz. 1982).



Food web effects

- Classic paradigm- try to maximize large daphnia
- Can be rather complex and hard to sustain
- Zebra mussels- can foster blooms and increased toxcity at low nutrient levels



Athen Municipal Water authority



Climate Change & Blooms?

WILEY Global Change Bio

The rise of harmful cyanobacteria blooms: The potential roles of eutrophication

and climate change

J.M. O'Neil a,*, T.W. Davis b, M.A. Burford b, C.J. Gobler c

Blooms Like It Hot

Hans W. Paerl¹ and Jef Huisman²

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

While the interactive effects of future eutrophication and climate change on harmful cyanobacterial blooms are complex, much of the current knowledge suggests these processes are likely to enhance the magnitude and frequency of these events.

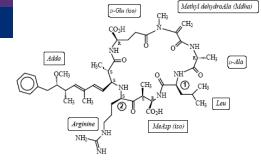
PRIMARY RESEARCH ARTICLE

Unexpected stasis in a changing world: Lake nutrient and chlorophyll trends since 1990

Samantha K. Oliver¹ | Sarah M. Collins^{1,2} | Patricia A. Soranno² | Tyler Wagner³ Emily H. Stanley¹ | John R. Jones⁴ | Craig A. Stow⁵ | Noah R. Lottig¹

We conclude that despite large environmental change and management efforts over recent decades, water quality of lakes in the Midwest and Northeast U.S. has not overwhelmingly degraded or improved.

Cyanobacterial Toxins

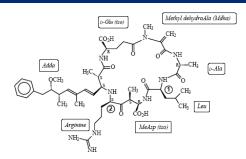


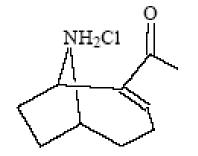
- Numerous structural variants with different toxicities
- Toxins contained within cells but are released to water upon lysis or as population ages.
- Not all strains of potentially toxic species produce toxins
- Toxin production varies and "ON/OFF" mechanisms are not well understood
 - Environmental (light, heat, nutrient levels/ratios)
 - Ecological (predation, competition, selection, and community structure)
 - It takes a lot on energy, therefore not an "accident"?



The Main Toxins

- Microcystins
 - Acts on the liver
 - Very common & studied worldwide
- Anatoxins (-a & -a(S))
 - Acts on the nervous system
 - Second most commonly studied, but fairly rare in NYS
- Others (Cylindrospermopsin, Saxitonins, Nodularin, Lyngbytoxin, BMAA, etc.)
- Dermatoxins/allergens (e.g. LPSs)
 - Not considered to be "toxins"
 - Very common worldwide, yet poorly studied and understood
 - Commonly causes symptoms in recreational water







Toxins analysis

- Can't be done just visually
- Expensive and time consuming
- Not standardized nationally
- NYS ELAP certified labs
- Sample collection is warranted





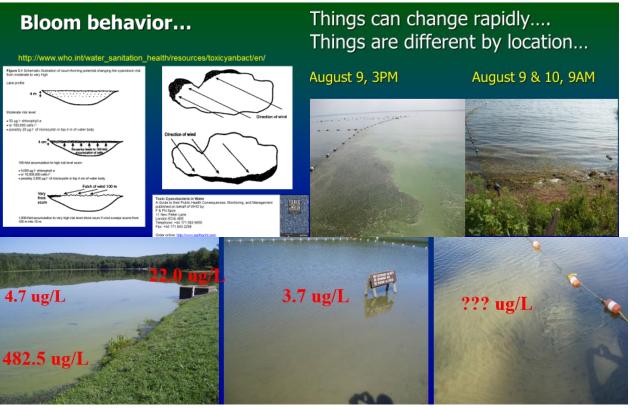
What is measured by the labs?

