Proceedings
March 12 – 13, 2008
Rainy River Community College
International Falls, Minnesota, USA

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Forum Sponsors

The organizing committee would like to thank our 2008 sponsors for contributing to the Lake of the Woods 5th annual International Water Quality Forum. This event would not be possible without the support of the following groups:

- Lake of the Woods Water Sustainability Foundation
- Minnesota Pollution Control Agency
- Ontario Ministry of the Environment
- Rainy River Basin Water Resources Center
- Rainy River Community College
- North American Lake Management Society
- Lake of the Woods District Property Owners Association
- St. Cloud State University
- Manitoba Water Stewardship
- Fisheries and Oceans Canada

List of Participating Organizations

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University of Minnesota Duluth - Large Lakes Observatory
University of Minnesota Duluth - Department of Biology
US Geological Survey
Voyageurs National Park
York University - Department of Biology

2008 Forum Overview

The fourth, annual, Lake of the Woods water quality forum was held at the Rainy River Community College on March 12-13, 2008. The forum was well attended by over 100 scientists, researchers, academics, educators, and other resource stakeholders who presented information or recent research findings that are relevant to Lake of the Woods and its watershed.

On the morning of the first day, three workshops were held to discuss issues and provide a platform for technical transfer between workshop participants.

On the afternoon of day one there were 7 presentations and on the second day of the forum there were a further 11 presentations and 8 posters which covered a diverse range of topics, many of which were additional findings from projects that were introduced at previous forums.

Record attendance of over 100 reflects increased research and policy focus on Lake of the Woods

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 start of the second day, two keynote speakers addressed the emerging issue of invading species. The organizing committee selected two speakers to address this issue from a political and technical angle. The speakers were Dick Osgood and Norman Yan respectively.

Larry Kallemeyn is the first recipient of the new achievement award, named in his honor, presented by the Foundation and the organizing committee of the Forum.

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.

Katt Rühland (Queen's University) and Dick Sjoberg (Foundation Director from Minnesota) discuss results of Katt's research into tracking historical water quality changes using diatoms in sediment cores taken from Bigstone Bay, Lake of the Woods, Ontario.

Schedule of Events

MARCH 12, 2008		
7:30	**Registration & Continental Breakfast**	
	WORKING GROUPS – CONCURRENT SESSIONS	
8:00	**Aquatic Invasive Species**	**Nutrients & Algae**
10:00	Break	
10:15	**Monitoring Coordination Working Group**	
12:15	Lunch	
	SYMPOSIUM SESSIONS	
1:00	**Welcome and Introduction To Symposium**	
1:30 – 2:30	**Session 1 - State of the Basin**	
• National Lakes Assessment Project (NLAP): Enhancements for Minnesota and Potential Applications for Lake of the Woods. Steve Heiskary, Minnesota Pollution Control Agency		
• State of the Basin Report for Lake of the Woods and the Rainy River – Part 1: Overview and Data Summary. Anna DeSellas, Lake of the Woods Water Sustainability Foundation and Ontario Ministry of the Environment		
• State of the Basin Report for Lake of the Woods and the Rainy River – Part 2: Data Gaps and Monitoring Needs. Andrew Paterson, Dorset Environmental Science Centre, Ontario Ministry of the Environment		
2:30 – 3:30	Break & Poster Session	
3:30 – 5:00	**Session 2 – Lake of the Woods Basin Perspectives**	
• Lake Winnipeg and Lake of the Woods, an inseparable connection. W. Lyle Lockhart, Lake Winnipeg Foundation		
• Lake Winnipeg Basin Initiative. Malcolm Conly, Environment Canada		
• Environment Canada Research Plan for Lake of the Woods. John Lawrence, Water Science & Technology Directorate, Environment Canada		
• Scenario-based Assessment of Modeling Approaches to Lake of the Woods Nutrient Management. Sue Watson, Environment Canada		
FOUNDATION RECEPTION (Holiday Inn)		
6:00	**Guest Speaker – Commissioner Brad Moore, MPCA | Presentation of the Kallemeyn Award**	

MARCH 13, 2008
Registration & Continental Breakfast
8:30 – 10:00 Session 3 - Emerging Issues: Aquatic Invasive Species
• Policies to prevent or control AIS Infestations. Dick Osgood, Osgood Consulting
• Assessing the risk of aquatic invasive species: the spiny water flea (*Bythotrephes*) in Canadian Shield lakes. Dr. Norman Yan, Department of Biology, York University
10:00 – 10:30 Break
10:30 – 12:00 Session 4 - AIS in the Lake of the Woods Basin
• A Progress Report on Basic and Applied Research Regarding *Bythotrephes longimanus*. Donn K. Branstrator, University of Minnesota Duluth
• The diatom *Didymosphenia geminata*, its spread, distribution, and formation of nuisance blooms. Mark Edlund, St. Croix Watershed Research Station, Science Museum of Minnesota
• Assessing Ecological Impacts of Exotic Rainbow Smelt, *Osmerus mordax*, in Rainy Lake, Minnesota-Ontario. Larry W. Kallemeyn, U. S. Geological Survey (retired)
• Minnesota DNR Invasive Species Program and its efforts in the Lake of the Woods Basin. Jay Rendall, Minnesota Department of Natural Resources

12:00 – 1:45	**Lunch & Poster Session**
1:45 – 3:30	**Session 5 - Nutrients and Algae**
• Phosphorus is the key to controlling eutrophication: Results of a 37 year eutrophication experiment. R.E. Hecky, Department of Biology and Large Lakes Observatory, University of Minnesota-Duluth	
• Microcystin Research in Southern Ontario: Some Recent Results. Dr. Stephanie J. Guildford, Department of Biology and Large Lakes Observatory, University Minnesota Duluth	
• Cyanobacteria (blue-green algal) species in Lake of the Woods. Hedy Kling, Algal Taxonomy and Ecology Inc.	
• Spatial and temporal variation in phytoplankton composition and nutrient and microcystin concentration during 2006 and 2007 surveys of Lake of the Woods. Huirong Chen, Department of Biological Sciences, University of Alberta	
• Anthropogenic induced impacts in Voyageurs National Park. Claire A. Serieyssol, Water Resources Science, University of Minnesota	
3:30 – 4:00	**Closing Remarks**

Working Group Reports

1. Monitoring Coordination

Kelli Saunders chaired the workshop and gave an overview, some background and a workshop agenda. Forms were distributed to participants to assess their capacity to monitor.

Following this there was an opportunity for the participants to outline or introduce monitoring activities in the basin.

- Andrew Paterson began by describing: 1) ongoing work in Clearwater Bay, 2) the MNR FAU rotating full suite water chemistry data collection, 3) the coring projects to describe diatom response to warming and 4) the Lake Partner Program. There was generally an appeal for science based and well organized monitoring to follow gap analysis. Andrew also briefly describes the MNR landscape based fisheries management initiative which would include work on Lake of the Woods as well as in other regional lakes.
- Norm Yan gave an overview of the implications of Ca declines in lakes and outlined ways in which volunteers could construct their own nets to monitor Bythotrephes invasions in the watershed.
- Larry Kallemyn mentioned that there might be ways to sample for invading species using the aircraft water collection process
- Joan Elias described chemical and biological monitoring on 4 lakes in Voyageurs Park with data analysis by MNDR
- Mike Turner from ELA reminded the group about long-term data collection sets from ELA that would be relevant to Lake of the Woods i.e. atmospheric deposition and hydrologic and chemical yield from indexed watersheds (5 lakes).
- Andrew P mentioned top /bottom coring with respect to climate change is also seen in regional lakes (Brian Cumming)
- Laury talked about Fish and Hg work in the Winnipeg River and how there was capacity in this program to collect additional samples.
- Shoal Lake intake monitoring (City of Winnipeg) and Shoal Lake monitoring 2x/yr for metals and full suite parameters (Manitoba Water Stewardship) was described. No plankton – could do hauls.
- Wolf Jansen described large monitoring programs with Manitoba Hydro where there is no real good handle on WQ.
- Someone mentioned transport of Ca in fish to eggs and that spawning fish might tell a Ca story

At the end there was a break-out session to discuss the questions presented in Kelli's overview. Group representatives were given the chance to summarize general discussions as follows:

- Larry Kallemyn's group focused on issues surrounding the LOW TMDLs and the fact that there was no coordination of international information. There was talk of the IJC control board convening a technical workgroup but no talk on specifics.
- Brenda Hann's group talked about values and threats questions with AIS themes, i.e. how to address management decisions that are based on data inputs, how to identify threats, do we wait for gap analysis with this group, is money what is holding us back, do we need an internet team room.
- Kelli talked about the need for a coordinator

- Jesse Anderson talked about gaps in inflows information i.e. 10 unguaged inflow on the east and a need for upstream information on the RR – huge logistics problems.
- Kylie Hansen offered to be involved with RR missing info based on the State of the Basin report.
- Kelli posted her email address as an alternative way to send in capacity surveys (kelli.saunders@ontario.ca)

Eventually we will attempt to link capacity to monitor with monitoring needs based on science plans and gap analysis. Waiting on: surveys, input from science committee, and published gap analysis/recommendations.

2. Nutrients and Algae

Andrew Paterson (OMOE) and Steve Heiskary (MPCA) co-chaired this working group. On-going monitoring and research initiatives were reviewed with several short presentations under the following topics:

The State of the Basin Report

The purpose of the report is to develop a baseline water quality report for the Lake of the Woods & Rainy R. Basin. At the LOW Water Quality Forum, 2004 there were initial discussions around the concept. In the summer of 2006 an Inter-agency partnership was formalized and in January, 2007 a one-year research contract was initiated.

The content of the report will include/outline:

1. Defining the System – Information on regional climate, geology, geography and basin characteristics
2. Current state of knowledge – summary of baseline data on water quality and ecology
3. A window into the future – gap analysis and discussion of emerging threats to water quality and biological communities.

