Proceedings of the Forum held

March 11 - 12, 2009

Rainy River Community College

International Falls, Minnesota, USA

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Forum Sponsors – 2009

The organizing committee would like to thank our 2009 sponsors for contributing to the 6th Annual International Lake of the Woods 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 Participant Organizations

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United States Geologic Survey
Voyageurs National Park

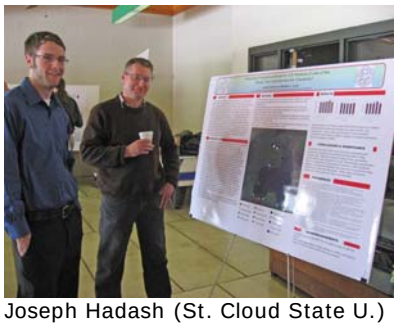
Overview of Forum

The sixth annual Lake of the Woods Water Quality Forum was held at the Rainy River Community College on March 11-12, 2009. Eighty-one scientists, researchers, academics, educators and other resource stakeholders from both Canada and the U.S. attended this year despite the blizzard that hit the region. The workshops and presentations provided a forum to present and discuss information and recent research findings that are relevant to Lake of the Woods and its watershed. In these proceedings we present a set of technical abstracts that summarize the findings of each presenter for both the presentations and the posters.

Despite the blizzard of 2009, 81 participants made the Forum a success again this year

Morning workshops provided a venue for technical transfer between workshop participants. Working group sessions focused on Aquatic Invasive Species and Monitoring Coordination on Lake of the Woods. The key points generated by these working groups are provided in the "Working Groups" section of these proceedings.

The symposium consisted of 17 presentations and 9 posters which covered a diverse range of topics, many of which were additional findings from projects that were introduced at previous Forums. Symposium presentation on March 11, consisted of two back-to-back sessions that featured presentations on the topics of Nutrients and Algae and Hydro-management in Lake of the Woods basin. The breaks and afternoon poster session provided an important time for attendees to intermingle and discuss various aspects of their involvement with Lake of the Woods.

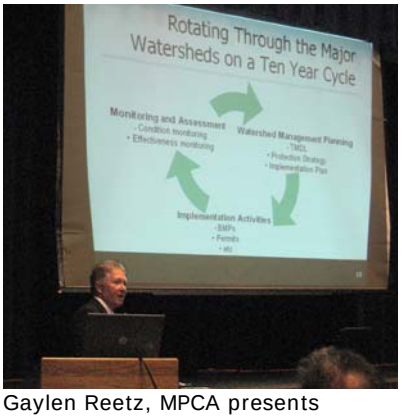


Joseph Hadash (St. Cloud State U.) and Tom Mosindy (Ontario Ministry of Natural Resources) discuss preliminary results of Joseph's research into developing a nutrient budget and water quality model for the US portion of Lake of the Woods

At the Foundation Reception at the Holiday Inn on the evening of the day one, Bev Clark of AECOM was presented with the Kallemeyn Award for his outstanding contributions to advancing science and stewardship in the Lake of the Woods basin. The Assistant Deputy Minister of Manitoba Water Stewardship, Dwight Williamson, provided the guest lecture on Manitoba's support for Lake of the Woods.

Bev Clark receives the Larry Kallemeyn Award, presented by the Foundation and the organizing committee of the Forum. Pictued (l-r) Joan Richardson (Foundation), Bev Clark (AECOM), Todd Sellers (Foundation)

On the morning of second day, two keynote speakers addressed the emerging issue of International Coordination between the U.S. and Canada. The speakers were Gaylen Reetz, Director of Pollution Control at the Minnesota Pollution Control Agency, and Franca Dignem, Director of the Ontario Ministry of the Environment's Northern Region.



Gaylen Reetz, MPCA presents overview of his agencies plans to monitor and assess waters in Minnesota

The Lake of the Woods Water Quality Forum has been instrumental in moving critical science forward as it pertains to Lake of the Woods and its watershed. The Forum provides a unique opportunity to share scientific findings on an internationally-shared resource. The ongoing success of the Forum would not be possible without the contribution of a number of skilled and insightful people who continue to donate both time and effort. Thanks to all.

Schedule of Events

Day One – March 11

8:00 am – 1:00 pm Registration Open / 8:00 am – Continental Breakfast		
	WORKING GROUPS – CONCURRENT SESSIONS	
9:00	**Aquatic Invasive Species**	**Monitoring Coordination**
10:30	Break	
10:45	**Aquatic Invasive Species - Continued**	**Monitoring Coordination - Continued**
12:00	Lunch	
	SYMPOSIUM SESSIONS	
1:00	**Welcome and Introduction To Symposium**	
1:30 – 3:00	**Session 1 – Nutrients & Algae**	
• **A preliminary total phosphorus budget for the Lake of the Woods.** Kathryn Hargan[1], Peter Dillon[1], and Andrew Paterson[2]. [1]Trent University, Department of Chemistry; [2]Dorset Environmental Science Centre, Ontario Ministry of the Environment		
• **Whole-ecosystem research at the Experimental Lakes Area: Applications to the Lake of the Woods.** Michael Paterson, D.L. Findlay, P. Blanchfield, Fisheries & Oceans Canada		
• **Environment Canada Lake of the Woods Water Quality and Harmful Algal Blooms Assessment Initiative: Year I.** Sue Watson, Jay Guo, Paul Klawunn, Tim Pascoe, John Struger & Ram Yerubandi, Environment Canada		
• **Lake Sturgeon Population Characteristics, Movements, and Habitat Use in the Namakan Reservoir: Preliminary Results.** Steve Windels[1], Stephanie Shaw[2], Steve Chipps[2], David Willis[2], Darryl McLeod[3]. [1]Voyageurs National Park; [2]USGS; [3]OMNR		
3:00 – 3:30	**Break & Poster Session**	
3:30 – 5:00	**Session 2 –Hydromanagement**	
• **Reduced winter drawdown and earlier spring refill corresponds with improved macroinvertebrate community structure in Namakan Reservoir.** Daniel C. McEwen[1] and Malcolm G. Butler[2]. [1]Minnesota State U. Moorhead, [2]North Dakota State U.		
• **Monitoring the ecological effects of lake level management on Voyageurs National Park using beavers (*Castor canadensis*).** Steve Windels, National Park Service, Voyageurs National Park		
• **Interactive effects of hydromanagement, land use and climate on water quality of border lakes in Voyageurs National Park and vicinity**. Claire Serieyssol[1], Mark Edlund [2],Larry Kallemeyn[3], and Joy Ramstack[2]. [1]University of Minnesota; [2]St. Croix Watershed Research Station of the Science Museum of Minnesota; [3]USGS, CERC-International Falls Biological Station		
• **Assessing the implications of multiple stressors and recent diatom shifts in the Lake of the Woods, Ontario, Canada.** K.M. Rühland[1], A.M. Paterson[2], K. Hargan[3], A. Jenkin[1], N. Michelutti[1], B.J. Clark[4], and J.P. Smol. [1]Queen's University; [2]Ontario Ministry of the Environment; [3]Trent University; [4]Gartner Lee Ltd.		
6:00	**FOUNDATION RECEPTION (Holiday Inn)** **Presentation of 2009 Kallemeyn Award**	

Day Two – March 12

7:30	**Registration & Continental Breakfast**
8:30 – 10:00	**Session 3 - Emerging Issues – International Coordination**
•	**International Coordination** Gaylen Reetz, Director Pollution Control, Minnesota Pollution Control Agency
•	**International Coordination** Franca Dignem, Director Northern Region, Ontario Ministry of Environment
10:00 – 10:30	**Break**
10:30 – 12:00	**Session 4**
•	**Report from Working Groups** (Aquatic Invasive Species; Monitoring Coordination)
•	**Kallemeyn Award Recipient Guest Lecture** Bev Clark, AECOM
•	**Reducing nutrient loading to Lake Winnipeg and its watershed: Our collective responsibility and commitment to action.** William (Bill) Barlow and Sharon Gurney, Lake Winnipeg Stewardship Board
•	**On the edge: Developing a frame of reference to explore the potential importance of the littoral zone in Lake of the Woods.** Michael A. Turner[1], Kelly A. Hille[1], Thomas Mosindy[2] and Helen M. Baulch[3]. [1]Experimental Lakes Area, Environmental Sciences Division, Fisheries and Oceans Canada; [2]Lake of the Woods Fisheries Assessment Unit, Ontario Ministry of Natural Resources; [3]Department of Environmental and Resource Studies, Trent University.
12:00 – 1:45	**Lunch, Poster Session & Video of "Rainy River Restoration"**
1:45 – 3:05	**Session 5**
•	**Minnesota Waters: Empowering citizen involvement in water quality issues.** Courtney Kowalczak, Minnesota Waters
•	**The Application of CABIN Biomonitoring in Lake of the Woods.** T. Pascoe, J. Struger and R. Kent, Environment Canada
•	**Aquatic invaders in Lake of the Woods Basin and others on the way.** Darrin Hoverson, MN DNR, Itasca State Park.
•	**Aquatic Invasive Species Watercraft Inspection Program in NW Ontario, Canada. Laurie Wesson' Fisheries and Oceans Canada.** Laurie Wesson[1], Alyson Rob[2], Vern Pham[3], Moriah Rogoza[4] and Kevin Empey[5]. [1]Fisheries and Oceans Canada; [2]Ontario Ministry of Natural Resources; [3]Alberta, Canada; [4]Red River College; [5]University of Manitoba
3:05 – 3:30	**Closing Remarks**

Reports From The Working Groups

The working groups serve to:

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

This section summarizes the key findings of the 2009 Working Groups on Aquatic Invasive Species and Monitoring Coordination.

