I. Project Title: MERHAB 2002: Tier-Based Monitoring for Toxic Cyanobacteria in the Lower Great Lakes

a. Grant Number: PL-3103/OrAp-1208 (Award number NA16OP2788)

b. Amount of Grant (5yr): $ 3,622,350

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e. Award Period: 9/1/02 - 8/31/2008

II. Executive Summary

The MERHAB-Lower Great Lakes Project was a multi-investigator and multi-institutional project designed to look at a broad spectrum of monitoring and response techniques that could be used for toxic cyanobacterial blooms on Lake Ontario, Lake Erie and Lake Champlain. This project compared chemical and biological methods for toxin determination, classical taxonomy and molecular methods for identifying toxic and potentially toxic species, event-driven, formal bi-weekly, synoptic and volunteer based sample collection protocols, remote sensing techniques and the application of particle drift models to predict future movement of the blooms. It developed a broad based outreach program that has been used as a model by several of the Great Lakes Sea Grant programs and has generated widespread interest and visibility regarding toxic cyanobacteria in these essential resources.

The group participated in more than 65 research cruises between 2002 and 2008, plus hundreds of additional weekly, biweekly and spot sampling trips. Most important were the first every whole lake synoptic and temporal surveys of Lake Ontario, Lake Erie and Lake Champlain. More than 55 publications appeared in scientific journals to date; the project generated 11 M.S. and 5 Ph.D. dissertations, and MERHAB investigators gave more than 200 presentations at seminars, scientific meetings or workshops. The toxin analysis group established itself as a national presence and now collaborates and runs samples for Universities and Government health departments nationwide – providing a needed consistency in analytical methods. Tools were developed that help outside users track eventual movement of a bloom, use satellite imagery to gather whole lake information and provide valuable instruction in how to incorporate molecular techniques and citizen monitors into any future monitoring program.

III Purpose and Overarching Goals

The overall goal of this program is to develop a unified tier-based monitoring system for toxic cyanobacteria in the lower Great Lakes region. It was envisioned that this tier-based system would utilize a series of indicators or alerts, in which a positive response in one or more of these indicators would trigger a next or higher level of monitoring. This type of approach is not new to the HAB community. For example, monitoring for PSP toxins along the coast of Maine uses several indicator sites. Detection of either toxic algae, in this case *Alexandrium* species, or PSP toxin in shellfish collected from these sites, triggers more extensive shellfish collection and monitoring. Our goal was to develop a similar staged response for cyanobacteria toxins in the lower Great Lakes region, using chemical, biological and physical approaches.

It is important to recognize that the focus of this proposal was not to "explain" why harmful algal blooms occur in this region (e.g. ECOHAB); we accepted *a priori* that they will happen. Our focus is on the integration of detection and response protocols so that we can provide maximum protection to the public at a minimum cost. The end result was thus to evaluate and decide on cost effective "Alert" protocols that can be used to monitor for toxic cyanobacterial blooms, with each alert protocol triggering additional and sampling or analysis.

IV. Approach:

Our approach was to divide our study site into three distinct regions. These were (1) Lake Erie, This lake had well known toxic blooms of Microcystis in the western basin, but there was little available knowledge about the occurrence of cyanobacterial blooms in other regions of the lake, (2) Lake Ontario, this lake was characterized by eutrophic embayments along the nearshore, but virtually no knowledge about cyanobacteria populations in the more nutrient limited offshore waters. (3) Lake Champlain, This lake was essentially an aggregate of the issues with Lake Erie and Lake Ontario; namely it has a very eutrophic Missisquoi Bay region and a relatively nutrient poor main lake. It has had the most active citizen involvement of the three lakes and thus was an excellent site to test citizen monitoring protocols.

The project was divided into 7 working groups (listed below) with a totally of 28 specific objectives. Each working group was headed designated Co-PI and assisted by other Co-PI working in the region. To ensure coordination between investigators, an "All-PI" meeting was held every winter to allow the different laboratories to share findings and discuss common problems. These yearly meeting were supplemented by additional meetings during the sampling season between interested parties.

The specific working groups and their lead PI's were:

1. Lake Erie Working Group (project managers Wilhelm and Boyer)
2. Lake Champlain Working Group (project managers Watzin and Makarewicz)
3. Lake Ontario Working Group (project managers Boyer and Makarewicz)
4. Toxin Analysis Working Group (project manager Boyer)
5. Remote Sensing Working Group (project managers Hopkins and then Sultan)
6. Hydrodynamic Modeling working group (project manager Atkinson)
7. Education and Public Outreach Working Group (project manager O'Neill + all)

V. Task Descriptions and Key Findings

Task 1: Lake Erie Working Group (Project Managers Wilhelm and Boyer)

The objectives for this working group were as follows:

a. To investigate the spatial distribution of toxic *Microcystis* in Lake Erie.
b. To evaluate the chemical diversity of microcystin(s) produced *in situ*, especially as it affects the different assays for microcystins.
c. To evaluate the use of molecular markers for microcystin biosynthesis as monitoring tools for toxigenic species.
d. To evaluate the use of nutritional probes for iron, nitrogen and phosphorus as predictors for toxic cyanobacterial blooms and/or conditions likely to lead to such blooms.

When this project started, there was a very poor understanding of the bloom dynamics of toxic cyanobacteria in Lake Erie with only a single report of a microcystin-containing bloom in 1995. There was no understanding of their spatial distribution, if blooms were composed of toxic or non-toxic species, how to detect these species, and if toxins other than microcystin needed to be considered. All these questions were answered during the course of this work.

Table 1 Lake Erie Research Cruises

Year	Cruise Names (dates)
2002	MELEE VII (July 18-24th);
2003	MELEE VIII (July 21 – 25th), EPA-Western Basin (Aug 14-18)
2004	MELEE IX (July 12 – 15th), UToledo-GLC (Aug 17-20th)
2005	IFYLE-1 (May 11-15), IFYLE-2 (June 6-12), MELEE-Xa (July 11-14) IFYLE-3 (July16-19), IFYLE-4 (Aug 8-12), MELEE-Xb (Aug22-29), IFYLE-5 (Sept 7-10).
2006	MELEE-XI (Aug 10-18), EC-Hamilton (Aug 8), COSEE-LE (Jun 18-24)
2007	GLERL-1 (Jul 23-27), MELEE-XII (Aug 20-23), GLERL-2 (Sept 12-14)
2008	MELEE-XIII (Aug 5 – 10)

To address the spatial distribution of toxins in Lake Erie, MERHAB investigators participated in 19 research cruises on Lake Erie between 2002 and 2008 (Table 1). Especially notable were the IFYLE cruises in 2005 as this represented the first look at the spatial distribution of the cyanobacteria toxins on a whole lake basis over an entire summer season (objective 1a). A unified sampling protocol was developed for analysis of microcystins and the diversity of toxins was examine both spatially and temporally (objective 1b). While *Microcystis* in Lake Erie is predominately a microcystin-LR producer, this congener was not necessarily the sole or major congener, with microcystin RR and other congeners identified in these samples. This has implications for those laboratories using commercially available ELISA assays for their detection. A molecular method was identified to be able to identify potential microcystin producers and use of the *mcy*-A method for identifying the source organisms for microcystin production was developed (objective1 c). In addition, a quantitative PCR method was developed to tell what fraction of the *Microcystis* population actually contained the genes for toxin-production. These molecular methods have now become a standard operating procedure for looking at unknown populations of microcystin-producing organisms. They tell us that the issue

is much more complex than initially thought and that simple morphological examination, such as proposed by the WHO cannot be used to properly evaluate the risk from harmful cyanobacteria.

We also looked at nutritional effects and their impact on toxin production. Trace metals (Cu, Zn, Fe) did not impact microcystin production and nutrients *per se* were generally a poor predictor if the population was toxic or non-toxic. Total cyanobacteria populations in the western basin of Lake Erie are generally controlled by the bioavailability of phosphorus and to a lesser degree nitrogen and the results from the MERHAB project generally agreed with that observation. A temperature threshold was observed for toxic blooms in both Lake Erie and Lake Champlain and laboratory studies suggested that toxic strains may be selectively enhanced at elevated temperatures relative to non-toxic strains. This may have important implications in regards to future climate change scenarios.

Task 2. Lake Champlain Working Group (project manager Watzin)

The focus of this working group was:

a. To investigate the occurrence of anatoxin-a and microcystins in Lake Champlain, including the identification of the species responsible for toxin formation in this system.
b. To examine the correlation between blue-green algal density and toxin production.
c. To calibration and validate a rapid assay for anatoxin-a.
d. To evaluate cyanotoxin screening protocols for potential use by water treatment operators.
e. To develop training programs for water quality managers (joint with education).
f. To investigate the potential of using surrogate monitoring systems (mussel watch) as a monitoring tool for cyanobacteria toxins (also with Lake Ontario).

To address the spatial distribution of toxins in Lake Champlain (objective 2a), MERHAB investigators participated in 17 research cruises on Lake Champlain between 2002 and 2006 (Table 2). This was supplemented by extensive biweekly sampling coordinated between UVM and the Lake Champlain Basin Association. Lake Champlain provides special problems for whole lake synoptic sampling due to its large distance along its N-S axis. To get same day synoptic sampling, a series of sample blitzes was orchestrated between the three institutions at multiple times during the season in 2003, 2004 and 2005. Use of the WHO protocol was evaluated for use on Lake Champlain (objective 2b); it was successful with modifications for identifying event that required additional testing. A rapid assay for anatoxin-a was developed (objective 2c) but was not implemented due to technical difficulties in handling the assay. This remains an area for future research. Screening and training protocols for water treatment operators were developed and implemented (objectives 2d, 2e). We also used laboratory and field studies to investigate the potential of using surrogate monitoring systems such as zebra mussels. Dressenids fed on *Microcystis* with clearance rates similar to other comparable algae, but apparently metabolized the toxin within 24 hrs, thus limiting their use in a monitoring protocol. We are currently working to see if we can identify the metabolites as biomarkers of exposure is these mussels. We also investigated the use of a physical surrogate monitoring system, namely the cyanobacteria pigment phycocyanin via a ship board ferry box sensor. This allowed us to rapidly generate distribution maps of cyanobacteria that could be used to guide further sample. We are currently investigating the use of these autonomous monitoring systems on buoy's and/or ships located in Lake Ontario, Lake Erie and Lake Champlain.

