

Lake Winnipeg Research Consortium Inc.  
Programs & Ship Operations

Update Report  
2020 to 2022

Prepared by  
Dr. Karen J. Scott (Programs)  
Ryan Johnson (Superintendent of Vessel Operations)

April 2022



**LAKE WINNIPEG**  
RESEARCH CONSORTIUM

# Table of Contents

<b>Background .....</b>	<b>1</b>
<b>Introduction.....</b>	<b>1</b>
<b>Programs.....</b>	<b>1</b>
<b>Science Program .....</b>	<b>2</b>
Field Program .....	2
Science Workshop .....	3
Dr. G. H. Lawler Memorial Scholarship .....	3
Other Activities or Initiatives .....	4
<b>Education Program .....</b>	<b>5</b>
Field Programs.....	5
Lake Winnipeg Water Award.....	5
<b>Ship Operations.....</b>	<b>6</b>
<b>Appendices.....</b>	<b>7</b>
<b>Appendix A. Station Network – Offshore, River Mouths, Nearshore, Outflows .....</b>	<b>7</b>
<b>Appendix B. Research and monitoring activities, 2020 and 2021 (fall).....</b>	<b>8</b>
<b>Appendix C. Pre-workshop questionnaire to participants.....</b>	<b>9</b>
<b>Appendix D. Research and Monitoring Summaries &amp; Updates .....</b>	<b>11</b>

## Background

The Lake Winnipeg Research Consortium (LWRC) Inc. is a registered charity that was founded in 1998 to address the need for scientific studies on Lake Winnipeg following signs of water quality deterioration associated with the 1997 Red River flood of the century. A brief 15-minute video describing the LWRC is available [here](#).

In brief, the LWRC owns and operates two research vessels, M/V *Fylgja* and M/V *Namao*. Three part-time personnel are required to: oversee the day-to-day operations of the LWRC (Managing Director); develop and coordinate science and education programming (Programs Coordinator); and maintain and operate the research vessels (Superintendent of Vessel Operations). The M/V *Namao* requires a seasonal crew of nine, while the M/V *Fylgja* requires two crew members.

The LWRC is governed by a board of nine directors with representation from its various classes of membership, which includes: Research (3 directors); Contributing (3 directors); Participating (2 directors); and General (1 director). Current membership of the LWRC is over 30 agencies representing various government and university departments, municipalities, communities, corporate and other organizations. Many of the research members comprise the active on-lake science team.

## Introduction

The LWRC's 2020/21 and 2021/22 fiscal years were unprecedented, being met with two significant challenges, both of which continue to a greater or lesser extent. The first goes without saying—a global pandemic—which has resulted in considerable disruptions to programming. The second challenge is related to ship maintenance and repairs, including the replacement of the M/V *Namao*'s engines. Although always a challenge without adequate drydock facilities for a vessel of this size, the last two seasons were also fraught with Covid-related supply chain issues, and extremely low lake levels due to drought conditions.

Despite the obstacles and uncertainties, two research surveys were successfully carried out during this time period, and additional progress was made on programming that could not have otherwise occurred. Below is a summary of the activities that were accomplished during these unprecedented years, including ongoing program developments, scholarship and award recipients, and an update on the status of the M/Vs *Namao* and *Fylgja*, prepared by Ryan Johnson, Superintendent of Vessel Operations.

## Programs

The main objective of the LWRC, realized through the **Science Program**, is to facilitate science on Lake Winnipeg by providing dedicated research platforms, the M/Vs *Namao* and *Fylgja*, within an established infrastructure of sampling stations (Appendix A), to its science members. In addition, the LWRC convenes those members and others who are actively involved in Lake

Winnipeg science, at an annual Science Workshop. The LWRC also awards up to \$5,000 through the *Dr. G. H. Lawler Memorial Scholarship* to honours and graduate university students.

A secondary objective of the LWRC, met through its **Education Program**, is to provide educational opportunities in various forms to schools and other institutions of learning. The primary goal of the LWRC's Education Program is to contribute to greater environmental literacy through the study of Lake Winnipeg. To this end, we currently offer a unique, experiential learning opportunity aboard the M/V *Namao* through the *Lake Ecology Field Program*, and have a new pilot program in development, which will be introduced in 2022 (described below). The LWRC also offers the *Lake Winnipeg Water Award* to students in Grades 7 to 12 through the Manitoba Schools Science Symposium.

## Science Program

### Field Program

Research and monitoring activities for the 2020 and 2021 field seasons are summarized in Appendix B, and all field logs are available on the LWRC's website ([Documents page](#)).

