

A stylized map of Lake of the Woods, showing the lake's irregular shape in blue and the surrounding land area in light green. The text "Lake of the Woods" is overlaid on the map in a large, black, serif font. Below the lake's name, the text "4<sup>th</sup> Annual - International Water Quality Forum" is written in a smaller, black, serif font.

# Lake of the Woods

4<sup>th</sup> Annual - International  
Water Quality Forum

*March 7 - 8, 2007*

*Rainy River Community College*

*International Falls, Minnesota, USA*

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### *Sponsored by*

Lake of the Woods Water Sustainability Foundation

Lake of the Woods District Property Owners Association

Minnesota Pollution Control Agency

North American Lake Management Society

Ontario Ministry of the Environment

Rainy River Community College (RRCC)

Rainy River Basin Water Resources Center

## List of participating organizations

Organization	City	Prov	Country
AlgalTox International	Pine Falls	MB	Canada
Border Lakes Association	Rainier	MN	USA
City of Kenora	Kenora	ON	Canada
Environment Canada	Burlington	ON	Canada
Fisheries & Oceans Canada	Winnipeg	MB	Canada
Fisheries & Oceans Canada - Experimental Lakes Area	Manitoba	MB	Canada
Gartner Lee Limited	Bracebridge	ON	Canada
International Rainy Lake Board of Control - IJC	International Falls	MN	USA
Koochiching County	International Falls	MN	USA
Lake of the Woods Control Board	Gatineau	QC	Canada
Lake of the Woods County	Baudette	MN	USA
Lake of the Woods District Property Owners Association	Kenora	ON	Canada
Lake of the Woods Soil and Water Conservation District	Baudette	MN	USA
Lake of the Woods Water Sustainability Foundation	Kenora	ON	Canada
Lake Superior College	International Falls	MN	USA
Lakehead University	Thunder Bay	ON	Canada
MDNR Fisheries	International Falls	MN	USA
Minnesota Pollution Control Agency	Duluth	MN	USA
Minnesota Dept. of Natural Resources	Baudette	MN	USA
Minnesota Pollution Control Agency	Int. Falls/Duluth/St.Paul	MN	USA
MN DNR - Fisheries	International Falls	MN	USA
National Park Service, St. Croix Watershed Research Station	Marine on St. Croix	MN	USA
Nature Conservancy of Canada / Rainy River Field Naturalists	Fort Frances	ON	Canada
NE MN Higher Education District	Chisholm	MN	USA
North Koochiching Area Sanitary District	International Falls	MN	USA
Northeast Technical Services	Virginia	MN	USA
NRRI, Center for Water and the Environment	Ely	MN	USA
Ontario Ministry of Natural Resources	Kenora	ON	Canada
Ontario Ministry of the Environment	Dorset/Kenora	ON	Canada
Queens University - PEARL	Kingston	ON	Canada
Quetico-Superior Foundation's Wilderness News	Northfield	MN	USA
Rainy Lake Conservancy	New Brighton	MN	USA
Rainy River Community College	International Falls	MN	USA
Rainy River Watershed Program, Rainy River First Nations	Emo	ON	Canada
Ridgewater College	Willmar	MN	USA
RMB Environmental Laboratories	Detroit Lakes	MN	USA
Roseau County	Warroad	MN	USA
St. Cloud State University	Merrifield	MN	USA
St. Croix Basin Water Resources Planning Team	Scandia	MN	USA
St. Croix Watershed Research Station	Marine on St. Croix	MN	USA
Superior National Forest		MN	USA
University of Alberta	Edmonton	AB	Canada
University of Manitoba	Winnipeg	MB	Canada
University of Minnesota	St. Paul	MN	USA
US Geological Survey	International Falls	MN	USA
USDA-Forest Service - Superior National Forest	Aurora	MN	USA
Voyageurs National Park	International Falls	MN	USA
York University - Faculty of Environmental Studies	Toronto	ON	Canada

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## *2007 Forum Overview*

The forth, annual, Lake of the Woods water quality forum was held at the Rainy River Community College on March 7-8 2007. The forum was well attended by over 70 scientists, researchers, academics, educators, and other resource stakeholders who participated to present information or to hear about recent research findings that are relevant to Lake of the Woods and its watershed.



On the first day, three separate workshops were held to discuss issues and provide a platform for technical transfer between workshop participants. The outcomes of these workshops are presented here.



On the second day of the forum there were 15 presentations and 11 posters which covered a diverse range of topics many of which were additional findings from projects that were introduced at previous forums.

In these proceedings we present a set of technical or expanded abstracts that summarize the findings of each presenter for both the presentations and the posters.

At the end of the second day, two keynote speakers addressed emerging issues. The

organizing committee selected two speakers; Randy Ferrin to provide insight into a political topic and Lewis Molot to present a science topic.

The Lake of the Woods Water Quality Forum has been instrumental in moving critical science forward as it pertains to the Lake of the Woods and its watershed. Opportunities to share scientific findings specific to an internationally shared resource are often tactically difficult to develop. However, a unique willingness to share information and donate time and effort to this forum by a number of skilled and insightful people has guaranteed success for this and future forums. Thanks to all.



## *2007 Water Quality Forum Schedule of Events*

### **Wednesday, March 7<sup>th</sup>**

#### **Workshops**

<b>Time</b>	<b>Slot 1 – Rm. SC-114</b>	<b>Slot 2 – Rm. SC-115</b>
1:00 – 2:45 pm	Monitoring Coordination	Nutrients and Algae
2:45 – 3:00 pm	BREAK	
3:00 – 4:45 pm		Aquatic Invasive Species
4:45 – 5:45 pm	Preparation of Summary Notes/Slides for Presentation	

### **Thursday, March 8<sup>th</sup>**

**7:30 - 8:00 am – Registration**

**8:00 - 8:20 am – Welcome and Introduction to Symposium**

**8:20 - 10:00 am – Session 1 - Cyanobacteria**

1. Working groups' report - *Andrew Paterson, Ontario Ministry of the Environment*
2. Microcystin levels in eutrophic south central Minnesota lakes - *Steven Heiskary, Minnesota Pollution Control Agency*
3. Cyanobacterial liver toxins in Lake of the Woods: preliminary results from 2006 - *Brian Kotak, AlgalTox International*
4. Lake of the Woods: Data summary for Minnesota Impaired Waters Assessment - *Steven Heiskary, Minnesota Pollution Control Agency*

**10:00 - 10:20 am - Break**

**10:20 - noon – Session 2 – Water Quality**

5. Historical changes of diatom communities and water quality in Namakan Lake and Lac La Croix - *Claire Serieyssol, University of Minnesota*
6. Paleolimnological evidence from diatoms for recent environmental and climatic changes in the Lake of the Woods - *Kathleen Rühland, Queen's University*
7. Recovery and analysis of sediment cores from Lake of the Woods and Shoal Lake – predicting the future by establishing the past climate using ostracodes and the stratigraphic record - *Trevor Mellors, University of Manitoba*
8. Analysis of land use changes in Little Fork River riparian zone - *Lee Engel, University of Minnesota*



9. Seasonal discharge and nutrient dynamics of Boreal Shield headwater streams in north-western Ontario within an industrial forest context - *Paul Dinsmore, Lakehead University*

**12:00 - 1:30 pm – Lunch and Poster Session**

**1:30 - 3:10 pm - Session 3 – Water Quality (continued) and Adaptive Management**

10. Mercury in fish in Voyageurs National Park - is the situation improving, getting worse, or staying the same? - *Larry Kallemeyn, USGS*
11. Influence of prescribed forest fire on the re-mobilization of mercury in the Boundary Waters Canoe Area Wilderness - update - *Trent Wickman, USDA Forest Service Superior National Forest*
12. Service learning partnerships as a model for enhancing biological monitoring efforts with Voyageurs National Park - *Matthew Julius, St. Cloud State University*
13. Requirements, development and utility of a nutrient mass balance model as a management tool for Lake of the Woods - *Tammy Karst-Riddoch, Gartner Lee Limited*

**3:10 - 3:30 pm – Break**

**3:30 - 5:00 pm – Session 4 - Emerging Issues**

14. Protecting water quality through inter-agency collaboration - the St. Croix Basin Water Resources Planning Team - *Randy Ferrin, St. Croix Basin Water Resources Planning Team*
15. Risk factors vs. mechanistic explanations: regulation of cyanobacterial abundance - *Lewis Molot, York University*

**5:00 - 5:20 pm – Closing Remarks**

**6:00 pm – Lake of the Woods Water Sustainability Foundation Reception**



## **1. Monitoring Coordination**

### ***Review and Update Recommendations from 2006 Working Group***

#### *Monitoring Coordinator*

Nolan Baratono provided an update on the Coordinator position – the funding and the contract had been made available, but in the end the position was not filled. Another attempt will be made to hire someone with other viable partners.

#### *School Based Education Programs*

Funding has been applied for with the Northwest Foundation (U.S.) through River Watch to engage in long-term, water-quality monitoring with a school in Minnesota – the program will involve various grade levels who will be responsible for grade-appropriate activities. This has been made part of the regular curriculum at some schools in the state.

### ***Review of Ongoing Efforts***

#### *Kawishiwi Watershed Monitoring Project*

As part of this project, traditional parameters have been monitored on Garden Lake, along with temperature profiles and testing for chlorophyll *a*, algae and phosphorus. A watershed partners committee was put together (government, NGOs) to finalize the watershed monitoring plan – everything but the lab work has been self-funded and the data are stored in a database. Monitoring has begun on the South Kawishiwi. There is a meeting scheduled in April to review ongoing monitoring and to identify data requirements.

#### *River Watch Program*

There is a River Watch Program focused on the main stem of the Big Fork River.

#### *Rainy Lake Monitoring*

The only data currently being collected on Rainy Lake are on the Canadian side and these are being compared with the MOE TP data.

#### *Needs of these Groups:*

- start up a work group to ensure that there is continuity among monitoring group procedures in the basin (e.g. collection of data; data handling and management including where data are stored, how to access results; resources of each group; training opportunities; comparing notes/success stories/constraints)
- discuss ways to incorporate monitoring into curriculum

#### *Implementation of Basin-Wide Condition Monitoring Project*

This is ongoing as part of the Rainy Basin plan

#### *Lake Partner Program*

Currently, there are 50-60 sites being monitored on the Canadian side of L.O.W. There is a requirement for more seasonal data (monthly sampling) and more sites in the south end of the lake. Trends have shown significant variability at any one site. New collection sites in Voyageurs National Park will make spatial phosphorus data available. Last year, microcystin analyses were done on a subset of the Lake Partner samples.

#### *Inter-Lab Comparison between MOE Dorset and MPCA*

This will require field duplicate sampling or splitting of samples at selected locations with submission to the two different labs.

#### *Potential for Strategic Monitoring following the State of the Basin Report gap analysis*

Following the State of the Basin report and the Gartner Lee scoping study, there will be sufficient guidance to begin more strategic monitoring as recommended by these reports.

#### *Satellite Ground Truth Project 2006*

This was a very successful project where TP, chlorophyll and water clarity were sampled to calibrate to satellite image spectral data. There was discussion around making this more of an operational tool to identify the connections between variations in satellite based algal densities and external parameters that may be exacerbating the algal blooms.

