Name, Affiliation: Sarah Dorner, Department of Civil, Geological and Mining Engineering, Polytechnique Montréal

Contact Information: sarah.dorner@polymtl.ca, 514-340-4711 ext. 3951

Current Research Focus in Missisquoi Bay or Basin:

- Fate of cyanotoxins in Missisquoi Bay and in drinking water treatment plants
- Identification of cyanotoxin-degrading bacteria in Missisquoi Bay
- Cyanobacteria monitoring (phycocyanin, application to drinking water sources)
- Linking watershed hydrology and nutrient loading to cyanobacterial blooms in Missisquoi Bay
- Hydrodynamic modeling of cyanobacterial behavior
- Hydrodynamic modeling of Missisquoi Bay

Future research ideas: List or briefly describe any research ideas or themes that you would like to discuss at the networking workshop

- Hydrodynamic modeling of Missisquoi Bay

Name, Affiliation and Contact Information:
Nathalie Fortin, M.Sc.
National Research Council Canada
Biomonitoring group/Energy Mining and Environment
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Telephone: (514) 496-5298

Current Research Focus:
We have been collecting water and sediment samples in Missisquoi Bay (Quebec) for several years (2006 to present). Our main objective has been to develop molecular tools for the detection of toxin-producing cyanobacteria. We are also interested in the environmental factors and conditions that trigger the development of toxic blooms.

For example, we have been monitoring nutrient concentrations (nitrogen and phosphorus) in the water and compared these data to rainfall events. A substantial amount of nutrients is brought into the bay after rainfall events, especially in the spring and in the fall following the fertilization of agricultural fields with manure and chemical fertilizers. We have also observed an increase in *E. coli* and total coliforms concentrations following these events. Source tracking analyses, targeting mitochondrial DNA, has allowed us to identify the animals responsible for fecal contamination. These include humans, cattle, and birds.

We have also been collecting sediment samples for several years. The sediments are rich in phosphorus and nitrogen and probably contribute as a reservoir of nutrients for cyanobacteria during the growing season.
Quantitative-PCR has revealed that cyanobacteria with the ability to produce microcystin can survive in the sediments during the winter months. We suspect that these cells constitute the inoculum for the next growing season. As summer progresses, the disappearance of cyanobacteria from the sediments coincides with their appearance in the water column.

In 2009, as part of an epidemiological study of cyanobacterial contamination of recreational and drinking water, we carried out an intensive daily sampling in three lakes including Missisquoi Bay. We sampled 4-5 littoral stations in each lake at risk for cyanobacterial blooms. Twice-weekly samples were also collected at 1-2 pelagic stations. Sampling covered the summer recreational exposure period, for a total of 1067 station-days. We observed that cyanobacterial biomass in the water increased with nutrient concentration. Rates ranged from a sustained low of 8-12% per day in a mesotrophic lake, up to 44% per day in the most eutrophic lake.
The dominance of cyanobacteria in Missisquoi Bay in 2009, corresponded to water temperatures of ≥ 25°C and a TN/TP ration of ≥11. Our results suggest that nitrogen concentrations also have to be taken into consideration for the development of management strategies to reduce the input of nutrients into the bay.

Future Research Ideas:
We are interested in developing in line real-time monitoring methods for detecting bacterial and viral pathogens as well as cyanobacterial toxins such as microcystins, anatoxin-a and cylindrospermopsin. There is an urgent need in monitoring strategies for recreational water and a drinking water producing plants**Name, Affiliation:** Liv Herdman, Postdoc at University of Vermont

Contact Information: lherdman@uvm.edu (510) 717-4696

Current Research Focus: Not currently working in the basin but I would like to create a numerical hydrodynamic model to study the internal seiche dynamics of Lake Champlain. Once developed, I would love to use this model to support research on other lake processes (including Missisquoi Basin) where the hydrodynamics play an important role.

Future research ideas:
Physical mediation of biogeochemical fluxes between the bottom boundary layer and the water column
Historic and future changing ice coverage, and the feedbacks to lake circulation

Name, Affiliation Peter Isles, University of Vermont, Vermont EPSCoR (PhD Student)

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Current Research Focus

My research focuses on the drivers of harmful algal blooms in Missisquoi bay at multiple temporal scales. I am particularly interested in the role of nutrient release from lake sediments, and how the timing of this release interacts with resource limitation dynamics to drive phytoplankton community changes. I am also interested in the role of spring snowmelt and the spring diatom blooms in generating conditions conducive to cyanobacterial blooms later in the summer, and how climate change may affect the timing of these community shifts.

