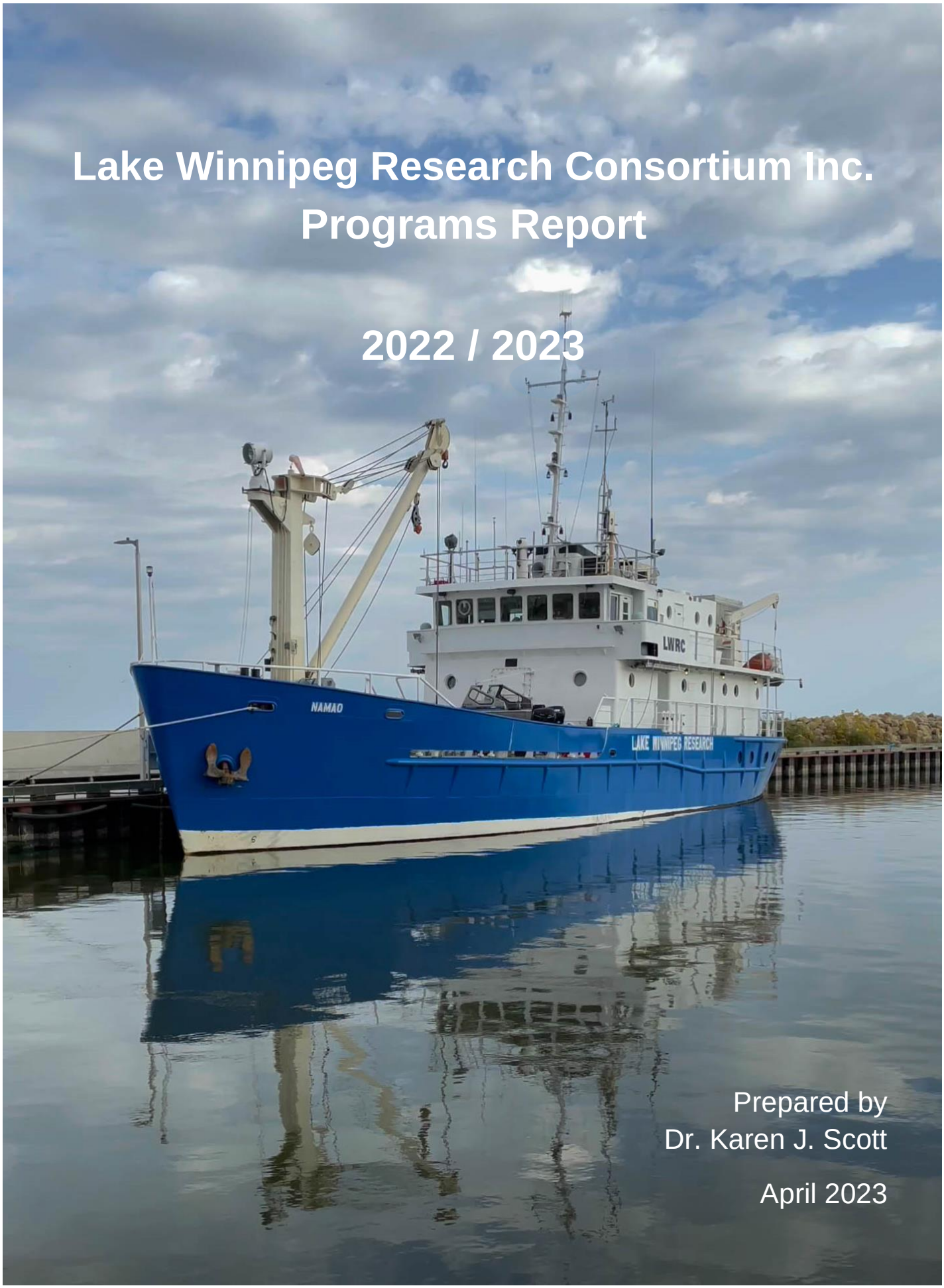
Lake Winnipeg Research Consortium Inc.
Programs Report

2022 / 2023



Prepared by
Dr. Karen J. Scott

April 2023

Table of Contents

LWRC

INTRODUCTION

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.

The LWRC owns and operates two research vessels, the Motor Vessel (M/V) *Namao*, and the M/V *Fylgja*, a smaller vessel. The main objective of the LWRC, realized through the **Science Program**, is to facilitate research and monitoring on Lake Winnipeg by providing access to its science members to an established network of on-lake stations (Appendix A) using these vessels. In addition to the *on-lake Field Program*, the LWRC convenes its science members and others who are actively involved in Lake Winnipeg science, at an annual *Science Workshop*.

A secondary objective of the LWRC is met through its **Education Program**, the primary goal of which is to contribute to greater environmental literacy through the study of Lake Winnipeg. Two core programs comprise the Education Program: the *Lake Ecology Field Program* is a unique, experiential field-based opportunity aboard the M/V *Namao* offered to schools and other institutions of learning from Grade 8 to university; and the *Lake Winnipeg Discovery Camp: Sail and Science*, a shore-based program for children between ages 7 and 13.

Lastly, the LWRC's programs include two scholarships: the *Dr. G. H. Lawler Memorial Scholarship*, which is offered to honours and graduate university students; and the *Lake Winnipeg Water Award* for younger students (Grades 7 to 12) through the Manitoba Schools Science Symposium.

This report summarizes the activities of the LWRC's Science and Education Programs for the 2022/23 fiscal year and provides a brief overview of ship operations. Since the pandemic, this year was the first that resembled a somewhat "normal" year with respect to programming, notably three on-lake surveys, the annual science workshop returning to an in-person format, and in-person school programs. However, the year was also marked by the passing of founding director Dr. Al Kristofferson—a brief tribute is included here.

