

A stylized map of the Lake of the Woods region, showing the lake system in blue and the surrounding landmass in a light greenish-yellow color. The text is overlaid on the map.

# Lake of the Woods

7th Annual - International  
Water Quality Forum

March 10 - 11, 2010

Rainy River Community College  
International Falls, Minnesota, USA

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# Program At A Glance

## MARCH 10

08:00 – 14:00 Registration open

12:00 – 13:00 Lunch

### 13:00 – 17:00 Working Group Sessions

13:00 Session 1: Upper Basin Participation Working Group – Leader, Jessie Anderson, MPCA

14:45 Break

15:15 Session 2: Paleolimnology Working Group: Leader, Andrew Paterson, OMOE

### 18:00 – 21:00 Foundation Reception (Holiday Inn)

- Guest Speaker – The Honourable Joseph Comuzzi, Canadian Chair, International Joint Commission
- Kallemeyn Award Presentation

## MARCH 11

08:00 Welcome and Introductions

### 08:15 SESSION 1

1. International Multi-Agency Arrangement (IMA) Report
2. Paleo Working Group Report
3. Upper Basin Integration Working Group Report
4. The IJC: International Watersheds Initiative – Binational Hydrographic Data Harmonization Effort. [Conrad. J. Wyrzykowski<sup>1</sup>](#) and [M. T. Laitta<sup>2</sup>](#). <sup>1</sup>Agriculture and Agri-Food Canada; <sup>2</sup>International Joint Commission.
5. Kallemeyn Recipient Lecture [Nolan Baratonu](#), Minnesota Pollution Control Agency

09:30 Break

### 10:00 Session 2

1. Keynote – The power of the past: using lake sediments to address key management issues. [Dr. John P. Smol](#), Director of the Paleocological Environmental Assessment and Research Laboratory (PEARL), Queen's University
2. Keynote: Lake-sediment records of environmental change in large complex systems. [Dr. Daniel R. Engstrom](#), Director of the St. Croix Watershed Research Station
3. Changes in the Productivity and Composition of the Algal Community of the Lake of the Woods as Evidenced in the Recent Sedimentary Record. [Mike Stainton<sup>1</sup>](#), [H. Kling<sup>2</sup>](#) and [P. Ramlal<sup>1</sup>](#). <sup>1</sup>Fisheries & Oceans Canada; <sup>2</sup>Algal Taxonomy and Ecology Inc.

11:50 Lunch and Poster Session

### 13:20 Session 3

1. The effects of shoreline development and climate warming on water quality in the Lake of the Woods: a paleolimnological investigation. [Crystal Hyatt<sup>1</sup>](#), [K.M. Rühland<sup>1</sup>](#), [A.M. Paterson<sup>2</sup>](#), and [J. P. Smol<sup>1</sup>](#). <sup>1</sup>PEARL – Queen's University; <sup>2</sup>Ontario Ministry of Environment.
2. Holocene paleohydrology interpreted from long cores in Lake of the Woods and Shoal Lake Using Ostracodes, thecamoebian microfossils, and sediment properties. [Trevor Mellors](#) and [J. Teller](#). University of Manitoba
3. Lake sediments as integrative biological samplers to understand recent and historical changes in Voyageurs inland lakes. [Mark B. Edlund<sup>1</sup>](#), [J.M. Ramstack<sup>1</sup>](#), [J. Elias<sup>2</sup>](#) and [D.R. Engstrom<sup>1</sup>](#). <sup>1</sup>St. Croix Watershed Research Station; <sup>2</sup>National Park Service
4. A total phosphorus budget and steady-state model for the Lake of the Woods. [Kathryn Hargan<sup>1</sup>](#), [A.M. Paterson<sup>2</sup>](#) and [P.J. Dillon<sup>1</sup>](#). <sup>1</sup>Trent University; <sup>2</sup>Ontario Ministry of Environment
5. Preliminary Phosphorus Model for U.S. Portions of Lake of the Woods. [Joseph Hadash](#) and [M. Julius](#). St. Cloud State University

15:00 Break and Poster Session

### 15:30 Session 4

1. Environment Canada Lake of the Woods Water Quality and Harmful Algal Blooms Assessment Initiative: Year 2. [Sue Watson](#). Environment Canada.
2. Nutrient Cycling and Relation to Changes in Water Levels for Kabetogama Lake, Voyageurs National Park, 2008-09. [Victoria Christensen<sup>1</sup>](#) and [R. Maki<sup>2</sup>](#). <sup>1</sup>U.S. Geological Survey; <sup>2</sup>Voyageurs National Park
3. Monitoring in a complex system: Water quality in Lake of the Woods and the Rainy River. [Tim Pascoe](#), [T. McDaniel](#), [S. Watson](#), [J. Guo](#). Environment Canada
4. Physical Limnology: Modelling circulation and water quality in Lake of the Woods. [R. Yerubandi](#), [P. Chittibabu](#), [W. Zhang](#) and [Sue B. Watson](#). Environment Canada