- FluoroProbe Chlorophyll –
 Measures chlorophyll (total,
 bluegreen, diatoms, green algae)
- Microscopy Quick scan, check for most common taxa
- Toxins (lab dependent) LC-MSMS or ELISA; Microcystins, Anatoxin-a, Cylindrospermopsin, BMAA





Bloom behavior: monitoring & health implications



- Blooms/toxins are very dynamic
- We have 1,321 regulated beaches
- Illness possible in the absence of measured "toxins"



NYS HABs Program





Combatting HABs in NYS

December 2017: Governor Cuomo announced a 4-point initiative

Part of the \$2.5B Clean Water Infrastructure Act of 2017:

- 1. Selection of priority lakes
- 2. Regional HABs summits
- 3. Completion of Action Plans
- 4. Implementation of treatment and monitoring







Selection of Priority Lakes

- There are 16,000 lakes in NYS, so a difficult task
- Wide variety of types, locations, sizes and vulnerabilities
- All Priority Lakes are water supplies or critical tourism drivers
 - Western Group: Conesus; Honeoye; Chautauqua
 - Central Group: Owasco; Skaneateles; Cayuga
 - North Country Group: Parts of Lake Champlain; Lake George
 - Greater Hudson Valley Group: Lake Carmel; Palmer Lake; Putnam Lake; Monhagen Brook watershed (five reservoirs)



HABs roles and responsibilities

NYS DEC

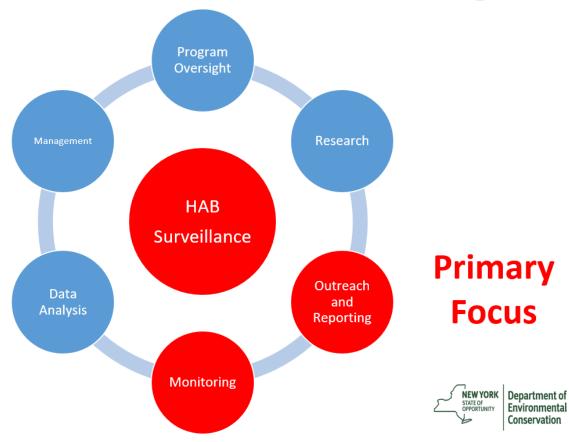
- Implement Clean Water Act (CWA)
- Responsible for ambient waters (i.e. lakes and streams)
- Source water protection
- Identify and implement water quality improvement needs

NYS DOH

- Implement Safe Drinking Water Act (SDWA)
- Responsible for regulated beaches, drinking water & illness surveillance
- Source water protection
- Identify drinking water problems & solutions



Elements of the DEC HABs Program





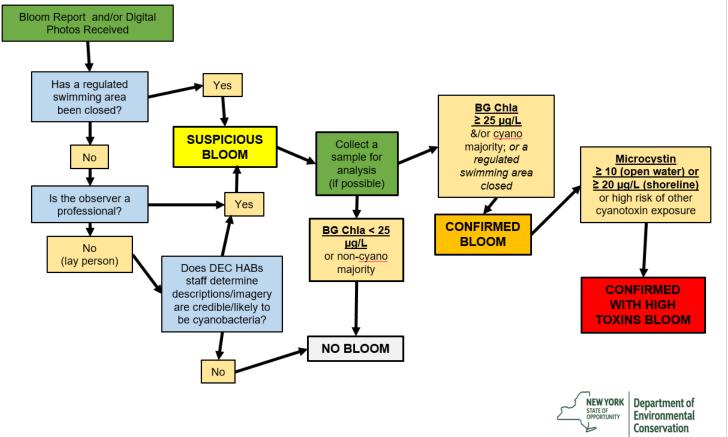
December 9, 2018

NEW YORK STATE OF OPPORTUNITY.