Aquatic Invasive Species (AIS)

The Aquatic Invasive Species (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 March 11, 2009, with approximately ten people in attendance at Rainy River Community College, International Falls, MN. Dr. Hann was unable to attend due to the great March blizzard of 2009, so Ryan Maki, Voyageurs National Park, International Falls, MN, coordinated the working group and summarized the group discussion.

This year, the Aquatic Invasive Species Group tackled the same agenda as last year since there was not enough time to discuss all of the agenda topics during the 2008 session:

1. Review ongoing monitoring and research initiatives in an informal setting. The participants took turns describing ongoing monitoring and research initiatives.
2. 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 some participants providing brief updates to the group regarding status of ongoing research and monitoring projects throughout the basin. A summary is presented below:

Status Updates

Darrin Hoverson, Minnesota Department of Natural Resources (MN DNR) – Park Rapids, and Nick Schlesser, MN DNR – International Falls, summarized the efforts of MN DNR. The MN DNR Fisheries Division has been active in monitoring for spiny water flea, rusty crayfish, rainbow smelt, and the exotic fish disease, viral hemorrhagic septicemia (VHS). In general the fisheries group keeps an eye out for exotics while conducting fisheries activities, and they specifically sample a set number of fish each spring from high risk and high priority lakes and rivers for VHS testing. In addition to this work, the MN DNR has dedicated staff working on exotic species monitoring, treatment, and on educating the public. Ecological Services staff monitor for many exotics, including purple loosestrife and exotic snails and mussels in addition to the exotics mentioned above.

Tom Mosindy, Ontario Ministry of Natural Resources (OMNR) – Kenora, summarized OMNR efforts regarding exotic species in Lake of the Woods. Tom's group monitors rainbow smelt and multiple species of invasive crayfish, including rusty crayfish. He has also been collecting zooplankton tows at existing water quality monitoring sites as part of a partnership with Brenda Hann, University of Manitoba, to

monitor spiny water flea and the effects of its invasion on the zooplankton community of Lake of the Woods.

Alyson Rob and Melissa Mosley, OMNR – Fort Frances, summarized OMNR spiny water flea monitoring efforts in the Fort Frances District. Alyson's group monitored for spiny water flea in six lakes near the infested Rainy Lake in 2007-2008 and did not detect any new invasions. Alyson did mention recent spiny water flea detections by OMNR in Pickerel Lake on the North end of Quetico Provincial Park and by MN DNR in Loon Lake upstream of the Namakan Reservoir and Rainy Lake. A stewardship program may be forthcoming in which citizen monitoring would be conducted using kits and recommendations provided by the Ontario Federation of Anglers and Hunters.

Ryan Maki and Cam Trembath, Voyageurs National Park – Park staff monitor zooplankton monthly on Rainy, Kabetogama, Namakan, Sand Point, Crane, and Little Vermilion Lakes, all of which are infested with spiny water flea. A research project is underway to test the effects of the spiny water flea invasion on the zooplankton communities of several of these lakes. Larry Kallemeyn, USGS – retired, had the foresight to collect pre–invasion zooplankton community samples on these lakes from 2001-2003, so we will have a fairly comprehensive dataset for this study. Another component of this project is to study yellow perch - both to test for effects of the invasion on growth rate and to assess how intensively these perch are consuming spiny water fleas. Park staff and a team from Michigan Tech University will also sample to look for new infestations on smaller lakes within the Park. Sampling conducted during the summer of 2008 confirmed the rusty crayfish invasion of Sand Point Lake and established the northern extent of the invasion in that lake. Researchers cooperating with the Park have investigated the extent of various exotic plants in Park lakes and wetlands. Park staff, along with USGS staff, have used genetics to investigate the prevalence of exotic cattails and hybrids between exotic and native cattail species in Park wetlands and lakes.

Discussion: Design a Spiny Water Flea Monitoring Program for the Lake of the Woods Basin

- Elements: Zooplankton tows should be used to detect the impact of the invasion on zooplankton community; zooplankton tows and grab samples of lake bottom sediments should be used for detection of new invasions in frequently used (boat access, fishing pressure, etc.) bodies of water
- Temporal scale: To study the effects of the invasion, zooplankton tows should be taken at least three times per open water season (monthly tows preferred); for detection sampling, tows should be collected in late summer or early fall when spiny water flea density peaks in lakes of this region - sediment grabs can be collected any time of year since the spines of the dead spiny water fleas build up in the upper layers of the sediments and remain intact, offering an easy method of detection using Ekman or Ponar grab samplers, a sieve to separate spines from sediments, and a microscope to confirm identification of spiny water flea spines.
- Spatial scale: Monitoring of the Canadian side of Lake of the Woods should focus on the seven sectors that are currently sampled for water quality. Zooplankton tows should be taken at the deep hole in each of these basins in conjunction with the water quality sampling that is done at these sites (Tom Mosindy has been collecting these zooplankton samples). Similarly, zooplankton tows should be taken in conjunction with water quality monitoring at existing sites on the United States side of the lake.
- Other parameters to monitor in conjunction with zooplankton tows: Temperature, dissolved oxygen, pH, specific conductivity, transparency, silica, nutrients, and chlorophyll

Moving Beyond AIS Monitoring: Logical Next Steps for Research and Management

Research Questions:

- Does spiny water flea infestation affect fish growth in lakes of this region (especially game fish)?
- What waters are most at risk of invasion by various exotic species?
- What aquatic ecosystems are most at risk of impacts due to invasion by various exotic species?

- What are the effects of rusty crayfish invasions on the aquatic ecosystems of this region?
- Management Actions:
- Produce one list of practices for people to follow to prevent the spread of aquatic invasive species and diseases. Each component (or practice) on this list needs to be stringent enough to prevent the spread of the invasive species or disease that is most tolerant to that stress (for example, if one invasive species is killed by a 24 hour drying time but another survives for nearly five days of drying time, the recommended practice needs to be a five day drying time).
- Invest heavily in education and outreach – successfully preventing the spread of exotic species hinges on the compliance of lake users
- Provide watercraft wash stations at boat access points

Monitoring Coordination

Short presentations by Stakeholders/Partners

MPCA – Nolan Baratono

- Proposed work for 2009 (Best Case Scenario - requested money for these phases but funding may not be available this year)
    - Nutrient sediment loading study phase 1 – fill-in gaps that were identified
        - Focus on Rainy R. and tributaries
        - Challenges: expensive and often chasing storms
        - Contract with the USGS to do this
    - In-lake nutrient study Phase I
        - Focus on nutrient transfer out of L. Traverse
        - In-lake nutrients and/or nutrient transfer out of L. Traverse – needed for the modeling studies
        - contract with USGS
    - Big Traverse Outlet Hydrology Study Phase 1
        - USGS measures outflow – negative and positive results for outflow – next day it can reverse = net positive outflow – wind a big factor
        - Projected as a 3-5 year study to get the flow rating – needs a lot of monitoring to do this
        - Flow in wetlands was significant
    - Internal Loading data collection study
        - Sample sediment – what is happening with internal loading
        - More funding required for next year
        - Targeted areas include Big Traverse, Buffalo Bay
    - Ongoing efforts
        - Modeling flux and running Bathtub model
        - it is what we need for the TMDL – 1st step recommended by EPA for TMDL
        - nutrient load monitoring (LF, BF and Rapids)
    - Next Best Case
        - Nutrient and sediment loading data collection for Matt Julius (St. Cloud State University) to model
        - In-lake nutrient data collection
        - Modeling (Flux and Bathtub)
        - Load Monitoring (LF, BF and Rapid)

MPCA – Jesse Anderson

- MPCA Monitoring Activities in the Rainy River Basin
- Impaired Waters Monitoring
- Little Fork River - Intensive Biological Monitoring (http://www.pca.state.mn.us/water/biomonitoring/index.html)
- Sediment Load Monitoring – Little Fork and Big Fork Rivers
- Lakes assessment – 13 lakes in the Ely area; Jessie Lake (as part of Impaired Waters study – most phosphorus coming from internal loading)
- Bathymetric monitoring survey
- Little Fork River Watershed USGS
    - 58 stations sampled for biology (random selection)
    - Generating Index of Biotic Integrity
    - Based on the aquatic life rather than on water chemistry alone
    - 2010 – Big Fork River will be sampled
    - Intensive water quality monitoring being done including temperature loggers
- Major watershed load monitoring network
    - 85 major watersheds in Minnesota
    - Little Fork and Big Fork watersheds in 2008 and ramping up in 2009
    - 30 samples annually at USGS
    - Estimate annual sediment and nutrient budgets to Rainy River and run models – phosphorus and sediment loads
    - Not sampling at Baudette in Rainy River as it is significantly influenced by LOW
    - Phosphorus bound to sediment along Rainy River – 30 to 50 thousand tons per year
- 2009 Monitoring activities
    - Major watershed loading sites include Big Fork, Little Fork, Kawishiwi and Vermillion Rivers (Rainy River at Manitou and Rapid Rivers)
    - Using high resolution photos to pinpoint areas for restoration (one foot contour photos)