Passing of Dr. Al Kristofferson

It is with deep sadness that we announce the passing of Dr. Al Kristofferson, the LWRC's founding Director, on Sunday February 26th, 2023. Al was the face and voice of the LWRC, fighting passionately to form the organization and to keep it running for over 25 years. Indeed, without Al Kristofferson, there would be no LWRC. From the halls of the Freshwater Institute where he worked as a fisheries biologist, to the offices of politicians, Al's steadfast determination to have a dedicated research vessel on Lake Winnipeg was unrelenting.

The M/V *Namao* was originally destined for disposal by Crown Assets as her career as a buoy tender for the Canadian Coast Guard (CCG) on Lake Winnipeg came to an end in 1997. However, that fate was not meant to be. The following year, Al had gathered a team of like-minded individuals to form the LWRC and, by 2002, the M/V *Namao* was ready to carry out her first whole lake, multi-season scientific expedition. In 2005, Al had negotiated the transfer of the ship's ownership from the CCG, and to this day, the M/V *Namao* has served as the main platform for science dedicated to understanding the ecological status of Lake Winnipeg.

The value of long-term, whole ecosystem science is easily overlooked or trivialized. However, as the changes in Lake Winnipeg continue—extremes in water flow, excess nutrients, the ongoing arrival of invasive species, plastic and other types of pollution—an understanding of how the whole ecosystem is responding to these changes, as well as to mitigative efforts in the watershed, is imperative to successful lake management, from water quality to the fishery. Without a dedicated research vessel, this understanding is simply not possible given the size, complexity, and precocious nature of Lake Winnipeg.

Al not only understood this, he made it happen—for that we are grateful. To celebrate his remarkable achievements and contributions, we will be holding a memorial service aboard M/V *Namao* in the summer of 2023—details to be posted on the LWRC website. Until then, we will fondly remember Al's passionate "rants" about the importance of a dedicated research vessel on Lake Winnipeg, one of the world's largest and most magnificent lakes, and continue to work with his dedication toward ensuring its protection.

PROGRAMS

Science Program

Field Program

Three surveys were successfully carried out during the 2022 field season, the first time since the pandemic began. The spring survey ran between May 30th and June 15th; the summer survey from July 20th to July 29th and August 8th to 15th; and the fall survey between September 16th and 28th. Appendix A is a map of the LWRC's station networks; Appendix B shows the ship tracks for the 2022 season; and Appendix C provides a summary of the research and monitoring activities for the 2022 field season carried out by participating science agencies. The 2022 field log is available on the LWRC's website, Documents page.

In sum, spring arrived late in Manitoba and brought with it very high water. This was in stark contrast to the drought conditions of the previous season, which left some boats in Gimli Harbour stuck in the bottom of the lake unable to leave harbour. These high flows carried considerable debris to the lake, both organic and plastic debris, floating and on shorelines, even in the most remote northern areas of the lake. The spring survey was also marked by very cold water and even a few chunks of ice that refused to melt in the north basin.

It took until 2022 for Covid to finally catch up to our Science Program, hitting us during the summer survey just after completing the north basin. The timing at least allowed us to continue the survey by workboat in the south basin with some of the remaining crew. The fall survey revealed that rainbow smelt continue their comeback with increasing catches

The high water in 2022 submerged the wharf at Pine Dock where the *Namao* routinely ties up

in the north basin. Also noteworthy were the migrating songbirds that used the ship to rest and snack on insects before resuming their journey south. There were so many at one point that the 2nd Engineer had to don eye protection during his midnight deck inspection.

The abundance of rainbow smelt, an invasive species that became an important food source for walleye in the north basin, continues to increase in the pelagic trawls after a steep decline

One of the many visitors we encountered during the fall survey

Science Workshop

We returned to an in-person Science Workshop on March 1st, 2023, held at the Qualico Family Centre in Assiniboine Park; again, the first in-person meeting since the pandemic. There were 14 speakers lined up until food poisoning and Covid reduced it to 12 speakers. Although unfortunate, it did allow for a more relaxed pace and longer discussions after two years of not convening as a science group. The talks were focused primarily on the lake science, with two exceptions from the watershed, and it was encouraging to have three student presenters ranging from undergraduate to Ph.D. candidate.

All told, the Workshop was a good first step to regaining some level of momentum and dialogue among those working on Lake Winnipeg. Starting in the watershed, the first two presentations demonstrated the importance of land use, whether urban or rural, in the management of surface waters, especially in the Red River Basin with respect to Lake Winnipeg's water quality. We then moved closer toward the lake with presentations that aimed to further refine estimates for Lake Winnipeg's phosphorous budget, notably the amount of phosphorous sequestered in the sediments of the Netley-Libau marshes and therefore not reaching the lake itself, and the phosphorus contributed directly to the lake by atmospheric loading. Once in the lake, speakers took us from the spatially diverse nearshore area to the big picture perspective of whole lake modeling, which has begun to explore data-driven machine learning models. We were then updated on the stock status of the three commercial fish species caught under the quota system—walleye, sauger, and lake whitefish—using traditional gillnetting methods, and a new non-invasive technique using environmental DNA (eDNA) was presented. Diving deeper into our understanding of the fishery was a presentation on lake whitefish migration behaviour using telemetry, and an update on the status of the pelagic fish community—the small fish that ultimately feed the economically valuable quota species. Moving down the food web to water quality itself, updates included the provincial water quality monitoring program and a student metagenomic project aiming to describe the structure of cyanobacterial populations in and around Lake Winnipeg. We ended the day with the carbon budget, notably an update of an

ongoing study examining inorganic carbon and greenhouse gas production in Lake Winnipeg. Abstracts and the Agenda can be found in Appendix D and E, respectively.