Along with the rest of the RACC Q1 lake team, I work on maintaining an instrumented sampling platform in the southeast portion of Missisquoi bay. This invovles collecting and analyzing automated sonde data, automated and manual water samples for water chemistry, phytoplankton, and zooplankton, and time-series sediment cores analyzed for different P fractions as well as nitrogen, carbon, and metals fractions. In addition to this highly resolved dataset at our main site, this summer we have also undertaken a spatial sampling effort in cooperation with Pat Manley and Declan McCabe; our spatial sampling effort includes sediment cores from 12 sites around the bay representing a variety of depths and substrates, with cores taken before, during, and after the summer bloom season. This data will supplement our time-series sediment cores taken at the main research site at finer temporal scales (monthly to bi-weekly). Hopefully comparing this data with Dr. Manley's sediment particle size analyses, bathymetry, and other spatial data (subaqueous soils map, macrophyte community map) will allow us to quantitatively estimate sediment stores of nutrients in Missisquoi Bay, as well as the portion of those nutrients that are released over the course of the season. Our spatial sampling efforts also include water sampling for nutrient and plankton species, which will allow us to investigate the spatial heterogeneity of water column nutrient concentrations, and the extent to which differences between sites are driven by local sediment characteristics.

The final phase of my research will focus on using this data in a model of the bay. The specifics of this modeling effort are still being worked out.
More info on the RACC project can be found at http://www.uvm.edu/~epscor/new02/?q=node/30. Slides from a presentation given at the 2013 EPSCoR annual meeting are available online at http://www.uvm.edu/~epscor/conference/2013/presentations/andrew_peter_SchrothIslesEPSCoR2013.pdf. My presentation begins about halfway through the slideshow.

Future research ideas:

I think that it would be helpful to start to pull together all of the diverse data on Missisquoi bay into a central repository, where we can begin to examine the gaps in the available data, and to limit duplication of research efforts in the bay. This would also be useful for future modeling efforts, which seem to be an appropriate method for tying together various datasets and for hypothesis formulation about different aspects of the bay ecosystem.

With respect to future research efforts in the bay, I would be particularly interested in looking at dynamics of the river delta system. Some questions that come up with relevance to our RACC project are: what proportions of river sediment coming into the delta are deposited in the bay and in the delta? What are the effects of major interannual changes in water level on the health of the delta, and how will inconsistent lake levels affect sediment and nutrient processing within the wetland/delta? What are the relative flow rates of the several distributaries of the Missisquoi river in the delta (and how might the history channel migrations within the delta affect the interpretation of historical sediment core data *vis-à-vis* historical sedimentation rates and phosphorus loading)? These questions are beyond the scope of my dissertation research, but it does seem to me that we have a gap between data collected at the gage station at Swanton and the data collected in the bay proper (at least with respect to what I have seen), with a big question mark as far as what is happening in between.

With respect to algae bloom monitoring, I believe that more effort should be given to using satellite data to examine the spatial distribution of algae blooms. More high-quality spatially explicit data, coupled with the high temporal-resolution data collected by our monitoring platform and the network of ADCP's and LISSTs maintained by Middlebury, should allow for more accurate modeling of system processes. It would be helpful if some of this data could be acquired for the period in which we are collecting high-resolution time-series data.

Name, Affiliation Tom and Pat Manley, Middlebury College

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Current Research Focus: Circulation Dynamics of the Bay

Future research ideas: List or briefly describe any research ideas or themes that you would like to discuss at the networking workshop
– There really has to be 3D model set up for this region of the lake

Name, Affiliation: Jamie Shanley, Laura Medalie, USGS
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Current Research Focus: USGS has 3 real-time streamgages on the Missisquoi River and 1 on Hungerford Brook.