Department

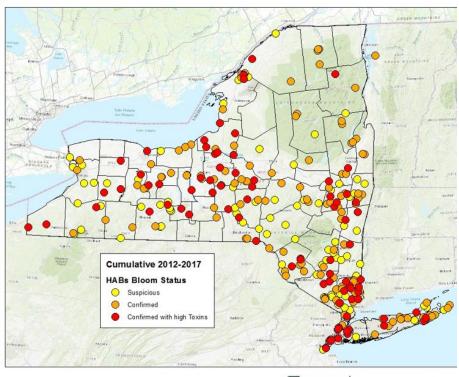
of Health

DEC Bloom Status Designation

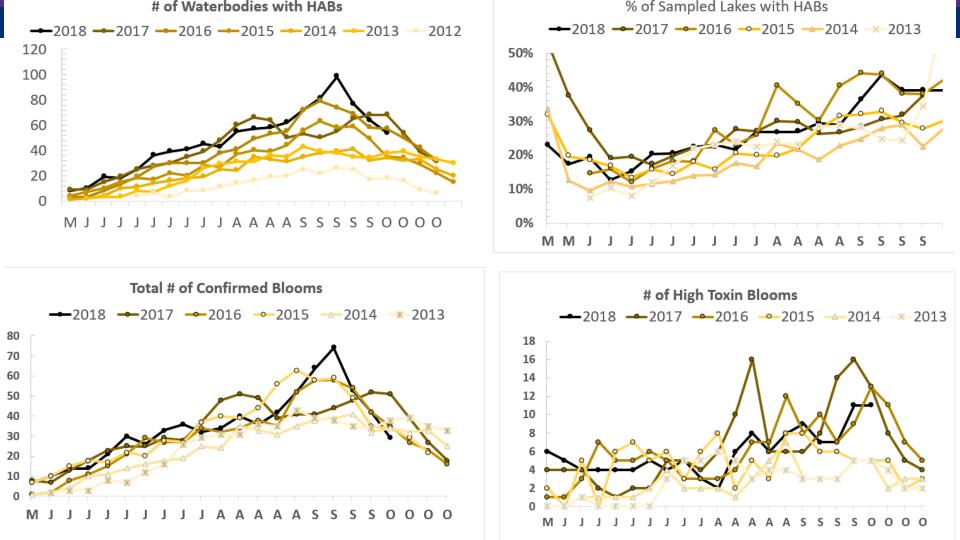


HABS in New York 2012-2017

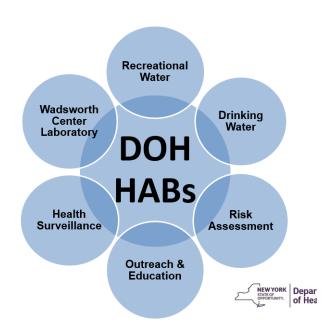
Year	Suspicious	Confirmed	High Toxins	Total
2012	20	29	9	58
2013	17	37	22	76
2014	19	51	23	93
2015	40	62	35	137
2016	41	95	38	174
2017	48	85	35	168
12-17	75	133	77	340







HABs and health





HABs and Health It is not just about

It is not just about toxins...





cylinderospermopsin

anatoxins

LPSs endotoxins

Toxin "eating"

Coliforms/indicators

Opportunistic pathogens (e.g. *Aeromonas, Vibrio*)

Bacteria



Exposure to HABs

Potential for exposure to **both** cyanobacteria and cyanotoxins



Photo Source: NYS Depart of Environmental Conservation

Recreational Water Exposure Routes

- Oral
 - Incidental ingestion (accidentally swallowing water while swimming)
- Dermal
- Inhalation of airborne droplets (i.e., aerosols)
 - Recreational activities (e.g., boating) can aerosolize water

Drinking Water Exposure Routes*

- Oral (consumption of drinking water)
- Dermal exposure and inhalation of airborne droplets (i.e., aerosols)
 - Showering, bathing, washing

^{*}Drinking water treatment

Blue-green Algae & Health

Potential Symptoms

- Allergic or irritative skin, eye, ear, throat reaction
- Respiratory difficulties
- Diarrhea
- Nausea
- Jaundice
- Vomiting
- Neurological





HAB-Associated Illness Cases Reported to NYSDOH

- Up to 2015 few, sporadic illness reports
- 2009-2014 CDC funded HABISS study
- 2015 CDC/CSTE* fellow performed pilot study with partner counties
 - Outreach, active and passive surveillance
 - 51 complaints → 32 human cases, 3 canine cases (Figgatt et al. 2017 MMWR)
- 2016 passive surveillance, no cases reported
- 2017 CDC/CSTE* fellow collected case data
 - Passive surveillance
 - 39 complaints → 14 human cases, 2 canine cases

None associated with drinking water

Sources: Hilborn et al. 2014 (MMWR), NYSDOH CEH Bureau of Community Environmental Health and Food Protection (BCEHFP), Bureau of Water Supply Protection (BWSP)



^{*}The Applied Epidemiology Fellowship program is funded by the Centers for Disease Control and Prevention (CDC) and administered by the Council of State and Territorial Epidemiologists (CSTE).

of skin.