Other Science Activities or Initiatives

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 several 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 and aboard the M/V *Namao*. In addition to improved access to data, establishing this "ship to database" 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. Moreover, establishing a robust data management process for the LWRC's Science Program also contributes to the LWRC's succession planning.

The beta phase of the platform is now complete, and data and other products are accessible to users here. Datasets currently include Seabird rosette data (2008 to present), field logs (2007 to present), Automated Voluntary Observing Ship (AVOS) meteorological data (2010 to present), and ODAS meteorological buoy data (various years depending on basin).

Education Program

Field Programs

The LWRC's Education Program provides unique opportunities for hands-on, experiential learning for students from Grade 3 to university. Our keystone program, the ***Lake Ecology Field Program***, takes place during the school year aboard the M/V *Namao* and is aimed at students in Grades 8 to 12, but is available to university students as well. Due to the remote learning restrictions imposed during the Covid-19 pandemic, the *Lake Ecology Field Program* has not been offered in recent years. This hiatus, however, has allowed time to re-evaluate programming and develop 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 new shore-based education program that combines sport, science, and art, all in one program. *Sail and Science* is aimed at students from Grades 3 to 7 and is offered during the summer as a 5-day camp in conjunction with the Gimli Yacht Club's (GYC) *Learn to Sail Program*. Kids learn to sail in the mornings with the GYC. After lunch (provided by the Kiwanis Club of Gimli), they explore the lake ecosystem, and how it is changing, with microscopes and sampling equipment commonly used aboard the M/V *Namao*. Art is used daily to unwind after a long day of being outside and to revisit and reinforce the scientific and ecological concepts being learned using a different part of the brain.

Components of the Lake Winnipeg food web—diatoms, blue-green algae, zooplankton, a snail, and fish—along with a few undesirables, like face masks and microplastics, that find their way into lakes (made from sculpting clay)

Using a microscope to examine the algae and zooplankton in Lake Winnipeg

Taking a sediment sample to study the organisms (“benthos”) that live in the bottom of the lake

Making a mosaic walleye at the end of a long day

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 have an opportunity to join the science team for a half day on board M/V *Namao* during the summer survey to participate in some of the research and monitoring. The winner is also invited to showcase their project at our Open House on the ship.

The 2022 Water Award recipient was Grade 9 student Emma Strachan for her project simply entitled "*Microplastics*". Ella started her project during the summer at her cottage where she designed, constructed, and deployed a microplastics trap. During the winter months, she analyzed her water samples and characterized the microplastics found. Congratulations Emma on carrying out an innovative and inspiring project.

Emma on board the M/V *Namao* helping to sort forage fish

SHIP OPERATIONS (Ryan Johnson)

Prepared by Ryan Johnson, Superintendent of Ship Operations

The new engines have proven to be more efficient than the previous engines. The previous engines would consume as much as 5 liters of lube oil per day each and the new engines did not consume any oil for the entire season. The new engines are more environmentally friendly than the previous engines due to the advanced technology of the new engines. The new engines also have an aftertreatment system for the exhaust which reduces the NOX gasses by up to 87 % from the already more efficient new engines.

The previous engines required a disassembly and inspection due to Transport Canada regulations every 5 years at an continually increasing cost of around $150,000.00 per engine. The new engines now have a manufactures recommended time between overhaul of 10,000 hours. With the Namao only operating the engines for approximately 500 hours per year we will not be required to disassemble the new engines for inspection for many years.

The Namao had grounded in the fall of 2018 and sustained a fracture of the hull plating in the engine room which led to water entering into the engine room. The fracture was temporarily repaired with a patch which allowed us to finish the 2018 season. This temporary repair was to be permanently repaired along with some other areas of the hull, identified during the drydocking inspection in the spring of 2018, which have shown thinning due to corrosion. Due to low water levels, Covid , and the unavailability of the dry dock these repairs have not been completed. With the cooperation of the local Transport Canada office, we had been luckily granted permission to continue to operate the Namao to carry out our research on Lake Winnipeg up until now. However, we have exhausted all possible extensions and options to continue to operate without completing the repairs. We are now required to have the Namao hauled out of the water and have all repairs completed before we continue to operate.

We are currently in a position of waiting for the availability of the dry dock facility in Hnausa which is owned and operated by Freshwater Fish. Currently the dry dock is occupied by the vessel owned by Freshwater Fish and is undergoing major repair of damage sustained during