Table 2. Lake Champlain Research Cruises

Year	Cruise Names (dates)
2002	Champs-0 (Aug 13-16) plus biweekly sampling by UVM.
2003	Champs -1 (June 30-July1), Champs-2 (Aug 12-14), Champs-3 (Sept 10-12), + UVM biweekly sampling.
2004	Champs-4 (Jul 7-8), Champs-5 (Jul 26-27), Champs-6 (Aug 17-18), Champs-7 (Sep14-16)
2005	Champs-8 (Jun 15-16) Champs-9 (Jul 6-7), Champs-10 (Jul 26-27), Champs-11 (Aug16-18)
2006	Champs-12 (Jul 12-14), Champs-13 (Jul 24-28), Champs-14 (Aug 7-9), Champs-15 (Sep 19-21), bi-weekly sampling by UVM
2007	Champs 16 (Jul 31-Aug 1), bi-weekly sampling by UVM, and spot SUNY-Plattsburgh
2008	bi-weekly sampling by UVM, spot sampling by SUNY-Plattsburgh

Task 3. Lake Ontario Working Group (project managers Boyer and Makarewicz)

In contrast to Lake Erie and Lake Champlain, Lake Ontario's deeper basin and oligotrophic nature results in much lower mid-lake phytoplankton densities. However, the surrounding embayments are highly productive and extensively eutrophied. This group focused on the role these embayments play as sources of toxins to the open waters. Specific objectives included:

a. To investigate the occurrence of toxic cyanobacteria in the Lake Ontario's embayments.
b. To investigate these embayments as a source of cyanobacteria and toxins to the open waters.
c. To investigate if Lake Ontario is a source of cyanobacteria toxins to the St. Lawrence River.

To investigate the spatial and temporal distribution of cyanobacteria toxins, MERHAB-LGL personnel participated in 19 cruises on Lake Ontario (Table 3). The Taste and Odor Cruises organized by Environment Canada offered a unique six year time span going to the same sites each year. These were supplemented by detail studies by Environment Canada scientists at specific locations such as Hamilton Harbor or the Bay of Quinte. Many of these samples are still be analyzed at this time but preliminary results from those cruises and supplement shoreline and by MERHAB personnel in studies conducted in 2004 and 2005 studies of the embayments along New York's northern shoreline suggest (a) these nearshore waters are not likely to be a major contributor to offshore cyanobacteria blooms (objective 3b). While these embayments generally have much higher productivity than the offshore waters, this productivity is not directly related to microcystin toxicity. Similar to what was observed in Lake Erie, we have a complex mixture of non-toxic, potentially toxic and toxic isolates coexisting (objective 3a) with some localized water bodies (Lake Neatahwanta) with very high concentrations of toxins. Molecular studies suggest that those toxic populations that are present within the embayments are distinct from the near-by open Lake waters, suggesting that there is limited exchange between the two locations. Similarly, there were very little cyanobacteria or their toxins (objective 2c) transported out of Lake Ontario to the St. Lawrence River. In those location where taste and odor or cyanobacterial toxins where observed in the river, this was generally due to local populations and not due to transport from the lake.

Table 3. Lake Ontario Research Cruises

Year	Cruise Names (dates)
2003	EC-ONT (Jul 14–18), LOLA-1 (Aug 8-11), LOLA-2 (Aug 19–21), Environment Canada (EC)-Taste & Odor (Aug 25–28).
2004	EC-Taste & Odor (Aug 30 - Sep 3), Oswego bi-weekly, Embayments (multi), EPA Finger Lakes Project (May-Oct)
2005	EC-Taste & Odor (Aug 29-Sep 2), Oswego and Embayments (Jun, Jul, Aug, Sep)
2006	EC-Taste & Odor (Aug 28-Sep 2),
2007	EC-Taste & Odor (Aug 27-31), EPA Finger Lakes Rivers project (May – Oct).
2008	EC Taste & Odor (Aug 25-29), LONNS 1,2,3,4,5,6,7,8,and 9, (multi), LOLA-1 (May 21-24), LOLA-2 (Jul 20-26), LOLA-3 (Sep 2-4), COSEE-LO (Jul 13-19).

Task 4. Toxin Analysis Working Group (project manager Boyer)

Because of the large number of different toxins that could potentially be present in these systems, we established a centralized toxin analysis facility to provide analytical support for all three working groups (Objective 4a). In addition, this working group had the following tasks:

a) To provide toxin analysis for all lakes, either in the form of direct analysis, or indirect support in the form of quality control and validation.
b) To develop a uniform analytical approach that is suitable for all major cyanobacteria toxins.
c) To evaluate the role of semi-qualitative field assays in a monitoring program.
d) To establish a rapid response team and protocols that can determine the presence or absence of toxigenic cyanobacteria in real time in response to potential HABs.

The toxin analytical group was very active, running more than 4300 samples for toxin analysis in support of the MERHAB sampling program (objective 4a) and another 4600 submitted by over 90 different Universities and government agencies across the US and Canada (objective 4d). An additional 3000+ samples were run by directly by other MERHAB investigators at UVM and SUNY-Brockport. The toxin analysis facility at ESF remains one of the few facilities nationwide capable of running all five classes of cyanobacterial toxins at a single location. As such, it served (and continues to serve) as a valuable analytical resource for investigators from around the world. MERHAB scientists were asked to respond to events ranging from sea-lion intoxications in California, a human poisoning in Canada and wildlife fatalities across the continent.

Considerable effort was put forward to develop a uniform analytical approach (objective 4b) published in 2007. Several new analytical techniques were developed (objective 4c) including the first reported quantitative analysis of peptides using MALDI-TOF mass spectrometry, and testing of a dipstick assay for microcystins that eventually turned out to be unsuitable for routine use. Other highlights include development of an internal standard for use with the extraction of free microcystins fish and animal tissue, and an estimate of the potential toxicity of bound microcystin in food.

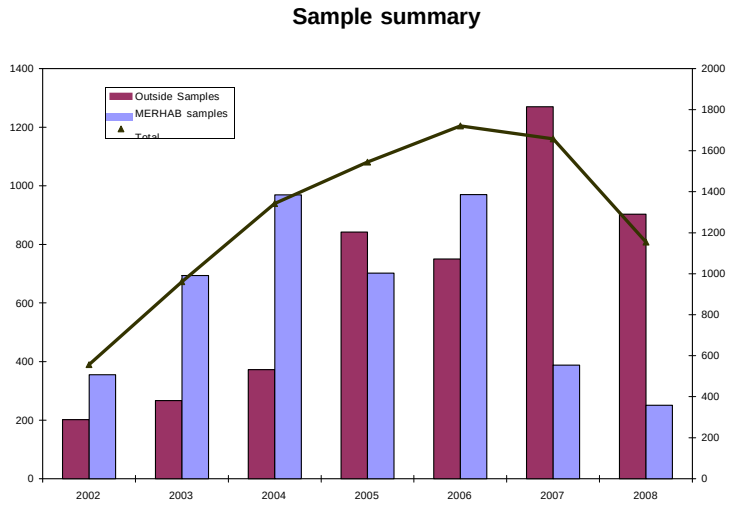

Figure 1. Distribution o f the samples run by the MERHAB-LGL analytical chemistry group by year. Blue represents samples generated by MERHAB investigators, Red are samples submitted by outside agencies. Services of this group continue to be in high demand nation-wide.

Task 5. Remote Sensing Working Group (project managers Hopkins/Sultan)

Remote sensing can help guide field sampling to make it more efficient and effective. In addition, remote sensing can effectively generalize sample data over space and time, rapidly determining the extent and intensity of blooms, and monitor temporal changes. To support the monitoring programs described above, the remote sensing working group was to provide the following:

a) To provide information on the occurrence/movement of phytoplankton blooms in the lower Great Lakes region.
b) To apply new remote sensing platforms to the occurrence of toxic cyanobacteria blooms.

This group was initially headed by Co-PI Hopkins, who unfortunately suffered a heart attach and died at the end of year 1. This set us back two years as we were unable to identify and fund another remote sensing specialist until year 1. At that time, Mohammed Sultan (UWM) joined the group and has been providing image support to the project (Objective 5a). That image support is now available online through an automated web-based GIS image processing and concentration extraction program located at http://www.esrs.wmich.edu/index.htm. Current plans are to keep this serve functioning into the near future. In addition, the remote sensing group has also rewritten some of the methodology for obtaining the algal pigment chlorophyll-a and the cyanobacteria-specific pigment phycocyanin from satellite imagery (objective 5b). This should provide for a better estimate of cyanobacteria bloom concentration in the future.

Task 6. Hydrodynamic Modeling working group (project manager Atkinson)

The specific tasks for the Hydrodynamic modeling working group were to:

a) To refine the configuration of POM for Lake Ontario and develop and link a particle tracking model.
b) To set up the overall modeling system structure, following the GLFS example.
c) Repeat the two objectives for Lake Erie and Lake Champlain.

The project proposed to develop a transport modeling capability that can be used to predict

the movement of an algal bloom in a lake with the overall goal being to set up a web page where, once a bloom has been identified, a user could specify the bloom location at a known point in time and run the model (combined POM and particle tracking) to predict the bloom trajectory over a given interval. This objective was successfully accomplished by Co-PI Atkinson for Lake Erie and Lake Ontario (Figure 2; objective 6a, 6b, 6c). That model is now running in real time on the SUNY-Buffalo computer system (http://www.eng.buffalo.edu/glp/merhab/) and available for public access by researchers and water quality personnel. We were unsuccessful in doing a similar model for Lake Champlain due to complications with the hydrology of the lake.

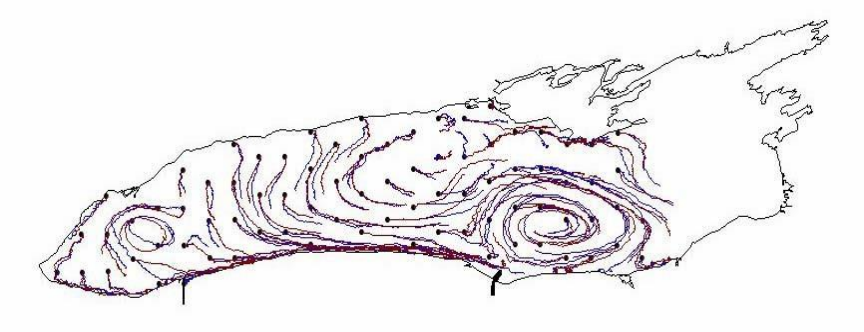

Figure 2. Tracking Model for Lake Ontario showing the release and movement of hypothetical particles. (Figure curtsey of Co-PI Atkinson)

Task 7. Education & Public Outreach Working Group (project manager O'Neill)

A key emphasis of this work was to provide accurate information to constituents including the general public, government, and non-government agencies. The outreach program was coordinated with ongoing efforts by New York Sea Grant, the Great Lakes Research Consortium and the Lake Champlain Research Consortium. Specific tasks included:

a) To develop a public awareness program for cyanobacteria toxins in the LGLR.
b) To inform and educate local environmental, health, and monitoring agencies of the analytical and predictive capabilities available through this MERHAB program.
c) To provide a central clearing house for information of toxic cyanobacteria and cyanotoxins in the LGLR. Included will be the integration of recent field studies into up to date information on management strategies, detection techniques, health risks, and what is likely to be an appropriate public response.
d) To have a yearly symposium specifically focusing on toxic cyanobacteria in the LGLR.
e) To offer technical workshops on toxin analysis and toxic species identification.
f) To provide research experience for graduate and undergraduate students.

