FAQ ABOUT GLOEOTRICHIA

HOW DO I USE THESE FREQUENTLY ASKED QUESTIONS (FAQ)?

These questions are divided into sections that cover some basic information on Gloeotrichia, what was found in the two year study of the organism in Great and Long Ponds, and some thoughts on action.

Some of the information is readily understood, some more technical material requires a little study. We have tried to make all of the facts accessible while giving them the detail and accuracy they deserve.

Twice in these questions you will find a brief list of conclusions reached during the study. Several web citations will take the reader to still more detailed coverage of certain areas. From time to time we expect to update some of this material and add explanations as more becomes known.

We welcome your comments and suggestions.
http://www.belgradelakesassociation.com/contact.asp

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I. GLOEOTRICHIA BASICS

WHAT IS THE GREEN BLOOM SEEN IN GREAT AND LONG PONDS OVER THE LAST SEVERAL SUMMERS?

What we call algal blooms in Great and Long Ponds result from growth of blue-green algae, now known more properly as cyanobacteria. The most prevalent form is Gloeotrichia echinulata. There are three common types of cyanobacteria. Although Gloeotrichia predominates in Great Pond, other types—Anabaena, Aphanizomenon flos-aquae—are present in smaller quantities. In East Pond, we have a different story: there the mix changes, and Anabaena dominates.

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WHY HAS IT APPEARED?

Cyanobacteria are bacteria that grow in water and are photosynthetic (use sunlight to support life). Cyanobacteria blooms occur when organisms that are normally present grow at an increased rate. Blooms can form in still and slow-moving waters that are rich in nutrients. Nutrients can be derived from natural processes as well as sediments washed from roads, construction sites, patches of bare soil, fertilizer runoff or septic system malfunctions. Blooms can appear at any time but most often occur in late summer or early fall. Cyanobactera blooms are common in lakes and ponds worldwide and are often triggered by warm temperatures, plentiful sunlight, and available phosphate. Unlike other such organisms, cyanobacteria are able to gain a competitive edge by meeting some or all of their cellular nitrogen requirement through chemically processing nitrogen dissolved in water.

These are relevant facts, but they reveal nothing specific to Great or Long Pond. Questions proliferate when blooms appear in home waters. The following timeline chronicles events leading to the cooperative study of 2005 and 2006:

- 1987: DEP Lake Monitors first observe Gloeotrichia as present in Great Pond
- 1987-2002: Gloeotrichia appears for approximately 2 to 3 weeks mid-summer each year in low concentrations most easily observed in locations where the lake bottom isn't visible due to the depth of the water. (i.e. it is seen scattered through the top few meters of the water column by lake monitors taking observations at the deep holes shown in blue on maps in answers to following questions)
- July 2002: First intense Gloeotrichia bloom noted in Swann's Brook cove, north end Great Pond on July 4th weekend. Water temperature 90 degrees Fahrenheit.
- July, 2002: BLA President contacts DEP to gather information about Gloeotrichia. Roy Bouchard offers to search the literature.
- October 2002: BLA newsletter publishes first article on Gloeotrichia (informed by Bouchard research). It includes information about cyanobacteria, life cycle of Gloeotrichia and its toxicity. First article contains warning about skin rash and gastro-enteritis and instructs residents not to allow children to swim in heavy blooms since youngsters often swallow water as they swim. BLA newsletter continues to publish information about Gloeotrichia as new material is discovered in years following.
- BLA President discovers that there is relatively little information about this life form and that even its classification as an alga (blue-green) or as a cyanobacterium is debated. Some reports indicate that Gloeotrichia blooms have occasionally disappeared in a water body as suddenly as they appeared. Bouchard makes clear there is no quick fix, that nutrient enrichment is the cause.
- Summer 2003: Blooms intensify.
- August, 2003: BLA President delivers gallon container showing intensity of Gloeotrichia bloom taken from Swann's Brook cove to Roy Bouchard, Maine DEP.
- November 2003: BLA President contacts Scott Williams, Volunteer Lake Monitoring Program (VLMP) Director, for suggestions about what the Lake Association should do. Williams advises consultation with algal expert, campaign to prevent Phosphorus loading, and developing a volunteer monitoring program.
- March 2004: BLA President attends North American Lake Management Society meeting in Chicago, attends Kenneth J. Wagner's seminar "Identification and Control of Freshwater Algae," and asks Dr. Wagner's help. Dr. Wagner replies: no remediation is possible until a thorough lake assessment is performed. Cost estimated at $200,000. Dr. Wagner knows Great Pond, Roy Bouchard and Scott Williams and advises BLA to collaborate with the DEP and VLMP to cut costs of the lake assessment.
- March 2004: BLA President visits Colby College President, Bro Adams, and inquires if the Colby lake research team can help with data collection to explain the Gloeotrichia blooms and help with remediation. Adams puts BLA in touch with Whitney King who agrees to include Gloeotrichia research in his ongoing work on Great Pond if Roy Bouchard is included in the study set up.
- May 2004: BLA Water Quality representative Roger Shannon and the BLA President meet with Drs. King and Firmage of Colby and Roy Bouchard of Maine DEP to begin

preparations for the study. Dr. King hires a research assistant to do a world literature search and prepare a report for the study group. Bouchard re-iterates the warning that the cause is nutrient-rich sediments.

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WHAT DO WE KNOW ABOUT THE LIFE CYCLE OF GLOEOTRICHIA?

The answer In short, Gloeotrichia echinulata is a photosynthetic organism, the life cycle of which includes two separate stages. Initially, Gloeotrichia is found as an ‘akinete package’ or germling on the lake bottom (benthos) as spring begins (that means a dormant form lying in the bottom sediment). Germination is triggered by warm water temperatures (19^{o}C) and sunlight. The organism begins to grow on the sediment surface and acquires nutrients in excess of its immediate needs from the sediments (1). After developing ample nutrients it forms gas vesicles that enable it to float, and it begins to migrate into the water column, up toward the surface (2). Once in the epilimnion (upper part of the lake), it goes through a series of growth (3) and colonial divisions (4). We think that this growth stage is where the sheer mass necessary for the visible Gloeotrichia bloom is created.

Later in the summer, as phosphorous reserves within the colonies dwindle, akinetes form at the base of its hundreds of filaments (5). Shortly after, the long outer part of the filaments is lost along with the gas vesicles (6), and the akinetes fall out of the water column (7). Eventually the colonies settle onto the sediment where they will lie awaiting the proper conditions to reactivate in the spring.

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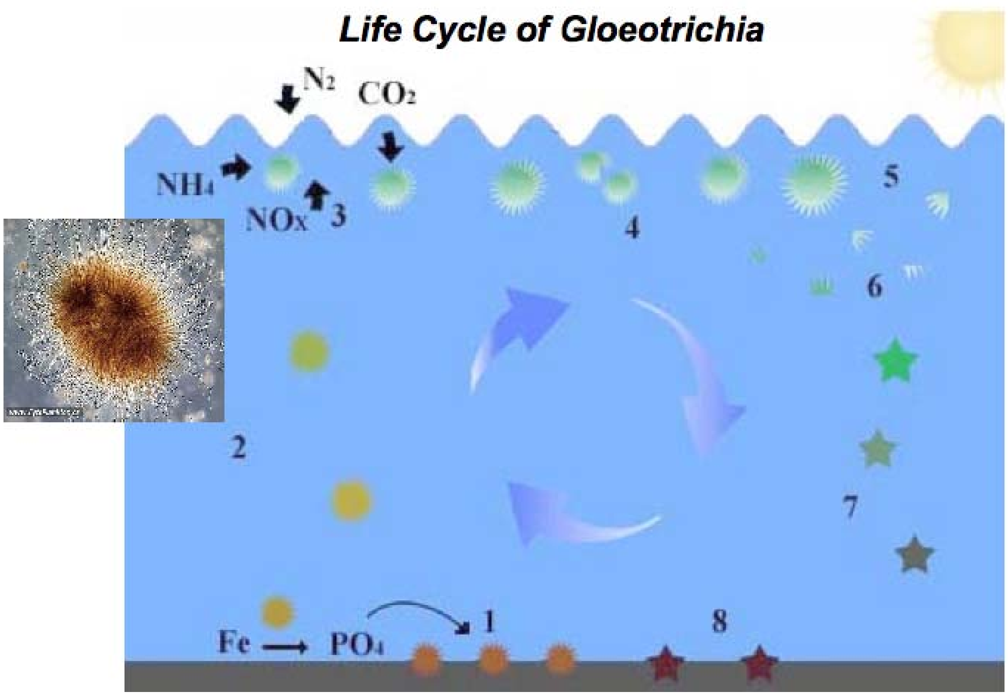

