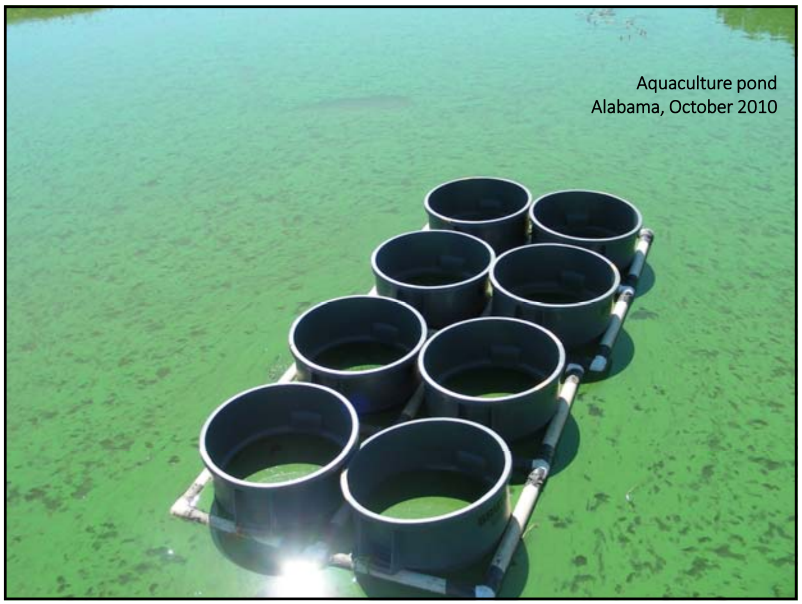
2007-present, Faculty, Auburn University
Fisheries, Aquaculture, and Aquatic Sciences
www.wilsonlab.com



Aquaculture pond
Alabama, August 2008

Outline

- **Harmful algal blooms (HABs) background**
  - **Important taxa**
  - **Defining an algal bloom**
  - **Approaches for studying algal blooms**
  - **Factors that promote algal blooms**
- **Data about U.S. conditions related to HABs**
  - **2007 EPA National Lakes Assessment**
  - **2014 Toxic algae news report**

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NATURE

May 2, 1878

Poisonous Australian Lake

George Francis

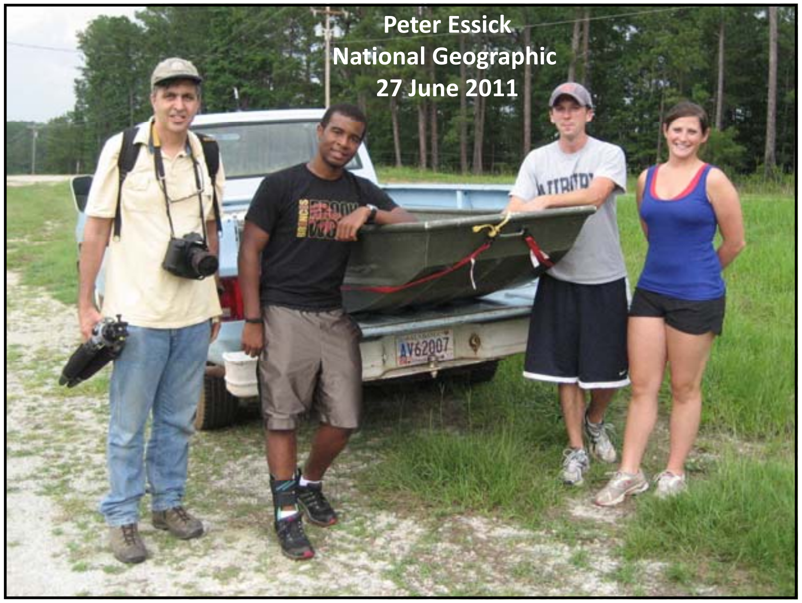
Jackson Lake, Georgia
September 2007
(credit: Tom Broadwell, GA Power)