#### *Riverine Dragonfly Inventory*

Ilka Milne of the Nature Conservancy explained her desire to engage the local naturalist club in an inventory of dragonfly exuviae. The information will be provided to the Minnesota/Ontario/Manitoba atlas. Nolan Baratono suggested that a sample site be established on the Little Fork and Big Fork rivers with another suggestion to set up a dragonfly inventory site where other biological monitoring is being done on L.O.W. Ilka indicated that new species that are good indicators of environmental health have been identified in the Rainy Basin.

#### *MPCA Assessment of Lake of the Woods*

Nolan Baratono explained that the MPCA will likely be listing L.O.W. (U.S. side) as "impaired" for excess nutrients. This listing requires that a loading study be done and funded through the TMDL program, including all waters that flow into Big Traverse on both sides of the border. In order to assess nutrient loads, there may be a requirement for specific volunteers who can do particular measurements at inflows to the lake. This may open doors for additional partnerships between MOE, Manitoba and Minnesota.

#### *RNB Environmental*

This group has trained volunteers monitor water quality on over 400 lakes in Minnesota; cost is \$200 per lake association and all analyses are done by RNB Environmental. They store data on STORET and on a website, for easy access. They have taken part in the River Watch program on the Red River and have engaged students in their projects.

#### *College of Foods, Agriculture and Natural Resource Science (Minnesota)*

A professor from this institution indicated he is developing a student recruitment program and would like information from various agencies in the meeting who may need students to help with their programs. He would make the links back to interested students.

### ***New initiatives: Development of Action Items and Recommendations for 2007-08***

#### *1. Monitoring on Vermilion Watershed needed*

There is an active Sportsman's Group that could be approached to get involved in monitoring. Suggestion was made to include this group and other lake associations on the annual forum distribution list (e.g. Quetico group) and, perhaps, to have a focused working group in which these associations and organizations can discuss monitoring.

## *2. Strategic Monitoring*

Complete an inventory of which organizations have volunteers doing monitoring and which agencies do monitoring, how many individuals/sites, as well as their capabilities (e.g. resources, boats, etc.). Kelli S. and Bev C. offered to develop a questionnaire to email to all forum participants asking these questions

## *3. Dragonfly Initiative*

Contact Ilka Milne to further discuss the option to combine a dragonfly study with current Big Fork/Little Fork River monitoring.

## *4. Support for Ongoing Studies*

There is a need to support the work being conducted by Jesse Anderson (satellite ground truth study), Brian Kotak (microcystin study) and Voyageur National Park (TP monitoring).

## *5. Inter-Lab Comparison*

Bev, Jesse, Nolan and other interested labs should discuss comparing methodologies, QA/QC procedures and results.

## *6. Documentation*

There is a need for a strongly worded, effective document which will outline the steps required to support and sustain monitoring within the watershed.

# **2. Nutrients and Algae**

## ***Review and Update Recommendations from 2006 Working Group***

### *Paleolimnology inventory of cores from Rainy River Basin and LOW*

Researchers were contacted by Euan Reavie and asked to provide information on core location, methods, details (length, purpose), evaluation methods, storage and contact information and details about any publications.

At least four major groups of researchers that conducting paleolimnological research in the basin:

- 1) Minnesota group (St. Croix Watershed Research Centre-Science Museum of Minnesota, Centre for Water and the Environment-UMN Duluth, MPCA)
- 2) Department of Fisheries and Oceans
- 3) University of Manitoba (Jim Teller and Trevor Mellors, and Brenda Hann);
- 4) Queen's University and MOE

### *Scoping study of blue-green algal toxicity in LOW*

Brian Kotak outlined the results of a study conducted in 2006 to measure spatial and temporal variations in microcystin levels. There are no guidelines for recreational use with respect to microcystin (WHO = <10ug/L – low risk, 10-20 – moderate, 20-2000 – high, >2000 – very high risk). Almost all samples collected in May in the Lake of the Woods were below detection. Lily Pad Bay in September had very high levels (1312 ug/L) with 99% aphanizomenon. Five MPCA samples had detectable but low concentrations. In the SE portion of the lake the highest concentration was 44ug/L but

the majority were below detection. Samples collected near Frenchman's Rock were 394-607 ug/L on August 7<sup>th</sup>. Concentrations accumulate along shorelines with considerable inter sample variation.

*Development of public information campaign for LOW patterned after MN approach –*  
Not done

*Preliminary nutrient modeling*

Gartner Lee was hired to conduct a nutrient budget feasibility study. The preliminary results were presented at the conference with completion of the report expected early in 2007.

*Review of MPCA 2006 sampling*

MPCA recommended that Lake of the Woods be placed on a draft list as impaired water in the Minnesota Sections of the Lake. The State will be required to assess the condition of the water and provide a schedule to improve water quality. Details were provided at the conference.

***Review of Ongoing Efforts***

*State of the Basin report – Update*

A partnership between the Lake of the Woods Water Sustainability Foundation, Environment Canada, Ontario Ministry of the Environment and the Minnesota Pollution Control Agency has been created to develop the State of the Basin Report for Lake of the Woods and the Rainy River Basin. This report will provide baseline data on regional climate, basin characteristics, water chemistry and general biology. The document will include a gap analysis in which future research questions will be discussed. The report will also contain the Nutrient Budget Scoping study being prepared by Gartner Lee. The State of the basin Report will be compiled by Anna DeSellas (M.Sc.), working at the Dorset Environmental Science Centre, Dorset, ON. A draft report will be completed by September 15, 2007 with the final report due by December 31, 2007.

*Nutrient budget/modeling scoping study*

The nutrient-budget-scoping-study draft report has been submitted by Gartner Lee for review at the time of this writing and will be included in the State of the Basin Report in December 2007.

***New initiatives: Development of Action Items and Recommendations for 2007-08***

*Lake of the Woods: Data Summary for Minnesota Impaired Waters Assessment*

Data collection and summaries following the placement of Lake of the Woods onto the draft list of impaired waters will continue in 2007.

*State of the Basin report and Nutrient budget/modeling scoping study*

Consideration of recommendations provided by these two reports.

### **3. Aquatic Invasive Species**

#### ***Review and Update Recommendations from 2006 Working Group***

This was the first meeting of this group with tentative plans to conduct a formal session in 2008. There have been initial collaborations to address AIS between DFO, MNR.

#### ***Review of Ongoing Efforts***

##### *Introduction*

Lake of the Woods and Rainy Lake are part of the Winnipeg-Nelson River drainage system which empties into Hudson Bay. The watershed upstream of Lake of the Woods drains over 7 million ha - along both sides of the US /Canada border eastwards to the height of land separating it from the Great Lakes drainage. The lake's location and its popularity as a tourism destination make it especially vulnerable to introductions of aquatic organisms. Its headwaters are less than 100 km from Lake Superior. The south end of Lake of the Woods is located less than 100 km from the headwaters of the Mississippi drainage and is even closer to the Red River – Nelson system. In this regard, Environmental conditions are suitable for further invasions from surrounding watersheds (e.g. zebra mussels).

##### *Rusty Crayfish*

The first report of rusty crayfish from Lake of the Woods was made by Crocker and Barr (1968) from the Regina Bay / Lobstick Bay area, just east of Sioux Narrows. Since 1968 rusty crayfish have spread throughout Whitefish Bay and northwards along the eastern shore to Kenora and along the Barrier Islands. By the 1990s they were found as far west as the Big Narrows area near Portage Bay and at the south end of Hay Island in Sabaskong Bay. This is close to Turtle Portage which had remained open as a navigable channel between Whitefish and Sabaskong Bays until the mid-1990s. Up until year 2000, there were no reports or observations in Shoal Lake, the Ptarmigan and Clearwater Bay area, and the area south of the Aulneau Peninsula including OMNR South Sectors and American waters.

##### *Papershell Crayfish*

Another non-native crayfish, the papershell crayfish (*O. immunis*) was reported from Snake Bay on the eastern side of Whitefish Bay from the late 1960's. Several potential invasion fronts have been identified:

- Entrance to Ptarmigan – Clearwater Bay area in North Sector
- Northwest Angle and Bishop Bay in Central and Sector 6
- Entrance to Sabaskong Bay and Miles Bay area in Sector 5

Studies indicate further expansion westwards and northwards from the entrance to Ptarmigan Bay up through the Corkscrew Channel into the east end of Clearwater Bay and westwards along the south shore of Ptarmigan to the east side entrance to Ash Bay.

##### *General observations*

- papershell crayfish (*O. immunis*) were found in areas which were over 100 km from the last known observation in Whitefish Bay
- The fish-community-index, gill-netting crew also observed several northern clearwater crayfish (*O. propinquus*) at Okie Island in Whitefish Bay. This was the first reported sighting of this species in Lake of the Woods
- Minnesota DNR reported the first rusty crayfish from their waters this fall in the vicinity of Garden Island.

- Concern: Winnipeg River could act as gateway for western expansion of *O. rusticus* from Lake of the Woods, known in lake; reported in river downstream of Norman Dam
- Goal: assess status of the invasion front in the Winnipeg River
- *O. rusticus* remains upstream of Whitedog Falls in ON
- Northern clearwater and papershell crayfish are below Whitedog Falls

#### *Bythotrephes*

Response to Spiny Waterfleas in Lake of the Woods Basin - Jay Rendall - March 7, 2007. First designations effective March 12:

- Namakan
- Rainy Lake
- Rainy River
- Lake of the Woods

#### *Regulations*

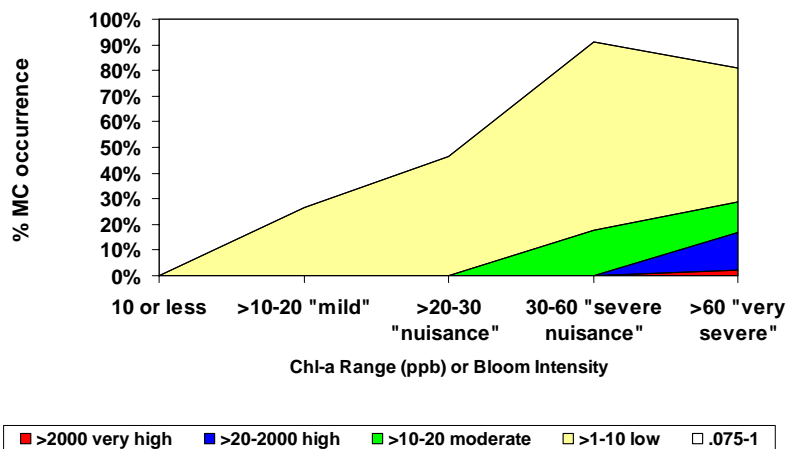
- *"The taking of wild animals from infested waters for bait is prohibited, except ... may be permitted for: commercial taking according to a permit. Harvest may be allowed when and where the Department determines that risks can be kept to a minimum.*
- Already in effect: *Infested waters may not be transported on a public road*
- Will become effective: *A person leaving infested waters designated as having ... zebra mussel ... must drain bait containers, other boating-related equipment holding water..., and livewells and bilges by removing the drain plug*
- *Watercraft inspections*

## 2. Microcystin Levels in Eutrophic South Central Minnesota Lakes

Steven Heiskary and Matthew Lindon, Minnesota Pollution Control Agency, Environmental Analysis and Outcomes Division, 520 Lafayette Road, St. Paul MN 55155 651-296-72127, [steven.heiskary@pca.state.mn.us](mailto:steven.heiskary@pca.state.mn.us)