16:50 – 17:00 Closing Remarks

## POSTER SESSIONS – MARCH 11

1. The Legacy Forest Small Streams Project: a headwater catchment harvesting study on the Boreal Shield of northwestern Ontario. [Paul Dinsmore](#)<sup>1</sup>, [Janice Burke](#)<sup>1</sup>, [Ellie Prepas](#)<sup>1,2</sup>, [Gordon Putz](#)<sup>3</sup> and [Daniel Smith](#)<sup>4</sup>.  
<sup>1</sup>Faculty of Forestry and the Forest Environment, Lakehead University; <sup>2</sup>Department of Biological Sciences, University of Alberta; <sup>3</sup>Department of Civil and Geological Engineering, University of Saskatchewan, <sup>4</sup>Department of Civil and Environmental Engineering, University of Alberta
2. Lake of the Woods County's Comprehensive Local Water Management Plan 2010 – 2020 Update and Featured Projects. [Josh Stromlund](#), [Mike Hirst](#), [Corryn Trask](#) Lake of the Woods Soil and Water Conservation District.
3. Holocene diatom trends from Whiting Bay, Lake of the Woods, Ontario, Canada. [Rühland, K.M.](#)<sup>1</sup>, [Paterson, A.M.](#)<sup>2</sup>, [Teller, J.T.](#)<sup>3</sup>, [Mellors T.](#)<sup>3</sup>, and [Smol, J.P.](#)<sup>1</sup>. <sup>1</sup>Paleoecological Environmental Assessment and Research Laboratory (PEARL), Queen's University; <sup>2</sup>Ontario Ministry of the Environment, Dorset Environmental Science Centre; <sup>3</sup>Department of Geological Sciences, University of Manitoba.
4. Diatom response to 19th Century hydromanagement and recent warming on the Lake of the Woods, Ontario. [Rühland, K.M.](#)<sup>1</sup>, [Paterson, A.M.](#)<sup>2</sup>, [Hargan, K.](#)<sup>1</sup>, [Jenkin, A.](#)<sup>1</sup>, [Clark, B.J.](#)<sup>2,3</sup>, and [Smol, J.P.](#)<sup>1</sup>.  
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5. Design and implementation of a comprehensive data management system for long-term research in the Boreal forest of northwestern Ontario and Alberta. [Mark Serediak](#)<sup>1</sup>, [Grant Burkell](#)<sup>2</sup>, [Janice M. Burke](#)<sup>3</sup> and [Nicole Fraser](#)<sup>1</sup>. <sup>1</sup>Department of Biological Sciences, University of Alberta; <sup>2</sup>The Forestry Corp.; <sup>3</sup>Faculty of Forestry and the Forest Environment, Lakehead University.
6. Digging through data: first steps in mining the FORWARD Project's water quality datasets for patterns of response. [Nancy Serediak](#), Lakehead University.
7. Watershed Stewardship on Lake of the Woods: International Collaboration and Individual Responsibility. [Kelli Saunders](#), Ontario Ministry of Environment, Kenora.
8. Lake of the Woods Lake Partner Program water quality monitoring data. [Anna DeSellas](#), Ontario Ministry of Environment, Dorset Environmental Sciences Centre.
9. Transboundary Basins, [Michael Thomas Laitta](#)<sup>1</sup> and [Conrad Joseph Wyrzykowski](#)<sup>2</sup>. <sup>1</sup>International Joint Commission; <sup>2</sup>Agriculture and Agri-Food Canada.

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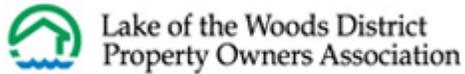
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## Forum Partners – 2010

The organizing committee would like to thank our 2010 partners for assisting with the 7th Annual International Lake of the Woods Water Quality Forum. This event would not be possible without the assistance of the following groups:

- Lake of the Woods Water Sustainability Foundation
- Minnesota Pollution Control Agency
- Ontario Ministry of Environment, Kenora & Dorset Environmental Sciences Centre
- Lake of the Woods District Property Owners Association
- Rainy River Community College
- St. Cloud State University
- North American Lake Management Society
- Consulate General of Canada - Minneapolis



## Presentation Abstracts

### The International Joint Commission of Canada and the United States: International Watersheds Initiative - Binational Hydrographic Data Harmonization Effort

Conrad Joseph Wyrzykowski<sup>1</sup> & Michael Thomas Laitta<sup>2</sup>

<sup>1</sup>Agriculture and Agri-Food Canada

<sup>2</sup>International Joint Commission

**Abstract:**

Responding to the absence of seamless transboundary hydrographic data, the International Joint Commission of Canada and the United States convened a binational taskforce comprised of Canadian and U.S. federal level natural resource agencies to address this lack of seamless datasets. The *Transboundary Hydrographic Data Harmonization Taskforce* (THDHTF) comprised of representatives from Environment Canada, U.S. Geologic Survey, Natural Resources Canada, Agriculture Canada and the U.S. Environmental Protection Agency first convened in July 2008. The Taskforce identified two fundamental hydrographic datasets that if harmonized would create a shared geospatial foundation within which local, regional and federal agencies could share, study and archive data without the fault line of the international boundary. Coordination has proceeded to an unprecedented degree on two fronts- *hydrography* and *drainage areas*. The presentation will describe the coordination and technical requirements associated with the creation of transboundary harmonized hydrographic datasets with a focus on the Rainy River and Lake-of-the Woods binational drainage areas.

**Kallemeyn Recipient Lecture**

Nolan Baratono, Minnesota Pollution Control Agency

**Abstract:**  
Not Available.

## **The power of the past: using lake sediments to address key management issues**

John P. Smol

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One of the greatest challenges faced by ecologists and environmental scientists is using appropriate time scales. When managing aquatic ecosystems, important questions include: Is water quality or quantity changing? If so, why is it changing and by how much? What is the timing and the causes of these changes? What were natural or pre-disturbance conditions like (and therefore what are reasonable mitigation targets)? Each of these questions has a temporal component associated with it. However, due to the general lack of reliable long-term monitoring data, it is often difficult to determine the nature and timing of ecosystem changes. In lieu of direct monitoring data, a large number of powerful paleolimnological approaches have been developed over the last ~25 years using a variety of physical, chemical, and biological approaches to track past changes in aquatic ecosystems using proxy data archived in lake and river sediments.

This presentation will review paleolimnological approaches that are especially relevant to studying lake management issues, with a specific focus on eutrophication and the new “threat multiplier” of recent climatic change. A major thrust of this presentation will be to provide a review of the strengths, assumptions, and limitations of the various techniques. Tremendous progress has been made over recent years in validating and quantifying a large spectrum of approaches that are especially relevant to problems being studied at Lake of the Woods. Moreover, standard paleolimnological procedures have now been vigorously tested, repeatedly peer-reviewed, and summarized in standardized methodological manuals (e.g. Smol et al, 2001a,b; Last and Smol 2001 a,b) and textbooks (e.g., Cohen 2003, Smol 2008). These standard methods, which have been subjected to stringent quality control assessments, are now routinely used by the vast majority of professional paleolimnologists from around the world.

