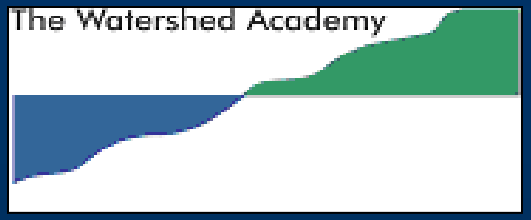
An Overview of Harmful Algal Blooms (HABs) and Their Impacts in Freshwater and Marine Ecosystems

Part 1: Summer Webinar Series to Build Awareness About Harmful Algal Blooms and Nutrient Pollution

Tuesday, June 25, 2013
1:00pm – 2:30pm ET



Speakers:

Dr. Jennifer Graham, Research Hydrologist, U.S. Geological Survey
Region 7 Director, North American Lake Management Society

Dr. Quay Dortch, Coordinator, Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program, National Oceanic and Atmospheric Administration

Moderated by: Dr. Mario Sengco, Office of Science and Technology, U.S. EPA

Today's Schedule

- Introduction and GoToWebinar Logistics
- Dr. Jennifer Graham
  - NALMS
  - Algae, Blooms, and Cyanobacteria
- Dr. Quay Dortch
  - Coastal HABs
  - NOAA
- Polling Questions
- Q&As
- Final Announcements

#greenwater

Webinar Logistics

- **To ask a question** – Type your question in the “Questions” tool box on the right side of your screen and click “Send.” Our panelists and moderator will respond to the entire audience.

- **To report any technical issues** (such as audio problems) – Type your issue in the “Questions” tool box on the right side of your screen and click “Send” and we will respond by posting an answer in the “Questions” box.

- **To find additional support online** – Refer to GoToWebinar’s website: http://support.citrixonline.com/GoToWebinar/ or call 1-800-263-6317 for toll-free support.

Today's Topic and Speakers

Freshwater HABs

Jennifer Graham, PhD

- Research Hydrologist, USGS
- Region 7 Director, NALMS

Coastal HABs

Quay Dortch, PhD

- Center for Sponsored Coastal Ocean Research, NOAA
- ECOHAB and PCMHAB Programs, NOAA

North American Lake Management Society (NALMS)

- NALMS mission is to forge partnerships among citizens, scientists, and professionals to foster the management and protection of lakes and reservoirs for today and tomorrow.

- NALMS membership is diverse and includes citizens, scientists, lake professionals, and policy makers.

- Membership benefits include:
  - Monthly newsletters
  - *LakeLine* magazine
  - *Lake and Reservoir Management* scientific journal
  - Annual symposium
  - Networking with lake-minded individuals
  - Opportunities to be involved at local, regional, national, and international levels

www.nalms.org

July is Lakes Appreciation Month

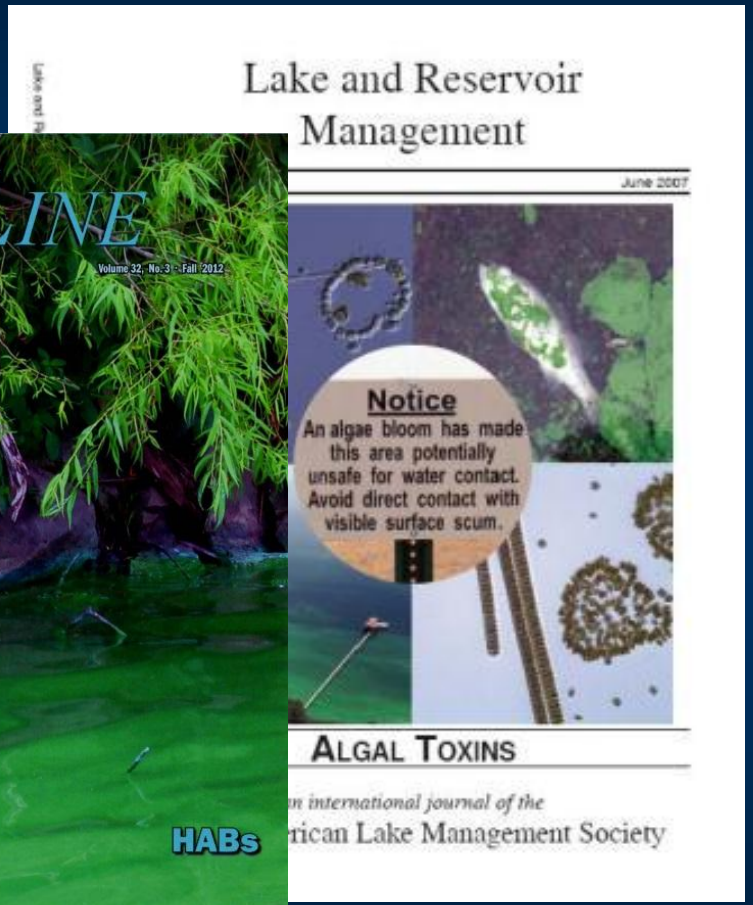
Enjoy and bring attention to local freshwater resources

- State Proclamations in recognition of the importance of lakes
  - 2013 Proclamations: CO, IL, MO, NH, NV, OH, VT
- Get involved:
  - Volunteer monitoring activities
  - Annual Secchi Dip-In
  - Lake/Watershed Clean-Up Events

NALMS INLAND HAB PROGRAM

Information Resource for HABs

- **Web Resources:** http://www.nalms.org/home/programs/blue-green-algae-initiative/blue-green-algae
- **Dedicated issues of *LakeLine* and *Lake and Reservoir Management***
- **Special sessions at annual symposia**



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USGS
science for a changing world

Freshwater Harmful Algal Blooms



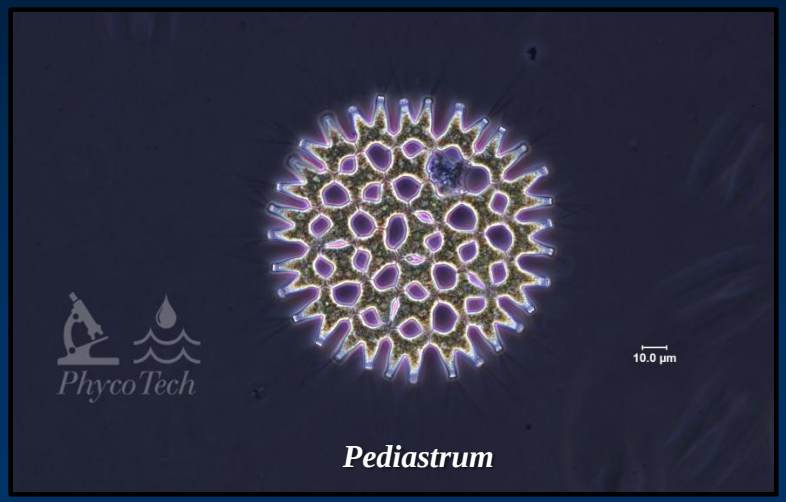
Jennifer L. Graham

U.S. Geological Survey

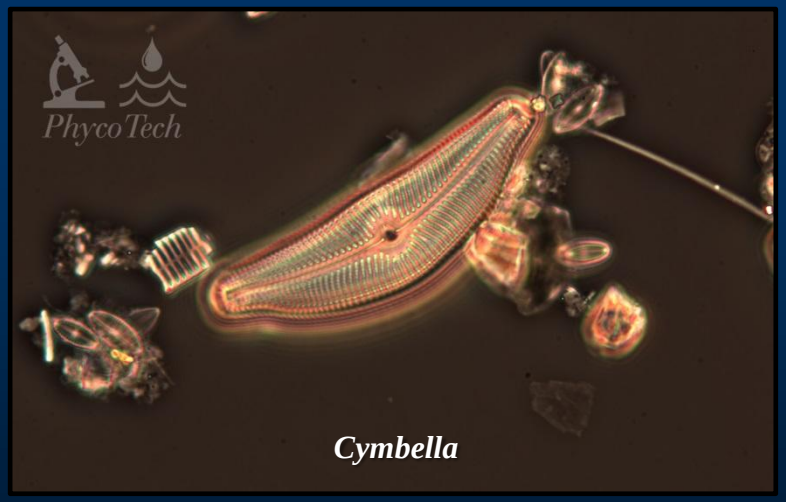
Lawrence, Kansas

What Are Algae?