In summary, both the spring and summer research surveys in 2020 were cancelled due to the Covid-19 pandemic. For the fall survey, Covid-19 Standard Operating Procedures (SOPs) were developed and implemented, and additional measures taken to ensure the safety of on-board personnel including the installation of hand-sanitizer stations throughout the ship. As vaccines were not yet available, no shared accommodation for either science or ship's personnel was permitted, thereby limiting the total number of science personnel able to participate in the survey. To help overcome this issue, a lab was converted into accommodation space and one science crew served double duty as ship's crew—this provided space for two science personnel on board. These measures permitted an abridged fall survey to commence October 5<sup>th</sup>, which is roughly when a fall survey would normally be winding down.

In addition to starting late, the fall survey was abridged for several other reasons. Due to federal restrictions, no Environment and Climate Change Canada (ECCC) personnel were engaged in any field operations. Thus, the Seabird rosette was not available for the survey, nor were any federal technicians to retrieve or deploy moorings. Consequently, three moorings remained in the lake over winter. Stations were also prioritized with W stations being highest priority, followed by offshore, outflow and nearshore (south basin) stations (Appendix A). Despite everything, notably a global pandemic, persistent heavy weather in the north basin, and a reduced science crew, the fall 2020 survey was accomplished efficiently and without incident.

In 2021, the spring and summer research surveys were again cancelled, but this time it was only indirectly due to the pandemic, notably through supply chain issues and subsequent delays for the replacement of the ship's engines. A complete fall survey was carried out between September 24<sup>th</sup> and October 14<sup>th</sup>. All but two stations were sampled, the Seabird rosette was back on-board, and two of the three remaining moorings were successfully retrieved despite being in the lake for over a year longer than scheduled.

## Science Workshop

In 2020, the annual Science Workshop was cancelled due to the reduced field season and limited science participation in the survey. With the short field season in 2021, there was little new research to present at the annual workshop—nevertheless, a virtual science workshop was held to regroup and explore potential new ideas moving forward in a post-pandemic milieu. To that end, a pre-workshop survey (Appendix C) was sent out to members of the active on-lake science team to request brief updates on the status of research and monitoring initiatives (Appendix D) and to gauge interest in a number of new ideas, including but not limited to:

- The development of a university-level field course aboard M/Vs *Namao* or *Fylgja*;
- Ways to enhance student engagement in lake research, including identifying existing research projects and datasets;
- The need or interest to expand upon the three annual, whole-lake survey approach; and
- Interest in exploring the development of a Canada Foundation for Innovation (CFI) grant.

Comments by survey respondents were summarized and discussed further during the workshop. Given the inherent limitations of the Zoom environment, more in-depth discussions and decisions intended to advance some of these ideas will occur in working groups during the year and at the next in-person science workshop.

## Dr. G. H. Lawler Memorial Scholarship

The 2021 Dr. G. H. Lawler Memorial Scholarship was awarded to Madelynn Perry in support of her thesis project examining the effects of different soil amendments in reducing phosphorus losses from agricultural fields throughout the spring snowmelt period. Madelynn is a Master's student at the University of Winnipeg in the Master of Environmental and Social Change program, working under Dr. Darshani Kumaragamage. She is shown here happily collecting snowmelt samples from one her sites this spring.



## Other Activities or Initiatives

### *Journal of Great Lakes Research Special Section on Lake Winnipeg*

The Journal of Great Lakes Research (JGLR) is the official journal of the International Association of Great Lakes Research (IAGLR), devoted to research on large lakes of the world and their watersheds. The LWRC's Science Program worked with the IAGLR editors – Drs. Bob Hecky and Stephanie Guildford – to lead the second Special Section for Lake Winnipeg entitled *Lake Winnipeg – the emerging view after 15 years of whole-ecosystem science*. A total of 21 papers (six open access) were published by June 2021 in JGLR's Volume 47, Issue 3 (pages 553 - 994). The Lake Winnipeg Special Section can be accessed [here](#).

### *Canadian Watershed Information Network*

The Canadian Watershed Information Network (CANWIN), formerly the Lake Winnipeg Basin Information Network, is a web-based open-access data network. In 2012, management of the network was transferred from Environment and Climate Change Canada to the Centre for Earth Observation Science (CEOS) within the Faculty of Environment, Earth and Resources, and is now hosted by the University of Manitoba. The interoperable infrastructure of this platform facilitates dataset searches through sites such as Google and others, enhancing accessibility of water and climate-related data within the Nelson River Watershed and into the Arctic via Hudson Bay, including Lake Winnipeg.