The presentation will include examples of paleoenvironmental research that have examined the effects of multiple stressors on lake ecosystems. Moreover, meta-analyses of paleolimnological profiles can now be used to help disentangle the effects of climate warming from other environmental variables to determine how various components of lake ecosystems are responding to these multiple stressors. The economic costs of not taking appropriate environmental action will also be highlighted.

Cohen, A.S. (2003) *Paleolimnology: The History and Evolution of Lake Systems*. Oxford University Press, Oxford.

Last, W.M. and Smol, J.P. (eds) (2001a) *Tracking Environmental Change Using Lake Sediments. Volume 1: Basin Analysis, Coring, and Chronological Techniques*. Kluwer Academic Publishers, Dordrecht.

Last, W.M. and Smol, J.P. (eds) (2001b) *Tracking Environmental Change Using Lake Sediments. Volume 2: Physical and Geochemical Methods*. Kluwer Academic Publishers, Dordrecht.

Smol, J.P. 2008. *Pollution of Lakes and Rivers: A Paleoenvironmental Perspective – 2nd Edition*. Wiley-Blackwell Publishing, Oxford. 383 pp.

Smol, J.P. Birks, H.J.B. and Last, W.M. (eds) (2001a). *Tracking Environmental Change Using Lake Sediments. Volume 3: Terrestrial, Algal, and Siliceous Indicators*. Kluwer Academic Publishers, Dordrecht.

Smol, J.P. Birks, H.J.B. and Last, W.M. (eds) (2001b) *Tracking Environmental Change Using Lake Sediments. Volume 4: Zoological Indicators*. Kluwer Academic Publishers, Dordrecht.

## Lake-sediment records of environmental change in large complex systems

Daniel R. Engstrom

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### Abstract:

Lake-sediment records are a powerful implement in the lake-management toolbox and can greatly complement monitoring and modeling efforts to provide a more complete picture of environmental change in lakes and their watersheds. Paleolimnological analysis of sediment cores can provide information on baseline states and natural variability, explore the causes of change through hypotheses generation and testing, help define sustainable recovery targets, and evaluate both empirical and process-based models. Large systems, such as Lake of the Woods, are a particular challenge to lake managers owing to their geomorphic and geographic complexity, spatial heterogeneity, and diverse and multiple stressors. This is true in contemporary monitoring and modeling, and equally so for paleolimnological studies where a single sediment core and a few simple proxies are seldom sufficient to tell the whole story.

In this presentation I will review two paleolimnological case studies involving large Minnesota lakes with large watersheds – Lake St. Croix and Lake Pepin – to demonstrate how multiple cores and multiple proxies can be used to quantitatively reconstruct changes in sediment, nutrient, and heavy metal loads and sources and associated changes in biological productivity. Both studies employ a mass-balance approach by which external loads are determined from whole-lake burial rates and historical outflow estimates. The biophysical data are augmented in these studies by reconstruction of point-source loads from waste-water treatment facilities and historical land-use changes (forest clearance, farming, and urbanization) to derive a better understanding of the importance and sequencing of environmental stressors and their effects.

These studies were driven by the need to understand environmental change for the purposes of management and restoration. In that sense they have already had a large influence on policy development and the adoption of water-quality objectives to substantially reduce nutrient and sediment runoff and restore ecological health to these impaired systems. On the scientific side, the studies represent a major advancement in the application of paleolimnological methods to large complex systems. And because of their close proximity and contrasting environmental histories, Lakes Pepin and St. Croix constitute a large-scale, paired-watershed experiment on the limnological consequences of land-use change.

## **Changes in the Productivity and Composition of the Algal Community of the Lake of the Woods as Evidenced in the Recent Sedimentary Record**

Mike Stainton<sup>1</sup>, Hedy Kling<sup>2</sup> and Patricia Ramlal<sup>1</sup>

<sup>1</sup>Department of Fisheries and Oceans, 501 University Crescent, Winnipeg Canada, R3T 2N6

<sup>2</sup>Algal Taxonomy and Ecology Inc., 31 Laval Drive, Winnipeg Canada R3T 2X8

### **Abstract:**

We report on results obtained from seven short cores collected from the Lake of the Woods in the winter of 2002 at three open water sites and in four isolated bays. Dated strata were analyzed for their chemical, isotopic and biological record. The record indicates significant differences in chemistry and biota between open water and isolated bays and between bays of differing degrees of shoreline development. Overall changes in chemistry and biological remains suggest an increase in productivity and a shift to a more meso-eutrophic nitrogen limited system.

## **The effects of shoreline development and climate warming on water quality in the Lake of the Woods: a paleolimnological investigation**

Hyatt<sup>1\*</sup>, C.V., Rühland<sup>1</sup>, K.M., Paterson<sup>2</sup>, A.M., and Smol<sup>1</sup>, J.P.

<sup>1</sup> Paleoecological Environmental Assessment and Research Laboratory (PEARL), Department of Biology, Queen's University, Kingston, ON.

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### **Abstract :**

Lake of the Woods (LOW) is a hydrologically complex international waterbody exhibiting both spatial and seasonal variations in water quality and algal productivity. This region of northwestern Ontario is particularly sensitive to climate warming, with the Kenora climate station recording substantial increases in air temperatures in the last 100 years (~1.5°C). In addition, available lake ice records from the LOW since ca. 1964 indicate that the ice-free season has lengthened by approximately one month. Warmer temperatures, escalating shoreline development and perceived increases in the severity of cyanobacterial blooms have raised concerns about water quality for lake managers, cottagers and recreational users of the LOW. Effective ecosystem management requires knowledge of the 'natural' or baseline conditions of a system prior to human disturbance. In the absence of long-term monitoring data, paleolimnological techniques provide a useful tool for inferring historical lake-water conditions. Here, we first conducted a spatial comparison of modern and pre-industrial water quality in 17 sites in the Ontario portion of the LOW to reveal a snapshot of the effects of human disturbance on LOW. 94% of the sites showed either no change or a decline in diatom-inferred total phosphorus (DI-TP). Second, we collected and analyzed sediment cores from three bays spanning a gradient of shoreline development (i.e., recently to historically developed). These bays are located in the northwest region of LOW and are unique in that they are isolated from north-central bays and do not experience cyanobacterial blue-green algal blooms. Diatom assemblages were analyzed in these high-resolution, <sup>210</sup>Pb-dated profiles as a proxy indicator of changes in water quality. All three cores showed no directional trends in historical lake-water TP concentrations over the last ca. 200 years, suggesting that TP does not appear to be increasing in these bays. Additionally, the largest changes in the diatom assemblages occur during the warmest period (ca. mid-1970s) recorded for this region, thus highlighting the critical role that climate plays in community composition in these deep, clear stratified bays. On a larger scale, climate warming has the potential to exacerbate the effects of shoreline development and other environmental stressors in this complex lake system.