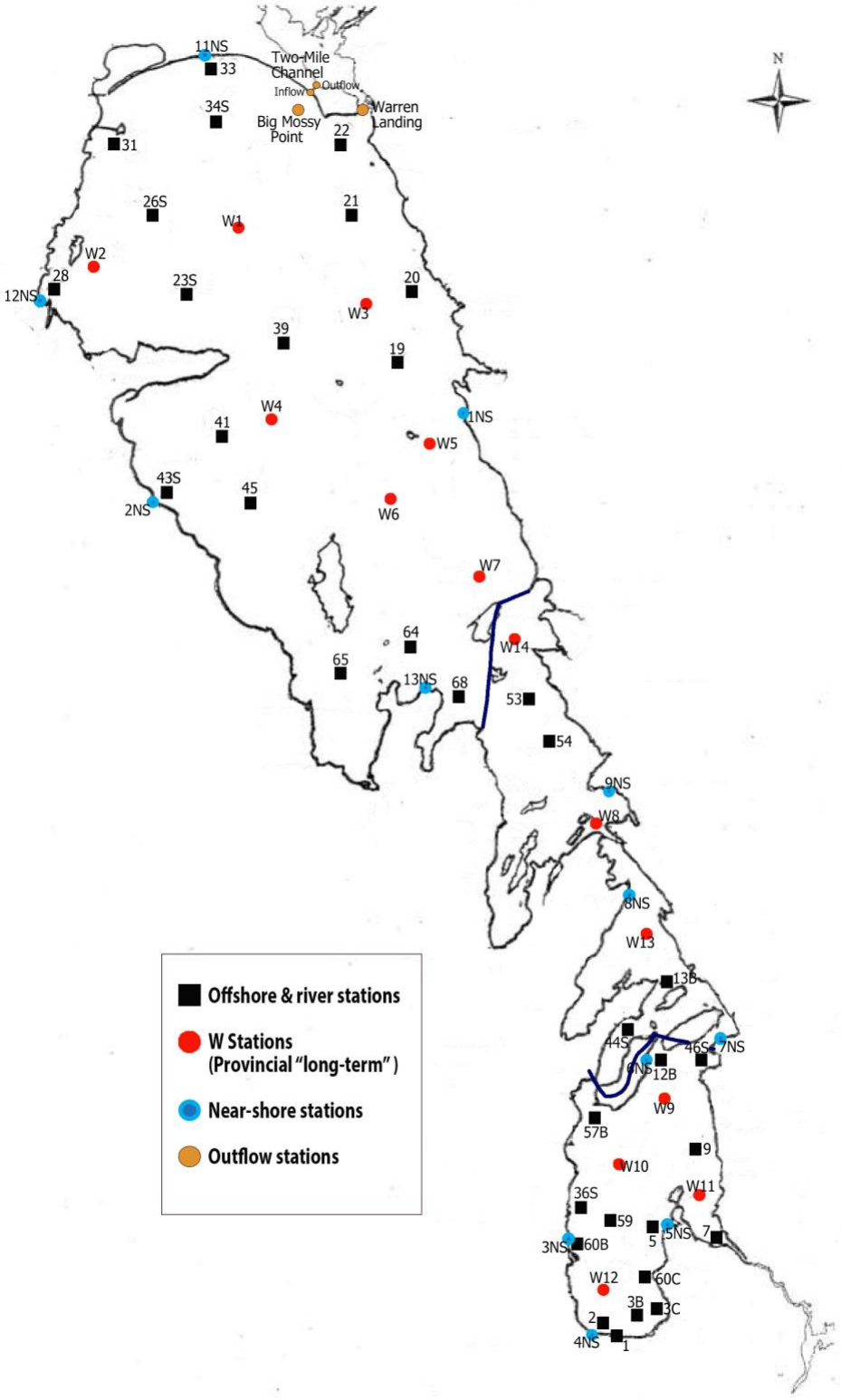
an explosion on their vessel while in dry dock in the spring of 2022. Also the local company which we contracted in the past to complete the work on the Namao is not currently able to work on the ship. We have been in contact with a company out of Ontario which has experience working on ships and knows the requirements for the repairs of the hull plating. We are hopeful that the dry dock will be available by the end of May and that the repairs can be completed within 10 weeks of the ship being hauled out of the water.

The 2022 season we also saw our Regular Captain Walter Lea unavailable and Caitlin Simpson who previously sailed as Chief Mate was able to step up into the Captains position and we were able to operate for all 3 surveys. Walter Lea will be returning as Captain for the coming season. We have a number of local crew members which will work in the position of Deckhand, these members will require Transport Canada mandated training to continue to work this upcoming season.