Symptoms and Medical Care Characteristics of HAB-associated Human Illness Cases (n=14)					
Reported to NYSDOH (Jul-Oct 2017)					
Symptom ¹ / Medical Care Characteristic	number of cases (%)				
Time to symptom onset (range)	1 hour - < 3 days				
<= 1 day	10 (71)				
> 1 day to < 3 days	4 (29)				
Dermal	12 (86)				
Rash (duration range = 2 to 18 days)	11 (79)				
Eye irritation, irritation of skin around eyes, watery eyes and/or red eyes	3 (23)				
Respiratory (stuffy or runny nose, sore throat, shortness of breath,					
chest tightness, weakness and/or cough)	9 (64)				
Gastrointestinal (diarrhea, nausea, vomiting and/or abdominal pain)	4 (29)				
Neurologic (confusion, weakness or tingling sensation in fingers or toes)	4 (29)				
¹ Symptoms are not mutually exclusive. Rash was described as itchy by 10 cases, raised and red by 10 cases, and not painful by					
all 11 human cases who reported rash symptoms; six cases reported that the rash spread from the initial area to other areas					



Recreational Water







NYS HAB beach Protocol:

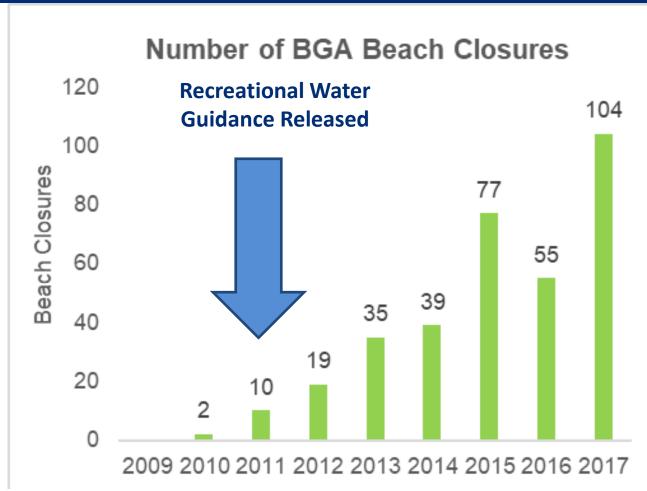
- Closure based on visual determinations
- Reopened after being clear for 24 hours and microcystins are < 4.0





NYS BGA Impact at Beaches

- Know it, Avoid it, Report it
- Beaches closed on visual evidence of bloom
- Reopened day after HAB is gone and toxin testing



35 **December 9, 2018**

Avoid blooms in surface waters

It might be a blue-green algae

bloom if you see:

Strongly colored water

· Paint-like appearance.

· Floating rafts or soums.

Dense blooms

surface waters:

because blue-green algae can cause

health effects in people and animals.

Know it.

Avoid it.

Always stay away from blooms in

. Don't swim, fish, boat or wade near

blooms, or eat fish from water with

· Bloom or no bloom, never drink or

ice) untreated surface water

If you're not on a public water supply:

consuma incorpare fond, cook or make

· During a bloom, don't drink/consume

surface water, even if you treate

If you are on a public water supply: Your water is treated, monitored, managed and protected for drinking/

consuming and household use.

Report it. Report blooms and symptoms to:

· Consider visiting a health care provider if you, your family or animals are

experiencing symptoms that might be related to blue-green algae exposure.

Learn more health.ny.gov/hamfulalgae

it. Also consider not using it for showering, bathing, or washing.



If You are Are Exposed

- · Rinse off yourself, children and animals with clean water if exposed to water that has blooms, surface scums or is visibly discolored.
- · Stop using the water and consider medical attention if people or animals have symptoms and might have contacted, consumed or inhaled surface waters with possible blooms. Symptoms Include diarrhea, nausea or vomiting, skin, eye or throat irritation, allergic reactions or breathing difficulties.

Report it.

· Please report suspicious blooms and related symptoms to harmfulalgae@health.ny.gov and your local health department.