The answer in greater depth and breadth: the lakes in Maine are a valuable state resource supporting a diversity of wildlife in a spectacular natural setting, attracting tourists from all over the world. Unfortunately, some of Maine lakes are suffering decreased water quality due to excessive growth in phytoplankton species, and free-floating microscopic-sized plants. The process is part of eutrophication. It is a natural process but may be dramatically accelerated by human activity. This excessive growth causes a reduction in lake water clarity and turns the water green or brown. In highly eutrophic lakes the amount of dissolved oxygen in the deep lake will fall because of the high level of organic material forming in the lake and being oxidized at depth. Removal of oxygen in the deep water may severely impact many trout and salmon species that require cold, well oxygenated water.

Elevated concentrations of phosphorus in lake water are often the trigger for algal blooms. Phosphorus is an essential nutrient for plant growth, and is the limiting reagent in most lakes, controlling the rate at which plants grow and the final phytoplankton biomass. There is a quantitative relationship between biomass formation and phosphate concentrations.

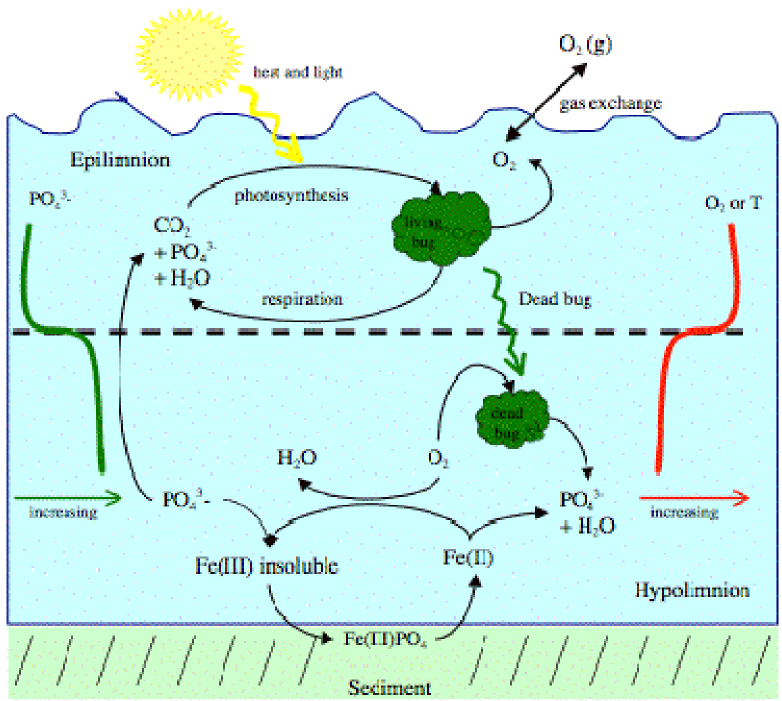

Figure 1. Schematic of phosphorus cycling in a temperate lake.

$$106CO_2 + 122H_2O + 16HNO_3 + H_3PO_4 \xrightarrow{light} (CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 132O_2$$

This equation is a simplified chemical stoichiometry for photosynthesis as it proceeds to the right. The reverse reaction to the left represents respiration. In this expression (CH2O)106(NH3)16(H3PO4) stands for biomass. The coefficients in the expression indicate that 106 moles of carbon dioxide can be converted into plant biomass per mole of phosphate. Thus, small additions of phosphate to a lake ecosystem can produce significant quantities of algal biomass, approximately at 35-fold amplification on a mass basis (mass plankton to mass H3PO4).

Phosphorus enters the water column of lakes from upstream lakes, sewage inputs, rainfall, overland runoff, and from the benthic sediments of the lake. Phosphorus leaves the lake by stream outflow or accumulation in the sediments. The sediments are a significant reservoir of phosphorus; however, most of this phosphorus is locked up in organic material or absorbed on metal oxides leaving only a small amount for plant growth. The organic material can become a source of phosphorus if oxidized by bacteria or zooplankton. Absorbed phosphorus in the sediment can also be released into the water column if active redox processes reduce metal oxides releasing bound phosphate. The depth at which phosphate enters the lake is also relevant since many Maine lakes are thermally stratified in the summer reducing mixing between the warm surface water (epilimnion) and the cold deep water (hypolimnion). The thin stratum between these layers is the thermocline.

Many of these processes are shown schematically in Figure 1 above. Dissolved phosphorus in the inorganic form (PO_4^{3-})is readily available for plants to use for photosynthesis. Particulate phosphorus is mostly in the form of organic material such as plant and animal tissue. Dissolved phosphorus can be converted into particulate phosphorus through primary production occurring in the epilimnion. Particulate phosphorus is often negatively buoyant and will settle out of the epilimnion into the hypolimnion as dead cells and organic detritus. If there is enough oxygen present in the hypolimnion the particulate phosphorus will be converted into dissolved phosphorus through decomposition by aerobic bacteria and reabsorbed on particles. This process, often called the biological pump, transports phosphorus from the epilimnion to the hypolimnion of the lake independent of physical mixing.

When the concentration of phosphorus in the epilimnion is elevated due to surface water inputs or storm-induced deep water mixing, eutrophication may occur. G. echinulata has evolved to short-circuit the regular nutrient cycle of phosphorus by sequestering phosphorus from the sediments and carrying phosphorus in cellular reserves to the epilimnion. Understanding how G. echinulata blooms in Great and Long Ponds are changing the nutrient cycling of phosphorus has been one of the study objectives.

[For references and more complete discussion see the paper preliminary to this study project by King and Laliberte at:
http://www.colby.edu/reload/chemistry/Gloeotrichia/Gloeotrichia%20background.htm]

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WHAT ARE THE TOXICITY AND OTHER POSSIBLE HEALTH EFFECTS OF GLOEOTRICHIA?

Gloeotrichia toxicity has not been thoroughly studied, but interest is mounting in many quarters. Gloeotrichia often has no effect on health. When effects are observed, they are usually limited to gastrointestinal upsets and skin or mucous membrane irritation rather than the more severe effects on liver and nervous system observed with other blooming organisms.

King and Laliberte stated in their review of the literature for the Great and Long Pond study that reported toxic effects of *G. echinulata* on humans can range from skin irritation by contact, to liver damage as a result of continued ingestion. Water may also develop an offensive odor and a foul taste.

Wiley InterScience published online 11 May 2007 a paper titled, “First report of microcystin-LR in the cyanobacterium *Gloeotrichia echinulata”* by Carey et al. who described finding low level liver toxicity for Gloeotrichia in Lake Sunapee, NH. They concluded that, This suggests that recent outbreaks of G. echinulata in clear lakes used as water sources throughout New England (USA) may pose a health concern. “The toxicity of G. echinulata reported here suggests the need for future monitoring of microcystins in oligotrophic lakes.” This is an alert to watch for toxins in lakes we consider clean.

Tolerances for swimming are usually higher, but the warning flag is raised, and other studies have shown that toxicity of cyanobacteria can change over time. (Carey’s abstract is at: http://www3.interscience.wiley.com/cgi-bin/abstract/114262433/ABSTRACT?CRETRY=1&SRETRY=0 .)