## **Holocene Paleohydrology interpreted from long cores in Lake of the Woods and Shoal Lake using ostracodes, Thecamoebian microfossils**

Trevor Mellors and James Teller

Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba, R3T 2N2

### **Abstract:**

Lake of the Woods (LOTWs) and Shoal Lake (SL) became isolated from Lake Agassiz, the world's largest freshwater lake, about 9000 calendar years before present (cal yrs BP). The differential isostatic rebound from the northeast retreat of the LIS caused LOTWs to transgress toward the southwest, increasing the area and depth of LOTWs particularly in the southern portion of the lake basin. The depth and area of the lake was controlled by the rebounding outlets at Kenora which controlled the overflow into the Winnipeg River drainage system, and by the changing climatic conditions. SL would have also fluctuated with climate, and periodically would have been disconnected from LOTW.

Ten sediment cores (2.0-6.9 m long) were recovered from various locations in Lake of the Woods (LOTWs) and Shoal Lake (SL) in August 2006, using a Kullenberg piston corer operated by the Limnological Research Center (University of Minnesota). The entire postglacial sequence is composed of silty clay with scattered organic materials, paleosols, and sandy zones. One core contains a pink clay bed which reflects a brief input of waters from the Superior basin during the Marquette glacial readvance about 11300 cal yrs BP. From the study of macrofossils (primarily ostracodes and thecamoebians) and sediments, variations in paleo-environmental conditions were identified both spatially and temporally, and the timing of these changes was established from 30 AMS radiocarbon dates in the >10,000 cal yrs of postglacial LOTWs history. Ostracodes disappeared from various locations in the LOTWs record about 9000 to 7600 cal yrs BP, depending on the location in the basin. They disappeared about 5800 cal yrs BP in SL. Thecamoebians appeared in many cores beginning around 2000 cal yrs BP, although their earliest appearance is at 9200 near the outflow channel. Buried paleosols in three cores indicate portions of the lake dried on several occasions during the warmer hypsithermal period in the mid-Holocene about 4000-7000 cal yrs BP; this warmer time also roughly coincides with the end of ostracodes in the record. This perhaps indicates the region's future climatic response to the current warming trend.

## Lake sediments as integrative biological samplers to understand recent and historical changes in Voyageurs inland lakes

Mark B. Edlund<sup>1\*</sup>, Joy M. Ramstack<sup>1</sup>, Joan Elias<sup>2</sup>, Daniel R. Engstrom<sup>1</sup>

<sup>1</sup>St. Croix Watershed Research Station, Science Museum of Minnesota, 16910 152<sup>nd</sup> St. N, Marine on St. Croix, MN 55047, ([mbedlund@smm.org](mailto:mbedlund@smm.org))

<sup>2</sup>National Park Service, Great Lakes Inventory and Monitoring Network, 2800 Lake Shore Drive East, Ashland, WI 54806

### **Abstract:**

The National Park Service's Great Lakes Inventory and Monitoring Network (GLKN) is using modern water quality sampling coupled with the analysis of diatom communities in lake sediments to identify recent ecological trends of lakes in nine national park units, including over 20 lakes in Voyageurs National Park (VOYA). Index lakes have been identified within each park for water quality and biomonitoring. Each lake is sampled for water quality three times per year. A single surface sediment sample is also collected from index lakes during fall sampling every 3-5 years; this sample integrates spatial/temporal variability of diatom production in the lake. Finally, long sediment cores (~200 years) have been taken from 1-3 lakes in most parks to provide historical context to modern lake condition and a measure of natural lake variability in each park unit. Based on water quality monitoring, inland lakes at VOYA are low alkalinity and circumneutral systems, and most are characterized as mesotrophic but range from eutrophic Ek Lake to oligotrophic Cruiser Lake. Many lakes have shallow Secchi disk measurements due to tannin staining. Sediment cores were taken from three inland lakes in VOYA: Ek, Peary, and Cruiser. Geochemistry, radioisotopes, and diatoms were analyzed from each core to reconstruct a historical record of change in each lake. Diatom communities changed in all lakes around the time of logging and settlement and some lakes also showed more recent changes in diatom communities that may be linked to climate warming or other land-use changes. Diatom-inferred water quality reconstructions show that there has been minimal change in water quality of VOYA inland lakes. The historical magnitude of change recorded in diatom communities from VOYA sediment cores will be compared to recent changes in diatom communities based on repeat surface sediment sampling planned in 2010 and 2011.

## **A total phosphorus budget and steady-state model for the Lake of the Woods**

Kathryn E. Hargan<sup>1</sup>, A.M. Paterson<sup>2</sup>, and P.J. Dillon<sup>3</sup>.