Paleolimnological Assessment of Nutrients and Algae

Three presentations were given:

1. Claire Serieyssol

   Provided a summary of work on Zippel Bay (Reavie et.al.)

   - Used cores to infer past conditions in water quality and past trends from depositional basin
   - Found increase in diatom-inferred phosphorus and sediment accumulation, and anoxic periods in Zippel Bay are likely more frequency than in past

2. Hedy Kling

   Noted concerns that blue-green blooms have increased in frequency in Lake of the Woods and found that:

   - sedimentation rate has been variable in the lake over time
   - organic carbon increases at some site in the Lake of the Woods over time, beginning in the 1950s; nitrogen concentrations have increased in some cores
   - nitrogen phosphorus ratio has been declining in sediment cores
   - biogenic silica, increase at very top suggests recent increase in primary productivity

- increase in precipitation and temperature in lake a possible contributor to observed changes

3. Kathleen Rühland

    - presented paleo work on the northern side of the basin
    - used paleo to explore possible link between recent algal blooms and TP
    - consisted of a survey of modern diatom assemblages and full-core analyses
    - top sediments – diatoms change in relation to TP gradient in the Lake of the Woods
    - developed model for reconstructing total phosphorus concentrations in the Lake
    - changes in species assemblages in all cores, and in particular at reference site (Whitefish Bay):
        - strong correlations with annual temperature and ice dynamics
        - diatom-inferred total phosphorus declined slightly over past two decades
        - climate effects are important; chlorophyll a has increased in some sites

LOW as an Impaired Water Body

Steve Heiskary

- LOW - MN has a responsibility to report to USEPA on the status of its waters on a biennial basis;
- LOW water quality studies in 1999 and 2005 allowed LOW to be assessed as a part of Minnesota's 2008 assessment process;
- South end (Minnesota portion) of LOW was included on Minnesota's 2008 list of Impaired Waters because of excess nutrients, which requires development of a TMDL;
- TMDL study of LOW slated to begin in 2010 with funding from TMDL program;

Survey of Algal Toxins and Remote Sensing

- Kotak et al. – survey of microtoxins – a lesson in collaboration – breadth in distribution of sites used for toxin monitoring
- Remote sensing – another example of collaboration across multiple agencies – use of MODIS technology to assess chlorophyll

General Discussion

Q. LOW impaired body – what kinds of data are needed?

A. TDML – assessing water relative to water quality standards etc. Nutrient impairment – listing since 2002 for lakes –criteria

- Assess loads to the water – get a handle on nutrient budget – what is the target to shoot for in the LOW – standard is <30 ug/L (LOW is 36)
- Money and funding once it is listed will be put toward better understanding the modeling work. Listing of the lake as impaired with implementation plans identified – these studies may bring about more funding. Currently a great deal of competition for funding.

Q. Is this the first international water body that has been listed as impaired? Is there a mechanism in place for discussing among groups from Can – US.

A. There is good collaboration among the LOW groups and is why Nolan has been able to advance the LOW to this status. Modeling efforts between Trent U. and an Minnesota St. Cloud State University - as well as bathymetry work for Big Traverse Bay is proposed as an example.

Comment: LOW District Property Owners Assoc. – proposal to do work on LOW specifically on drinking water supplies – microcystin concentrations on the properties of cottagers and on shorelines. Assoc. is currently evaluating whether or not to fund this project.

Comment: LOWDPOA has funds available – many cottagers put money into an environmental fund - initially for students but not many have applied so it is being used for other projects.

Q. Can paleo work be used to assess historical nutrient loads? Reference or baseline study?

A. Some paleo work has been used for this. Heiskary says it seems reasonable to do this for the LOW to establish the historical conditions. Back-calculating loadings after you have established background loads. What is a reasonable reduction? – paleo work could be helpful.

Q. Rainy River contributes to lake – what are the things that are the major contributing factors for increases in nutrients? What can we do to minimize the impacts to get lake off the list of impaired lakes?

A. Difficult to answer – phosphorus concentrations are not always that high – hard to really answer – need to get the nutrient budget first and then back up and look at what the Rainy contributes to the load and its sources. Pay particular attention to areas that are regulated (storm water etc.) – those things that are more affected by this particular basin.

Comment: Impaired listing is there because what people think (observed conditions relative to a standard) is going on but no real evidence that nutrients are increasing in the lake.

Comment: If loads have not changed we may need to look at site-specific conditions on the lake. Detailed loadings are needed.

Comment: Standards are there to achieve and maintain its designated use – no matter what the natural background is but we do need to keep the target to the standard.

Q. Climate – how do you deal with the interaction of climate in nutrient dynamics?

A. It is an equation that we have to account for – and there is no room for that equation right now but we are now starting to look into this influence – right now we cannot account for climate in the TMDL. Margin of safety is accounted for in the TMDL - How large is that "margin of safety"?

A. The modeling has not yet been tested – this comes later now that the listing is there

Comment: On the Canadian side – very early in establishing modeling. Nutrient budget – gap analysis – 2010 – two master's level projects. But that is the goal of this working group.

Q. Other lakes in Minnesota – are they on the TMDL list?

A. Yes there are over 300 lakes on Minnesota's TMDL list because of "excess nutrients." LOW is close to the thresholds; however, many other listed lakes may be two or three-fold above the listing thresholds.

Comment: It will be a tough challenge to incorporate the relationships between phosphorus and temperature – move forward in steps.

Q. What are the most critical types of data that is needed and can we work on this right now?

A. What we need is the phosphorus load from the Rainy River. Establish flow gauges and sediment gauges to start monitoring – USGS has a flow gauge but we need sediment gauge. Phosphorus levels are lower in the Rainy River than it is 5 km into the lake – complicated process. Need more ppt and temp data – sensor data on buoys. Need everyone's assistance.

A. Internal loading is complicated and there is some evidence that it may be an important part of the nutrient budget for LOW. TMDL study will help discern its importance.

Comment: Lake-ice records available for various regions of the lake

Q. Do we have seasonal data for the phytoplankton ?

A. Ellie Prepas for ice-free season only

A. For models need to look at the physiological responses of the phytoplankton communities seasonally and how they respond to phosphorus and climate – need also to know the mixing regimes (wind etc.)

3. Aquatic Invasive Species

The AIS Working Group was organized by Dr. Andrew Paterson, Ontario Ministry of the Environment, Dorset Environmental Science Centre, Dorset, ON, and Dr. Brenda Hann, Department of Biological Sciences, University of Manitoba, Winnipeg, MB. It was convened on 12 March 2008 with approximately 25 in attendance at Rainy River Community College, International Falls, MN.

The working group serves two purposes:

1) to provide a forum for researchers to discuss concerns specific to their field, share successes, and to collaboratively fulfill research needs for the entire basin, and

2) to generate and integrate specific recommendations that may be used by resource managers and agencies on both sides of the international border.

This year, the Aquatic Invasive Species Working Group provided researches and resource managers with a forum to:

- Review ongoing monitoring and research initiatives in an informal setting
    - A few attendees presented a brief summary (5 minutes / 3-5 presentation slides) of recent monitoring and/or research on AIS in the basin.
- In a breakout session, discuss and share ideas on the following questions:
    - With the recent arrival of the spiny water flea (*Bythotrephes*) in the Lake of the Woods basin, additional monitoring will now be required to assess its invasion pathway and impact in the LOW. If you were to design a monitoring program for this invader from the ground up, what elements would you include in your program? For example, over what temporal and spatial scales should monitoring occur? What physical, chemical and biological parameters should be examined?
    - A monitoring program(s) for AIS in the Basin will form an important foundation for future research and management initiatives. Choosing one of these directions (research or management), what are the logical steps for moving beyond monitoring? For management, what preventative measures should be put in place to reduce or delay possible impacts on lake ecology? For research, what are the key questions that should be addressed?

The session opened with brief presentations to update participants regarding status of ongoing research projects. Presenters and topics are listed below:

Norm Yan, York University, ON summarized the aims and objectives of CAISN (Canadian Aquatic Invading Species Network), managed out of University of Windsor by Hugh MacIsaac. There are 16 projects, 14 universities, and 5 DFO regional laboratories involved, with an overall budget of over $5.7 million. Research is focused on vectors and pathways, factors affecting establishment success, and risk assessment modeling.

Ryan Maki, Voyageurs National Park, MN summarized a project to examine the invasion status and ecological effects of an exotic zooplankter, *Bythotrephes*, in several Great Lakes area parks, including Voyageurs National Park, Sleeping Bear Dunes National Lakeshore, Isle Royale National Park, Pictured Rocks National Lakeshore. This project is planned for 2007-2010 and will evaluate effects of the invader on zooplankton and fish communities.

Laurie Wesson, Freshwater Institute, DFO, Winnipeg, MB described a monitoring project initiated by Fisheries & Oceans Canada that focused on watercraft inspection at International borders in NW Ontario at Fort Frances/International Falls and Rainy River/Baudette. The primary pathway of dispersal of AIS into NW Ontario is via the Rainy River-LOW-Winnipeg River systems. The program began in summer 2007 and will continue in 2008 at US borders and local boat launches, resorts, and campgrounds. The program's objective was to inspect trailered watercraft coming from the US for positive AIS, and conduct a short survey on angler demographics, bait use, and AIS awareness.

John Van den Broeck and Alyson Rob, MNR, Fort Frances, ON mapped waterbodies in Fort Frances/ Kenora Districts infested with Spiny Waterflea as of 2007. These included Rainy Lake, Saganagons Lake, Sydney Lake, Rainy River, and the south-eastern quadrant of Lake of the Woods.