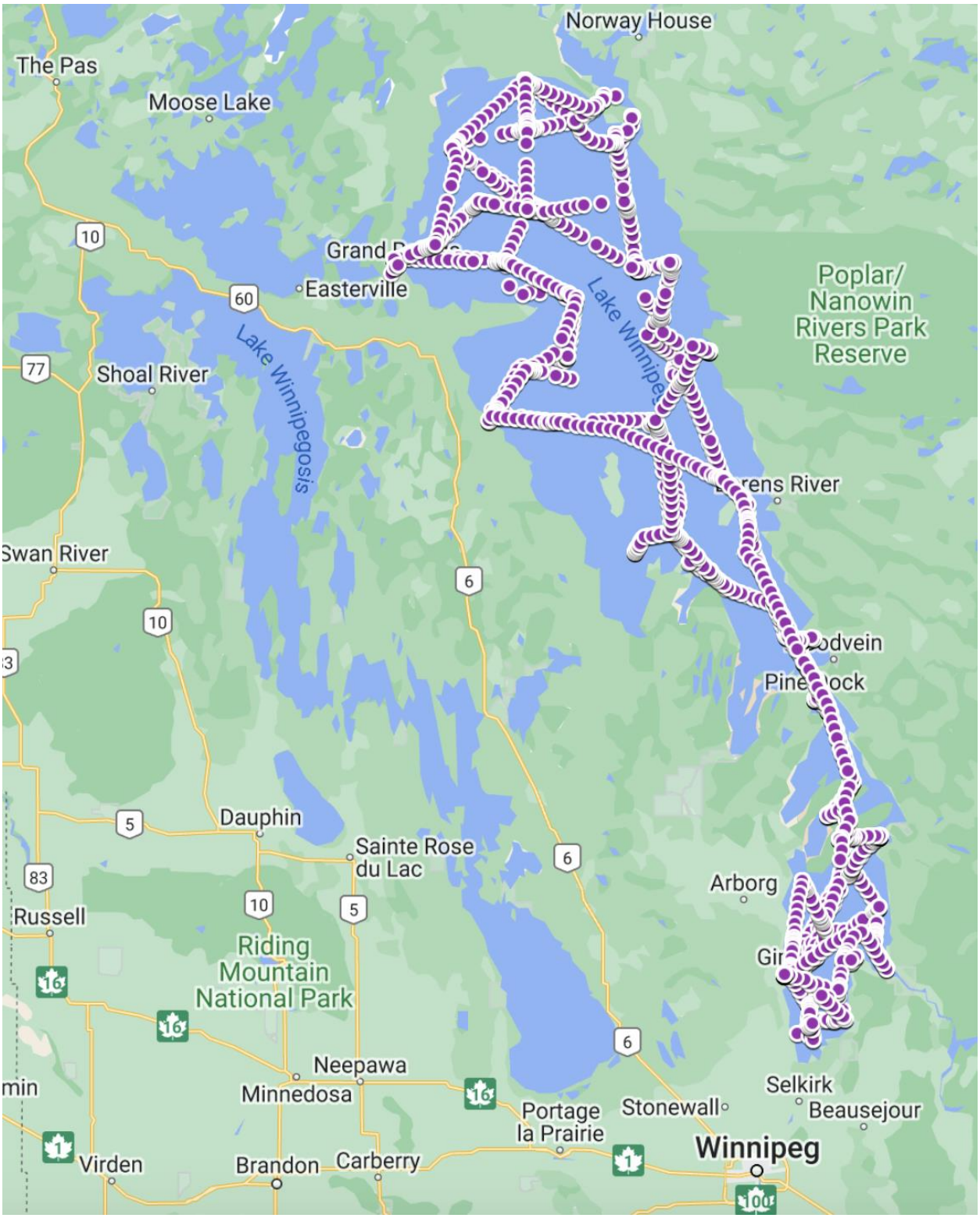
Captain Caitlin Simpson in the wheelhouse of M/V *Namao*

APPENDICES

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



Appendix B. Tracks of M/V *Namao* during the 2022 field season



Appendix C. Research and Monitoring Activities during the 2022 field season

Agency	Lead	Project	Survey	Details
Environment & Climate Change Canada	Yerubandi, Valipour	Moorings	Spring	Retrieve mooring 505 Deploy moorings 500, 502, 505
	Koehler	Stable isotopes	Spring	Water (all offshore) and zooplankton (W stations)
	Depew	Internal phosphorus loading	Spring	Sediment cores at stations W1 and W10
Manitoba Agriculture and Resource Development	Morison	Long-term water quality monitoring of Lake Winnipeg	All	**All offshore, nearshore and outflow stations** - nutrients, chl-a, other chem, vertical depth profiles of light, dissolved oxygen, temp, turbidity, conductivity (Seabird), *E. coli*. **14 long-term stations** – as above with metals and major ions, Hg, whole water phytoplankton for id, biovolume estimates & enumeration, macroinvertebrate samples (triplicate, spring only), surface sediment samples (summer only) for metals, nutrients, organic content, and particle size analysis (percent sand, silt, and clay). **Three stations nearest the inflow of the Red, Winnipeg, and Saskatchewan rivers** - pesticides (summer only starting 2013). **Blooms** - microcystin-LR and cyanobacterial cell counts
	Morison	Nearshore water quality monitoring	All	**Nearshore stations at 2m depth** - general chemistry, N and P (total particulate and dissolved), chlorophyll, TSS, turbidity, PAR, calcium

Agency	Lead	Project	Survey	Details
	Janusz	*Bythotrephes* monitoring	Summer Fall	Two vertical zooplankton hauls taken at all stations - 64 µm mesh size - composited. Samples taken from 1 m off the lake bottom
Fisheries & Oceans Canada	Watkinson	Forage fish trawl	All	43 offshore stations
Manitoba Hydro	Chaze	CAMP/MB Hydro	All	Warren Landing, Two-Mile Channel (inflow and outflow), station 22, Big Mossy, Playgreen (summer)
University of Manitoba	Papakyriakou	Carbon biogeochemistry and air-lake CO_2 exchange	All	Surface and bottom water samples select stations - offshore and nearshore
	Collins	Cyanobacterial genomics	Summer Fall	All stations
	Goharrokhi	Sedimentation	Summer Fall	Off station sediment (ponar) x6
U of British Columbia	Murch	BMAA and isomers	Summer Fall	Algal blooms

Appendix D. Science Workshop Abstracts

The full extent of surface waterways in the agricultural landscapes of the Red River Basin and their role in the delivery of water, sediments, and nutrients to Lake Winnipeg

David Lobb and Brendan Brooks

Water, sediments, nutrients, and associated contaminants are largely delivered to Lake Winnipeg via surface waterways. Although the focus of interest and research has been on the major rivers, such as the Red River and Assiniboine River, a vast network of surface waterways connects the land to these waterways and, ultimately, Lake Winnipeg. Over the past several years, many student research projects have been carried to assess the extent of surface waterways within the landscapes of agricultural watersheds in the Red River Valley. Results of this study clearly demonstrate the intimate connection between agricultural activities on the land and surface waterways, beginning with surface drainage within fields, and drainage ditches within and around farms. The conclusion of this work reinforces the fact that the most efficient approach to managing surface waters is to focus efforts on the land.