By all accounts, MERHAB-LGL has been a very visible program operating in the Lower Great lakes Region. The MERHAB-LGL website was widely distributed to researchers, water quality managers and agency personnel and has served as an essential entry point into the entire MERHAB project (objective 7a, 7b, 7c). This site discusses the finding and services offered by the MERHAB investigators and more than 500 magnets displaying the address have been distributed at local and national events (Figure 3). The group has been very prolific in its publications (57), presentations (>200) at scientific conferences and has participated in more than 30 workshops and public meetings (objective 7e). The highlight was a series of three workshops, covering both the Lower Great Lakes (Erie and Ontario) and Lake Champlain regions that were presented across the state. Entitled "Toxic Algae - What Water Treatment Professionals Need to Know", these workshops were attended by government officials and water quality providers. MERHAB scientists were also asked to organize a number of high profile community events dealing specifically with toxic cyanobacteria blooms in the lower

Great Lakes and Lake Champlain. More detail on specific workshops is available in section VIIA(iv) below.

Figure 3. The MERHAB-LGL magnet advertising our website. Over 500 of these magnets were distributed an local national and international conferences.

In addition to holding workshops for our end users, MERHAB PI were all asked to attend a yearly meeting in Syracuse NY to specifically discuss issue and problems that arose between the individual research groups (Objective 7d). These were successfully held six of the seven years (last year was canceled due to a blizzard) and graduate students and post-docs were encouraged to attend and ask questions. These small symposia formed a critical part of their graduate education and training (objective 7f). At last count, more than 25 different graduate students and over 30 different undergraduate students from 15 different institutions have participated in MERHAB-LGL sponsored research. The project has directly supported 16 graduate degrees from the seven member campuses (section VIIA(iii) below). Many of those students presented their research findings local, national and international conferences. Several of those presentations won national (Rinta-Kanto, 2003/2004) and international (Smith 2007) awards.

Unanswered Questions and future work.

MERHAB-LGL was very successful in address its core mission, namely how do you monitor and respond to toxic cyanobacterial blooms in large lake ecosystems. The initial supposition was that we accepted *a priori* that these blooms were going to occur. The next step is to develop methods to predict and forecast the occurrence of these blooms. This will eventually lead to a better understanding of which conditions can be changed to reduce bloom frequency and intensity, and thus lead to direct management options. However we have several unanswered questions that need to be addressed prior to that goal:

- How does internal nutrient loading in Missisquoi and St. Albans Bays (Lake Champlain) or the western basin of Lake Erie contribute to bloom initiation and duration?
- How do water circulation patterns relate to water quality? Are blooms intensified by their being concentrated against an “immovable” object such as the Lake Erie Islands or the northern shore of Missisquoi Bay, or are they distributed lake-wide through the normal circulation patterns?
- How does mixing between lake segments affect water quality and distribution of cyanobacteria?
- Are there specific hot spots, Missisquoi Bay in Lake Erie, Maumee River outflow in western Lake Erie or the embayments of Lake Ontario that specific initiate and seed

blooms located throughout the lake?

- What is the relationship between nutrients and environmental factors on the growth of different subpopulations (toxic, potentially toxic and non-toxic) of Microcystis? What environmental factors trigger toxin production?
- What is the relative contribution of food web changes and top-down pressures on the development of these blooms?
- What is the causative organism producing anatoxin-a in Lake Champlain, Lake Erie and the embayments of Lake Ontario? Can we identify molecular targets for this organism similar to the mcy operon that can be used to separate toxic and non-toxic strains?
- We saw very little occurrence of the toxins cylindrospermopsin and paralytic shellfish toxins, despite the common occurrence of genera (*Cylindrospermopsis* and *Aphanizomenon* reported to produce these toxins. Was that because we were looking at the wrong genera, these genera lacked the necessary genes for toxin formation and were non-toxic, or the genes were present but environmentally silent.

A second area that still needs work is how we best communicate these finding to our target audience. While we developed a number of chemical, biochemical and taxonomic monitoring techniques, we still need to publish a reference volume that summarizes these techniques and brings them all into a common location. This would greatly facilitate their adaptation by the Great Lakes and harmful cyanobacteria community as a whole. In addition, we need to upgrade and maintain our current website to incorporate those finding. We envision that this site would also serve as a portal for access to the particle tracking, remote sensing and Lake Champlain websites. We are currently in negotiation with the Great Lakes Research Consortium at SUNY-ESF to arrange for them to continue to host the site.

VII. Applications

Many of the outcomes listed below where discussed above under key findings. For ease of reference, they are listed again here.

A. Outputs (numerics):

i. New Fundamental or Applied Knowledge

This project generated 57 publications, most if not all of that articulating new fundamental and applied knowledge. Key findings are presented in the publications list below and summarized n the sections on new tools and methodology [section A(iv) and A(v)] listed below.

ii. Scientific Publications (57)

Allender, C. J., G. R. LeCleir, J. M. Rinta-Kanto, R. L. Smith, M. F. Satchwell, G. L. Boyer, and S. W. Wilhelm (2009) Identifying the source of unknown microcystin genes and predicting microcystin variants by linking multiple genes within uncultured cyanobacterial cells. Appl. Environ. Microbiol. *in revision*.

Becker, R. H., M. I. Sultan, G. L. Boyer, M. R. Twiss, and E. Konopko (2009) Mapping cyanobacterial blooms in the Great Lakes using MODIS. J. Great Lakes Research. *in revision*.

Davis, T. W., D. L. Berry, G. L. Boyer, and C. J. Gobler (2008) The effects of nutrient loading and temperature on toxic and non-toxic strains of *Microcystis* during wild cyanobacteria blooms. Harmful Algae, *in revision*.

Makarewicz, J. C., G. L. Boyer, T. W. Lewis, W. Guenther, and M. Arnold (2009) Spatial distribution of the cyanotoxin microcystin in Lake Ontario ecosystem: Coastal embayments, rivers nearshore and offshore. J. Great Lakes Research. *in press.*

Rinta-Kanto, J. M., E. A. Konopko, J. M. DeBruyn, R. A. Boubonniere, G. L. Boyer, and S. W. Wilhelm (2009) Lake Erie *Microcystis*: relationship between microcystin production, dynamics of genotypes and environmental parameters in a large lake. Harmful Algae. *in press.*

Rinta-Kanto, J. M., M. A. Saxton, J. M. DeBruyn, J. L. Smith, C. H. Marvin, K. A. Krieger, G. S. Sayler, G. L. Boyer, and S. W. Wilhelm (2009) The diversity and distribution of toxigenic *Microcystis* spp. in present day and archived pelagic and sediment samples from Lake Erie. Harmful Algae. 8:385-394.

Smith, J. L., and G. L. Boyer (2009) Standardization of microcystin extraction from fish tissues: A novel internal standard as a surrogate for polar and non-polar variants. Toxicon. 53(2) 238-245.

Boyer, G. L. (2008) Algal Toxins and their Detection. In: "Shellfish Safety" S. Shumway, Ed., Woodhead, New York NY., *in press*

Boyer, G. L. (2008) Cyanobacterial toxins in New York and the Lower Great Lakes ecosystems. In: "Proceedings of the Interagency, International Symposium on Cyanobacterial Harmful Algal Blooms", H.K. Hudnell, ed. Adv. Exp. Med. Biol. pp 151-163.

Cohn, A. B., T.O. Manley, P.L. Manley, E. Smeltzer, and M. C. Watzin. 2008. Lake Champlain. Invited profile in Lakeline, Winter 2007-2008, 46-56.

Couture, S.C. and M.C. Watzin. 2008. Diet of invasive adult white perch (*Morone americana*) and their effects on the zooplankton community in Missisquoi Bay, Lake Champlain. J. Great Lakes Research 34:485–494.

de la Cruz, A. A., P. Rublee, J. M. Hungerford, P. V. Simba, S. W. Wilhelm, J. A. O. Meriluoto, K. Echols, M. T. Meyer, G. Stelma, R. Mandeville, L. Lawton, K. Sivonen, and A. Furey (2008) Analytical methods work group report. In: "Proceedings of the Interagency International Symposium on Cyanobacterial Harmful Algal Blooms" H. K. Hudnell, Ed., Adv. Exp. Med. Biol., pp. 475-488.

Fristachi, A., J. L. Sinclair, J. A. Hambrook-Berkman, G. Boyer, J. Burkholder, J. Burns, W. Carmichael, A. du Four, W. Frazier, S. L. Morton, E. O'Brien, and S. Walker (2008) Occurrence of Cyanobacterial Harmful Algal Blooms. Proceedings of the Interagency, International Symposium on Cyanobacterial Harmful Algal Blooms, H.K. Hudnell, ed. Adv, Exper. Med. Biol. pp. 37-97.

Gobler C.J., T.W. Davis, S.N. Deonarine, M.A. Saxton, P.J. Lavrentyev, F.J. Jochem and S.W. Wilhelm. (2008) Zooplankton and viral induced mortality of microbial populations before and during the onset of hypoxia in Lake Erie. Aquatic Microbial Ecology 51:117-128.

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iii. MS and Ph.D. Dissertations (16)

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Becker, R. H. (2008) Remotes sensing studies for the assessment of geohazards: Toxic Algal Blooms in the Lower Great lakes and Land Subsidence in the Nile Delta. PhD. Thesis,. Western Michigan University.

Hotto, A. (2007) Application of Molecular Techniques to the Detection of Potential Microcystin-producing organisms in New York State Waters. Ph.D. thesis. State University of New York, College of Environmental Science and Forestry. 166p.

Howard, K. (2007) Quantitative Analysis of Cyanobacterial Toxins by MALDI-TOF Mass Spectrometry. Ph.D. Thesis, State University of New York, College of Environmental Science and Forestry. 180p.

Konopko, E. (2007) Development of a flow-through fluorometric system for the detection of phycocyanin in the lower Great Lakes. M.S. Thesis, State University of New York, College of Environmental Science and Forestry. 151p.

Yang, X. (2007) Occurrence of a cyanobacterial neurotoxin, anatoxin-a in New York State waters. Ph.D. Thesis, State University of New York, College of Environmental Science and Forestry. 230p.