The LWRC's Science Program worked closely with the CanWIN team over the last two years during the beta development phase of the data network. The intention is to align Lake Winnipeg science with more effective management, accessibility, acknowledgement, and citation of data generated through the LWRC's Science Program. In addition to improved access to data, establishing this process enables more effective tracking of scientific output, which is an important outcome for the LWRC's continued support by its core funders, and, in turn, of the LWRC's support of the scientific community. Establishing a robust data management process also enhances the LWRC's succession planning. As of March 2022, the beta phase of the platform is complete and accessible to users [here](#).

### *Other*

The LWRC's Science Program coordinator serves annually on the committee for the Jennifer Robinson Memorial Scholarship of the Arctic Institute of North America and was a mentor with African Women in Science (AWIS). AWIS is a program that is co-hosted by the International Institute of Sustainable Development (IISD) and African Centre for Aquatic Research and Education (ACARE). It is designed to support early-career female scientists working on Africa's freshwater issues, by enhancing capacity building and international networking opportunities to help protect North America and Africa's Great Lakes through research. The new 2022 cohort of African women scientists will be touring the M/V *Namao* in spring 2022 before heading to the Experimental Lakes Area to visit that research facility.

## Education Program

### *Field Programs*

The LWRC's Education Program provides unique opportunities for hands-on, experiential learning for students in Grades 3 to 12. Our keystone program, the ***Lake Ecology Field Program***, takes place during the school year aboard the research ship the M/V *Namao* and is aimed at students in Grades 8 to 12. Due to the remote learning restrictions imposed during the Covid-19 pandemic, the *Lake Ecology Field Program* was cancelled in both 2020 and 2021. This hiatus, however, allowed time to re-evaluate programming and consider alternatives to shipboard learning and classroom visits, such as virtual field trips aboard the M/V *Namao* and shore-based day camps.

The ***Lake Winnipeg Discovery Camp: Sail and Science*** is a pilot program aimed at students in Grades 3 to 7, to be offered in the summer of 2022 for two weeks in conjunction with the Gimli Yacht Club's *Learn to Sail Program*. Kids will learn to sail in the morning and then explore the lake ecosystem through science (and art) in the afternoon. Lunch will be provided by the Kiwanis Club.

### *Lake Winnipeg Water Award*

The LWRC's Water Award is offered at the Manitoba Schools Science Symposium (MSSS) and is open to Juniors (Grades 7 and 8), Intermediates (Grades 9 and 10) and Seniors (Grades 11 and 12). In addition to a cash prize, Water Award recipients are invited to join the LWRC's science team for a half day on board our research ship M/V *Namao* on Lake Winnipeg during the summer research survey. Setting sail from Gimli Harbour, recipients have an opportunity to participate in some of the research and monitoring being conducted on this magnificent body of water, as well as showcase their project at our Open House.

In 2020, the MSSS event was cancelled, and consequently, the LWRC was not able to offer its Lake Winnipeg Water Award. In 2021, the event was held virtually, and Marissa Magsino from St. Mary's Academy was the recipient for her project entitled *Optimal environmental conditions maximizing the biodegradation of polystyrene using Tenbrio molitor*.

## Ship Operations

In 2020–2021, neither vessel, M/V *Fylgja* or M/V *Namao*, sailed for the spring or summer surveys and the time was used to catch up on maintenance that could be accomplished on the water, as opposed to drydock. For the *Namao*, the port generator was overhauled and all of the ABS black water lines for the vacuum system were replaced with steel, as required by Transport Canada. Both projects were shut down for four weeks due to Covid-19 but resumed once restrictions were eased and completed in June. In addition, the forward decks were cleaned and scraped, and fresh paint applied, the old winch for the retractable stairs was replaced, new LED lighting was installed throughout the accommodation, and new life rafts were acquired and installed. The M/V *Fylgja* also underwent some repairs during the spring in the event the *Namao* could not sail due to required repairs (see below). This included replacing a worn shaft bearing and shaft.

In order to sail for a fall survey, an extension on the dry docking of the *Namao* was required. The ship has numerous sections of the hull that have been damaged over the years, mostly before the LWRC took ownership of the vessel. This damage includes three areas of the hull that are upset and show signs of wastage or thinning. There is also a 15-centimeter crack, which occurred when the ship grounded at George Island in the fall of 2018 and was temporarily patched. These areas were identified by Transport Canada as requiring repair in order to continue operations, with a due date for repairs to be completed before the 2020 season. An extension for drydock was therefore requested and a 30-day certificate was received.