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CAN GLOEOTRICHIA BLOOMS DISAPPEAR NATURALLY IN SUBSEQUENT YEARS?

It is unlikely that Gloeotrichia blooms will disappear in future years. It is likely that the incidence and extent of blooms will vary from year to year.

In answers to following questions, the reader will find explanation of the effects of changing wind patterns on the incidence and severity of upwelling of water from the lake’s depths. This will affect the feeding of Gloeotrichia blooms and their impact on lakers from year to year. Underlying the feeding will be the effect of available deep-water nutrients. Continued deposit of organic matter in deep-water sediment of Great Pond and Long Pond may be expected, as it decays, to consume more oxygen from the sediments. Oxygen depletion (anoxia) will mobilize phosphorous from the sediments that can stimulate future Gloeotrichia blooms. This process of “internal loading” supplements phosphorous added to the lake from shoreland phenomena. Together these phosphorous sources increase the threat of blooms.

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II. FIGHTING GLOEOTRICHIA

BRIEFLY, WHAT ARE THE CONCLUSIONS OF THE STUDY?

- Recreational pleasure has been diminished by the bloom in some areas.
- Gloeotrichia is found everywhere in the lakes, but is concentrated along the north shores.
- Gloeotrichia bloom events are localized, episodic, and concentrated at the surface.
- Gloeotrichia is not loading P to the surface waters. Instead, small P additions will trigger blooms.
- Deep water adjacent to the north shores of both lakes enhances wind-induced upwelling of P, a probable cause of localized Gloeotrichia blooms.
- Gloeotrichia, and other nuisance algal blooms will likely get worse in the future.

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WHAT MUST THE BLA CONSIDER NOW?

There is no easy remedy for current Gloeotrichia blooms which stem from a complex set of chemical and environmental factors. They appear to be a consequence of gradual nutrient enrichment (eutrophication) of the lakes over the last century or more. The size of the lakes makes widespread specific treatment for Gloeotrichia impractical.

BLA is committed to practicing good science and good stewardship of the lakes to ensure that any actions taken are effective and do not create a negative impact. The BLA is currently evaluating options to address the Gloeotrichia blooms through three basic approaches: 1) reducing the phosphorous nutrient inputs to the lakes; 2) preventing existing phosphorous-rich sediments in deep areas of the lake from upwelling and contributing to blooms, and 3) destroying colonies of Gloeotrichia during active blooms

The BLA will evaluate potential actions with respect to 1) feasibility of implementation, 2) cost, 3) short-term effectiveness, 4) long-term effectiveness, 5) permitting requirements, 6) short-term and long-term impacts to water quality and other lake species; and 7) acceptability to the public and other stakeholders.

We plan to conduct small scale remediation tests of the most promising approaches. In addition, we are continuing to work on many fronts to reduce the amount of sediment runoff and other nutrient pollutants entering the lake.

The BLA is a part of the new Lake Trust of the Belgrade Regional Conservation Alliance (BRCA) which will allow collaboration with all of the Lake Associations in the entire Belgrade Watershed.

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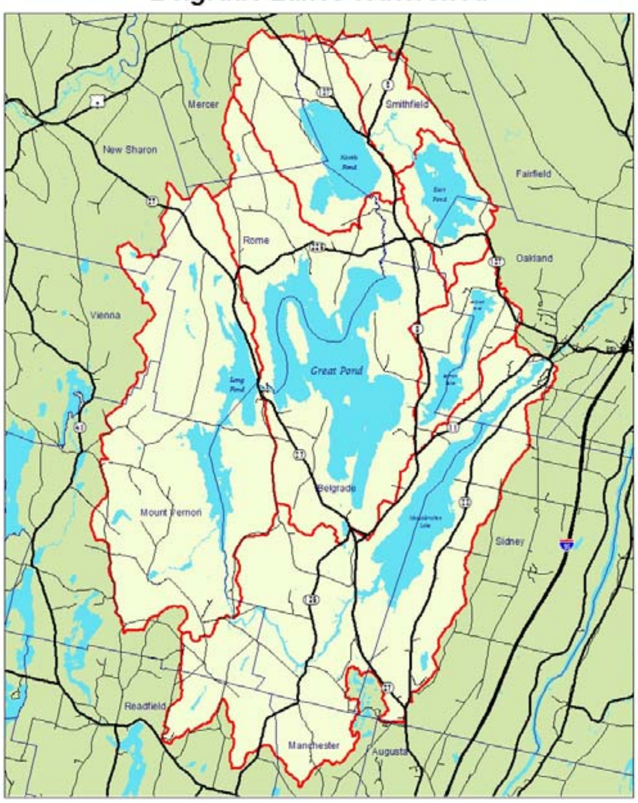
WHAT IS THE BELGRADE WATERSHED LAKETRUST?

Representatives of the area's lake associations as well as the regional Milfoil Committee and Conservation Corps have joined to work together closely as a LAKE TRUST Board within the Belgrade Regional Conservation Alliance (BRCA) to more effectively address water quality concerns in the Belgrade Watershed. The watershed concept takes in all land and water bodies that contribute drainage to some given point, in our case into Messalonskee Stream. Watershed has been a primary perspective of the US EPA since 1994.

Here is a map of our watershed.

Belgrade Lakes Watershed



The newly formed Lake Trust has three objectives:

1. to improve and maintain water quality in the lakes of the Belgrade Watershed,
2. to build the capacity and strengthen the branding of lake associations, and
3. to create public support and increase funding for water quality restoration.

The Lake Trust Board meets on the 4th Monday of each month from 6 to 8 pm in the BRCA/BLA office in Belgrade Lakes Village, and the public is cordially invited to attend. The new board is made up of lake association presidents or their appointed designees, and representatives from the BRCA, the Conservation Corps and the Milfoil Committee.

Lake Trust Board Members, March, 2007:

Belgrade Lakes Association	Kathy Lowell
BRCA	Charlie Baeder and Roy Bouchard
Conservation Corps	Roger Shannon
East Pond Association	Jerry Tipper
McGrath Pond/Salmon Lake Association	Rick Tonge
Milfoil Committee	Maureen Maslak
North Pond, ex officio	Cheryl Murdock
Snow Pond/Messalonskee Lake Association	Bill Libby
Chair	Maggie Shannon

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WHAT CAN WE AS RESIDENTS DO?

STOP Phosphorus input to the lake from fertilizers, failing septic systems, camp road and driveway erosion, and patches of bare soil.

It is not possible to turn back the clock and restore Great and Long ponds to the state our parents knew. However, we can slow degradation, possibly arrest it, and perhaps even improve water quality if each of us does his or her best.

Each of us fortunate enough to live on the lakefront must stop erosion and the use of phosphates now.

The LakeSmart program launched by the Maine Department of Environmental Protection (DEP) is one of the easiest ways to learn about what one person can do. Check out how to get started with LakeSmart on the BLA website at: (http://www.belgradelakesassociation.com/lakesmart.asp).

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III. FINDINGS OF THE COLLABORATIVE STUDY OF GREAT AND LONG PONDS 2005 – 2006

WHAT IS THE TIMELINE OF THE LOCAL GLOEOTRICHIA STUDY PROJECT?

- Summer 2004: Gloeotrichia blooms continue.
- Fall-Winter 2004-2005: Gloeotrichia Study Group, headed by Dr. King and Roy Bouchard and including BLA Water Quality representative Roger Shannon meet to review the findings of the literature search and prepare for the Study. The group determines what questions the Study will seek to answer and what chemical, biological and other measurements need to be taken, develops sampling protocols for volunteers and interns working during Summer 2005, and decides research needs to continue for two consecutive summers.
- BLA commits to supporting a 2-Year Study. This will involve recruiting, training and gathering data from 20 volunteer samplers around the perimeter of Great and Long Ponds and supporting the cost of two summer interns from Colby College to monitor in-lake Gloeotrichia conditions and to collect lake chemistry data for the Study.
- Summer 2005: Blooms continue and intensify. Volunteer monitors collect perimeter data according to the protocol developed by King and Bouchard. Colby Interns collect in-lake data from real-time sampling and weekly collections from 2 collecting devices invented by Dr. King anchored in 2 Great Pond locations.
- Winter 2005-2006: Dr. King assesses 2005 Summer Study results and posts the information on the Colby 'Gloeotrichia Website' which he has created to keep the public and academic community informed.
- Summer 2006: Blooms continue unabated. Perimeter and in-lake samples are taken by volunteers, Colby interns and 2 permanent sampling devices.
- Winter 2006-2007: Dr. King analyses 2-year Study data to prepare August report for BLA and article on GP Gloeotrichia research for peer-reviewed journals.
- April 2007: King, Bouchard, Firmage and Shannon meet to discuss preliminary findings and collaborate on reporting to the public.