Blue-green algae, more appropriately referred to as Cyanobacteria, are a common component of the algal community in lakes and rivers in Minnesota and elsewhere in the world. It has been long known that certain forms of blue-greens have the ability to produce toxins and these toxins have been implicated in animal deaths and human-health related problems. These toxins: anatoxin, saxitoxin, microcystin and a more recently described toxin: cylindrospermopsin vary in their toxicity; and of these, microcystin (MC) is the most commonly measured in most studies. In the summer of 2006 the MPCA conducted a study to characterize the magnitude of MC concentrations in a set of highly eutrophic lakes. For this purpose 12 lakes in south central Minnesota were selected and sampled monthly from May through September. Standard limnological and MC samples were collected at a mid-lake (pelagic) site on each occasion. In addition a near-shore "bloom" site was sampled as well for MC. A summary of our findings indicate that MC was measurable in over 90% of the pelagic and near-shore samples, though most were in the WHO "low risk" range. While MC frequency distributions were somewhat similar among the pelagic and near-shore sites there was a higher frequency of the moderate to severe risk MC levels found at the near-shore sites (about 20%) and these were often associated with a distinct surface bloom. Based on this one summer of sampling there was no distinct seasonal pattern. In general, MC was positively associated with chlorophyll-a, abundance of MC-producing blue-greens and pH (presumed surrogate for photosynthesis) and was negatively associated with Secchi transparency and alkalinity. There was a distinct relationship among MC and bloom intensity (Figure 1). When chlorophyll-a levels were < 20 ppb MC remained in the low risk category; however as chlorophyll-a increased above 30 ppb (severe nuisance blooms) the risk of moderate-risk MC increased to 10-15% and as chlorophyll-a increased above 30 ppb there is a potential for high to very high risk MC.

These results further suggest the importance of minimizing the frequency and intensity of algal blooms as a water quality management strategy. As for communicating risk to the public these data suggest that it is prudent to avoid contact (human or animal) with blue-green algal scums. While these data were collected on highly eutrophic lakes it would seem that this precaution and overall strategy (minimize frequency and intensity of blooms) may be appropriate for LOW.



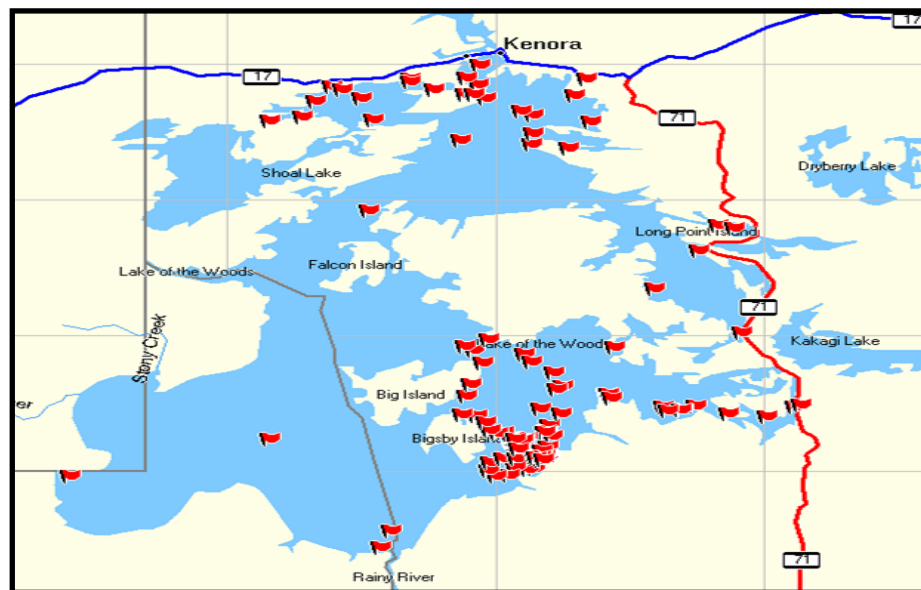
**Figure 1.** Microcystin concentrations as a function of algal bloom intensity



### 3. Cyanobacterial Liver Toxins in Lake of the Woods: Preliminary Results From 2006

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A series of surveys were conducted during the summer and autumn of 2006 on Lake of the Woods to assess the occurrence and concentration of the cyanobacterial liver toxin, microcystin, in three main areas of the lake: near Kenora, in the Canadian part of the south basin from near Bigsby Island to Nestor Falls and in the US part of the south basin in Big Traverse Bay (see map). Microcystin was not detected from open water samples (i.e., those collected away from shorelines) in the northern part of the lake, and concentrations were low (<1.0 ug/L) in the south basin in the U.S. side of the lake. Open water samples from the Canadian part of the south basin were much higher and ranged from below detection limits to up to 67 ug/L. The proportion of samples containing toxin and the toxin concentrations were highest in August and September, corresponding to periods of large, algae blooms. Microcystin concentrations in samples collected along shorelines of islands, along mainland beaches and in front of cottages in the Canadian part of the south basin were much higher than in open water locations, especially where algae blooms had accumulated along shorelines. Shoreline concentrations of microcystins were up to 607 ug/L. Highest shoreline concentrations of microcystin occurred in August and September, although high concentrations persisted into early October. In some instances, concentrations of microcystin in both open water locations and along shorelines would constitute a moderate to high risk for exposure and human health impacts according to World Health Organization guidelines for recreational contact with water.

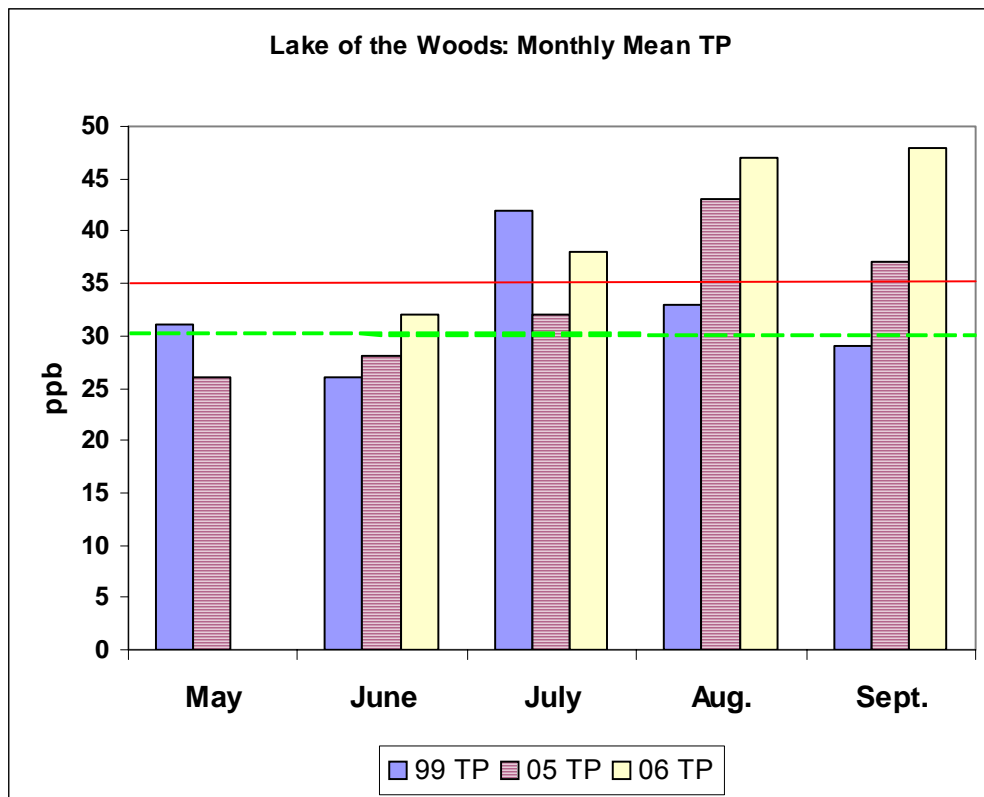


**Map:** Location of sampling sites for microcystin in 2006.

#### 4. Lake of the Woods: Data Summary for Minnesota Impaired Waters Assessment

Steve Heiskary, Minnesota Pollution Control Agency, Environmental Analysis and Outcomes Division, 520 Lafayette Road, St. Paul MN 55155, 651-296-72127, [steven.heiskary@pca.state.mn.us](mailto:steven.heiskary@pca.state.mn.us)

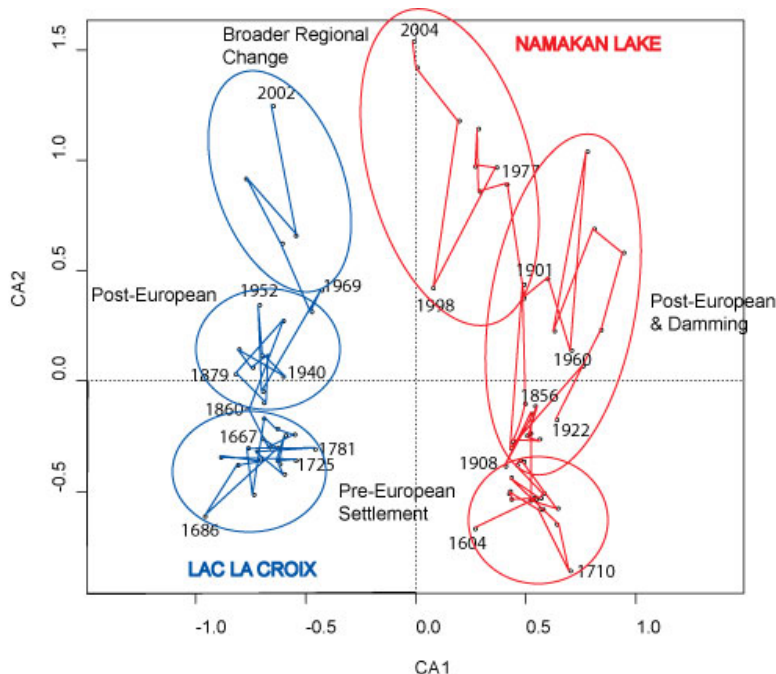
Data collected during three summers at four locations in the Minnesota portion of Lake of the Woods are shown relative to the current thresholds for 303(d) assessment. The average data for 12 visits in 1999, 2005 and 2006 show: TP = 36 $\mu$ g/L, Chl  $\bar{a}$  = 9.9  $\mu$ g/L, and Secchi depth = 1.3 m. Thresholds for full use support would be <30  $\mu$ g, <10  $\mu$ g, and  $\geq$  1.6m respectively. Northern Lakes and Forests ecoregion draft nutrient criteria for Class 2B waters (Aquatic Recreational use) which is the most lenient of three categories has thresholds of <30 $\mu$ g, <9.9 $\mu$ g, and  $\geq$  1.8m respectively. Water quality observations for this portion of Lake of the Woods indicate a significant number of occurrences where values exceed threshold targets.