- Algae are simple photosynthetic plants.
- Like all plants, algae have chlorophyll, which is a pigment used to capture light for photosynthesis.
- Algae are an important part of the food web in aquatic ecosystems and are eaten by many simple animals and some fish.



Pediastrum

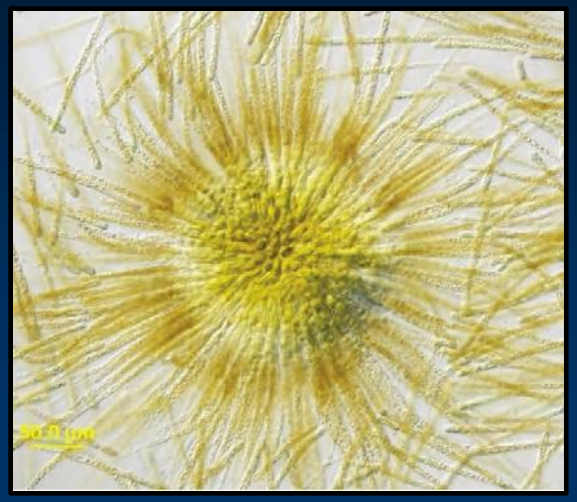


Cymbella

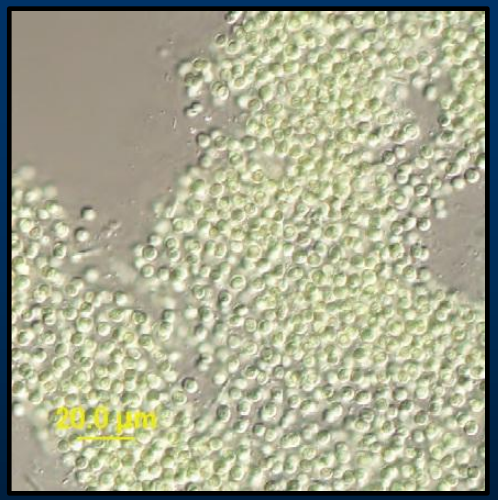
photos courtesy of PhycoTech, Inc.

What Are Cyanobacteria?

- Cyanobacteria are true bacteria, but have chlorophyll-*a* like algae.
- Structurally the cyanobacteria are bacteria-like, but functionally they are algae-like.
- Because cyanobacteria function like algae in aquatic ecosystems, they typically are considered to be part of algal communities (this is why they often are called blue-green algae).



Gloeotrichia echinulata



Microcystis aeruginosa

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Images from Rosen and others, OFR 2010-1289
http://pubs.usgs.gov/of/2010/1289/

What is an Algal Bloom?

- The definition of a “bloom” is somewhat subjective.
- Common definitions include:
  - Algae have extremely high cell densities (20,000 to 100,000 cells per milliliter)
  - Proliferation of algae is dominated by a single or a few species
  - There is a visible accumulation of algae

South Dakota - green algae bloom

Idaho - cyanobacteria bloom
photo courtesy of F. Wilhelm

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What Makes Some Algal Blooms Harmful?

Harmful algal blooms (HABs) can occur anytime water use is impaired due to excessive accumulations of algae

- **Ecologic Concerns**
  - **Low dissolved oxygen**
  - **Food-web disruption**
- **Economic Concerns**
  - **Loss of recreational revenue**
  - **Taste and odor**
  - **Added drinking water treatment costs**
- **Public Health Concerns**
  - **Allergic reactions**
  - **Toxicity (cyanobacteria only)**

Texas – golden algae bloom
Photo courtesy of TPWD and G. Turner

Kansas – cyanobacteria bloom

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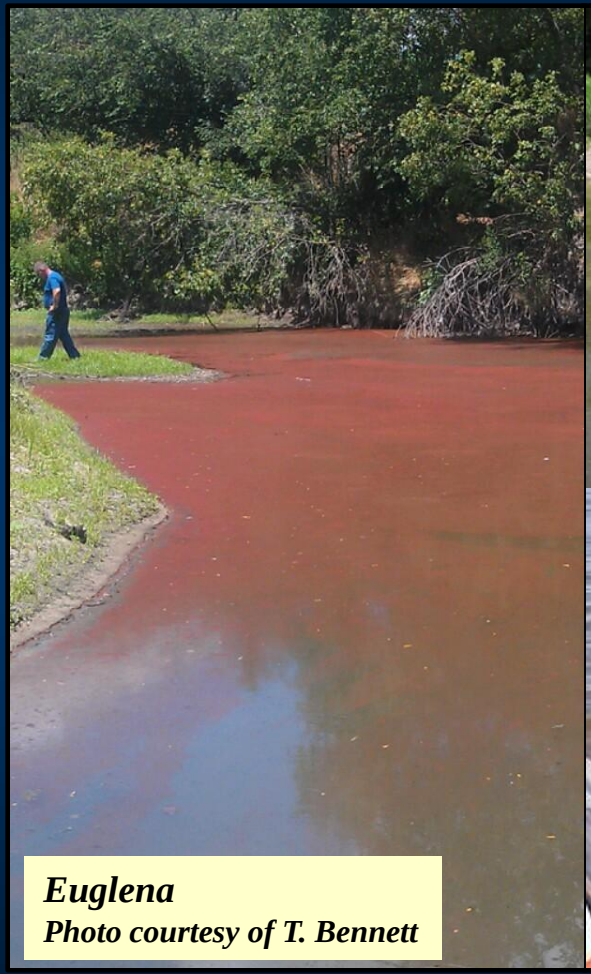
What Types of Algae Cause Blooms?

All types of algae can cause harmful algal blooms under the right conditions.



Euglena
Photo courtesy of T. Bennett

Diatoms
Photo courtesy of N. Clercin

Golden Algae
Photo courtesy of TDWP

Cyanobacteria
Photo courtesy of B. Brink

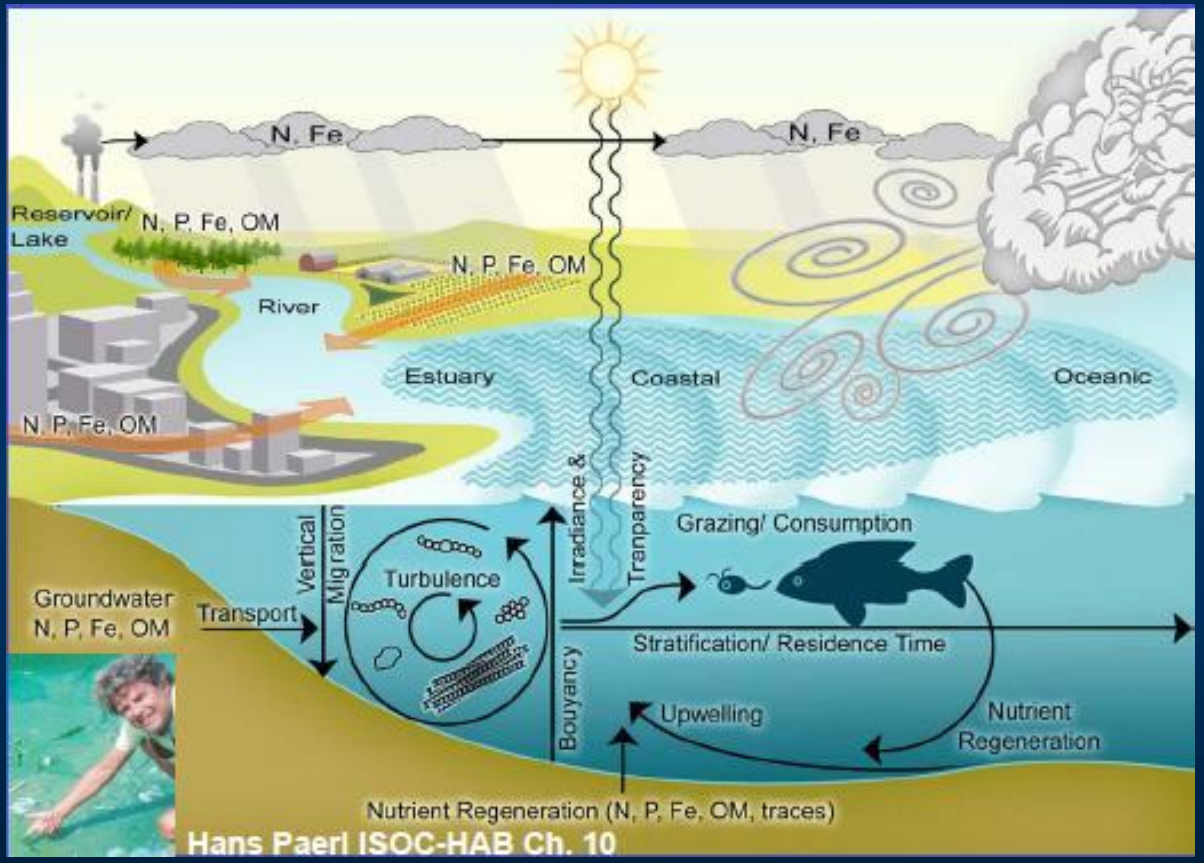
Green Algae
Photo courtesy of N. Clercin

