Lake Winnipeg Research Consortium Inc.

2012 Annual Report

Science and Education Programs

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INTRODUCTION

The Lake Winnipeg Research Consortium (LWRC) Inc. was founded in 1998 to address the need for scientific studies on Lake Winnipeg following evidence of water quality deterioration related to the 1997 Red River flood. The LWRC was incorporated in 2001 and received charitable status in 2008.

The year 2012 marks the 10th year that the LWRC's **Science Program** has enabled whole lake, multi-season scientific surveys on Lake Winnipeg by providing the Motor Vessel (M.V.) *Namao* as a sampling platform to various agencies carrying out research and monitoring. In addition to coordinating three scientific surveys at over 65 lake-wide sites annually, recent effort is aimed at facilitating non-routine, off-station projects. The LWRC Science Program also includes an annual ***Science Workshop*** where results derived from the on-lake research and monitoring are presented by the respective agencies to gain an improved understanding of the status of Lake Winnipeg. In recent years, the structure, format and venue of the Science Workshop have changed in an effort to promote dialogue and the synthesis of knowledge gained in the last 10 years. Lastly, in 2011, the LWRC created an annual ***Scholarship*** for honours and graduate students working on Lake Winnipeg and its watershed. In addition to supporting student research, the scholarship aims to attract more members of the academic community. In 2012, there were six graduate students at various stages of their programs working on Lake Winnipeg.

The LWRC also has a formal **Education Program** aimed primarily at Grades 8 to 12, but includes Grade 2 up to fourth year University. Most noteworthy is the ***Lake Ecology Field Program***, which takes place in the spring and fall on-board M.V. *Namao.* This hands-on learning opportunity includes the use of a variety of sampling and analytical equipment, as well as microscopes and taxonomic keys. For teachers who wish to introduce Lake Winnipeg into the classroom environment without leaving the classroom, the LWRC Education Program is developing a series of "out of the box" ***Web-based Resources***, as time and funding permit. Lastly, the LWRC has a ***Special Projects*** *Program* designed to facilitate or provide support to water-related grassroots initiatives, in both the arts and sciences.

The LWRC website (www.lakewinnipegresearch.org) continues to serve as the primary repository for information related to both the Science and Education Programs. As well, the website is populated with information suitable for the general public, such as the ***Image Library*** and ***Satellite Image Blog***, found at www.lakewinnipegresearch.org/blog. This resource is intended to explore the Lake Winnipeg ecosystem through imagery, including satellite images, aerial photographs, microscopy, student art, and data.

This report summarizes the activities of the Science and Education Programs, including the Science Workshop, open water season, scholarship recipients, the Lake Ecology Field Program, and some of the Special Projects that took place in 2012.

SCIENCE PROGRAM

Science Workshop

The 2012 Science Workshop was held on April 24th and 25th at the Siobhan Richardson Field Station, Fort Whyte Centre in Winnipeg. The venue, being somewhat remote and self-contained in nature, was chosen deliberately in an effort to promote participation and dialogue among invitees both during and between workshop sessions. The primary objective of the workshop was to evaluate research progress within the context of moving forward toward an improved understanding of the Lake Winnipeg ecosystem despite diminishing scientific capacity on the lake.

Workshop Structure

To accomplish the workshop objective, the workshop was divided into two sections - Where we are (Day 1) and Moving forward (Day 2) (Appendix A - Agenda). Day 1 was largely spent on science and monitoring updates, with the remaining time used to discuss successes and obstacles to success. Day 2 began with a presentation on the development of eutrophication indicators followed by a comprehensive review of projects being undertaken in the upcoming field season.

The structure of the workshop again deviated from the traditional format of presentations followed by questions. Indeed, there were only two formal presentations - one on the stock status of the commercial species (Day 1) and the other on eutrophication indicators (Day 2). Instead, participants provided key updates on their research and monitoring activities. This approach was taken for two reasons, notably to emphasize dialogue and discussions, and to build on and maintain continuity from the previous year's workshop; a considerable undertaking that resulted in the report entitled *State of the Science: What is the scientific basis for understanding and protecting Lake Winnipeg?* Given that the 2011 and 2012 workshops were integrally linked, it is recommended that interested readers review the aforementioned 2011 *State of the Science* report, available on the LWRC website.

Pre-Workshop Preparation

Prior to the workshop, participants were asked to provide an update on the status of their research or monitoring projects and submit a few key slides of accompanying data (Appendix B). The information submitted was then collated and integrated with the summary tables produced for the 2011 *State of the Science* report referred to above. This interim table served as the framework within which the ensuing 2012 science and monitoring updates took place on Day 1, and ultimately became Table 1.

Day 1 – Science and Monitoring Updates

Fish Communities (Proposal F1)

Index Netting

Geoff Kline (Fisheries Branch) was the only speaker invited to give a full presentation for the science updates on Day 1. Entitled *Lake Winnipeg Fisheries: What I Think We Know*, the presentation outlined the histories of the Provincial Index Netting Program and current quota system that guides the fishery on the lake. In addition, Kline discussed the status of the three commercial species that are regulated by quota (lake whitefish, walleye and sauger), provided a brief summary of the status of the eco-certification process for the Lake Winnipeg commercial fishery, and ended with an update on the female spawning study. The full presentation can be found on the LWRC website.

It is apparent that there is a lack of capacity in terms of Fisheries Branch personnel and funding to collect important data that could add considerably to understanding the impact of multiple stressors on the lake, such as eutrophication and aquatic invasive species. For example, of the three quota species, the least is known about lake whitefish despite its importance as a sentinel species. This is likely not going to change in the future as no new data for lake whitefish have been collected since 2000 when the whitefish index-netting program ended. As a bottom feeder, lake whitefish will likely be among the first species to be affected by changes in the benthic community, as well as by the presence of zebra mussels and spiny water flea, two aquatic invasives. In addition, there can be considerable by-catch in the index-netting program but time constraints of Fisheries Branch personnel limit the characterization of these fish to being counted by mesh and bulk weighed - no individual data are collected. Further, the index-netting program has reasonable coverage in the near-shore fishery but not the north basin pelagic area or east side of the lake. These are areas that could be accessed via the M.V. *Namao*; however, there is no manpower to fill a berth on the ship.

To compound the issue of capacity, there is currently no quantitative, long-term fisheries dataset for Lake Winnipeg. The Provincial index-netting program was interrupted in the early 2000s due to staffing and methodological changes. For this reason there is a sizable gap in the Provincial data set and in some instances, two datasets that are difficult to compare. In terms of commercial data, the Freshwater Fish Marketing Corporation maintains the longest dataset for fish harvested from Lake Winnipeg. However, despite going back over 100 years, these data include no measure of effort, apart from deliveries, making it difficult to evaluate the fishery quantitatively.

An important consequence of these shortcomings is that there remains a low level of understanding of trophic relationships and the drivers of fish productivity. Thus, establishing a balance between lake productivity, through phosphorus abatement actions in the watershed, and a productive fishery will be difficult, if not impossible.

Trawling

Chelsey Lumb (Fisheries Branch) provided a preliminary comparison of the forage fish biomass data collected during day and night trawls in the south basin (August 2 and 3, 2011) and north basin (July 25 to 27, 2011). In this study, surface, mid and deep water trawls were conducted along three transects. In addition, temperature, dissolved oxygen, conductivity and turbidity profiles were taken from surface to bottom at 0.1 metre increments at the start of each transect. The data presented included the catch composition for all species caught in the nine day and night trawls in each basin. Analysis of variance was used to determine if there was a significant effect on biomass of diel period or trawl depth of the six most commonly caught species in trawls (Appendix B). The next step of this project will be to look at environmental factors and variation to see how they drive the forage fish biomass. Additional day/night trawls coupled with hydroacoustics will take place in 2012 in addition to the day trawls that have been routinely carried out at each station during the research surveys since 2002 (Table 2 - Field Studies).

Pelagic otter trawls were conducted by Environment Canada at three stations in 2010 and the data are on the data portal. There are no plans to continue otter trawls as part of EC's 2012 field season despite its value in providing a more complete picture of the fish community.

Fish Diets

Two graduate student projects will contribute to this area and ultimately to knowledge on food web dynamics and energy flow in Lake Winnipeg. Katie Sheppard (University of Manitoba) provided a brief overview of the status of her Master's thesis project that is examining the diet, growth, and condition of walleye (normal and dwarf morphotypes) and sauger, as well as their prey in Lake Winnipeg. Ultimately, these factors will be modeled using a Wisconsin bioenergetics model. Andrew Olynyk (University of Manitoba) is aiming to determine the effects of the invasive rainbow smelt on the food web, especially its interactions with the zooplankton community and cisco, a native species to Lake Winnipeg. The study could also provide insight into the influence of rainbow smelt on zooplankton grazing and ultimately on the proliferation of algal blooms in the north basin. At the time of the workshop, all field work for these two projects was completed and data analysis was in progress. Thus, the data presented at the workshop were few and in the early stages of interpretation (Appendix B). The final defenses of these ambitious projects will take place in early 2013.