More Information

NYS Department of Health www.health.ny.gov/harmfulalgae

NYS Department of Environmental Conservation

www.dec.ny.gov/chemical/77118.html

US Centers of Disease Control and Prevention www.cdc.gov/nceh/hsb/hab/default.htm

US Environmental Protection Agency www2.epa.gov/nutrient-policy-data/cyanohabs Avoid blooms in surface waters because blue-green algae can cause health effects in people and animals.



Know it.

It might be a blue-green algae bloom if you see:

- Dense blooms.
- · Strongly colored water.
- · Paint-like appearance. · Floating rafts or scums.



Avoid it.

Always stay away from blooms in surface waters: . Don't swim, fish, boat or wade near blooms, or eat fish from water with blooms.

If you're not on a public water supply:

- . Bloom or no bloom, never drink or consume (prepare food, cook or make ice) untreated
- . During a bloom, don't drink/consume surface water, even if you treat it yourself. Also consider not using it for showering, bathing, or washing.
- If you are on a public water supply: · Your water is treated, monitored, managed and protected for drinking/consuming and



household use.

Report it.

leport blooms and symptoms to: harmfulalgae@health.ny.gov

Consider visiting a health care provider if you, your family or your animals are experiencing symptoms that might be related to blue-green algae exposure.

Learn more health.ny.gov/harmfulalgae







Health



Blue-green

Algae and



















Blue-Green Algae and Health





Avoid it. (



Blue-green algae are microscopic organisms that can form dense blooms in surface waters. People and animals should avoid blooms because bluegreen algae can cause health effects.

It could be blue-green algae in surface water if you see:



Dense blooms.

- Strongly colored water (blue-green, green, yellow, white, brown, purple or red).
- Paint-like appearance.
- Floating rafts or scums.

Always stay away from blooms in surface waters:

o Don't swim, fish, boat or wade near blooms, or eat fish from water with blooms.

If you are not on a public water supply and are using surface water in your home:



Report it.

Avoid it.

- o Bloom or no bloom, never drink or consume (prepare food, cook or make ice) untreated surface water.
- Even if you are treating surface water yourself, don't drink or consume it during a bloom. Also consider not using it for showering, bathing, or washing.

If you are on public water:

- Your water is treated, monitored and managed to protect it for drinking/consuming and household uses.
- Report suspicious blooms to harmfulalgae@health.ny.gov and your local health department.



- Report bloom-related symptoms in people or animals to harmfulalgae@health.ny.gov and your local health department.
- Consider visiting your health care provider if you, your family or your animals are experiencing symptoms related to blue-green algae exposure. Symptoms include diarrhea, nausea or vomiting, skin, eye or throat irritation, allergic reactions or breathing difficulties.

Blue-green Algae





Drinking water





EPA 2015 Drinking Water Health Advisory Summary

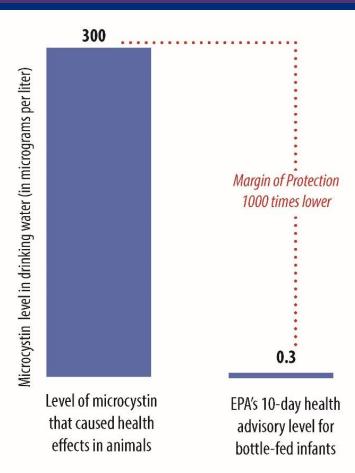
- Protects the public from being exposed to unregulated drinking water contaminants.
- Build in a large margin of protection between the health effects observed in animal and human studies and factor in vulnerable populations

Cyanotoxins	10-day Advisory	
	Bottle-fed infants and pre-school children	School-age children and adults
Microcystins	0.3 μg/L	1.6 μg/L
Cylindrospermopsin	0.7 μg/L	3 μg/L

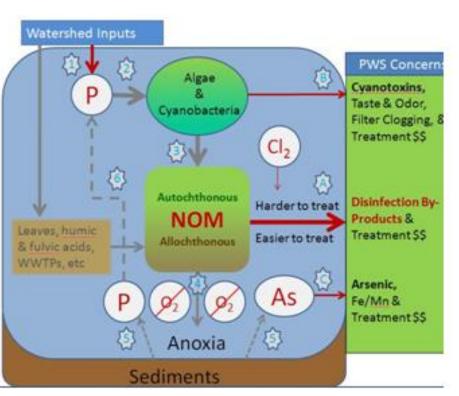
EPA Microcystin Drinking Water Health Advisory:

Builds in a large margin of protection:

- Exceedance indicates actions should be taken to reduce levels to preserve the margin of protection,
- Does not mean health effects are likely to occur
- Actions include:
 - Optimize to reduce microcystins
 - Notify public



DOH's drinking water program

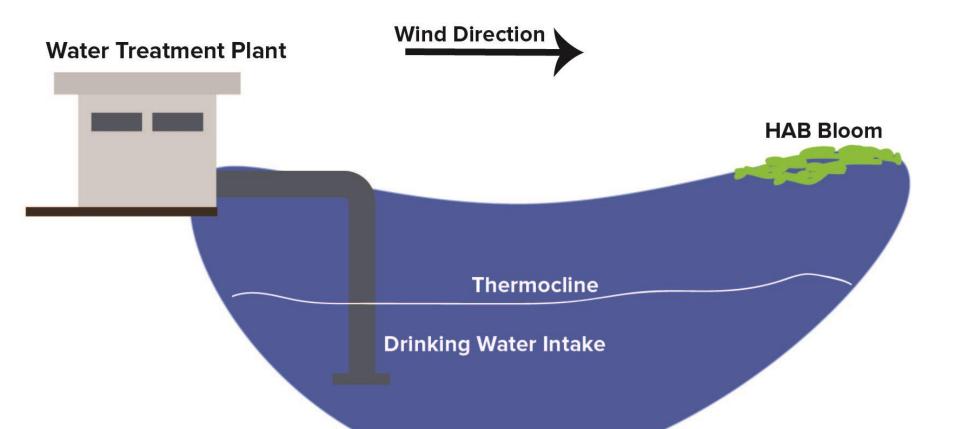


- It is not just about toxins...
 - Taste and odor
 - Disinfections by-products
 - Treatment difficulty and costs
- Long history with partners
- Monitoring and treatment optimization

Outreach and public

notification

HABs Drinking Water Treatment & Optimization



Criteria for Microcystin Sampling

- Outbreak/illness potentially associated with HAB and potable water
- HAB has been treated with an algaecide (without prior source water sampling showing toxins are not an issue)
- Water treatment has become substantially more difficult during a bloom (e.g. more chemical additions and/or filter backwashing is needed)

- Noted change in raw water quality associated with a HAB
- Widespread HAB in lake
- HAB concentrated near intake
- Shallow intake near a lesser HAB
- A taste and odor event associated with a HAB with no other difficulties in treatment or change in raw water quality



PWS Treatment Impaired Cases

HAB shuts down drinking water plant

- My first PWS HAB event 2001
- I got a call "Copper sulfate is not working and the plant is clogged"
- Nostoc sp. bloom could have related to a poorly designed lake destratification bubbler system
- A sample sent to SUNY ESF showed it was not toxic.

Boil Water Order associated with a HAB

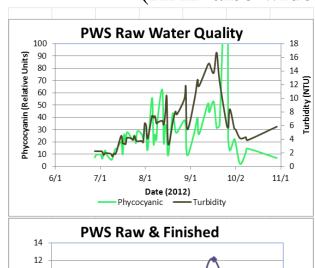


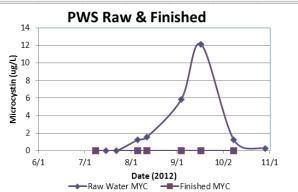
- Not meeting turbidity goals resulted in BWO in 2009
- Attributed to "lake turnover"
- We realized it was a HAB during a DOH training
- No illness reported or later found in syndromic surveillance
- HAB toxins have been found in the lake



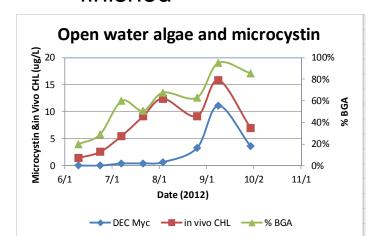
Noted change in raw water quality

(HAB also widespread in lake & shallow intake (z = 10 feet)





- 2012 case study under CDC grant
- Eutrophic lake- thick near-shore scums, recreational illness & dog deaths
- Highest raw to date, not detected in finished





2018 event



October 11, 2018 DOH issues a Do Not Drink Advisory for Rushville

This afternoon, the New York State Department of Health issued a Do Not Drink advisory for water customers served ONLY by the Village of Rushville's public water supply, including customers in the hamlet of Middlesex water district.