Brenda Hann, University of Manitoba and **Tom Mosindy, Fishery Assessment Unit, MNR, Kenora, ON**, summarized a zooplankton sampling program in several sectors of LOW to detect the presence of spiny waterflea, *Bythotrephes longimanus*, and assess its impact on both the zooplankton and fish communities in LOW. During 2007, *Bythotrephes* was detected in September in Miles Bay in the SE sector of LOW, specifically at the Horseshoe Island sampling station. However, spiny waterflea were also present in abundance in the stomachs of fish caught in index gill nets (Cisco, Black Crappie, Yellow Perch) in Miles Bay.

Michael Turner, Freshwater Institute, DFO, Winnipeg, MB provided an update on monitoring of invading crayfish in LOW and Winnipeg River. These included Rusty Crayfish (*Orconectes rusticus*) present at 23% of sampling sites and which is displacing the native Virile Crayfish (*Orconectes virilis*) which is still the most widespread crayfish and found at 68% of sites sampled. Papershell or Calico Crayfish (*Orconectes immunis*) was present at 9% of sampling sites, and the Northern Clearwater Crayfish (*Orconectes propinquus*) also occurred in low numbers.

Mark Edlund, Science Museum of Minnesota, MN warned about the exotic diatom, *Didymosphenia geminata*, also known as "rock snot" that forms nuisance blooms and is causing problems in clear water streams in North America.

A wide-ranging discussion of aquatic invasive species ensued but focused on the question posed by Norm Yan, i.e., "What are the biggest threats to LOW"? Non-indigenous species (NIS)! Issues relating to design of monitoring programs, achieving management goals, and research questions associated with habitat vulnerability to invading species were all discussed. Although many of the short presentations dealt with spiny waterflea (*Bythotrephes)*, Jay Rendal, MN-DNR, reminded us of the long list of NIS that are potential invaders of LOW: zebra mussel, quagga mussel, Eurasian milfoil, hydrilla, faucet snail, NZ mud snail, round goby.

Consensus was that there was not enough time to discuss the queries posed in advance but valuable information was exchanged.

Presentations – Technical Abstracts

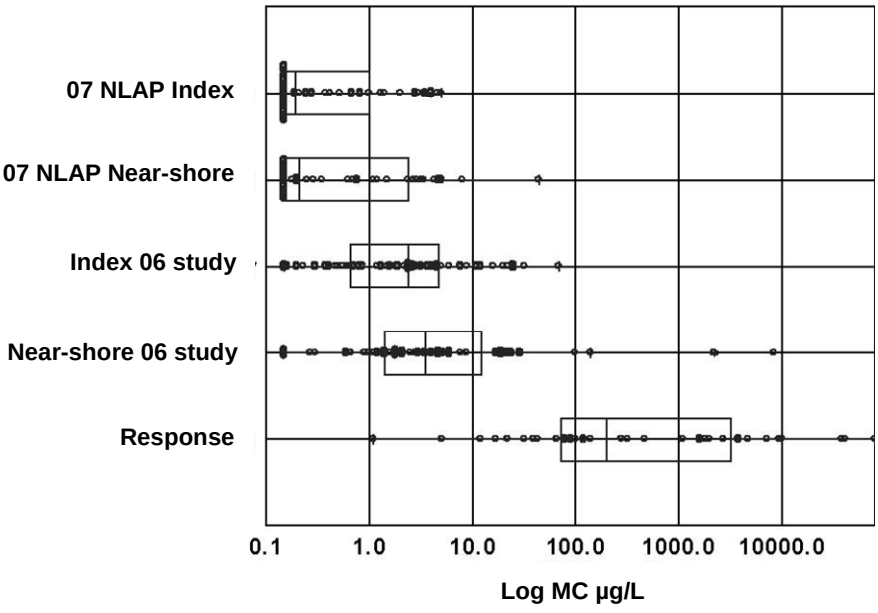
1. National Lakes Assessment Project (NLAP): Enhancements for Minnesota and Potential Applications for Lake of the Woods.

Steve Heiskary, Minnesota Pollution Control Agency.520 Lafayette Road St. Paul MN 55155 (ph) 651-296-7217/651-297-8324 (e-mail) steven.heiskary@pca.state.mn.us

USEPA led a survey of the Nation's lakes in conjunction with the states in 2007. A total of 909 lakes were included in this survey. Minnesota's NLAP effort is lead by the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Natural Resources (MDNR). Minnesota drew 41 lakes as a part of the initial draw for this statistically-based national survey effort and added nine lakes to allow for state-based assessment. Communication with various groups around the state led to several enhancements that were added to the base-level program including: collaboration with USFS in sampling in the BWCA Wilderness; near-shore assessments that included macrophyte identification and determination of maximum rooting depth of plants; sampling in support of lake IBI development; measurement of water Hg; measurement of water pesticides in conjunction with an ongoing MN Department of Agriculture Program; measurement of sediment contaminants to provide improved baseline and spatial data; and a region-wide assessment of the Prairie Pothole Region conducted in conjunction with the states of ND, SD, MT, and IA.

The presentation provided a brief update of 2007 NLAP survey efforts and progress to date on data analysis with an emphasis on: 1) microcystin concentrations as derived from NLAP and previous targeted studies (Figure 1); and 2) water mercury concentrations as derived from NLAP. NLAP datasets provide perspective on concentrations of various constituents that may prove useful when assessing LOW data or as a template for similar statistically-based surveys on LOW.

Figure 1. Boxplot comparison of: 2007 NLAP index and near-shore MC; 2006 study index and near-shore; and response-based samples (2004-2007). Figure notes: minima – lowest concentration; maxima – highest concentration; interquartile range (25^{th}-75^{th} % tiles) – box; line in box – median.



2. The State of the Basin Report for Lake of the Woods and the Rainy River Part 1: Overview and Data Summary

Anna DeSellas, Andrew Paterson, Bev Clark, & Nolan Baratono
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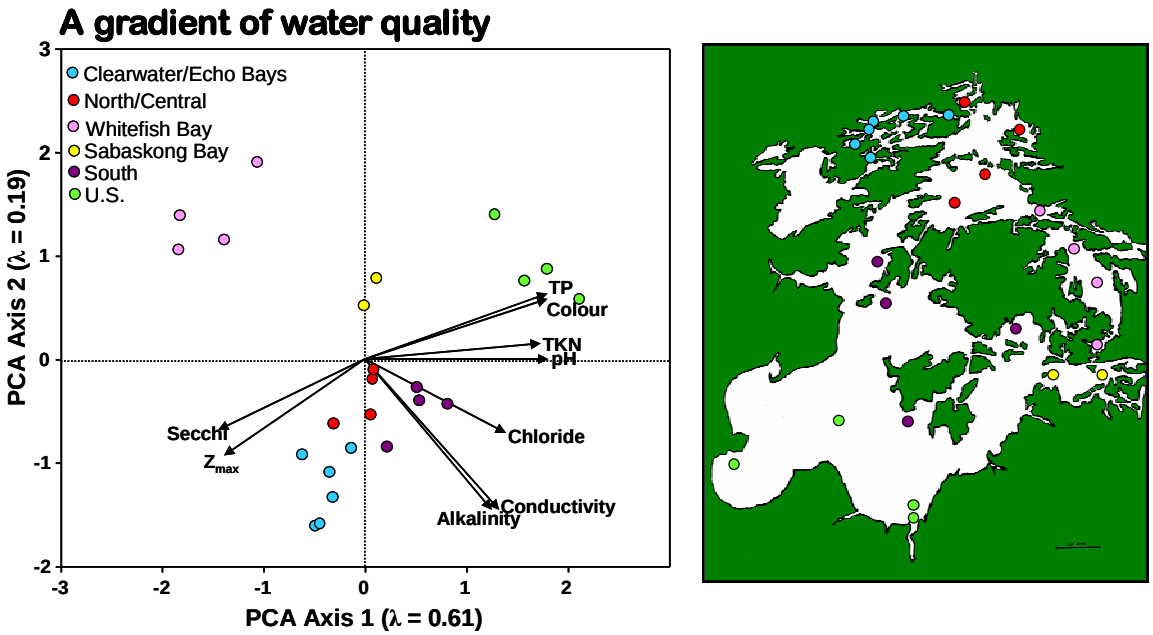
Lake of the Woods is a large, complex, and international water body that is located within the provinces of Ontario and Manitoba, and the state of Minnesota. Its watershed forms part of the larger Winnipeg River Drainage Basin and it borders several important sub-basins, including those of the Rainy River Basin. It is valued for many reasons, including its freshwater fishery, tourist industry, hydroelectric power generation, and as a water resource in general. The Lake of the Woods basin is also a popular region for cottaging and other recreational activities. In recent years concerns have been raised regarding the link between increased shoreline development and changes in land-use, nutrient enrichment in the lake, and a perceived increased in the frequency and intensity of blue-green algal blooms. In response to water quality concerns in the Lake of the Woods, it has been recognized that there is a need to both enhance existing monitoring programs on the lake, and to develop sound management strategies to address present and future environmental concerns. As a first step in developing a management and sustainability plan for the Lake of the Woods, a baseline water quality report was initiated to synthesize existing limnological and biological data that has been gathered for Lake of the Woods and the Rainy River Basin over the past several decades. In January of 2007, the Lake of the Woods Water Sustainability Foundation, in conjunction with the Ontario Ministry of the Environment, Environment Canada, and the Minnesota Pollution Control Agency, co-funded the research and writing of the *State of the Basin Report for the Lake of the Woods and the Rainy River*. This report presents baseline monitoring data that can be used to assess future changes in water quality and ecology in response to emerging environmental stressors (e.g., climate change, invasive species). This presentation provides a summary of the major conclusions of the *State of the Basin Report* and includes an overview of the basin in terms of agency jurisdiction, drainage basin and climatic characteristics, temporal and spatial water quality trends, and the state of biological communities. The figure below demonstrates the spatial variability in water quality across Lake of the Woods by identifying geographically distinct groups of sampling sites based on a strong primary gradient of nutrients, pH, and depth and a weaker secondary gradient of alkalinity and ions.



