

Golden Brown Algae 2015 Study in Torch Lake (3/4/2015)

Summary

This study proposes to address the question of the effect of groundwater nutrients on the proliferation of Golden Brown algae mats which have been reported by lakeshore homeowners to be increasing in the shallow shelf areas of Torch Lake. This is to be accomplished by measuring groundwater nutrients and chemicals and benthic diatom composition at sites of low and high land development at three different times during the summer of 2015 when there are expected to be differences in water temperature and human occupancy of lakeshore homes. To serve as confirmation of the results of these analyses a nutrient manipulation study is to be undertaken to confirm stimulation of diatom growth by appropriately selected concentrations of nutrients.

Introduction (written by Dr. Stevenson)

Proliferations of golden brown algae have been observed growing on sands in Torch and Elk Lakes. In August 2014, three samples of golden brown benthic algae were collected from the shallow south-eastern shoals of Torch Lake and were subsequently analyzed by Dr. Rex Lowe. Diatoms with fine filaments of a blue green alga were the dominant algae in the samples. The blue green alga identified was *Geitlerinema* and the dominant diatom in the samples was identified as *Epithemia*. *Epithemia* is normally an indicator of a nitrogen limited situation which can occur with excess phosphorus. This is an example of how diatoms can be used as indicators of nutrient conditions. Diatoms are commonly used as indicators of water quality in lakes, rivers, streams, and coastal zones around the world.¹

Based on observations from the shoreline, from 5 – 6 feet above the surface water (recreational boat) and from about 600 ft above the lake (private plane) during the summer of 2014, this golden brown algae appeared to be pervasive around the lake on both eastside, westside, and northern shoals but absent on the southern Sand Bar shoal and a few other shoreline zones. The golden brown patches were observed in water depths of approximately 4 feet extending to the first lake drop off at depths of approximately 15 feet. From the air, the darker coloration on the shoals appeared in bands. Two years prior to the appearance of the golden brown algae in 2014, the lake bottom, of both Torch and Elk Lakes, was observed to have changed with a beige scum appearing on the benthic rocks. Concerned about this change in lake conditions, Elk-Skegemog Lake Association collected and sent bottom samples to Phycotech.

According to analyses by Phycotech, this scum was composed of algae, both cyanobacteria and diatoms. Waterfront property owners on both lakes report that one could see the outline and individual color of each rock below their docks before the 1980s. The change in lake bottom has been an ongoing phenomenon that could be related to the increase in residential development along the lake shore. Many alternative hypotheses exist for causes of the recent proliferation of golden brown benthic algae. Benthic refers to organisms growing on the bottom of aquatic habitats. The favored alternative hypothesis is phosphorus rich groundwater is moving through sandy shoal sediments from shoreline septic system sources in sufficient quantities that it enriches the sand surface and stimulates growth of benthic algae. Other possible causes for the benthic algal proliferations are changes in water temperature, snow melt and runoff, grazers, bioturbation by benthic animals, dreissenid mussel focusing of phosphorus on the lake bottom, or early stages of natural eutrophication processes. Evidence from multiple sources, including existing scientific literature, indicate the most likely reason for the golden brown algal proliferations is groundwater phosphorus changes over recent years. Therefore, we propose research to learn more about the benthic algal proliferations and test the hypotheses related to groundwater phosphorus causing the proliferations.

Objectives

1. Assessment of the impact of groundwater nutrients on the proliferation of benthic algae in Torch Lake sites.
2. Determination of the extent to which nutrient manipulation mimics the growth of benthic algae as found in Torch Lake sites.

Study Design

Two sites are selected for in-depth study, one with minimal development (Hayo-Went-Ha), and one with substantial development (Sunset Torch Condominiums). Additional sites around Torch Lake where benthic algae are found are to be selected for superficial study.

In-depth study will include benthic diatom characterization, groundwater nutrient characteristics, anthropological markers, near-shore surface water phosphorus, and algal response to benthic nutrient manipulation.

Superficial study will include only benthic diatom characterization.

Methods

Site Selection

The two sites for in-depth study have been selected because of their contrasting levels of development, their visually different levels of benthic algal mat presence, and the willingness of the property owners to allow the study to be conducted on their bottomlands. Rationale for this are the hypotheses that, 1) groundwater nutrients are expected to be in higher concentration where development is present than where it is absent and, 2) groundwater nutrients are driving the growth of the benthic algae.

The additional sites for superficial study are to be selected based on visual assessment of the extent of benthic algal mats. Rationale for this is that the benthic algae biomass may be composed of different species at different locations.

Piezometer Placement

Temperature mapping will be done with hand-held temperature probes at each of the two in-depth study sites to identify spots where groundwater is likely to be entering the lake. Piezometers (small shallow wells) will then be installed at four locations at each of the two in-depth study sites where the water is 2 – 3 feet deep, placement being guided by the findings of the temperature mapping. Rationale for this is that groundwater temperature is likely to be different from lake water and siting the piezometers where temperature differences are found enhances the likelihood that our water samples will truly be groundwater.