What Causes Algal Blooms?

Many environmental factors influence the occurrence of algal blooms. In general, an algal bloom indicates an ecosystem imbalance.

Factors influencing the occurrence of algal blooms include:

- **Nutrients**
- **Water Clarity (Sediment)**
- **Circulation Patterns**
- **Hydrology**
- **Climate and Weather**
- **Biological Community Interactions**

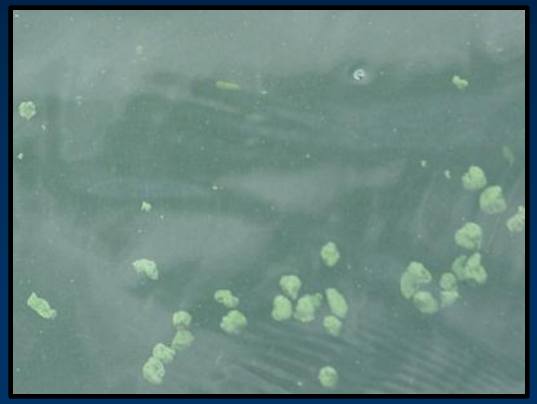


When Do Harmful Algal Blooms Occur?

Algal blooms can occur any time of the year:

- **Green algae and diatom blooms are common in the spring.**
- **Cyanobacterial blooms are common during summer and early fall.**
- **Golden algae blooms are common in the winter.**

Missouri Lake
January, 2007



Missouri Lake
June, 2000

Kansas Lake
August, 2006

Missouri Lake
October, 2001

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What Types of Toxins Do Cyanobacteria Produce?

- **Hepatotoxins (liver toxins)**
  - **Common toxins:** microcystins, cylindrospermopsins
  - **Symptoms of exposure:**
    - Vomiting
    - Diarrhea
    - Fever
    - Cramps
- **Neurotoxins**
  - **Common toxins:** anatoxins, saxitoxins
  - **Symptoms of exposure:**
    - Paralysis
    - Seizure
- **Dermatoxins**
  - **Common toxins:** lipopolysaccharides, lyngbyatoxin
  - **Symptoms of exposure:**
    - Irritation to eyes, ears, throat
    - Rashes
    - Skin Lesions

Photo courtesy of L. Merchant-Masonbrink

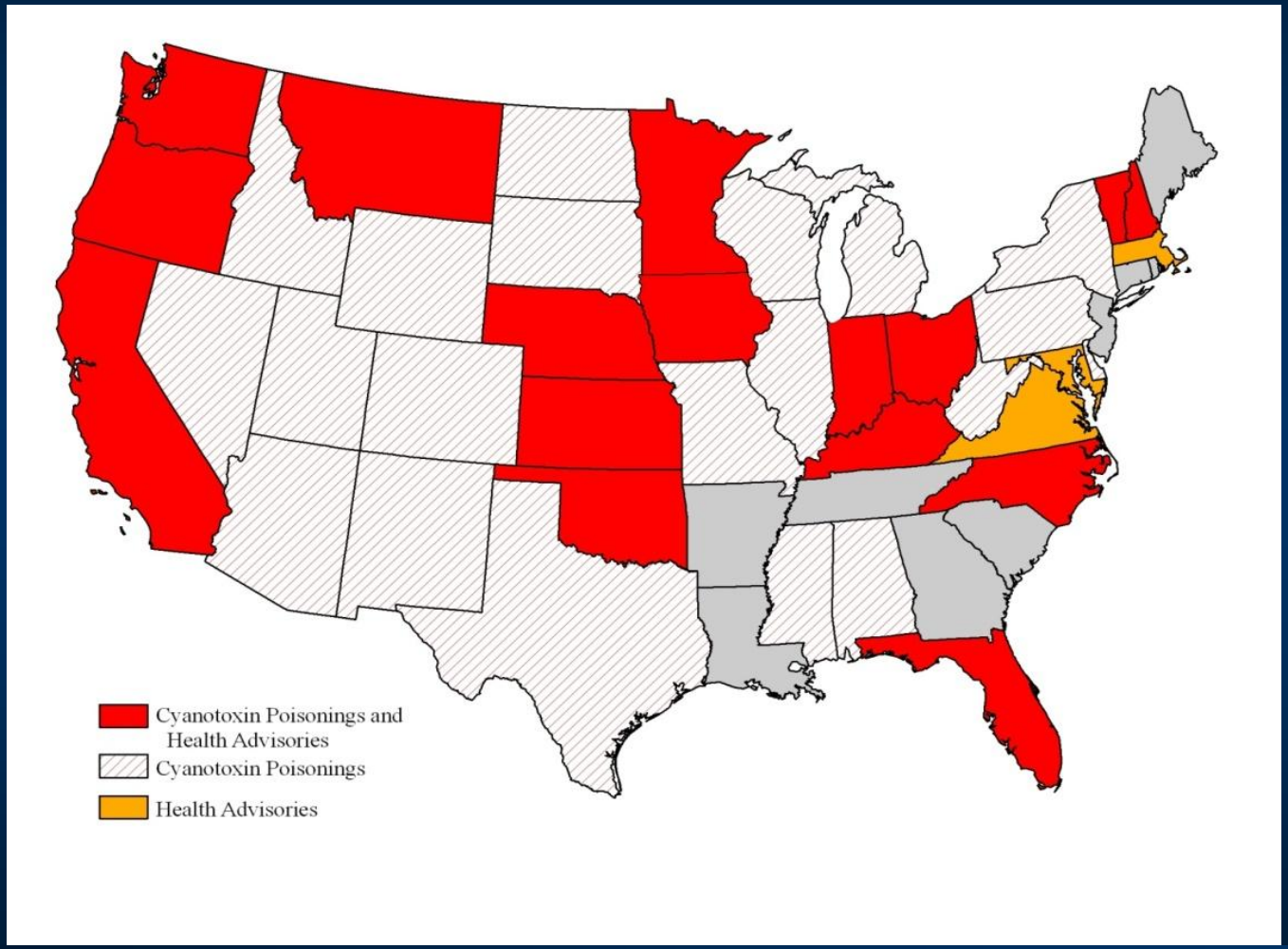
What Cyanobacteria Produce Toxins?

	Hepatotoxins		Neurotoxins		Dermatoxins	Taste/Odor	
	CYL	MC	ANA	SAX		GEOS	MIB
Anabaena	X	X	X	X	X	X	?
Aphanizomenon	X	?	X	X	X	X	
Microcystis		X			X		
Oscillatoria/Planktothrix		X	X	X	X	X	X

Photos courtesy of PhycoTech, Inc.

How Common are Toxic Cyanobacterial Blooms?

At least 36 U.S. states have anecdotal reports of human or animal poisonings associated with cyanotoxins, but there are not good records of how frequently cyanotoxin-related poisonings occur.



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After Graham and others, 2009

How Common are Toxic Cyanobacterial Blooms?