OMOE - Jim Sutton (Thunder Bay office)

- Beginning tributary monitoring program in 2009
    - Will include monitoring of three tributaries to the Rainy River on the Canadian side of the border
    - Will also include monitoring of six tributaries to LOW in Ontario
    - Monitoring proposed as open water season only – regular temporal sampling proposed – storm event monitoring not proposed at this time
    - Estimated 18 sampling trips
    - Some historical flow data available from water survey of Canada for some tribs – other flows will have to be modeled or assessed it spot measurements

Lake of the Woods Soil and Water Conservation District – Mike Hirst

- Monitoring – working with private landowners and volunteers on the US side of border

- Two small watersheds (Baudette and Zippel) found to be low for dissolved oxygen = impaired listing
- Also monitored storm water sites
- 9 sites monitored on Zippel Bay – issues include sediment – higher % agriculture
- Baudette watershed and Winter Road river watershed – River Watch monitoring program with LOW high school was initiated – measuring YSI parameters, including TP, Chl a and TSS
- Future – continue with monitoring and River Watch program
- Entire LOW county will be imaged using LIDAR – information should be widely available

Environment Canada – Tim Pascoe

- Monitoring program on Lake of the Woods – 5 year program to include: assessing existing hydrologic and water quality/nutrient databases; improved characterization of hydrologic loading and physical limnology; improve estimate of nutrient loading and budget; improve characterization of biological communities and productivity
    - 2008 – visited lake in June, examined lab facilities, explored possibilities for establishing permanent boat on site
    - July-Sept, 2008 – set up lab equipment and established 5 stations
    - Sampled 22 stations in September
    - 3 automated rain gauges Buffalo Point, Sioux narrows and Kenora
    - Ongoing monitoring includes:
        - 14 stations – boxcore sediments for benthic sampling
        - Will establish biological stations over 5 years to get 10 benthic sampling zones to characterize the major water body
    - Bathymetry – only available in paper-form and will be converted into digital
    - Moorings proposed to go in to measure sedimentation
    - Enhanced work monitoring algal blooms
    - Establish tributary monitoring

OMOE / OMNR – Andrew Paterson and Tom Mosindy

- MNR's LOW Fisheries Assessment Unit will monitor Sectors 1 and 2 (north and central) for next two years
- Focus for MNR is Fish Community Index Netting to assess current status of fish community in these Sectors; includes some spawning population assessments
- 11 water quality monitoring sites are also sampled monthly (plus an additional site at the outflow)
- Includes standard chemical suite analysed at Dorset lab, temp and DO, Secchi

Queen's University – Kathleen Rühland and John Smol

- New gravity cores collected from Clearwater Bay, White Partridge Bay and Poplar Bay
- New collaboration with Jim Teller (University of Manitoba) to examine the Holocene history of the Lake of the Woods
- Funded through Ontario's Best In Science program
- Queen's paleo work now on Lake of the Woods is summarized at website: http://biology.queensu.ca/low/

AlgalTox International – Brian Kotak

- Monitoring of microcystins – Pine Falls, Manitoba
- In 2006 – collected sampled for analysis in northern part of Lake of the Woods – Clearwater Bay
- Most collections since have been from the southern part of the basin
- Found concentrations as high as 500 – 600 micrograms/L for some samples; worked with Ontario Lake Partner Volunteers to collect samples
- Drinking water perspective – what comes out of the taps?
- New funding in place for 2009 – partnership with Environment Canada

General Discussion

Tributary monitoring: as new programs are developed is there a minimum sampling strategy that should be applied?

- Weekly sampling is suggested as a minimum with more sampling during the shoulder seasons, if possible
- MPCA perspective – chasing storms is hard work and you have to know the watershed, BUT if you want to get accurate loads/quantify sediment loads from a watershed you need to chase storms. It could work out to 20-30 events per year – MPCA sampled as frequently as every other day in April during snowmelt
- It may take a few years to understand the watershed – modifications can be made
- Essential to focus on April and part of May; 60-80% of total water load comes in April-June

Lake backwater effects: How far upstream do you need to be sample to avoid a lake effect?

- Flow information needs to be accurate or it's not worth the effort; backwater can be significant in south end of Lake of the Woods

Atmospheric nutrient loads: How can we best characterize the atmospheric nutrient load? Do we need to add stations?

- Environment Canada has three precipitation stations – Kenora, Sioux Narrows, and Buffalo Point
- In N. Minnesota there is a site near Ely that has been in long-time operation
- We should look at the data from the existing sites and see if there is any overlap; we may be able to remove one of the sites and place it somewhere else in the future

Symposium Presentations - Technical Abstracts

A preliminary total phosphorus budget for the Lake of the Woods

Kathryn Hargan[1], Peter Dillon[1], and Andrew Paterson[2]

[1]Trent University, Department of Chemistry, Peterborough, Ontario, K9J 7B8 (email: kathrynhargan@trentu.ca) 705-748-1011 ext. 7781; [2]Dorset Environmental Science Centre, Ontario Ministry of the Environment, 1026 Bellwood Acres Road, Dorset, Ontario, P0A 1E0

Abstract:

Lake of the Woods (LoW) is a large (385,000 ha), freshwater lake, that is located within the boundaries of the provinces of Ontario and Manitoba and the state of Minnesota. With the presence of toxin-producing cyanobacteria, and seasonally-elevated nutrient concentrations, there are increasing concerns that LoW water quality has deteriorated in recent years. In addition to local concerns in the three jurisdictions, the issue of LoW water quality has wider significance downstream. Nutrient loading to Lake Winnipeg via the Winnipeg River watershed is the second largest source of nutrients to Lake Winnipeg (after the Red River), with more than half of the Winnipeg River flow originating from LoW. Shoal Lake, also closely connected to LoW, is the main source of drinking water to the City of Winnipeg. Thus, a clear understanding of the relative sources of nutrients that are influencing LoW water quality is needed to provide sound management objectives for LoW basin, and also to improve our understanding of the LoW's linkage with Lake Winnipeg and Shoal Lake. A comprehensive review of both the natural and anthropogenic sources of phosphorus to LoW has been compiled using existing hydrology and nutrient data collected by various agencies. Due to the lack of some key monitoring data, particularly for tributaries in the LoW basin, the total phosphorus (TP) load to LoW from the surrounding catchment is estimated from published TP export coefficients. Mass balance measurements have been utilized to evaluate our estimates of TP loading to the lake. A predicted [TP] lower than observed whole-lake [TP] indicates that one or more sources of P may be underestimated or unaccounted for. For example, P resuspension in the turbid southern bay may be contributing to a higher whole lake [TP]. Additionally, it is suggested that TP load from the ungauged LoW basin should be more closely examined through field monitoring and modeling.

Whole-ecosystem research at the Experimental Lakes Area: Applications to the Lake of the Woods

Michael Paterson, D.L. Findlay, P. Blanchfield.

Fisheries & Oceans Canada. Freshwater Institute, 501 University Cres. Winnipeg, MB Canada R3T 2N6. 204-984-4508. michael.paterson@dfo-mpo.gc.ca

Abstract:

For 40 years, scientists have been conducting whole-ecosystem experiments and monitoring at the Experimental Lakes Area (ELA), near Kenora in northwestern Ontario. Because of its close proximity, research from ELA is relevant to the development of water management strategies for the Lake of the Woods and the facility can be used as a platform to explore future mitigation options. Results from two ongoing studies will be presented as examples: the Mercury Experiment To Assess Atmospheric Loading In Canada and the United States (METAALICUS) and the Lake 227 eutrophication experiment. The METAALICUS study is examining the potential effectiveness of proposed legislation to reduce mercury emissions to the atmosphere on methylmercury concentrations in fish. This question is being addressed by adding stable isotopes of mercury to a small lake and its surrounding watershed. The L227 eutrophication experiment is now entering its 41st year and has been used to better understand the effectiveness of controlling different nutrients (especially nitrogen and phosphorus) for limiting cyanobacterial blooms.

Environment Canada Lake of the Woods Water Quality and Harmful Algal Blooms Assessment Initiative: Year I

Sue Watson, Jay Guo, Paul Klawunn, Tim Pascoe, John Struger & Ram Yerubandi
Environment Canada

Abstract:

Lake of the Woods (LOW) is a large complex international waterbody spanning Minnesota, Manitoba, and Ontario and an important component of the Lake Winnipeg drainage basin. Similar to Lake Winnipeg, LOW has recently developed signs of severe deterioration in water quality and ecosystem integrity, with growing concern with potentially toxic blooms of cyanobacteria, widely perceived to be increasing in frequency and distribution. Such blooms are usually driven by high nutrient levels; however despite a large database collected by US-Canadian partners, the sources, bioavailability and transport/sequesterment of nutrients in LOW are not well defined. The Lake in fact consists of two major sectors with significant differences in physical, chemical and biological characteristics; a large mixed South Basin and a northern collection of interconnected smaller sub-basins with different depths and mixing regimes and numerous islands. By far the largest inflow to this system drains an area that is predominantly glacial till, and discharges into the South Basin via the Rainy R. The northern sub-basins each receive markedly different hydrological and material inputs from both this southern basin and the northern shield drainage, resulting in N_S gradients of productivity and water chemistry which are logistically challenging to study.