3. The State of the Basin Report for Lake of the Woods and the Rainy River Part 2: Data Gaps and Monitoring Needs

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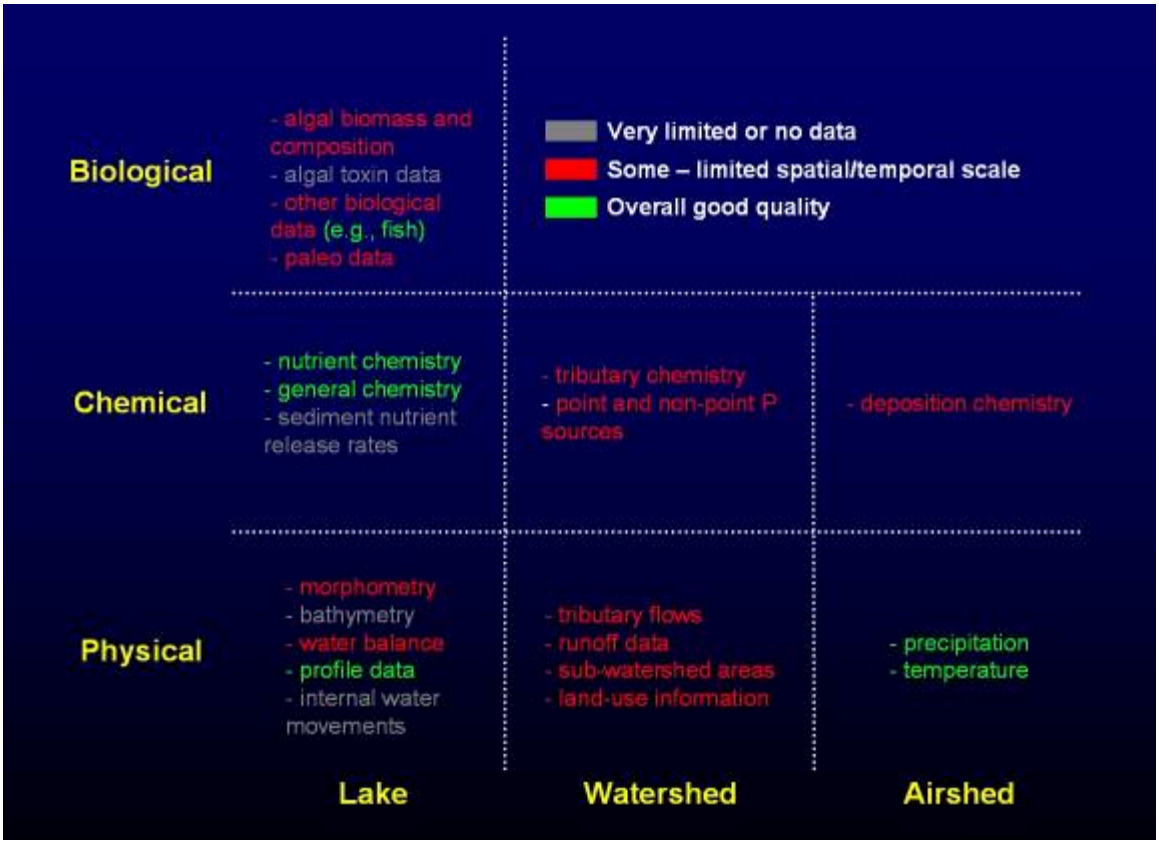
The creation of a scientifically-defensible plan for protecting water quality within the Lake of the Woods basin is of interest to many stakeholders. Consequently, the Lake of the Woods Water Sustainability Foundation, in partnership with the Ontario Ministry of the Environment, Environment Canada, and the Minnesota Pollution Control Agency has co-funded the development a 'State of the Basin Report' for the Lake of the Woods and the Rainy River. This report, now in draft form, synthesizes existing limnological and biological data for the basin, and provides an environmental baseline from which future changes may be assessed. Following the report overview and the description of key data provided in Part I, this presentation will highlight existing gaps in the current data, and provide a list of essential and desired monitoring needs as data collection continues over the next several years. Diverse monitoring strategies, covering multiple spatial and temporal scales, will be required to assess impacts from an increasing number of environmental stressors (e.g., climate warming, invasive species, land-use pressure). The implementation of monitoring strategies will be complicated by jurisdictional responsibilities and geographic borders. However, through careful planning, there is an opportunity to coordinate future monitoring initiatives, with an aim at overcoming these barriers.



4. Lake Winnipeg and Lake of the Woods, an inseparable connection

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The three major water supplies to Lake Winnipeg are the Winnipeg River, the Saskatchewan River and the Red River. Lake Winnipeg's drainage basin encompasses almost 1 million sq km with the largest area drained by the Saskatchewan River which originates in the Rocky Mountains. The volumes of water supplied by these rivers have changed significantly over the past century. The Saskatchewan River now supplies less water than it used to while the Winnipeg River and the Red River now supply more. The distribution of rainfall over the watershed has been changing at the same time as temperatures have been warming. Warmer, dryer conditions in the western part of the watershed have enhanced evaporation and reduced flows in the Saskatchewan River. Average rainfall has increased or remained about the same in the eastern and southern parts of the watershed and flows have increased in both Winnipeg and Red Rivers. The main issue in Lake Winnipeg now is the extent and frequency of blooms of blue-green algae, a problem we share increasingly with Lake of the Woods. Scientific evidence informs us that these blooms are driven by abundant supplies of phosphorus in the water and by sunlight. The kinds of blue-green algae we have are capable of fixing the nitrogen they need and so they cannot be controlled by reducing supplies of nitrogen. Sunlight is beyond our control and that leaves phosphorus. While flows in the Red and Winnipeg Rivers have increased, so have the concentrations of phosphorus in them with the result that both rivers deliver greater and greater quantities of phosphorus to the lake. The Red River is the most important source of phosphorus but the Winnipeg River is the second most important. The origins of this phosphorus, at least in the Red River drainage, are largely non-point sources. As an organization of citizens, our role is to promote the health of the lake and we support efforts to improve understanding of the sources and dynamics of phosphorus in the watershed and to reduce inputs of phosphorus to Lake Winnipeg.

5. Lake Winnipeg Basin Initiative

Malcolm Conly, Environment Canada

For several years water quality in Lake Winnipeg has been deteriorating dramatically. This has potentially serious repercussions as Lake Winnipeg plays a vital role in Manitoba's economic prosperity and well-being. The chief concern is nutrient loading (phosphorous and nitrogen) mainly from agricultural run-off and municipal wastewater effluent leading to advanced eutrophication of the Lake. While the primary responsibility for most aspects of water management rests with the provinces and territories, the federal government has a significant role to play in protecting water by providing science and information, regulating toxic substances, promoting pollution prevention and as a facilitator in inter-jurisdictional matters. Watersheds that cross political boundaries often present unique challenges for provinces, particularly when a significant contributor to the source of a given problem may lie beyond their jurisdictional boundaries. An example of this type of inter-jurisdictional challenge is manifest in the issues affecting Lake Winnipeg (LW), which is located entirely within the province of Manitoba. As the world's10th largest lake, Lake Winnipeg plays a vital role in Manitoba's economic stability and well-being, however, its contributing basin covers approximately 1,000,000 km^2 extending across four provinces and four states. The broader basin is home to six million Canadians and comprised of three major sub-basins – Saskatchewan River Basin, Red River Basin and Winnipeg River/Lake of the Woods Basin, which flow into Lake Winnipeg. Activities outside of Manitoba's borders, but within the larger basin, directly impact the health of Lake Winnipeg. As a large proportion of the nutrient loading to Lake Winnipeg originates from beyond the Manitoba border the problem and solution are both inter-provincial and international in scope, involving a myriad of stakeholders. This presentation will discuss the approach being undertaken by Environment Canada to assist in the remediation of Lake Winnipeg within the context of the Lake Winnipeg Basin. Specifically this presentation will outline the federal government's actions relative to facilitating inter-jurisdictional governance; supporting science and monitoring; and encouraging stewardship activities in the context of improving the sustainability of Lake Winnipeg.

6. Environment Canada Research Plan for Lake of the Woods

John Lawrence, Sue Watson and Ram Yerubandi, Water Science & Technology Directorate, Environment Canada, 867 Lakeshore Road, Burlington, Ontario L7R 4A6 (905) 336-4913 J.Lawrence@ec.gc.ca

As part of the broader Lake Winnipeg Basin initiative, Environment Canada scientists have prepared a multi-year plan for Lake of the Woods, LOW. This program will contribute to the science understanding required to manage the Lake of the Woods in an environmentally sustainable manner. This research program will address nutrient sources and their impact on the ecology of the Lake, with a view to providing the basis for ecologically-relevant guidelines for nutrient loading and management strategies for harmful algal blooms.

Environment Canada will work in collaboration with binational, provincial, regional and local partners to identify and address current data and knowledge gaps and develop a science-based nutrient and bloom management program within a viable socioeconomic framework. Federal efforts will build upon work and expertise already in place. The associated studies will address many of the gaps derived from the 2007 Lake of the Woods Baseline Nutrient Compilation and Guidance Document prepared by Gartner Lee Ltd, for Environment Canada and the Lake of the Woods Water Sustainability Foundation as well as the soon to be released Lake of the Woods State of the Basin Report. The proposed scope of the multi-year research program will include:

- Scientific assessment of existing LOW hydrologic and water quality / nutrient databases;
- Improved characterization of hydrological loading and physical limnology of the Lake;
- Improved estimation of LOW open lake and nearshore nutrient loading and nutrient budget;
- Improved characterization of biological community and productivity;
- Hydrodynamic modeling of the Lake.