Aquaculture pond
Alabama, August 2008


Lago de Pátzcuaro
Mexico, July 2008

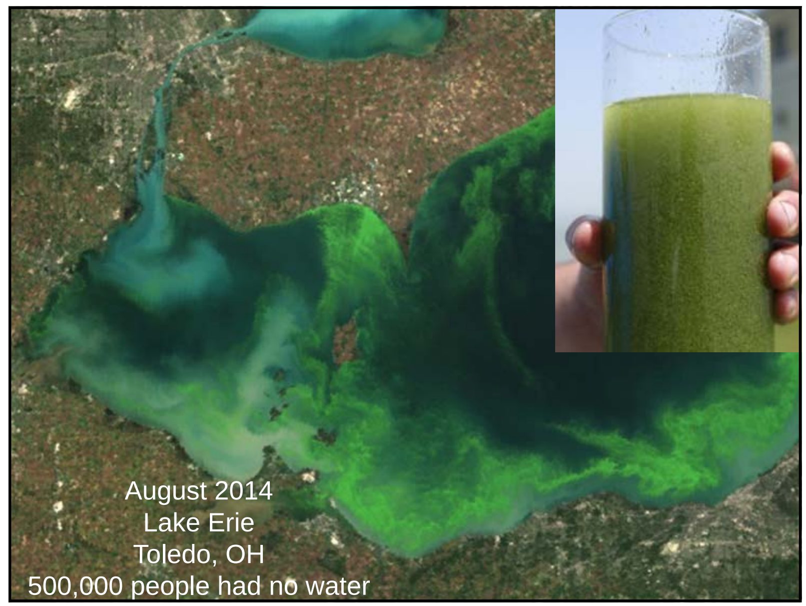

Lake Erie
August 2006

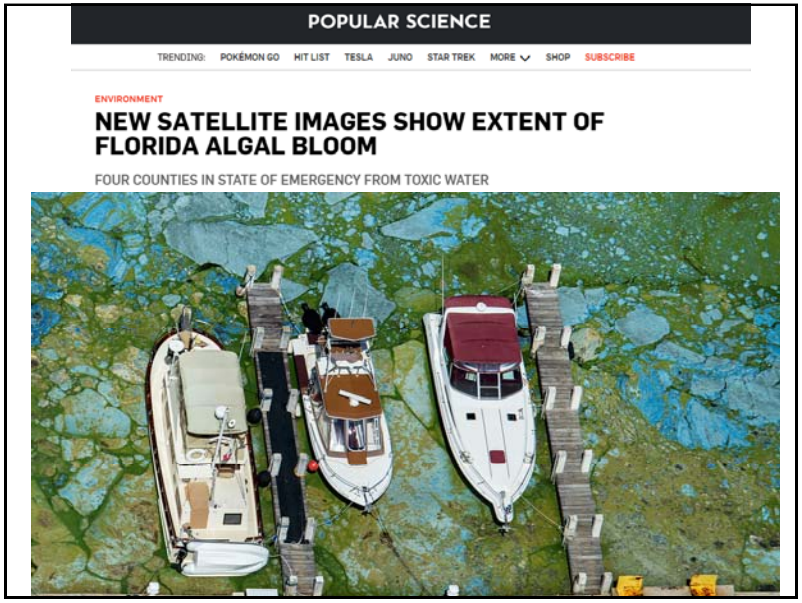

May 2013
NATIONAL GEOGRAPHIC
THIS BABY WILL LIVE TO BE 120*

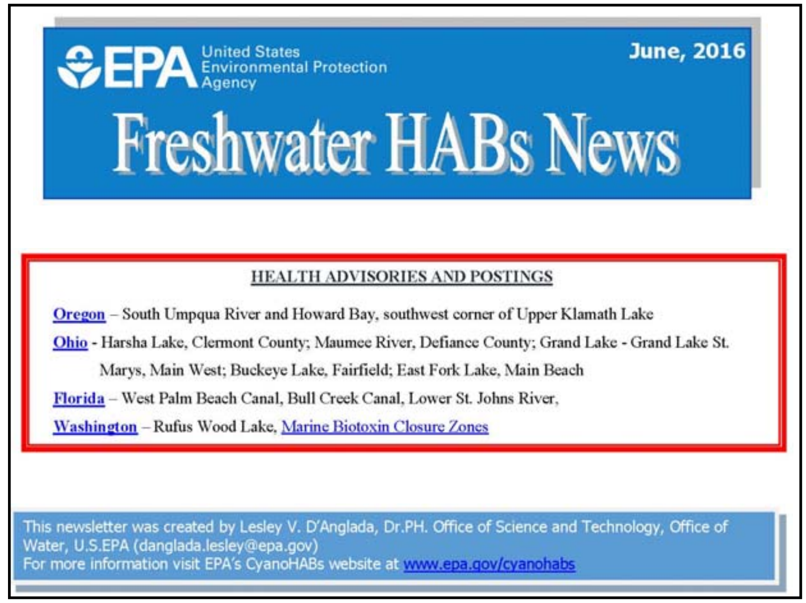

Peter Essick
National Geographic
27 June 2011


AU pond S10
27 June 2011


Lake Erie (photo: summer 2011)
http://ngm.nationalgeographic.com/2013/05/fertilized-world/essick-photography


August 2014
Lake Erie
Toledo, OH
500,000 people had no water




EPA United States Environmental Protection Agency

June, 2016

Freshwater HABs News

HEALTH ADVISORIES AND POSTINGS

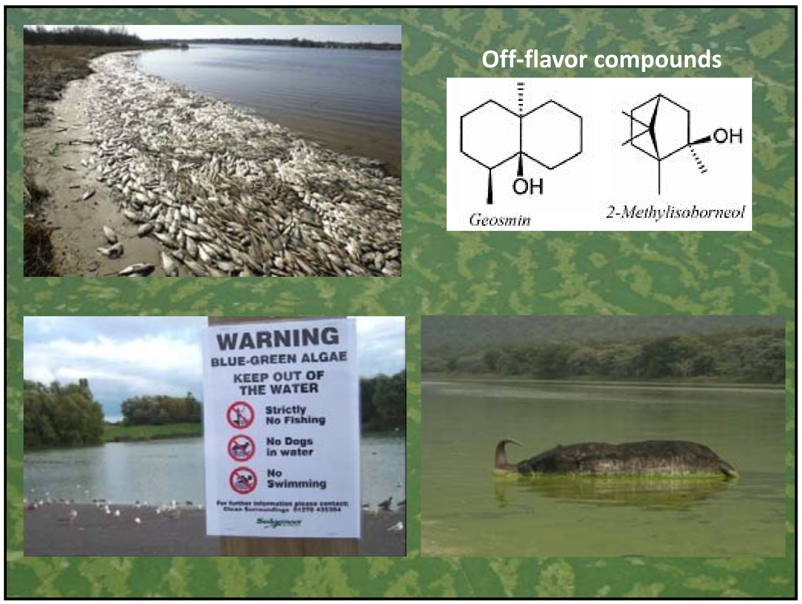
Oregon – South Umpqua River and Howard Bay, southwest corner of Upper Klamath Lake

Ohio - Harsha Lake, Clermont County; Maumee River, Defiance County; Grand Lake - Grand Lake St. Marys, Main West; Buckeye Lake, Fairfield; East Fork Lake, Main Beach

Florida – West Palm Beach Canal, Bull Creek Canal, Lower St. Johns River,

Washington – Rufus Wood Lake, Marine Biotoxin Closure Zones

This newsletter was created by Lesley V. D'Anglada, Dr.PH. Office of Science and Technology, Office of Water, U.S.EPA (danglada.lesley@epa.gov)
For more information visit EPA's CyanoHABs website at www.epa.gov/cyanohabs




Santa Cruz Sentinel

Serving Santa Cruz County for More Than 100 Years

SANTA CRUZ, CALIFORNIA, FRIDAY, AUGUST 18, 1961

EIGHTEEN PAGES

Seabird Invasion Hits Coastal Homes

He Got The Bird—Or Was It Vice Versa

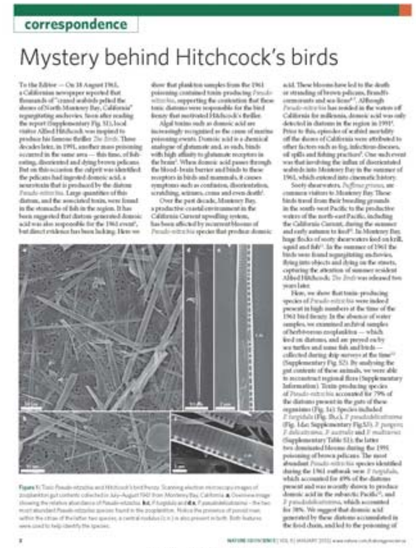
Thousands Of Birds Floundering In Streets

Did Lights Bring Birds Ashore

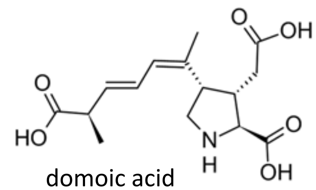
Agency Okays SL Park Pact With Shaffer

University May Use Cabrillo Facilities To Open Its Doors

Brick Wall Being Built By German Reds To Reinforce Barbed Wire Barricades


correspondence

Mystery behind Hitchcock's birds

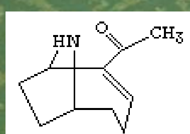


domoic acid (neurotoxin)

Bargu et al. 2012 Nature Geoscience

Coroner cites algae in teen's death *Milwaukee Journal Sentinel, 5 Sept 2003*

…Two days after swallowing water while splashing and diving in a scum-covered pond at a Dane County (WI) golf facility in July 2002, Dane Rogers went into shock and suffered a seizure before his heart failed, according to Coroner John Stanley's report… Tests of stool and blood samples found the common blue-green algae, known as *Anabaena flos-aquae*, and its toxin, anatoxin-a…



anatoxin-a

Articles

Human Fatalities from Cyanobacteria: Chemical and Biological Evidence for Cyanotoxins