Spatial Considerations

Efforts between the Freshwater Fish Marketing Corporation and north basin fishers, with guidance from Fisheries Branch, to acquire whitefish data through a *Whitefish Index-Netting Program* (described previously in the *State of the Science* Report) were not successful in 2012.

Sources of Mortality (Proposal F2)

No new information was available on the partitioning of the sources of mortality other than the commercial harvest. Although likely insignificant compared with fishing mortality, this information could be valuable on a local scale and also necessary for the eco-certification of the walleye fishery.

Zoobenthos (Proposal H8)

Dr. Brenda Hann (University of Manitoba) presented summer benthic abundance data by basin (south, channel and north) comparing1969 to the period from 2002 to 2011. In addition, *Diporeia* densities were presented for spring, summer and fall, for the three basins and same time period (Appendix B). Of note was that the same technician has carried out the identification of benthic organisms since 2003, which provides important consistency among years of data collection. Hann described general trends but no statistical analyses of the data were presented. Also noted was the high variability in *Diporeia* densities among stations and a possible relationship with sediment particle size. Interpretation of data for individual taxa is underway. Workshop participants remarked that *Diporeia* densities in the narrows appear to be well over most places in lakes Huron and Michigan. In addition, it was again remarked that "whitefish diet needs to be collected from two years ago" as lake whitefish are an important consumer of *Diporeia*. Concerning the presentation of data, it was suggested that the whole lake density data be areally weighted to account for the large size discrepancy among basins. At present, the data are averaged per unit surface area sampled (by Ekman dredge) relative to the number of stations. The collection of benthic samples will continue in 2012 (Table 2 - Field Studies).

Graduate student Matthew Bryan (University of Manitoba) will take a three-pronged approach (Table 2 - Field Studies) to look at interactions between cyanobacteria and chironomids to determine if cyanobacterial blooms are positively (as a food source) or adversely (due to toxin production) impacting the benthic community when large blooms fall to the bottom of the lake. Gut content analysis of previously sampled chironomids (from 2006/07) has begun and will help determine if ingestion of cyanobacteria does occur. In addition, the field collection for stable isotope analyses (chironomids, zooplankton, and their food sources) will take place in 2012 to get additional information on diet. Lastly, chironimids will be cultured in the lab with cyanobacteria and microcystin isolates to evaluate their response to varying levels of exposure.

Manitoba Conservation and Water Stewardship continues to routinely monitor the benthic community at the 14 long-term monitoring sites on the lake in the spring (Table 2 Field Studies).

Zooplankton

Zooplankton was not included in the 2004 Federal-Provincial Workshop and, therefore, does not have its own stand-alone proposal.

Daigo Kamada's (University of Manitoba) graduate work examined the response of the Lake Winnipeg zooplankton community to environmental changes between 1969 and the last decade. Results presented at the workshop focused solely on potential diel vertical migration of zooplankton (Appendix B), which had not been examined in Lake Winnipeg prior to the day/night work carried out in 2011. Kamada successfully defended his thesis in the fall of 2012.

Although the collection of pelagic zooplankton samples continues, a growing number of samples remain unanalyzed, and, with the exception of the above study, the data have not been interpreted or published in the peer-reviewed literature. According to Alex Salki, (retired, Fisheries and Oceans Canada) the analyzed zooplankton samples include all pelagic samples collected in 1969, 1994, 1998, 1999 along with most of the samples collected in 2002, 2003, 2004 summer, 2005 fall and 2006 summer. Samples that remain archived and un-analyzed include pelagic samples collected in the spring and fall of 2004 and 2006 and all subsequent samples up until fall 2011, with the exception of spring 2010 and 2011 samples. South basin near-shore samples collected in 2010 and 2011 by Environment Canada have been analyzed, and although the data are on the data portal, the results have not been interpreted.

The sampling protocol for zooplankton remains consistent since the 1969 surveys thereby allowing a direct comparison of data over this time period. Moreover, Salki analyzed all samples, again providing valuable consistency over the years. As an integral component of the food web and fundamental parameter in ecosystem models, the issues of archived, unanalyzed samples and un-interpreted data must be addressed.

Relative Importance of Nutrients, Light, and Temperature to Algal Community (Proposal H7)

Light

Hedy Kling (Algal Taxonomy and Ecology Inc.) provided a summary of her observations, which now date back to 1994, on the effect of snow cover on phytoplankton growth. In general, years with high snow cover are primarily dominated by dinoflagellates, whereas during years of low snow cover, and therefore greater ice transparency, the diatom *Aulacoseira* tends to dominate. In addition, it appears that the diatoms remain intact as long filaments (up to a mm) under the ice, which likely contributes to their tendency to catch on fishers' nets. This explains why the biomass of *Aulacoseira* from samples taken near fishing spots in 2011 tended to be higher than at sampling stations. Although a nuisance for fishers, diatoms are considered favourable to the fishery as they serve as a good source of food for the benthos and zooplankton. This

is contrary to the dinoflagellates (tend to dominant in high snow cover years), as they can produce toxins that have been known to kill fish in other systems.

Dr. Sue Watson (Environment Canada, Burlington) presented some preliminary data on picoplankton, which are photosynthetically active plankton the size of bacteria and an important component of the microbial food web (Appendix B). Picoplankton are difficult to enumerate under a microscope due to their size, thus flow cytometric analysis was used. Two pigment types, phycocyanin and phycoerythrin, were measured to distinguish the types of picoplankton between seasons and basins. In brief, concentrations were up to an order of magnitude higher in the north basin, especially in the summer, and were predominantly phycoerythrin, which responds to a higher light regime and deeper penetration of light. By contrast, the south basin showed a predominance of phycocyanin rich cells, typically more abundant in more eutrophic systems characterized by low light. The levels measured in Lake Winnipeg are comparable to those in Lake Erie. This work is ongoing.

Carbon

No updates were given for primary production estimates.

Michael Stainton (Fisheries and Oceans Canada) in collaboration with Dr. Sue Watson (Environment Canada, Burlington) will examine carbon fixation and respiration rates during the 2012 field season (Table 2 - Field Studies).

Cyanobacteria

Dr. Caren Binding (Environment Canada, Burlington) was not in attendance but provided a brief written summary of her remote sensing work (below). Real-time data will ultimately be available on-line via a dedicated website or the data portal.

> *The project has utilized satellite observations of aquatic colour to develop methods for monitoring algal blooms on Lake Winnipeg and Lake of the Woods. MERIS imagery depicting blooms have been used to provide quantitative assessments of bloom timing, intensity and extent over the lakes.*

Another remote sensing project is using algorithms to map Lake Winnipeg turbidity, chlorophyll and cyanophytes (%) in near real-time. As Mike Stainton (Fisheries and Oceans Canada) explained, the overall project is a joint effort between the University of Manitoba (McCullough and others) and NOETIX with support from the Canadian Space Agency. The project has been in development for the last four to five years and is now operational with excellent algorithms. However, as of April 2012, the satellite used to generate algorithms went silent and until the European Space Agency is able to mount the next generation satellite with a similar sensor, the data will not be available online. In the interim, the group is limited to generating maps with historical imagery. It is anticipated that the project will be back up and running in 2013.

Cyanobacterial Toxins

Dr. Sue Watson (Environment Canada, Burlington) presented some of the toxin data collected by various agencies over the years in an effort to amalgamate the datasets (Appendix B). Overall, concentrations of microcystin toxins are generally found to be well below the World Health Organization's guideline for drinking water (1 µg/L total microcystin-LR), although some higher levels are measured on occasion. Moreover, other algal toxins, such as anatoxin and saxatoxin, appear to also be low or undetectable. In sum, it appears that with the predominance of *Aphanizomenon* in the lake, the capacity to produce toxins is certainly there; however, the risk of algal toxins to human health is low. On the other hand, if zebra mussels are able to colonize the lake, the potential shift from *Aphanizomenon* to *Microcystis* dominance due to greater water clarity may increase the risk of greater toxicity (as has been documented in the Great Lakes).