Kuchikulla, P. (2006) Applications of particle tracking model for large lakes. M.S. Dissertation, State University of New York at Buffalo.

Rinta-Kanto, J. (2006) Biogeography and genetic diversity of toxin producing cyanobacteria in a Laurentian Great Lake. Ph.D. Dissertation, University of Tennessee. 197p.

Stephen, P. (2006) Mapping chlorophyll a concentrations in Oneida lake, New York using remote sensing and a semi-analytical reflectance model as a proxy for detecting harmful algal blooms. M.S. Thesis, State University of New York, College of Environmental Science and Forestry. 103p.

Gandhi, Kavin (2006), "Conceptual Framework for Coupled Hydrodynamic/Algae Population Dynamics Model for Large Lakes", M.S. thesis, Dept. Civil, Structural and Environ. Eng., Univ. at Buffalo, September, 91 pp.

Kuchikulla, Preetam (2006), "Applications of Particle Tracking Model for Large Lakes", M.S. thesis, Dept. Civil,

Structural and Environ. Eng., Univ. at Buffalo, February, 279 pp.

Brines, E. (2004). The effects of zebra mussels on the lower plank tonic food web of Lake Champlain. MS Thesis, University of Vermont. 117 pp.

Efteland, S. P. (2004) The effects of iron on the growth and physiology of the cyanobacterium *Microcystis aeruginosa*. M.S. Dissertation, University of Tennessee. 56p.

Somarelli, J. (2004) Identification of E. coli sources in Conesus lake wub-watersheds using box AIR-derived genetic fingerprints. M.S. thesis, The College of Brockport. Brockport, NY 64pp.

Szprygada, Kristy (2004) Investigating the use of Zebra Mussels, *Dreissena polymorpha*, as a biomonitoring tool for toxic cyanobacterial blooms. M.S. Fisheries Biology, SUNY-ESF.

Prakash, Shwet (2004), "Semi-Lagrangian Evaluation of Circulation and Transport in Lake Ontario", M.S. thesis, Dept. Civil, Structural and Environ. Eng., Univ. at Buffalo, February, 235 pp.

iv. New Methods or Technology (highlights)

- Development of a quantitative MALDI-TOF method for analysis of microcystins (Howard and Boyer, 2006).
- Development of an enzyme linked immunoassay for anatoxin-a (Boyer et al, in preparation).
- Identifying the source of unknown microcystin genes and predicting microcystin variants by linking multiple genes within uncultured cyanobacterial cells. (Allender et al, 2009).
- Development of mcy-A as a tool to indentify the potential source species for microcystin-protduction *in situ* (Rinta Kanto and Wilhelm, 2006)
- Development of a standardized method for cyanobacterial toxin extraction and a tier-based protocol for its analysis (Boyer, 2007)
- Development of a internal standard for extraction of free microcystins from fish tissue (Smith et al, 2008)

v. New or Advanced Tools (highlights)

- Development of a Citizens monitoring protocol for cyanobacteria toxins (Watzin et al, 2007)
- Development of a rapid cell counting protocol (
- Pioneered the use and developed with Vermont DOH an intergrated website that can be used to alert the public to the dangers of toxic cyanobacteria (Watzin; see http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx)
- Mapping cyanobacterial blooms in the Great Lakes using MODIS (Becker et al, 2009)
- Application of Ferry-boxes for detection of cyanobacterial blooms in the Great Lakes and Lake Champlain (Boyer et al 2007; MiHuc et al in preparation).
- Development of a semi-Lagrangian study of circulation and transport in Lake Ontario (Prakash et al, 2007) and Lake Erie.
- Development of a user accessable website to provide ready access to satellite imagery for Lake Erie and Lake Ontario (http://www.esrs.wmich.edu/index.htm)

vi. Workshops.

The MERHAB-LGL project presented a large number of formal (we organized and conducted) as well as informal (we were asked to participate at someone elses) workshops. Most of these were listed in the individual yearly progress reports or are listed in the section on presentations

(section VIIA(vi) below. For that reason, they will not be repeated here. Highlights included:

- Presented an invited presentation at EPA's Federal-State Toxicology and Risk Analysis Committee (FASTC) Meeting, Arlington VA, entitled "Toxic Algae with an Emphasis on Cyanobacteria" (2002)
- Presented workshop entitled "Cyanobacteria in Lake Champlain: Identifying Blooms and Potential Health Risks" to public health officials in the Lake Champlain area on September 19, 2002.
- Governor's Summit on Lake Champlain (Mary Watzin) December 2, 2003
- Public meetings held for citizens concerned about toxic cyanobacteria blooms (Mary Watzin) July 8, 2003, August 28, 2003
- Invited presentation at the Second International Symposium on Harmful Marine Algae in the US (G L. Boyer) December 2003
- Workshop for the Revision of the National Plan for Harmful Algal Blooms, Charleston SC, (G. L. Boyer) March 20-26th (Member of the steering committee)
- Missisquoi Bay volunteers training workshop. (Mary Watzin) July 1, 2004
- Public meetings held for citizens concerned about toxic cyanobacteria blooms (Mary Watzin, Emily Brines and Angela Shambaugh) May, June, and October 2004.
- Combating Terrorisms; New Techniques for the detection of Chemical, Biological and Radiological Agents. Conference, (Boyer) University of Rochester. June 3 2004.
- Third International Symposium on Harmful Marine Algae in the US (G L. Boyer) December 2004
- Lake Erie Science Planning Workshop, hosted by the Great Lakes Environmental Research Lab in Ann Arbor, MI, (J. Atkinson) March 4-5, 2004.
- 3rd International Symposium on Harmful Marine Algae in the US (Boyer) Oct 2, 2005
- International Field Year on Lake Erie Planning Workshop, hosted by the Great Lakes Environmental Research Lab in Ann Arbor, MI, (Boyer, Wilhelm) March 4-5, 2004.
- Update on microcystin work in Conesus Lake to Livingston County Health and Planning Department, January, 2006 (Makarewicz).
- Presentation on MERHAB research at Conesus Lake Day, Vitale Park, Lakeville, NY, July 2005 (Makarewicz).
- Presentation to Silver Lake Association on the developing a Tier-Response system for Silver Lake toxic blooms, Silver Lake, NY, May 2005 (Makarewicz).
- Presentation to Silver Lake Association on microcystins and algae blooms. (Makarewicz) Silver Lake, NY, July 23 2005.
- Presentation to NOAA AIS Database Summit, Stone Marine Lab, Put-in-Bay, OH Sep 13, 2005 (O'Neill).
- Presentation to National Invasive Species Advisory Committee (O'Neill), Washington, DC, Oct 12, 2005.
- Presentation on Public Health Issues and BGA Blooms in Missisquoi Bay. Friends of Missisquoi Bay and VT Citizen's Advisory Committee Public Workshop (Watzin). Swanton, VT, May 2005. Also led discussion/ Q&A.
- Presentation on Cyanobacteria and Lake Champlain (Watzin). Friends of Missisquoi Bay Annual Meeting, Swanton, VT, May 2005.
- Presentation on Blue-green Algae in Lake Champlain (Watzin). Public Meeting sponsored by VT Dept. of Health, Swanton, VT. June 23, 2005.

- Presentation on Blue-green Algae in Lake Champlain – 2004 Summary of Monitoring Results (Watzin). Lake Champlain Basin Program Technical Advisory Committee Meeting. September 2005.
- Presentation on Cyanobacteria Abundances, Cyanotoxin Concentrations and Nutrient distribution in Missisquoi Bay (Watzin). Lake Champlain Research Consortium PRIME meeting on Missisquoi Bay research and results. September 2005.
- Summary of Issues Surrounding Blue-green Algae in Lake Champlain (Watzin). VT Citizens Advisory Committee Meeting. November 14, 2005.
- Meeting with VT Dept. of Health to discuss cyanobacteria monitoring, communication coordination and outreach (Watzin), Burlington VT, February 2005
- Meeting with water suppliers and the Association of Water System Managers at the Champlain Water District to discuss BGA monitoring and alert framework and develop communications email list (Watzin), Burlington VT, May 2005
- "Voices of the Lake" public meeting at ECHO (Watzin). Display on toxic cyanobacteria, with fact sheets and microscope viewing opportunity. Burlington VT, June 25-26, 2005
- "Naturally produced noxious chemicals and toxins in the Great Lakes. State of the Lake Ecosystem (SOLEC- 2006). Milwaukee WI, November 2006 (Watson and Boyer).
- "Harmful Algal Blooms in the Great Lakes", A resource workshop for government officials, SOLEC -2006, Milwaukee WI November 2006 (Boyer).
- "Toxic Algae - What Water Treatment Professionals Need to Know", a series of three workshops, covering both the Lower Great Lakes (Erie and Ontario) and Lake Champlain regions were presented at SUNY-ESF (May 5th 2006), SUNY College at Brockport (May 12th 2006) and University of Vermont (May 18th 2006). (O'Neill, Boyer, Makarewicz, Watzin).
- "Nutrient Status of the Coastal Zone of Lake Ontario". Presented at the Lake Ontario Contaminant Monitoring, Modeling and Research Workshop. 27 and 28 March 2007. Sponsored by the USEPA and Ontario Ministry of the Environment (Makarewicz).
- "People and the Land: Impacts on Water Quality. Unifying Economic Development and the Environment Conference. Finger Lakes-Lake Ontario Watershed Protection Alliance, 2007 Rochester, NY (Makarewicz)
- Molecular characterization of toxic cyanobacterial communities in the lower Great Lakes: a seven year synopsis. Presented at the US Conference on Harmful Algae. Woods Hole, MA October 2007 (Wilhelm)
- Platform and student-award winning presentations at the 7th International Conference on Toxic Cyanobacteria, Rio de Janeiro, Brazil, August 2007 (Boyer, Smith).
- "Lake Erie". Presented at the State of the Lake Ecosystem Conference. Niagara Fall, October 2008. sponsored by Environment Canada, US EPA and the IJC (Boyer).
- Toxic cyanobacteria in the Laurentian Great lakes - an overview of the past and a look glass to the future. Presented at the US EPA Toxicology and Risk Assessment Conference,. Cincinnati OH, April 2008 (Wilhelm and Boyer)
- Climate change and food webs in the Great Lakes: Implication for the changing seasons. Michigan State University Conference on Climate Change in the Great Lakes Region. East Lansing, MI, April 2008. (Wilhelm)
- Harmful algal blooms, A Public dialog and discussion session at the CAWQA public dialogs, Feb 2008, Burlington Ontario (Boyer)

- Newer Analytical Techniques and the Development of Automated Monitoring Programs. EPA Conference "Emerging Aspects on Freshwater Harmful Cyanobacterial Blooms and their Effects on Drinking Water. Cincinnati OH, November 2008 (Boyer)

vii. Presentations at local, national and international meeting by year (198)

2009 (partial)

Boyer, G. L., J. S. Smith, J. L. Gibson, and M. F. Satchwell (2009) New Approaches for Assessing the Risk from Microcystin-Contaminated Fish. Abstracts, Intl Assoc Great Lakes Research. Toledo OH, May 2009.