In 2021–22, the *Namao* underwent a major upgrade of the main propulsion. New main engines were installed which meet the highest emission standards at time of installation. The removal of the old engines started in the fall of 2020 and continued through the winter into the spring of 2021. The old engines were required to be partially disassembled to bring the weight and physical size down to be manageable and fit out of the engine room. The new engines are smaller and lighter however have the same power rating. The new engines require an exhaust aftertreatment system to reduce the emissions to acceptable levels. The replacement of the main engines should help extend the life of the *Namao* for many years to come.

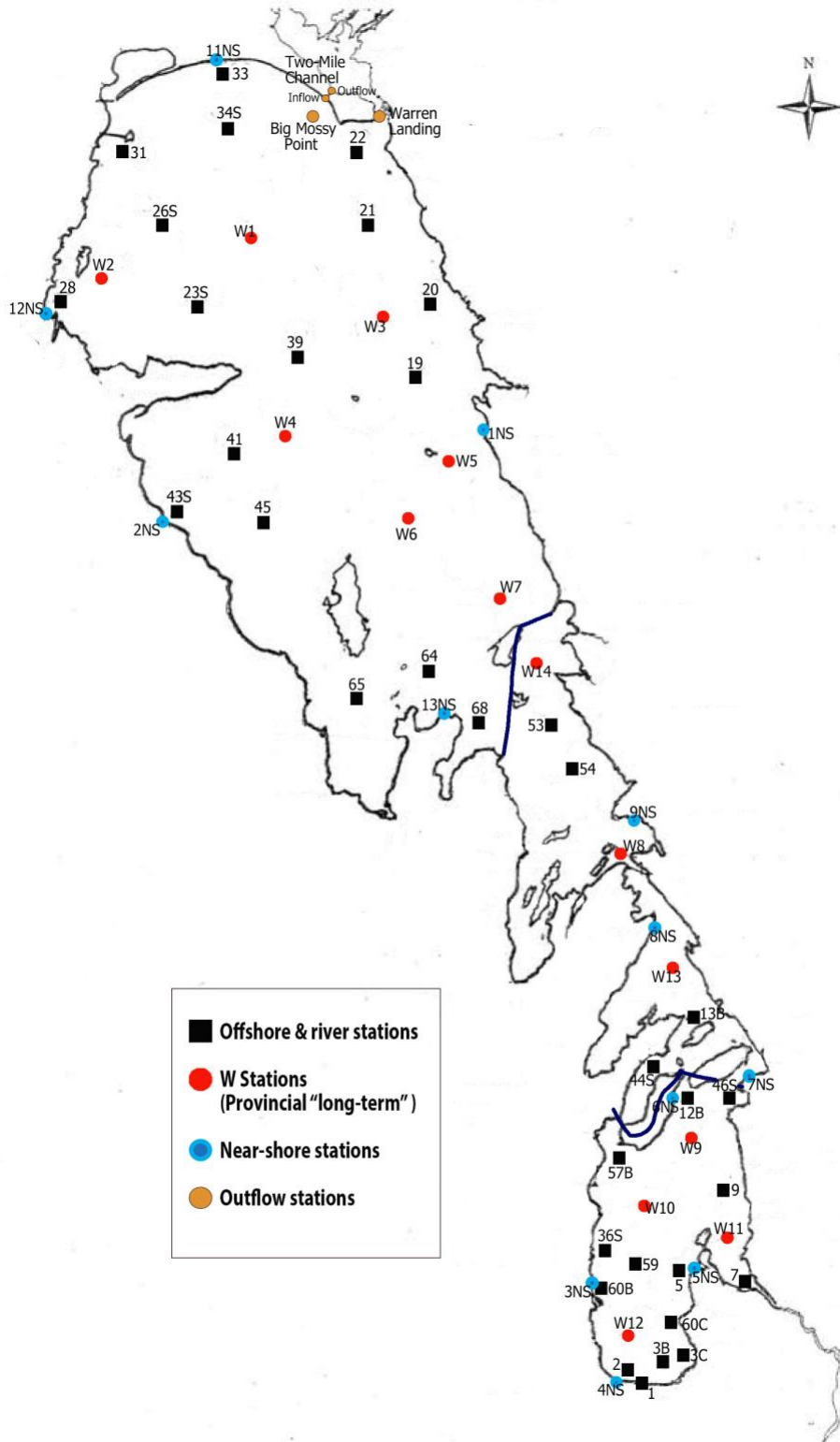
The *Namao* was able to sail for a fall survey in 2021 and the new equipment worked very well. The new engines are more fuel efficient as well and do not consume lube oil like the old engines did. This should help to reduce the operating cost of the vessel and extend the service life of the ship.