Wayne W. Carmichael,[1] Sandra M.F.O. Azevedo,[2] Ji Si An,[1] Renato J. R. Molica,[3] Elise M. Jochimsen,[4] Sharon Lau,[5] Kenneth L. Rinehart,[5] Glen R. Shaw,[6] and Geoff K. Eaglesham[7]

[1]Department of Biological Sciences, Wright State University, Dayton, Ohio, USA; [2]Instituto de Biofisica Carlos Chagas Filho, Universidade do Brasil, Rio de Janeiro, Brasil; [3]Instituto Technologico de Pernambuco, Recife, Brasil; [4]Hospital Infections Program, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, USA; [5]Roger Adams Laboratory, School of Chemical Sciences, University of Illinois, Urbana, Illinois, USA; [6]National Research Center for Environmental Toxicology, Coopers Plains, Queensland, Australia; [7]Queensland Health Scientific Services, Coopers Plains, Queensland, Australia

World Health Organization

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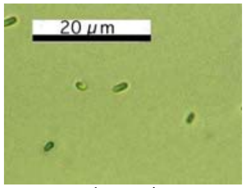
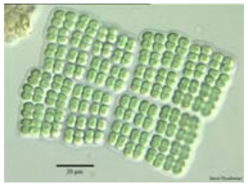
Examples of cyanobacteria

single-celled	colonial	filamentous
<10 µm length <2 µm width	15 µm to >1 mm diameter	<10 µm width >1 mm length



Anacystis



Merismopedia

Cylindrospermopsis

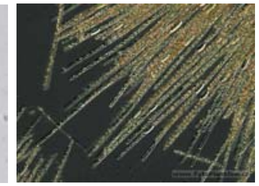
Synechococcus

Microcystis

Oscillatoria

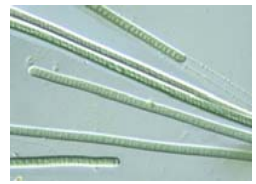
Examples of toxigenic cyanobacteria

Anabaena



Aphanizomenon

Cylindrospermopsis



Lyngbya

Microcystis

Oscillatoria

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What is a bloom?

- World Health Organization

Table 5.2 Guidelines for safe practice in managing bathing waters which may produce or contain cyanobacterial cells and/or toxins

Guidance level or situation	How guidance level derived	Health risks	Recommended action
Cyanobacterial scum formation in bathing areas	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 prevent contact with scums; possible prohibition of swimming and other water-contact activities Public health follow-up investigation Inform relevant authorities
100,000 cells cyanobacteria per ml or 50 µg chlorophyll a per litre with dominance of cyanobacteria	From provisional drinking water guideline for microcystin-LR, 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 Restrict bathing and further investigate hazard Post on-site risk advisory signs Inform relevant health authorities
20,000 cells cyanobacteria per ml or 10 µg chlorophyll a per litre with dominance of cyanobacteria	From human bathing epidemiological study	Short-term adverse health outcomes, e.g. skin irritations, gastrointestinal illness, probably at low frequency	Post on-site risk advisory signs Inform relevant authorities

<u>WHO Thresholds</u>
Cell density ≥ 20,000 cells/ml
Chlorophyll ≥ 10 µg/L
Microcystin drinking water ≥ 1 µg/L

- http://www.who.int/water_sanitation_health/resourcesquality/toxicyanbact/en/

Chorus and Bartram 1999

What is a bloom?

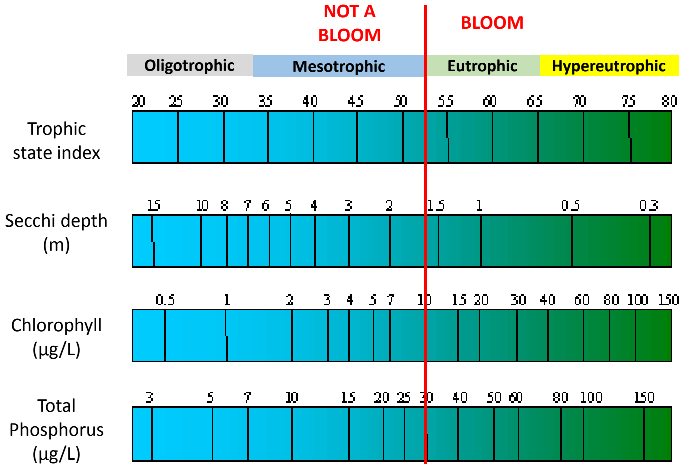
- World Health Organization
- Carlson Trophic State Index (TSI)
  - widely used classification scheme
  - based on transparency (Secchi depth), chlorophyll a, total phosphorus to relate to algal biomass typically during the summer
  - scale from 0 – 110; increase of 10 TSI units = 2x algal biomass
  - TSI useful for comparing lakes within a region and for assessing changes in trophic status over time
  - Carlson 1977 Limnology and Oceanography
  - http://aslo.net/lo/toc/vol_22/issue_2/0361.pdf

TSI values vs. water quality

<40	Oligotrophic; clear water; high hypolimnetic O_2 year-round but possible anoxia in the deeper hypolimnion part of year
40-50	Mesotrophic; moderately clear water; possible hypolimnetic anoxia in summer and/or under ice. Fully supportive of all swimmable/aesthetic uses; possible cold-water fishery
50-60	Mildly eutrophic; decreased Secchi; anoxic hypolimnion; possible macrophyte “problems”; warm-water fishery; supportive of all swimmable/aesthetic uses but “threatened”
60-70	blue-green algal dominance with scums possible; extensive macrophyte problems; not supportive of all beneficial uses
>70	Heavy blooms and scums in summer likely; dense “weed” beds; hypereutrophic; possible fish kills; fewer plant beds due to high algae; not supportive of many beneficial uses

Carlson 1977 Limnology and Oceanography

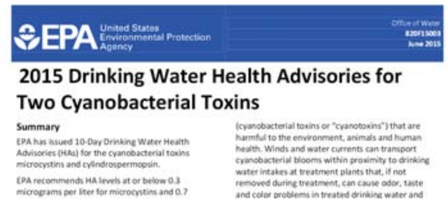
TSI values



Carlson 1977 Limnology and Oceanography

What is a bloom?