Characterization of surface water salinity in the Lake Winnipeg Watershed 2020-21

Braedon Humeniuk, Jose Luis Rodriguez-Gil, and Mark Hanson

The concentrations of salts in freshwater systems have been increasing globally (from both natural and anthropogenic sources), making the ecological impacts of salinization a pressing concern. We are interested in characterizing the current state of salinity and salinization in the Lake Winnipeg watershed, as evaluated through the lens of a community-based monitoring (CBM) program. Volunteers gathered samples over two field seasons (2020 and 2021), from more than 130 sites across Manitoba, northwestern Ontario, and North Dakota. The exposure concentrations were compared with freshwater chloride toxicity data to assess the risk to sensitive species. As well, these data were used in conjunction with land-use data and other geographically explicit datasets to determine the possible sources and drivers of salinity in the Lake Winnipeg watershed. During the 2020 and 2021 field seasons, multiple sites exceeded the Long-Term Canadian Water Quality Guideline for the Chloride Ion and the United States Environmental Protection Agency's National Aquatic Life Criteria for Chloride (>500 mg/L of chloride). Sites that experienced the greatest salinity levels were in the Red River Valley and near the city of Winnipeg, Manitoba, suggesting that anthropogenic factors may be driving salinity in these regions. Future work includes analyzing samples from the 2022 field season, collecting additional exposure data in 2023 and 2024, identifying factors that may influence effective volunteer participation in CBM programs, generating species sensitivity distributions (SSDs) using available chloride toxicity data, developing a standard laboratory test protocolfor wild rice (*Zizania palustris*), and determining if the generated SSDs and wild rice results are reliable for risk assessment using mesocosm (e.g., model wetland ecosystem) studies.

Nutrient sequestration in the Netley Libau marshes

Greg McCullough

Coastal wetlands are often assumed to sequester nutrients, either directly during water exchange with the lakes they border, or by intercepting flow from the watershed. This may be the case with the Netley-Libau marshes (NLM) through which the Red River passes before flowing into Lake Winnipeg. However, how much phosphorus they may sequester remains at best uncertain, or more honestly, unknown. One current estimate is 80 tonnes P/y estimated by influx/outflux observations in a small sub-region (unpublished data from the Demo Channel Study, multiple authors). In this presentation, a mass sedimentation rate estimated for Netley Lake is combined with suspended solids phosphorus concentration data to present an alternative estimate of phosphorus deposition in the marshes. Goharrokhi et al. (2021) estimated that ~900,000 tonnes/y of sediment are deposited in the marshes, most of which is deposited in Netley Lake. This value is supported by data from a GSC core (Nielsen et al. 2003) and by repeated bathymetry (Schilberg and Clark, unpublished). If the phosphorus concentration in these sediments is similar to the 548 mg/mg in bottom sediments in eastern Libau marsh lakes (Ackerman 2007) this sedimentation rate would support 450 tonnes/y phosphorus diverted into NLM sediments, that is, 9% of the annual mean load measured in the Red River at Selkirk. I conclude this presentation with recommendations for a program to improve current estimates of watershed-sourced sediment and nutrients intercepted in the NLM.

Atmospheric deposition of phosphorus into Lake Winnipeg: application of different scenarios

Masoud Goharrokhi, Greg McCullough, David Lobb, Phil Owens, and Alexander Koiter

Based on the most recent State of Lake Winnipeg report (2020), the estimate of phosphorus loading into Lake Winnipeg from direct atmospheric deposition is about 500 t yr^{-1} (20 kg TP km^{-2} yr^{-1}). This value, which is about 7 % of the total annual load, is derived from a single study of a small lake in Alberta in the 1980s (i.e., Narrow Lake, surface area = 1.1 km^2). This ongoing research endeavours to verify and improve the accuracy and precision of the current estimate of atmospheric deposition of phosphorus into Lake Winnipeg. A comprehensive review will be conducted of existing, relevant published data on the production, transport, and deposition of sediment/dust/smoke and associated phosphorus over land and water surfaces. The global database used in this presentation includes data for more than 400 sites (including the Laurentian Great Lakes) and covers the period 1954 to 2021. Using data and approaches available in the literature, a transport model is developed and used to estimate the atmospheric loading of phosphorus for Lake Winnipeg under different scenarios. Recommendations for future assessment of atmospheric deposition of phosphorus into Lake Winnipeg are also discussed.

Lake Winnipeg nearshore water quality monitoring by Environment and Climate Change Canada Hudson Bay Water Quality Monitoring and Surveillance

Allison Waedt and Elise Watchorn

Water quality monitoring of five nearshore sites in the South Basin of Lake Winnipeg started in 2009. In 2017, sampling parameters were expanded, sampling frequency increased, and the number of sites increased to examine a wider geographic range of the lake including four sites in the narrows and North Basin of the lake as well as four sites in the Netley-Libau Marsh. Using standard field techniques, a variety of water and biological samples are collected to describe the littoral environment of the lake. Preliminary analysis of the water transparency parameters suggests that water clarity is affected by proximity to shore, dominant substrate and the overall basin of the lake. A preliminary analysis indicates that nearshore zooplankton communities also vary spatially especially across the difference basins of the lake. This data provides new insight to the aquatic community in various littoral areas of the lake and marsh, an otherwise understudied part of the overall aquatic ecosystem of Lake Winnipeg.

Lake water quality modeling in Lake Winnipeg

Shuqi Lin, Jun Zhao, and Yongbo Liu

Lake Winnipeg has experienced accelerated nutrient loading and an increase in algal bloom over the last two decades due to intensified agricultural and urban watershed development and changing hydrology.