The *Namao* requires to be drydocked to carry out the required 5-year survey of the hull as well as repair the damage from the grounding in the fall of 2018. The facility in Hnausa, operated by Freshwater Fish, is available this summer to haul the *Namao* out of the water. The biggest hurdle we face now is the low water levels on the lake. The Hnausa Harbour entrance has been dredged this spring, but it is still uncertain if the ship will have enough water to access the dry dock ramp in the harbour. We will be able to have a better idea of water levels and access once the ice is gone and we are able to carry out soundings of the harbour.



# Appendices

## Appendix A. Station Network – Offshore, River Mouths, Nearshore, Outflows



## Appendix B. Research and monitoring activities, 2020 and 2021 (fall)

Agency	Lead	Project	Details
Manitoba Agriculture and Resource Development	Burton	Long-term water quality monitoring of Lake Winnipeg	<b>All offshore, nearshore and outflow stations</b> - nutrients, chl-a, other chem, vertical depth profiles of light, dissolved oxygen, temp, turbidity, conductivity (Seabird), <i>E. coli</i> . <b>14 long-term stations</b> – as above with metals and major ions, Hg, whole water phyto for id, biovolume estimates & enumeration, macroinvert samples (triplicate, spring only), surface sediment samples (summer only) for metals, nutrients, organic content, and particle size analysis (percent sand, silt, and clay). <b>Three stations nearest the inflow of the Red, Winnipeg, and Saskatchewan rivers</b> - pesticides (summer only starting 2013). <b>Blooms</b> - microcystin-LR and cyanobacterial cell counts
	Burton	Nearshore water quality monitoring	<b>Nearshore station transects at 1m, 2m and 3m depths</b> - general chemistry, N and P (total particulate and dissolved), chlorophyll, TSS, turbidity, PAR, calcium
	Janusz	<i>Bythotrephes</i> monitoring	Two vertical zooplankton hauls taken at all stations - 64 µm mesh size - composited. Samples taken from 1 m off the lake bottom
	Janusz	Zebra mussel veligers	Veliger sampling at all narrows and NB stations (14 m) - offshore and nearshore (2020)
Environment & Climate Change Canada	Koehler	Stable isotopes	Water (all offshore) and zooplankton (W stations)
Fisheries & Oceans Canada	Enders	Forage fish trawl	43 offshore stations
Manitoba Hydro	Chaze	CAMP	Warren Landing, Two-Mile Channel (inflow and outflow), Playgreen Lake, station 22, Big Mossy
University of Manitoba	Papakyriakou	C biogeochemistry and air-lake CO <sub>2</sub> exchange	Surface and bottom water samples select stations - offshore and nearshore
University of British Columbia	Murch	BMAA and isomers	Algal blooms

## Appendix C. Pre-workshop questionnaire to participants

### Section 1 — Research & Monitoring Updates

**Title of your project**

**Principal Investigator(s)**

**Abstract**

**Most exciting findings as of late**

- Figure, table, other... (add slides if you wish)

**Status of your work**

- Timeframe – obstacles – successes – publications...

**Future plans**

- Concrete plans that are already in the works – for instance, submitted or funded proposals
- Less concrete plans like a brilliant idea that isn't yet off the ground or that requires some missing ingredients (such as collaborators, a student, data, more shipboard support...)

### Section 2 — Potential Discussion Questions

**Science Program — Field Program (M/V NAMAQ)**

- Is there anything in terms of equipment that could be added, modified, replaced... that would assist your program?
- The forward hold will be gutted and redesigned, including a new lab. Are you interested in contributing ideas to the new lab layout when discussions begin in the next fiscal year?
- Other comments

**Science Program — Field Program (Sampling)**

We currently sample ~65 stations during each of the three surveys (spring, summer, fall), daylight hours only.

- Is there a need to re-evaluate this approach? For instance, to better address the lake's response to climate change.
- Is there an interest, if not a need, to re-evaluate this approach?
- Other comments

**Science Program — Field Program (Students)**

- Any thoughts on how to attract more students to work on Lake Winnipeg?
- Is there any interest in student-sharing among agencies?
- Do you know of projects that would be suitable for honours or graduate students?

**Science Program — Field Program (Citizen Science)**

- Do you have any interest in, or would your program benefit from, engaging lake users in data/sample collection? For instance – sailors, fishers, remote lake communities.