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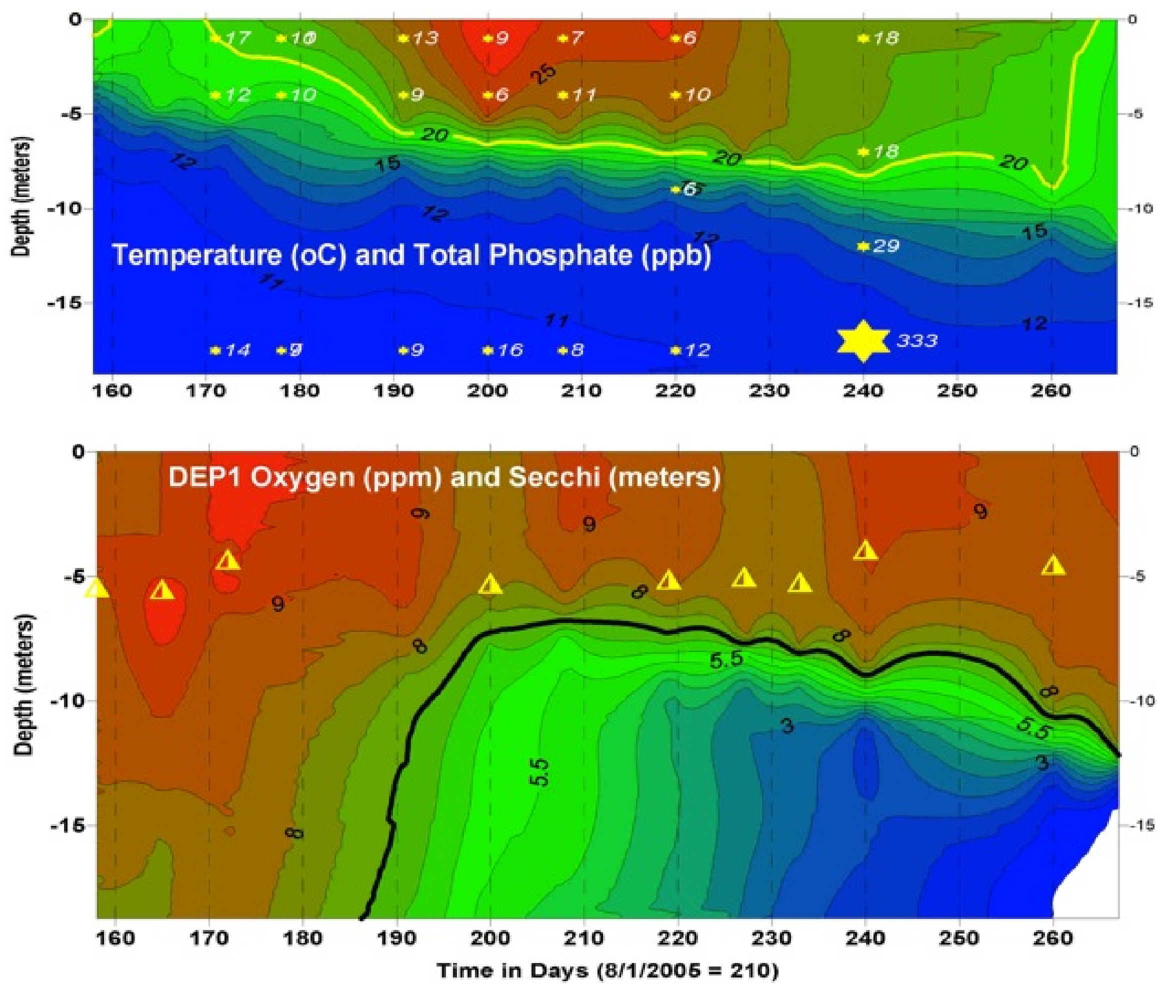
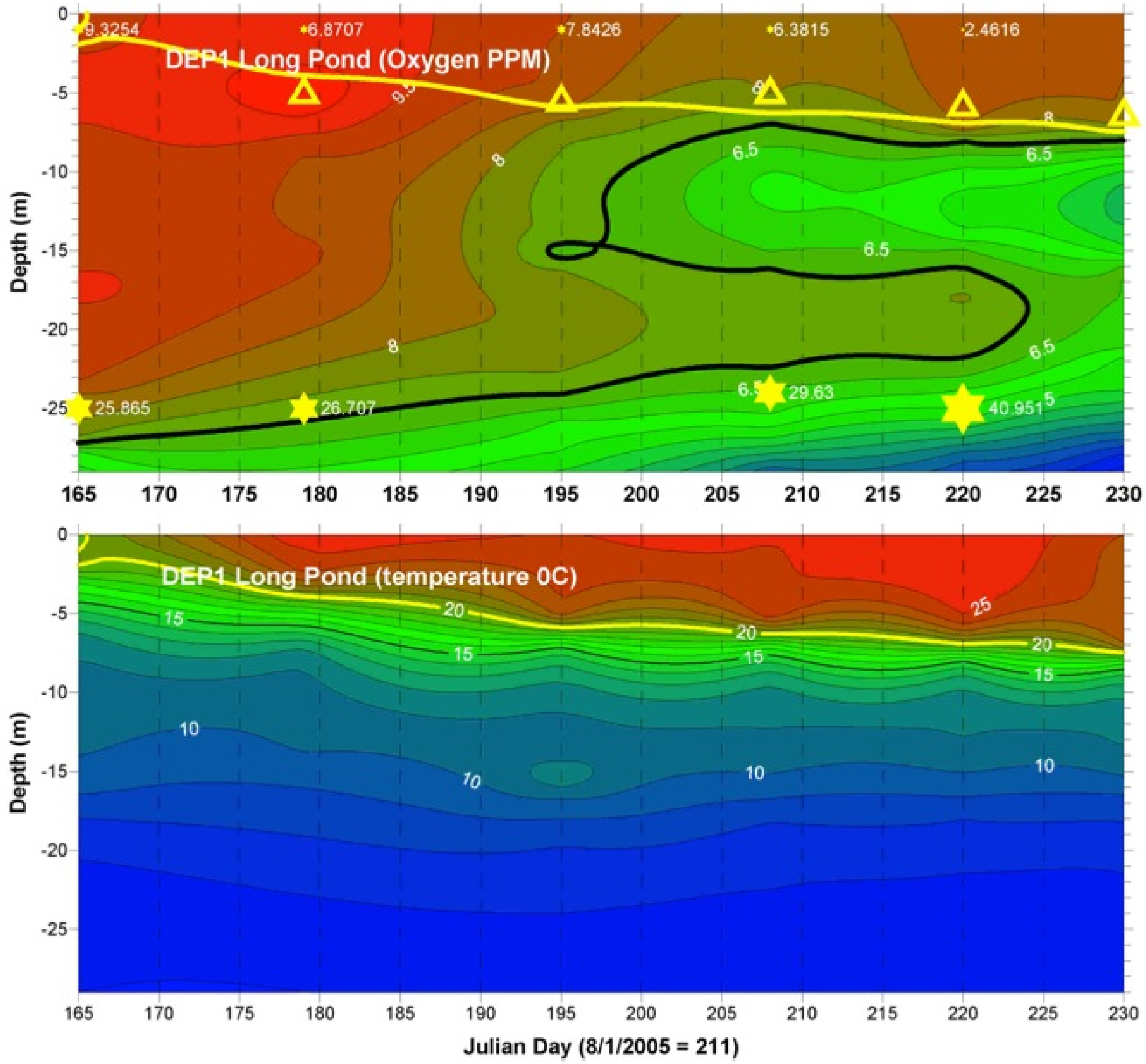
WHAT WAS DISCOVERED ABOUT GLOEOTRICHIA BLOOMS?