Ecologic, economic, and public health concerns surrounding cyanobacterial harmful algal blooms are a reality.

Summer 2011 Headlines

Livestock producers beware: Watch for toxic blue-green algae

By a Drovers

Updated: 9:44 PM Jun 1, 2011

Watch the Water as Algae Bloom Season Approaches

We're hea
algae bloo

Posted: 9
Reporter

Veterinarians warn dog owners about dangers of blue-green algae

'It's going to be a bad year' for algae blooms in area lakes

BLUE-GREEN ALGAE DETECTED IN NINE KANSAS LAKES

Updated: 7/19/11

Most facilities open for recreation; KDHE recommends caution

Heat and algae cut county tourism in half

Inhofe blames illness on Grand Lake algae

Grand Lake blue-green algal scare could cause long-term economic damage

Pig peril – boars asphyxiated by algae

9:36 AM Friday Jul 29, 2011

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How Common are Toxic Cyanobacterial Blooms?

Thirty percent of lakes included in the 2007 EPA National Lakes Assessment had detectable microcystins.

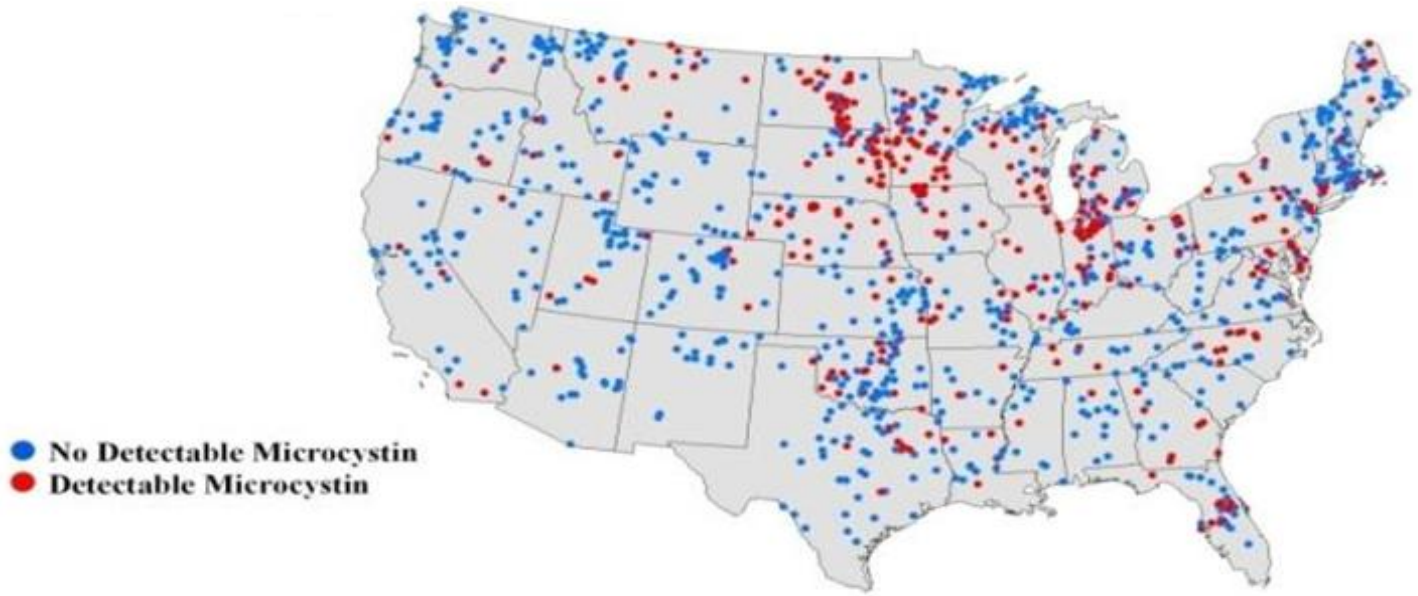
30% of lakes had detections (n=1,028)

Maximum concentration: 230 µg/L

Median: <0.10 µg/L (0.52 µg/L*)

Mean: 1.0 µg/L (3.0 µg/L*)

*Detections only



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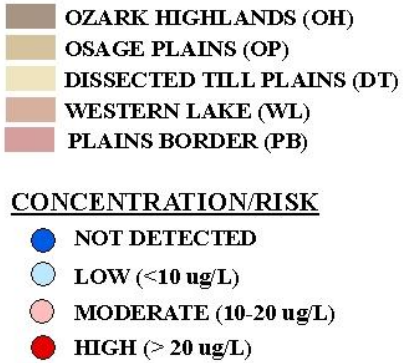
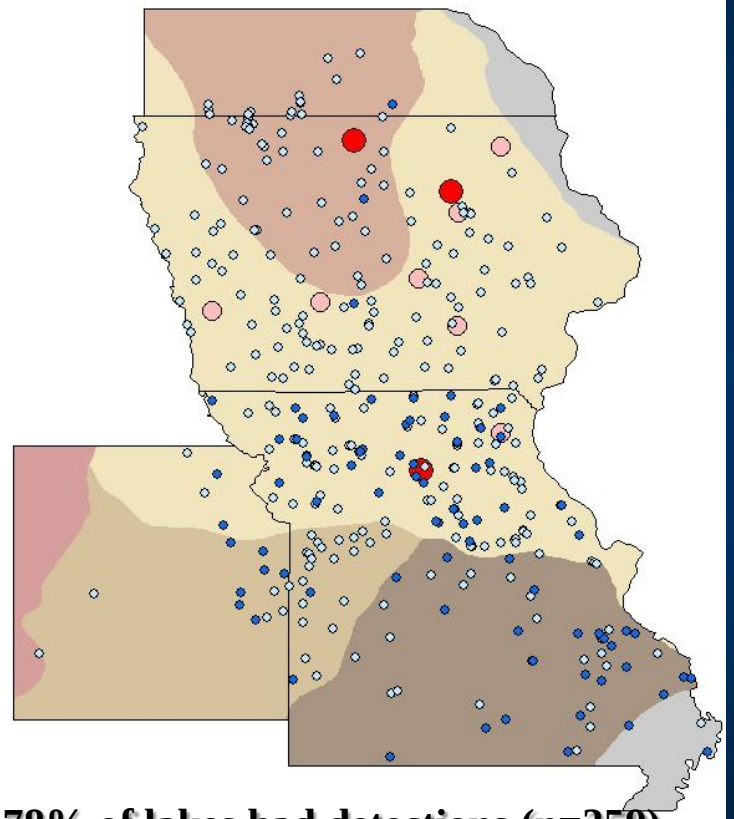
***Map generated by USGS using data from EPA 2007 National Lakes Assessment http://water.epa.gov/type/lakes/lakessurvey_index.cfm**

How Common are Toxic Cyanobacterial Blooms?

Seventy-eight percent of lakes in a regional study had detectable microcystins at least once during 1999-2006.





78% of lakes had detections (n=359)

Maximum concentration: 52 µg/L

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After Graham and others 2004, 2006, and 2009

How are People and Animals Exposed to Cyanobacterial Toxins?

- Ingestion and inhalation during recreational activities
- Inhalation of aerosolized toxins
- Consumption in drinking water
  - Drinking-water treatment processes effectively remove most toxins

Do not try this at home (or anywhere else)!

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What Do Cyanobacterial Blooms Look Like?

- Cyanobacterial bloom appearance varies, but common characteristics include:
  - Bright green or blue green in color
  - Thick scums or accumulations that may look like spilled paint
  - May be accompanied by earthy, musty, septic, or “rotten egg” odors

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What Do Cyanobacterial Blooms Look Like?

Common Bloom Appearance

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What Do Cyanobacterial Blooms Look Like?

- Red or brown color
- Occurrence in old river channels
- Occurrence in winter under ice

Less Common Bloom Appearance

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What Do Cyanobacterial Blooms Look Like?

Other aquatic plants may look like algal blooms from a distance, but have distinct roots and leaves upon closer inspection.