### **Science Program — Field Program (Field Data)**

The Science Program is working toward better management of and access to shipboard-collected data. This includes working in collaboration with CanWIN at the U of M. Currently, ‘communal’ ship data includes Field Logs, Seabird, AVOS, Humminbird (not a spelling mistake).

- Do you have field data needs that are not being met?

### **Science Program — Annual Workshop**

- Any thoughts on how the LWRC’s annual Science Workshop could better serve Lake Winnipeg, from science and management perspectives?
- Could the annual Workshop serve a more prominent role in facilitating the preparation of the State of the Lake report? (and/or reporting on lake indicators)

### **Education Program**

The LWRC has two field-based Education Programs covering Grades 2 to 12—Lake Ecology Field Program (Grades 8 to 12, some university) and Lake Winnipeg Discovery Camp: Sail & Science (Grades 2 to 7).

We also offer two Scholarships—Dr. G.H. Lawler Memorial Scholarship (Honours and Graduate students) and MSSS Lake Winnipeg Water Award (Grades 7 to 12).

- Is there interest in developing a field-based course for university level students? (aboard M/V Fylgja or Namao). What might it look like?

### **Outreach / Fundraising (M/V NAMAQ)**

From a science or management perspective, please share any thoughts you may have on the following additional uses of the M/V Namao and your interest in participating in them.

- Annual Open House (in Gimli Harbour and other harbours)
- Mini-camp for elected officials
- A venue for speaker series, art exhibits / films, fundraising, other ideas

## Appendix D. Research and Monitoring Summaries & Updates

### **Pelagic fish trawl**

Doug Watkinson, Eva Enders  
Fisheries and Oceans Canada

In the fall survey of 2021, we trawled 48 stations. A total of 115,625 fish were collected. The majority of the catch (i.e., 103,907 fish) was caught in the south basin. Emerald Shiner (*Notropis atherinoides*) dominated the catch (114,907). In comparison to catches in the early 2000s, Rainbow Smelt (*Osmerus mordax*) was still rare in the catch (n=83), but the highest since 2015. DFO plans on continuing the sampling in 2022 and beyond to support our understanding of changes to and productivity of the pelagic fish community.

### **Lake Winnipeg Basin Fish Movement Project**

Mark Pegg, Ken Jeffries, Darren Gillis, Jason Treberg, Mike Rennie, Saman Muthukumarana, Jen Jeffrey, Nicole Turner, Inesh Munaweera, Matt Thorstensen, Henry Hansen, Lily Wiens, Geoff Klein, Doug Watkinson, Tyana Rudolfsen, Colin Charles, Colin Kovachik, Eva Enders

The Lake Winnipeg Basin Fish Movement project began in 2016 and has successfully tagged 883 to date with 60 Walleye (Red River; Selkirk) and 40 Lake Sturgeon (Red River; US) planned this spring. The tagging has included eight different fish species, and currently has >200 receivers deployed in the basin. A Vemco Positioning System (VPS) was deployed in 2021 to investigate fine scale movements.

Walleye tagged in 2022 will have accelerometry tags implanted to study movements as well as swimming speed. Walleye populations will also be tagged with similar methods and respirometry experiments conducted in a DFO lab in Ontario to develop a bioenergetic model for Walleye. This will be used to understand and contrast the relative costs of movement for Walleye populations in the Great Lakes as well as Lake Winnipeg.

The timeframe for this project is 2016 to 2024 at a minimum. To date, nine papers have been published and can be accessed [here](#).

### **Monitoring of ecological and trophic structure impacts in response to eutrophication and invasive species impacts on LW.**

Geoff Koehler, David Depew  
Environment and Climate Change Canada (Saskatoon, Burlington)

Food web dynamics have been identified as an important knowledge gap in Lake Winnipeg. It is essential to know the mechanisms and structure of the energy flow from nutrients to fish in order to predict any changes in the food web in response to environmental stressors. Changes to climate, nutrient loading, and introduction of invasive species can all potentially disrupt or redirect nutrient pathways and trophic structure. Knowledge of the effects of invasive species or changes in nutrient loading on the foodweb is essential to proactive science-based decision making regarding nutrient management or lake remediation efforts.

The objective of this work is to: 1) improve understanding of nutrient cycling processes and food web representation in the lake model; and 2) contribute to setting ecologically relevant objectives and advise on management objects related to climate change and zebra mussel impacts on lake ecology.

High resolution hydrogen stable isotope isoscape of water in Lake Winnipeg, from >200 geolocated water samples were collected in the fall, 2020. Ultimately can be used to proof lake circulation models and help define river contributions.