An initial Environment Canada assessment and modelling exercise identified key knowledge gaps that need to be filled prior to the development of a scientifically based sustainable LOW management plan. As part of a broader programme to assess, remediate and manage water quality and Harmful Algal Blooms (HABs) in the Lake Winnipeg Basin, in 2008 Environment Canada initiated a LOW nutrient and HABs assessment plan to address these data-gaps in partnership with provincial and US state agencies. This talk presents an overview of the issue, the key goals of the initiative and preliminary data collected during the first field year of this project. The field and modelling study programme targets three key components: the Rainy R., selected sites in LOW, and the discharge into the Winnipeg R. It also addresses critical issues of compatibility among historic and current sampling protocols, analyses and databases collected by different agencies, compatibility which is essential to a partnered scientifically based basin-wide management and monitoring programme.

Lake Sturgeon Population Characteristics, Movements, and Habitat Use in the Namakan Reservoir: Preliminary Results

Steve Windels[1], Stephanie Shaw[2], Steve Chipps[2], David Willis[2] and Darryl McLeod[3]

[1]Voyageurs National ParK, 3131 Hwy 53, International Falls, MN 56649; [2]USGS Cooperative Fish & Wildlife Research Unit, Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007; [3] Ontario Ministry of Natural Resources, Fort Frances, ON

Since the late 1800s lake sturgeon (*Acipenser fulvescens*) populations in the Laurentian Great Lakes have declined. These declines have been attributed to overharvest, pollution, and dam creation fragmenting lake sturgeon spawning and nursery habitat. Lake sturgeon are listed as a species of special concern in Minnesota and Ontario. Lake sturgeon are also proposed to be listed under Canada's Species-at-Risk Act. Little information is known about lake sturgeon in the Namakan Reservoir. The purpose of this study is to determine population characteristics, movement patterns, and potential spawning locations of adult lake sturgeon within the Namakan Reservoir. In the spring of 2007 and 2008 sixty adult lake sturgeon were collected by a multi-agency effort in US and Canadian waters of the reservoir and implanted with Vemco V16 acoustic transmitters. Sturgeon movements were monitored using 26 stationary Vemco VR2W receivers deployed throughout the Namakan Reservoir and its tributaries. Transmitter data has verified that sturgeon currently move freely between the lakes in the Namakan Reservoir and most of the Namakan River, suggesting a shared international fish stock. Current and future aspects of this project will be discussed.

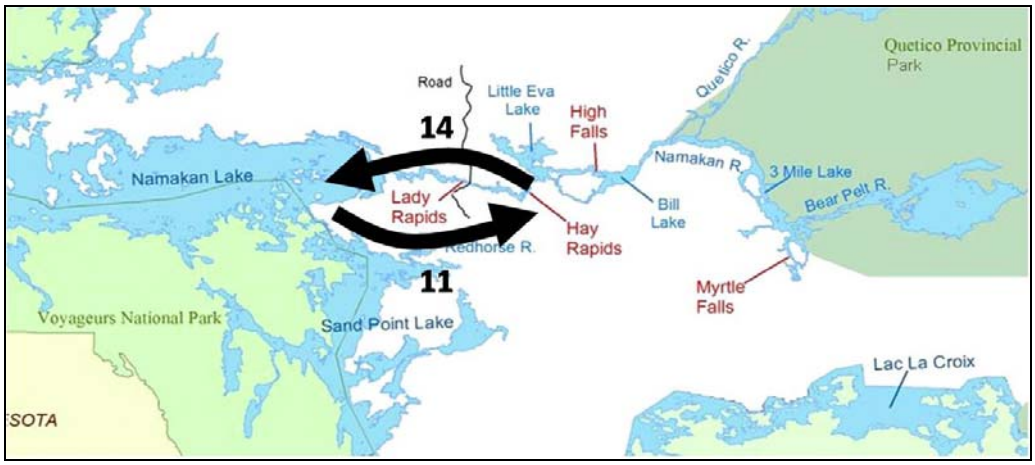


Figure 1. As of October 1, 2008, ≥11 of 26 fish implanted with acoustic transmitters in the Namakan Reservoir in May 2008 had moved into the Namakan River upstream of Lady Rapids. Likewise, ≥14 of 34 sturgeon implanted with transmitters in the Namakan River (by the OMNR) had moved into the Namakan Reservoir, demonstrating a shared international fish stock.

Reduced winter drawdown and earlier spring refill corresponds with improved macroinvertebrate community structure in Namakan Reservoir

Daniel C. McEwen[1] (Presenter) and Malcolm G. Butler[2]

[1]Minnesota State University Moorhead, Department of Biosciences, Moorhead, MN 56563 ph: 701-388-3857 mcewenda@mnstate.edu; [2]North Dakota State University, Department of Biological Sciences, Fargo, North Dakota 58105-5517 ph: 701-231-7398 malcolm.butler@ndsu.edu

Abstract:

We assessed changes in macroinvertebrate community structure corresponding with a change in water-level management within Voyageurs National Park, Minnesota (VOYA), using a before-after control-impact (BACI) experimental design. Littoral zone benthos was sampled in Rainy Lake (i.e., control system) and Namakan Reservoir (i.e., impact system) in 1984-1986, and again in 2004-2005 following a change in water-level management that began in January 2000. The new regime reduced the magnitude of winter drawdown in Namakan Reservoir from 2.5 to 1.5 meters and allowed the reservoir to fill to capacity in late-May, a month earlier than under the prior regime. Rainy Lake water levels were not altered substantially. In 2004-2005, Namakan Reservoir benthos showed larger-bodied taxa but lower overall abundance relative to the earlier survey, yet we found no comparable changes in Rainy Lake. Changes in the benthic community in Namakan likely resulted from cooler water and lower production under the new regime, as heat input became diluted by greater water volume. We generated a numerical model based on metabolic theory in an effort to tie our empirical findings to mechanisms driven by body size and environmental temperature. We also conducted a network analysis of feeding relationships in the VOYA food web, to look for changes associated with water-level fluctuation. A food web with higher levels of complexity appeared to result from reduced winter draw-down. This is the only study we are aware of to assess impacts of water-level management on reservoir macroinvertebrates using a BACI experimental design, or to apply metabolic and food-web theory to this issue.

Monitoring the Ecological Effects of Lake Level Management on Voyageurs National Park Using Beavers (Castor canadensis)

Steve Windels

National Park Service, Voyageurs National Park, International Falls, MN 56649 (email: steve_windels@nps.gov) 218-283-9821

Abstract:

Water levels and flow regimes of the international waters of Rainy Lake and the Namakan Reservoir 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, the International Joint Commission (IJC) issued the 2000 Rule Curves to mimic a more natural water cycle, particularly in reducing the winter drawdown in the Namakan Reservoir. Beavers (Castor canadensis) were selected as part of a suite of best bet indicators for assessing the ecological effects of the new hydrologic regimes. Several aspects of beaver ecology have been studied from 2004 to the present in the park to compare with similar data collected in 1984-1986 during the previous water level management regime (i.e., the 1970 Rule Curves). Beavers appear to have deeper and more stable access to water during the winter drawdown at present than during the 1970 Rule Curves. However, data available to date suggest that beavers in the Namakan Reservoir are still being negatively affected under the 2000 Rule Curves. Other aspects of beaver ecology related to water level management, including body condition, reproduction and survival, and availability of aquatic forages will be discussed.

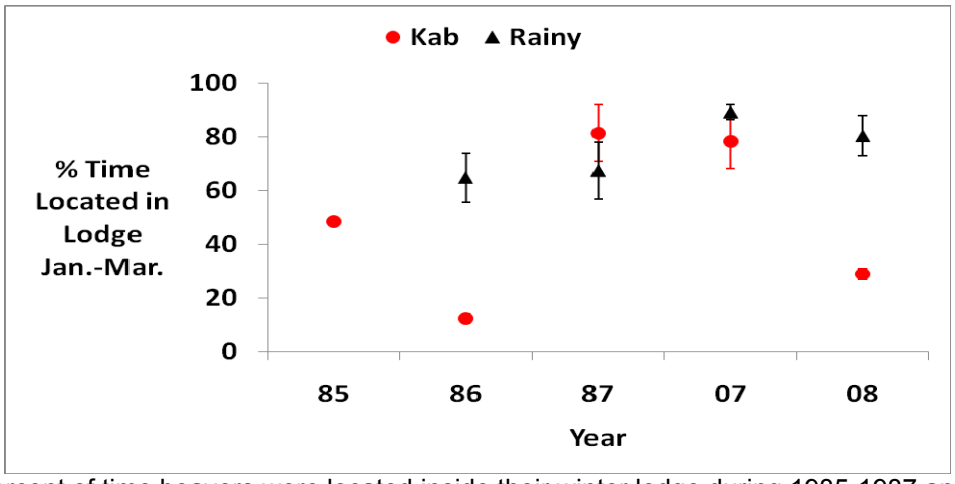


Figure 1. Percent of time beavers were located inside their winter lodge during 1985-1987 and 2007-2008 in Kabetogama Lake (Kab) and Rainy Lake (Rainy), Voyageurs National Park.