7. Scenario-based Assessment of Modeling Approaches to Lake of the Woods Nutrient Management

Ram Yerubandi and Sue Watson (presenting) AEMRD, Environment Canada, 867 Lakeshore Rd. Burlington ON L7R 4A6

Lake management models are widely used to simulate the input and fate of nutrients from point and non-point sources. These models are generally considered to be valuable tools which can provide the basis for ecologically-relevant nutrient loading targets and management strategies for harmful algal blooms. However, the overall utility of this approach is highly dependent on the quality and relevance of the data used to parameterize these models, and the configurations of the models themselves. Above all, it is important to be cognitive of the model assumptions and limitations and not to overextend their application and interpretation, which can undermine their successful application. The most commonly applied approaches are based on simple mass balances which assume a uniform mixing mixed and steady state condition. Such a single box model has been proposed as diagnostic tool under the Lake of the Woods (LOW) nutrient management initiative. To both assess of the utility and limitations of this model and identify key data gaps, we applied it to total phosphorus (TP), using several different scenarios for estimated nutrient inputs to LOW and generating likelihood conditions of in-lake concentrations with for each. Initially, we used the limited hydrologic data, estimates of TP inputs and in-lake data available from unpublished reports data to calibrate the model. Two different scenarios were tested, assuming i) the lake as a single mixed box, and ii) that some stratification may develop. In addition, given the large surface area and spatial complexity of LOW, we also developed a low resolution hydrodynamic model with different wind conditions to demonstrate the local variability of circulation.

8. Policies to prevent or control Aquatic Invasive Species infestations

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Policies to prevent or control aquatic invasive species (AIS) are largely permissive, meaning they rely on voluntary actions and minimal enforcement. Furthermore, there is a patchwork of regulatory oversight and control at multiple levels. As a result of a lack of clarity regarding legal frameworks and priorities, the resulting system of prevention and control is limited in its effect and scope. Positive steps have been taken and significant improvements have occurred, especially with respect education, awareness and voluntary action. However, other more direct prevention measures are needed to complement these initiatives. To effectively reduce the risk of AIS introductions, individual water bodies must take initiatives at this last line of defense. For many AIS control measures are not technically feasible. Where feasible, controls need to be as aggressive as the pert being controlled.

NALMS Issues and Positions

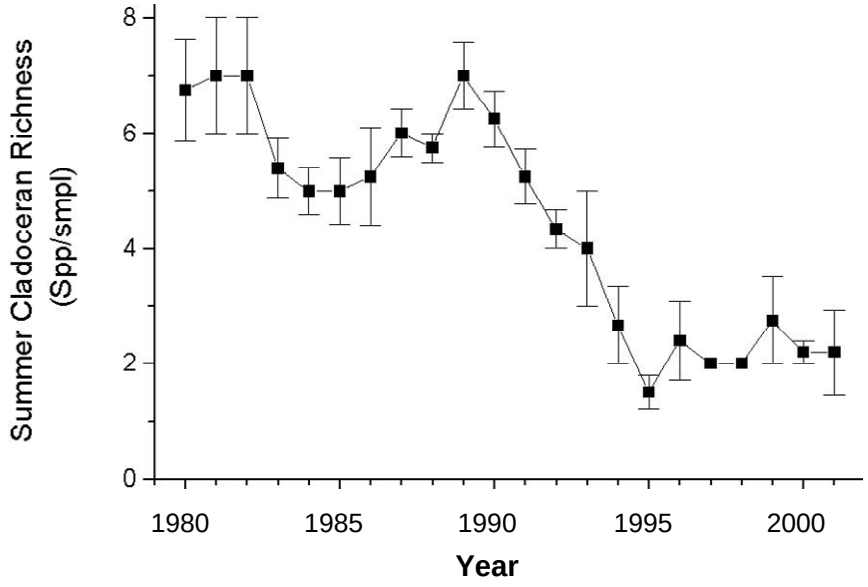
- National & international policies inadequate
- Need more coordination among levels
- Ecologic & economic impacts large
- Need better regulation of exotics trades
- Boat inspections are an effective tool
- Local protection/control efforts are poorly supported
- Supports international & national efforts to restrict, control & mitigate exotic species movement
- Supports research in new control methods
- Encourages and supports local efforts to protect lakes – including monitoring, education & mitigation programs

Invading species: not a new problem

9. Assessing the risk of aquatic invasive species: the spiny water flea (Bythotrephes) in Canadian Shield lakes

Norman Yan, Young, J., Weisz, E., and Cairns A. Professor, Department of Biology, York University

There is a growing public awareness that the collective threat posed by aquatic invasive species can no longer be ignored, but that we are not in a position to simply transfer approaches to their management from other categories of environmental stressors, eg. pollutants or unsustainable harvesting. A new body of applied science must be developed. Using the example of the Eurasian predatory Cladoceran *Bythotrephes* (the spiny water flea) which has recently invaded Lake of the Woods, I review the needed components of this new body of applied science. I summarize current understanding on factors needed to evaluate the threat of the spiny water flea on the boreal shield, namely: 1) how many lakes provide the invader with suitable habitat, 2) how quickly is it spreading, 3) what are the determinants of establishment success, 4) what ecological changes ensue, 5) Is *Bythotrephes* responsible for these changes, 6) If the changes are density dependent, what control *Bythotrephes* density, and 7) should we care? I conclude that *Bythotrephes* is likely the largest new threat to native plankton diversity since acid rain, and it does produce changes in pelagic communities which should cause us some concern.



10. A Progress Report on Basic and Applied Research Regarding Bythotrephes longimanus

Donn K. Branstrator, Shannon, L.J., Brown, M.E., Thabes M.C. and Olson, V.V. University of Minnesota Duluth, Biology Department, 1035 Kirby Drive Duluth, MN 55812 dbranstr@d.umn.edu

We have been studying several issues pertinent to the biology and range expansion of the spiny waterflea (*Bythotrephes longimanus*). In this presentation I will review key findings from several of our studies and provide an overview of our current projects. In particular I will discuss the results of 3 years of experiments in which we identified levels of salinity, chlorination, temperature, desiccation, pH and oxygen tolerable by the resting egg of *Bythotrephes*. I will also discuss patterns of density and diel vertical migration of *Bythotrephes* populations across inland lakes in the region. Together these studies provide an interesting template for the design of prevention efforts aimed at slowing the spread of this invasive. Our current studies include an expansive survey of lakes within and outside of federally protected wilderness areas (Quetico in Canada and BWCAW in USA) as well as a comparison of mercury in sport fishes from a lake with and a lake without *Bythotrephes* in the food web.

11. The diatom Didymosphenia geminata, its spread, distribution, and formation of nuisance blooms

Mark Edlund, Sarah A. Spaulding and Sunil Kumar. St. Croix Watershed Research Station, Science Museum of Minnesota 16910 152nd St. N, Marine on St. Croix, MN 55047, (mbedlund@smm.org)

Historically, the diatom *Didymosphenia geminata* (Lyngbye) Schmidt was considered widespread in geographic occurrence, but rare in local occurrence. In recent years, nuisance blooms have become frequent in some parts of North America, New Zealand, and Europe. Previously, this diatom was considered restricted to cold, low nutrient waters (e.g. Lake Superior), but now it occurs in warmer (up to 25°C) and more nutrient-rich sites. In severe blooms, thick periphytic mats of "*didymo*" coat all benthic substrates, alter benthic food webs, and impact higher trophic levels and recreational uses of streams. Presence/absence data from federal monitoring programs have been used to model and predict suitable habitats for *D. geminata*. Climatic (e.g., mean temperature of the warmest quarter, frequency of precipitation) and hydrologic (e.g., base flow index and flow accumulation) factors largely explain current distributions. Because of the relationship to climate and also to the association of nuisance blooms with flow-regulated rivers, we expect that the expansion of *D. geminata* is favored under projected warmer climate and increased drought conditions in the western U.S. We conclude that human-induced change is both creating favorable environments and encouraging the spread (through physical transport) of *D. geminata* into new habitats. Potential responses to the spread and occurrence of blooms are 1) to inform and encourage agencies to recognize the threat of *didymo*, 2) to continue to expand public education programs to reduce the spread of microorganisms, and 3) to implement an international research program including a global population study using molecular and morphological markers to determine the source populations for nuisance and invasive blooms, and to understand the natural controls on growth in endemic populations. Information on the distribution, spread, and control of "*didymo*" can be found at: www.epa.gov/Region8/water/didymosphenia/, www.biosecurity.govt.nz/didymo.