## 5. Historical changes of diatom communities and water quality in Namakan Lake and Lac La Croix

*Claire A. Serreyssol<sup>1\*</sup>, Mark B. Edlund<sup>2</sup> and Larry Kallemeyn<sup>3</sup>* <sup>1</sup>Water Resources Science, University of Minnesota, Saint Paul, MN, 55108, USA, [seri00262umn.edu](mailto:seri00262umn.edu); <sup>2</sup>St. Croix Watershed Research Station of the Science Museum of Minnesota, Marine on St. Croix, MN, 55407, USA; <sup>3</sup>USGS, CERC-IFBS, International Falls, MN 56449 [SERI0026@UMN.EDU](mailto:SERI0026@UMN.EDU)

We studied the timing and magnitude of ecological change resulting from historical water-level manipulation in Voyageurs National Park (VOYA) using a before-after, control-impact paleolimnological study. Sediment cores were recovered from 4 lakes. Rainy, Namakan and Kabetogama Lake were dammed in the early 20<sup>th</sup> century and have undergone periods of hydromanagement. Lac La Croix, the control lake, is upstream of VOYA and was not impacted by water-level manipulation. The cores were dated using <sup>210</sup>Pb activity and sediment biogeochemistry was determined using loss-on-ignition analysis. Subfossil diatom communities and chironomids are being analyzed to determine natural variability of biological communities and their response to European settlement, landuse shifts, damming, and historical water-level management plans. A diatom calibration set from 145 Minnesota lakes will be used to explore quantitative reconstruction of historical water quality parameters (e.g., TP, pH, ANC). Initial analyses use the Namakan Lake and Lac La Croix sediment cores. Lead-210 dating indicated that pre-European (c. 1865) sediment is present below 25 cm in Namakan Lake and 30 cm in Lac La Croix. Damming of the Rainy-Namakan-Kabetogoma system has resulted in a two-fold increase in sediment accumulation rates in the impacted site, whereas sediment accumulation rates in Lac La Croix remained unchanged. A diverse diatom community (>40 genera) is preserved throughout the cores but distinct differences exist between cores as evidenced in a correspondence analysis of the diatom communities (Figure 1). Both lakes have 270 common taxa. However, they are separated in ordination space by taxa that are unique with tight clusters of samples before European settlement, which denotes minimal ecological variability among samples during that time period. Both lakes show clear community shifts away from pre-European settlement likely in response to initial logging and settlement. However, ecological variability in diatom communities is greater in Namakan Lake than in Lac La Croix probably due to damming and hydromanagement. There is also a distinct broader regional change starting from the 1970s perhaps due to climate change.

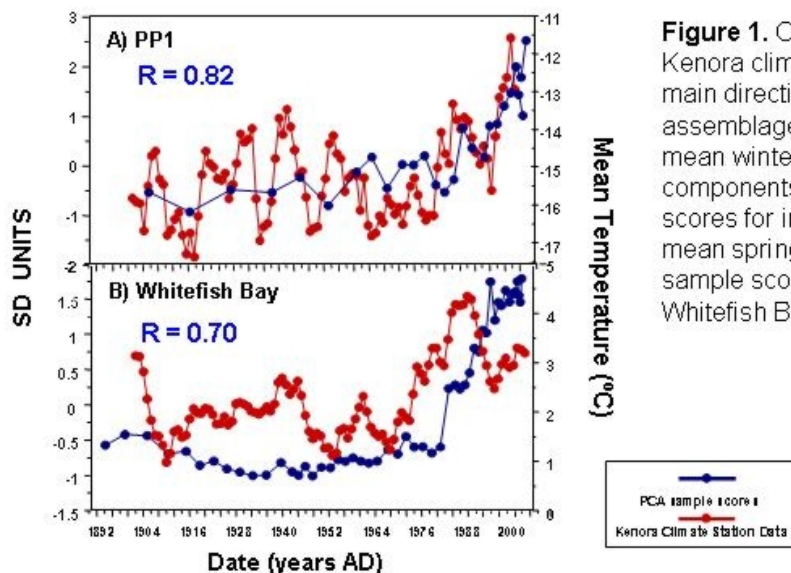


**Figure 1.** Correspondence analysis plot using Bray-Curtis similarity calculations showing community shifts through time in Lac La Croix and Namakan Lake

## 6. Paleolimnological evidence from diatoms for recent environmental and climatic changes in the Lake of the Woods

Rühland, K.M.<sup>1</sup>, Paterson, A.M.<sup>2</sup>, and Smol, J.P.<sup>1</sup> <sup>1</sup>*Paleoecological Environmental Assessment and Research Laboratory (PEARL), Department of Biology, Queen's University, Kingston, ON, Canada, K7L 3N6, [3kmr5@biology.queensu.ca](mailto:3kmr5@biology.queensu.ca);* <sup>2</sup>*Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, Canada, P0A 1E0, [andrew.Paterson@ontario.ca](mailto:andrew.Paterson@ontario.ca)*

One of the important requirements to understanding environmental change and a key lake management issue is determining the 'natural' or baseline condition for a given aquatic system. Insights into a lake's water-quality history can help determine whether or not the state of the ecosystem at present has changed substantially over time, and subsequently, the direction and magnitude of the change. In the Lake of the Woods, there has been much interest in determining whether there have been historical changes in total phosphorus (TP) concentrations throughout the basin and whether the purported increase in the frequency and intensity of cyanobacterial algal blooms in the northern basin can be linked to recent increases in TP concentrations. Dated sediment cores retrieved from Whitefish Bay and a site in the north end (NE of Thompson Island) were analyzed for changes in the relative abundances of diatoms over the past ca. 100-150 years. Shifts in diatom assemblage composition were used to interpret the effects of historical changes to the basin including changes in water levels and the opening and closing of the canal near Whitefish Bay. Quantitatively, a diatom-based inference model was applied to these cores to determine whether TP concentrations have changed substantially over the last ca. century. An emerging trend from this study is that dramatic changes in the diatom assemblages over the past few decades is consistent with recent climatic warming and coeval with the two warmest decades on record (1980s and 1990s).



**Figure 1.** Correlations between Kenora climate station data and the main directions of variation in diatom assemblage composition using A) mean winter temperature and principal components axis 2 (PC2) sample scores for impacted site, PP1, and B) mean spring temperature and PC1 sample scores for reference site, Whitefish Bay.

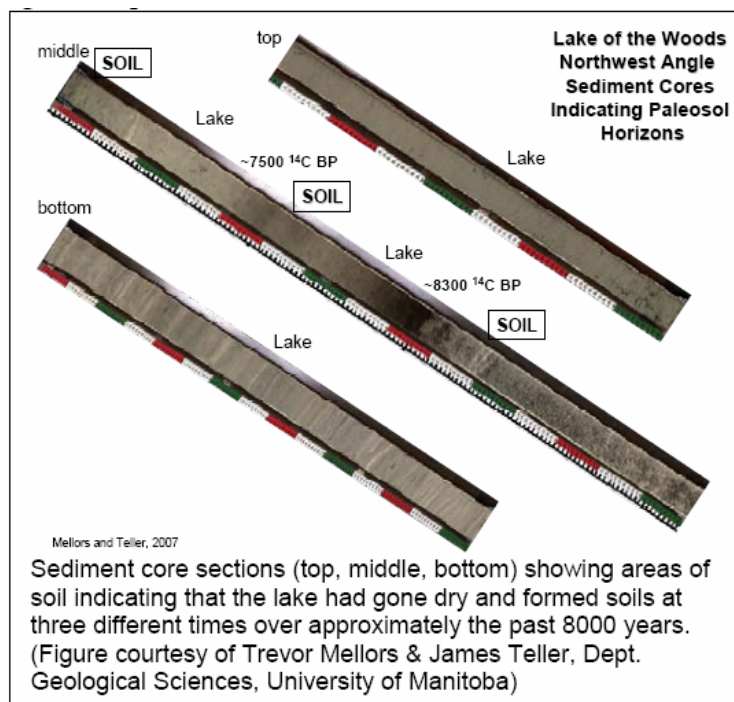
## 7. Recovery and analysis of sediment cores from Lake of the Woods and Shoal Lake – predicting the future by establishing the past climate using ostracodes and the stratigraphic record

*Trevor Mellors and James Teller, Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2*

Ten sediment cores were collected from Lake of the Woods and Shoal Lake in 2006 from an anchored floating platform using a 5-10 m long Kullenberg piston corer from the Limnological Research Center at the University of Minnesota. Two cores came from the southern end of the lake (MN), four cores from the NW Angle area (MN & ON), two cores from the Kenora area (ON), and two cores from Shoal Lake (ON). A preliminary examination of three cores shows a wide variation in sediment type in the sequence which spans several thousand years, including soils buried in the sediment that indicate the lake floor was dry for long periods on several occasions.

This sediment study provides the means to establish the paleo-hydrology in Lake of the Woods and the paleo-climate of the region. Modern changes underway in the earth's climate system have been compared to the dramatic changes of the mid-Holocene warming, 4000-7000 years ago, which followed the last ice age. This paleo-record may be an indication of what we can expect in the future, as the current climate warms and moves away from the relatively stable conditions of the past millennium.

Stratigraphic information (e.g. grain size, mineralogy, bedding, remnant magnetism, organic content, etc.) are being studied to decipher the recent environmental and hydrological history of Lake of the Woods watershed. Ostracode identification and analysis will play a major role in this study, because they can be used as a proxy for the paleohydrology of a lake. Different species prefer deeper or shallower water environments and hence by identifying ostracode species and their relative abundance over the sediment core length, variations in water level can be identified. Similarly, certain species prefer higher salinity and can be used to identify past increases in salinity associated with less precipitation and increased lake evaporation in the watershed.





## 8. Analysis of land use changes in Little Fork River riparian zone

Lee Engel <sup>1</sup>, Andrew Streitz <sup>2</sup>, and Jesse Anderson <sup>2</sup>

<sup>1.</sup> University of Minnesota, Duluth; Environmental Studies Department

<sup>2.</sup> Minnesota Pollution Control Agency, Duluth Minnesota

The Little Fork River was added to Minnesota's impaired waters list in 2006 for excess turbidity. Recent research indicates that stream bank erosion is likely the primary source of the turbidity. It is important to understand land use patterns in the River's riparian zone and their effect on water quality. Aerial photographs and satellite imagery of the Little Fork River from 1940 and 2003 were compared for 117 river miles, ending at the confluence with the Rainy River. The University of Minnesota provided the 1940 photographs, taken by the Agricultural Stabilization and Conservation Service (ASCS). The 2003 satellite images were provided by the Farm Service Agency (FSA). A shape file was created in Arc Map 9.1 to trace the course of the Little Fork River in the studied area. From the shape file, 100 and 300 meter wide buffers were created to define the riparian boundary for land use analysis. Twenty-five sites were selected at random in which land uses were calculated within the buffers 500 meters upstream and downstream of each site. The 1940 photographs were scanned and compared side-by-side with the 2003 georectified images. Minnesota Department of Natural Resources mapped forest disturbances in the watershed were overlaid on 2003 FSA images. Percentages of recently disturbed land (primarily from 1990-2005 logging) identified by the DNR were measured within each buffer along with cleared land not identified by the DNR- such as 'open' land used for agriculture or residential development. Percentages were calculated using an area measurement tool in Arc Map 9.1 for the 25 randomly selected sites along the river. Comparisons of land use between historical (1940) and present day (2003) conditions can now be made.