Interactive effects of hydromanagement, land use and climate on water quality of border lakes in Voyageurs National Park and vicinity

Serieyssol, Claire[1*], Edlund, Mark[2], Kallemeyn, Larry[3], Ramstack, Joy[2]

[1]Water Resources Science, University of Minnesota, St Paul, MN, 55108, USA; [2]St. Croix Watershed Research Station of the Science Museum of Minnesota, Marine on St. Croix, MN, 55407, USA; [3]USGS, CERC-International Falls Biological Station, International Falls, MN 56449 *Author for correspondence (seri0026@umn.edu)

Abstract:

In the past century, the border lakes in and near Voyageurs National Park have been subject to anthropogenic and natural stressors. These stressors include logging, damming, hydromanagement, population growth, and climate change, which can be broadly categorized into three groups: land use, hydromanagement, and climate. In order to determine how these stressors have impacted the lakes, we developed a before-after control-impact paleolimnological study. Lakes included in the study were the dammed lakes of Namakan, Rainy, and Kabetogama, which are all in the Voyageurs National Park region, and undammed Lac La Croix, which is upgradient in protected wilderness lands. One sediment core was retrieved from each lake and analyzed for 210Pb inventory, loss-on-ignition, and diatoms. Multiple statistical analyses (species richness and turnover, cluster analysis, multivariate ordination, diatom-inferred water quality, and variance partitioning) were used to provide a more comprehensive picture of how these lakes were affected uniquely and interactively by the different stressors. Among the various stressors, land use generally explained the greatest amount of variance in diatom communities. Nevertheless, it is important to note that the interactive effects among land use, climate, and hydromanagement were also highly significant. Although hydromanagement is a primary source of concern in this region, multiple stressors and their interactions were identified as drivers of change in the diatom community and therefore must be considered in the management of the border lakes.

Assessing the implications of multiple stressors and recent diatom shifts in the Lake of the Woods, Ontario, Canada

Rühland, K.M.[1], Paterson, A.M[2], Hargan, K.[3], Jenkin, A.[1], Michelutti, N.[1], Clark, B.J.[4], and Smol, J.P.[1]

[1]Paleoecological Environmental Assessment and Research Laboratory (PEARL), Department of Biology, Queen's University, Kingston, Ontario, K7L 3N6, Canada (email: ruhlandk@queensu.ca); [2]Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, Ontario, P0A 1E0, Canada; [3]Department of Resource and Environmental Studies, Trent University, Peterborough, Ontario, K9J 7B8, Canada; [4]AECOM, 11B Taylor Road, Bracebridge, Ontario, P1L 1S6, Canada

Abstract:

We 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, Ontario, Canada. Comparisons between a reference site (Whitefish Bay) and three impact sites (PP-1, Bigstone Bay, and Forrest Island) will provide insights into the effects that multiple stressors (particularly hydromanagement, total phosphorus (TP) and recent warming) have had on the lake's biota. Trends in air temperature, lake ice cover, and primary production (estimated from spectrally-inferred chlorophyll a) will be compared to overall patterns of diatom assemblage compositional changes analysed from 210Pb-dated sediment cores retrieved from each site. By examining the relationships between these measured and historical records and our diatom data, we provide evidence that both dam construction in the early 1900s and recent warming have played key roles in the diatom changes we report in the Lake of the Woods for both our reference and our impact sites. From these data, we examine the possibility that a sharp rise in temperature over the past few decades may be related to an increase in the severity of cyanobacterial blooms at our impact sites where diatom-inferred TP concentrations (although currently elevated) have decreased notably during this period. Our results suggest that recent changes in climate must become an integral part of lake management strategies.

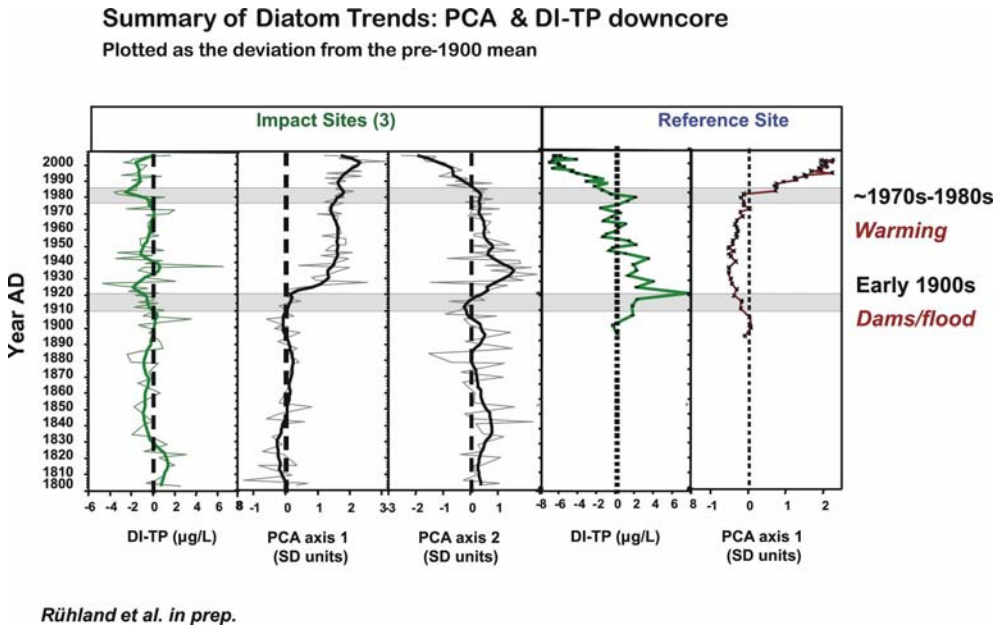


Figure 1. Stratigraphic summaries of diatom data presented as principal components analysis (PCA) samples scores and diatom-inferred total phosphorus (DI-TP) for the three impact sites (PP-1, Bigstone Bay, Forrest Island site) and for the reference site (Whitefish Bay). Data are expressed as the deviation from the pre-1900 mean (represented by dashed vertical lines).

Emerging Issues: Lake of the Woods International Coordination

Gaylen Reetz, Director Pollution Control, Minnesota Pollution Control Agency

Note: No technical abstract

Emerging Issues: Lake of the Woods International Coordination

Franca Dignem, Director Northern Region, Ontario Ministry of Environment

Note: No technical abstract

Kallemeyn Award Recipient Guest Lecture – Towards Objective Management of Inland Lakes

Bev Clark

AECOM, 11B Taylor Road, Bracebridge, ON P1L 1S6, Canada bev.clark@aecom.com

Abstract:

Aside from setting limits to inputs, the practice of managing lakes in Ontario, compared to many other jurisdictions, is a relatively new and somewhat rare endeavour. Generally the water quality of our inland lakes is such that they do not require a great deal in the way of management. When problems do arise, the first order of business is often to affirm the need to manage and then go forward to collect information to see if our initial assessment of the problem and its causes can hold water. While this may work in cases where the problem is obvious, this process involves placing the cart before the horse. A more careful approach involves the formulation of a resesrach or management question, followed by the collection of scientific data to answer the question. The final step is an assessment of the need for management actions that are based on the interpretation of the data. The management actions that follow would therefore be based on an objective assessment, and the management options and outcomes themselves would be well defined. This, of course, requires that we ask the proper questions and arrive at defensible answers. The commitment to manage the resource, when identified in this manner, arrives towards the end of the process. My presentation will show examples that illustrate both good and bad management activities.

Reducing nutrient loading to Lake Winnipeg and its watershed: Our collective responsibility and commitment to action

William (Bill) Barlow and Sharon Gurney

Lake Winnipeg Stewardship Board, P.O. Box 305, Gimli MB R0C 1B0 ph: (204) 642-8157 wilbar@mts.net

Abstract:

On February 18, 2003, the Manitoba Government announced the "The Lake Winnipeg Action Plan" to help protect Lake Winnipeg. As part of the Plan, the Lake Winnipeg Stewardship Board was established in July 2003 to help the public identify and implement actions needed to reduce nitrogen and phosphorus loadings to Lake Winnipeg to pre-1970's levels.

Excessive concentrations of plants nutrients such as nitrogen and phosphorus are causing significant changes to the lake's water quality and biological communities. Algal blooms on Lake Winnipeg continue to increase in frequency, duration and intensity. Water quality changes in Lake Winnipeg reflect the increasing quantities of nutrients that are reaching the lake from human activities throughout Lake Winnipeg's vast watershed.

In its last report, the Board has detailed a series of comprehensive strategies to reduce nutrient loading to Lake Winnipeg. This report prescribes what can be done for the health of Lake Winnipeg and its watershed and asks all Manitobans and our neighbours to work together and take action in a spirit of collective responsibility. Central to the effort will be an educated public, equipped to make positive changes on the landscape, and to encourage governments to do the same. In addition, a proactive and coordinated approach must be taken by governments to include upstream jurisdictions in the process. It is estimated that the Lake of the Woods/Winnipeg River watershed contributes 18% of the nitrogen loading and 11% of the phosphorus loading to Lake Winnipeg. Reductions in nutrient loading to the Lake of the Woods will not only benefit local conditions, but also downstream conditions in Lake Winnipeg.