The advisory came after a sample that was collected on Tuesday, October 9, 2018 came back with 0.66 ug/L (micrograms per liter) of microcystin in the finished drinking water. Microcystin is a toxin produced by Blue Green Algae. This level is higher than the U.S. Environmental Protection Agency's 10-day Health Advisory level of 0.3 micrograms per liter of microcystins for bottle fed infants and children under 6 years old. For individuals not included in that group, the EPA's health advisory level is 1.6 micrograms per liter. However, out of an abundance of caution, the state is recommending all consumers of Rushville water do not consume water at this time. Confirmatory samples are being collected and tested at the Wadsworth Center, the NYSDOH's public health laboratory.

THIS ADVISORY DOES NOT INCLUDE the other water suppliers from Canandaigua Lake including: CANANDAIGUA, GORHAM, NEWARK AND PALMYRA that serve customers across a wide geographic area. These water

- Done out of an abundance of caution
- EPA's 10 day Health Advisory Level for bottle fed infants & pre-school age children is 0.3 ug/L
- Exceedance was observed for 1 day with a maximum value of 0.66 ug/L



Private Surface Water Intakes

- Never use surface water for drinking water or preparing food
- Always connect to public water system if available
- Private wells are often the next best option
- There are treatments that may REDUCE toxin levels for private surface water users but we don't recommend this for potable water.

CENTER FOR ENVIRONMENTAL HEALTH



Harmful Blue-green Algae Blooms: Understanding the Risks of Piping Surface Water into Your Home

This fact sheet provides information and advice for people who are not able to connect their homes to a public water supply or to a drilled well for their drinking water and are using a surface water source such as a lake, river, stream or spring for their household water, it is important to understand the risk of illness associated with using surface water that could contain harmful blue-green algae and their toxins, as well as bacteria, parasites and viruses.

About Harmful Blue-green Algae and Health Effects

Hammid blue-green algae blooms have been occurring in surface waters throughout. New York State. Contact with water with blue-green algae and their toxins can cause health effects. Symptoms include diarrhea, nausea or vonsting skin, eye or throat instation; and allergic reactions or breathing difficulties. Animal illnesses and deaths also have occurred when animals consumed large amounts of accumulated alast scum from along shorelines or when animals proomed blue-green algal scums from their land.

Recommendations for People with Private Surface Water Intakes

- Never drink untreated surface water, bloom or no bloom. Untreated surface water might contain blue-green align and their toxins, it can also contain other bacteria, parasities or visues that can cuse symptoms such as diarrhea, nausea and voniting. Young children, pregnant women, older adults and people with health issues are at higher risk from symptoms associated with these drinking water contaminants.
- If you must wash dishes with untreated surface water, rinse with bottled water. You may also consider not using it during a bloom for showering, bathing or washing, especially if your water looks cloudy.
- Even if you have an in-home treatment system, use bottled water during a bloom. Don't drink, prepare food, cook or make ice with surface water during a bloom. Boiling the water will not remove blue-green algae or their toxins.

Your Household Water Could Contain Blue-green Algae and Toxins if:

- The surface water is strongly colored (blue-green, green, yellow, white, brown, purple or red) or has a paint-like appearance, or you see floating mats or scurss on the water, especially near your surface water intake or shore well.
- There has been public notification of blue-green algae blooms or beach closures near your water intake. The New York State Department of Environmental Conservation (DEC) also lists waterbodies as having a blue-green algae bloom at www.dec.nv.gov/themical/8230.bhml.
- Your water looks cloudy coming out of the tap or water pressure changes. This could indicate that your
 water contains blue-green aligne and their toxins as well as bacteria, parasites or viruses that can cause
 illness. If your water is treated, it could indicate that your system needs service.