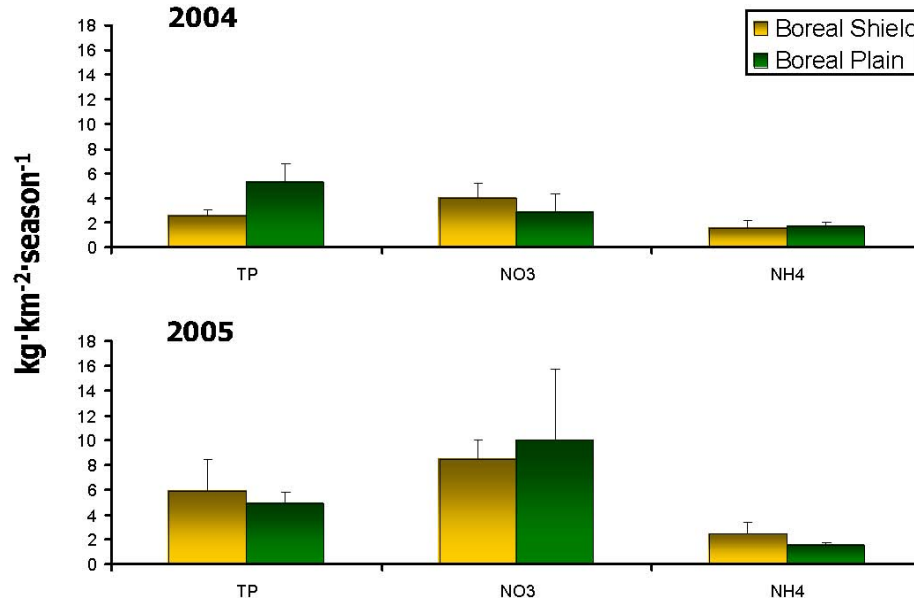
**Photos:** Recent, 2003 (left) and 1940 (right) aerial photographs of the Little Fork River.



## 9. Seasonal discharge and nutrient dynamics of Boreal Shield headwater streams in north-western Ontario within an industrial forest context

Paul Dinsmore, Janice Burke, Chantal Nicholson, Elyse Mussell, Yanyan Chen and Ellie Prepas\* Faculty of Forestry and the Forest Environment, Lakehead University 955 Oliver Road, Thunder Bay, ON, P7B 5E1; \*also at Department of Biological Sciences, University of Alberta, Edmonton, AB, T6G 2E9

First-to third-order watersheds provide the majority of forest cover in the Lake of the Woods drainage, and are intensively impacted by forestry operations in northwestern Ontario. The Forest Watershed and Riparian Disturbance (FORWARD) Project compared baseline runoff and water quality data collected May-October of 2004 and 2005 from first-to third-order Boreal Shield streams to similar data from the Boreal Plain ecozone of western Canada. Mean total runoff from Boreal Shield and Boreal Plain watersheds was similar in 2004 (116 and 92 mm, respectively,  $P = 0.41$ ), but was higher in the Boreal Shield in 2005 (163 and 75 mm, respectively,  $P = 0.02$ ). Mean total phosphorus, nitrate, and ammonium export coefficients (Figure 1) were similar between study areas during both years ( $P = 0.14$ - $0.87$ ). Where significant, relationships between total phosphorus concentration and stream flow were negative for Boreal Shield streams, but positive for Boreal Plain streams. We postulate that, while peak flow events promote erosion of phosphorus-rich materials within Boreal Plain watersheds, typically thin Boreal Shield soils become rapidly depleted of phosphorus during similar events. Experimental forest harvesting of selected Boreal Shield watersheds is planned for the winter of 2007/2008. We expect dramatic short-term (1-2 year) increases of in-stream phosphorus, followed by a rapid return to baseline concentrations as soil reserves of dissolved phosphorus are depleted.



**Figure 1.** Mean nutrient export coefficients for Boreal Shield (NW Ontario) and Boreal Plain (Alberta) study streams, 2004 and 2005.

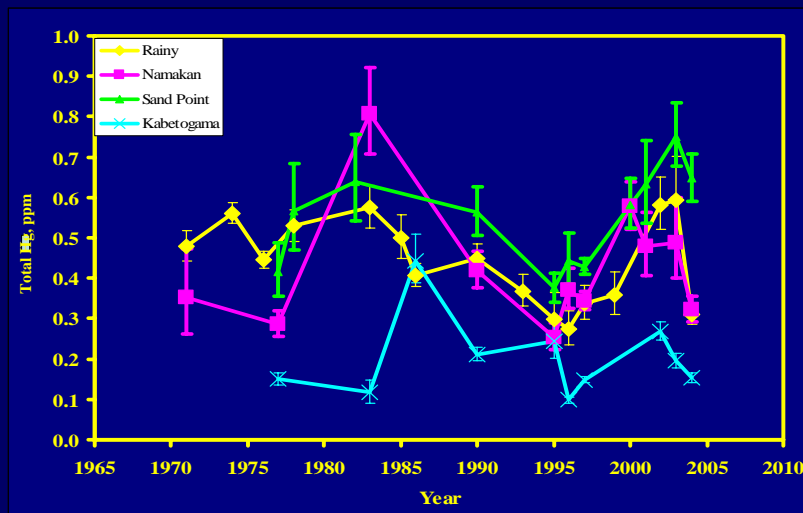


## 10. Mercury in fish in Voyageurs National Park – is the situation improving, getting worse, or staying the same?

Larry Kallemeyn, USGS-CERC-IFBS, 3131 Highway 53, International Falls, MN 56649, 218-283-9821, [Larry\\_Kallemeyn@usgs.gov](mailto:Larry_Kallemeyn@usgs.gov); John Sorensen, Environmental Physics Laboratory, University of Minnesota-Duluth, 10 University Drive, Duluth, MN 55812, 218-726-8469, [Jsorensen@D.umn.edu](mailto:Jsorensen@D.umn.edu).

In the 1970s, the large lakes of Voyageurs National Park were some of the first lakes in Minnesota identified as containing fish with mercury concentrations high enough to make fish consumption advisories necessary. Governmental agencies and researchers, because of the environmental threat posed by mercury, particularly to human health, have since then monitored mercury in fish in the Park lakes and conducted studies to gain a better understanding of the factors contributing to variation in ecosystem sensitivity and mercury concentrations in fish and other components of the aquatic food web. Although a variety of fish species have been analyzed over the years, the primary focus has been on northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*), the most widely distributed and frequently sampled species. While significant spatiotemporal variation has been observed in mercury concentrations in both species, they continue to be high enough to make consumption advisories necessary. Mercury concentrations in northern pike from the Park's large lakes do not seem to be decreasing as might be predicted given that the reservoirs are nearly 100 years old.

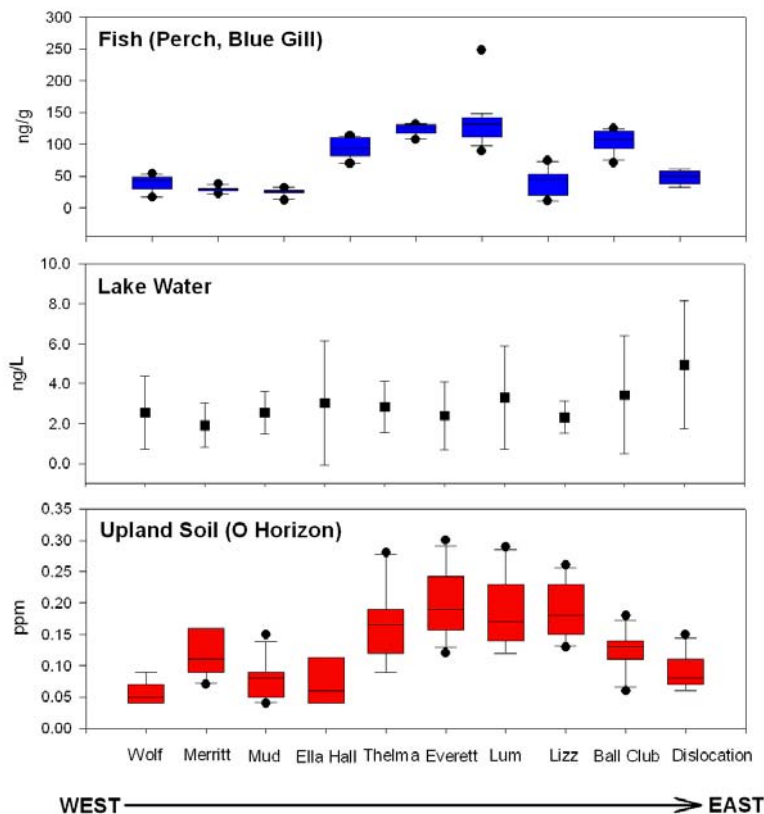
**Total mercury concentrations in 55 cm northern pike from Rainy, Namakan, Sand Point, and Kabetogama lakes, 1971-2005**



## 11. Influence of prescribed forest fire on the re-mobilization of mercury in the Boundary Waters Canoe Area Wilderness - update

Trent Wickman<sup>1</sup>, Mark Gabriel<sup>2</sup>, Randy Kolka<sup>3</sup>, Jason Butcher<sup>1</sup>, Kenneth Gebhardt<sup>1</sup>, Laurel Woodruff<sup>4</sup>, William Cannon<sup>4</sup>, and Emma Witt<sup>5</sup> <sup>1</sup>USDA Forest Service Superior National Forest <sup>2</sup>South Florida Water Management District Station <sup>3</sup>USDA Forest Service Northern Research <sup>4</sup>US Geological Survey <sup>5</sup>University of Minnesota

A prescribed fire burning program was established by the US Forest Service for the Boundary Waters Canoe Area Wilderness (BWCAW) in response to a major blowdown event that occurred in 1999. Under this program nearly 75,000 of the 1.1 million acres of the BWCAW will be burned as strategic patches in the blowdown area over a 5 to 7 year period to reduce fuel loads. The Northern Research Station and the Superior National Forest established a plan to monitor Hg changes in various environmental media in concert with conducting prescribed forest fire operations in the BWCAW. Upland soil, water, fish (perch, blue gill), and tree throughfall chemistry will be gathered before and after burns from 10 lakes inside and outside areas of burn activities to determine if prescribed burning increases total mercury (THg) concentrations in fish. Following 2 yrs that were free from burning activities, we found statistically significant ( $p < 0.001$ ) background variation in fish and upland soil THg for several lakes. Regression modeling determined the best predictor for THg variation in fish to be O horizon soil THg (65 - 82% of the spatial variation). Other important factors for fish THg variation include lake and watershed area and area of lacustrine and palustrine wetlands. Even though these components are highly co-linear, they play important roles in fish THg prediction. Principal component analyses show that soil O THg is highly correlated ( $p < 0.001$ ,  $r \geq 0.8$ ) with common trace metals/metalloids (i.e. Pb, As, Sn, Ti) suggesting surface



geochemistry, in particular changes in organic content and type, as the main cause for the observed variation in soil O THg. Since local atmospheric Hg sources are negligible and regional impacts are fairly uniform, this suggests the importance of prescribed and natural forest fires with respect to Hg mobilization as each can alter O horizon geochemistry and organic content. Spatial variation in lake water THg is much less than in soil and fish. The spatial trend in lake water THg is also different for each year including best predictors, although the best predictors are related chemically and/or biologically.