Boyer, G. L., and J. Smith (2009) Cyanobacteria toxins in Fish: Implications for Human Health and Safety. Abstracts, Gordon Research Conference on Mycotoxins and Phycotoxins. Colby-Sawyer College, June 2009.

Edwards, W., J. Atkinson, S. Thomas, M. Pavlac, G. Boyer, T. Lewis, J. Makarewicz, C. Pennuto, C. Basiliko, and M. Clapsadl (2009) Lake Ontario Nearshore Nutrient Transport Study (LONNS): hydrodynamics of the nearshore region. Abstracts, Intl. Assoc. Great Lakes Research. Toledo, OH, May 2009.

Makarewicz, J. C., T. Lewis, C. Pennuto, G. Bloyer, and W. Edwards (2009) Nearshore nutreint chemistry of lake Ontario. Abstracts, Intl. Assoc. Great Lakes Research. Toledo, OH, May 2009.

Pavlac, M. M., T. T. Smith, S. P. Thomas, and G. L. Boyer (2009) Application of continuous monitoring in the lake Ontario Nearshore Nutrient Survey. Abstract, Intl Conference on Great Lakes Research. Toledo, OH May 2009.

Pennuto, C. M., C. P. Janik, A. Fischer, C. Basiliko, and J. Makarewicz (2009) Cladophora, gobies and mussels, oh my: A LONNS update on their distribution and abundance in nearshore Lake Ontario. Abstracts, Intl. Assoc. Great Lakes Research. Toledo, OH, May 2009.

2008

Allender, C. J., and S. W. Wilhelm (2008) Identifying the source of unknown microcystin genes and predicting microcystin variants by linking multi-gene diversity within uncultured individual cyanobacteria. Abstracts, Intl Assoc. Great Lakes Research. Peterborough, ONT, May 2008.

Boyer, G. L. (2008) Blue green algae and you: Separating fact from fallacy. Canadian Center for Inland Waters, Public dialogs. Burlington ONT, Feb 12 2008.

Boyer, G. L. (2008) Harmful Algal Blooms in the Great Lakes; it is not just a marine issue. Seminar, Raymond Andersen Natural Products and Drug Discovery Symposium. Vancouver, BC July 26th, 2008.

Boyer, G. L. (2008) Science Cafe: "The Great Lakes - Global Warming - Energy". Seminar. Oswego NY, September 18th 2008.

Boyer, G. L. (2008) Toxic Cyanobacteria in the Great lakes: Problems, Issues and Solutions:. Seminar. SUNY-Geneseo, Oct 3, 2008.

Boyer, G. L. (2008) The Future of the Lake Ontario Ecosystem: Is there a crystal ball? Workshop. SUNY-Oswego, November 8, 2008.

Boyer, G. L. (2008) Newer Analytical Techniques and the Development of Automated Monitoring Programs. EPA Conference "Emerging Aspects on Freshwater Harmful Cyanobacterial Blooms and their Effects on Drinking Water. Cincinnati OH, November 18, 2008.

Boyer, G., M. Satchwell, R. Damon, A. Hotto, and X. Yang (2008) Analysis of cyanobacteria toxins in Lake Champlain; What this tells us about harmful algal blooms in other large lake ecosystems. Abstract, Int. Assoc. Great Lakes Res. Trent Ont., May 2008.

Boyer, G., M. Satchwell, R. Damon, A. Hotto, and X. Yang (2008) Distribution and molecular analysis of cyanobacteria toxins in lake Champlain: a 5-year review. Abstracts, Lake Champlain Research Conference. Burlington VT, January 8, 2008.

Boyer, G. L., and X. Yang (2008) Photochemistry of the cyanobacteria neurotoxin Anatoxin-a: What that means for Lake Champlain. Abstracts, 37th Northeast Regional Meeting American Chem. Soc. Burlington, VT June 2008.

Boyer, G., X. Yang, and S. Thomas (2008) The occurrence of anatoxin-a and other cyanobacterial toxins in Lake Erie and Lake Ontario: It is more than just microcystins. Abstracts, 43rd Canadian Symposium on Water Quality Research. Burlington ONT, February 11, 2008.

Boyer, G. L., and S. W. Watson (2008) Lake Erie. Seminar, State of the Lake Ecosystem Conference. Niagara Fall, October 2008.

Druschel, G.K., L.G. Smith, M. Melchiors and M.C. Watzin (2008) Redox Chemistry and Internal Nutrient Loading Mechanisms across the Sediment-Water Interface In Lake Champlain Bays. Abstracts, 37th Northeast Regional Meeting of the American Chemical Society, Burlington, VT, June 29-July 2.

Kohanski, T. D., G. L. Boyer, and M. R. Twiss (2008) Testing the limits of the BBE FluoroProbe to measure phytoplankton. Abstracts, Great Lakes Research Consortium. SUNY-ESF, March 14, 2008.

Makarewicz, J.C. (2008) Lake Ontario 2008 Intensive Sampling/Cooperative Monitoring Year. The Lake Ontario Nearshore Zone: Status and assessment Needs. Center for Inland Waters, Burlington, Ontario.

Pavlac, M. M., and G. L. Boyer (2008) Monitoring of cyanobacteria in the Lower Great Lakes using real time fluorescence. Abstracts, Great Lakes Research Consortium Annual Conference. SUNY-ESF, March 14 2008.

Pavlac, M. M., and G. L. Boyer (2008) Monitoring cyanobacteria in the lower Great Lakes using continuous real-time fluorescence. Abstract, SUNY-ESF Graduate and undergraduate research Symposium. Syracuse NY April 2008.

Pavlac, M. M., and G. L. Boyer (2008) Monitoring of cyanobacteria in the lower Great lakes using Real-time fluorescence. Abstracts, Int. Assoc. Great Lakes Res. Annual Conference. Trent, Ont. May 2008.

Saxton, M. A., D. Truitt, R. M. L. McKay, R. A. Bourbonniere, and S. W. Wilhelm (2008) Defining the role(s) of phosphorus in promoting toxic cyanobacterial blooms. Abstracts, Intl. Assoc. Great Lakes Research. Petersborough, ONT, May 2008.

Smith, J. L., K. L. Schultz, and G. L. Boyer (2008) The two step detoxification pathway of microcystins in fish. Abstracts, SUNY-ESF Graduate and undergraduate research symposium. Syracuse NY, April 2008.

Smith, T. T., and G. L. Boyer (2008) Effects of salt concentrations on the growth and toxin production in the cyanobacterium Microcystis aeruginosa. Abstracts, SUNY ESF Graduate and undergraduate research symposium. Syracuse NY April 2008.

Sullivan, J. M., J. A. Liberatore, and G. L. Boyer (2008) Carotenoid pigment signatures in the blue green algae Microcystis aeruginosa. Abstracts, SUNY-ESF Graduate and undergraduate research symposium. Syracuse NY April 2008.

Sunkin, M. D., and G. L. Boyer (208) High performance liquid chromatography analysis of paralytic shellfish poisons (PSP) found in cyanobacteria Lyngbya samples from Lake Erie NY. Abstracts, SUNY-ESF Graduate and undergraduate research symposium. Syracuse NY April 2008.

Thomas, S. P., J. Jones, C. Pershyn, E. Allen, M. Greene, T. B. Mihuc, M. F. Satchwell, and G. L. Boyer (2008) A geospatial mapping method to detect Lake Champlain cyanobacteria blooms. Abstracts, Int. Assoc. Great Lakes Res. Trent Ont., May 2008.

Watzin, M.C. (2008) Managing Phosphorus In the Lake Champlain Basin - the Importance of An Adaptive Management Approach. Abstracts, 37th Northeast Regional Meeting of the American Chemical Society, Burlington, VT, United States, June 29-July 2.

Watzin, M.C. (2008) A Systematic Approach to Monitoring and Managing Cyanobacteria Blooms in Lake Champlain., Les Algues Bleu-Vert: Symposium sur une gestion concertée environnement et santé, Quebec City

Wilhelm, S., and G. L. Boyer (2008) Toxic cyanobacteria in the Laurentian Great lakes - an overview of the past and a look glass to the future. US EPA Toxicology and Risk Assessment Conference,. Cincinnati OH, April 2008

Wilhelm, S. W. (2008) Climate change and food webs in the Great Lakes: Implication for the changing seasons. Michigan State University Conference on Climate Change in the Great Lakes Region. East Lansing, MI, April 2008.

2007

Becker, R. (2007) Satellite mapping of cyanobacterial blooms in the lower Great Lakes, Marquette University Physics Colloquium, Mar 1, 2007

Becker, R.H., Integrating Remote Sensing Techniques in Surface Processes Studies of the Lower Great Lakes and the Nile River Watershed, Dec 2007, University of Toledo, Department of Environmental Sciences

Becker, R., M. Sultan, G. Boyer, M. Twiss, and E. Konopko (2007) Mapping cyanobacterial blooms in the lower great lakes from MODIS and SEAWIFS data. Abstracts, American Soc. Limnol. Oceanogr. Santa Fe, February 4, 2007.

Becker, R., M. Sultan, G. Boyer, M. Twiss, and E. Konopko (2007) Mapping cyanobacterial blooms in the lower great lakes from MODIS and SEAWIFS data. Abstracts, Int. Assoc. Great Lakes Research Annual Meeting. University Park, PA; May 28th 2007

Boyer, G. L. (2007) The History and Mission of the State University of New York's Great Lakes Research Consortium. Abstracts, Int. Assoc. Great Lakes Research Annual Meeting. University Park, PA; May 28th 2007.

Boyer, G.L. (2007) Toxic Algae in the Great Lakes, Problems, issues and solutions, Cornell University, November 2 2007

Boyer, G. L., K. L. Howard, and M. F. Satchwell (2007) Quantification of particulate microcystins in natural waters using MALDI-TOF and ESI mass spectrometry. Abstracts, 7th Internal Conference on Toxic Cyanobacteria,. Rio de Janeiro, Brazil, August 10, 2007.

Boyer, G. L., and J. Dyble (2007) Harmful Algal Blooms, A newly emerging pathogen in water. White Paper, Michigan State University Water Fellows Program. East Lansing, MI, March 1, 2007.