<sup>1</sup>Trent University, Environmental and Life Sciences, Peterborough, ON, K9J 7B8 (email: [kathrynhargan@trentu.ca](mailto:kathrynhargan@trentu.ca))

<sup>2</sup>Dorset Environmental Science Centre, Ontario Ministry of the Environment, 1026 Bellwood Acres Road, Dorset, Ontario, P0A 1E0

<sup>3</sup>Trent University, Department of Chemistry, Peterborough, Ontario, K9J 7B8

### **Abstract:**

This presentation summarizes a two-year effort of gathering data to quantify all phosphorus (P) sources to and losses from the Lake of the Woods (LoW). This project was initiated in response to the perception that annual cyanobacteria blooms in the lake, and recent declines in hypolimnetic O<sub>2</sub> concentrations are a result of changes in water quality in LoW in recent years. Accounting for all sources and sinks of total P and balancing this against the concentrations in the lake allows lake managers to identify whether there are unknown sources of nutrients to a lake. A nutrient budget also allows contributions of anthropogenic and natural P to a lake to be compared. A one-dimensional steady-state mass balance model, referred to as the Lakeshore Capacity Model (LCM) has been used as a first step to predict the LoW whole-lake total P concentration as a function of P inputs and losses. The LCM was developed to measure the impact of shoreline development on inland lake water quality and can yield an estimate of lake total P prior to shoreline development. However, in the LoW, the nutrient budget demonstrates that currently, there is only a small total P contribution from shoreline developments (6-9 tons; 1%), relative to the large P loads from atmospheric deposition (95±55 tons; 12%) and the primary tributary, the Rainy River (590±188 tons; 66%). Additionally, a preliminary P budget for the Rainy River catchment directs attention to contributions from anthropogenic point sources along the river rather than to shoreline development. Quantifying sources of P to this large, transboundary lake presents many challenges and it is essential that mass budgets and models be refined using additional lake and catchment monitoring.

## **Preliminary Phosphorus Model for U.S. Portions of Lake of the Woods**

Joseph Hadash and Matthew Julius

St. Cloud State University, Department of Biological Sciences, St. Cloud, MN 56301

### **Abstract:**

The US portion of Lake of the Woods has been placed on the 303(d) Threatened and Impaired Waters List due to high phosphorus concentrations present in the lake. This, along with the increased presence of blue-green algal blooms, has caused concern that the overall water quality of the lake has deteriorated in recent years. To remove the lake from its impaired listing a Total Maximum Daily Load (TMDL) study must be conducted. With the use of water quality modeling programs FLUX and BATHTUB to estimate nutrient loads for tributaries and reservoirs, respectively, a preliminary TMDL can be established for Lake of the Woods. In this study FLUX and BATHTUB were used to help accomplish this goal and phosphorus load estimates were generated. Estimates were based upon measured data from the main tributary, and a combination of measured and estimated data from other tributaries entering the lake. Techniques for estimating tributary inputs into the system will be presented along with variations in model output based variations in these estimate techniques. Results with all methods of tributary estimation indicate that internal loading in the US basins may represent a major source of phosphorus and represent a significant challenge to efforts in reducing phosphorus levels in an environmentally relevant manner.

## **Life in a complex system: Water quality and plankton responses in Lake of the Woods**

Sue Watson, H. Kling<sup>2</sup>, T. Pascoe<sup>1</sup>, T. McDaniel<sup>1</sup>, J. Guo<sup>1</sup>

<sup>1</sup>Environment Canada, Science and Technology Branch, PO Box 5050, 867 Lakeshore Rd E, Burlington, ON L7R 4A6

<sup>2</sup>Algal Taxonomy and Ecology Inc., 31 Laval Drive, Winnipeg MN R3T 2X8

### **Abstract:**

Excess nutrient loading and cyanobacteria blooms in Lake of the Woods (LOW) are a major concern. As part of a larger program to address similar issues in Lake Winnipeg, Environment Canada is conducting a Lake of the Woods Science Initiative to address knowledge and data gaps that would increase our ability to predict and manage phytoplankton assemblages and their relationship to nutrients and other factors in LoW. Over the past two years, water quality (physical and chemical parameters) sediment characteristics and key biological measures have been monitored across the lake and connecting tributaries, in conjunction with other agency partners. Inter-laboratory comparisons have also been made to examine the consistency and compatibility of monitoring data, a key requirement for validating management models.

Here we report the preliminary results from three annual lake wide surveys in 2008 and 2009 at a total of 33 stations. During these surveys, YSI profiles were taken at each site for dissolved O<sub>2</sub>, temp, conductivity and pH. Dissolved and particulate nutrient fractions (phosphorus (P), Nitrogen N) and carbon (C)) and other physico-chemical measures were analysed from samples taken from 1m, integrated (euphotic zone) and 2m above the bottom. The plankton was assessed for chl<sub>a</sub> content and nutrient deficiency as measured using alkaline phosphatase, N-debt and stoichiometry. Subsamples were preserved for identification and enumeration of algal and cyanobacterial taxa; major taxa in live net material were also qualitatively identified at selected sites. Picoplankton were sampled for classification (group, major pigments), size and abundance using flow cytometry, while cyanotoxins (microcystin and others) were measured at all sites during the late summer sampling. Water quality and mercury levels were also monitored at four transects on the Rainy River from Fort Frances to the town of Rainy River. In addition, other important data gaps are being addressed by our team. To assess the deposition patterns and potential impacts of sediment loading in different basins, sediments were sampled at 21 stations for particle size, and other characteristics including contaminants, while to further address the issue of anthropogenic pollutants, pesticides were analysed from water samples collected at selected stations.

## **Nutrient Cycling and Relation to Changes in Water Levels for Kabetogama Lake, Voyageurs National Park, 2008-09**

Victoria Christensen<sup>1\*</sup> and Ryan Maki<sup>2</sup>

<sup>1</sup>U.S. Geological Survey, 2280 Woodale Dr., Mounds View, MN 55112, 701-277-0682, [vglenn@usgs.gov](mailto:vglenn@usgs.gov),

<sup>2</sup>Ryan P. Maki, Voyageurs National Park, 415 S Pokegama Ave., Grand Rapids, MN 55744, 218-326-1297 Ext 12, [ryan\\_maki@nps.gov](mailto:ryan_maki@nps.gov)

### **Abstract**

Water and sediment samples were collected by the U.S. Geological Survey and the National Park Service during 2008-2009 to assess nutrient loading, both internal and external, to Kabetogama Lake. Data collection was focused on Kabetogama Lake and its inflows because Kabetogama produces annual cyanobacterial blooms and previous studies have shown it to have larger nutrient and chlorophyll concentrations than the other large lakes in Voyageurs National Park. Kabetogama is shallower than the other large lakes and has polymictic circulation, which suggests a possible link between the frequent recirculation and the internal recycling of phosphorus.