The thermal structure and circulation pattern in Lake Winnipeg have been well simulated via a process-based three-dimensional lake model (AEM3D). Based on the hydrodynamic process simulations, we extended the modelling to the biogeochemical processes and water quality in the lake. Since the limited and unevenly distributed river nutrient loading monitoring data, previous process-based lake models either make linear interpolation on river nutrient observations or use the outputs from watershed models, which only cover parts of the rivers and need heavy calibration work. Here, we explored the possibility of using data-driven machine learning models to fill the gaps in river nutrient loading observations and investigate whether this technique can improve the accuracy of process-based lake model and the uncertainties coincided with that. The successful application of this technique could benefit water quality hindcast and forecast in various lake systems.

Stock assessment results for Lake Winnipeg's three commercial quota species

Geoff Klein

A stock assessment of the three Lake Winnipeg commercial quota species; Lake Whitefish, Sauger, and Walleye was completed in August 2022.

Whitefish were assessed as five separate stocks based on past studies and recent age demographics. Limited biological data were available, so whitefish stocks were assessed using

surplus production modelling. Modelling produced a mix of results where one stock was neither overfished, nor was overfishing occurring, but the remaining four stocks were over fished, and overfishing may be occurring in three of those stocks.

The Sauger stock in the south basin and channel area is collapsed. Although it is in an overfished condition, overfishing is no longer occurring following the increase in the minimum allowable mesh size. In the Walleye fishery, overfishing was just barely occurring in 2021 at the end of a slow growth regime under the larger minimum mesh size. Growth rates are recovering in Lake

Winnipeg Walleye as forage species' numbers improve. Under a faster growth regime, overfishing is expected to increase.

Tracking Lake Winnipeg fish stocks using two monitoring techniques: gillnetting and environmental DNA (eDNA)

Katrina Audet, Arfa Khan, Caleb Hasler and Margaret Docker

Annual monitoring of Lake Winnipeg's fish stocks is traditionally carried out by gillnet index surveys. Environmental DNA (eDNA) is a non-invasive technique where fishes' genetic materials are collected through water samples and tested for the presence of the target species' DNA using species-specific TaqMan probe-based quantitative polymerase chain reaction (qPCR) assays. In this study, both monitoring techniques will be compared in terms of their detection capabilities of eight fish species, costs, and estimating the relative abundance of fish stocks. The eight fish were selected based on their: importance in recreational and commercial fisheries; economic value in Manitoba; value as a prey species; or characteristics making them harder to detect (e.g., small body size, habitat preferences).

Pelagic fish survey 2002-2022

Doug Watkinson, Eva Enders, Chelsey Lumb, and Lee Gutowsky

Lake Winnipeg has undergone extensive changes in environmental conditions and fish community structure during recent decades. Several factors all have the potential to impact the native fish community, including cyanobacteria, invasive species, eutrophication, flow regulation, fishing pressure, and climate change. To study the pelagic fish community a 3 m beam trawl has been deployed in daylight hours from the Motor Vessel Namao from 2002-2022, during the spring, summer, and fall cruises. In total, >2300 trawls have been conducted, collecting ~4000 kg of fish, represented by 33 species. Five species dominant the catch, Emerald Shiner, Cisco, Rainbow Smelt, Walleye, and Yellow Perch. Since 2016, Rainbow Smelt have been nearly absent from the catch (completely absent in 2017) with the potential beginning of a recovery in 2021 and 2022. There has been a general decline in the CPUE for all species over the 21-year sample period.

Missing the boat? Migratory timing and escapement of south basin Lake Whitefish stocks in Lake Winnipeg

Doug Watkinson, Colin Kovachik, Geoff Klein, Eva Enders, and Lee Gutowsky

Lake Winnipeg supports one of North America's largest commercial fisheries for Lake Whitefish. Despite the species' importance to the local economy, communities, and aquatic ecosystem, little is known about swimming behaviour and habitat use here. Moreover, Lake Winnipeg offers a unique opportunity to study Lake Whitefish behaviour in a large waterbody (25,000 km^2) outside of the Laurentian Great Lakes. In 2021, 80 Lake Whitefish were tagged with acoustic telemetry transmitters and tracked for nearly one year across a grid-array covering ~ 10,000 km^2 of Lake Winnipeg's North and South Basins. Tagging was split evenly between fish captured from the Red River (n = 40) and Winnipeg River (n = 40). Preliminary analyses indicated that both tagging groups embarked on a migration of 300 km or more into the North Basin. However, fish tagged in the Winnipeg River appeared to move toward the North Basin slightly earlier than conspecifics tagged in the Red River. These behaviours including newly documented long-distance migration in Lake Winnipeg further underscore the seasonal differences and ecological importance of the two major basins to Lake Whitefish stocks in the south.

Seasonality of opportunistic algal bloom sampling on Lake Winnipeg: matching sampling periods with peak bloom intensity & extent

Matt Morison, Emilio Enriquez, Kelly-Anne Richmond, and Desiree Stratton

Since 1999, Manitoba Environment and Climate has been monitoring the health of Lake Winnipeg in partnership with the Lake Winnipeg Research Consortium Inc. (LWRC), Manitoba Hydro, and other collaborators. The objective of the provincial Lake Winnipeg Water Quality Monitoring Program is to understand better the existing condition of the lake, 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, carbon constituents, pesticides) and biological (e.g., *E. coli*, chlorophyll *a*, algae ID and the algal toxin microcystin) parameters. During the open water season (i.e., spring, summer, and fall), water samples are collected from up to 55 stations (near shore, offshore, river mouths, outflows) on Lake Winnipeg via the *MV Namao* or workboat. Sediment chemistry and benthic invertebrate species composition and enumeration samples are also collected during the open water season 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. Information collected as part of the provincial Lake Winnipeg Water Quality Monitoring Program is also required to support reporting requirements under The Water Protection Act. Data collected also provide key information to support current and future research on Lake Winnipeg. This presentation will include reporting on the routine monitoring program. In

addition, satellite observations of algal bloom extent, intensity, and severity from the Government of Canada EOLakeWatch program are employed to determine how historical sampling frequency is related to periods of peak bloom severity, with implications for understanding how whole-lake estimates of bloom status and nutrient concentrations may be sensitive to sampling design.