Boyer, G. L., J. Makarewicz, M. C. Watzin, S. W. Wilhelm, and T. B. Mihuc (2007) Development of a Unified Monitoring Strategy for Cyanobacterial Toxins in Large Lake Ecosystems. Abstracts, Int. Assoc. Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Boyer, G. L., X. Yang, and J. Liberatore (2007) The occurrence of anatoxin-a and other cyanobacterial toxins in lake Erie and Lake Ontario: It is more than just microcystins. Abstracts, Int Assoc. Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2007) Relationship between microcystin potential and environmental variables in Lakes across New York State. Abstracts, 4th US conference on Harmful Algae. Woods Hole MA, October 2007.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2007) Relationship between microcystin potential and environmental variables in lakes across New York State. Abstracts, 7th Intern. Conf. Toxic Cyanobacteria. Reo De Janeiro, Brazil, August 6, 2007.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2007) Characterization of Lake Ontario embayments for potential microcystin production and a unique mcyA genotype. Abstracts Great Lakes Research Consortium Annual Meeting. Syracuse NY March 16, 2007.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2007) Molecular characterization of Lake Ontario embayments using multiple microcystin specific PCR primers reveals the potential for microcystin production and a unique mcyA genotype. Abstracts, Intl. Assoc, Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Howard, K., M. F. Satchwell, and G. L. Boyer (2007) New Tricks with old Toys: Application of Mass Spectrometry to the Analysis of Peptide Toxins. Abstracts, 4th US Conference on Harmful Algae. Woods Hole, MA October 2007.

Howard, K. L., and G. L. Boyer (2007) Quantitative MALDI-TOF Analysis of cyanobacterial toxins. Abstract. Pittcom 2007.

Makarewicz, J.C. (2007) Lake Ontario Contaminant Monitoring, Modeling and Research Workshop. Grand Island Holiday Inn. 27 and 28 March 2007. "Nutrient Status of the Coastal Zone of Lake Ontario". Sponsored by the USEPA and Ontario Ministry of the Environment.

Makarewicz, J.C. (2007) "People and the Land: Impacts on Water Quality. Unifying Economic Development and the Environment Conference. Finger Lakes-Lake Ontario Watershed Protection Alliance, Rochester, NY

Mihuc, T., S. Thomas, G. Boyer, M. Satchwell, J. Jones, C. Pershyn, and M. Greene (2007) A geospatial mapping method to detect Lake Champlain cyanobacteria blooms. Abstracts, Societas Internationale Limnologie. Montreal Canada, August 2007.

Pavlac, M. M., and G. L. Boyer (2007) Application of ship-board real-time fluorescence for the detection of cyanobacteria in Lake Erie. Abstracts, Intern. Assoc. Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Pershyn, C., S. Thomas, T. B. Mihuc, G. Boyer, M. Satchwell, J. Jones, and M. Greene (2007) A geospatial mapping method to detect Lake Champlain cyanobacteria blooms. Abstracts, Sigm Xi Research Consortium. Plattsburgh, NY April 2007.

Pershyn, C., T. B. Mihuc, S. Thomas, G. Boyer, M. Satchwell, J. Jones, and M. Greens (2007) Cyanobacteria and the sixth Great Lake: Community dynamics of toxic algal blooms in Lake Champlain, USA. Abstracts, Botanical Society of America. Chicago, IL July 2007.

Satchwell, M. F., A. M. Hotto, and G. L. Boyer (2007) Using the microcystin mcyA gene to track toxin movements in Northern Lake Champlain. Abstracts, 7th Intern. Conf. toxic Cyanobacteria. Reo De Janeiro, Brazil, August 6, 2007.

Smith, J. L., K. Schultz, and G. L. Boyer (2007) Development of an internal standard for the measurement of free microcystins in fish tissue and sediments. Abstracts, 7th Intern. Conf. Toxic Cyanobacteria. Reo de Janeiro, Brazil, August 6, 2007.

Smith, J., K. Schulz, and G. Boyer (2007) Development of an internal standard for the measurement of free microcystins in fish tissue and sediments. Abstracts, Int. Assoc. Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Thomas, S., T. B. Mihuc, G. Boyer, M. Satchwell, J. Jones, C. Pershyn, and M. Greene (2007) A geospatial mapping method to detect Lake Champlain cyanobacterial blooms. Abstracts, Great Lakes Research Consortium Annual Meeting. Syracuse, NY March 2007.

Watson, S. B., and G. L. Boyer (2007) Cyanobacterial toxins and taste-odour impairment, prediction and management in the Great Lakes. Abstracts, 10th Canadian Workshop on Harmful Algal. Mont Joli, Quebec, May 16, 2007.

Watson, S. B., G. L. Boyer (2007) Cyanobacterial toxins and taste-odour in the North American Great Lakes: Impairment, prediction and management. Abstracts, Intern. Assoc. Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Watson, S. B., G. L. Boyer, M. Charleton, and J. Ridal (2007) Taste and odour and cyanobacterial toxins: Impairment, prediction and management in the Great Lakes. Abstracts, 7th Intern. Conf. Toxic Cyanobacteria. Reo de Janeiro, Brazil, August 6th, 2007.

Watson, S. B., and G. L. Boyer (2007) Cyanobacterial toxins and taste-odour in the North American Great Lakes: Impairment, prediction and management. Abstracts, 7th Intern. Conf. Toxic Cyanobacteria. Reo de Janeiro, Brazil, August 6th, 2007.

Watson, S., G. Boyer, R. Yerubandi, V. Hiriart-Baer, M. Charlton, and J. Milne (2007) Cyanobacteria blooms in Hamilton Harbour: Risk, Causes, and Consequences. Seminar, Hamilton Harbour LAMP conference. Burlington, ONT, Jan 2007.

Watzin, M.C. (2007) Taking Informed Risks – Adaptive Management of Nonpoint Source Phosphorus. Chesapeake Bay, Great Lakes, and Lake Champlain Nonpoint Source Exchange, Burlington, VT

Wilhelm, S. W., G. L. Boyer, J. Rinta-Kanto, and R. A. Bourbonniere (2007) The ecology and biogeography of Lake Erie Microcystis blooms. Abstracts, Int. Assoc. Great Lakes Res. Annual Meeting. University Park, PA; May 28th 2007.

Wilhelm, S. W., and G. L. Boyer (2007) Molecular characterization of toxic cyanobacterial communities in the lower Great Lakes: a seven year synopsis. Abstracts, 4 US Conference on Harmful Algae. Woods Hole, MA October 2007.

2006

Becker, R. (2006) Mapping algal blooms in the lower Great Lakes, Western Michigan Creative Research Scholar Presentation, May 2006.

Becker, R. (2006) Distribution of Algal blooms in the Lower Great Lakes poster presentation; Shared Boundary Waters Symposium, Western Michigan University, Kalamazoo, MI

Boyer, G. L. (2006) Spatial and temporal Distribution of Cyanobacterial Toxins in Lake Erie, 2005. Abstracts, Fourth Biennial Conference on the Lake Erie Millennium Network. 2006. SUNY-ESF.

Boyer, G. L., H. Gilbert, E. Konopko, and J. Makarewicz (2006) Rapid field based monitoring systems for the detection of toxic cyanobacteria blooms: Microcystin immunostrips and fluorescence based monitoring systems. Abstracts, Am. Soc. Limnol. Oceanogr. Victoria BC, June 4-9, 2006.

Boyer, G. L., H. Gilbert, E. Konopko, and J. Makarewicz (2006) Rapid field based monitoring systems for the detection of toxic cyanobacteria blooms: Microcystin immunostrips and fluorescence based monitoring systems. Abstracts, 12th International Conference on Harmful Algae, Copenhagen, DEN, September 3-9, 2006.

Boyer, G. L., M. F. Satchwell, A. Hotto, and S. Watson (2006) Distribution of Cyanobacteria Toxicity in Lake Ontario: an emerging issue. Abstracts, Internat. Assoc. Great Lakes Research Annual Meeting. Windsor, ONT, May 22, 2006.

Boyer, G. L., M. F. Satchwell, X. Yang, S. Ragonese, K. Howard, E. Konopko, A. Hotto, and J. Smith (2006) Distribution of Cyanobacterial toxins in Lake Erie; Results of the 2005 IFYLE cruises. Abstracts, Internat. Assoc. Great Lakes Res. Annual Meeting. Windsor, ONT, May 22, 2006.

Fischedick, J., and G. L. Boyer (2006) Can target toxin producing genes and microcystin toxins be detected in glutaraldehyde preserved samples of Microcystis aeruginosa? Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse, NY, April 19, 2006.

Gobler CJ, DL Berry, TW Davis, GL Boyer and SW Wilhelm. (2006) Distribution and ecology of toxic and non-toxic strains of Microcystis populations in North American Great Lakes. International Society for the Study of Harmful Algal Blooms, Copenhagen, Denmark, September 2006.

Hotto, A., and M. L. Boyer (2006) Microcystin production in Lake Ontario. Abstracts, American Chemical Society Northeast Regional meeting. Binghamton, NY, October 6th 2006.

Hotto, A., M. Satchwell, and G. Boyer (2006) Microcystin production in Lake Ontario. Abstracts, Northeast Algal Symposium. Poughkeepsie NY April 23, 2006.

Hotto, A., M. Satchwell, and G. L. Boyer (2006) Microcystin production in lake Ontario. SUNY-ESF Graduate and Undergraduate Research Symposium. April 19, 2006 Syracuse NY.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2006) Microcystin production in Lake Ontario. Abstracts, Am. Soc. Limnol. Oceanogr. Victoria, BC, June 4-9, 2006.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2006) Microcystin Production in Lake Ontario. Abstracts, Great Lake Research Consortium. Syracuse, NY March 17, 2006.

Howard, K. L., and G. L. Boyer (2006) Rapid quantitative analysis of Cyanobacterial toxins in natural waters using MALDI-TOF mass spectrometry. Abstracts, The Pittsburgh Conferences. Orlando FL, March 12, 2006.

Konopko, E., and G. L. Boyer (2006) Development of a flow through fluorometric system for the detection of phycocyanin in the lower great lakes. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse NY April 19, 2006.

Lehman, P. W., G. Boyer, and S. Waller (2006) Seasonal variation of Microcystis aeruginosa biomass and toxicity in the upper San Francisco Estuary. Abstracts, Amer. Soc. Limnol. Oceanogr. Victoria, BC June 2006.

Magnien, R. E., V. L. Trainor, and G. L. Boyer (2006) The need for harmful algal bloom forecasting. Abstracts, Amer. Soc. Limnol. Oceanogr. Annual Meeting. Victoria BC, June 4-9, 2006.

McNamara, S., G. L. Boyer, R. Kremens, M. Satchwell, and T. Vodacek (2006) Identification of harmful algae in Lake Champlain using optimized bands on a multispectral airborne sensor. Abstracts, Finger Lakes Institute Annual Meeting. Geneseo, NY, October 2006.