12. Assessing Ecological Impacts of Exotic Rainbow Smelt, Osmerus mordax, in Rainy Lake, Minnesota-Ontario

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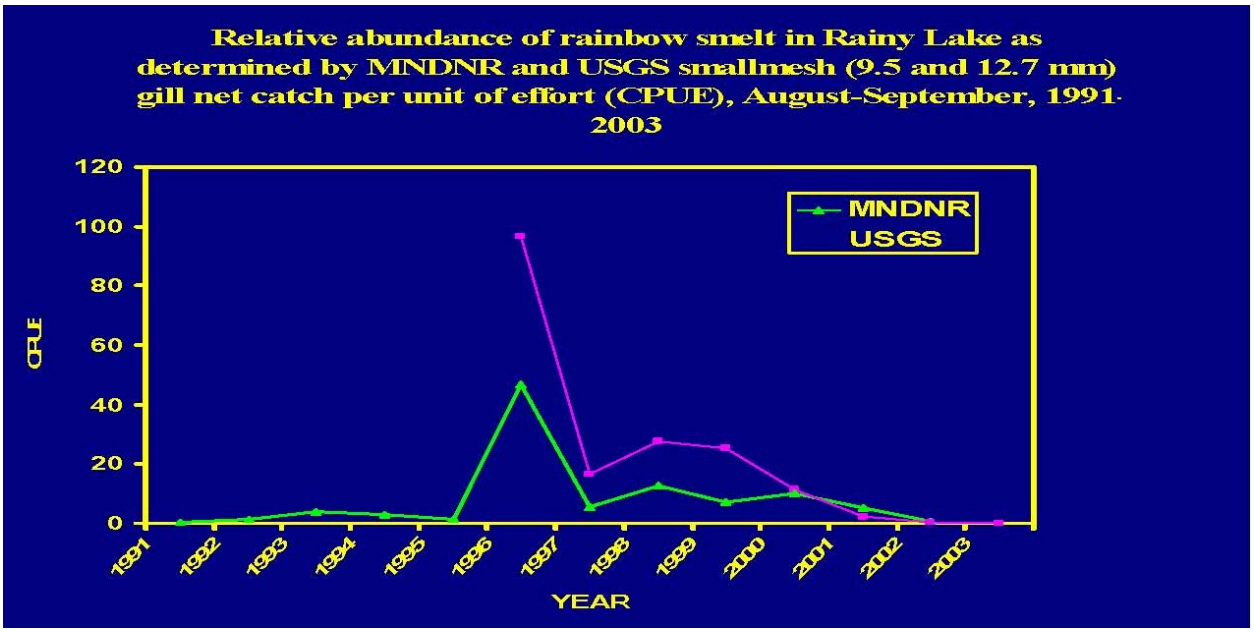
Exotic rainbow smelt, which had been present since 1972 in the upper Rainy Lake watershed, first appeared in Rainy Lake in 1990. Based on studies conducted elsewhere it appeared their invasion could have a significant effect on the aquatic ecosystem of Rainy Lake and the other large lakes in Voyageurs National Park, and in particular its cool- and cold-water fish species. Their invasion might also exacerbate an existing mercury contamination problem since there was some evidence that the rate of mercury accumulation in top level predators accelerates if they switch to a diet of smelt. To assess the effect of the smelt invasion in the South Arm of Rainy Lake (1) potential sampling methods were identified and tested, (2) food habits analyses were conducted to determine how the smelt were fitting into the food web, (3) long-term monitoring program data were used to the possible effect of the smelt on the growth and condition of walleye, *Sander vitreus*, and (4) mercury concentrations in smelt and native prey species were compared as were pre- and post-invasion concentrations in walleye and northern pike, *Esox lucius*. Based on long-term monitoring data, rainbow smelt abundance peaked in the mid-1990s at which time hydroacoustic analysis indicated the biomass was similar to reported estimates from the Great Lakes. By the early 2000s smelt abundance had fallen significantly. The smelt occupied their characteristic position in the food web – feeding primarily on invertebrates and in turn being preyed upon by large piscivores. Contrary to expectations, the smelt invasion does not appear to have contributed significantly to changes in growth and condition of walleye and in the bioaccumulation of mercury in walleye and northern pike. Assessment of the smelt's effect on the overall fish community was hindered by the limited information that was available for many of the fish species prior to the smelt invasion.



13. Minnesota DNR Invasive Species Program and its efforts in the Lake of the Woods Basin

Jay Rendall and Dan Swanson Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN 55155 651-259-5131 jay.rendall@dnr.state.mn.us

The Minnesota Department of Natural Resources – Invasive Species Program has been addressing aquatic invasive species (AIS) issues in Minnesota since 1991. Program efforts include prevention of new introductions, early detection and rapid response, containment of established AIS populations, and reducing the harm caused by established AIS populations. Recently, the program has conducted containment efforts focused on spiny waterfleas in the Lake of the Woods basin. Educational efforts using the national Stop Aquatic Hitchhikers! campaign logo and slogan, as well as watercraft inspections, regulations, and enforcement were used to help contain the waterfleas in 2007 and will be continued and expanded in 2008.

14. Phosphorus is the key to controlling eutrophication: Results of a 37 year eutrophication experiment

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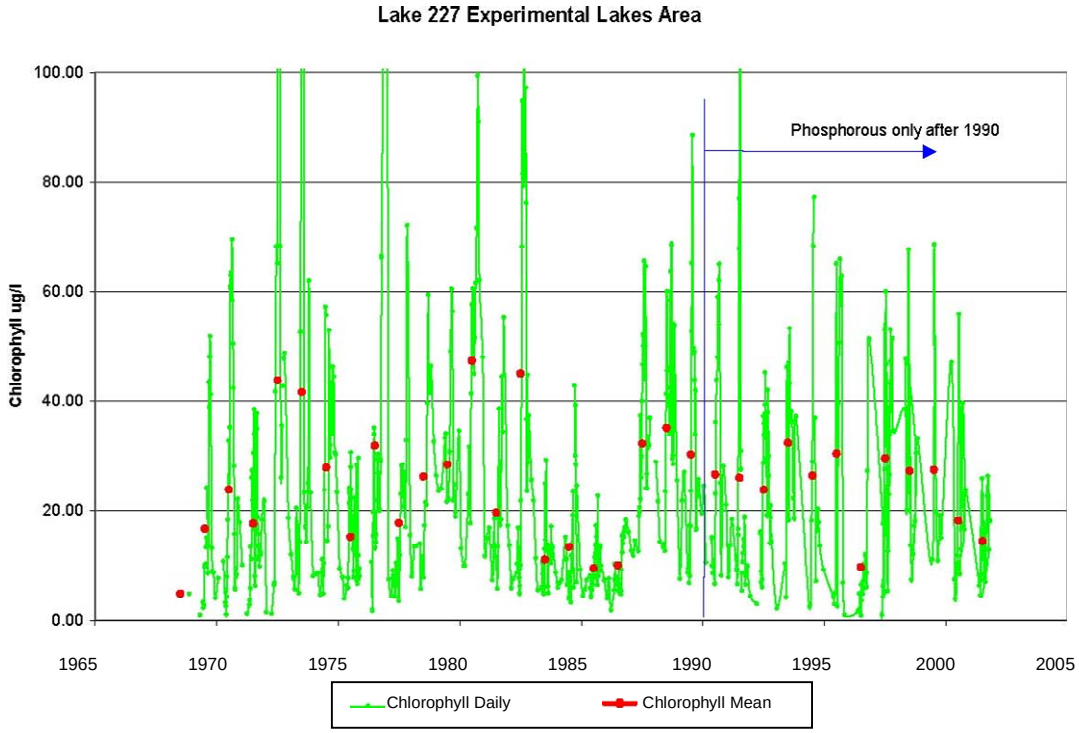
Schindler et al in a recent manuscript review the results of long term fertilization experiment. Lake 227 in the Experimental Lakes Area, just east of Lake of the Woods in northwestern Ontario, has been fertilized for 37 years since 1969 under a fixed regime for phosphorus (P) addition while nitrogen (N) was added at varying ratio over time (first 5 years at weight ratio of 14:1, 1975-1989 at a ratio of 4:1 but no N added since 1990). Initially the experiment served to demonstrate that algal populations could draw on the atmosphere to meet their carbon requirement and produce algal biomass proportional to the P added. The subsequent reduction in N was done to determine if N fixing Cyanobacteria were favoured under conditions of low N availability. The fixation of atmospheric N allowed total algal biomass to remain proportional to P. Elimination of N artificial loading since 1990 was done to determine if N removal from eutrophic lakes could provide any benefit in reducing algal populations. N removal increased the competitive advantage of N fixing Cyanobacteria. As of 2005 algal abundance was as high as in the early years of eutrophication when N and P were both added at 14:1, and rates of N fixation by Cyanobacteria were at their highest, as annual mean, for the entire 37 year experiment. The elimination of N does not generate any benefit to lakes because N deficits can be overcome by N fixation. N deficiency is a result of excess P loading, not a cause of eutrophication in most lakes.



15. Microcystin Research in Southern Ontario: Some Recent Results

Stephanie J. Guildford, Poste, A.E., Yakobowski, S.J., Chhun, A., Chiavaroli, L.A., Muller, K. & Kling, H.J. Department of Biology and Large Lakes Observatory, University Minnesota Duluth 2205 E. 5th St. Duluth, MN 55812-2401 (218) 726 8064 sguildfo@d.umn.edu

During 2005 and 2006 seasonal sampling was conducted in the Bay of Quinte (Lake Ontario), Maumee Bay (Lake Erie) and three small reservoirs in southern Ontario to examine physical, chemical and biological conditions associated with microcystin production. Microcystin concentration, estimated using the protein phosphatase inhibition assay (PPIA) was highly correlated to total phosphorus concentration in the lakes. Molecular characterization of water samples demonstrated that toxic strains of *Microcystis* and/or *Anabaena* were present when microcystin was detected and the genes for microcystin production were also detected. The number of toxic cells estimated from the detection of the mcy gene did not always correlate with microcystin concentration measured using PPIA. We assessed the nutrient status of the Cyanobactieria communities by examining the seston stoichiometric ratio of particulate organic carbon to phosphorus (C:P) and by measuring the quantum yield of photosynthesis using a pulse amplitude fluorometer. The nutrient status results indicated that when microcystin production was greatest, the Cyanobacteria populations were not nutrient stressed. These results support previous research that points to phosphorus as being the most important environmental factor controlling microcystin production.

16. Cyanobacteria (blue-green algal) species in Lake of the Woods

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Blue-green blooms have historically been present on Lake of the Woods and recently seem to be increasing in abundance and duration. Since there are large gaps in monitoring records sediment analysis using cyanobacteria (akinetes) remains provided evidence of increasing presence in certain regions of the lake. Select phytoplankton biomass analysis records from the later part of the 20th century plus more recent work give some indication of an increase in the proportion of the plankton community composed of Cyanobacteria especially during the latter part of the summer. Since the blue-green algal blooms do not always consist of the same taxa this presentation deals with the most common cyanobacteria species currently present in the Lake of the Woods plankton with some reference to their ecology and contribution to toxin production.