- World Health Organization
- Carlson Trophic State Index (TSI)
- US Environmental Protection Agency


EPA United States Environmental Protection Agency

2015 Drinking Water Health Advisories for Two Cyanobacterial Toxins

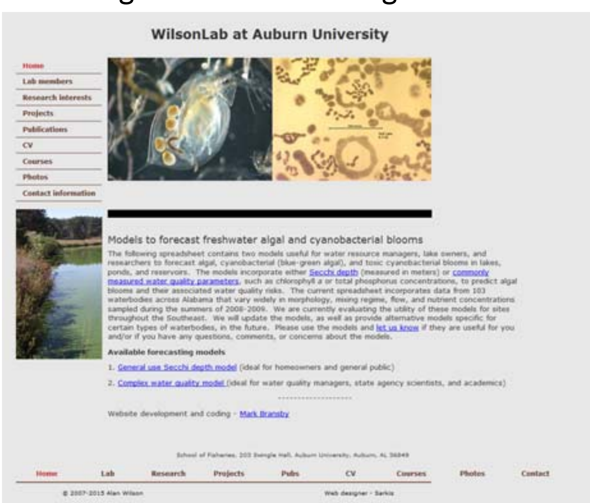
USEPA drinking water advisories

1) Microcystin
   - 0.3 µg/L for children 0-6yrs
   - 1.6 µg/L for everyone >6yrs

2) Cylindrospermopsin
   - 0.7 µg/L for children 0-6yrs
   - 3.0 µg/L for everyone >6yrs

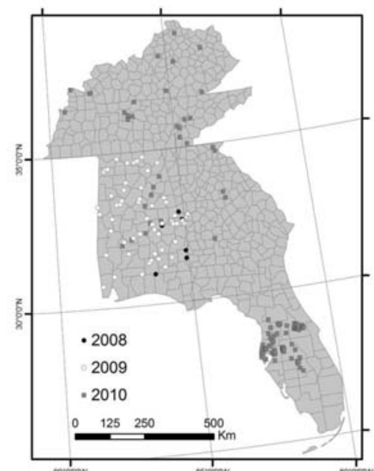
- https://www.epa.gov/nutrient-policy-data/drinking-water-health-advisory-documents

Algal bloom forecasting website



http://wilsonlab.com/forecasting.html

Algal bloom forecasting website



http://wilsonlab.com/forecasting.html

Algal bloom forecasting website

SECCHI DEPTH MODEL

Secchi depth model to forecast freshwater algal and cyanobacterial blooms

How to use the model

Input Secchi depth (meters) in the first white box below. This value will be used to calculate the predicted concentrations of algae, cyanobacteria, or toxic cyanobacteria and associated risk level for your waterbody. Note that "risk" is a relative term. We used our knowledge of our dataset to relate risk with certain water quality parameters. If you are concerned about your waterbody, we encourage you to contact a local USDA extension agent.

SECCHI DEPTH (meters) .3
(1ft = 0.305m)

	ALGAL BLOOM TYPES		
	Phytoplankton	**Cyanobacteria**	**Toxic cyanobacteria**
	chlorophyll (µg/L)	phycocyanin (µg/L)	microcystin (µg/L)
PREDICTED CONCENTRATIONS	48	78	0.00919
RISK LEVEL	High Risk	High Risk	Low Risk

Important note about the Secchi depth model

Please keep in mind that these models will be most relevant to systems sampled during warm summer months. Also, since Secchi depth is influenced by organic (phytoplankton) and inorganic (suspended sediment) particles, Secchi depths collected after rain events may provide spurious predictions.

http://wilsonlab.com/forecasting.html

Algal bloom forecasting website

WATER QUALITY MODEL

Water quality model to forecast freshwater algal and cyanobacterial blooms

How to use the model

Input water quality parameters in the white cells below for the algal bloom type of interest (phytoplankton, cyanobacteria, or toxic cyanobacteria). These data will be used to calculate the predicted concentrations of algae, cyanobacteria, or toxic cyanobacteria and associated risk level for your waterbody. Note that "risk" is a relative term. We used our knowledge of our dataset to relate risk with certain water quality parameters. If you are concerned about your waterbody, we encourage you to contact a local USDA extension agent.

PHYTOPLANKTON AND CYANOBACTERIAL FORECASTING MODELS

		ALGAL BLOOM TYPES		
WATER QUALITY DATA		**Phytoplankton**	**Cyanobacteria**	**Toxic cyanobacteria**
Chlorophyll (CHL)	µg/L		50	
Total Phosphorus (TP)	µg/L			
Soluble Reactive Phosphorus (SRP)	µg/L			
Total Nitrogen (TN)	µg/L			
Nitrogen:Phosphorus (N:P)	molar			
		chlorophyll (µg/L)	phycocyanin (µg/L)	microcystin (µg/L)
PREDICTED CONCENTRATIONS			24	
RISK LEVEL			High Risk	

http://wilsonlab.com/forecasting.html

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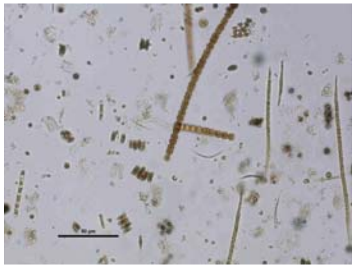
Approaches for studying HABs

- Go sample!
  - Integrated and/or surface samples
  - Whole water samples
  - Secchi depth



Graham et al. 2008 USGS report
http://pubs.usgs.gov/sir/2008/5038/pdf/SIR2008-5038.pdf

Approaches for studying HABs

- Go sample!
  - Integrated and/or surface samples
  - Whole water samples
  - Secchi depth

http://wilsonlab.com/bloom_network/gear.html

Approaches for studying HABs

Table 10.1 Approaches to monitoring for cyanobacteria and analysis for cyanotoxins: requirements and options for their organisation

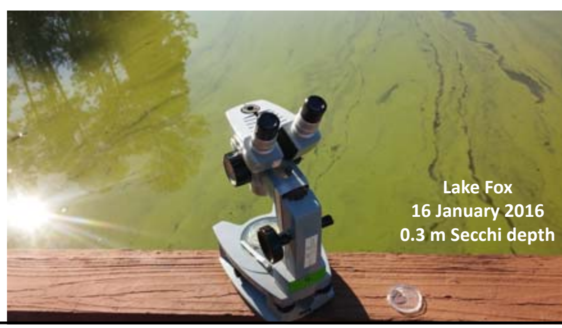
Monitoring type	Parameters/variables	Demands on equipment and skills	Who	Where
Basic		Minimal		
Site inspection for indicators of toxic cyanobacteria in waterbody	Transparency, discolouration, scum formation, detached mat accumulation	Secchi disc, regular site inspection by trained staff, skill requirement basic, training easily provided	Environmental or health officers, trained health staff or supervised local	Local
Background		Low to moderate		
Potential for cyanotoxin problems in waterbody	Total phosphorus, nitrate and ammonia, flow regime, thermal stratification, transparency	Photometer, boat, depth sampler, Secchi disc, submersible temperature/oxygen probe, skills basic but require specific training and supervision	Environmental officers or experts with limnological expertise	Local, regional
Cyanobacteria		Low to moderate		
In waterbody and drinking water	Dominant taxa (quantity) often determination to genus level only is sufficiently precise; quantification only as precise as needed for management	Microscope, photometer is useful; specific training and supervision is required, but quite easily achieved	Environmental or health officers (with occasional quality control by experts); consultants with limnological expertise	Local, regional
Toxicity assessment		Moderate		
In waterbody and drinking water	Toxicity	Demands on equipment are low, but rather high on skills	Toxicologists	Central
Toxin concentration		Moderate to high		
In waterbody and drinking water	Toxin concentration	New methods with lower financial demands presently in development for some cyanotoxins (e.g. immuno-assay); skill requirements vary widely from moderate to very high	Skilled analysts	Central

Lakeside monitoring approaches

Chorus and Bartram 1999
http://apps.who.int/iris/bitstream/10665/42827/1/0419239308_eng.pdf?ua=1

Approaches for studying HABs

- Go sample!
  - Integrated and/or surface samples
  - Whole water samples
  - Secchi depth
- Important targets
  - Poor transparency
  - Toxigenic cyanobacteria
  - Toxins (cell-bound and/or dissolved)

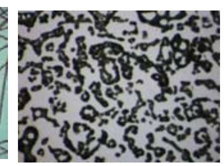


How do we quantify cyanobacterial abundance?