Graduate student Jonathon Challis (University of Manitoba) will commence a new toxin study in 2012 to characterize concentrations and potential bioaccumulation of algal toxins in water (POCIS) and fish tissue derived from the Provincial trawling program archive pending funding (Table 2 - Field Studies)

The Province continues to monitor microcystin off the M.V. *Namao* and from the near-shore areas when blooms are present. Generally, microcystins are low but on a few occasions levels have exceeded the recreational guideline of 20 µg/L. Of the eight samples collected in 2011, two had detectable levels of microcystin with the highest being 2.1 µg/L, exceeding the drinking water guideline but well below the recreational guideline.

Carbon Cycling & Sequestration (Proposal W2)

No updates.

The relative contribution of heterotrophy to Lake Winnipeg productivity, as well as the potential role of allochthonous carbon in this transfer of energy, remain extremely important knowledge gaps that have not, as yet, been adequately addressed.

Nutrient Balance Estimates (Proposal W5)

Fluvial Influxes

Dr. Jean-Francois Bibeault (Environment Canada, Montreal) presented research on nutrient sequestration in lakes and reservoirs (Appendix B) on behalf of Dr. Brian Parker who became the Director of Fisheries, Manitoba Conservation and Water Stewardship. The objective of the project was to evaluate nutrient sequestration and release in 30 large lakes and reservoirs in the Lake Winnipeg Basin from an input-output perspective. Thus, sequestration is the inflow mass plus precipitation mass minus the outflow mass. Overall, certain lakes and reservoirs, notably Cedar Lake, and lakes Winnipegosis and Manitoba,

were particularly effective at capturing nutrients, with retention as high as 89%. There was also a difference in the chemical form exported between lakes and reservoirs, with reservoirs exporting proportionally more dissolved phosphorus and lakes more particulate phosphorus than they receive. In terms of nutrient reduction objectives for Lake Winnipeg, reservoirs appear to have an important management capacity. However, the consequences for the receiving body of water may not be as favourable. The Portage Diversion, for example, diverts considerable phosphorus to Lake Manitoba, especially in high flow years like 2011. There are clearly both environmental and socio-economic trade-offs.

Environment Canada will likely continue this work by examining the effect of smaller lakes and reservoirs on the retention and release of nutrients. In addition, they will continue monitoring at trans-boundary sites as part of the nutrient budget. It is yet to be determined if sampling of the east-side rivers of Lake Winnipeg and the outflow will continue in the future.

Nitrogen Fixation (and nutrient deficiency)

Dr. Sue Watson (Environment Canada, Burlington) reported on some ongoing studies on nutrient deficiency and physiological status of major algal taxa (Appendix B). For the most part, there was no significant phosphorus deficiency over most sites and seasons, although it was apparent in the north basin late summer when blooms were forming. Similarly, some patterns of nitrogen deficiency were apparent, albeit highly variable. PAM-based fluorescence was used to assess the physiological status of the major plankton groups, thus providing a measure of photosynthetic efficiency, or how well cells respond to light. Results indicated that cyanobacteria had a superior physiological status than diatoms and other taxa as the season progressed. Watson and colleagues will revisit an earlier model for nitrogen fixation and heterocyst frequency with these more recent data, and evaluate the short and long term nutrient status as it relates to water chemistry and other variables.

No studies appear to be planned or underway by any agency to address the potential contribution of denitrification to the nitrogen budget.

Phosphorus Retention, Internal Recycling, Bioavailability

Dr. Sue Watson (Environment Canada, Burlington) provided a brief summary of some of the ongoing sediment work pertaining to internal phosphorus loading and bioavailability (Appendix B). In brief, there were distinct differences in sediment particle size between basins, which will have implications for re-suspension events. In addition, smaller particle size was associated with higher bioavailability of phosphorus, while there was little relationship between grain size and total phosphorus. This work is ongoing.

Fish Habitat Classification (South Basin) (H2)

As explained by Alex Salki, the Lake Winnipeg Basin Initiative Phase I provided funds to the Lake Winnipeg Foundation in 2011 to carry out a Sensitive Habitat Inventory Mapping (SHIM) pilot project in the south basin of Lake Winnipeg. In brief, the study assessed the foreshore area from Riverton to Traverse Bay for various characteristics that were ranked in terms of their habitat sensitivity, suitability for protected zones and for development. In essence, it is an attempt to document and map what currently exists in an effort to better manage it. The final report will be finished in April 2012.

Decline in Wetland Habitat (H4)

The Wetland Restoration Group is still active but has not met in at least a year. One topic of discussion was to look at engineering options in Netley-Libau to create some islands.

Contaminants (Proposal F7)

Monitoring and Research

In 2012, Environment Canada's National Fish Contaminants Monitoring and Surveillance Program will expand to include forage fish and bulk plankton sampled off the M.V. *Namao* in the north basin (Table 2 - Field Studies) with the intention of collecting samples from Lake Winnipeg on a 3-year cycle. Analyses will include stable isotopes of carbon and nitrogen, lipid (%), and moisture (%). Contaminants of interest include a suite of polybrominated diphenyl ethers (PBDEs), which are organobromine compounds used as flame-retardants in a variety of polymer resins and plastics, perfluorinated compounds (PFCs) and metals. PFCs are considered persistent organic pollutants as they do not degrade by natural processes. Once collected, samples will be homogenized and stored in the specimen bank, to be submitted for analysis in the subsequent year; essentially a one year lag between capture and analysis. Below is a link to the indicator report recently completed for PBDEs in fish and sediment, and which provides an overview of where Lake Winnipeg fits relative to other lakes in Canada.
http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=0970C75C-1

As part of the aforementioned sediment work (particle size and nutrients) by Dr. Sue Watson, metals were analyzed in surficial sediments. Preliminary results showed that, of the metals analyzed, all were below Canadian guidelines. The data are available to anyone who can use them.

Dr. Mark Hansen (University of Manitoba) described a watershed project that examined pharmaceuticals coming out of lagoons in rural Manitoba, notably the Dead Horse Creek watershed (includes the communities of Morden and Winkler). A brief description of the objectives is included in Appendix B along with some results. Overall, the results were typical of other regions of Canada. That is to say, the communities examined are not

releasing more pharmaceuticals than anywhere else in Canada. This work was recently published in Science of the Total Environment (2013).

Hansen and colleagues had yet to analyze lake samples taken in 2011 by POCIS at three sites for a suite of pesticides, pharmaceuticals and algal toxins. Graduate student Jonathon Challis will continue the POCIS work on the lake focusing on algal toxins (described above).

Invasive Exotics (Proposals H9 and H4)

Justin Shead (Manitoba Conservation and Water Stewardship) provided an update on the status of the zebra mussel and spiny water flea (*Bythotrephes*). At the time of the workshop, zebra mussels were in South Dakota and Minnesota, but not directly in the Red River yet, and there did not appear to be any movement in the last year. The threat of human mediated transport is high and therefore where Provincial efforts are now focused, including watercraft inspections at the border. Passive monitoring includes the inspection of buoys, and Manitoba Hydro has substrate colonizers at select locations.

Fisheries and Oceans Canada and the Centre of Excellence for Ecological Risk Assessment did a national zebra mussel risk assessment for western Canada. The primary factors considered were substrate and calcium. According to their findings, everything throughout the Red River system to Hudson Bay is prime for zebra mussel colonization. Interestingly, the one part of the province that is not at high risk of colonization is east of Lake Winnipeg, due to the low calcium concentrations. The concern in this area is more related to recreational boaters who travel between the Great Lakes, Lake of the Woods and Lake Winnipeg.

Bythotrephes, or the spiny water flea, is also a cause for concern. It was first detected in Traverse Bay in September 2011, and in the gut contents of cisco found near Victoria Beach; numbers were low at one or two per stomach. Monitoring by the Province will continue off the M.V. *Namao* during the 2012 open water season.

To reduce the risk of inadvertent transport of aquatic invasives, Manitoba is working on a set of decontamination protocols similar to Ontario's for water-based equipment. In addition, the Province has applied for funding for two portable decontamination units to help with cleaning boats and equipment.

Future monitoring technology being developed at the Canadian Aquatic Invasive Species Network may include environmental DNA testing that will allow the on-site determination of the presence of about 40 aquatic invasive species.

Models

Dr. Michael Rennie (Fisheries and Oceans Canada) described a new modeling project that will apply the thermal optical habitat model that Nigel Lester (Trent University,

Peterborough) developed to predict walleye yield in Ontario. Rennie and graduate student Marianne Geisler (University of Manitoba) will evaluate whether the model fits with Lake Winnipeg data and other Manitoba lakes, and then apply it to predict what the consequences of dreissenid invasion might be on walleye yield based on changes in water clarity.

At the time of the workshop, the future status of a number of important Phase 1 Lake Winnipeg Basin Initiative projects, such as the hydrodynamic and water quality models, was unknown.