All organisms need specific compounds to grow and these include carbon, hydrogen, oxygen, nitrogen, phosphorus, and trace elements like iron. In a lake environment there is plenty of carbon, hydrogen, and oxygen from carbon dioxide and water. Iron concentrations were measured in all of the Belgrade Lakes. Both the deep water and surface waters contain plenty of iron. Nitrogen and phosphorus are often in limited supply and are considered the limiting nutrients for algal growth in lakes. Blue green algae, like Gloeotrichia, are capable of obtaining nitrogen from the air via nitrogen fixation, while most other algae do not have this capability. Therefore, in the presence of abundant phosphate and nitrate (the biologically useful forms of these nutrients) a diverse algal population will bloom until the nutrients are consumed. In the presence of just phosphate, Gloeotrichia (or other blue greens) blooms will dominate due to their ability to convert nitrogen gas to nitrate.

Excess nitrate will eventually be removed from the ecosystem by denitrifying bacteria. Phosphate is removed from the lake by stream outflow and accumulation in well-oxygenated sediments. Consider the diagram below showing the thermal structure of Great and Long Ponds in 2005. (Blue is low value, red is high.)



Great Pond temperature and depth contours for 2005 (observation station DEP1 SE of Hoyt's island). Notice the thermocline formed at 10 meters depth and deep anoxia forming at day 230 in the hypolimnion (deep layer). Yellow triangles are Secchi depth and yellow stars are total phosphorus concentration. Notice the dramatic increase in phosphate with the onset of anoxia (very low oxygen level) at day 230.

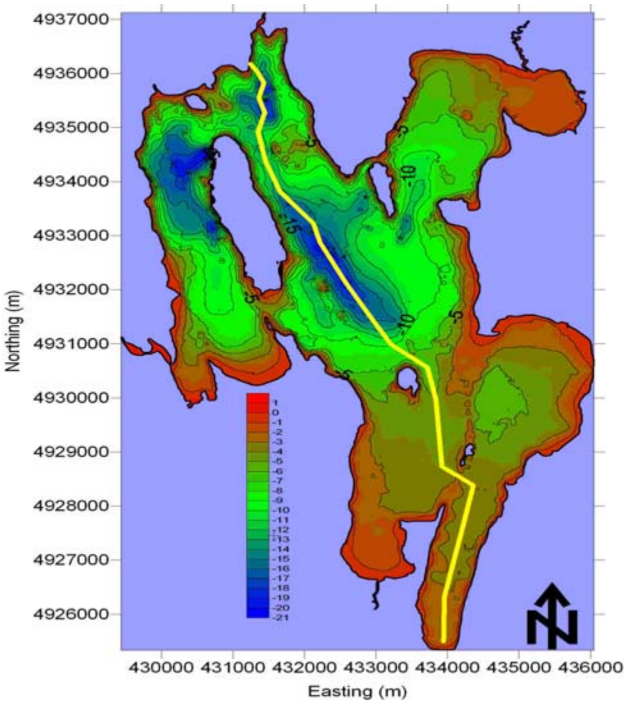


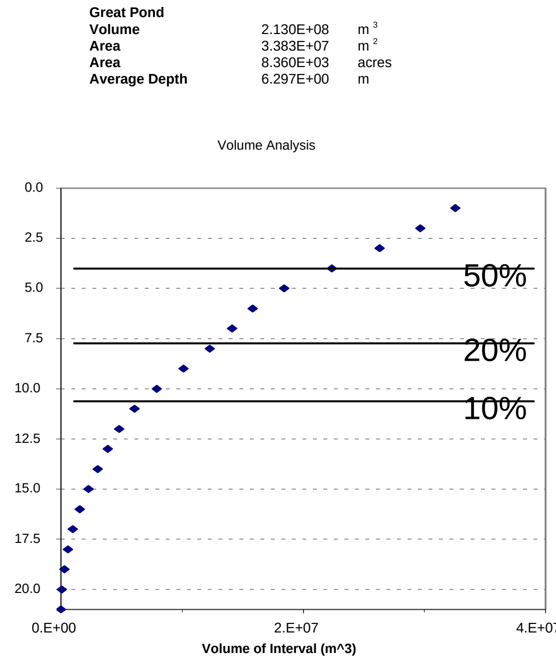
Long Pond temperature and depth contours for 2005 (south basin observation station DEP1).

In both lakes the onset of anoxia in the deep water creates chemical reducing conditions that release phosphate from the sediments. If this phosphate makes it to the surface it may trigger a bloom. Phosphate additions to surface water in the absence of nitrate will favor Gloeotrichia blooms.

Generally, the thermal structure of the lakes prevents communication of the deep, cold, nutrient rich water with the surface water. However, the bathymetry (bottom configuration) and physical setting of each lake does provide a mechanism to bring the bottom water (containing phosphate) to the surface.