The presentation will describe water quality conditions in Lake Winnipeg, present an overview of the Board's recommendations made to the Minister of Water Stewardship, and detail some of the progress made to date.

On the edge: Developing a frame of reference to explore the potential importance of the littoral zone in Lake of the Woods.

Michael A. Turner[1], Kelly A. Hille[1], Thomas Mosindy[2] and Helen M. Baulch[3]

[1]Experimental Lakes Area, Environmental Sciences Division, Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, Manitoba, R3T 2N6, [2]Lake of the Woods Fisheries Assessment Unit, Ontario Ministry of Natural Resources, 808 Robertson Street, Kenora, ON, P9N 3X9, [3]Department of Environmental and Resource Studies, Trent University, 1600 West Bank Drive, Peterborough, Ontario, K9J 7V8

Abstract:

The near-shore region of lakes (littoral zone) is critical to the health and productivity of most aquatic ecosystems. In many cases it is also the zone that is most sensitive to human influences. One of many remarkable properties of the Lake of the Woods is its extensive littoral zone. Yet despite the importance of this subecosystem, with the exception of fisheries, most aquatic research emphasizes the open-water region (pelagic zone). As a result, policies that are developed for the protection of aquatic ecosystems often assume that the littoral and pelagic zones respond similarly to stressors. We explore this assumption for several issues of importance to Lake of the Woods: nutrient management, cyanobacteria and toxins, invasive species, habitat disturbance, and climate change. We conclude that the littoral and pelagic subecosystems should not be assumed to respond equivalently to stressors without confirmation. As a result, the design of both monitoring programs and policies for protecting the health of aquatic ecosystems should consider the sometimes unique properties of the littoral zone.

Minnesota Waters: Empowering citizen involvement in water quality issues

Courtney Kowalczak

Minnesota Waters, 3907 Porter Road Duluth, MN 55803 218-343-2180 courtneyk@minnesotawaters.org

Abstract:

The mission of Minnesota Waters is to promote responsible stewardship of our water resources by engaging citizens, local organizations, and other partners in the protection and restoration of Minnesota's lakes and rivers. Minnesota Waters empowers citizen volunteers through:

- Outreach, training, and support
- Funding
- Building Peer Networks
- Issue Advocacy

Using our Data to Information to Action Pathway, Minnesota Waters enable and empowers this vital workforce to make real progress towards improving water quality. The challenges to our state's unique and beautiful waters are many. Only by empowering the citizens of our state can Minnesota effectively manage these resources for the benefit of all.

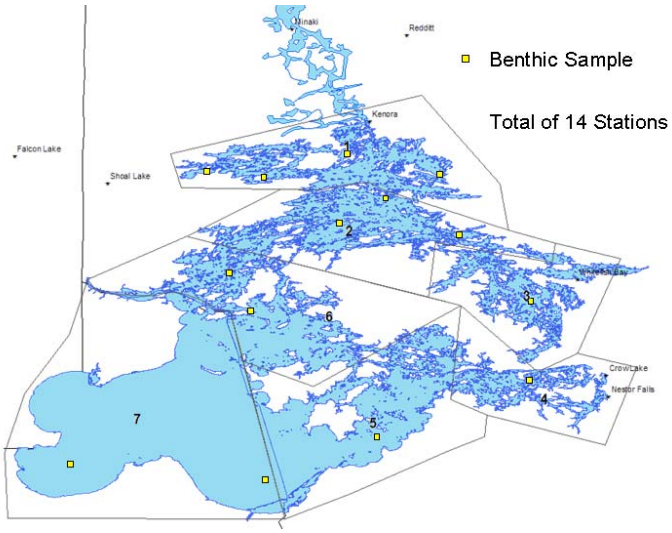
The Application of CABIN Biomonitoring in Lake of the Woods

T. Pascoe, J. Struger, and R. Kent

Environment Canada, 867 Lakeshore Rd. Burlington, ON. L7R 4A6 (905) 336-6239 tim.pascoe@ec.gc.ca

Abstract:

The Canadian Aquatic Biomonitoring Network (CABIN) is an integrated national approach and network for collecting, managing, assessing, and distributing information on the biological condition and biodiversity of aquatic ecosystems in Canada. Environment Canada and CABIN partners have produced a set of nationally-consistent benthic monitoring protocols, together with internet-based tools for storing data, assessing, and reporting the ecological condition of Canada's aquatic ecosystems. Biological data collected using the CABIN approach can be used to facilitate effective adaptive management at the watershed level. Recently, concerns over potentially toxic blooms of cyanobacteria have lead to the initiation of a nutrient assessment plan for Lake of the Woods. The 3yr field study will target three key components of the basin: the Rainy River at the south end, selected sites in the major basins within the lake, and the discharge at the northern end via the Winnipeg River. As part of this initiative, a CABIN reference model will be established through the collection of CABIN benthic samples in the major basins of the lake. The approach complements traditional stressor-based physical and chemical water quality monitoring by providing an effect-based indicator of biotic response representing the biological integrity of a watershed.This talk presents an overview of the CABIN program as a whole, identifies key goals, and discusses future trends for CABIN biomonitoring in relation to Lake of the Woods.



Aquatic invaders in Lake of the Woods Basin and others on the way

Darrin Hoverson

MN DNR - Division of Ecological Resources, Itasca State Park, 36750 Main Park Drive, Park Rapids, MN 56470 (218) 266-2106
darrin.hoverson@dnr.state.mn.us

Abstract:

Several invasive aquatic species of fish, snails, mussels, crayfish, zooplankton, and plants have become established in Minnesota's lakes, rivers and wetlands and have harmful impacts on water recreation and aquatic ecosystems. Additional aquatic invaders are headed toward the state via natural movement and through human mediated pathways. This presentation will provide an overview of impacts and distributions of aquatic animal invaders established in the state and LOW watershed, and those that are future threats. Zebra mussels (*Dreissena polymorpha*), round gobies (*Neogobius melanostomus*), spiny waterfleas (*Bythotrephes longimanus*), rusty crayfish (*Orconectes rusticus*), Chinese mystery snails (*Bellamya chinensis*), Eurasian watermilfoil (*Myriophyllum spicatum*), and curlyleaf pondweed (*Potamogeton crispus*) are examples of species that have been in Minnesota for many years. Faucet snails (*Bithynia tentaculata*), present in the Mississippi River south of Winona, were recently found in Lake Winnibigoshish. New Zealand mudsnails (*Potamopyrgus antipodarum*) and quagga mussels (*Dreissena bugensis*) are more recent invaders to the Duluth harbor. Bighead (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) were recently caught by commercial fishermen on the Mississippi River this past November. Black carp (*Mylopharyngodon piceus*), northern snakehead fish (*Channa argus*), water chestnut (*Trapa natans*), and hydrilla (*Hydrilla verticillata*) as well as pathogens such as Viral Hemorrhagic Septicemia (VHS) are some of the invaders that could threaten the state's waters in the future.

Aquatic Invasive Species Watercraft Inspection Program in NW Ontario, Canada

Laurie Wesson[1] Alyson Rob[2], Voung Pham[3], Moriah Rogoza[4] and Kevin Empey[5],

[1]Fisheries and Oceans Canada, Winnipeg, MB, [2]Ontario Ministry of Natural Resources, Fort Frances ON, [3]Alberta, Canada, [4]Red River College, Winnipeg, MB, [5]University of Manitoba, Winnipeg, MB

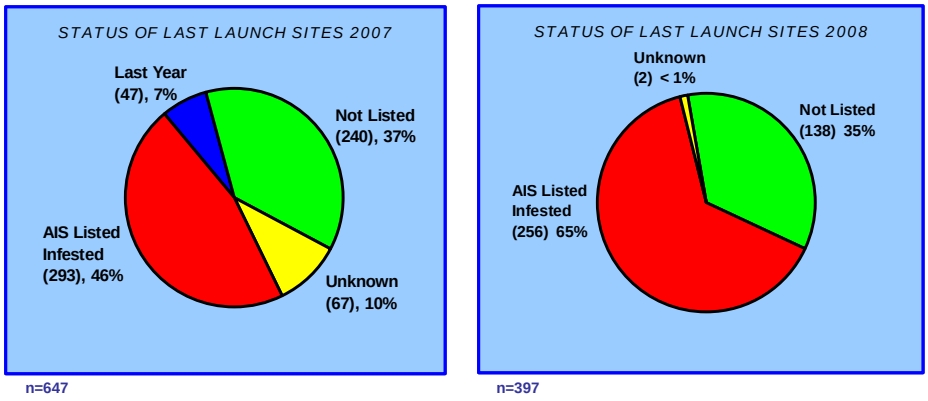
In response to the invasion of Spiny Water flea (*Bythotrephes longimanus*) and Rusty Crayfish (*Orconectes rusticus*) into the waters of NW Ontario, Fisheries and Oceans Canada in 2007 initiated a Watercraft Inspection Program at International Borders in NW Ontario. The Canadian/US borders at Fort Frances (International Falls, MN), and Rainy River (Baudette, MN), have large numbers of recreational watercraft pass through them yearly.

Anglers move through the Rainy River – Lake of the Woods – Winnipeg River systems. This is a primary pathway for the introduction of Aquatic Invasive Species (AIS) from neighbouring states into NW Ontario and the Lake Winnipeg watershed.