Day 1 - Focused Conversation

With the remaining time on Day 1, workshop participants were asked to take part in what is known as a Focused Conversation. This facilitation method is structured so that a group can discuss a specific topic at greater depth than could potentially be achieved by having no structure[1]. There are four levels to the 'conversation' - *objective, reflective, interpretive and decisional*. As its name suggests, the *objective level* represents the objective information, in this case the data derived from the science and monitoring updates. The *reflective level* of discussion allows one to reflect on the objective information and draw from one's own experience with regard to the emerging picture. The *interpretive level* allows the group to dredge deeper for meaning in an effort to get at the significance and importance of what has been said. Lastly, the *decisional level* is where implications and new directions are discussed in order to find some level of resolution.

Due to time limitations, only the first two levels, objective and reflective, were discussed as a group. Despite not completing the exercise, the insight gained will provide additional guidance to the LWRC in its role as facilitator of on-lake science.

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[1] Stanfield, R. B. ed.: *The Art of the Focused Conversation*, New Society Publishers, Gabriola Island, B.C., Canada, 2000

Table 1: Evaluation of knowledge related to topics discussed during the 2011 LWRC Science Workshop (columns 1 – 3) and updates, if any, to that knowledge during the 2012 Workshop (column 4).

2011 Workshop			2012 Workshop
Evaluation Topic	**Rank**	**Comments**	**Update**
F1 – Fish Communities			
Index-netting	Critical info gap	- Continuity of data interrupted resulting in very few years of data - Interpretation and use of data for management decision making is not evident - Whitefish population data needed - Acoustic surveys would be beneficial (species-specific biomass, abundance, distribution) - FFMC data could be better used to advantage	Personnel constraints prevent some useful data collection, such as: - whitefish index netting - non-quota, bycatch species characterization (currently only bulk weighed and counted by mesh) - sampling in north basin pelagic zone and east side of lake
Trawling	Adequate knowledge available	- Data from 2002 onward only - Recruitment indices could be developed - Importance of trawl avoidance and possible night trawls added to program - Uncertain annual funding	Day/night trawls introduced as a Special Project (Lumb, MB) Funding for Provincial off-shore trawling program remains uncertain Otter trawls (EC) not continued
Near-shore	Non-critical gap	- Limited to south basin only; north basin required - Two years only, future uncertain	North basin near-shore seining to commence in 2012 at 2 sites as part of new *NB Near-Shore Program* (Lumb, MB) South basin near-shore seining not continued (EC) South basin near-shore seining data (2 years) on portal; not interpreted (Parker, EC)
Fish Diets	Critical gap	- Whitefish diet needed; sauger, walleye under investigation - Forage fishes needed; smelt diet under investigation	Whitefish diet remains an important knowledge gap Two graduate research projects (UM) to be completed in early 2013: Sheppard (walleye & sauger); Olynyk (cisco & smelt)

Spatial Considerations	Critical gap	- Sentinel fishers programs (Whitefish-Index Netting Program) - Tagging studies needed for all commercial species	No progress made on implementing a north basin whitefish sampling program (FFMC, north basin fishers, Fisheries Branch)
F2 – Sources of Mortality			
Domestic/Subsistence	Critical info gap	- No consistent studies undertaken	No updates
Recreational	Critical info gap	- Useful information but cost prohibitive given funding limitations	No updates
Toxins, Hypoxia	Critical info gap	- Unknown	No updates
H8 – Zoobenthos			
Changes	Non-critical gap	- Inconsistent methods MWS and others - Low taxonomic resolution - Biomass estimates recommended - Emphasis on pelagic area only; near-shore required - Early interpretation of data	Samples analyzed up to 2011; data interpretation underway (Hann, UM) Near-shore south basin on portal; not interpreted (Parker, EC) No benthic participation in new *NB Near-shore Program*
Causes	Critical info gap	- Interpretation limited by above - Oxygen dynamics at sediment/water interface unknown	Graduate research project underway (Bryan, UM)
Consequences	Critical info gap	- Unknown - Piscivore and forage fish diets recommended	No updates
Zooplankton	Critical info gap	- Interpretation of existing data limited	Graduate research (Kamada, UM) completed in 2012 Pelagic sample collection continues but many samples remain unanalyzed and data uninterpreted No near-shore sampling in north basin.

H7 – Relative Importance of Nutrients, Light and Temperature to Algal Community			
Light	Non-critical info gap	- Importance of snow cover on ice transparency, algal succession and secondary productivity - Winter sampling is critical	Important differences observed between low and high snow depth over ice (Kling, ATE Inc.) Numerous projects underway (see Watson update Appendix B) including spatial and temporal trends of picoplankton & heterotrophic bacteria, and physiological status of diatoms and cyanobacteria
Silica	Critical info gap	- Role of silica and temperature on diatom growth and cyanobacterial succession	No updates
Carbon	Non-critical gap	- Interpretation of existing diurnal CO_2 data for productivity estimates needed	No updates Carbon metabolism study planned for 2012 (Stainton, DFO)
Cyanobacteria	Non-critical info gap	- Species level identification of some cyanobacteria would be beneficial	Two remote sensing projects are underway: - Real-time data for bloom timing, intensity & extent (Binding, EC) - operational internet service for distribution of near-time-maps of chlorophyll and surface phytoplankton blooms (McCullough, UM & NOETIX Research Inc.)
Cyanobacterial toxins	Critical info gap	- Range of toxins unknown - Fate in food web unknown	Microcystins deemed a low risk to human health. A change in dominant species (i.e. to microcystis) could change risk level (Watson, EC) Graduate research (Challis, UM) underway Provincial monitoring of blooms continues
W2 – Carbon Cycling & Sequestration			
Sources	Non-critical	- Importance of terrestrial carbon subsidy (to heterotrophy)	No updates

Fate of carbon	Non-critical info gap	- Role of microbial loop, especially protozoa, unknown (relative importance of heterotrophy) - Sequestration of algal carbon - Effect of reservoir management unknown	No updates
W5 – Nutrient Balance Estimates			
Fluvial influxes	Quite well understood	- East side stream monitoring improved - Spring freshet and rain event sampling - Sequestration study in watershed	**S**equestration study completed but may continue on smaller water bodies (EC) Future of eastside river & stream monitoring uncertain (EC) Various fluvial measures including bioavailable P (Red & Assiniboine) & sediment are underway (Watson, EC)
Wetfall/dryfall	Non-critical info gap	- No work has been done - Complex task	No updates
Nitrogen Fixation	Critical info gap	- Additional measures required	Spatial & temporal trends in nutrient deficiency & N fixation underway (Watson, EC)
Denitrification	Critical info gap	- No work has been done - Required to balance nitrogen budget	No updates
Outflow	Critical info gap	- Long-term data set does not sample at true lake outlet - Outflow sampling initiated - Necessary for nutrient budgets and other estimates	No updates Warren Landing sampling (water chem.) to begin in 2012; no sampling at 2-Mile Channel
Phosphorus Retention	Critical info gap	- Outflow data required - Necessary for phosphorus budget	Preliminary findings of studies that are underway (Watson & Guo, EC) include: - distinct differences in sediment particle size between basins may have implications for re-suspension events
Internal Recycling	Critical info gap	- Largely unknown - Critical for estimates of long-term remediation	

Bioavailable Phosphorus	Critical info gap	- Poorly understood	- smaller particle size was associated with higher bioavailability of phosphorus - little relationship between grain size and total phosphorus Study examining anoxic P release & role of Fe (sediment cores) completed (Molot, YorkU & Watson)
Water balance	Non-critical info gap	- Evaporation term not yet determined - Also important for climate-related changes - Groundwater input not known	No updates
Remaining Proposals – F3, F5, H2, H3, H4, H6			
Sub-Population Structure (F3)	Critical gap	- Tagging studies required - Evaluation of management on a stock delineation basis warranted	No updates
Traditional and Local Knowledge (F5)	Non-critical gap	- Collection of local knowledge remains random - Role of Co-Management Board	Suggestion made to consult communities for input *before* projects undertaken
Fish Habitat Classification (South Basin) (H2)	Critical info gap	- Bathymetry and substrate mapping required and should include both north and south basins	Sensitive Habitat Inventory Mapping (Salki, LWF) completed 2012
Use of Tributaries and Reefs by Fish (H3)	Critical info gap	- Valuable information but no work carried out to date	No updates
Decline in Wetland Habitat (H4)	Non-critical gap	- Wetland Restoration Group formed	Wetland Restoration Group sill active but had not met in 1 year
Critical Habitat for SAR (H6)	Non-critical gap	- Sturgeon Working Group formed; no studies on critical habitat	No updates
F6 – Climate Change			