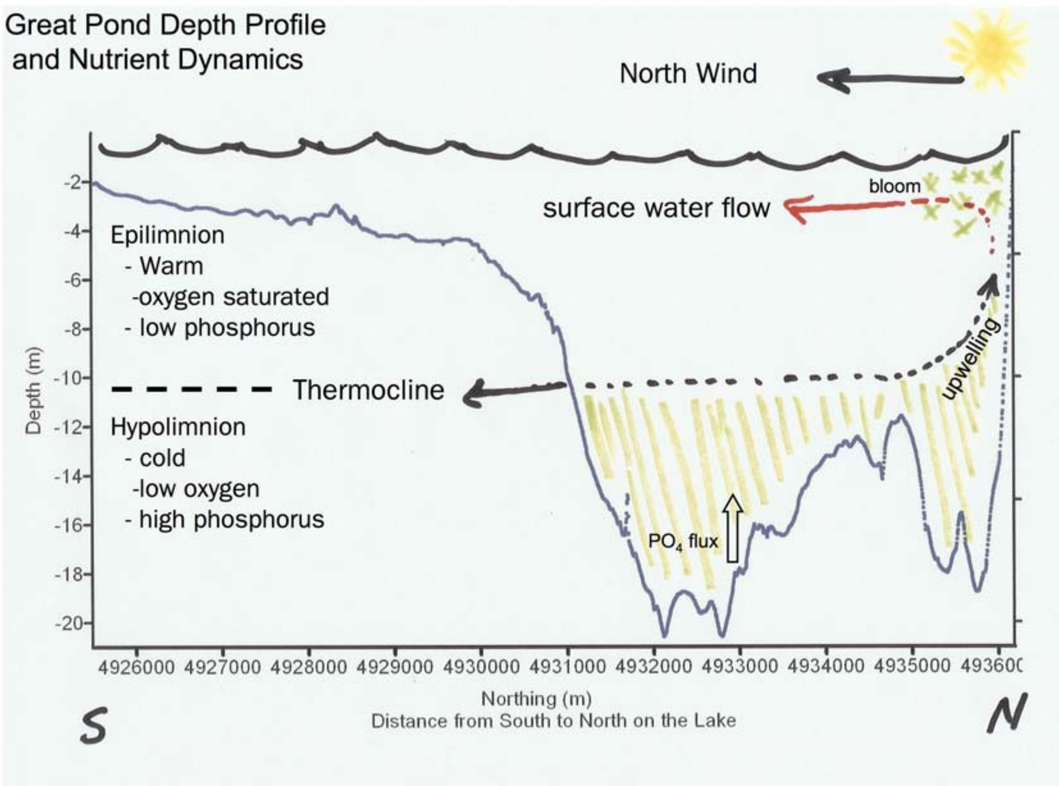
Three dimensions of Great Pond





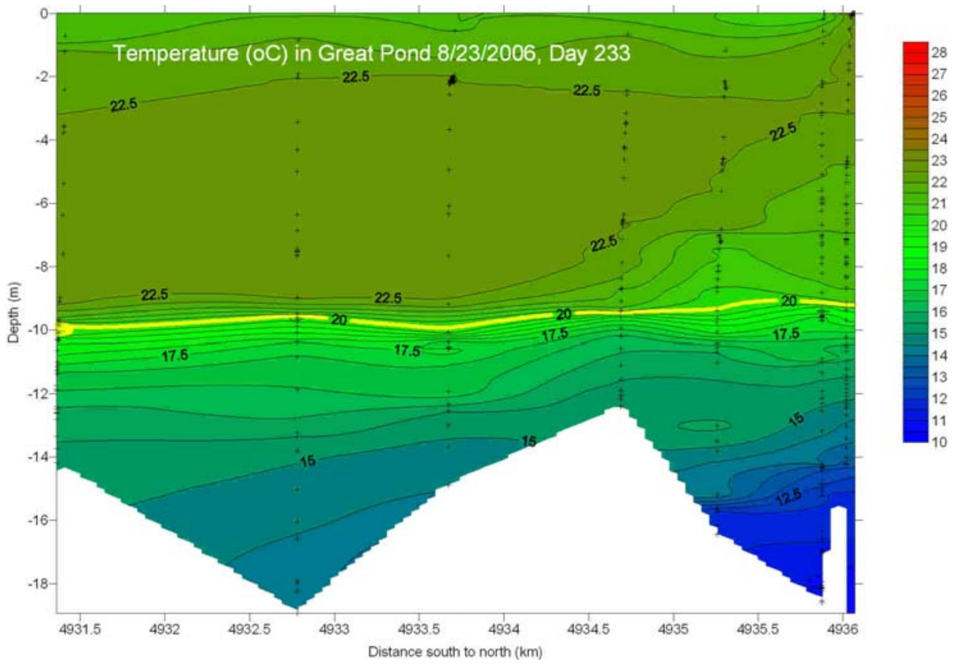
Consider the data shown above for Great Pond. The left panel shows a contour map of depth for the lake. The dark blue areas are the deep holes on each side of Hoyt's Island. The panel on the right shows the volume of lake water contained in each 1 meter layer of water by depth below the surface, a hypsographic profile. The important point of these data is that 50% of the lake water is located in the top 4 meters of the lake and only 10% of the lake volume is deeper than 10 meters in depth. Since the deep, anoxic water starts where the thermocline is formed at a depth of 10 meters, only 10% of the lake water is anoxic on a volume-adjusted basis. (An issue for future concern is the swallowing of the thermocline in future years. If conditions cause the thermocline to form at less depth by just a few meters, the volume of anoxic water could double.)

The contemporary issue with the thermocline formation and phosphate accumulation in the deep water is that episodic wind events can disrupt this simple model of a vertically stratified lake. Consider the south to north profile drawn as a yellow line on the left panel above. The next figure shows a vertical slice of the lake along this profile. Wind events in excess of 5 m/s from the north will move significant quantities of surface water from the north end of the lake southward. This water must be replaced causing a counter flow of deeper water to move north and upwell. This return flow entrains the deep, cold, high nutrient, low oxygen water from below the thermocline and carries it to the surface. We hypothesize that these deep-water upwelling events provide the necessary nutrients to feed the episodic Gloeotrichia blooms. Given a doubling rate of the amount of Gloeotricha of 0.6 day^{-1}, we would expect significant bloom events to follow an upwelling event by several days.

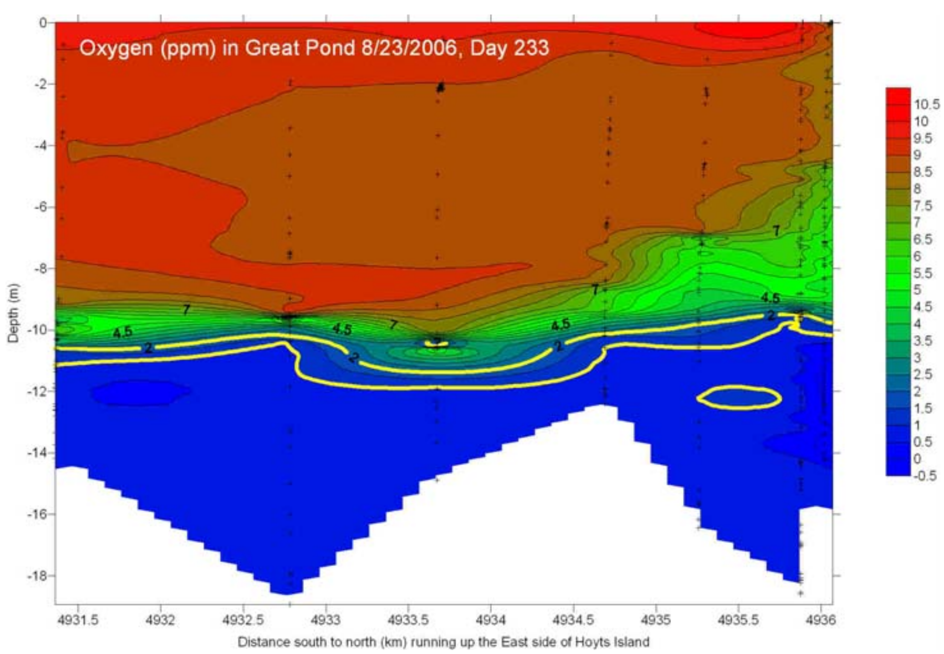


Cartoon of a Great Pond wind-induced mixing events. The profile is the actual depth of Great Pond measured along the yellow path (transect) from the south to the north end of the lake.

Throughout the summers of 2005 and 2006 our water column sampling of Great and Long Ponds was concentrated at two points on each lake. However, on August 23, 2006 a series of measurements were made along the profile shown above. These data show a clear upwelling of water at 4935.000 N demonstrated by the temperature and oxygen contours.

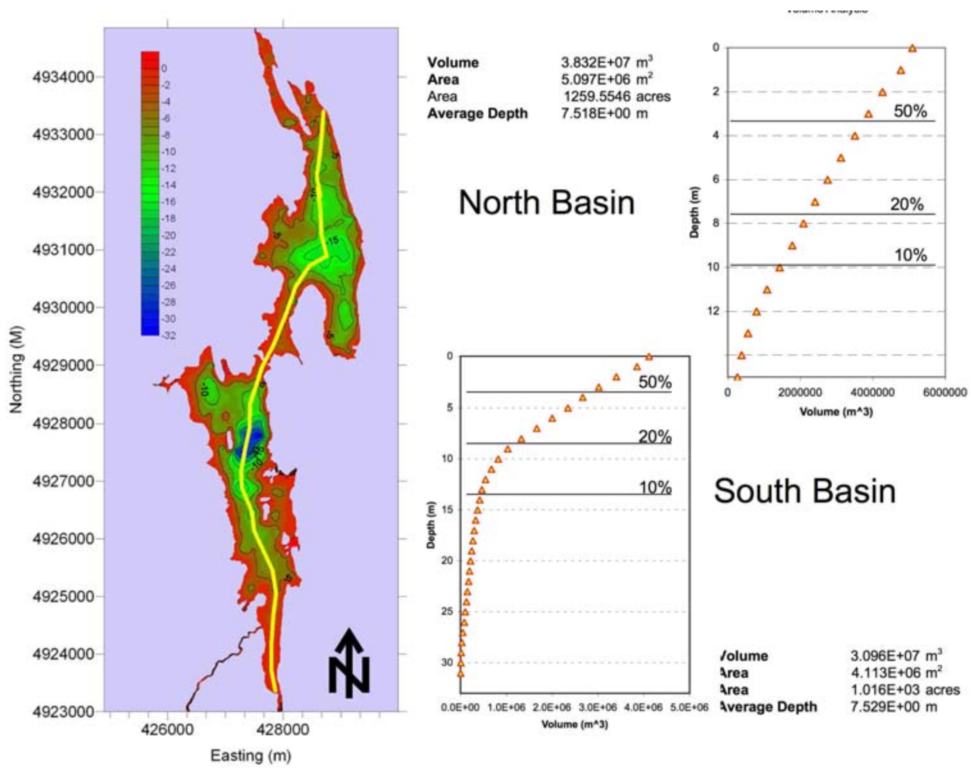


Temperature contour along a south to north transect on Great Pond, 8/23/2006. Notice the up-slope of the 22.5 °C isotherm.