Future initiatives will include:

- Monitoring of nitrate isotopic compositions at selected locations for source tracing and to determine internal nitrate loadings within Lake Winnipeg;
- Measurement of phosphate stable isotopic compositions at river inputs and selected lake stations to try to determine in-lake and external phosphorous loadings;
- Measurement of dissolved  $\text{NO}_3^-$  concentrations, isotopic compositions to determine past and present nitrification-denitrification pathways and rates;
- Implementation of new Ti-oxide denitrification methods for N and O Isotopic analyses of dissolved nitrates. This method is has less sample preparation and uses much safer reagent materials than previous methods; and
- Pilot Study (2022-2023) to evaluate microplastic sources to LW and in the LW watershed using stable isotopic methods ( $^2\text{H}$ ,  $^{13}\text{C}$ ,  $^{37}\text{Cl}$ ).

### **Toxin Analysis of Cyanobacterial Blooms in Lake Winnipeg**

Susan J. Murch

Department of Chemistry, University of British Columbia (Okanagan Campus)

Cyanobacterial blooms are a global human health risk because they form large algae blooms and produce toxins which can bioaccumulate in common food sources. Exposure to one of these cyanobacterial toxins, the non-protein amino acid  $\beta$ -N-methylamino-L-alanine (BMAA), is linked to increased risk of developing neurodegenerative disease. Analysis of BMAA is complicated and three of its isomers: 2,4-diaminobutyric acid (DAB), N-(2-aminoethyl)glycine (AEG) and  $\beta$ -aminomethyl-L-alanine (BAMA) are also measured.

Our overall research objective is to develop research methods and approaches for studies of non-protein amino acids in diverse ecosystems. To achieve this, we partnered with LWRC to assess samples from Lake Winnipeg from 2017-2022. Our specific objectives are: (a) to determine the best analytical methods for BMAA analysis to fully understand the state of the art; (b) to develop a method to isolate a cyanobacterial protein that can bind specifically to BMAA for use in a field-deployable biosensor; (c) to quantify BMAA and its isomers in cyanobacteria from Canadian freshwater lakes including Lake Winnipeg and Pavilion Lake.

Using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) review process, the largest discrepancy between data generated from different methods arose

from the analysis of cyanobacterial matrices suggesting that the sample matrix effects are important, and methods must be fully validated and rigorous. To provide an alternate type of method that may be used in the future to help resolve method discrepancies, we are working on developing a BMAA-bound affinity chromatography resin to isolate BMAA-binding cyanobacterial proteins and we are developing several types of field deployable biosensors.

Our studies investigating BMAA and its isomers in Lake Winnipeg found BMAA and BAMA in highest concentration (average 4.05  $\mu\text{g/g}$  and 1.46  $\text{mg/g}$ ) in the north basin, the lowest nitrogen region of the lake. AEG and DAB were found in the slightly shallower and more nitrogen-rich zone of the lake (average 2.12  $\text{mg/g}$  and 0.17  $\text{mg/g}$ ). We conducted genomic analysis of the samples and found that the cyanobacterial cultures were contaminated with other fungi and bacterial. We have been sequentially isolating and purifying the cultures for more than a year but there seems to be a persistent fungal symbiont co—habituating with the cyanobacteria in Lake Winnipeg. Ongoing efforts to regenerate axenic cultures of both the fungi and the cyanobacteria will lead to new discoveries next year.

Future plans

- Keep trying to isolate axenic cultures of cyanobacteria
- Repeat metagenomics with axenic cyanobacteria
- Discover new non-protein amino acids in cyanobacteria
- Develop biosensors or hand-held mass spectrometer method for field deployments

### **Lake Winnipeg Carbon Budget**

Tim Papakyriakou

Centre for Earth Observation Science, University of Manitoba

Lake Winnipeg is a vast freshwater system with diverse nutrient inputs, and has undergone notable change within the past two decades (i.e., hypereutrophication). The role of inland waters as heterotrophic carbon emitters has recently been recognized, and it is important to understand how this unique major water body functions in this regard and how it transforms carbon before delivery to downstream aquatic and estuarine systems. To this end, water samples will be collected throughout Lake Winnipeg from 2018 to 2022 (ongoing) and analyzed for aqueous inorganic and organic carbon species. In addition,  $\text{d}^{13}\text{C}$ -DIC isotopes and  $\text{d}^2\text{H}/\text{d}^{18}\text{O}$  isotopes in water will be used to provide ancillary information on the carbon species. The goal of research is to better understand the quantity and fate of carbon species within Lake Winnipeg and the nature of carbon export from the system. Data analysis is ongoing.

