The Who, Why, and What can be Done about Golden Brown Algae in Torch Lake

Patrick Kociolek (University of Colorado & UMBS), Rex Lowe (University of Wisconsin & UMBS), and Jan Stevenson (Michigan State University)

Algae

- Mostly Aquatic
- **Photosynthetic;** many different groups represented by many different colors (red, green, blue-green, yellow-green golden brown, etc)
- But not so "advanced" morphologically as terrestrial plants
- But some groups have, based on the fossil record, been around for over 1 billion years, and they are **extremely advanced in terms of their physiology.**



- Planktonic, floating or drifting near the surface of the water
- Benthic, attached to the sides of lakes or on the bottom



©2009 University of Colorado Museum of Natural Histo

Algae in Lakes

- Three groups, not very closely related to one another, can be dominant in lakes. They can all be either benthic or planktonic
- Blue Green Algae
- Green Algae
- Diatoms

Blue-Green Algae

"Fanny" (Aphanizomenon)

121 µr

"Annie" (Anabaena)

"Mike" (Microcystis)

Microcystis bloom on Lake Erie



×

THESE ARE NOT GOLDEN BROWN ALGAE

Green Algae in Lakes: Mostly Benthic





THESE ARE NOT GOLDEN BROWN ALGAE

Algae in Torch Lake

Diatoms.

Many diatoms are planktonic, but Torch Lake has benthic diatoms!

THESE ARE GOLDEN BROWN ALGAE!





Benthic Bloom

Shallow area w/ minimal or no bloom

Deep area, no visible bloom



Benthic Diatoms On rocks and consolidating the sediments !!!!!!







Diatoms

- Important Ecologically:
- Base of the food chain in most aquatic ecosystems-preferred food source for most primary consumers



Diatoms

- Unicells (but can form colonies by a variety of mechanisms)
- Chlorophylls a, c
- Accessory pigments: Xanthophylls, Carotenoids
- Storage compound: Lipid (oil)
- Cell wall: silica dioxide



Diatoms ("break into two")

- Put together like a Petri dish or Pill box.
- Two overlapping valves, the large called the epivalve, the smaller called the hypovalve. Between the valves are called girdle bands.
- Two views: Valve View, Girdle View



Orientation of the Frustule







Diatoms of Torch Lake

- Based on ca. 12 collections made last summer, we analyzed the species composition of the diatoms present.
- Not an exercise to document all of the species present, but to get a sense of the community. This effort was shared with MSU to support their analyses of diatom communities.
- Over 180 species present. That is quite a large number (given no seasonality sampling, few number of samples, from few depths, from few substrate types).
- About 10% of these are new to science.







Causes, Consequences and Correctives.

Dr. Rex L. Lowe University of Michigan Biological Station

Torch Lake

Benthic Bloom

Shallow area w/ minimal or no bloom Deep area, no visible bloom



Diatomdominated Periphyton





Why is this happening? Why now?

• An increase in some algal resource that was previously limiting?



C HOPKNS CaFe Mg Si

Leaky septic systems?

Benthification from zebra mussels??

Terrestrial runoff from fertilization?

Lake warming = longer ice-free time & more mixing?

Periphyton nutrient bioassay

3 treatments:

- 0.5 M Sodium Nitrate (N+)
- 0.5 Sodium Phosphate (P+)
- 0.5 M Sodium Nitrate & 0.5 M Sodium Phosphate (N+P)
- Control (no nutrients)
- 3 replicates per site



Periphyton nutrient analysis

- Two sites
 - Petty
 - YMCA
- 3 week incubation period







AND THEN



Chlorophyll a Analysis





GBA Research

- 1. Taxonomy of Diatoms in Torch Lake
- 2. Nutrient Limitation Experiment
- 3. Survey of Algae and Water Chemistry
 - Jan Stevenson MSU
 - Sherry Martin MSU
 - Liu Bo MSU
 - Shenpan Lin MSU

2015 Study of Golden Brown Algae on the Bottom of Torch Lake

R. Jan Stevenson, Professor **Department of Integrative Biology and** Center for Water Sciences **Michigan State University** East Lansing, MI 48824 April 18, 2016



Image Credits: Stevenson's image of common benthic diatoms in Torch lake (scale bar = $10 \mu m$). Map of Torch Lake and surrounding watershed by Google[®].