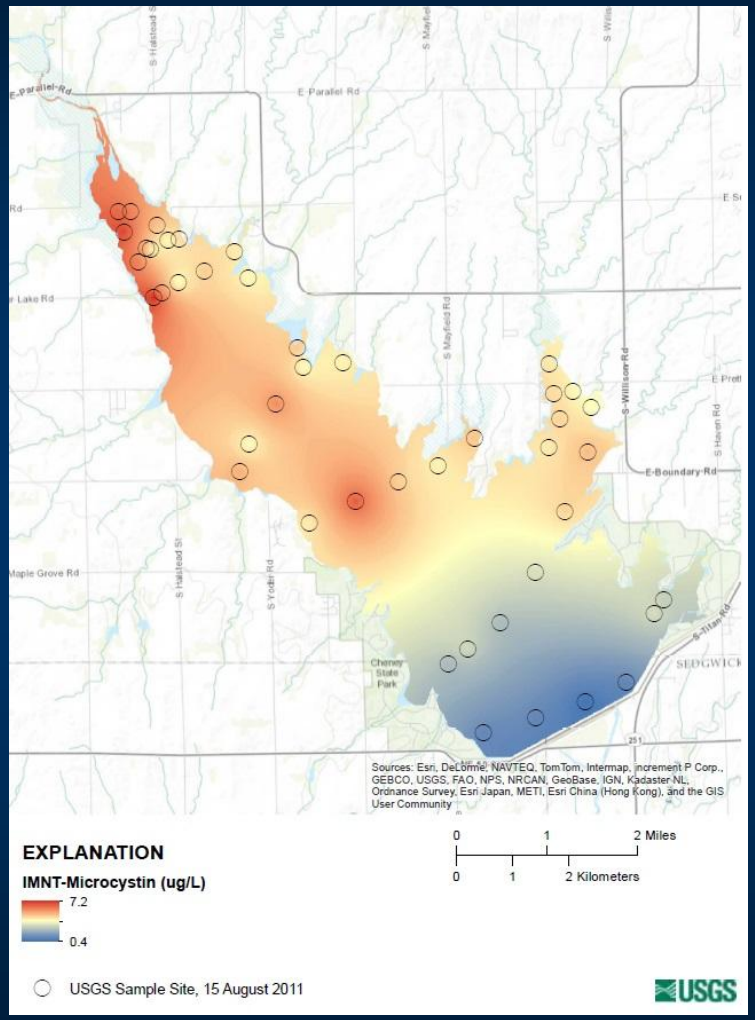
Water Fern (*Azolla*)

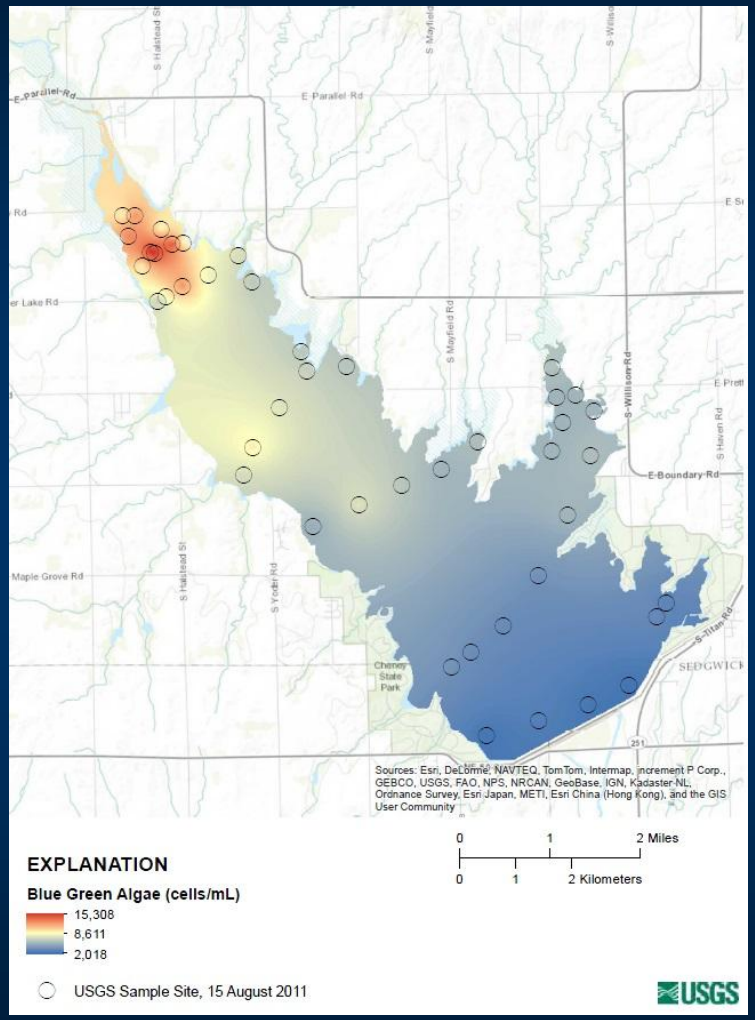
Duckweed (Lemna)

Photos courtesy of the MO DNR and B. Betros

What Do Cyanobacterial Blooms Look Like?

Cyanobacterial blooms likely vary spatially within a lake.





What Do Cyanobacterial Blooms Look Like?

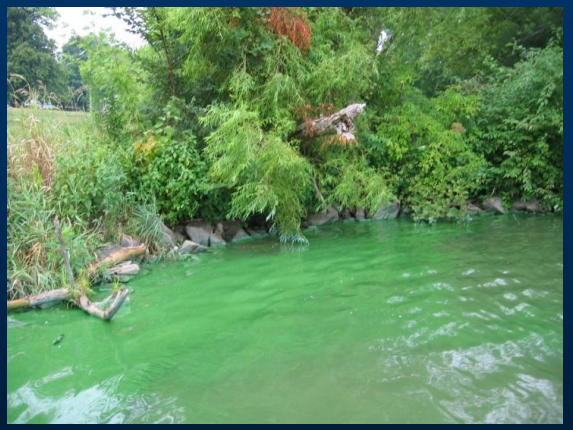
Vertical migration or wind movement of surface accumulations may rapidly change the areal distribution of cyanobacteria.

Beach Area
Monday
July 31

Photos Courtesy of IA DNR

Beach Area
Thursday
August 3

Photo Courtesy of IA DNR



Boat Ramps
Friday
August 11

What Can I Do to Protect My Family and Pets?

- Educate yourself about harmful algal blooms and what kind of blooms are common in your area.
- Check available local resources to see if any the areas you plan to visit are experiencing blooms.
- Avoid direct contact with the affected areas (especially children and pets).
- Contact the local health department if you suspect a cyanobacterial bloom is present.

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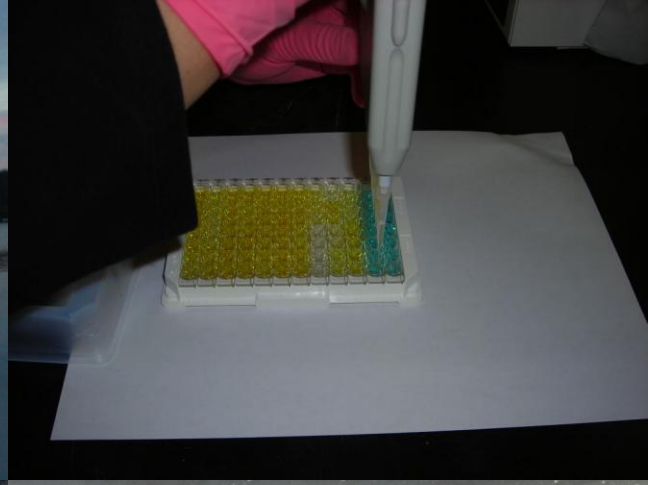



USGS:

http://ks.water.usgs.gov/51-Cyanobacteria

jlgraham@usgs.gov
785-832-3511

North American Lake Management Society:

http://www.nalms.org/home/programs/blue-green-algae-initiative/blue-green-algae

Questions?