Precipitation and Run-Off	Quite well understood	- Additional modeling on land use would prove valuable	No updates
Thermal Regime	Non-critical gap	- No studies underway - Good temperature record available - Development of biological indicators of climate change would be useful	No updates
F7 – Contaminants			
Monitoring and Research	Critical info gap	- Seemingly disparate and uncoordinated - Recommend housing all data in Data Portal - Paucity of research studies - Pharmaceuticals poorly represented - Importance of Red River should be pursued	National Fish Contaminants Monitoring and Surveillance Program (McGoldrick, EC) to include forage fish and bulk plankton (north basin) 2012 Preliminary results of some metals in surficial sediment below national guidelines (Watson, EC). Province continues to monitor metals in water and sediment – no results available Paper on pharmaceuticals in Dead Horse Creek published in Sci of the Total Environ 2013
H9 and H4 – Invasive Exotics			
Rainbow Smelt	Adequate knowledge available	- Commercial species diet studies recommended as well as rainbow smelt diet	See Olynyk (UM) under DIET
Zebra Mussels (pre-invasion)	Critical info gap	- Whitefish data needed (diet, length, weight etc) - Better knowledge of base of food web for littoral and pelagic areas	Little change in zebra mussel distribution; still only includes S Dakota and MN, but not yet in the Red River
Bythotrephes	Critical info gap	- Pelagic forage fish diet and nutrition data needed	Spiny water flea detected in south basin 2011; monitoring continues (Shead, MB)
Models			Graduate student research (Geisler, UM) to begin in 2012 on optical/thermal habitat of walleye under Rennie (DFO)

Day 2 – Eutrophication Indicators and Field Planning

Day 2 of the Science Workshop focused on plans for the future, including the upcoming open water season, which is discussed in more detail in the next section, and the longer-term development of a suite of eutrophication indicators for Lake Winnipeg by Environment Canada.

Phase 2 of Environment Canada's Lake Winnipeg Basin Initiative (LWBI) will focus on the watershed, as opposed to the lake, as described in the call for Letters of Interest for funding Phase 2 projects.

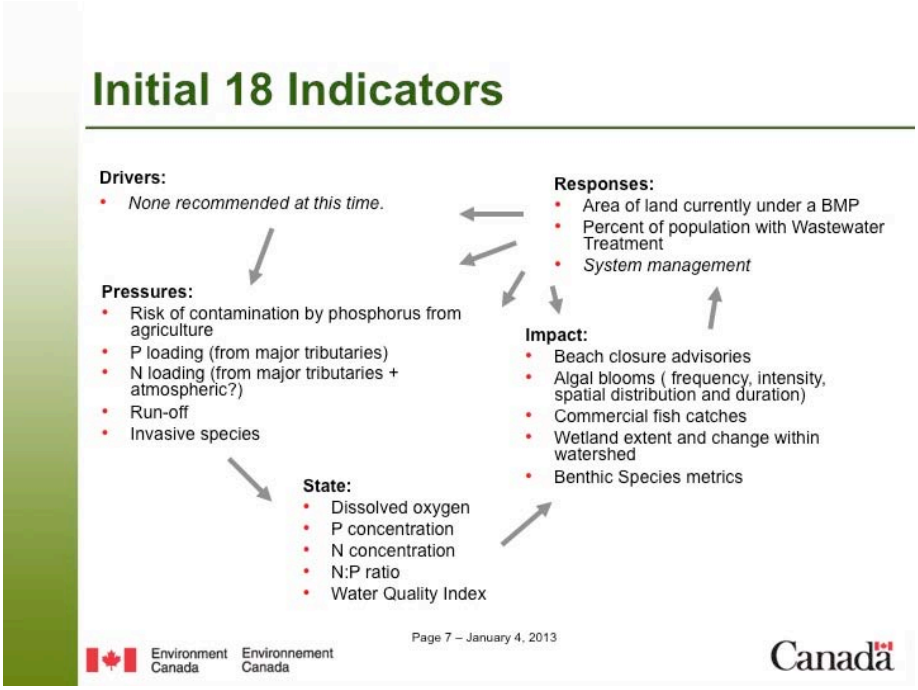
> *"…to implement high-impact solution-oriented projects aimed at reducing nutrient loads, and improving the ecological sustainability of the lake and watershed. The Fund will support projects or activities having concrete, demonstrable results to reduce pollutants, and in particular, nutrient loads entering Lake Winnipeg."*

Clearly, lake monitoring and research must continue; at a minimum to evaluate the success of the *"high-impact solution-oriented projects"*, if not to better understand the multiple stressors imposed on this ecosystem. An indicator serves as a simple yet quantitative measure that helps to follow the condition or state of something over time. Thus, the development of eutrophication indicators for Lake Winnipeg, which falls within the Lake Winnipeg Basin Initiative science plan, should provide insight into how the lake is responding to remediation efforts and whether nutrient objectives are being met over time.

Dr. Jean-Francois Bibeault (Environment Canada, Montreal) gave the presentation entitled *Development of a Suite of Eutrophication Indicators for Lake Winnipeg*, which outlined Environment Canada's efforts and progress to develop eutrophication indicators for Lake Winnipeg. The presentation can be found on the LWRC website.

In brief, the goal of the project is to review relevant eutrophication indicators for Lake Winnipeg and recommend a sub-set that could form the basis for future monitoring, assessment, and reporting activities. Thus far, the project is at the early, pre-screening stage of 18 key indicators. The framework within which these key indicators were selected and evaluated is known as the Driver-Pressure-State-Impact-Response (DPSIR) model. This conceptual model recognizes that *Driving* forces (D), such as societal and economic developments, can exert *Pressures* (P) on the environment, such as wastewater loadings, which may lead to changes in *State* (S) (chemical, physical, biological) and result in *Impacts* (I) to the system. These impacts may, in turn, promote a societal or human *Response* (R), which may then feed back on the driving forces, pressures, or directly on the states or impacts. The DPSIR framework allows decision-makers to understand the linkages between the condition of the ecosystem, pressures on the ecosystem, and how human activities are related.

The figure below shows the 18 indicators that have, thus far, been selected by Environment Canada for Lake Winnipeg. No *Drivers* were recommended as part of the pre-screening phase. The main *Pressures* relate to nutrient loading, with the exception of invasive species. *State* changes, which result from these pressures, include some key measurements like dissolved oxygen, nitrogen, phosphorus, N:P and a water quality index, which summarizes many parameters through a simple index. The *Impacts* linked to *State* changes include beach closures, algal blooms, among others. The algal blooms would ultimately be linked to a more standardized means to combine information derived from remote sensing, such as the frequency, intensity, spatial distribution, and duration of algal blooms. The *Response* indicators relate to the implementation and adoption of policies or beneficial management practices.



Proposed suite of 18 eutrophication indicators for Lake Winnipeg.

The next stage of the project is a peer-review of these 18 key indicators and finalization of the internal report and recommendations, all of which should be accomplished in the 2012 fiscal year. The implementation strategy will follow, although it was not clear at the time of the workshop who will lead that phase. Ultimately, the aim is to make the information available to the public in a variety of forms, including possibly as a web tool or via social media. The challenge of this component of the project will be to translate the scientific information for public consumption in a timely, meaningful and engaging way.

The remainder of Day 2 was used to discuss the upcoming field season, the details of which are summarized in the next section below. Of particular note was the discussion on implementing a *North Basin Near-Shore Sampling Program*. As described in the 2011 Workshop Report, *State of the Science*, most of the data on Lake Winnipeg describe the pelagic area of the lake. Consequently, knowledge of the near-shore area is lacking.

Moreover, given the imminent arrival of zebra mussels to Lake Winnipeg, characterizing the near-shore areas is of value as this is where the predominant effects of zebra mussels will manifest. Thus, two new near-shore sites were chosen during the Day 2 field planning discussions - one near George Island on the east side and the other near station 43S on the west.

Open Water Season

The 2012 open water program consisted of three surveys. The spring survey commenced with the *Lake Ecology Field Program* (see Education program below for details) followed by the research survey (May 31 to June 17). The summer research survey took place between July 16 and August 9, and the fall survey ran from Sept 10 to October 10, followed by the *Lake Ecology Field Program*. The number of days on the lake were 19.5, 21 and 21.5 days for the spring, summer and fall surveys respectively. In addition, 10.5 days were lost to high winds, 8.5 of which occurred during the fall survey.