Name, Affiliation Aubert Michaud, Ph.D, Institut de recherche et de développement en agroenvironnement

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Current Research Focus in Missisquoi Bay or Basin (abstracts are fine)

- **Hydrologic modeling (SWAT Qc II):** coupling with climate change models, routing preferential/matricial flow and P fluxes to drains,
- **Soil and water engineering:** Reviewing hydrologic criteria for structural runoff design; snowmelt hydrology.
- **Phosphorus speciation and hydrologic pathways:** field/micro-watershed scale monitoring and modeling of surface and subsurface pathways;
- **Remote sensing applications:** High resolution tactic tools for soil and water mgt, soil zone management backed up by LiDAR and multi-spectral imagery; Indexing field scale P export coefficients (ODEP/P-Edit)

Future research ideas: List or briefly describe any research ideas or themes that you would like to discuss at the networking workshop

- Validating bioavaibility indices of P loadings (P speciation in relation to algual avaibility) with respect to sources;
- Identifying/validating triggers of cyano's blooms (P, N, Temp, timing & interactions,… Watershed vs Bay time series)
- Documenting efficiencies of BMP's in N, P fluxes abatement from agr. Non-point sources;

Name, Affiliation Julie Moore, Stone Environmental
Contact Information:
jmoore@stone-env.com; (802)229-1881
Current Research Focus:
Edge-of-field monitoring, with a site in MBB and other sites throughout Champlain basin as described below:

> *Two major information gaps persist in Vermont that hamper development of efficient management programs to reduce polluted runoff from farms: poor understanding of the locations of pollution source areas, and a paucity of documentation concerning the effectiveness of agricultural conservation practices on Vermont farms. To begin to address the latter issue, in 2012 Stone began an edge-of-field runoff monitoring program for the Vermont Agency of Agriculture, Food, and Markets (AAFM). The study will provide critical data on the effectiveness of several practices currently promoted by AAFM and USDA in Vermont to control nutrient and sediment pollution in farm runoff. Funding for this initiative was provided by the USDA Natural Resources Conservation Service (NRCS), the State of Vermont, and the Lake Champlain Basin Program.*
>
> *The monitoring period began in September 2012 and will continue for three to five years. Six farms in the Vermont portion of the Lake Champlain Basin, including one in Franklin, are participating in the study; additional study sites may be added in fall 2013.*
>
> *This work will yield multiple benefits, including:*
>
> - *More accurate estimates of pollutant reductions achievable by several conservation practices in Vermont-specific climate, landscape, and management settings;*
> - *Data that inform incentive program structure to ensure that the most effective practices are emphasized; and*
> - *Identification of potential modifications to conservation practices that may improve performance.*
>
> *The Project Team is employing a paired-watershed design to test the effects of conservation practices on event discharge and pollutant export in surface runoff from study fields. The practices we are evaluating in MBB include: cover cropping, reduced tillage and manure injection on cornland, and a water and sediment control basin treating runoff from a cornfield.*

Future research ideas: List or briefly describe any research ideas or themes that you would like to discuss at the networking workshop

Name and Affiliation: Dr. Donna Rizzo, Civil and Environmental Engineering, UVM

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Research Focus: My research focuses on the development of new computational/statistical tools to improve the understanding of human-induced changes on natural systems and the way we make decisions about natural resources.

Keywords: Groundwater and surface water modeling/statistics; optimization; groundwater remediation, watershed classification, predicting local disease risk indicators

Name, Affiliation: Don Ross, UVM, Plant & Soil Science

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Current Research Focus: P speciation in stream corridor soils
Website under development in cooperation with the NRCS:
http://www.uvm.edu/~riparian/

Future research ideas: List or briefly describe any research ideas or themes that you would like to discuss at the networking workshop:
Understanding the movement of eroded sediments downstream and into the bay.
Are these eroded soils sources or sinks for P?
How can we accurately determine the realistic amount of P that can be released from eroded soils once in the bay sediment (i.e. beyond soil test and total P measurements)?

Phosphorus Speciation in Riparian Soils: A Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy and Enzyme Hydrolysis Study