References

- NYS DOH HABs Resources www.health.ny.gov/harmfulalgae
- DEC HABs Resources on.ny.gov/hab
- EPA HABs Resources https://www.epa.gov/nutrient-policy-data/cyanobacterial-harmful-algal-blooms-water
 - EPA HABs Control and Treatment
 - https://www.epa.gov/nutrient-policy-data/control-and-treatment
 - EPA HAB Detection
 - https://www.epa.gov/nutrient-policy-data/detection#what1



Thank you for your time



James Hyde, Research Scientist,
NYS DOH, Bureau of Water Supply Protection,
James.Hyde@health.ny.gov



Algaecides



- Copper sulfate, chelated copper products, and peroxide products
 - Alkalinity
 - When & where to apply?
 - Away from intake
 - Pre-bloom is best, but fixed interval is bad
 - Copper resistance & non-target toxicity
 - Toxin release concerns and water treatment
- Toxin testing prior to use is recommended



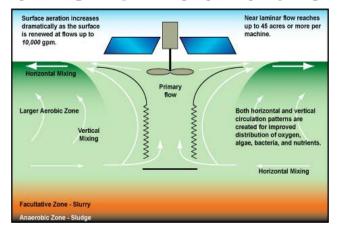
Getting the best water possible...

- Source blending and intakes
- Nutrient control
 - Watershed (point and non-point)
 - In lake
 - Alum
 - Dredging
 - Aeration

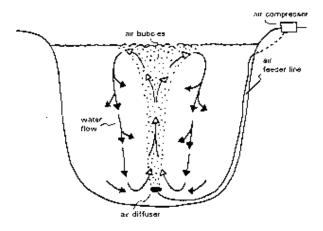




Lake Circulation and Destratification



- Mixes upper water column only
- Newer approach
- Needs more objective evaluation



- Mixes full water column
- Often increases nutrients turbidity, and algae
- Sizing VERY important
- Can be effective for HABs
- Over sold?



A major bloom on a filtration avoidance source water

CENTRAL NY NEWS

Algae toxins found in Skaneateles drinking water, officials say

Updated Sep 20, 2017; Posted Sep 20, 2017



Gallery: Skaneateles Lake algae bloom aerials

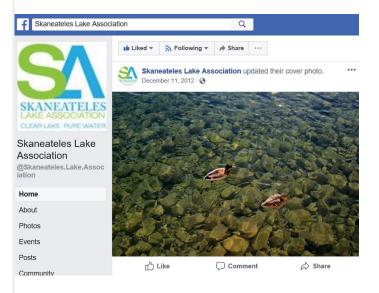








This how the lake normally looks

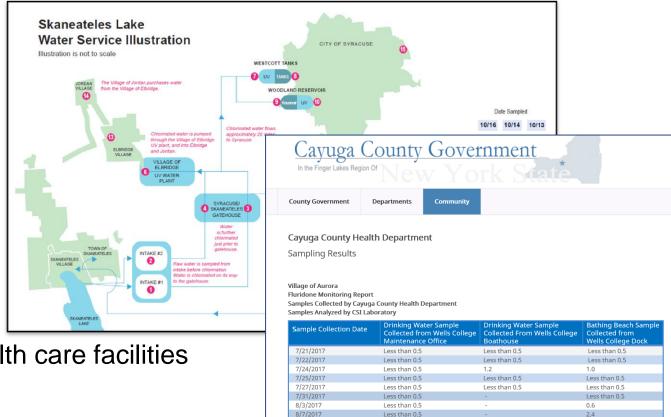


- Oligotrophic lake with a widespread bloom
- All non-detects
 in finished
 drinking water
 (with initial confusion regarding a partially treated sample)
- Immediate and massive sampling and outreach efforts



Outreach & Notification: How and Who

- Websites
- Printed materials
- Templates for stakeholders
- Social media
- Workshops
- Technical consultation
- Water consumers
- Regulated and health care facilities
- Water Suppliers



8/11/2017

8/14/2017

Less than 0.5

Less than 0.5

Less than 0.5

Other Sampling Needs

- UCMR associated sampling
- Public confidence (e.g. blooms not near intakes, reports/rumors of HAB associated illness)
- Optimization & verification of treatment effectiveness
 - Check each treatment step within WTP for algae/toxins
 - Check within distribution & purchase systems for further toxin degradation