Chroococcus

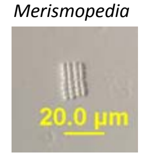
Planktothrix

Microcystis



Anabaena

Merismopedia



Cylindrospermopsis

Lyngbya

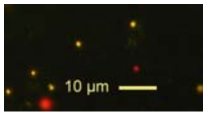
Coelosphaerium

Huge size range

Algal group	Length (µm)
Picoplankton	0.2-2.0
Nanoplankton	2.0-30
Microplankton	30-200
Mesoplankton	200-20,000

100,000x difference

Kalff 2002 Limnology



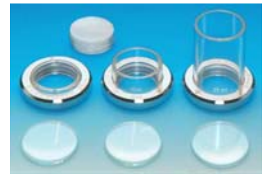
Picoplankton

Mesoplankton

Human (2m)

Burj Khalifa in Dubai (830m)

Common techniques for enumerating phytoplankton



Hydrobios settling chambers

Field sonde
Hydrolab minisonde

Quantitative PCR

Flow CAM imaging particle analyzer

Benchtop fluorometer
Turner Designs Trilogy

High performance liquid chromatography

CellScope

- http://cellscope.berkeley.edu

Common toxin analytical approaches

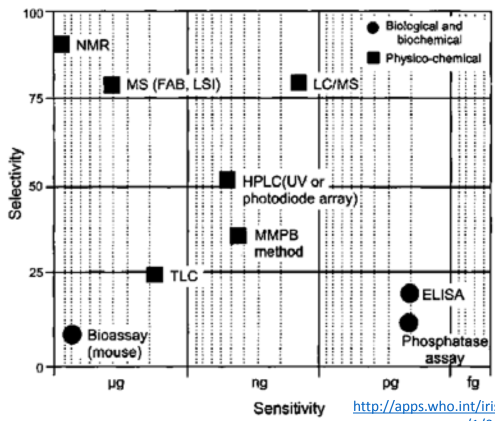
Table 3. Relative advantages and disadvantages of common analytical techniques utilized for analysis of cyanobacterial toxins and taste-and-odor compounds.

Analytical techniques	Advantages	Disadvantages
	Bioassays	
Enzyme-Linked Immunosorbent Assay (ELISA)	Relatively easy to use	Data interpretation can be difficult
Inhibition Assays	Cost per analyses lowest of all techniques	Inhibition assays and radioassays not always available
Radioassays	Can be useful as screening tools	Bioassays frequently possess some reactivity towards compounds other than the intended target
	Can indicate toxicity in some cases	Radioassays require permits to work with radioisotopes
		Research objectives may require a chromatographic technique for compound specific quantitation
	Gas Chromatography (GC)	
Flame Ionization Detector (GC/FID)	Compound specific	Toxins will most likely require derivitization
Mass Spectrometry (GC/MS)	Cost per analyses intermediate	Not all compounds amenable to derivitization
	Compound identification by GC/MS is superior to GC/FID	GC/FID may require further confirmation
		Sample concentration techniques may be necessary
	Liquid Chromatography (LC)	
Ultraviolet-Visible (LC/UV-Vis)	Derivitization typically not necessary	Matrix effects can be substantial
Fluorescence (LC/Fluorescence)	Compound specific	Cost per sample most expensive
Mass Spectrometry (LC/MS)	Greatest number of toxins are amenable to LC techniques	Spectroscopic techniques may require further confirmation
Tandem Mass Spectrometry (LC/MS/MS)	Cost per analyte can be lowest in a multi-analyte method	Sample concentration techniques may be necessary
Ion Trap Mass Spectrometry (LC/ITMS)	Compound identification is superior by LC/MS/MS or LC/ITMS	

Graham et al. 2008 USGS report
http://pubs.usgs.gov/sir/2008/5038/pdf/SIR2008-5038.pdf

Common toxin analytical approaches

Figure 13.1 Relationship between sensitivity and selectivity of analytical methods for microcystins (see text for explanation of methods)



Chorus and Bartram 1999
http://apps.who.int/iris/bitstream/10665/42827/1/0419239308_eng.pdf?ua=1

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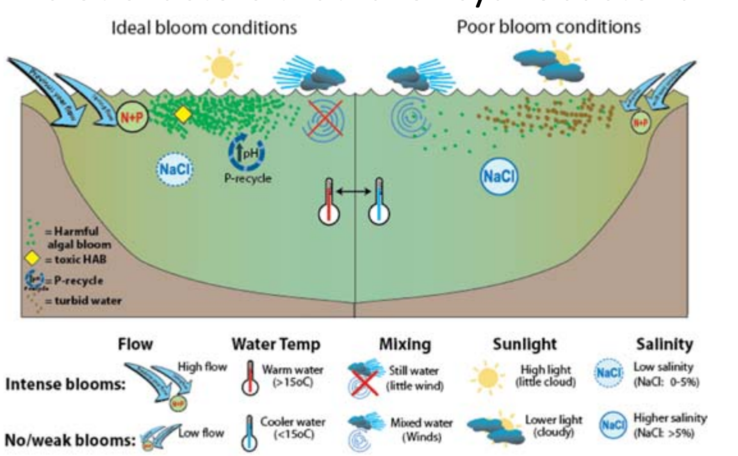
Abiotic factors that favor cyanobacteria



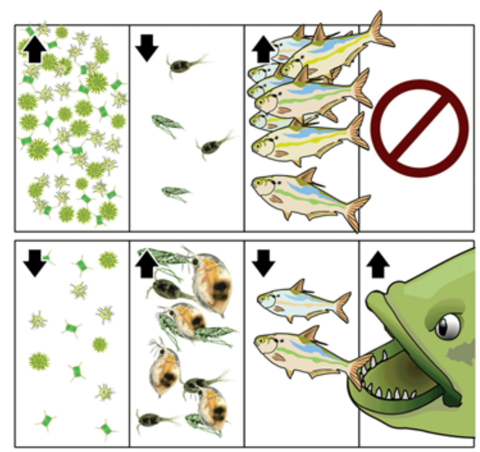
Conceptual diagram detailing the main factors that determine HAB occurrence and characteristics in the Potomac River

Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Ecocheck

http://ian.umces.edu/

Biotic factors that favor cyanobacteria

- Few piscivores
- Few large zooplankton
- Presence of dreissenid mussels



http://www.waterworld.com/articles/wwi/print/volume-26/issue-2/regulars/water-leader-focus/leading-a-blooming-revolution.html