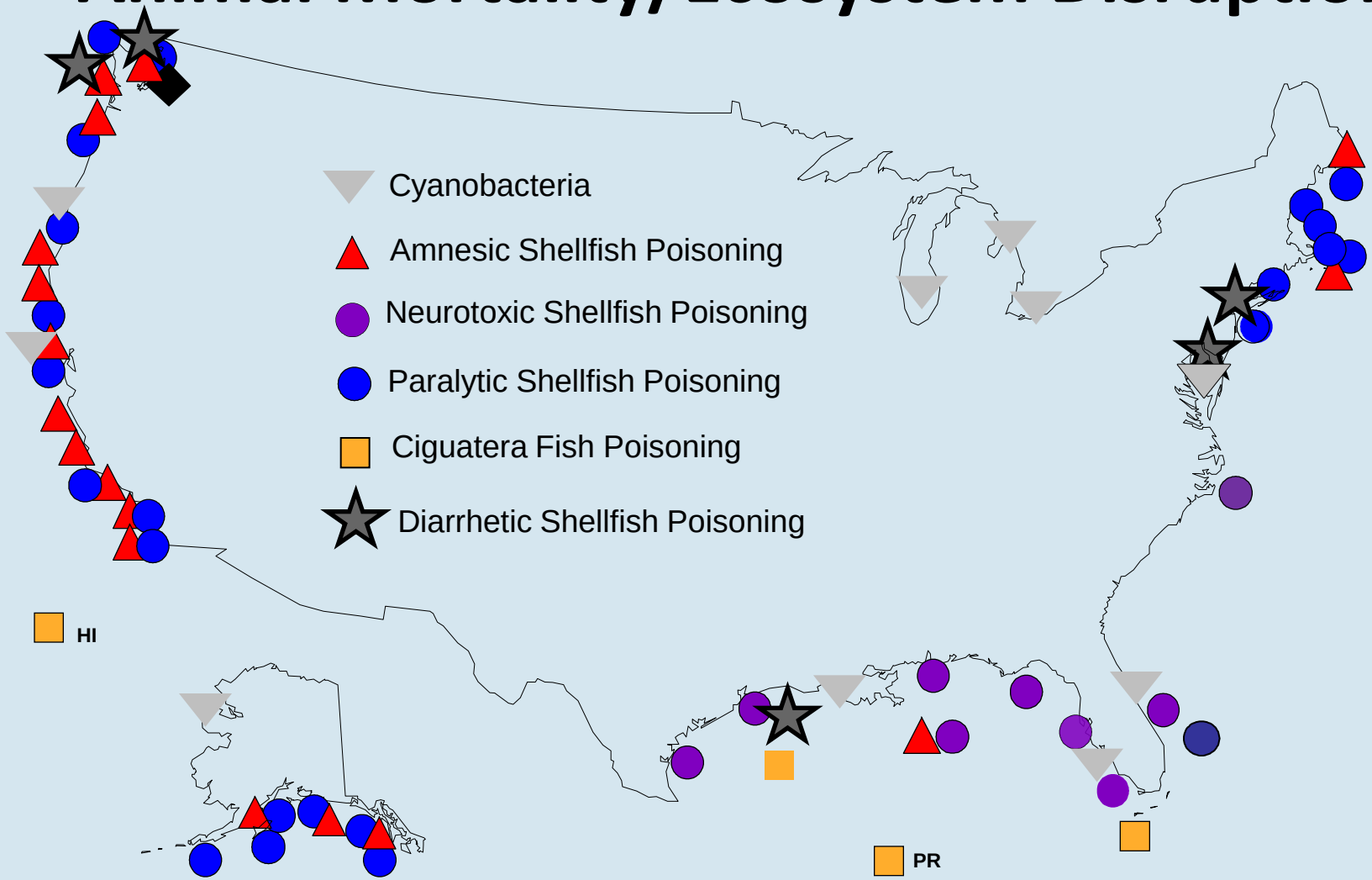
Coastal Harmful Algal Blooms in the U.S.

Quay Dortch

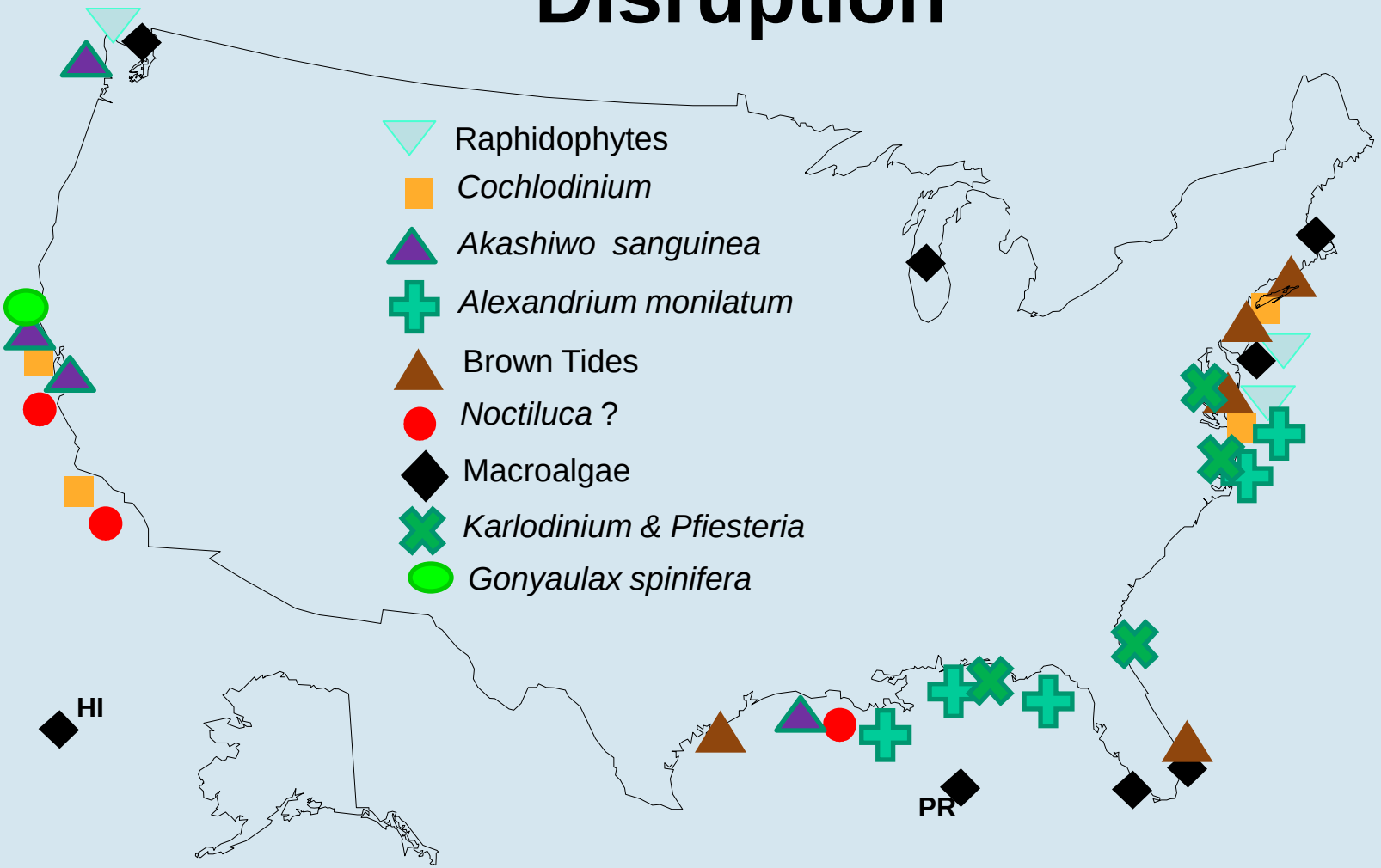
NOAA/NOS/NCCOS/Center for Sponsored Coastal Ocean Research

Ecology and Oceanography of Harmful Algal Blooms (ECOHAB)
Prevention, Control, and Mitigation of Harmful Algal Blooms (PCMHAB)