As boats were inspected a short survey of anglers (n=1043) was conducted in 2007 and 2008. Anglers were primarily from Minnesota and Wisconsin, though some traveled from as far away as Texas, Arizona and South Carolina. The survey found that many last launch lakes were listed as AIS infested; many of these lakes contained multiple AIS (figure below). Anglers primarily purchased live bait en route to their destination. Most anglers disposed of bait on land; however some gave bait to other anglers or disposed of bait directly into the lake. We removed small amounts of vegetation from boats and trailers; fortunately no Zebra Mussels, Eurasian Water milfoil or other potential AIS were detected.

The watercraft inspection program was increased in scope in 2008 to include trailer checks (n=1125), AIS presentations and information booths at fishing tournaments throughout NW Ontario.

Percent AIS in Last Launch 2007 - 2008



The majority of last launch sites were infested in both 2007 and 2008

Poster Session – Abstracts

Preliminary Phosphorus Model for U.S. Portions of Lake of the Woods: How Important are the Tributaries

Joseph Hadash and Matthew Julius

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

Abstract:

A mass-balance model for U.S. portions of Lake of the Woods should include nutrient loading data from all tributaries entering the system. There is sufficient data for the main tributary, the Rainy River, which will help approximate the nutrient inputs entering the lake. Along with nutrient data from other tributaries entering the lake, a more precise estimate of phosphorus loading can be established. Due to lacking or absent data from these other inputs, the total phosphorus loading for Lake of the Woods cannot be determined. A BATHTUB model can be run on the data that there is by manipulating or filling in the missing tributary data so as to still develop an estimate for phosphorus loading. This being said, a model will be run with just Rainy River nutrient data and again with manipulated tributary data. The manipulated data will consist of the phosphorus inputs at their potentially highest thresholds. If there is not a significant difference between the two models, then further tributary data will not need to be obtained for the future phosphorus budget for Lake of the Woods.

Removing Cyanobacteria and cyanotoxins in rural settings

Rachel Lindgren and Matthew Julius

St. Cloud State University, Department of Biological Sciences, St. Cloud, MN 56379

Abstract:

In recent years the issues of cyanobacterial blooms and the cyanotoxins produced have called into question the safety of freshwater systems. Due to weaknesses of current monitoring programs, techniques, and nature of the toxin it is safest to always assume that the water is contaminated in rural settings without an onsite laboratory for immediate analysis. Therefore, water filtration/purification becomes an important and proactive way to reduce toxin risk. These techniques including sand, activated carbon, ultraviolet photolysis, and boiling are typical and/or potential protection methods utilized by residents and visitors of Voyagers National Park. Further examination of commercially available water filter/purification systems allowed me to test the resilience of each system when used repeatedly. Activated carbon yielded the best results reducing the toxin concentration below the WHO guideline of 1 ppb. All other methods did not reduce the microcystin-LR concentration and as in the cases of boiling and ultraviolet photolysis through cell lysis made the samples more toxic.

Transboundary Cooperation to Manage the Rainy River

Kelli Saunders[1] and Nolan Baratono[2]

[1]Ontario Ministry of Environment; [2]Minnesota Pollution Control Agency

Abstract:

The success of the Rainy River clean up over the past several decades is as a result of efforts of the International Joint Commission (IJC) through the Rainy River Water Pollution Board established in 1965 and legislative commitments of Canada and the U.S. in the early 1970s that regulated pollutant discharges into the environment. Enhanced treatment of effluent, stringent discharge limits and, most recently, the establishment of an international Working Group for Lake of the Woods water quality and Minnesota's impaired waters study on LOW support the movement to protect and restore the international waters of the Rainy River and LOW.

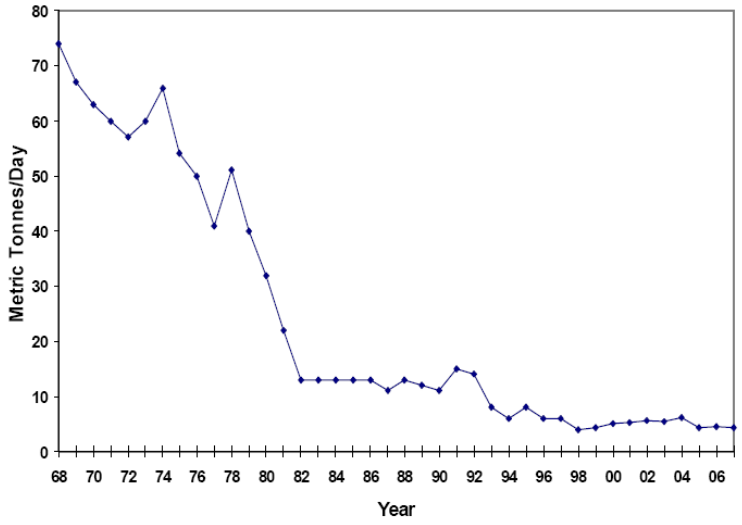


Figure: Reduction in average biological oxygen demand loading (metric tons/day) from 1968 to 2008.

The Boundary Waters Treaty: A century of cooperation protecting our shared waters

Gail Faveri

Environment Canada member to IJC International Rainy Lake Board of Control

Abstract:

The Treaty provides principles for Canada and the United States to follow in using the waters they share. For example, both countries must agree to any project that would change the natural levels or flows of boundary waters. Far ahead of its time, the treaty states that waters shall not be polluted on either side of the boundary to the injury of health or property on the other side. The principles in the treaty are as relevant today as they were in 1909.

Signed at a time when disagreement over the shared waterways – in several regions – could have divided the nations, the Boundary Waters Treaty established an organization, the International Joint Commission, to investigate, resolve and prevent boundary water disputes between the two countries.

The International Joint Commission, reviews applications for projects that affect water levels and flows across the boundary and investigates issues on request from the U.S. and Canadian governments. It has acted on more than 100 such matters during the last century.

The IJC oversees ongoing operations of dams it has approved and monitors compliance with international water quality objectives. It is assisted by boards made up of an equal number of members from each country. Two of these boards are active in the headwaters of Lake of the Woods, the International Rainy River Water Pollution Board and the International Rainy Lake Board of Control, which are actively participating in the International Watershed Initiative. The International Watersheds Initiative promotes an integrated, ecosystem approach to issues arising in transboundary waters through enhanced local participation and strengthened local capacity.

As required by the treaty, the IJC involves the public in all of its activities.

Water Quality Monitoring in Voyageurs National Park

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

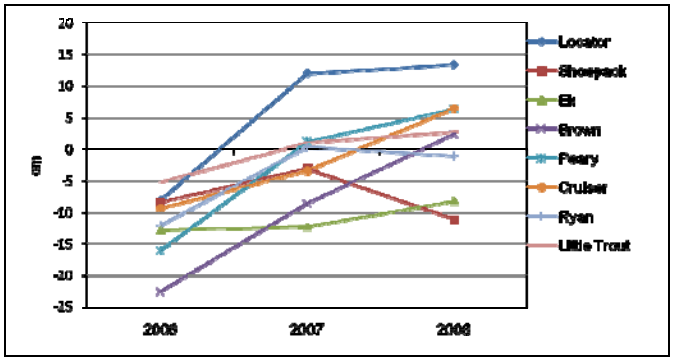
The Great Lakes Inventory and Monitoring Network (GLKN) is one of 32 National Park Service monitoring networks throughout the United States, which together include over 270 national park units. The GLKN consists of 9 park units, including Voyageurs National Park (VOYA). The inland lake resources of GLKN parks are astounding, numbering in the thousands. VOYA, alone, contains nearly 300 lakes >1 ha.

GLKN began monitoring water quality in Voyageurs National Park (VOYA) interior lakes in 2006. Monitoring consists of sampling 8 index lakes 3 times annually during the open water season, and 14 additional lakes on a longer rotation, as funding permits. We selected the index lakes to span gradients of lake type (based on classification by MDNR), geographical location within each park, visitor use, lake basin morphometry, and watershed size. Parameters measured include a 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.

Results of 3 years of monitoring show that the index lakes of VOYA are dilute and poorly buffered. Mean pH values range from a low of 6.4 (Shoepack Lake) to 7.7 (Little Trout Lake). Dissolved organic carbon concentrations are generally high, and Secchi depth measurements are generally low, indicating the tannin-stained nature of the lakes. Most lakes are mesotrophic, with relatively low nutrient and chlorophyll levels. Nevertheless, several lakes exceed EPA reference criteria for the ecoregion. Lake water levels generally decline 10 – 30 cm throughout the summer, though average lake levels have risen over the past three years.

Comparisons of our data with those of previous projects show some consistent differences that may be real, or may be due to changes in equipment, methods, or personnel. Our long-term water quality monitoring program includes rigorous quality assurance and quality control measures that ensure consistency and minimize bias. In time, we expect to be able to identify and determine the magnitude of the sources of noise and variability, and then determine whether or not a lake is undergoing directional change.

Summary results of the first 3 years of monitoring are discussed relative to the challenges of implementing a long-term monitoring program.



Average lake levels, 2006-2008, relativized to June 2006, Voyageurs National Park.