## **Nutrient flow through the Manitoba Great Lakes**

Greg McCullough

Centre for Earth Observation Science, University of Manitoba

Lake Winnipeg, the 11<sup>th</sup> largest lake in the world, is a part of a system of Manitoba Great Lakes (MBGL) including Lakes Manitoba and Winnipegosis, the 31<sup>st</sup> and 26<sup>th</sup> largest freshwater lakes in the world, respectively. Over 2/3<sup>rd</sup> of nutrients from urban wastewater and agricultural runoff in the Fairford/Dauphin River watershed (tributary to Lake Winnipeg) are sequestered in the two upper MBGL. Up to half of runoff in large flood events in Assiniboine River watershed has been diverted through Lake Manitoba since 1966, and with it as much as 90% nutrients that would otherwise flow directly into Lake Winnipeg. In this study, we use recorded river discharge and water quality data to drive a multi-box model of water and nutrient flow through the MBGL, and we discuss the implications for Lake Winnipeg. Submission of manuscript in 2022.

## **Lake Winnipeg Water Quality Monitoring Program**

Matt Morison

Water Quality Management Section

Water Science and Watershed Management Branch

Manitoba Environment, Climate and Parks

Since 1999, Manitoba Environment, Climate and Parks (ECP) has been monitoring the health of Lake Winnipeg in partnership with the Lake Winnipeg Research Consortium (LWRC), Manitoba Hydro, and others. The objective of the provincial Lake Winnipeg Water Quality Monitoring Program is to better understand the lakes existing condition, to evaluate impacts to water uses (e.g., recreation, protection of aquatic life), and to assess long-term changes in ecosystem health. Water samples are collected four times per year from various locations around the lake and are analyzed for a variety of physical (e.g., temperature, pH, dissolved oxygen), chemical (e.g., nutrients, ions, metals, pesticides, carbon constituents) and biological (e.g., E. coli, chlorophyll-a, algae ID and toxins) parameters. During the open water season (i.e., spring, summer, and fall), water samples are collected from up to 65 stations (near shore, offshore, river mouths, outflows) on Lake Winnipeg via the M/V *Namao* or workboat. Sediment and benthic invertebrate samples are also routinely collected from a reduced number of sites and are analyzed to provide an indicator of ecosystem health. Water samples are collected from a reduced number of sites in the winter via helicopter. The information collected as part of the provincial Lake Winnipeg program is necessary for meeting reporting requirements under the *Water Protection Act*, and for tracking progress and change over time. This data also provides key information to support current and future research on Lake Winnipeg.

Long-term monitoring program operating quarterly since 1999 to present in partnership with LWRC at 65 open-water stations (16 in winter):

- Water Sampling (e.g., general chemistry, ions, nutrients, trace elements, mercury, pesticides)



- Sediment Sampling (e.g., particle size, pH, nutrients, ions, carbon content, trace elements)
- Biological Sampling (e.g., benthic invertebrates, algae identification and biovolume, phytoplankton, algal toxins, chlorophyll a)
- Microbiology (e.g., E. coli if can be analyzed within 48 hours; cyanobacterial cell count if an algae bloom is present).

Long-term water quality monitoring of north basin and south basin in winter, spring, summer, and fall in 2022 will continue, as will ongoing reporting work as outlined in Canada-Manitoba Memorandum of Understanding: Respecting Lake Winnipeg and the Lake Winnipeg Basin (2021). There are three major areas of focus in the recently renewed MOU: Adaptive management, Indigenous engagement, and response to climatic change.

### **Canadian Watershed Information Network**

Claire Herbert

Centre for Earth Observation Science, University of Manitoba

CanWIN is part of the Canadian Consortium for Arctic Data Interoperability (CCADI), a pan-Canadian collaboration between six universities and multiple Indigenous, governmental and non-profit organizations to develop an Arctic Research Data Infrastructure (ARDI). Through our various project initiatives, CanWIN collaborates with national and global data partners including IISD-ELA, Datastream, Living Lakes Canada, the Arctic Data Committee (ADC), the Open Geospatial Consortium (OGC), and the Research Data Alliance (RDA). In practice, our platform allows us to make data discoverable by sites such as google dataset search and the Federated Research Data Repository (a Canadian Research Data Aggregator) as well as by our international partners. By the end of March our geospatial platform will be available, where we have shared spatial data layers of the basin. Here users can perform more advance geospatial searches and create their own maps.