Coastal HABS
Public Health/
Animal Mortality/Ecosystem Disruption

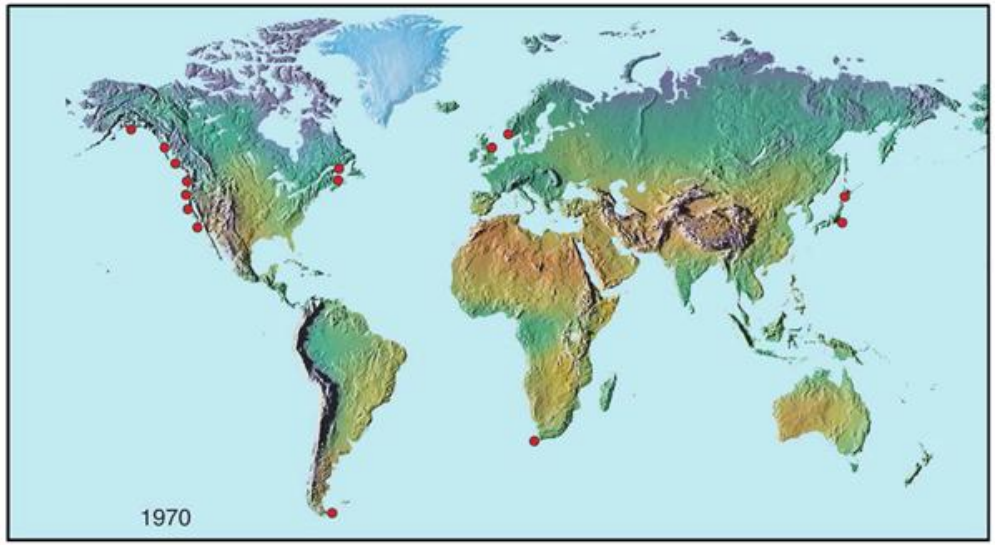


Coastal HABs
Animal Mortality/Ecosystem Disruption

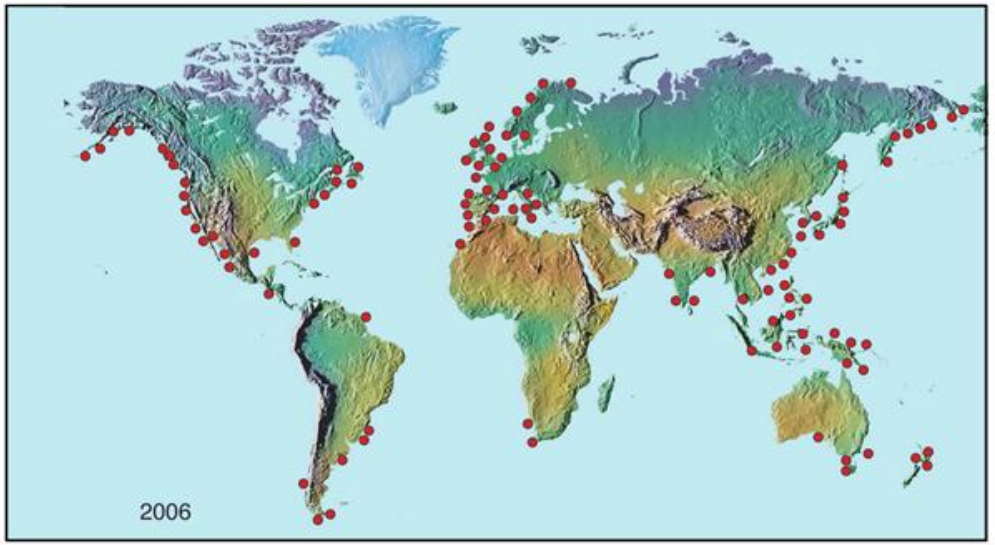


Change in Reports of Paralytic Shellfish Poisoning (PSP)

1970

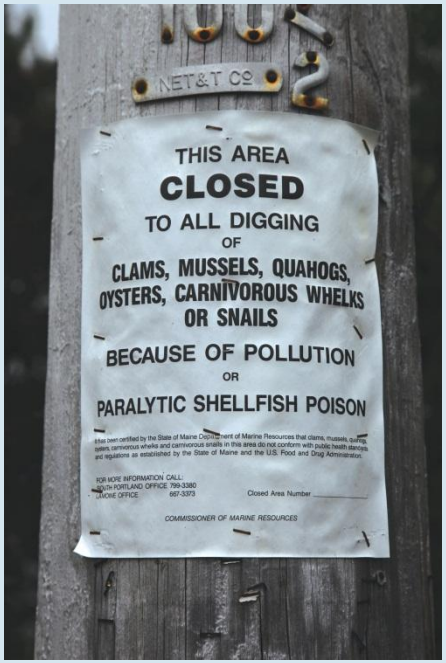


2006



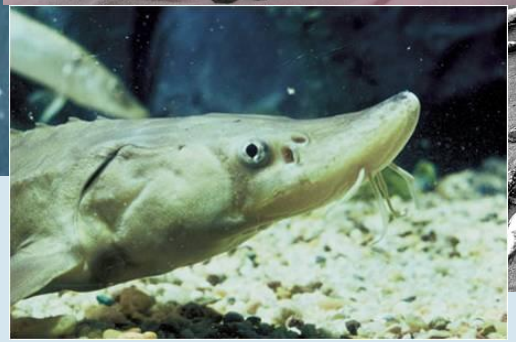
What is the Harm?

- **Human health threat from toxins**
  - **Accumulate in shellfish, fish, (birds?)**
    - **Human illness & death**
      - **AK & ME—Paralytic Shellfish Poisoning (PSP)**
      - **FL—Neurotoxic Shellfish Poisoning (NSP)**
      - **Caribbean, Gulf of Mexico, HI—**
        Ciguatera Fish Poisoning (CFP)
    - **Ban harvesting**
  - **Accumulate in drinking water**
    - **Find other water sources**
    - **Treat water**
  - **Recreational exposure**
    - **Warn/close recreational use**



What is the Harm?

- **Animal illness and death**
  - **Fish**
  - **Endangered and protected species: mammals, birds, turtles, fish**
  - **Livestock and pets**



What is the Harm?

- **Environmental degradation & habitat alteration**
  - **Discolor water & cause foul odors**
  - **Reduce growth sea grasses**
  - **Overgrow corals**
  - **Accumulate on beaches**
  - **Poor food quality**
  - **Alter water quality**

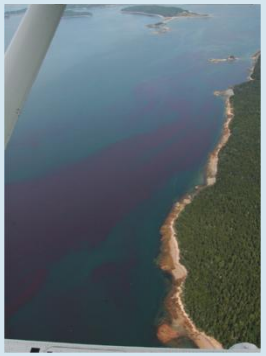
What is the Harm?

- **Economic Impacts 1987-2000**
  - **$82 M/yr (in 2007 dollars)**
  - **Does not include:**
    - **Many large events**
    - **Unreported public health costs**
    - **Seafood that cannot be harvested**
    - **Economic multipliers**
    - **Estimates of environmental impacts**

- **Many HABs spreading and new ones emerging**
- **Role of increasing coastal populations**

Causes of HABs

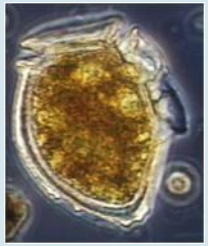
- **Many naturally occurring—optimal growth requires**
  - **Light**
  - **Nutrients**
  - **Temperature**
  - **Salinity**
  - **Water stratification**
- **Human activities cause or make worse**
  - **Nutrient enrichment**
  - **Increasing temperatures and water stratification**
  - **Introductions**
    - **Ballast water**
    - **Shellfish farming**
    - **Hydrological modifications**