The LWRC sampled on behalf of a number of agencies that were unable to provide their own on-board personnel to carry out their programs. That sampling included: benthos and zooplankton; pelagic trawls (spring and fall surveys); graduate student sampling (summer survey); and deployment and retrieval of POCIS (all seasons). In addition, the LWRC assisted the Province in the operation of the Seabird since Environment Canada did not have a dedicated technician on board in 2012 to oversee its operation, as it has done in past years.

In addition to the on-station research and monitoring carried out by various agencies and assisted by LWRC, a number of new, off-station initiatives took place in 2012 (Table 2 – Field Studies) outside of the routine surveys. Briefly, they included: a study to compare two independent assessment methods, traditional trawl surveys and large-scale fisheries acoustics, during the day and night to improve understanding of fish distribution and to compare biomass estimates of prey fishes; the expansion of the national Fish Contaminants Surveillance Program to include forage fish and bulk plankton from the north basin; a colonial water bird survey (north basin) for the Manitoba Breeding Bird Atlas; a carbon metabolism study to develop monitoring methodology; and lastly, a north shore sampling effort to determine the contribution of peat and clay to the sediment and nutrient budget of the lake. Moreover, as mentioned above, the LWRC introduced a *North Basin Near-Shore Sampling Program* in the fall of 2012. The coordinates for each station are 1) 52º 53.421N / 97º 23.945W for station 67NS (east shore), and 2) 52º 38.431N / 98º 42.528W for Station 68NS (west shore). The purpose of this new program is to enable member agencies to characterize the near-shore environment prior to the arrival and possible colonization of zebra mussels. In its first year, few agencies took advantage of the opportunity with the exception of Manitoba Conservation and Water Stewardship.

Table 2 – Research and Monitoring Activities Conducted off M.V. *Namao* during the 2012 Open Water Season

Category	Agency	PIs	Details	Spring	Summer	Fall	Other
Forage Fish	Fisheries Branch	Lumb Heuring	Lakewide trawl surveys for status and trend monitoring of pelagic fish populations	X	X	X	LWRC sampled NB in spring and fall
	Fisheries Branch	Lumb, Heuring	Compare two independent assessment methods - traditional trawl surveys and large-scale fisheries acoustics, to improve understanding of fish distribution and to compare biomass estimates of prey fishes		NB & SB		~ 3 days each in both basins; day and night
	EC	McGoldrick	Fish Contaminants Surveillance Program - to determine the environmental trends in contaminant levels and relate these to sources of pollution. Analyses to include metals, PBDEs, and PFCAs and possibly some compounds in personal care products.		NB		Station representative of fish assemblage; bulk (~100 each) of key forage species; bulk plankton; stable isotope ratios of C & N, % lipid and % moisture; Fisheries Branch & LWRC sampled
Zooplankton	U MB	Bryan Hann	Differentiating effects of cyanobacteria from cyanotoxins on benthic invertebrates	NB only	NB only	NB only	Vertical haul; stable isotopes
	U MB	Hann	Zooplankton community	X	X	X	Vertical haul; LWRC sampled in absence of student; 30 stations
	Provincial WQ	Shead	Spiny water flea	X	X	X	
Benthos	U MB	Bryan Hann	Differentiating effects of cyanobacteria from cyanotoxins on benthic invertebrates	NB	NB	NB	Chironimids; stable isotopes
	Provincial WQ	Page	Benthic inverts (triplicate)	X			14 long-term stations

Category	Agency	PIs	Details	Spring	Summer	Fall	Other
	U MB	Hann	Benthic community	X	X	X	LWRC sampled in absence of student; all stations
Phytoplankton	Provincial WQ	Page	Phyto (whole water) – id, enumeration, biovolume	X	X	X	14 long-term stations
	EC	Binding	Use profiling spectro-optical instrumentation to measure *in situ* optical properties and coincident water quality information to validate and further develop methods for satellite detection of algal blooms.		X		Two profilers used, an AC9 (winch deployment) and a free-falling Satlantic radiometer (deployed by hand)
	U MB	Bryan	Differentiating effects of cyanobacteria from cyanotoxins on benthic invertebrates	NB	NB	NB	Stable isotopes; euphotic zone; cyanobacteria from blooms
	EC ATE Inc	Watson Kling	Pico/bacterio-plankton, phytoplankton	X	X	X	
	EC	McGoldrick	Fish Contaminants Surveillance Program		NB		Horizontal tows; central NB
Algal Toxins	U MB U Wpg	Challis Hanson	Characterize concentrations & potential bioaccumulation of algal toxins in water	X	X	X	POCIS deployed on 3 weather buoys; surface
	Provincial WQ	Page Watchorn	MC-LR & cyano cell counts				In nuisance blooms only
	U MB U Wpg	Challis Hanson	Characterize concentrations & potential bioaccumulation of algal toxins in archived fish				Funding unconfirmed
	EC	Watson	Archived fish				Funding unconfirmed
Water Chemistry	Provincial WQ	Page Watchorn	Nutrients, chl-a, routine chem.	X	X	X	All stations

Category	Agency	PIs	Details	Spring	Summer	Fall	Other
	Provincial WQ	Page Watchorn	Metals, major ions	X	X	X	14 long-term stations
	Provincial WQ	Page Watchorn	Pesticides	X	X	X	Inflow stations @ Winnipeg, Red, & Saskatchewan rivers
	MB Hydro	Chaze	Same chemistry as Province	X	X	X	Warren's Landing only
	DFO UM	Watson Stainton McCullough	In lake nutrient processing & trophic indicators. NB buoy (chlorophyll, phycocyanin); on board (chl, C-DOM, algal groups); TP, part P, DOP, SRP, ammonium, NO23, TKN, part N, fluroprobe, phycocyanin, chlorophyll, turbidity	X	X	X	
Physical Limnology	EC Seabird	Bibeault	Vertical depth profiles taken on the downcast - temperature pH, DO, %sat DO, turbidity, conductivity & PAR.	X	X	X	All stations; MB (WQ) to operate Seabird; data extraction by EC (Rowsell)
	EC Moorings	Yerubandi	Meteorological & thermal properties				Deploy moorings; sediment traps
	Provincial WQ	Page Watchorn	Vertical depth profiles: light, T, DO, turbidity, conductivity	X	X	X	
Sediment	Provincial WQ	Page Watchorn	Surface - metals, nutrients, particle size, organic content		X		14 long-term stations
	EC	Guo Watson	Origination of suspended sediments to be determined using the ratio of Be and Pb isotopes	X			Suspended sediment via bag filtration while in transit; cores at most stations

Category	Agency	PIs	Details	Spring	Summer	Fall	Other
	U MB	Lobb Kuzyk McCullough	Longitudinal survey of sediments from the La Salle & Morris Rivers through Red River & L Winnipeg to Nelson Estuary using laser diffraction & imaging to achieve detailed measurements of sediment particle size & morphology			X	Various locations
Other	U MB	McCullough	Contribution of north shore peat and clay to assess contribution to sediment and nutrient budgets. Two on-shore sites: ~10-15 km west of Two-Mile Channel & near Station 33			X	Samples to be analyzed for bulk density, particle size and major nutrients (C, N, P, Si, with fractionation of P to describe bioavailability)
	MB Breeding Bird Atlas	Artuso	Distribution and abundance data for all species of bird that breed in MB		X		North basin shoreline and islands
	DFO EC	Stainton Watson	Carbon metabolism			X	Ship at anchor for a 24-hour period; measurements at hourly intervals with use of CDT
	Multi-agency	Page, Watchorn Lumb Kling	NB Near-Shore Program: seining (Fisheries Branch); nutrients, chl, turbidity, DO, conductivity, temperature PAR (Prov WQ); phyto & periphyton (AT&E Inc.)			X	Two new sites: near George Island (east) and near station 43S (west)

Honours and Graduate Student Scholarship

As part of its Science and Education programming, the LWRC created an *Honours and Graduate Student Scholarship* in 2011/12 to encourage and promote research initiatives by young scientists on Lake Winnipeg. A generous initial contribution of $20,000 over five years by the Manitoba Government and General Employees' Union (MGEU) allowed the establishment of the fund, and subsequent smaller contributions were made. In 2012, 19-year-old University of Toronto student Erik Friesen undertook a 475 km fundraising bike ride called the *Water Cycle* in support of the scholarship fund. Erik rode from the headwaters of the Red River in Minnesota to Winnipeg without stopping, except for the usual types of breaks. Exhausted after riding for nearly 24 hours, Erik muttered, "it was easier on paper." Despite the pain, Erik raised $3,000 – and for that, we are extremely grateful - even more so in knowing that young adults like Erik care deeply about the future of Lake Winnipeg.

Of the six honours and graduate students who applied in 2011/12, three received the scholarship for a total of $5,000.