Water was sampled from the lake surface, near the sediment-water interface, and from inflows and outflows. Samples collected at the surface were analyzed to determine concentrations of nutrients and chlorophyll. Samples collected near the sediment-water interface and inflows and outflows were analyzed to determine nutrient concentrations. Vertical profiles of temperature, dissolved oxygen, pH, and specific conductance were measured at each lake site. Secchi-disk transparency was measured at each vertical profile to determine the extent that light limits algal growth. Streamflow and direction were measured at Namakan River, Vermilion River, Gold Portage, Kettle Falls, Ash River at Sullivan Bay, Tom Cod Bay, Daley Brook, and the narrows between Namakan and Kabetogama. Preliminary results indicate that average phosphorus concentrations in water samples were 22.3 µg/L (micrograms per liter; median=20.0 µg/L) for inflows, 26.3 µg/L (median = 19.0 µg/L) for lake-surface samples, 68.8 µg/L (median = 18.0 µg/L) for water samples collected near the sediment-water interface, and 12.3 µg/L (median = 11.5 µg/L) for the outflows. However, concentrations were variable, indicating that some lake sites may be more susceptible to phosphorus release from sediments than others.

Nutrient and algal data will be used to determine trophic status and to evaluate in relation to changes in Kabetogama Lake water levels. This is critical information since the International Joint Commission, which set new rules governing dam operation in 2000, will decide whether to keep or change these rules in 2015 based, in part, on the effects of the rules on the aquatic ecosystem. This research will provide resource managers with crucial data regarding both the effects of lake-level management on water quality and on internal and external nutrient loading in the most eutrophic large lake in Voyageurs National Park. This research also will provide resource managers with data on the effects of the current rule curves (water-quantity conditions) on water-quality conditions. This study will provide resource managers and the International Joint Commission more information to help protect the Park's aquatic ecosystem.

## **Monitoring in a complex system: Water quality in Lake of the Woods and the Rainy River**

Tim Pascoe\*, Tana McDaniel, Sue Watson, Jay Guo  
Environment Canada, Science and Technology Branch, PO Box 5050, 867 Lakeshore Rd E, Burlington,  
ON L7R 4A6

### **Abstract:**

Concerns regarding excess nutrient loading and cyanobacteria blooms in Lake of the Woods (LOW) prompted the formation of Environment Canada's Lake of the Woods Science Initiative. As part of a larger program to assess and remediate deteriorating water quality in Lake Winnipeg, this initiative seeks to identify and fill knowledge and data gaps in nutrient transport and cycling in LOW. Due to its multijurisdictional nature, monitoring in LOW requires the cooperation of multiple agencies. In conjunction with provincial and state partner agencies, water quality (physical and chemical parameters) sediment quality and biological indicators are being monitored in Lake of the Woods and Rainy River.

Parameters were measured at a total of 33 stations in LOW in spring, mid-summer, and early fall. Water quality was also monitored at four transects on the Rainy River from Fort Frances to the town of Rainy River on a bi-weekly basis, from June to October. Here we focus on nutrients and mercury inputs from the Rainy River, and related sediment chemistry in LOW. Sediments were monitored at 21 stations for physical (particle size), and chemical (nutrients, metals, PCBs, PAHs) parameters. Benthic invertebrate community structure was also collected as a biological indicator of ecosystem health in LOW using the reference condition approach, as part of the CABIN program. Scans for Pesticides and Organic contaminants will be discussed if results are available. Inter-laboratory comparisons were also made as part of the Lab Proficiency Testing program at the National Lab for Environmental Testing (NLET).

## **Physical Limnology: Modelling circulation and water quality in Lake of the Woods**

Ram Yerubandi, Padala Chittibabu, Weitao Zhang and Sue B. Watson

Aquatic Ecosystem Management Research Division (AEMRD), Water Science and Technology Directorate, Environment Canada, 867 Lakeshore Rd., Burlington, ON, Canada L7R 4A6

### **Abstract:**

As part of the Lake of the Woods (LoW) science initiative, Environment Canada is developing physical limnology and models to addressing science-based nutrient and bloom management in the lake, in collaboration with several partners. During 2009, several moorings have been deployed to provide temperature distribution, circulation and real time measures of basic water quality, such as conductivity, turbidity, dissolved oxygen, chlorophyll a in the lake. As a secondary objective, a high resolution unstructured grid two-dimensional finite element model was applied, to simulate the water levels and circulation patterns in Lake of the Woods (LoW). The model was forced with a time varying spatially uniform wind field and with water surface elevations at the Rainy River inlet and at Keewatin, on the outflowing Winnipeg River north of LoW. Observations and model results are analyzed to characterize the circulation, water balance and nutrient loads into the lake. The model was validated with the available water levels measured by Water Survey of Canada at several stations in the lake. Initial results showed that this model is able to capture the temporal and spatial variability of circulation patterns in the lake reasonably well. The model results will be used to provide the exchange flows between sub-basins for calculating nutrient balance in LoW.

## Poster Abstracts

### **The Legacy Forest Small Streams Project: a headwater catchment harvesting study on the Boreal Shield of northwestern Ontario.**

Paul Dinsmore<sup>1</sup>, Janice Burke<sup>1</sup>, Ellie Prepas<sup>1,2</sup>, Gordon Putz<sup>3</sup> and Daniel Smith<sup>4</sup>

<sup>1</sup>Faculty of Forestry and the Forest Environment, Lakehead University, Thunder Bay, ON P7B 5E1

<sup>2</sup>Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9

<sup>3</sup>Department of Civil and Geological Engineering, University of Saskatchewan, Saskatoon, SK S7N 5A9