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In the Lake Champlain Basin, phosphorus (P) loading from streambank erosion and cropland are both important P sources, and a better understanding of the factors affecting riparian P loss is needed to help prioritize riparian restoration efforts. We utilized solution phosphorus-31 nuclear magnetic resonance (NMR) spectroscopy and an enzyme hydrolysis method to characterize P and assess bioavailability in 14 commonly mapped riparian soils from northwestern Vermont. Surface horizons were sampled from distinct series at two riparian restoration sites to capture a range of soil properties. Samples were extracted with sodium hydroxide–ethylenediaminetetra-acetic acid (NaOH-EDTA) and analyzed by solution ^{31}P NMR to speciate and quantify P compounds, and commercially available phosphatase enzymes were used to fractionate water-extractable molybdate unreactive P (MUP) into labile orthophosphate monoesters and orthophosphate diesters. Phosphorus extracted by NaOH-EDTA ranged from 74 to 510 mg P kg^{-1} (representing 14.2 to 31.9% of total soil P), of which 58 ± 13% was identified as organic P. Phosphorus compounds identified in all samples included *myo*-inositol hexakisphosphate (*myo*-IHP), *scyllo*-IHP, *neo*-IHP, *chir*-IHP, glycerophosphate, glucose 6-phosphate, mononucleotides, choline phosphate, glucose 1-phosphate, DNA, pyrophosphate, and orthophosphate. Orthophosphate monoesters accounted for 53.7 ± 12.3% of total NaOH-EDTA extractable P and 93 ± 3% of the NaOH-EDTA organic P, indicating the importance of organic P in these soils. Stereoisomers of IHP accounted for 29 ± 7% of NaOH-EDTA extractable P_o. For the water extractions, 78 ± 13% of total P was MUP, of which 18 ± 6% was labile orthophosphate monoesters and 31 ± 15% was orthophosphate diesters. Results suggest that analytical indices of riparian P loss potential should consider both organic and inorganic P.

Name, Affiliation Eric Smeltzer, Vermont Department of Environmental Conservation

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Current Research Focus in Missisquoi Bay or Basin
Lake Champlain Long-Term Water Quality and Biological Monitoring Program
Lake Champlain Cyanobacteria Monitoring Program
Lake Champlain Phosphorus Total Maximum Daily Load (TMDL)
Long-term trends analysis

Future research ideas:
Importance of the form of phosphorus loading (soluble, available, total)
Drivers of cyanobacteria blooms
BMP effectiveness evaluations

Name, Affiliation
Mike Winslow, Lake Champlain Committee

Contact Information
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Current Research Focus
Mapped aquatic vegetation communities of Missisquoi Bay.
Monitoring presence of blue-green algae blooms

Future research ideas: List or briefly describe any research ideas or themes that you would like to discuss at the networking workshop

- What triggers algae blooms?
- What triggers toxin production?
- Do toxins appear at low algae densities? We've never tested for toxins at low densities until 2012 with routine testing of North Beach and North Hero.
- What is the relative importance of the following factors in determining when an algae bloom occurs?
    - Total phosphorus
    - Dissolved phosphorus
    - The seasonal timing of phosphorus loading (for each form)
    - Conversion of sediment-bound phosphorus to bio-available forms
    - Water temperature
    - Air temperature
    - Nitrogen loading from the land
    - Nitrogen loading from the air
    - Nitrogen fixing by algae
    - Nitrogen release from the sediment
    - N:P ratios (and then which form of N and which form of P)
    - Anoxic sediment conditions (which can trigger N or P release)
    - Water pH
    - Trace minerals (Mn, Fe, etc.)
    - Presence/absence of planktonic consumers of algae (ie. food-chain affects)
    - Wind and waves
- What is the relative importance of those same factors in determining when an algae bloom becomes toxic?
- Could a reduction in atmospheric N-loading (associated with efforts to reduce acid rain) have led to a change in algae bloom development, duration, toxicity, or intensity?
- Do the triggers of algae blooms or bloom toxicity vary between lake segments? For different species of algae? For different toxins?
- What constitutes a "safe" level of algae toxin exposure with regards to human health? For drinking water? For recreational contact? For aerosol exposure?
- Are there strains of algae toxins in the lake that for which we are currently not testing? For example, we only look for one of the over 80 known types of microcystin; we don't test for any saxitoxins.
- Are there different strains of algae in different lake segments? We know that the ability to produce toxins varies with different strains even within the same species.

To what extent is there gene-flow between lake segments with a given species of algae?

- Why do fewer Lake Champlain algae blooms produce toxins than blooms in other water bodies? Is the relative lack of toxicity an artifact of what we test for, which blooms we test, or how we test?
- Why didn't algae bloom in Missisquoi Bay in 2007?
- Do algae toxins accumulate? How long do they persist in wildlife? Does the answer vary by species or class? Is there differential accumulation in muscle tissue compared to viscera compared to nerve tissue? Does bio-accumulation pose a human health risk? A risk to the wildlife?
- How long to algae toxins persist? In the water? In beach sand? Do the toxins break down or become diluted?
- What's the mechanism of toxin breakdown? Do they photo-degrade or are they eaten by bacteria or other microorganisms?