Alternative Hypotheses for Golden Brown Algal "Blooms"

- Zebra Mussels & Relatives
- Changing Light Conditions
- Runoff from Big Storms
- Disease Killed Grazers Allowing Algae to Grow
- Non-native Invasive Algal Species
- "Algae in the News and on Your Mind"
- Climate Change & A Warmer Lake
- Groundwater Contamination Progressive KEY QUESTION:

WHAT HAS CHANGED TO CAUSE GBA?

Algal Ecology

Freshwater Benthic Ecosystems



Edited by **R.** Jan Stevenson • Max L. Bothwell • Rex L. Lowe Alternative Hypotheses for Golden Brown Algal "Blooms"

- ?• Zebra Mussels & Relatives
- ?• Changing Light Conditions
- ?• Runoff from Big Storms
- Poisease Killed Grazers Allowing Algae to Grow
- ?• Non-native Invasive Algal Species
- ?• "Algae in the News and on Your Mind"
 - Climate Change & A Warmer Lake
 - Groundwater Contamination
 KEY QUESTION:

WHAT HAS CHANGED TO CAUSE GBA?

Satellite Assessment of Water Temperature

Red-Green-Blue Image



Water surface temperature, Landsat 8, Band 11 on same day



Surface Water Temperature Unchanged

Water surface temperature (Landsat 7)



Does Groundwater Contamination Cause GBA?



Groundwater Contamination and Paths to GBA?



Survey of Water Chemistry and GBA in Areas with Low and High Home Density

Measurements

- Surface Water Nutrients
- Groundwater Nutrients
- Benthic algal abundance
- Benthic algal species composition

Locations

- Low Home Density Location
 - Camp Hayo-Went-Ha
- High Home Density Location
 - Location 1
 - Location 2

Evidence for Groundwater Contamination in Piezometer Samples





Expected Results in Areas with High and Low Home Density

Low Home Density

High Home Density



We Found No Difference in Phosphorus at Our Locations



We Found No Difference in Phosphorus at Our Locations

Camp Hayo-Went-Ha

Two High Density Locations



Evidence for Groundwater Stimulating GBA:

Phosphorus concentrations are so low that adding nutrients will greatly stimulate algal growth. Slight increases in P should have big effects.

All Locations



We Found No Difference in Nitrogen at Our Locations, And N was Higher in the Water Column than Groundwater



Evidence for Groundwater Stimulating GBA: changes in diatom species composition are related to algal abundance in sand



Evidence for Groundwater Contamination in Cold Groundwater Co-located with GBA





Sampled by: Becky Norris and Fred Sittel



GBA Co-located with higher Groundwater influence

- Lake and subsurface temps increase in late spring.
- Subsurface slightly colder than Lake Floor temps indicating Groundwater influence.
- Subsurface with GBA slightly colder than
 Subsurface minus GBA.

What Can We Do About It? Depends on Causes.

Groundwater Contamination ?

- Supported by multiple lines of evidence
- Progressive & Early Warning of Worse Problems
- X Climate Change & Warmer Lake
- ? Zebra Mussels & Relatives
- **?** Changing Light Conditions
- **?** Runoff from Big Storms
- ? Disease Killed Grazers Allowing Algae to Grow
- ? Non-native Invasive Algal Species
- ? "Algae in the News and on Your Mind"

<u>Sources</u>

More likely septic and lawn fertilizers than agriculture, but more information is needed.

Precautions & Solutions Maintain & improve septic systems Reduce lawn fertilization

To Gather More Data and Increase Certainty: 2016 Study

- Repeat of the nutrient limitation experiment
- Continue survey of water chemistry and GBA
 - More thorough groundwater assessment
 - Seasonal monitoring of three locations studied intensively last year
 - Additional locations in Torch Lake, Clam Lake, and Lake Bellaire
 - Temperature surveys to detect groundwater inputs