Oxygen contour along a south to north transect on Great Pond, 8/23/2006. Notice the slope of 7 ppm oxygen contour reaching up to a depth of 4 meters on the north end of the lake. This implies that >30% of the water at 4 meters was mixed upward from the hypolimnion.

Three dimensions of Long Pond



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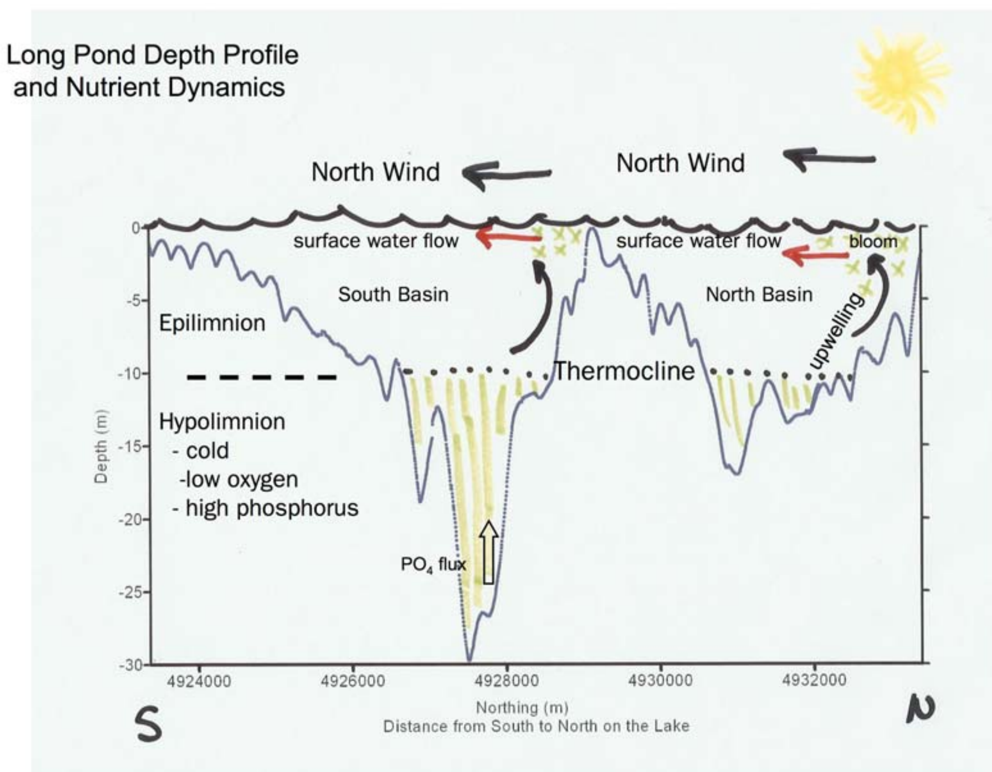
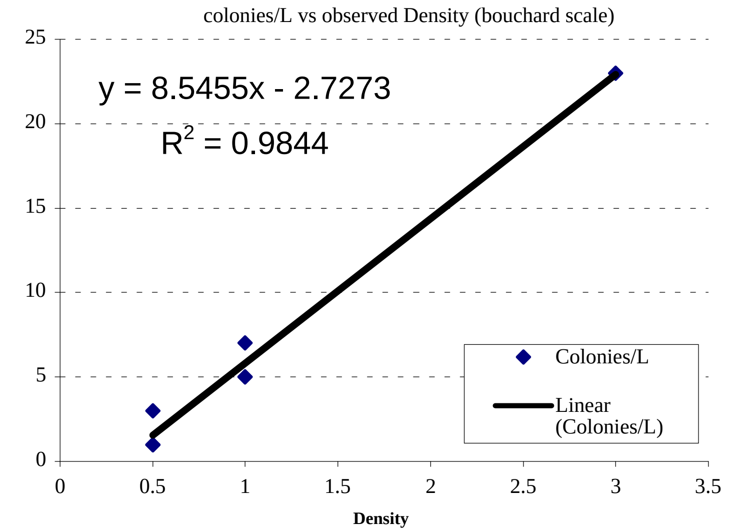


ARE THERE CHEMICAL CHANGES WITH THE GLOEOTRICHIA BLOOM?

On Phosphorous: We have calibrated the standardized estimates of Gloeotrichia abundance recorded by the BLA volunteers against actual counts of colonies.



Using this calibration and the observed vertical distribution of Gloeotrichia in the lake it is possible to estimate total colony numbers in the top 5 meters of the lake from the volunteer Gloeotrichia density measurements (scale 1 to 5 in Bouchard units). We estimate 5000 colonies/m^2 of lake area for each density interval. Using a value of 100 pg P/colony we obtain a phosphate flux in the lake of 0.1 ppb for each Gloeotrichia density interval. Even under significant bloom conditions (density = 5) the total phosphorus loading to the lake from Gloeotrichia is less than 1 ppb P. Nutrient loading from current Gloeotrichia blooms is minimal. This is good news about the nutrient dynamics of the lake as a whole. However, the low phosphate requirements for a significant Gloeotrichia bloom also means that small phosphorus inputs to surface water from wind-mixing has the potential to create significant blooms, in at least some parts of the lake.

On Nitrogen: Total nitrogen concentrations were measured in Great and Long Ponds. The data indicate that the nitrogen/phosphorus ratio is less than 8 (g/g), consistent with Gloeotrichia blooms. The low nitrogen concentrations reduce other green algae growth compared to Gloeotrichia because Gloeotrichia has the special ability to extract extra nitrogen from its environment.