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U.S. HABs in lakes

- National HABs water quality database does not exist
- National HABs human and animal health database just announced
  - One Health Harmful Algal Bloom System (OHHABS)
  - http://www.cdc.gov/habs/ohhabs.html
- Useful websites about inland HABs around the U.S.
  - https://www.epa.gov/nutrient-policy-data/cyanohabs
  - http://www.toxicalgaenews.com/
  - https://www.epa.gov/waterdata/storage-and-retrieval-and-water-quality-exchange

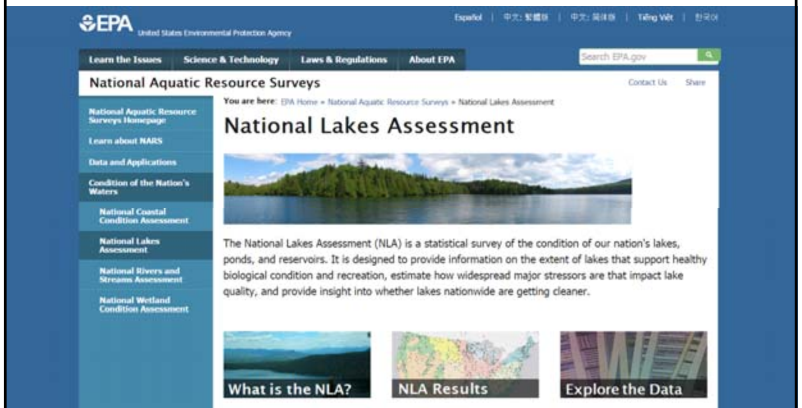
U.S. HABs in lakes

- Harmful algal blooms and hypoxia comprehensive research plan and action strategy: an interagency report – **February 2016**
- Recommendations
  - Add to and improve scientific understanding of HABs and hypoxia, and their causes and effects, as well as improve testing and research methods.
  - Strengthen and integrate new and existing monitoring programs.
  - Improve predictive capabilities by developing and enhancing HAB and hypoxia modeling programs; improve disease surveillance for human and animal exposure, illnesses, and death.
  - Improve stakeholder communications, including having more effective and readily-available public advisories, stronger connections with susceptible communities, and a better understanding of the socioeconomic and health-related impacts of HABs and hypoxia.
  - Continue and expand collaborations in research, management, and policy-related arenas.
- Legislation reauthorization but no funds appropriated
- https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/habs_hypoxia_research_plan_and_action_-_final.pdf

Outline

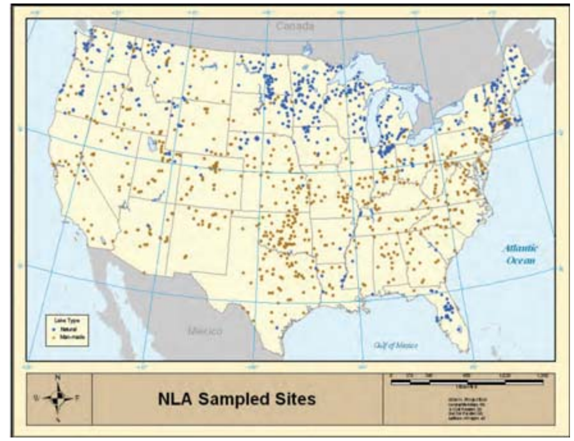
- Harmful algal blooms (HABs) background
  - Important taxa
  - Defining an algal bloom
  - Approaches for studying algal blooms
  - Factors that promote algal blooms
- **Data about U.S. conditions related to HABs**
  - **2007 EPA National Lakes Assessment**
  - 2014 Toxic algae news report

2007 EPA National Lakes Assessment



http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment



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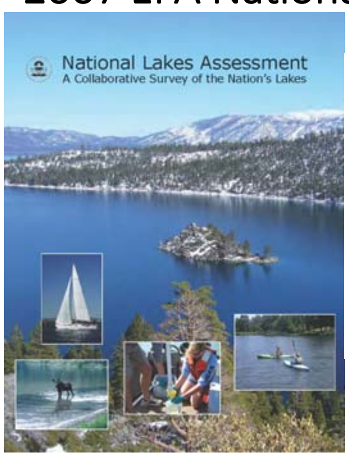
2007 EPA National Lakes Assessment



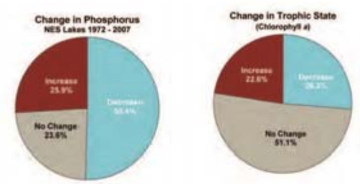
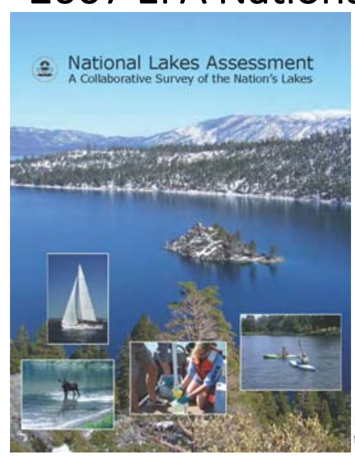


Figure 34. Proportion of NES lakes that exhibited improvement, degradation, or no change in phosphorus concentration based on the comparison of the 1972 National Eutrophication Survey and the 2007 National Lakes Assessment

Figure 35. Proportion of NES lakes that exhibited improvement, degradation, or no change in trophic state based on the comparison of the 1972 National Eutrophication Survey and the 2007 National Lakes Assessment.

http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment



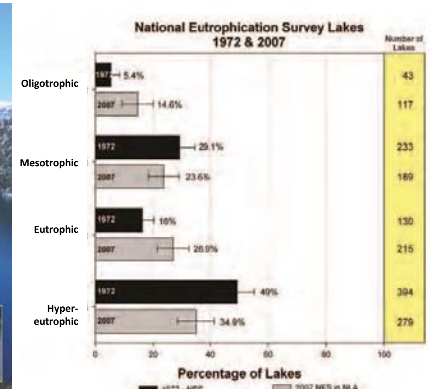


Figure 36. Percentage and number of NES lakes estimated in each of four trophic classes in 1972 and in 2007 based on chlorophyll-a concentrations.

http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment

Table 1. World Health Organization thresholds of risk associated with potential exposure to cyanotoxins.