Pavlac, M., and G. L. Boyer (2006) Flow-through system for the detection of cyanobacteria. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse NY, April 19, 2006.

Rinta-Kanto, J. M., R. Li, G. L. Boyer, R. A. Bourbonniere, and S. W. Wilhelm (2006) New views on the diversity of toxic cyanobacterial populations on Lake Erie. Abstracts, Internal Assoc. Great Lakes Res. Annual Meeting. Windsor, ONT, May 22 2006.

Rinta-Kanto J.M., R. Li, and S.W. Wilhelm. (2006) The use of conserved genes from the microcystin synthetase pathway to forecast toxin production potential of a cyanobacterial community in Lake Erie. Abstracts, American Society of Limnology and Oceanography. Victoria BC June 5-9, 2006.

Rinta-Kanto J.M. and S.W. Wilhelm (2006) The effect of virus size class enrichment on bacterial production. SCOR WG126 – Marine Virus Ecology Meetings, Vancouver, BC. June 2006.

Satchwell, M., A. Hotto, X. Yang, E. Konopko, S. Ragonese, K. Howard, and G. Boyer (2006) MERHAB - Lower Great lakes - Monitoring for harmful algal blooms in our inland seas. Abstracts, Northeast Algal Symposium. Poughkeepsie, NY April 21, 2006.

Satchwell, M., A. M. Hotto, and G. L. Boyer (2006) Method comparison for the detection of the cyanobacterial toxin microcystin. Abstracts, American Chemical Society Northeast Regional Meeting. October 5, 2006.

Smith, J., K. Schultz, and G. L. Boyer (2006) Impacts of microcystins, a cyanobacterial toxins, on the recruitment and survival of Hexagenia, the burrowing mayfly. Abstracts, Internal. Assoc. Great Lakes Res. Annual Meeting. Windsor, ONT, May 22, 2006.

Smith, J. L., G. L. Boyer, and K. Schulz (2006) Impacts of microcystins, a cyanobacterial toxins, on the recruitment and survival of *Hexagenia*, the burrowing mayfly. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. April 19, 2006.

Smith, J. L., G. L. Boyer, and K. L. Schulz (2006) Impacts of microcystins, a cyanobacterial toxin, on the recruitment and survival of *Hexagenia*, the burrowing mayfly. Abstracts, Amer. Soc. Limnol. Oceanogr. Annual Meeting. Victoria, BC, June 6, 2006.

Suomela, R. L., and G. L. Boyer (2006) Tracking down cyanobacterial toxin imposters. Abstracts, American Chemical Society National Meeting. Atlanta, GA, March 2, 2006.

Watson, S. B., G. L. Boyer, and E. Hinchey (2006) Naturally produced noxious chemicals and toxins in the Great Lakes. State of the Lake Ecosystem (SOLEC) 2006. Milwaukee WI, November 1-3, 2006.

Watzin, M.C. (2006) Integrated Water Resources Management: Understanding the Interconnections of Environment, Health, and the Human Spirit, Peking University, College of Environmental Sciences, Beijing,

Wilhelm, S. W., G. L. Boyer, J. M. Rinta-Kanto, A. J. A. Ouellette, R. Li, and R. A. Bourbonniere (2006)

An overview of cyanobacterial blooms in Lake Erie 2000-2005. Abstracts, American Society of Limnology and Oceanography. Victoria BC June 5-9, 2006.

Yang, X., and G. L. Boyer (2006) Does the cyanobacterial neurotoxin anatoxin-a pose a potential health risk for the lower great Lakes of the US and Canada? - A six-year review. Abstracts, American Soc. Limnol. Oceanogr. Victoria, BC June 6, 2006.

2005

Atkinson, J., M. Sultan, R. Becker, and G. Boyer (2005) Monitoring Algal Blooms in the Great lakes. Abstracts, 8th International Conference on Remote Sensing for Marine and Coastal Environments. Halifax, Nova Scotia, May 17-19.

Atkinson, J. F., P. Kuchikulla, M. Green, and G. Boyer (2005) A particle tracking model for algal blooms in the great Lakes. Submitted to IAGLR annual conference, May 2005 Ann Arbor, MI.

Becker, R., M. Sultan, G. Boyer, J. Atkinson, and E. Konopko (2005) Spatial and temporal variations of algal blooms in the lower great lakes. Abstracts, 8th international Conference on Remote Sensing for Marine and Coastal Environments. Halifax, Nova Scotia, May 17-19.

Boyer, G. L. (2005) Occurrence of Cyanobacterial Toxins in Lake Ontario. Seminar. SUNY-Oswego, February 2, 2005.

Boyer, G. L. (2005) Overview of the SUNY-ESF algal toxins lab: Harmful algal blooms and drinking water. Finger Lakes Institute Preliminary Planning Meeting. Geneva NY, May 7 2005.

Boyer, G. L. (2005) MERHAB-LGL: Monitoring and Event Response for Harmful Algal Blooms in the Lower Great Lakes. Invited Presentation, International Field Year on Lake Erie Planning Meeting. Ann Arbor, MI, May, 11, 2005.

Boyer, G. L. (2005) Cyanobacterial toxins in New York and the lower Great Lakes ecosystems. Abstracts, International Symposium on Cyanobacterial Harmful Algal Blooms. Raleigh, NC September 6, 2005.

Boyer, G. L. (2005) Evolution of a Sea Grant project from a local issue to a national need: The occurrence of cyanobacterial toxins in New York State waters. Poster Presentation. New York Sea Grant Peer Review Panel, Cornell NY, Sept 28, 2005.

Boyer, G. L., J. C. Makarewicz, M. Watzin, T. Mihuc, J. F. Atkinson, M. Sultan, and S. W. Wilhelm (2005) MERHAB - Lower Great lakes - Monitoring for harmful algal blooms in our inland seas. Abstracts, 3rd Symposium on Harmful Algae in the US. Pacific Grove, CA, October 2, 2005.

Boyer, G. L. (2005) The occurrence of cyanobacterial toxins in New York lakes. Abstracts, North American Lake Management Society Annual Meeting. Madison, WI, November 9, 2005.

Boyer, G. L., M. F. Satchwell, A. Hotto, X. Yang, T. Lewis, M. Oles, J. C. Makarewicz, S. B. Watson, and J. F. Atkinson (2005) The occurrence of cyanobacterial toxins in Lake Ontario. Abstracts, Amer. Soc. Limnol. Oceanogr. Annual meeting. Salt Lake City, February, 2005.

Boyer, G. L., Satchwell M. F., Hotto A., Yang X., Lewis, T., Oles, M., Makarewicz, J. C., Watson, S. B., and Atkinson, J. F. (2005), Occurrence of Cyanobacterial Toxins in Lake Ontario, USA, submitted to IAGLR annual conference, Ann Arbor, MI.

Bradley, H. Mihuc T B. (2005) 2003 Phytoplankton community composition in Lake Champlain. Seminar to Lake Champlain Research Institute and Center for Earth and Environmental Science, Sigma Xi Plattsburgh Chapter, Plattsburgh, NY April 2005.

Couture, Sam. (2005). The effects of white perch on the plankton community of Missisquoi Bay. Lake Champlain Research Consortium PRIME meeting, Swanton, VT, September 12, 2005.

Damon, R. M., M. F. Satchwell, A. M. Hotto, and G. L. Boyer (2005) Distribution and molecular analysis of microcystin cyanobacterial toxins in Lake Champlain, NY. Abstracts, Amer. Soc. Limnol. Oceanogr. Annual meeting. Salt Lake City, February 2005.

Fischedick, J., and G. Boyer (2005) Microcystin production among individual colonies of Microcystis using MALDI-TOF and PCR. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse NY April 13, 2005.

Gobler, C. J., T. W. Davis, and G. L. Boyer (2005) Impact of nutrient loading and zooplankton grazing on abundance, growth and toxin production of freshwater cyanobacteria. Abstracts, American Society of Limnology and Oceanography. Salt Lake City, February, 2005.

Guenther, W.B. and J.C. Makarewicz (2005) Surveillance of microcystins in Lake Ontario, its embayments and other New York lakes – year 2. Submitted to IAGLR annual conference, May 2005 Ann Arbor, MI.

Hotto, A., M. Satchwell, and G. L. Boyer (2005) Potential and actual microcystin production in Lake Ontario embayments. Abstracts, Int. Assoc Great Lakes Res., annual meeting. Ann Arbor, MI, May 23, 2005.

Hotto, A., M. Satchwell, and G. L. Boyer (2005) Potential and actual microcystin production in Lake Ontario embayments. Abstracts, Amer. Soc. Limnol. Oceanogr., Salt Lake City, February 22, 2005.

Hotto, A., M. Satchwell, and G. Boyer (2005) Potential and actual microcystin production in Lake Ontario Embayments. Abstracts, 3rd Symposium on Harmful Algae in the US. Pacific Grove, CA October 2, 2005.

Howard, K. and G.L. Boyer (2005) A rapid screening method for cyanobacterial toxins in the great lakes using MALDI-TOF mass spectrometry. Submitted to IAGLR annual conference, May 2005 Ann Arbor, MI.

Konopko, E., and G. Boyer (2005) Development of a flow-through fluorometric system for the detection of cyanobacterial blooms. Submitted to IAGLR annual conference, May 2005 Ann Arbor, MI.

Kreider, Meghan (2005). Evaluation of approaches to monitoring for toxic cyanobacteria: Lessons learned from Lake Champlain. Seminar presented at ECHO at the Leahy Center for Lake Champlain monthly meeting, February 15, 2005

Kreider, Meghan (2005). Evaluation of approaches to monitoring for toxic cyanobacteria: Lessons learned from Lake Champlain. ASLO Conference, Salt Lake City, UT. February 22, 2005.

Kreider, Meghan (2005). Evaluation of approaches to monitoring for toxic cyanobacteria: Lessons learned from Lake Champlain. Seminar presented at ECHO at the Leahy Center for Lake Champlain monthly meeting, February 15, 2005

Kuchikulla, P. (2005) Development of algal bloom tracking model for Lake Erie, Great Lakes Research Consortium Annual Student/Faculty Conference, SUNY-ESF, Syracuse, NY, March 2005.

Makarewicz, J.C. (2005) Lake Ontario and its future, at: "Morning with the Professors" Brockport, NY, March 29, 2005.

Makarewicz, J.C. (2005) Experimental manipulation of entire watersheds through BMPs: Nutrient fluxes, fate and transport and biotic responses. Invited Keynote at Tri-Society Meeting. New York Society of American Foresters, New York Chapter of the Wildlife Society and the New York Chapter of the American Fisheries Society, Syracuse, NY. February 2005

Makarewicz, J.C. (2005) Our Threatened Lakes: Getting Involved. Invited Keynote at Seventh Environmental Forum. Sponsored by the Sierra Club, Rochester, NY. April 21, 2005. (~200 in attendance).