Pascal Cardinal received $2,000 toward stipend support for his project entitled, "*The role of aquatic plants in the removal and pharmaceuticals from treatment lagoons and constructed wetlands"*.

Andrew Olynyk received $1,500 to attend a conference, at which he presented his findings on the *"Seasonal variation in the diet of invasive rainbow smelt and native cisco in Lake Winnipeg"*.

Katie Sheppard also received $1,500 to attend a conference at which she presented her work entitled, "*Seasonal and spatial variations in diet and growth of walleye and sauger in Lake Winnipeg"*.

EDUCATION PROGRAM

The LWRC's Education Program has two main components, the *Lake Ecology Field Program* and the development of *Web-Based, Mixed Media Resources*, both of which are aimed primarily at public and high school teachers and their students. In addition, the LWRC created a *Special Projects Program* in response to requests by special interest groups and individuals to assist in their efforts to become involved in Lake Winnipeg related stewardship activities in the arts and sciences. Below is a summary of the activities that took place within these areas in 2012.

Lake Ecology Field Program (LEFP)

The LEFP has evolved from an 'education component' of the Science Program, whereby students simply came aboard M.V. *Namao* and watched scientists at work, to a stand-alone Program that provides students with the opportunity for field-based, hands-on learning about aquatic ecosystems. Phase 1 (2008) of the LEFP provided schools with semi-dedicated ship time and through the generous support of the RBC Bluewater Fund and Thomas Sill Foundation, subsequent Phases (2009 to 2012) included dedicated ship time for schools.

The LEFP takes place on board the research vessel M.V. *Namao* in the south basin of Lake Winnipeg, and is aimed primarily at grades 8 to 12 students. All field trips are preceded by an in-class presentation to: provide an overview of the lake and research; link the field trip to in-class activities; and put the issues facing Lake Winnipeg into a global context. In addition, this presentation discusses ways in which students can reduce their impact on water with decisions they make on a daily basis. Students are also given a pre-trip reading assignment that is intended to reinforce some of the new concepts and issues that were introduced during the overview presentation.

Programming on board M.V. *Namao* focuses on the sampling and analyses of various components of the lake ecosystem (water, bacteria, plankton, benthos) using a variety of field and analytical equipment. In addition, students have the opportunity to discover the microscopic and macroscopic world of a lake using microscopes and taxonomic keys, and are encouraged to record observations using technical drawings and accurate and detailed field notes. Near the end of the field trip, students record their newly acquired skills, knowledge, and results on video to take back to their schools as a resource for other initiatives that will extend their experiences and new knowledge about water beyond the ship and into the community.

The LEFP integrates extremely well with the Provincial science curriculum including the Grade 8 Water Systems unit, Grade 10 Science, and advanced Grades 11 and 12 courses, such as Aquatic Sciences, Environmental Sciences, Advanced Placement Biology, and Conservation of Biodiversity. Interestingly, teachers of other subjects, such as Math and Social Studies, are using the LEFP to support their teaching outcomes as well. In addition

to complimenting the Provincial curriculum, the LEFP supports a number of recommendations as advocated by the Lake Winnipeg Stewardship Board. These include Recommendations 1.1 through 1.5, 1.9, and 2.1 through 2.5.

In 2012, over 275 students participated in the LEFP and Special Projects Program, including from two Hutterian schools and the Manitoba School for the Deaf. Table 3 includes a summary of participating schools and how the LEFP contributes to their curricular outcomes. In addition, many of the participating schools were engaged in other meaningful activities that promoted water stewardship, often beyond the classroom and into the larger community. As an inspiration to other teachers, some of those activities are listed below.

Students will be creating a photostory of the marine life in Lake Winnipeg including photographing their trek on the Namao demonstrating the steps involved in measuring the algae levels of the lake as well identifying organisms within the lake's ecosystem. In addition, students will complete a final presentation with conclusions about how we can keep our lake healthy. Students can post their stories on YouTube to try and get some attention on how to maintain and even improve Lake Winnipeg.

Will be involved in a school project that involves monitoring water in the Little Saskatchewan River Water District. Senior year students make presentations locally and at an international science symposium.

Students will participate in two field trips within the Netley Creek watershed: one involves a benthic-invertebrate study, and the other follows Netley Creek to the South Basin, starting at its headwaters. This trip includes a visit to a Riparian Enhancement Project and a Wetlands Project. After the field trips, students will prepare a summary and present it to the Interlake School Division's Sustainable Development Committee. Also, students will do an art project that directly relates to Healthy Water and a Healthy Environment.

When students do class trips, the Colony elder always accompanies the class and learns along with the students. His influence is great in the Hutterite Colony. I believe his increased knowledge, as well as the students', is shared with the rest of the community and hopefully instills values that speak to taking good care of our environment.

Students are involved in video weblink dialogues with students from Melbourne Australia to discuss issues surrounding water quality in each of the countries and brainstorming ideas to assist in the development of action plans. Both groups will be sharing their findings and plans with students from all over the world at the International Science Symposium that is being hosted at Fort Richmond Collegiate/University of Manitoba at the end of April. As well, students will be presenting their research and action plans at the Caring for Our Watersheds contest at Oak Hammock Marsh April 14th. Group members are also involved in the

conducting of field studies and the development of a watershed field study program for grade 10 and lower grade students at the division's test farm/ponds (Kelburn Farm). Students will also be involved in the presentation and delivery of these programs to the younger grades.

Students will host a Water Day event for early years students in June, present at the YES Celebration of Sustainability in May and Sustainability Conference next November as well as in their school. They will be doing some water quality testing as per the RiverWatch program. Further, students will be working with younger students as well as their peers to promote understanding and stewardship of LW. Students work in partnership with the East Interlake Conservation District on a number of projects. For their final showcase event, they will invite members of the community.

Students are participating in a Stream Diversity Study and the Wetland Ecology Program at Oak Hammock Marsh. In addition, students have a practical exam where they teach the grade 5 students in the surrounding communities about water and the ocean at Ocean Fest.

Class is learning about water filtration, and will be doing a water filtration activity for water quality sampling through Engineers Without Borders. In addition, we have students that are involved in raising money for clean water in developing countries – opp allows them to see the importance of water quality. Some of our students are also creating a video about water pollution and water access.

Involved in a comprehensive river monitoring program that involves 18 kits of equipment + five conservation districts + seven school divisions = one big project collecting data right across the Red River basin!

Students are doing a class project on Sturgeon Creek and a man-made pond near our school that compares species diversity or species heterogeneity to find out the similarities and differences of various pond micro-organisms between these bodies of water. In addition, the class will participate in The Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) to monitor daily precipitation observations at MSD. The Deaf community in Winnipeg owns and runs a Deaf camp, Camp Kakepitay, near Vermilion Bay in Ontario. Plans are underway to make a video on how we can protect the lake and the Deaf camp beach area.

Students are involved in a project called "Water: A Unique Resource", that is centered on educating the students about their possible roles in protecting the natural resources around them. The inquiry-based model is designed to have students gain knowledge and skills through a collection of activities, site visits and presentations … Students will begin to collect samples of numerous sources of water (Jackfish Creek, Lake Winnipeg, wells, dugouts, surface run off) throughout the community and around their homes. Students will use their science inquiry skills to collect samples, examine samples and test the quality of the water at each location. Students will use water

testing kits to allow them to make appropriate judgments on the quality of the water. Students will record the results in a lab report, which they will present to the school and community members. The students will then conclude, using a variety of different sources, what they feel could be the reason for the contamination of the water. Students will take pictures and record observations at each point. Students will complete a lab report and create a presentation to share their findings with their peers.

Table 3. A brief summary of the schools that participated in the 2012 Lake Ecology Field Program and how teachers are linking the on board Program to curriculum outcomes.