Indicator (units)	Low Risk of Exposure	Moderate Risk of Exposure	High Risk of Exposure
Chlorophyll-*a* (µg/L)	<10	10 - <50	>50
Cyanobacteria cell counts (#/L)	< 20,000	20,000 - <100,000	≥ 100,000
Microcystin (µg/L)	<10	10 - ≤20	>20

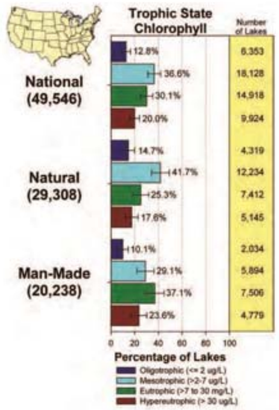


Figure 19. Trophic state of lakes in the lower continental U.S.

http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment

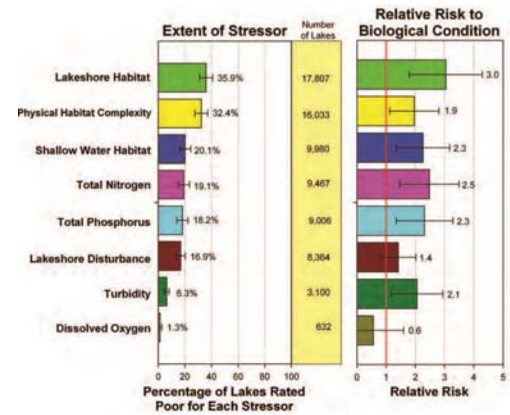


Figure ES-2. Extent of stressor and relative risk of stressor to biological condition.

http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment

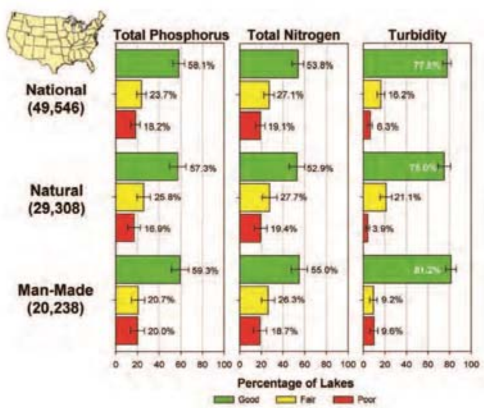


Figure 7. Phosphorus, nitrogen, and turbidity in three lake classes.

http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment

Table 1 Frequently occurring cyanobacteria genera. Genera occurring in >10% of samples shown or exceeding 100 000 cells mL^{-1} in at least 5 samples

Genus	Proportion of samples	Number of samples in which >100 000 cells mL^{-1}
Chroococcus	0.65	104
→ *Anabaena*	0.47	18
Aphanocapsa	0.41	95
→ *Aphanizomenon*	0.32	52
Pseudanabaena	0.29	41
Merismopedia	0.27	20
Planktolynbya	0.24	96
→ *Cylindrospermopsis*	0.16	62
Synechocystis	0.11	4
→ *Planktothrix*	0.09	41
Phormidium	0.06	19
→ *Microcystis*	0.05	5

Yuan and Pollard 2015 Freshwater Biology

2007 EPA National Lakes Assessment

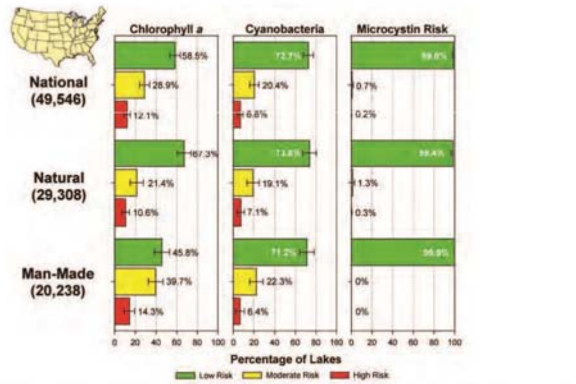


Figure 16. Percent of lakes, using three algal toxin indicators. In the first two graphs the percentage numbers indicate the risk or exposure to algal toxins associated with the presence of chlorophyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment

Table 1. World Health Organization thresholds of risk associated with potential exposure to cyanotoxins.

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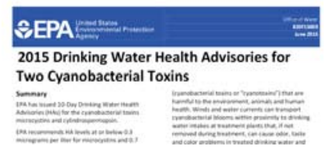


USEPA drinking water advisories

1) Microcystin

0.3 µg/L for children 0-6yrs

1.6 µg/L for everyone >6yrs

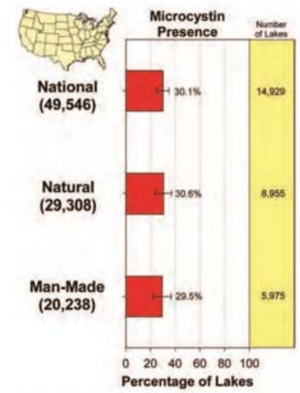
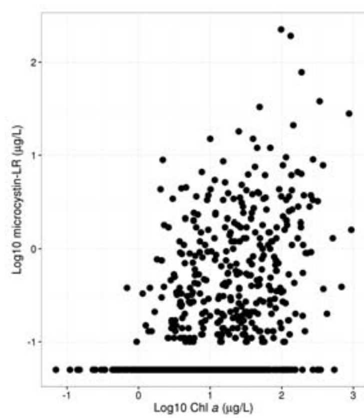


Figure 17. Occurrence of microcystin in lakes.

http://www.epa.gov/national-aquatic-resource-surveys/nla

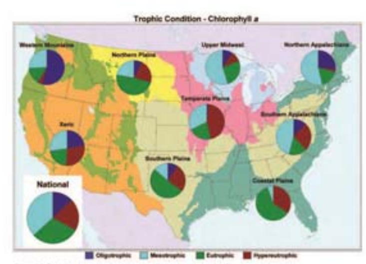
2007 EPA National Lakes Assessment

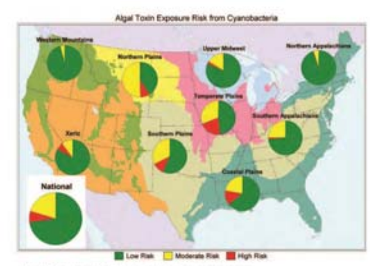
- 2007 EPA National Lakes Assessment
- 1252 samples for microcystin
  - Range 0-225 µg/L
  - 68% - undetectable
  - 16% - 0.05-0.5 µg/L
  - 5% - 0.5-1.0 µg/L
  - 9% - 1.0-5.0 µg/L
  - **2% - >5 µg/L**
- http://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys



Hollister et al. 2016 F1000Research
http://f1000research.com/articles/5-151/v1

2007 EPA National Lakes Assessment





http://www.epa.gov/national-aquatic-resource-surveys/nla

2007 EPA National Lakes Assessment

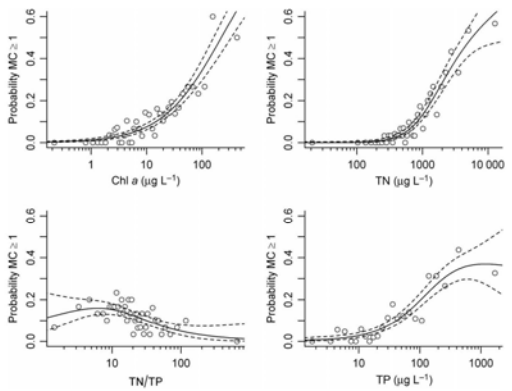


Fig. 1 Selected examples of nonparametric fit relating indicated explanatory variable and probability of microcystin ≥ 1 μg L^{-1}. Solid line: mean relationship; dashed line: estimated 90% confidence limits; open circles: average probability of occurrence in *c.* 30 samples in window centred about indicated value of the explanatory variable. Log scale shown on all *x* axes.