17. Spatial and temporal variation in phytoplankton composition and nutrient and microcystin concentration during 2006 and 2007 surveys of Lake of the Woods

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Monthly surveys were done within the Northern (Boreal Shield) basins of Lake of the Woods during the July to September period of 2006 (12 sites) and 2007 (10 sites).The aim of this study was to test the relationship between nutrient (nitrate, ammonium and phosphorus) concentrations, phytoplankton composition and microcystin-LR (MC-LR) concentration in lake water samples. Cyanobacteria (mostly *Aphanizomenon spp*. and *Anabaena spp*.) dominated August and September phytoplankton samples (56 to 99% in total biomass) from all sites. In 2006, September had the highest concentration for all tested nutrients, while in 2007 no temporal pattern was apparent. Total phosphorus was the only nutrient that was positively correlated ($P < 0.001$) to cyanobacterial biomass in both 2006 ($r = 0.67$) and 2007 ($r = 0.71$). In 2006, 19 out of 36 samples collected contained detectable MC-LR; the highest concentration was 0.69 µg/L, detected in September. All nutrient concentrations were significantly correlated to MC-LR concentration in 2006, especially total phosphorus ($r = 0.94$, $P < 0.001$). Samples collected in 2007 contained less MC-LR and no correlation existed between any nutrient and MC-LR concentration. Data from this study contribute to baseline information on nutrient dynamics, MC-LR occurrence and phytoplankton succession and/or migration among the complex Boreal Shield basins of Lake of the Woods.

18. Anthropogenic induced impacts in Voyageurs National Park

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Voyageurs National Park (VOYA) has been subject to several anthropogenic impacts which include logging, damming, water-level manipulations and climate change. In order to determine how these stressors have affected the major lakes in the park, we developed a before-after control-impact paleolimnological study. Sites in this project include Namakan, Rainy and Kabetogama Lakes located within and partly in VOYA as well as Lac La Croix situated upstream in the Boundary Waters Canoe Area Wilderness. Lac La Croix is our control lake as it has not been impacted by damming and hydromanagement. One core from each lake was retrieved for analysis of 210Pb inventory, loss-on-ignition, and diatom composition. Lead-210 dating indicates that sediment accumulation rates increased after logging and damming in both Kabetogama and Namakan Lake. However, Rainy Lake showed a delayed effect where an increase in accumulation occurred in the 1930's. Lac La Croix showed no change in sediment accumulation. Only Namakan Lake showed distinct changes in loss-on-ignition where the percentage of inorganic material increased after logging and damming. Minimal changes were observed for Kabetogama and Rainy Lakes and Lac La Croix. A clear decrease in taxonomic richness was identified in Kabetogama and Namakan Lakes after damming. Rainy Lake and Lac La Croix displayed a slight decrease that could be related to changes in sampling resolution. Species turnover increased in both Kabetogama and Namakan Lake after European settlement and again post-1970s. In contrast, Lac La Croix and Rainy Lake only showed an increase post-1970s. Diatom community analysis identified clear community shifts after logging and post-1970s in all lakes. However, ecological variability post-damming in Kabetogama, Namakan and Rainy Lakes was greater then the natural ecological variability identified in Lac La Croix during that same time period. A diatom calibration set was also applied to the cores to reconstruct conductivity and total phosphorus (TP). Lac La Croix and Rainy Lake showed no distinct historical changes in conductivity and TP. In contrast, Namakan and Kabetogama Lakes showed changes in TP and conductivity post-damming.

Poster Abstracts

1. Effects of Forest Type and Fire on Mercury Deposition in the Boundary Waters Canoe Wilderness Area

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The large blowdown that occurred on July 4, 1999 in the Boundary Waters Canoe Wilderness Area of the Superior National Forest, provided an opportunity to study the effect that fire has on mercury availability in aquatic systems. As part of a larger study aimed at understanding the effects of fire on the watershed cycling of mercury, we needed to assess the influence of fire on the deposition of mercury. In this study we measured atmospheric deposition in both control (non-fire) and fire susceptible forest systems. In control systems we found that forest canopy type and density were the primary influences on total (THg) and methyl mercury (MeHg) deposition. THg and MeHg concentrations where higher under conifer canopies than under deciduous canopies or open conditions. Fluxes of THg were also higher under conifers than deciduous or open, however, fluxes of MeHg where similar among canopy types. Among forest types, concentrations of both THg and MeHg were highest under the most dense conifer canopies. Concentrations of THg were also highest under the most dense deciduous canopies although we found no effect of deciduous canopy density on MeHg concentrations. Among forest types no canopy density differences were found for mercury fluxes. To understand the effect of fire on mercury deposition, we placed collectors in the path of three fires that occurred in 2005-2006. We grouped our samples by the number of collections since fire. Increases in THg (3X) and MeHg mercury (8.75X) concentrations were found between pre-burn samples and the first post-burn collection when all canopy types were considered. For THg concentrations, no increases were found after the first post-burn collection. For MeHg concentrations, the second sample collections were also higher than pre-burn concentrations. Among canopy types, THg and MeHg concentrations increased the first sampling following fire with exception that THg under deciduous canopies did not increase. It is apparent that from the compilation of our data that conifer canopies are very important contributors of mercury inputs to our watersheds and that fires mobilizes stored mercury that is deposited locally. The next step is to consider the larger question of whether this short term pulse of local Hg deposition is significant on an annual basis and if so whether it finds it's way into the food chain.

2. Aquatic Invasive Species: Watercraft Inspection at International Borders in NW Ontario

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One of the primary pathways for the introduction of Aquatic Invasive Species (AIS) into NW Ontario and the Lake Winnipeg watershed is through the Rainy River - Lake of the Woods - Winnipeg River system. In the summer of 2007 Fisheries and Oceans Canada initiated a program of watercraft inspection for AIS at the international borders of Fort Frances and Rainy River in NW Ontario. A short survey of fishers was conducted as watercrafts were inspected. The results of the survey found that 54% of last launch lakes were listed as AIS infested; some lakes containing multiple AIS. We removed small amounts of vegetation from boats, but no Zebra Mussels or other potential AIS were visible. The procurement and disposal of bait was an issue as fishers bring bait from home, or purchase live bait en route to a lake. Most fishers disposed of bait on land; however 8% gave bait to other fishers, and 7% disposed of bait directly into the lake.

3. Water Quality Monitoring in National Park Units of the Upper Great Lakes Region

Joan Elias National Park Service – Great Lakes Inventory and Monitoring Network 2800 Lake Shore Drive East, Ashland, WI 54806, 715-682-0631 x24, joan_elias@nps.gov

The Great Lakes Inventory and Monitoring Network (GLKN) is one of 32 National Park Service monitoring networks throughout the United States which include over 270 national park units. The GLKN consists of 9 park units, including Voyageurs National Park. The inland lake resources of GLKN parks are astounding, numbering in the thousands. Lakes larger than one hectare number in the hundreds, with nearly 300 occurring in Voyageurs National Park alone.

GLKN began monitoring water quality of inland lakes in 2005. Our sampling design consists of annual monitoring at 33 index lakes across 6 park units, with additional lakes sampled on a longer rotation as funding permits. Within each park, the index lakes were selected to span gradients of lake type as determined by ordinations of past water quality data, geographical location within each park, visitor use, lake basin morphometry, and watershed size. Particular management interest by the parks was also a selective factor. Across the Network, the lakes span a wide range of chemical and physical characteristics, as well as ease of access for monitoring.

Sampling is conducted three times annually during the open water season. Parameters measured include the core suite (profiles of temperature, pH, conductivity, and dissolved oxygen), water clarity, water level, chlorophyll-a, dissolved organic carbon, alkalinity, major anions and cations, and nutrients. In addition, because diatoms are powerful bio-indicators of environmental conditions in aquatic systems, we collected surface sediments from each lake, and will continue to do so approximately every 5 years for analysis of diatom communities. Our water quality monitoring program follows strict quality assurance/quality control procedures including calibration acceptance criteria, sonde stabilization criteria, check of instrument bias, alternative measurement sensitivity, field and lab duplicates, and equipment blanks.

A summary of the first 3 years of sampling are presented, with an emphasis on the inland lakes at Voyageurs National Park.

4. A Multidisciplinary Approach to Monitoring Ecological Effects of Lake Level Management on Voyageurs National Park

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Water levels and flow regimes of the international waters of Rainy Lake (92,000 ha) and the Namakan Reservoir (26,000 ha) on the Minnesota-Ontario border have been controlled by several private dams since the early 1900s. Voyageurs National Park, MN, contains more than 27% of these water bodies. In response to documented ecosystem degradation, rules governing water level management were changed by the International Joint Commission (IJC) in 2000 to mimic a more natural hydrologic regime, particularly by reducing the winter drawdown in the Namakan Reservoir. The IJC charged affected natural resource management agencies with the duty of monitoring whether the new hydrologic regime is beneficial to the ecosystem. A joint U.S. and Canadian coordinating committee was established to oversee development and implementation of a long-term, multidisciplinary monitoring plan that would accurately and reliably measure performance indicators. Voyageurs National Park and cooperators conducted monitoring programs for indicators including: aquatic vegetation communities, furbearer habitat and behavior, common loon nesting success, benthic invertebrate communities, harvested fish populations, mercury concentrations in game fish, chlorophyll-a and water chemistry, and diatom communities. Data analyses are ongoing for many of the individual response variables. Preliminary results indicate that mercury concentrations in young-of-the-year yellow perch are highly correlated with water level fluctuation in these reservoirs. Although preliminary results show that some of the predicted biological changes appear to have occurred in the Namakan Reservoir, changes also appear to have occurred in unregulated Lac la Croix and in Rainy Lake where hydrologic alteration was minimal. Other influences, including climate change, may increase the difficulty of identifying changes related to the altered hydrologic regime. A USGS/NPS analytical modeling project will be undertaken in 2008 using these monitoring data to assess the effects of the modified hydrologic regime on the aquatic ecosystem in a more holistic fashion.