Groundwater Samples

Water samples from the piezometers will be collected in triplicate at three different times over the summer, June, July, and August for a total of 72 samples. Rationale for these times is that changes in water temperature and human occupancy levels (which may alter the groundwater nutrient and human source chemicals composition and concentration) may affect the abundance of the various diatoms found at the study sites.

Analytes to be measured include TP (total phosphorus), SRP (soluble reactive phosphorus), TN (total nitrogen), NH₃-N (ammonia nitrogen), Nitrate:Nitrite, caffeine, trichlosan, and estrogen. Rationale for these nutrient analytes is that they represent the nutrients most likely to be influencing the growth of the algae. Rationale for the caffeine, trichlosan, and estrogen is that they are measurable at reasonable cost and

are good indicators of entry into groundwater of chemicals from human use that are not captured by septic distribution fields.

Surface Water Samples

At each of the two in-depth study sites surface water samples will be collected in triplicate near shore in water approximately 6 – 8 inches deep at the same times as the water samples are collected from the piezometers. These 18 samples will be used to measure only TP. Rationale for including surface water TP samples is that near-shore TP is expected to be substantially higher than mid-lake levels and the benthic algae are frequently found in water this shallow.

Laboratory Analysis of Water Samples

Samples will be collected in specimen containers of a type and size required by the MSU laboratory, stored, and shipped or transported to East Lansing according to their instructions. (Detailed instructions are pending at this time.) All of the analytes will be assayed by the MSU laboratory.

QA Samples

For the purpose of confirming that the phosphorus measurements from MSU are valid, split samples for TP will be collected in triplicate at each of the two in-depth study sites at each of the study sampling times. The extra samples thus generated will be analyzed at GLEC in Traverse City, a laboratory whose high quality is known to us.

Benthic Diatom Samples

At all sites algae mat samples will be harvested from the benthos for characterization at each of the study times. Rationale for this is that changes in water temperature and groundwater nutrient composition may impact the abundance of the various diatoms found at the study sites.

Benthic diatom samples will be collected, stored, and shipped or transported to Dr. Stevenson's laboratory according to his instructions. (Detailed instructions are pending at this time.)

Benthic Nutrient Manipulation

Petri dishes of agar containing various concentrations of phosphorus and nitrogen will be nested in the lake floor – protocol per Dr. Lowe² – and the resultant growth of various diatoms analyzed. Sites, duration of deployment, concentrations of nutrients, collection

of samples, etc. will be in accordance with protocol details pending from Dr. Lowe. Rationale for this element of the study is that it serves to confirm any relationship found between groundwater nutrient concentrations and abundance of the various diatoms. Micronutrients in the lake water vary from lake to lake and probably from different locations within a big lake (like Torch) and can also impact the types and abundance of diatoms found.

Data Interpretation

Water Analytes

These data will be generated by the MSU laboratory and interpreted by Dr. Martin's staff.

Benthic Diatom Samples

These data will be generated and interpreted by Dr. Stevenson's staff.

Benthic Nutrient Manipulation Samples

These data will be generated and interpreted by Dr. Lowe's staff.

Budget*

Item	Unit Price	Number	Total
Equipment:			
Piezometers	20	8	160
Temperature probes	50	4	200
MSU Laboratory			
TP	5	90	450
SRP	5	72	360
TN	5	72	360
NH3-N	5	72	360
Nitrate:Nitrite	5	72	360
Caffeine, Trichlosan, Estrogen	20	72	1440
GLEC TP QA	27	9	243
Benthic Diatom characterization			2000
Algal response to nutrient manipulation			4600
Investigator fee Dr. Stevenson	3000	1	3000
Consultant fee Dr. Martin	1500	1	1500
Grand Total			15033

*The University services are being provided on a fee-for-service basis and we expect a waiver of overhead charges.

Collaborators

R. J. Stevenson and S. L. Martin from Michigan State University

R. L. Lowe from University of Michigan

Three Lakes Association volunteers

Other Lakes Associations volunteers (TBD)

Study Report

Dr. Stevenson has agreed to be the principal author and will have available the input of the other collaborators as appropriate. It is anticipated that a draft report of this study will be completed by October 2015.

Bibliography

1. Stevenson, R. J. Ecological assessments with algae: a review and synthesis. *Journal of Phycology* 2014;50: 437-461.
2. Fairchild, G. W., Lowe, R. L., and Richardson, W. B. Algal Periphyton Growth on Nutrient-Diffusing Substrates: An In Situ Bioassay. *Ecology* 1985;66(2): 465-472.
3. Martin, S. L. and Soranno, P. A. Lake landscape position: Relationships to hydrologic connectivity and landscape features. *Limnology & Oceanography* 2006;51(2): 801-814.