## 12. Service learning partnerships as a model for enhancing biological monitoring efforts with Voyageurs National Park

Julius, M.L.<sup>1</sup>, M.J. Kuusisto<sup>1</sup> and C. Holbeck<sup>2</sup> <sup>1</sup>Department of Biological Sciences, 720 Fourth Avenue South, St. Cloud State University, St. Cloud, MN 56301 - (320) 308-5688 [mjkuusisto@stcloudstate.edu](mailto:mjkuusisto@stcloudstate.edu) <sup>2</sup> Voyageurs National Park, International Falls, MN

Voyageurs National Park and St. Cloud State University have formed a long-term partnership in an effort to mutually support ongoing resource monitoring and management efforts in the park and expand educational opportunities at SCSU. Projects of mutual interest (POI) have been and continue to be identified; currently these include water quality issues, cyanobacterial toxin risk assessment, and micro-organism diversity in aquatic systems. An intersession course has been conducted during the spring to develop protocols for POI's and a graduate student remains in residence over the remaining portion of the field season to complete the research. To support these activities VNP provides lodging, space to set up laboratory equipment, and watercraft.

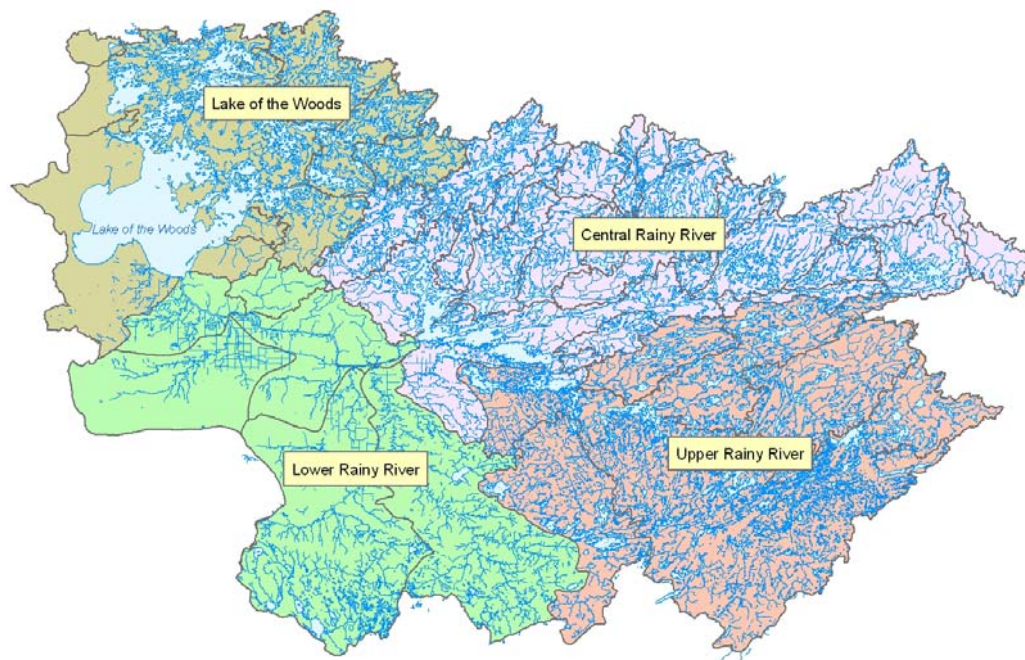




### 13. Requirements, development and utility of a nutrient mass balance model as a management tool for Lake of the Woods

*Tammy Karst-Riddoch and Neil J. Hutchinson, Gartner Lee Limited, 11B Taylor Rd., Bracebridge, ON P1L 1S6*

Concern over the role of plant nutrients in controlling development of nuisance and toxic summer algal blooms has led the Lake of the Woods Water Sustainability Foundation (LWWSF) and Environment Canada (EC) to consider the use of a nutrient budget as a management tool for the lake. Gartner Lee Limited, an environmental consulting firm with specialization in lake nutrient models, was retained by these agencies to assess the feasibility and usefulness of a nutrient budget for Lake of the Woods. Here, we document the availability and quality of existing hydrologic and nutrient data that are required to construct and calibrate an empirical nutrient model and identify data gaps and costs to obtain any necessary missing information. Based on these findings, the model requirements, and specific characteristics of the lake, we provide recommendations regarding the most suitable modeling approach for Lake of the Woods. Finally, we evaluate the effectiveness of a nutrient model to address important lake management issues for Lake of the Woods such as: a) potential lake responses to nutrient reduction strategies in terms of phosphorus concentrations and algal biomass, b) the contribution of nutrient inputs to Lake Winnipeg from Lake of the Woods, and c) the impact of damming in the early 20<sup>th</sup> Century and associated water level changes or fluctuations on nutrient loads and trophic state conditions in Lake of the Woods.



## Emerging Issues

### **14. Protecting water quality through inter-agency collaboration-the St. Croix Basin Water Resources Planning Team**

*Randy S. Ferrin, St. Croix Basin Water Resources Planning Team c/o 23290 Quentin Avenue, Scandia, MN 55073 - 651-433-4929 rsferrin@frontiernet.net*

The Wild and Scenic Rivers Act of 1968, and as amended in 1972, included the St. Croix River in Minnesota and Wisconsin in the original list of eight designated rivers. Status as a Wild and Scenic River has been critical in protecting and preserving the scenic, recreational, geologic and biological values of the Riverway along a narrow corridor in and paralleling the river. However, this thin ribbon of protection is threatened by activities outside its boundaries including agriculture, aggregate mining, logging, construction, and tremendous population growth in the Twin Cities Metropolitan area of eastern Minnesota and western Wisconsin. The cooperative management of the Riverway involving Federal and State agencies provided a useful framework for the expansion of efforts to protect the main stem corridor. In 1993, with evidence that conditions in the St. Croix were likely to be degraded, agencies with management interests in the Riverway agreed that protection of the St. Croix required a broader, basin-wide approach to water resource management. Subsequently, a Memorandum of Understanding was signed that year between the Minnesota Pollution Control Agency, the National Park Service, the Wisconsin Department of Natural Resources, and the Minnesota Department of Natural Resources. The MOU initiated a planning and collaboration process to better protect the water quality of the St. Croix.

In the ensuing years, other state, federal, and local agencies with an interest in protecting the St. Croix have joined the planning effort. With over twelve agencies now represented, the St. Croix Basin Water Resources Planning Team (The Basin Team) has been active since its inception. The Basin Team's existence has leveraged hundreds of thousands of dollars in funding for water quality studies over the last decade. Several subcommittees, particularly the Nutrient Subcommittee, have been extremely productive in providing guidance and direction for water quality protection initiatives. In 1999, six of the agencies participated in a season-long biweekly monitoring program at 27 main-stem and tributary sites. The monitoring, modeling, and trends analyses work of the subcommittee led to an interstate agreement being signed by officials of the Minnesota and Wisconsin water quality regulatory agencies in 2006. In the agreement, the States set a goal of returning Lake St. Croix to the ecological and water quality conditions that existed prior to 1950. The Team is currently working on an implementation plan to achieve that goal. To help meet its education and outreach objectives, the Basin Team has sponsored an annual St. Croix Basin Protection Conference since 2000, drawing well over a hundred participants each year. The future of the Team seems solid with the continuing support and involvement of the member agencies.



## 15. Risk factors vs. mechanistic explanations: regulation of cyanobacterial abundance

*Lewis A. Molot, Faculty of Environmental Studies, York University, Toronto, Ontario*

High nutrient loading is an important risk factor for the formation of summer cyanobacterial blooms. Management strategies that reduce loads, especially total phosphorus, have met with great success, for example in the Great Lakes. Nevertheless, resurgences in toxic cyanobacterial blooms, especially *Microcystis*, have been observed in the lower Great Lakes over the last decade in areas where total phosphorus levels are below historically high levels and where nitrogen is not limiting, suggesting that an important factor has been overlooked. The presentation will review published mechanisms that attempted to explain the displacement of eukaryotic algae by large cyanobacteria. A model of the role of iron in co-regulating cyanobacterial relative abundance in both in oligotrophic and eutrophic waters will then be presented using evidence from marine and freshwater studies.

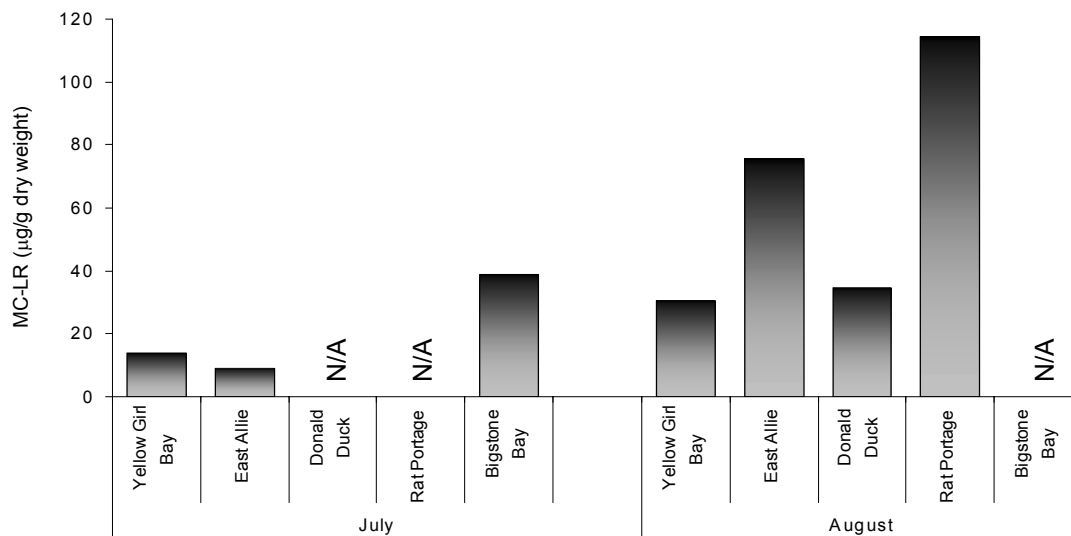


***Microcystis* bloom, October 2005 - Bay of Quinte, eastern Lake Ontario**

# 1. Nutrient concentrations, cyanobacterial biomass and microcystin-LR concentration in bloom material from the northern basins of Lake of the Woods

Huirong Chen<sup>1</sup>, Janice M. Burke<sup>2</sup>, W. Paul Dinsmore<sup>2</sup>, Ellie E. Prepas<sup>1,2</sup> and Phillip M. Fedorak<sup>1</sup> <sup>1</sup>Department of Biological Sciences, University of Alberta, Edmonton, AB, T6G 2E9; <sup>2</sup>Faculty of Forestry and the Forest Environment, Lakehead University, Thunder Bay, ON, P7B 5E1

Five sites in the Ontario portion of Lake of the Woods were sampled in June, July and August 2004 to study the species composition and microcystin-LR (MC-LR) concentration of the phytoplankton community. This liver toxin was detected at least once at each of five sites, but only in July and August. MC-LR concentrations in bloom material collected with a 64- $\mu$ m tow net and analyzed by High Performance Liquid Chromatography ranged from 9 to 115  $\mu$ g/g dry weight (Figure below). In June, cyanobacteria constituted 3.5 to 49% of total phytoplankton biomass and consisted largely of *Aphanothece* spp. In July and August, cyanobacteria comprised 54 to 98% of total phytoplankton biomass in surface water samples and consisted largely of *Aphanizomenon flos-aquae*, *Anabaena* spp., as well as *Homeothrix janthina*, *Pseudanabaena* spp. and *Aphanocapsa* spp. Among study sites, total phosphorus concentrations in surface grab samples ranged from 11 to 31  $\mu$ g/L and were positively associated with total cyanobacterial biomass ( $r = 0.64$ ,  $P = 0.01$ ). MC-LR concentrations were positively related to ammonium concentrations in surface grab samples ( $r = 0.94$ ,  $P = 0.001$ ), but not to the total biomass of cyanobacteria or any cyanobacterial taxon. In the isolated Boreal Shield basins of Lake of the Woods, cyanobacterial blooms and cyanotoxins like MC-LR may have ecological and human health consequences and may be sensitive indicators of human disturbance in the drainage basin.