Manitoba watersheds metagenomics project

Kallie Strong and Eric Collins

Cyanobacteria blooms in Lake Winnipeg have been a growing concern in recent years due to their potential to produce harmful toxins and negatively impact the lake's ecosystem. Research has focused on understanding the drivers of cyanobacteria blooms in the lake and identifying strategies to manage them, prompting the need for effective monitoring tools. Nanopore sequencing is a relatively new technology that has the potential to revolutionize water quality monitoring by enabling high-throughput sequencing of water samples in real-time. We collected water samples from various locations in the Lake Winnipeg watershed in 2022 and received samples collected from Lake Winnipeg aboard the R/V Namao during the cyanobacteria bloom season and will be performing long-read metagenomic sequencing using the Oxford Nanopore Technologies MinION to delineate cyanobacterial population structures and detect toxin biosynthetic genes.

Inorganic carbon cycling and greenhouse gas production in Lake Winnipeg (2018 – 2022)

Daniel Gedig and Tim Papakyriakou

Since 2018 water samples have been collected for inorganic carbon analyses from Lake Winnipeg as part of the MV Namao and Provincial water sampling programs. Data are collected to better understand both the Lake's carbon budget and carbon dynamics (transformations, emissions and export). Here we report on observed spatiotemporal variability in water total alkalinity (TA), the partial pressure of CO_2 (pCO_2), dissolved inorganic carbon (DIC), associated and $d^{13}C$ of measured DIC. Seasonally low values in TA were observed in the spring season and notable in the data are contrasting TA among large rivers entering the lake. Supporting previous studies, little spatial patterns in pCO_2 were observed. While both DIC were marginally lower in the south basin relative to the north basin, large differences in $d^{13}C$-DIC between basins were observed. We suggest the differences in the isotopic signature of DIC between basins is the result of different algal dynamics. The analysis to date has been fairly superficial. Additional analyses are needed.

Appendix E. Science Workshop Agenda

AGENDA
Science Workshop

Lake Winnipeg Research Consortium Inc.
Qualico Family Centre, Assiniboine Park
March 1st, 2023
8:30 AM to 4:30 PM

Welcome
Karen Scott[1]

PRESENTATIONS 8:40 – Noon
The full extent of surface waterways in the agricultural landscapes of the Red River Basin and their role in the delivery of water, sediments and nutrients to Lake Winnipeg David Lobb[2], Brendan Brooks[2]
Characterization of surface water salinity in the Lake Winnipeg Watershed 2020-21 Braedon Humeniuk[3], Jose Luis Rodriguez-Gil[4], Mark Hanson[3]
Nutrient sequestration in the Netley Libau marshes Greg McCullough[5]
COFFEE BREAK
Stable isotope isoscapes Geoff Koehler[6]
Atmospheric deposition of phosphorus in Lake Winnipeg: application of different scenarios Masoud Goharrokhi [2], Greg McCullough[5], David Lobb[2], Phil Owens[7], Alexander Koiter[8]
Lake Winnipeg nearshore water quality monitoring by Environment and Climate Change Canada Hudson Bay Water Quality Monitoring and Surveillance Allison Waedt[9] and Elise Watchorn[9]
Lake water quality modeling in Lake Winnipeg Shuqi Lin[10], Jun Zhao[10], Yongbo Liu[10]
LUNCH
PRESENTATIONS 1:00 PM – 4:30 PM
Lake Winnipeg quota species stock assessment results Geoff Klein[11]

Tracking Lake Winnipeg fish stocks using two monitoring techniques: Gillnetting and eDNA

Katrina J. Audet[12], Arfa Khan[12], Caleb Hasler[13], Margaret Docker[12]

Missing the boat? Migratory timing and escapement of south basin Lake Whitefish stocks in Lake Winnipeg

Doug Watkinson[14], Colin Kovachik[14], Geoff Klein[11], Eva Enders[14], Lee Gutowsky[14]

Lake Winnipeg pelagic fish trawl program

Doug Watkinson[14], Eva Enders[14], Chelsey Lumb[14], Lee Gutowsky[14]

COFFEE BREAK

Seasonality of opportunistic algal bloom sampling on Lake Winnipeg: Matching sampling periods with peak bloom intensity & extent

Matt Morison[15], Emilio Enriquez[16], Kelly-Anne Richmond[15], Desiree Stratton[15]

Metagenomic analysis of Lake Winnipeg microbial communities

Kallie Strong[3], Eric Collins[3]

Inorganic carbon cycling and greenhouse gas production in Lake Winnipeg

Daniel Gedig[5], Tim Papakyriakou[5]

LWRC Updates

SWOT Exercise – Gordon Goldsborough[1]
Field Season 2023 – Ryan Johnson[1] and Karen Scott[1]

Affiliations

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[6] Stable Isotope Laboratory, National Hydrology Research Centre, ECCC (Saskatoon)

[7] University of Northern British Columbia, Prince George

[8] Brandon University, Brandon

[9] Water Quality Monitoring and Surveillance, Environment and Climate Change Canada (Winnipeg)

[10] Canada Centre for Inland Waters, Environment and Climate Change Canada (Burlington)

[11] Fish and Wildlife, Manitoba Natural Resources and Northern Development

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