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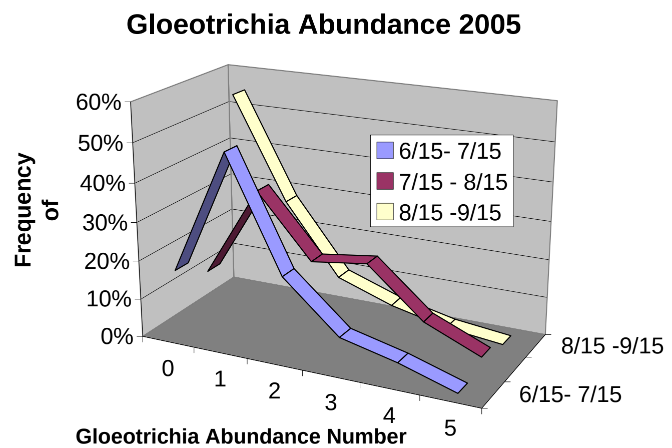
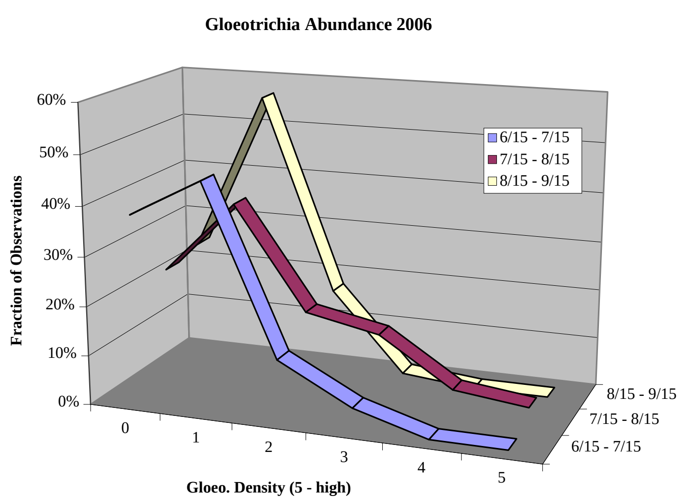
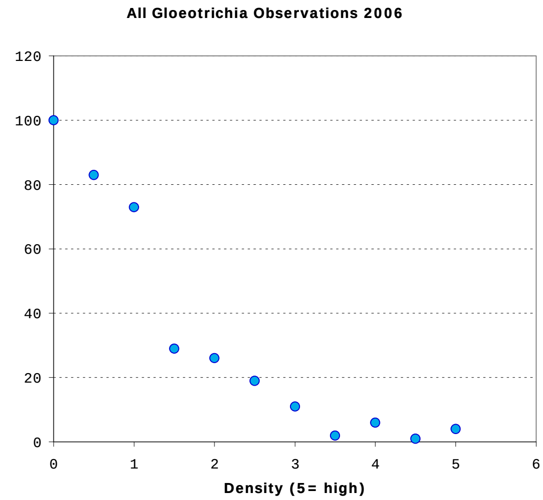
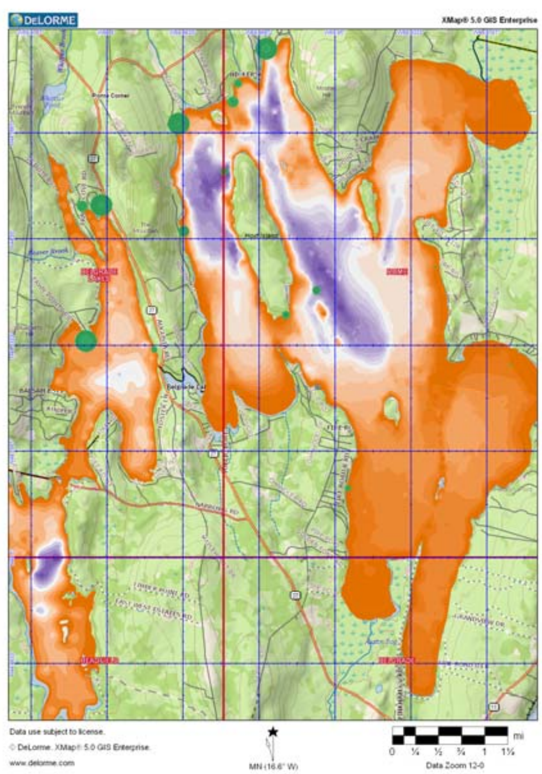
In 2005 and 2006 BLA volunteers and Colby researchers made over 1500 observations of Gloeotrichia density in the two lakes. The data show a clear temporal pattern in average Gloeotrichia abundance with maximum values during the first week of August. In general, the bloom was less severe in 2006.





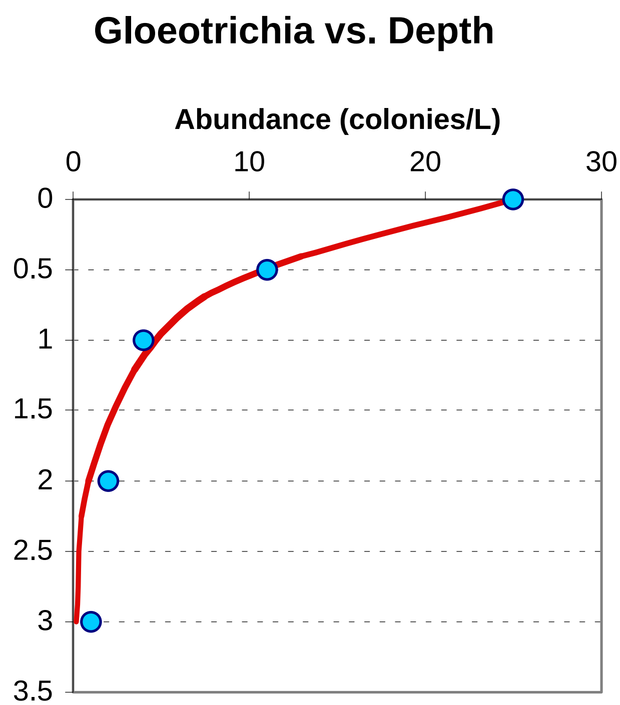


The spatial coverage is less well defined due to significant variations in Gloeotrichia distribution by day, often correlated with local wind. However, significant bloom events were almost always regionalized to the north ends of Great Pond and Long Pond. Wind transport alone does not explain Gloeotrichia spatial distributions because algal populations in the south end of the lake were always lower than the north end of the lake, in spite of the fact that wind patterns were equally distributed between north and south.



This spatial distribution is best illustrated in the 2006 volunteer data where the size of the green dots indicates bloom severity. Notice the lack of significant blooms in the south ends of both lakes.

Gloeotrichia densities were measured as a function of depth using a submersible pumping system. As shown in the figure below, 90% of the Gloeotrichia are concentrated in the top 2 meters of the lake. This implies that changes in total Gloeotrichia density in the lake (blooms) are due to changes in total colony numbers as opposed to vertical migration. Furthermore, vertical trap data from 2006 indicate that the sediments are a minor source of Gloeotrichia to the water column.

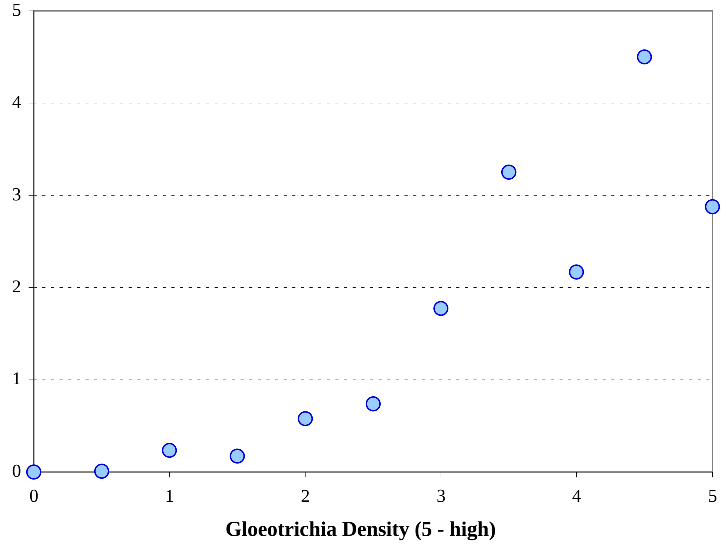


Go TOC

HOW IS GLOEOTRICHIA AFFECTING PUBLIC USE AND PERCEPTION OF WATER QUALITY?

Each of the BLA volunteer monitors measured both Gloeotrichia density and recreational impact of a bloom. These data are plotted below for all observations in 2006 (2005 looks the same).   It is a subjective judgment to define impact. There will be further analysis of the impact observations, but the majority of this high impact recordings was localized to the north shores of both lakes.

Would You Swim in the Lake? 2006



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BRIEFLY, WHAT ARE THE CONCLUSIONS OF THE STUDY?

- Recreational pleasure has been diminished by the bloom in some areas.
- Gloeotrichia is found everywhere in the lakes, but is concentrated along the north shores.
- Gloeotrichia bloom events are localized, episodic, and concentrated at the surface.
- Gloeotrichia is not loading P to the surface waters. Instead, small P additions will trigger blooms.
- Deep water adjacent to the north shores of both lakes enhances wind-induced upwelling of P, a probable cause of localized Gloeotrichia blooms.
- Gloeotrichia, and other nuisance algal blooms will likely get worse in the future.

Go TOC