**Figure.** Microcystin-LR concentration (ug/g dry weight) in phytoplankton bloom samples collected in summer 2004 from five sites in Lake of the Woods, Ontario. N/A = not analyzed.



## **2. Exploring the potential impacts of houseboat grey-water discharge on aquatic ecosystems within Voyageurs National Park**

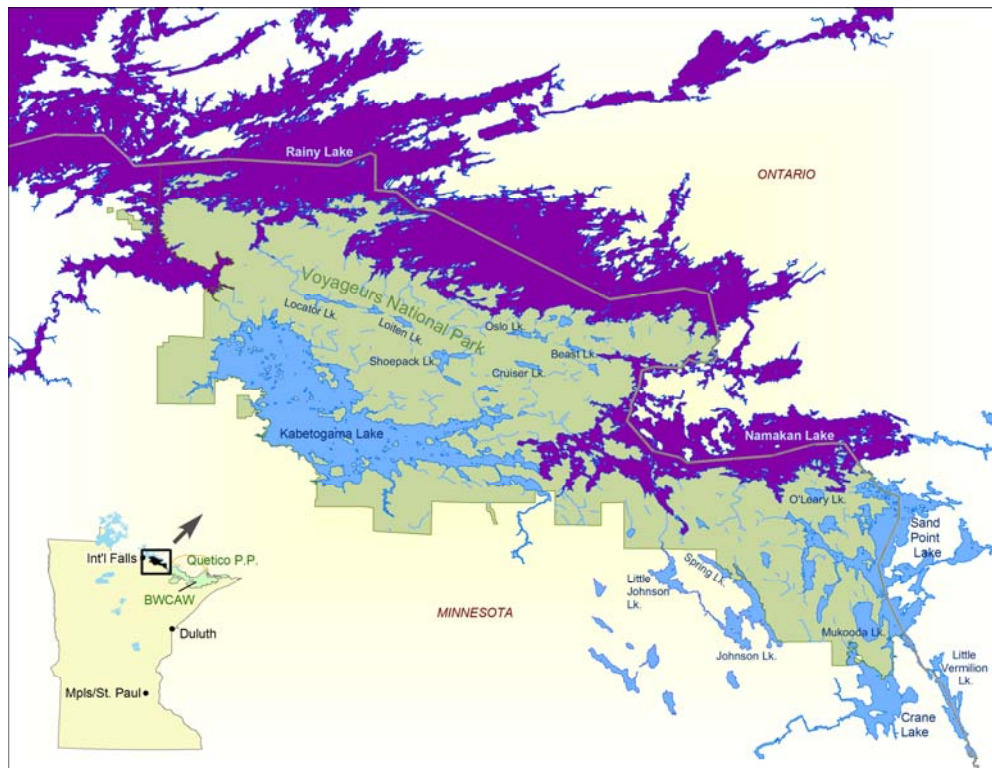
*Julius, M.L.<sup>1</sup>, M.J. Kuusisto<sup>1</sup> and C. Holbeck<sup>2</sup> <sup>1</sup>Department of Biological Sciences, 720 Fourth Avenue South, St. Cloud State University, St. Cloud, MN 56301 - (320) 308-5688 [mjkuusisto@stcloudstate.edu](mailto:mjkuusisto@stcloudstate.edu) <sup>2</sup> Voyageurs National Park, International Falls, MN*

While issues regarding greywater discharge impacts from freshwater watercraft have been unstudied, significant research effort has been invested in modeling wastewater dilution from marine vessels. Most of this work has concentrated on materials hazardous to human health. This scenario is analogous to areas within Voyageurs National Park experiencing multiple moorings from craft discharging greywater; thought to be quickly diluted. In the marine systems, no work to date has included fieldwork to determine the extent, if any, of impacts on biota from the actual nutrient inputs. This project addresses the impact of nutrient inputs on nutrient ratios and biota in a freshwater system. These data will allow a hypothesis development concerning potential long-term impacts of grey water discharge on Voyageurs National Park's aquatic systems. The data will also serve as a basis for developing an appropriate management strategy for managing houseboat grey water discharge in an effort to minimize their effect.

### 3. Recently documented aquatic exotic invasive species in Voyageurs National Park: spiny water flea and rusty crayfish

*Maki, R.P.*

Spiny water flea and rusty crayfish were both documented in Voyageurs National Park for the first time in 2006. Sampling for spiny water flea was conducted using a plankton net at multiple stations in Rainy Lake and in Kabetogama, Namakan, and Sand Point Lakes within the Namakan Reservoir. Spiny water flea was detected in most major portions of Rainy Lake. In the Namakan Reservoir, spiny water flea was only found in Namakan Lake, however, it is expected to spread rapidly to the remaining lakes within the Namakan Reservoir since they are hydrologically connected and heavily used. Sampling for rusty crayfish was conducted using baited, modified minnow traps in Namakan and Sand Point Lakes only since these lakes are closest to known infestations in Crane Lake and Johnson Lake. Rusty crayfish were documented in Sand Point Lake only. Resource managers at Voyageurs National Park are engaging in outreach and education efforts to help prevent the spread of these exotics. Park managers are considering additional strategies to prevent spread of spiny water flea and rusty crayfish to the hydrologically isolated interior lakes within the Park. Park staff will continue to sample for rusty crayfish and spiny water flea in 2007 to document spread or new infestations and will survey zooplankton for changes in community structure concurrent with the invasion of spiny water flea in Rainy Lake and the Namakan Reservoir.



**Figure.** Spiny water flea was detected in most major portions of Rainy Lake and on Namakan Lake. Infested lakes are shown in purple.

#### **4. Ecology and management of *Typha* (Cattail) invasions in the Great Lakes region**

*Steve Windels<sup>1</sup>, Steve Travis<sup>2</sup>, Joy Marburger<sup>3</sup>, and Daniel Mason<sup>4</sup><sup>1</sup>Voyageurs National Park, International Falls, MN<sup>2</sup>USGS National Wetlands Research Center, Lafayette, LA,<sup>3</sup>Great Lakes Science and Education Center, Porter, IN, <sup>4</sup>Indiana Dunes National Lakeshore, Porter, IN*

Two species of cattail (*Typha* spp.), one native to North America and the other an exotic from Europe, occur throughout the Lake of the Woods/Rainy Lake watersheds. These two species also readily hybridize and form complex associations of mixed genetic stock that may facilitate invasion. Cattails are aggressive invaders of shallow bays and quickly out-compete other aquatic plants, creating monocultures of low biological diversity that can alter nutrient dynamics and successional pathways. Cattails are especially adapted to invading disturbed systems such as those created by varying water levels or subject to external nutrient inputs. This poster will give an overview of the variation in *Typha* species/hybrid ecology and invasion ability in the region. We will also outline different management strategies that could be employed to manage these invasions.

## 5. Improving Volunteer Monitoring Identifications: An Aquatic Insect Online Verification System

Rufer<sup>1</sup>, M.M.; Wilcox<sup>2</sup> and L.C. Ferrington, Jr.<sup>1</sup> \* <sup>1</sup> Department of Entomology, University of Minnesota and <sup>2</sup> Digital Media Center, University of Minnesota - ferri016@umn.edu

The University of Minnesota Water Resources Center coordinates a Volunteer Stream Monitoring program (VSM). The VSM program also promotes the knowledge of aquatic insects and stewardship of streams and other water bodies to volunteers. Over 1,900 volunteers monitor stream sites in the Twin Cities metropolitan area and submit their results to the VSM. When this program began more than five years ago, there was only ~ 50% accuracy rate for identifications to family. However, two years ago we developed a printed key to aquatic insect families with easy to follow instructions and clear line drawings, which helped bring accuracy rates for most volunteer groups to >80%. Recently, we created an online interactive verification system (VSM- IVP) with photographs to supplement the printed key. The online VSM-IVP\*\* is used hand-in-hand with the printed key to increase accuracy of, and confidence in, identifications by volunteers. We have established a goal of >90% accuracy for VSM data. With both our key and the VSM-IVP software available free on the World Wide Web, other states are now adopting them for use in similar volunteer monitoring programs and benefiting from improved accuracy of data they facilitate. The software is appropriate for application within the Rainy River Basin and a hands-on example introduction will be provided to interested participants. \*\*Our software can be accessed at: <http://www.entomology.umn.edu/midge/>

Chironomidae Research Group  
University of Minnesota

**Volunteer Stream Monitoring  
Interactive Verification  
Program (VSM-IVP)**

**New! Use this program to verify your  
aquatic insect identifications!**

Chironomidae Research Group  
University of Minnesota  
Department of Entomology  
230 Alderman Hall  
1970 Folwell Ave.  
St. Paul, MN 55108

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## **6. 2006 water quality monitoring - Lake of the Woods County, MN**

*Mike Hirst, Lake of the Woods, Soil & Water Conservation District*

The Lake of the Woods Soil and Water Conservation District's (SWCD) water quality monitoring completed in 2006 reflected priorities outline in the "2006 Lake of the Woods County Monitoring Plan" which utilized the "Lake of the Woods County Comprehensive Local Water Management Plan" (2003) and the "Rainy River Basin Plan" (2004). The monitoring plan for 2006 projected to capture a total of 7 sampling events including 2 rain events on 5 minor watersheds. The sampling parameters included temperature, pH, conductivity, dissolved oxygen, transparency, turbidity, stage, appearance, TSS, TP, TKN, fecal coliform, and COD. Due to the dry summer, only 5 sampling events occurred. The results from the monitoring are intended to be shared with the public and other agencies to guide future monitoring efforts of the SWCD and other entities including the newly formed Lake of the Woods High School River Watch Program.



## **7. Docktalk: Part 2 - The continued quest to help shoreline property owners become environmental stewards**

*Kelli Saunders, Environmental Program Coordinator, Lake of the Woods District Property Owners' Association*

During the summer of 2006, Lake of the Woods District Property Owners' Association (LOWDPOA) was, for the second consecutive year, one of five cottage/lake associations in Ontario chosen to deliver an innovative new lake stewardship program, sponsored by the Federation of Ontario Cottagers' Association (FOCA) and funded through the Ontario Trillium Foundation. Through this program, one-on-one site visits were paid to interested property owners to discuss environmental stewardship opportunities and to help them understand the potential impact they may have on their lake. The primary topics addressed during these visits were shoreline naturalization, septic system maintenance, household and landscaping practices to encourage pollution prevention, enhancement of wildlife habitat and reducing threats from invasive species. Over the course of the summer, 110 property owners were visited in areas that included Sioux Narrows, Minaki, Clearwater Bay, Kenora, Rainy Lake and many areas in between. In addition, fifteen community events/workshops were held throughout the region at which resource management experts in the community and our Docktalk staff spoke to participants about these topics.