<sup>4</sup>Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB T6G 2W2

#### **Abstract:**

The Legacy Forest Small Streams (LFSS) Project is part of the Forest Watershed and Riparian Disturbance (FORWARD) Project, an academic-industry-government research partnership that seeks to understand the transfer of substances from watersheds to surface waters through well-designed experiments, and thus develop models that can work with the spatially-based planning tools used by industrial forest managers. Since 2004, the LFSS Project has monitored water quality, streamflow and meteorological parameters for up to ten small (< 10 km<sup>2</sup>) headwater catchments within the Dog River-Matawin Forest Management Area, an industrial forest land base on the Boreal Shield approximately 50 km NW of Thunder Bay, ON. LFSS field infrastructure includes V-notch weirs on six of the ten catchments, plus automated water level recorders, stormwater samplers and water temperature loggers at all ten sites. LFSS also maintains three weather stations within the Forest Management Area, supplemented by meteorological data from Environment Canada. Experimental harvesting is planned for three watersheds, two of which are paired with adjacent reference catchments. In addition to monitoring surface waters, the LFSS Project supports graduate students studying riparian vegetation responses to forest harvesting, and the role of wetlands in storage and release of nutrients. LFSS data complement FORWARD experiments and models in the Boreal Plain ecozone of north-central Alberta, expanding our focus beyond regionally centered patterns and processes, towards a continent-scaled land base.

## **Lake of the Woods County's Comprehensive Local Water Management Plan 2010 – 2020 Update and Featured Projects**

Josh Stromlund, Mike Hirst, Corryn Trask  
Lake of the Woods Soil and Water Conservation District  
119 1<sup>st</sup> Ave NW, PO Box 217, Baudette, MN 56623, 218-634-1842 x 3  
<http://www.lakeofthewoodsswcd.org/>

### **Abstract:**

The Lake of the Woods Soil and Water Conservation District (SWCD) is the Local Government Unit responsible for implementing Lake of the Woods County's Comprehensive Local Water Management Plan. This plan is an inventory, assessment, and action plan for the management of the County's water resources. An update for the plan has recently been completed for 2010-2020. Water Plans pull together multiple agencies and partners, and outline tasks and objectives for each to accomplish. Through the update process, landowners and all levels of governmental agencies are given the opportunity to participate and to provide comments on how they will contribute towards water quality objectives. To implement the plan, the SWCD coordinates these agencies and partners to accomplish objectives outlined in the plan.

## Holocene diatom trends from Whiting Bay, Lake of the Woods, Ontario, Canada

Rühland, K.M.<sup>1</sup>, Paterson, A.M.<sup>2</sup>, Teller, J.T.<sup>3</sup>, Mellors T.<sup>3</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, Ontario, K7L 3N6, Canada (email: ruhlandk@queensu.ca)

<sup>2</sup>Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, Ontario, P0A 1E0, Canada

<sup>3</sup>Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, Canada

### **Abstract:**

Data on long-term water quality changes in the Lake of the Woods (LOW) are necessary to place the present (and future) environmental state of this important and complex water body into a larger temporal context, and to establish baseline conditions for any future mitigation. Preliminary results of changes recorded in diatom assemblages over the Holocene (e.g., ~last 10,000 years) will be presented from a dated sedimentary sequence retrieved near Whiting Bay, in the northern part of the Lake of the Woods. This long temporal sequence may provide important insights into changes occurring today. Particular points in time during the Holocene may serve as temporal analogues for the sharp rise in temperature this region is currently experiencing, providing insights into possible impacts on limnological properties and aquatic biota. For example, is the magnitude of climatically-driven changes reported over the last few decades in the LOW exceptional from a millennial-scale perspective, or just part of natural variability? The diatom data presented here will be part of a larger study examining other biological indicators (e.g., ostracodes, chironomids), that will be used to help address these questions. This work builds on previous, century-scale paleolimnological records that have shown striking relationships between temperature and lake ice records over the last ca. 100 years. Although the effects of differential isostatic rebound in the LOW are reported to have resulted in substantial changes in lake level throughout the Holocene (i.e., over the last ca. 10,000 years), an assessment of long-term (Holocene) climate change impacts on lake water properties have yet to be undertaken in the lake.

## **Diatom response to 19<sup>th</sup> Century hydromanagement and recent warming on the Lake of the Woods, Ontario**

Rühland, K.M.<sup>1</sup>, Paterson, A.M.<sup>2</sup>, Hargan, K.<sup>1</sup>, Jenkin, A.<sup>1</sup>, Clark, B.J.<sup>2,3</sup>, and Smol, J.P.<sup>1</sup>

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<sup>3</sup>Hutchinson Environmental Sciences, Suite 303, 49 Manitoba St., Bracebridge, ON, P1L 2B2

### **Abstract:**

Paleolimnological approaches were used to assess the ecological and environmental implications of diatom assemblage compositional changes recorded over the last ca. 200 years from four sites in the Lake of the Woods (LoW), Ontario, Canada. Comparisons between a reference site (Whitefish Bay) and three impact sites (Bigstone Bay, PP-1, and Forrest Island) provide insights into the effects that multiple stressors (dam construction, total phosphorus (TP) changes and recent warming) have had on the biota of this highly complex freshwater system. Overall patterns of diatom compositional changes from high-resolution <sup>210</sup>Pb-dated sediment cores revealed a strong temporal coherence ca. 1910 and then again over the last few decades among all sites. From these data, we conclude that hydromanagement activities at the turn of the 19<sup>th</sup> century and recent warming over the last few decades have played key roles in the LoW diatom changes. Diatom compositional changes at all sites were significantly related to trends in nearby air temperature records and to changes in lake ice phenology over the past ca. 40 years from Whitefish Bay. Turn-of-the-century hydromanagement activities do not appear to have had long-term effects on diatom-inferred total phosphorus (DI-TP), particularly at the impact sites. However, clear decreases in DI-TP over the last few decades were evident at all sites, particularly at the reference site where DI-TP values were well below pre-disturbance levels. We link these recent declines in TP to recent warming but improved water quality on the Rainy River over the last few decades has likely played an additional role in this recent trend. Our results suggest that substantial changes in climate will amplify the effects of multiple stressors on many important aspects of lake ecology.