Makarewicz, J.C. (2005) The status of Lake Ontario. Presentation to American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). June 2005.

Makarewicz, J.C. (2005) State of the North Coast: The South Shore of Lake Ontario, presentation at "Saving New York's North Coast: The Lake Ontario Coastal Initiative. Rochester, NY, May, 2005.

Rinta-Kanto, J., G. L. Boyer, M. Satchwell, M. T. Smith, R. Li, and S. W. Wilhelm (2005) Analysis of toxic Microcystis blooms on Lake Erie using quantitative real-time PCR. Abstracts Amer. Soc. Limnol. Oceanogr. Annual Meeting. Salt Lake City, February 22, 2005.

Rinta-Kanto, J. M., R. Li, G. L. Boyer, and S. W. Wilhelm (2005) Analysis of the toxic cyanobacterial community during 2003 and 2004 blooms on Lake Erie. Abstracts, Internat. Assoc Great Lakes Research Annual Meeting. Ann Arbor, MI May 23-27, 2005.

Satchwell, M. F., A. M. Hotto, R.M. Damon and G. L. Boyer (2005) Distribution and molecular analysis of cyanobacterial toxins in Lake Champlain, New York, USA. Abstracts, Int. Assoc Great Lakes Res., annual meeting. Ann Arbor, MI, May 23, 2005.

Satchwell, M. F., A. M. Hotto, G. L. Boyer, and X. Yang (2005) Seasonal production of cyanobacterial toxins in Oneida Lake, New York, USA. Abstracts, Amer. Soc. Limnol. Oceanogr. Annual meeting. Salt lake City, February 22, 2005.

Satchwell, M., A. H. X. Yang, J. Jones, T. Mihuc, and G. Boyer (2005) Cyanobacterial toxins in Lake Champlain - a five year review. Abstracts, 3rd Symposium on Harmful Algae in the US. Pacific Grove, CA October 2, 2005.

Suomela, R. (2005) Tracking down algal imposters. Abstracts, First Finger Lakes Conference. Geneva, NY, October 8, 2005.

Watzin, M.C. (2005). Cyanobacteria and Lake Champlain. Lake Champlain Basin Program Conference on the State of the Lake. March 11, 2005.

Watzin, M.C. (2005). Blue-green algae in Lake Champlain and elsewhere. NALMS/VT Lakes and Ponds Annual Meeting. July 25, 2005.

Watzin, M.C. (2005). Blue-green algae in Lake Champlain. North Lake Association Annual Meeting. August 13, 2005.

Watzin, M.C. (2005). Linking land use change, stream geomorphic condition, and the ecological integrity of streams, watersheds, and Lake Champlain. NSF Biocomplexity Program Collaborative Sino-American Conference. October 21-22, 2005.

Wilhelm SW and JM Rinta-Kanto. Field methods in the study of toxic cyanobacterial blooms: results and insights from the Lake Erie experience. EPA – ISCOHAB, September 2005, Raleigh NC

Wilhelm, S. W. (2005) seminar presented at Department of Biology, SUNY Oswego, Oswego NY, November 2005.

Wilhelm, S. W. (2005) seminar presented at Department of Biology, The University of Denver, Denver, CO. February 2005.

Yang, X., and G. L. Boyer (2005) Occurrence of the cyanobacterial toxin, anatoxin-a, in the lower Great Lakes. Abstracts, International Assoc. Great Lakes Res. Annual Meeting, Ann Arbor, MI, May 23, 2005.

Yang, X., and G. L. Boyer (2005) Occurrence of the cyanobacterial neurotoxin, anatoxin-a, in the lower Great Lakes. Poster Presentation, New York Sea Grant Peer Review Panel. Cornell, NY, September 28, 2005.

2004

Boyer, G. L. (2004) Toxic Cyanobacteria, Nature's Bioterrorists. Seminar, Cornell University, Department of Environmental Toxicology. Ithaca NY, February 27 2004.

Boyer, G. L. (2004) Toxic Cyanobacteria, Nature's Bioterrorists. Seminar, Department of Chemistry SUNY-Oneonta. Oneonta NY, February 16, 2004.

Boyer, G. L., J. C. Makarewicz, M. Watzin, and T. Mihuc (2004) Monitoring strategies for harmful algal blooms in the lower great lakes; Lakes Erie, Ontario and Champlain, USA. Abtracts, 11th Internat Conference on Harmful Algae. Capetown, South Africa, November 15th, 2004.

Boyer, G. L., M. F. Satchwell, A. Hotto, X. Yang, T. Lewis, M. Oles, J. C. Makarewicz, and S. B. Watson (2004) Occurrence of Cyanobacterial Toxins in Lake Ontario, USA. 6th Internat Conf. Toxic Cyanobacteria. Bergen Norway, June 20 2004.

Gobler, C. J., T. W. Davis, and G. L. Boyer (2004) the first report of toxic cyanobacteria blooms on Long Island, NY, USA. Abstracts, 11th International Conference on Harmful Algae. Capetown, South Africa, November 15th 2004.

Hotto, A., M. Satchwell, and G. L. Boyer (2004) Molecular characterization of microcystin production in Oneida Lake, New York, USA. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse NY, April 13th 2004.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2004) Molecular Characterization of Cyanobacterial Toxin Production in Oneida lake. Abstracts, Great Lakes Research Consortium. Syracuse NY March 2004.

Hotto, A. M., M. F. Satchwell, and G. L. Boyer (2004) Molecular characterization of microcystin production in Oneida Lake. Abstracts, 6th Internat. Conf. Toxic Cyanboacteria. Bergen Norway, June 20 2004.

Howard, K. L., and G. L. Boyer (2004) Adventures in MALDI-TOF mass Spectrometry. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse NY April 13th 2004.

Konopko, E., and G. L. Boyer (2004) Pigment specific fluorescence detection of cyanobacteria. Abstracts, SUNY-ESF Graduate and Undergraduate Research Symposium. Syracuse NY, April 13th 2004.

Kreider, M.A. (2004). Assessing the Limiting Factors Preventing Zebra Mussel Invasion of Missisquoi Bay. Abstracts, The Rubenstein School of Environment and Natural Resources Twenty First Annual Graduate Research Symposium, October 8, 2004.

Mihuc, T. B., G. L. Boyer, M. Pellam, J. Visile, and A. Bouchard (2004) Algal Community composition and cyanobacterial toxins in Lake Champlain, NY. Abstracats, Societas Internat Limnol Congress. Lahti Finland, Aug 8, 2004.

Oles, M., J. C. Makarewicz, and G. L. Boyer (2004) Surveillance of microcystins in Lake Ontario and its embayments. Abstracts, Intl Assoc. Great Lakes Res. Waterloo Ont. June

Prakash, S., Atkinson, J.F., and Green, M.L. (2004), A Semi-Lagrangian Study of Mean Circulation in Lake Ontario, Intl. Assoc. Great Lakes Res. 47th Annual Conf., Waterloo, Ontario, May 24 – 28.

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viii. Outreach Activities (Selected)

In addition to the workshops, publications and presentations listed above, other outreach activities included:

- Preparation of the MERHAB-LGL website (www.MERHAB-LGL.org)
- Publication of the Great Lakes Research Review with the Great Lakes Research Consortium (http://www.esf.edu/glrc/GLRRPages/GLRRPDF/GLRR06.pdf)
- Participation in the Healthy Vermonter website describing cyanobacteria toxins in Lake Champlain (http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx).
- Preparation of an Internal Report for NOAA Coastal Ocean Program Monitoring and Event Response for Harmful Algal Blooms entitled Distribution and toxicity of a new *Microcystis aeruginosa* bloom in the upper San Francisco Bay region. (Lehman, P. W., S. Waller, G. Boyer, and K. Gehrts, 2004). (A rapid response event)
- Chief Scientists, Centers for Ocean Sciences Education Excellence (COSEE) K-12 educators cruise, Lake Erie, June 18-24, 2006, Responsible for on-water instruction.
- Presentation of a while paper on Harmful Algal Blooms as newly emerging pathogen in water. (Boyer, G. L., and J. Dyble, 2007), Michigan State University Water Fellows Program. East Lansing, MI, March 1, 2007.
- Preparation of a technical report on the influence of environmental conditions on the seasonal variation of *Microcystis aeruginosa* cell density and microcystins concentration in

the San Francisco Estuary, (Lehman, P., G. L. Boyer, M. F. Satchwell, and S. Waller, 2007)

- Development of a series of workshops entitled "Toxic Algae - What Water Treatment Professionals Need to Know" that were held at the SUNY College of Environmental Science and Forestry, SUNY College at Brockport and University of Vermont in 2006
- Chief Scientists, Centers for Ocean Sciences Education Excellence (COSEE) K-12 educators cruise, Lake Ontario, July 13-19, 2008, Responsible for on-water instruction.

B. Management Outcomes:

There were/ are several key management outcomes that arose from this work. For Lake Erie, probably the most interesting outcome is that the current *Microcystis* population was present in the 1970's, but did not bloom. This indicates that our current situation must be a manageable issue. Unfortunately most environmental parameters make weak predictors of *Microcystis* cell density, although there appears to be a temperature threshold. A second key point is that other organisms (e.g. *Planktothrix* in Sandusky Bay) and other toxins (anatoxin-a) are present in the Lake Erie ecosystem. Managers no longer have the luxury of focusing on a single species or toxin. For Lake Ontario and lake Champlain, the work we did in these water bodies (sampling along the Lake Ontario coastline and the set-up of the community based monitoring systems at Silver and Conesus Lake (NY) and in Lake Champlain (VT) created a lot of press and generated a lot of interest in the State and County Health Departments and in various lake associations. As a result these groups became more aware of this issue and the implications for animal and human health. Thus regionally societal conditions improved because of the knowledge base gained concerning HABs.

VIII. Evaluation

MERHAB-LGL was a highly successful and pioneering proposal for the MERHAB program. It illustrated that the issues surrounding freshwater cyanobacterial blooms are every bit as important, but very different from those found in marine systems. It highlighted the tools and techniques that are available for use with freshwater blooms, forged several groundbreaking international partnerships, and elevated the public awareness of cyanobacterial toxins to a level similar if not higher than that found with marine toxins. It also illustrated a interdisciplinary approach could successfully be used to address a large interregional problem, e.g. harmful algal blooms in the Great Lakes. It also identified the problem of divisions and agency boundaries that must be overcome if we are to successfully monitor and mitigate cyanobacterial harmful algal blooms in the Great Lakes and Lake Champlain region in the future.