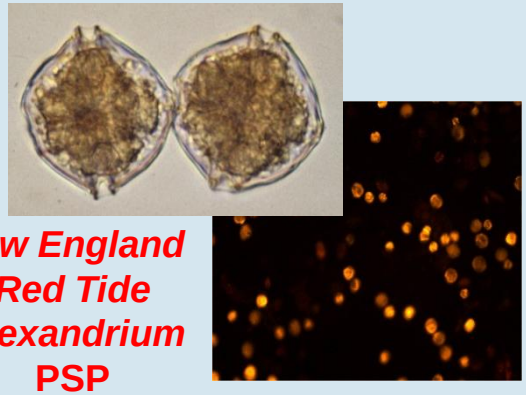
Many Species & Many Toxins

A few examples

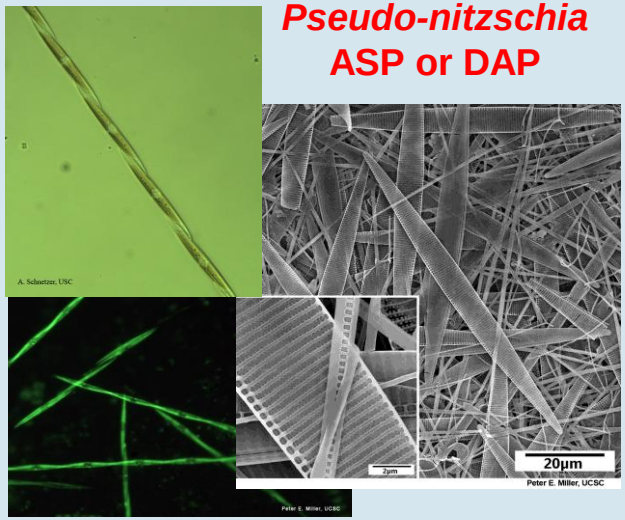
Gambierdiscus
CFP



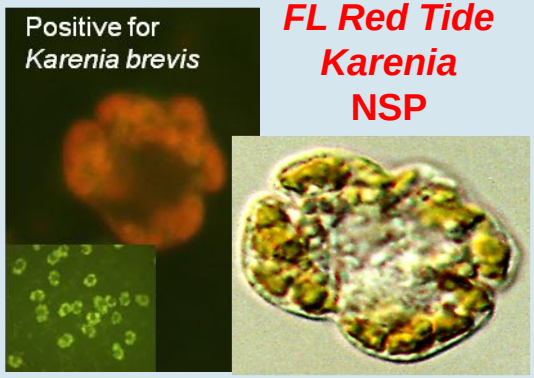
Dinophysis
DSP



New England Red Tide Alexandrium
PSP



Pseudo-nitzschia
ASP or DAP



FL Red Tide Karenia
NSP

HAB Detection

Not all species/cells toxic; toxins not equally toxic

- **Cells—identify and quantify**
  - **Microscope**
  - **New molecular methods**
  - **Remote methods**
    - **In water sensors**
    - **Satellite & aircraft**

- **Toxins—quantify & assess risk**
  - **Quick methods for screening**
  - **Detailed chemical analyses**
  - **In water remote methods**

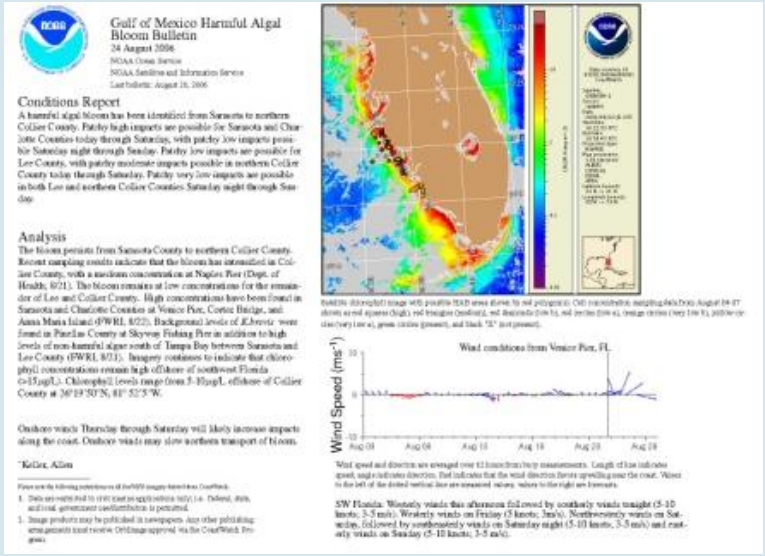
What Can Be Done?
Prevention, Control, Mitigation (PCM)

- **Mitigation—minimize impacts**
  - **Better monitoring & forecasting**
  - **Early warning**
- **Prevention—keep blooms from starting**
- **Control—stop/reduce blooms that have started**
  - **Physical**
  - **Chemical**
  - **Biological**

NOAA Response

Authorized by Harmful Algal Bloom and Hypoxia Research & Control Act (HABHRCA)

- **Conduct research**
  - **Provide funding**
    - **ECOHAB**
    - **MERHAB**
    - **PCMHAB**
  - **NOAA Labs**
- **Event Response Assistance**



Gulf of Mexico Harmful Algal Bloom Bulletin
24 August 2006
NOAA Ocean Service
NOAA Satellite and Information Service

Conditions Report

A harmful algal bloom has been identified from Sarasota to northern Collier County. Patchy high impacts are possible for Sarasota and Charlotte Counties today through Saturday, with patchy low impacts possible Saturday night through Sunday. Patchy low impacts are possible for Lee County, with patchy moderate impacts possible in northern Collier County today through Saturday. Patchy very low impacts are possible in both Lee and northern Collier Counties Saturday night through Sunday.

Analysis

The bloom persists from Sarasota County to northern Collier County. Recent sampling results indicate that the bloom has intensified in Collier County, with a maximum concentration at Naples Pier (Dept. of Health, 8/21). The bloom remains at low concentrations for the remainder of Lee and Collier County. High concentrations have been found in Sarasota and Charlotte Counties at Venice Pier, Cortez Bridge, and Anna Maria Island (FWRI, 8/22). Background levels of *K.brevis* were found on Pine Island Sound at Skyway Fishing Pier in addition to high levels of non-harmful algae south of Tampa Bay between Sarasota and Lee County (FWRI, 8/21). Imagery continues to indicate that chlorophyll concentrations remain high offshore of southwest Florida (>15 µg/L). Chlorophyll levels range from 5-10 µg/L offshore of Collier County at 26°19'50"N, 81°52'5"W.

Onshore winds Thursday through Saturday will likely increase impacts along the coast. Onshore winds may slow northern transport of bloom.

-Keller, Allen

Wind conditions from Venice Pier, FL

Wind Speed (ms^{-1})

Aug 09 Aug 11 Aug 13 Aug 15 Aug 17 Aug 19 Aug 21

Wind speed and direction are averaged over 61 hours from hourly measurements. Length of line indicates speed, angle indicates direction. Dot indicates that the wind direction flows upwelling near the coast. Values to the left of the dotted vertical line are measured values, values to the right are forecasts.

SW Florida: Westerly winds this afternoon followed by southerly winds tonight (5-10 knots; 3-5 m/s). Westerly winds on Friday (5 knots; 3m/s). Northwesterly winds on Saturday, followed by southeasterly winds on Saturday night (5-10 knots, 3-5 m/s) and easterly winds on Sunday (5-10 knots; 3-5 m/s).

- **Develop HAB Operational Forecasting System**
  - **FL & TX *Karenia* operational forecasts**
  - **Gulf of Maine *Alexandrium* & Lake Erie cyanobacteria transitioning**
  - **Others in development**
- **Develop HAB Observing System—research & planning**

What Can You Do?

- Check for HAB warnings
- Report fish kills, discolored water, human & animal illness
- Inform yourself about human activities that cause HABs or make them worse; take appropriate action
  - Nutrient enrichment
  - Increasing temperatures and water stratification
  - Introductions
    - Ballast water
    - Shellfish transport
    - Hydrological modifications
- Website for more information http://www.whoi.edu/redtide/

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http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-ecohab.aspx

http://www.cop.noaa.gov/stressors/extremeevents/hab/current/PCM_08.aspx

Questions?

Watershed Academy Certificate

- If you would like to obtain participation certificates, type the link below into your web browser:

  http://water.epa.gov/learn/training/wacademy/upload/Watershed-Acad-Webcast-certificate_061813.pdf
- You can type each of the attendees names into the PDF and print the certificates.

Additional Resources

HABs website:
http://www2.epa.gov/nutrientpollution/harmful-algal-blooms

Facebook:
https://www.facebook.com/EPAWaterIsWorthIt

Twitter: @EPAWater

Flickr: http://blog.epa.gov/epplocations/