5. Bostic Watershed Investigation and Restoration Activities Lake of the Woods County, MN

Lake of the Woods Soil & Water Conservation District Natural Resources Conservation Service

The Lake of the Woods Soil and Water Conservation District (SWCD) and the Natural Resources Conservation Service (NRCS) have partnered together with other federal, state and local agencies to address erosion and sedimentation problems in the Bostic Watershed. The Bostic Watershed has long been a priority watershed in Lake of the Woods County and has management strategies outlined in the "Lake of the Woods County Comprehensive Local Water Management Plan" (2003) and the "Rainy River Basin Plan" (2004).

Currently, the SWCD is collaborating with engineers, local governments, and land owners in developing strategies to minimize the extensive erosion. The NRCS has been very successful in protecting the watershed by utilizing Field Borders, Buffer Strips, and the Riparian Buffers. These practices help to minimize field runoff, and reestablish a riparian corridor along the Bostic Creek while excluding livestock from the banks. The goal is for this watershed is to minimize the erosion within the system and reduce the sedimentation that occurs within downstream bay.

6. Tracking historical water quality changes using diatoms in Bigstone Bay, Lake of the Woods, Ontario: a paleolimnological assessment

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There is much interest in determining whether or not water quality in the Lake of the Woods has deteriorated in the recent past as there is a purported increase in the frequency and intensity of cyanobacterial algal blooms in the northern portion of the lake. An important requirement to address key lake management questions is to establish the 'natural' or baseline condition for this complex aquatic system. For example, is the lake water quality substantially different today than it was in the past? If so, when did these changes occur? How much has the environment changed? What is the nature of these changes? Answers to these questions can give important insights into some of the possible mechanisms underlying these changes. Dated sediment cores retrieved from various locations in the northern part of the lake enabled us to make comparisons between sites that are currently elevated in total phosphorus (TP) and experience cyanobacterial algal blooms (impact sites) and a site that is currently low in nutrients and does not experience algal blooms (reference site). Here we present diatom trends from Bigstone Bay (impact site), located in a quiet, deep bay southeast of the city of Kenora. Shifts in diatom assemblage composition were used to interpret the effects of historical changes around the lake including increases in water levels with the installation of dams at the turn of the 20th century. Additionally, a diatom-based inference model was applied downcore to determine whether TP concentrations have changed substantially over the recent past. Possible triggers to these diatom changes were examined including relationships to instrumental temperature and historical lake-ice records. Lake sediment chlorophyll a concentrations from each core was used as an estimate of historical trends in lacustrine primary production. The trends from Bigstone Bay will be compared to the timing and nature of diatom changes previously reported from PP-1 (an impact site NE of Thompson Island) and Whitefish Bay (a reference site). Dramatic changes in the diatom assemblages from these three sites over the past few decades are consistent with recent climatic warming and coeval with the two warmest decades on record (1980s and 1990s).

7. Spiny Water Flea Monitoring Results

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In July 2007, nine lakes were evaluated in Fort Frances District, Ontario for the presence of spiny water flea (*Bythotrephes longimanus*). Sampling consisted of vertical or horizontal plankton tows conducted at three locations at each lake. Six of the lakes selected were upstream, and proximal, to the recently (2006) infested waters of Rainy Lake. Spiny water flea (SWF) was not detected in the following lakes: Lake Despair; Burditt; Big Sawbill; Cuttle; Little Turtle; and Bad Vermilion, suggesting that upstream movement as a result of accidental transport had not occurred into these systems. A strong downstream movement of SWF was detected within Rainy River in the spring of 2007. Shortly following this assessment the lower basin of Lake of the Woods were declared infested. In additional to the above assessments, three lakes within Quetico Provincial Park were sampled for the presence of SWF; Sydney, Kenny and Kawnipi lakes. These lakes were located downstream of Saganagons Lake which was documented in 2003 as an infested waterbody. Downstream movement was detected from this system into Sydney Lake in 2007. There is further risk and likelihood that SWF will continue to move downstream in this aquatic system. In summary, based on reports and information to date, SWF are currently (summer 2007) present in Saganagons Lake, Sydney Lake, Rainy Lake, Rainy River and lower basin of Lake of the Woods.

8. Distribution and habitat association of three crayfish species including Orconectes rusticus in Lake of the Woods, Ontario

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The goal of our study was to determine the distribution and relative abundance of two alien species of crayfish, the rusty crayfish (*Orconectes rusticus*) and papershell crayfish (*O. immunis*), and their native cogener, the virile crayfish (*O. virilis*). We also studied the influence of important habitat variables (substrate type, macrophyte presence and water depth) on their distribution in Lake of the Woods. We focused on potential invasion fronts of *O. rusticus* located within a 38 km^2 area 15 km SW of Kenora in Ptarmigan and Clearwater bays. Sampling by the Fisheries Assessment Unit of the Ontario Ministry of Natural Resources occurred during 10 weeks from June - September, 2006 when crayfish activity was most stable at surface water temperatures >20^{o}C. Each trapline, consisting of six baited minnow traps modified for crayfish collection, was set for about 24 hours, yielding a total of 2256 trap days of effort along 65 km of island and mainland shore.

A total of 9,827 crayfish were caught at 374 of 376 sites. The native crayfish (*O. virilis*) was the most common species, and present at all but 14 sites, representing 68.3% of the catch. The two alien species, *O. rusticus* and *O. immunis*, were 22.9% and 8.8%, respectively of the total catch. Current invasion fronts of *O. rusticus* were identified at the NW corner of Corkscrew Island and at the entrance to Ash Bay, 5-8 km west from Spruce Pt. where rusty crayfish were last caught in 2004 during fisheries assessment surveys. An approximate calculation indicates that *O. rusticus* has expanded its distribution by an average of 1.9 km per year (range 0.8-4.0 km), which is very rapid, and exceeds known movement rates in other lakes. Incidental crayfish catches during fish surveys show that *O. rusticus* had spread into most parts of the lake by 2006 with the possible exception of the southwest since its first record from Long Bay on the east side of LOW in 1963 Papershell crayfish, which had previously been reported in Whitefish Bay only, were found to be more widely distributed in the study area than rusty crayfish. Both virile and papershell crayfish were more common at sites outside of the rusty crayfish invasion front than within.

Highest catches of the virile and rusty crayfish were observed on hard, rocky substrates while papershell crayfish catches were highest on softer substrates containing both organic and inorganic fines. In the presence of macrophyte stands, mean catches were lower for rusty crayfish, higher for papershell crayfish and remained the same for virile crayfish. Water depth significantly affected the abundance of all three crayfish species. The virile crayfish favoured deeper water whereas the papershell crayfish preferred shallower depths than the other species. Neither water depth nor distance from mainland prevented *O. rusticus* from colonizing islands and using them as invasions pathways. Moreover, islands

surrounded by shallow (i.e., less than thermocline depth) water may serve as shortcuts for the expansion of primarily *O. rusticus* along convoluted shorelines.

The occurrence of *O. immunis* in the 2006 study area, 46 km distant from its last known location in the lake, emphasizes the potential for vectors outside of natural dispersal, such as anglers who use live bait, to rapidly expand the distribution of invasive species throughout this watershed. Our study provides evidence that rusty crayfish are displacing both papershell and the native crayfish within the Ptarmigan Bay invasion front. The rusty crayfish, of the two invasive species studied, has the greater potential for impacts on Lake of the Woods and adjacent watersheds.

9. Seasonal runoff patterns in forested headwater catchments in northwestern Ontario: expectations for changes to flow patterns to receiving waters after forest harvesting

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Headwater streams typically drain 70-80% of the area of a given catchment or watershed; therefore in the case of the Lake of the Woods catchment, headwater streams may drain an area of more than 56,000 km^2. Headwater watersheds also support the majority of forest cover in northwestern Ontario and thus the majority of forestry operations. Forest and soil conditions in these small watersheds are tightly linked to stream flow and water quality. Therefore forest removal, whether natural (insect outbreaks, wildfire) or human caused (forest harvest), in the Lake of the Woods catchment has a high potential to influence the water entering the lake.

Since 2004, the Forest Watershed and Riparian Disturbance (FORWARD) Project has collected an extensive database on headwater stream flow and water quality from northwestern Ontario to help direct industrial forest planning in this area. A major component of FORWARD is the experimental harvest of three headwater stream watersheds, with an additional two watersheds left undisturbed as reference sites. We present three years (2004-2006) of pre-treatment streamflow data from the five watersheds.

On average, 40% of the total annual streamflow in these watersheds occurred during snowmelt in April. Total annual precipitation (and therefore streamflow) varied, with 2005 being relatively wet, 2006 being relatively dry, and 2004 being intermediate. Differences in precipitation among years may help explain why a trend existed for increasing streamflow with increasing wetland cover in 2004 and 2006, but not 2005. In drier years, wetlands appear to play a role in moderating runoff through the watershed to the stream channel. Relationships that existed between in-stream phosphorus concentration and stream flow were negative for Boreal Shield streams, suggesting that typically thin Boreal Shield soils become rapidly depleted of phosphorus during peak flow events.

After experimental harvesting, we expect dramatic short-term (1-2 year) increases in peak flows and in-stream phosphorus, followed by a rapid return to baseline concentrations as soil reserves of phosphorus are depleted, and as vegetation cover regenerates. In addition, harvesting will enhance snowpack sublimation, cause earlier snowmelt in cleared areas and reduce meltwater/soil interaction. Future data collection will place more emphasis on parameters related to snowpack.