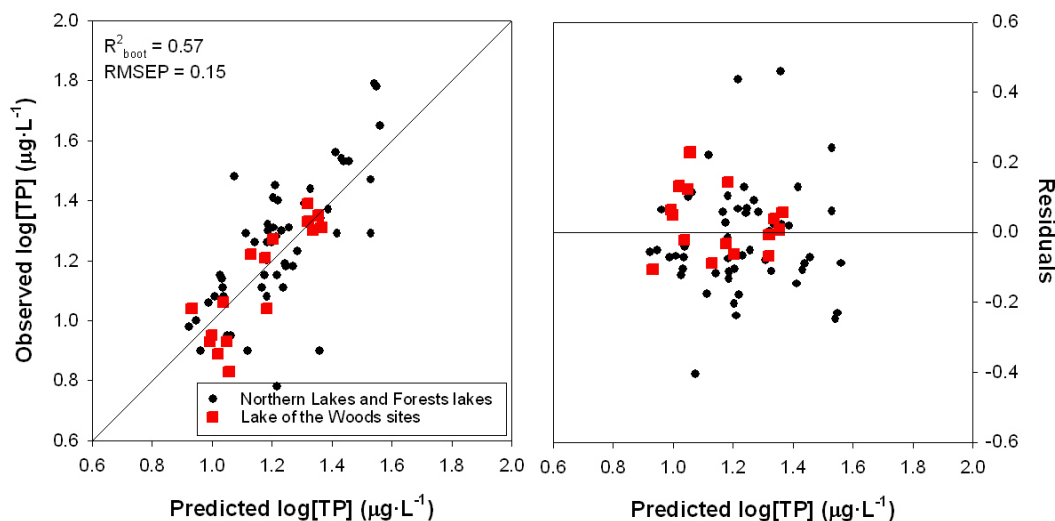
The presentation will provide an overview of the environmental programs delivered by the LOWDPOA, with a focus on the Docktalk program, its goals, the results from the 2006 surveys and how these compare to 2005. As was proven these past two summers, Docktalk was an excellent opportunity for participants to discuss issues of concern on their property or on their lake in general. Based on this success, LOWDPOA plans to offer the Docktalk program once again in the summer of 2007.



## 8. A diatom-based inference model for total phosphorus in the Lake of the Woods (LOW): combining Minnesota lakes with LOW sites.

Paterson<sup>1</sup>, A.M., Ruhland<sup>2</sup>, K.M., Pla<sup>2</sup>, S., Smol<sup>2</sup>, J.P., Edlund<sup>3</sup>, M.B., Heiskary<sup>4</sup>, S.A., Ramstack<sup>3</sup>, J.M., Reavie<sup>5</sup>, E.D. <sup>1</sup> Ontario Ministry of the Environment, Dorset Environmental Science Centre, Dorset, ON, Canada; <sup>2</sup> Paleocological Environmental Assessment and Research Laboratory, Department of Biology, Queen's University, Kingston, ON, Canada; <sup>3</sup> St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, MN, USA; <sup>4</sup> Minnesota Pollution Control Agency, Environmental Analysis and Outcomes Division, St. Paul, MN, USA; <sup>5</sup> Centre for Water and the Environment, Natural Resources Research Institute, University of Minnesota Duluth, Ely, MN, USA.

The perception that water quality has deteriorated in the Lake of the Woods (LOW) in recent years has led to increased efforts to collect and analyse water quality data in the Rainy River Basin. However, verification that conditions may have worsened is hampered by the lack of long-term chemical or biological data. In the absence of historical data paleoecological techniques may be applied to quantify long-term trends in water quality variables and biological assemblages through time. These changes may, in turn, be related to long-term changes in local or regional environmental stressors. Here, we describe the development of a diatom-based model for reconstructing historical phosphorus concentrations in the LOW. The remains of diatom algae were enumerated in surface sediments from 145 Minnesota lakes and 17 Lake of the Woods sites. Following the removal of chemical and biological outliers, the performances of two models were compared: 1) Full Model - 112 lakes from four ecoregions in Minnesota and the Twin Cities metropolitan area, and 16 sites across the LOW; and 2) Reduced Model – 55 lakes in Northern Lakes and Forests ecoregion and 16 LOW sites. The models were evaluated in their ability to predict observed phosphorus concentrations, with emphasis on the accuracy of prediction at the Lake of the Woods sites. Despite a higher coefficient of prediction [Full Model:  $R^2_{boot} = 0.75$ , Root Mean Squared Error of Prediction (RMSEP) = 0.20; Reduced Model:  $R^2_{boot} = 0.57$ , RMSEP = 0.15], the Full Model did not outperform the Reduced Model in predicting phosphorus in the Lake of the Woods sites (Linear Regression: Full Model,  $R^2 = 0.46$ , SE = 0.14, n = 16; Reduced Model,  $R^2 = 0.76$ , SE = 0.10, n = 16). We recommend that the Reduced Model be used to reconstruct historical phosphorus concentrations in the Lake of the Woods.





## 9. Lake of the Woods 2008 303(d) assessment

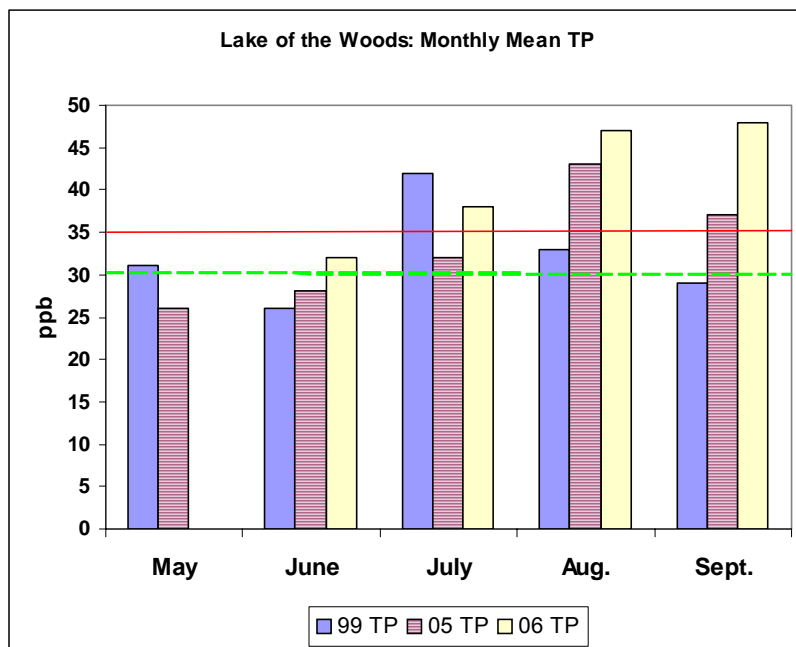
*S. Heiskary, Minnesota Pollution Control Agency*

Lake of the Woods (LOW) is located on the U.S. and Canadian border between Minnesota, Ontario and Manitoba (Figure 1). It is the largest lake in Minnesota, although only about one third of the lake's 950,400 acres are within the state. Rainy River is the largest tributary to the Lake, contributing over 70% of the inflow (Anderson et al. 1999). Water from the lake eventually makes its way to Hudson Bay, via the Winnipeg River at Kenora, Ontario.

Data used for this assessment were collected during the summers of 1999, 2005 and 2006. This effort was generally a collaboration among MPCA, MDNR and Lake of the Woods SWCD staff. Four sites were used in the monitoring as follows: : Site 101 in Four Mile Bay / Rainy River, site 101 in Big Traverse Bay, site 102 in Muskeg Bay, and site 105 near Long Point. Detailed status and assessment reports were completed based on the 1999 (Anderson et al. 2000) and 2005 (Anderson, Heiskary and Hirst, 2006) monitoring, available at: <http://www.pca.state.mn.us/water/lakereport.html#LakeWoods> .

Based on three years of data LOW remains near the NLF threshold for 303(d) listing. In comparison to current thresholds: TP is just above at 36 ppb (see graph), chlorophyll-a is just below at 9.9 ppb and Secchi is below (exceeds) at 1.3 meters. All of these values would exceed the draft criteria values for NLF lakes. A review of data for each summer indicates that one of three summers (2006) was above the 35 ppb TP threshold; two of three summers were at or above the 12 ppb chlorophyll-a threshold and all three summers were above the 1.4 m Secchi threshold.

In summary, trophic status data for LOW collected over the summers of 1999, 2005, and 2006 reveal TP, chlorophyll-a and Secchi values that are at or slightly above the thresholds used for 303(d) listing. Data included herein and in previous reports will be of value in determining whether LOW should be included on the 2008 303(d) list.



## **10. Baitfish as an invasion pathway: a case study of the Lake of the Woods winter fishery**

*Mark Gillespie<sup>1, 2</sup>, Paul Blanchfield<sup>2</sup> & Tom Mosindy<sup>3</sup> – (University of Manitoba<sup>1</sup>; Fisheries and Oceans Canada, Winnipeg<sup>2</sup>; Ontario Ministry of Natural Resources, Kenora<sup>3</sup>)*

The extensive use of live bait in the Lake of the Woods (LOW) sports fishery represents a potential vector for the introduction of aquatic invasive species (AIS). In the winter of 2006, we interviewed baitfish dealers and anglers regarding live bait purchase, transportation, disposal and AIS awareness. Angler surveys were part of a roving creel on the North/Central and Sabaskong Bay sectors of Lake of the Woods, ON. Although no AIS were found in surveys of dealer holding tanks or angler bait-buckets, baitfish dealers and anglers had limited knowledge of AIS in the area. Most anglers took their remaining bait home to use again (66%) but a few anglers (8%) dumped it into the lake. Six fishing parties had illegally brought live bait into Ontario; five from Manitoba and one from the USA.

## 11. Environmental Stewardship Programs on Lake of the Woods

*Kelli Saunders, Environmental Program Coordinator, Lake of the Woods District Property Owners' Association*

This display will provide information on the ongoing environmental stewardship programs currently being implemented by the Lake of the Woods District Property Owners' Association (LOWDPOA) with a focus on their recent two-year "Docktalk" program. As an association that represents 4,000 shoreline property owners within the Lake of the Woods watershed, environmental programming has become a large part of what the Association does for its members. As participants in the Ministry of the Environment's Lake Partner Program, Loon Watch, Invading Species Watch and partnering with businesses to promote the use of phosphate free products at the lake, the Association continues to reach its members and the general public by increasing their awareness of environmental stewardship opportunities. The Docktalk program alone has reached over 200 individual property owners through one-on-one site visits and over 1,000 individuals through community events and workshops. The Docktalk program focuses on education around shoreline naturalization, septic system maintenance, household and landscaping practices to encourage pollution prevention, enhancement of wildlife habitat and reducing threats from invasive species. For further information on how this program has been run or to have a Docktalk session scheduled, please contact Kelli Saunders at [ksaunders@lowdpoa.com](mailto:ksaunders@lowdpoa.com).