## **Design and implementation of a comprehensive data management system for long-term research in the Boreal forest of northwestern Ontario and Alberta**

Mark Serediak<sup>1</sup>, Grant Burkell<sup>2</sup>, Janice M. Burke<sup>3</sup> and Nicole Fraser<sup>1</sup>

<sup>1</sup>Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada T6G 2E9, mark.serediak@ualberta.ca, nrfraser@ualberta.ca

<sup>2</sup>The Forestry Corp., 101 11710 Kingsway Ave NW, Edmonton, AB, Canada T5G 0X5, grant\_burkell@forcorp.com

<sup>3</sup>Faculty of Forestry and the Forest Environment, Lakehead University, Thunder Bay, ON, Canada P7B 5E1, janicemarion@yahoo.com

### **Abstract:**

Data management, including cataloguing, storage, access, tracking and long term availability, is an issue for many research projects. Since 2001, Forest Watershed and Riparian Disturbance (FORWARD) Project partners have been collecting a wide range of empirical data from large study areas in the Canadian boreal forest: the Legacy Forest of Ontario and the Swan Hills of Alberta. Project goals are to elucidate processes underpinning hydrology and surface and ground water quality in undisturbed and disturbed watersheds and develop mapping procedures and models for industrial forest planning. Datasets, which include numeric and spatial data, photographs, documents and presentations, are stored in a central repository (Oracle database) managed by The Forestry Corp., Edmonton, Alberta. Using a user friendly online system, data are submitted by registered participants and include both the actual data and metadata formatted according to guidelines laid out in a comprehensive User Guide. FORWARD participants and outside users can use the online system to search and view metadata records and make data requests. The system includes controls for access to view and download data as per protocols outlined by the FORWARD Data Sharing Agreement. The system provides tracking of data uploads, metadata and data requests, release authorization and data downloads. Benefits of this system are that data are: 1) securely stored; 2) formatted consistently; 3) organized; 4) classified; and 5) accessible to FORWARD participants and outside parties who sign the FORWARD Data Sharing Agreement. The FORWARD data management system represents a functional framework to build and maintain long-term databases and ensure that valuable data can continue to contribute to future research and management.

## **Digging through data: first steps in mining the FORWARD Project's water quality datasets for patterns of response**

Nancy Serediak

Faculty of Forestry and the Forest Environment, Lakehead University, 955 Oliver Road, Thunder Bay, ON. P7B 5E1 [nseredia@lakeheadu.ca](mailto:nseredia@lakeheadu.ca)

### **Abstract:**

Humans are hardwired to seek and recognize patterns – in faces, rhythms of speech, seasons, landforms. We also strive to see pattern where it is not immediately obvious and sometimes impractical. Large datasets present challenges for analyses as well as opportunities to examine data in new ways. Linking multiple datasets would potentially increase the ability to unearth unifying or predictive features of water quality datasets. The Legacy Forest Small Streams dataset, now part of the Forest Watershed and Riparian Disturbance (FORWARD) Project, presents an opening to explore accumulated data that will potentially be missing an experimental impact component. Proposed analyses include traditional year-to-year variation in water chemistry parameters compared with slightly less traditional month-to-month summaries incorporating all years, and cluster analysis of all parameters per year. Additional comparisons will hopefully incorporate water chemistry values from watershed studies with both similar and dissimilar cover types in Canada and possibly the North eastern U.S.A. It is hoped that these comparisons will 1) be feasible, 2) provide more information on water chemistry responses under various cover types and 3) be functional by identifying predictive components of watershed response.

**Watershed Stewardship on Lake of the Woods: International Collaboration and Individual Responsibility.**

Kelli Saunders  
Ontario Ministry of Environment, Kenora.

**Abstract:**

The Ontario Ministry of the Environment has developed a Watershed Stewardship Strategy for Lake of the Woods that focuses on compliance, science/research, partnership building, international cooperation and education/outreach. With our international partners, our common goal is to protect/restore water quality on Lake of the Woods at a variety of levels. This includes conducting the research needed to develop effective watershed management strategies and providing information to a variety of stakeholder groups on stewardship options and best management practices they can adopt to help protect water quality.

## **Long-term trends in total phosphorus concentrations and lake water clarity in Lake of the Woods, 2002-2009: An update of volunteer-based collections**

Anna M. DeSellas<sup>1\*</sup>, Andrew M. Paterson<sup>1</sup>, Bev Clark<sup>2</sup> & Kelli Saunders<sup>3</sup>

<sup>1</sup> Ontario Ministry of the Environment, Dorset Environmental Science Centre, Dorset, Ontario

<sup>2</sup> Hutchinson Environmental Sciences, Bracebridge, Ontario

<sup>3</sup> Ontario Ministry of the Environment, Kenora, Ontario

### **Abstract:**

The Ontario Ministry of the Environment's Lake Partner Program is a volunteer-based lake monitoring program that engages citizens in monitoring the water quality of hundreds of Ontario lakes. Approximately 50 volunteers have routinely sampled different locations in Lake of the Woods for precise total phosphorus and water clarity for seven years (although some sites have over twelve years of less precise total phosphorus data). These data are now of sufficient length and quality to assess long-term trends in total phosphorus concentrations and water clarity from areas of Lake of the Woods that are not part of regular monitoring activities. We report trends through time in Lake Partner total phosphorus and Secchi data at approximately 10 long-term volunteer monitoring sites throughout Lake of the Woods from 2002-09. We report strong relationships between water clarity and total phosphorus concentrations at many sample locations and large spatial and seasonal variations in total phosphorus concentrations across the lake. These patterns of total phosphorus and water clarity do not follow typical patterns seen in other northern Ontario lakes within the Precambrian Shield.

## **Transboundary Basins**

Michael Thomas Laitta<sup>1</sup> and Conrad Joseph Wyrzykowski<sup>2</sup>.

<sup>1</sup>International Joint Commission;

<sup>2</sup>Agriculture and Agri-Food Canada

### **Abstract:**

A map of transboundary basin is presented that depicts the transboundary basins based on a preliminary harmonization of geospatial data for the Canadian and U.S. subregional drainage areas. The view, using a GSC North American 1983 CSRS Coordinate System, shows land areas in true proportion to one another, as if seen from outer space. Continental elevation data at a 1 square kilometre resolution, as well as 1:1,000,000 hydro-vector and polygon data have been superimposed on base layers.