Addressing data gaps in the total phosphorus budget for the Lake of the Woods

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Abstract:

Due to the size and hydrological complexity of the Lake of the Woods (LoW), seasonal water chemistry, especially total phosphorus (TP) is difficult to collect. In the recent past, the 'Lake Partner Program' has helped to broaden TP sampling in LoW both spatially and temporally. However, at the present time, the Rainy River remains the only tributary to LoW with monitored flow and TP data. The Lake of the Woods basin is ~10,000 km^2 (not including LoW), and using published phosphorus export coefficients, has been estimated to comprise one-fourth of the total TP load to LoW. Thus, a combination of monitoring and modeling of the tributaries within the LoW basin is necessary to fill in data gaps and achieve a more comprehensive study of the P sources to LoW. An example of a model that could be beneficially applied to LoW tributaries to predict [TP] is the integrated catchments model of phosphorus dynamics or INCA-P. INCA-P is a mass-balance model which tracks the temporal variations in the hydrological flow paths and phosphorus stores, in both the land and in-stream components of the catchment. It is being applied to many rivers and lakes in Ontario and the UK to help understand and manage P sources. Here, we present tributary monitoring plans for spring/summer 2009. We also provide background information on the INCA-P model and its application to LoW tributaries to help fill in data gaps in past and future monitoring. Tributaries to be sampled for flow and TP were selected based on their predicted TP load to LoW, and accessibility for monitoring. Tributaries for modeling were selected based upon load estimates, similarity to monitored tributaries (e.g. river size, drainage area, land use, etc.), and plans for future monitoring.

A diatom-based regional comparison between modern and pre-industrial water quality in the Lake of the Woods, Ontario.

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Abstract:

Blue-green algal blooms in the northern basin of the Lake of the Woods (LOW) has generated much interest in determining whether or not there have been historical changes in total phosphorus (TP) concentrations that could explain the perceived recent increases in the severity of these blooms. In order to effectively address these concerns the following research questions were examined: (1) What is the 'natural' or baseline condition of the LOW?; (2) Is the lake naturally eutrophic?; (3) Are diatom assemblage composition and water quality (e.g. TP) different today than in pre-industrial times (pre-1850's)?; (4) If so, are these changes consistent throughout the northern part of the LOW?; and (5) What are the potential mechanisms for these changes? In this study, sedimentary diatom analysis from a suite of sites along a relatively wide gradient of TP throughout the northern part of the LOW were used to assess regional trends in water quality changes using a top-bottom (before and after) paleolimnological approach. Differences in diatom assemblage composition between the top 0.5 cm interval (modern) and the bottom 0.5 cm interval (pre-1850's) of each sediment core were analyzed, providing a spatial survey of water quality changes over the last ca. 200 years throughout the Ontario portion of the LOW. To aid our interpretation of the diatom changes recorded at these sites, a diatom-based inference model for TP was applied to determine whether TP concentrations have changed substantially since pre-industrial times. Preliminary results show a shift from high abundances of benthic (e.g. *Achnanthes spp*.) and heavily silicified tychoplanktonic taxa (e.g. *Aulacoseira islandica*) in the pre-industrial sediments to planktonic taxa (e.g. *Cyclotella* taxa and *Fragilaria crotonensis*) in the modern sediments. DI-TP reconstructions indicate an overall decreasing trend in [TP] since pre-industrial times in the majority of our study sites. Although [TP] is currently elevated in many of these sites, the apparent increase in the frequency and intensity of algal blooms in the northern basins of LOW does not appear to be solely attributed to increasing nutrient concentrations (e.g. TP). Shifts towards higher relative abundances of Cyclotella and other planktonic taxa suggest climate warming may be an important factor for driving the observed changes in diatom assemblages.

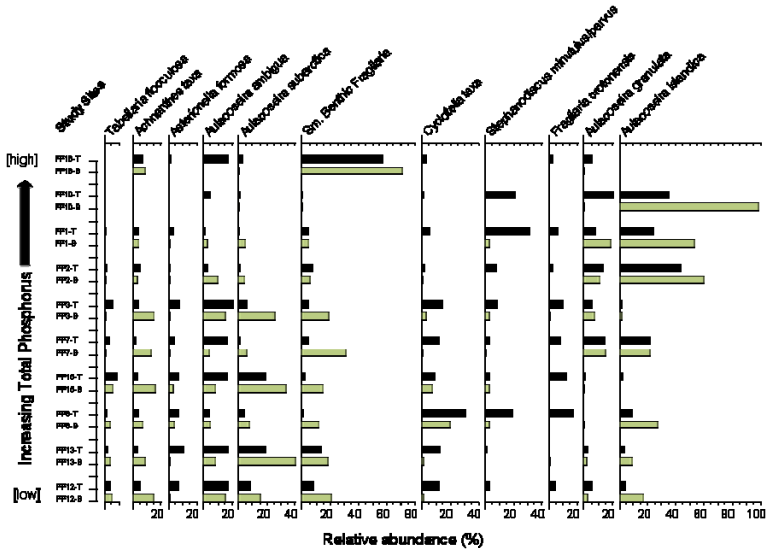

Figure. Simplified diatom stratigraphy comparing the relative percent abundances of the most common diatom taxa in modern and pre-industrial sediments for 10 LOW study sites. Modern diatom abundances are represented by black bars and fossil assemblages by lightly-shaded bars. Sites are arranged in order of increasing concentrations of total phosphorus.

Implications of body size, trophic position, species identity, and lake water quality for crayfish mercury burdens in and near Voyageurs National Park

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Abstract:

High mercury concentrations in fish and aquatic wildlife are common in the northern lakes of Voyageurs National Park. Crayfish are a key food web component, but little is known about their mercury burdens. In a series of studies from 2002-2006, we examined 1) factors influencing mercury burdens in the native crayfish *Orconectes virilis*, 2) potential differences in mercury burdens in *O. virilis* vs. the invasive *O. rusticus*, and 3) the potential for crayfish mercury concentrations to serve as an indicator of mercury burdens in other biota of interest. Using baited modified minnow traps, *O. virilis* were collected from seven interior lakes at Voyageurs National Park (VOYA) in 2002 and 2003. Additional crayfish were collected from two nearby lakes in 2006: *O. virilis* were collected from Little Johnson Lake, and *O. rusticus* were collected from Johnson Lake. Each crayfish was analyzed for total mercury (THg), and a subset of the 2002 samples was analyzed for methyl mercury (MeHg, n=30 crayfish). Crayfish trophic position was determined using carbon and nitrogen stable isotope analysis (n=29 crayfish). Watershed, morphometric, and water chemistry data were assembled from previous studies.

Crayfish total mercury concentrations averaged 51 ng/g among the seven VOYA lakes and were dominated by the methylated form (mean=88%). The concentrations spanned an order of magnitude and differed significantly among lakes ($p < 0.001$), with the highest crayfish mercury concentrations found in Ryan and Tooth Lakes. Crayfish THg was not significantly correlated with crayfish body weight ($r=-0.047$, $p=0.623$) among lakes. ^{13}C and ^{15}N signatures of crayfish differed little among lakes, and neither was significantly correlated with crayfish THg burden or body weight ($\alpha=0.1$). Few watershed, morphometric or chemical attributes explained much variation in crayfish THg; however, total organic carbon, which likely originated in catchment wetlands, independently explained 78% ($p=0.009$) of the variation in mean crayfish THg. After accounting for between-lake variation in THg, mercury concentration in native *O. virilis* did not differ significantly from that of invasive *O. rusticus*. Crayfish THg explained significant variation in northern pike THg over the nine lakes for which data on both species were available ($r^2=0.89$), suggesting that crayfish may be a useful proxy for mercury burdens in game fish. Overall, our results suggest that in this region lake-to-lake differences, particularly organic carbon concentrations, influence crayfish THg more than crayfish size, trophic position, or species identity.

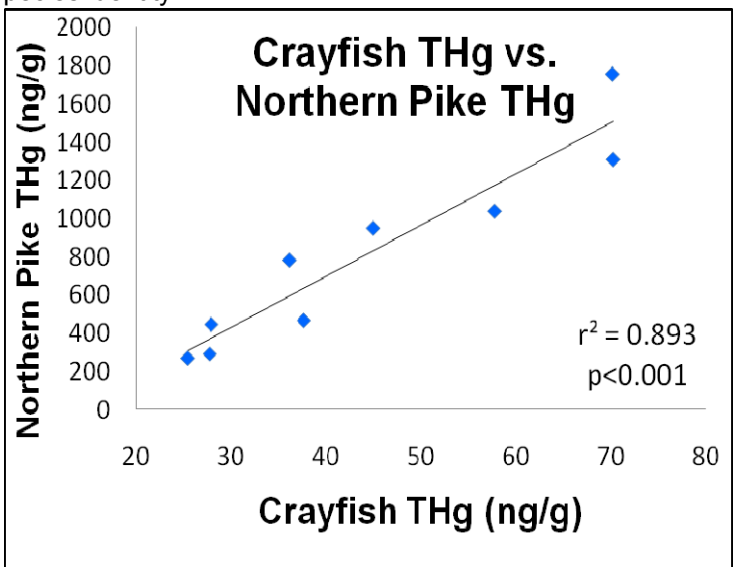

Figure: Relationship between crayfish THg concentrations and standard sized (55 cm) northern pike THg concentrations in nine lakes within or near Voyageurs National Park