Yuan et al. 2014 Freshwater Biology

2007 EPA National Lakes Assessment

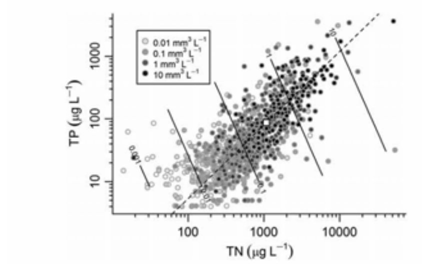
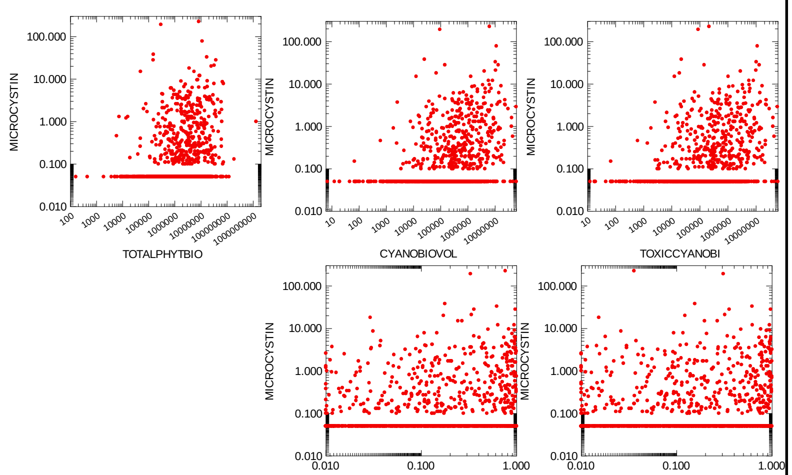


Fig. 1 Example showing calculation of total phosphorus (TP) and total nitrogen (TN) targets using predicted cyanobacterial biovolume and major axis regression relationship between TN and TP. Contour lines: predicted mean cyanobacterial biovolume, dashed line: estimated major axis regression between TN and TP, circles show the observed values of TN and TP with the observed values of cyanobacterial biovolume indicated by the colour of the circle, white square: example of unique TN and TP target for maintaining mean cyanobacterial biovolume at 0.29 mm^3 L^{-1}.

Yuan and Pollard 2015 Freshwater Biology

2007 EPA National Lakes Assessment



2007 EPA National Lakes Assessment

Table 3 Management targets for nutrient concentrations related to exceedance of WHO moderate risk threshold

	TN (μg L^{-1})			TP (μg L^{-1})		
Group	Mean	50% Conf Lim	25th and 75th %tile	Mean	50th Conf Lim	25th and 75th %tile
5	800	750–850	670–940	61	56–65	49–73
4	1400	1300–1500	1200–1600	79	73–84	65–93
3	1300	1100–1500	900–1700	250	220–300	170–360
National	1100	990–1200	750–1500	87	79–96	57–130

Mean: mean management target; 50% Conf Lim: 50% confidence limits on mean target; 25th and 75th %tile: 25th and 75th percentiles of the distribution of possible targets, including among-site variability; TP: total phosphorus; TN: total nitrogen.

Yuan and Pollard 2015 Freshwater Biology

2012 EPA National Lakes Assessment

2007 NLA timeline

	2006	2007	2008	2009	2010	2011	2012
Lakes	Design	Field	Lab and Data Analysis	Report	Design and Planning		Field

http://www.epa.gov/national-aquatic-resource-surveys/nla

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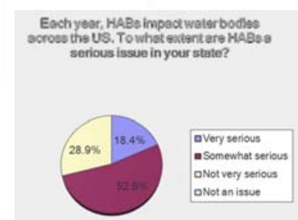
2014 Toxic algae news report

http://www.toxicalgaenews.com/

2014 Toxic algae news report

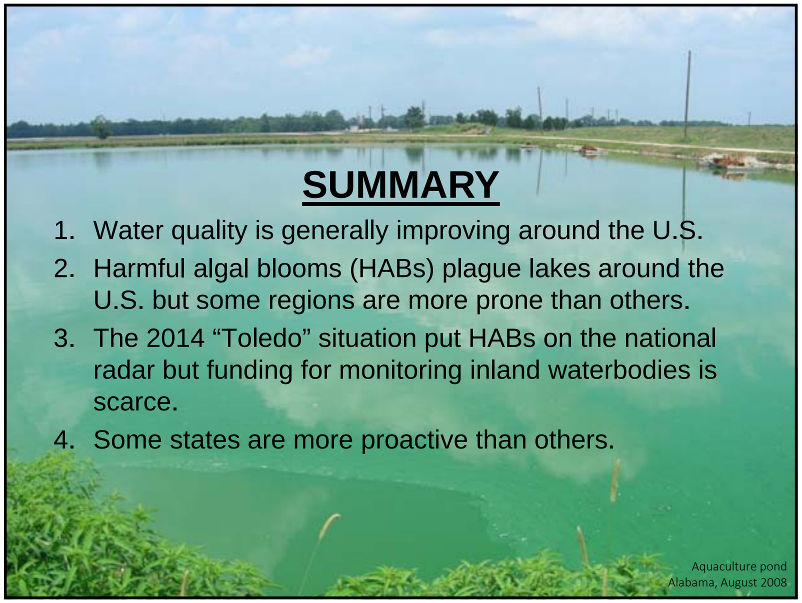


http://www.toxicalgaenews.com/

2014 Toxic algae news report

- 38 states and Washington, D.C. responded
- 71% of responding states say HABs are serious problem
- 0% of responding states say HABs are not an issue
- 53% of responding states say HABs occur every year
- 49% of responding states actively monitoring some public access sites for HABs in the past
- 1 state (NE) actively monitors all public access waterbodies for HABs
- 56% of responding states work with local govt and/or citizen scientists to report HABs
- 38% of responding states don't track impact of HABs
- 2 states (OK and VA) track ER submissions related to HABs
- 3 states (HI, KS, OK) track tourism effects of HABs
- 77% of responding states don't have HABs hotline for public

http://www.toxicalgaenews.com/



SUMMARY

1. Water quality is generally improving around the U.S.
2. Harmful algal blooms (HABs) plague lakes around the U.S. but some regions are more prone than others.
3. The 2014 "Toledo" situation put HABs on the national radar but funding for monitoring inland waterbodies is scarce.
4. Some states are more proactive than others.

Aquaculture pond
Alabama, August 2008

Available Opportunities

Collaborations and Student Openings

Water Quality Sampling and Analyses

Phytoplankton, Toxin, and Off-flavor Analyses

Training at AU and your facility

Aquaculture pond
Alabama, August 2008

Contact information

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Aquaculture pond
Alabama, August 2008