School	Grade	Class	Curriculum Link
Ecole Edward Schreyer School, Beausejour	11 & 12	Marine Science 31G	This Program will expand upon the information in the curriculum of this course, giving the students a broader view on topics that we have studied in the classroom.
Chief Peguis Junior High, Winnipeg	8	Science/Social Studies	The Namao Field Trip will be used to engage students in a year-end project called "Water, Water Everywhere". This hands-on learning experience on Namao vessel will complement the research projects carried out in the year-end projects in June 2012. The chosen students will share their Namao scientific findings with their classmates in order for all students to create informative and meaningful year-end projects that reflect an understanding of the outcomes in several curricular areas, most notably in the Grade 8 Science and Social Studies programs. In class, we examine the health of Lake Winnipeg and the factors that may be compromising its future. By having 30% of the students involved in the program, it will bring to life this issue.
Linden Meadows, Winnipeg	8	Science	The trip is a springboard for the involvement of students and awareness of the health of Lake Winnipeg and its future. Specifically, we have had in-depth examinations of the effect of erosion on lake front properties where several students have first hand experience. Flooding, waste management and the economics of water have also been a feature in my program. For the past 2 years, this educational trip has been a highlight for the Grade 8 students and has been mentioned by staff and students alike at the farewell ceremonies. The discussions and presentations after the excursion are very rich. It does bring the classroom out to the 'real world.'
Riverton Collegiate, Riverton	12	Biology 40S and Applied Math 40S	Living and going to school directly on the lake, it is important for the students to be aware of the ecology of the lake. Speaking about issues related to Lake Winnipeg is one thing, but actually seeing the research first hand, is something completely different. I hope to gather information to help my Applied Math students see why and how we can use data and statistics. Graphing of data will take on a whole new meaning. For my Biology students, they will have the opportunity to work hands-on with the observation and identification of marine life. They will be able to draw connections beyond the textbook and make what seems like a separated issue, seem very close to home, which it truly is.
Fort Richmond Collegiate, Winnipeg	12	Watersheds Enrichment Group	Students are involved in gathering information about the factors that affect water quality in Manitoba as well as the subsequent development and implementation of action plans that are

School	Grade	Class	Curriculum Link
			aimed at educating the public about the issue (development of watershed field study programs for grade 10 and younger students that include data gathering, analysis and information about the issue), and addressing a factor that can aid the quality of water in the watershed (replanting of wetlands, monitoring and promoting soil testing and controlled use of fertilizers). The talk given by Dr. Scott has given our FRC group a greater perspective about the issue and has shared some up to date research data that has assisted students in determining the areas on which to focus their action plans. Participating in the Lake Winnipeg water quality testing will give students an example on which to base their own Kelburn farm field study programs for grade 10 and lower grade students.
Gimli High School, Gimli	11/12	Interdisciplinary Topics in Sciences 40S; Current Topics in Sciences 30S	The MV Namao experience is hands-on and first-hand view of the science of Lake Winnipeg. The ITS course focuses upon LW and world water issues. The CTS course focuses upon ecology. This is an excellent opportunity to engage students in real lake science.
Springfield Collegiate, Springfield	11/12	Marine Science	The trip on the Namao will give the students the "real" version of how to sample water and look for indicators of water quality. It will help them put information they have learned into practical use.
Rivers Collegiate, Rivers	9	Current Topics in Science 3	The program corresponds to our courses's GLO's and SLO's that concern themselves with water ecology.
Omega School, Teulon	5 to 12	Science	This fall, Grades 3 – 6 are studying **Diversity of Living Things** and **Habitats and Communities**, which is a nice extension of the Water Unit. I feel that doing a Lake Ecology Field Study on Board the Namao would provide for an outstanding experience for our students. They'd be coming with a general understanding of water and its importance to them and to the organisms that inhabit the water, of the beauty of Lake Winnipeg, and of the affect people's actions have on the quality of the Lake. I think the last point is valuable, especially since the Colony is a farming community.
7 Oaks Met School	10	Science & Geography	Seeing and hearing about Lake Winnipeg's Ecology through hands-on learning is extremely important because our school is about holistic, hands-on and relevant to the real world learning. All of our students know that they live in Winnipeg and that there is water but not much about the water in Winnipeg.
Nellie McClung Collegiate, Manitou	10	Science 20F	Our intention is to use this excursion as a culminating activity for the Grade 10 Ecology unit. It is also related to our River Watch program and the group coming is also in the Envirothon.

School	Grade	Class	Curriculum Link
MB School for the Deaf, Winnipeg	11	Current topics in Science 30E & Biology 30S	This trip would be a great learning experience sampling Lake Winnipeg water. They will also find out other problems the lake is facing with algae blooms and high *E. coli* counts. I am hoping the students will experience sampling techniques and will later on try these out on other lakes, rivers and creeks.
Balmoral School, Balmoral	7/8	Math & Science	The experience on the Namao will allow for our students to be immersed in the Science and Math outcomes that they are learning in the classroom. Students will be learning from a year long cross curricular project involving **Water Systems** in Science, **Representing Data** in Math, and the **Information Communication Technology** continuum.

Web-Based, Mixed Media Resources and Special Projects

The development of Lake Winnipeg web-based, mixed-media resources for schools is an on-going initiative, as time permits, that is intended to support existing Provincial curricula. Although targeted at schools, resources are suitable for a wide range of audiences, including the general public and in some cases the scientific community. Due to outstanding copyright issues, some of the resources that have been developed are currently limited for school use and are not yet in the public domain.

Closed Captioning (Manitoba School for the Deaf)

Students from the Manitoba School for the Deaf worked on an in-class project to add closed captioning to some of the LWRC's on-line resources. Their initiative will help promote scientific study in the deaf community.

LWRC Image Library and Satellite Blog

Within the public domain, the LWRC website continues to be the primary repository for both the Science and Education Programs. The most recent addition is an image library and blog, found at www.lakewinipegresearch.org/blog. Despite it being in the early stages of development, the image library contains the satellite image archive from 2003 to present, photomicrographs of different species of phytoplankton and zooplankton, as well as student art derived from the LEFP. In addition, there is a 'satellite blog' to which one can subscribe to receive updates on new satellite imagery postings.

Science Teachers Association of Manitoba

An ongoing collaboration continues with the LWRC's Education Coordinator, Dr. Karen Scott, and Grade 10 teacher Cheryl Boguski, the lead person who developed the Grade 8 Lake Winnipeg unit for Manitoba Education. In an effort to encourage teachers to adopt this new unit in their classrooms, Scott and Boguski have united to present annually at the Science Teachers Association of Manitoba. Scott focuses on the ecology of Lake Winnipeg and hands-on learning opportunities with the LEFP, while Boguski reviews some of the resources she has developed. As an extension to this joint effort and to further facilitate the incorporation of Lake Winnipeg into classrooms, a collection of on-line resources for teachers will be posted on the LWRC website in the coming months.

Manitoba Schools Science Symposium (MSSS)

On an annual basis, the Save Our lake (SOUL) group from the Grindstone Cottage Owners' Association (an LWRC member) offers a Lake Winnipeg award valued at $150 at the MSSS event. In addition to the financial award, the LWRC offers a trip on the M.V. *Namao* during one of the scientific research cruises to each recipient of the prize. This award provides a very unique opportunity for individual students to experience real fieldwork and research, for which they have already demonstrated an interest and ability through their MSSS science projects. The 2012 recipient was Grade 7 student Mariel Roehr for her project entitled "*Are storm water retention ponds potential opportunities*

for phosphorus recovery?" In addition to the SOUL award, Mariel won a silver medal at the MSSS and a platinum medal at the Youth Encouraging Sustainability (YES) Showcase.

Manitoba Theatre for Young People (MTYP)

The MTYP held a Film Group in Gimli in the summer of 2012 that was lead by Kent Suss. In an interesting marriage of art and science, the student participants came on board M.V. *Namao* while in harbour to sample various components of the food web and to shoot scenes for their short fictional film, *The Lake*, which was premiered at the Gimli Film Festival in July. *The Lake* is also available on Vimio.

APPENDICES

Appendix A. Science Workshop Agenda

Moving Forward Despite Diminishing Scientific Capacity

Lake Winnipeg Research Consortium
2012 Science Workshop

Siobhan Richardson Field Station
Fort Whyte Nature Centre
1961 McCreary Road, Winnipeg
April 24th and 25th, 2012

Workshop Objective: *Evaluate research progress within the context of moving forward toward an improved understanding of the Lake Winnipeg ecosystem despite diminishing scientific capacity on the lake.*

Lunches, snacks and beverages will be served on site including coffee and tea upon arrival in the morning.

DAY 1 – WHERE WE ARE

8:30 a.m. – 4:30 p.m.

1) Workshop Overview – *Where We Left Off Last Year* Scott
2) A Focused Conversation on the Realities of Lake Winnipeg Science
    a. Objective *Feature – Fish Stock Status* Kline
       Science Updates – Table 1
    b. Reflective, Interpretive and Decisional
3) Other Topics of Interest (open mic)

DAY 2 – MOVING FORWARD

8:30 a.m. – ~3 p.m. (latest)

1) Indicators – *Development of a Suite of Eutrophication Indicators* Bibeault
2) Pelagic Sampling (Table 2) – Parameters being sampled vs should be sampled
3) North Basin Near-Shore Sampling – Locations, parameters, protocols etc.
4) Other Sampling – *Bythotrephes*, zebra mussel veligers, acoustic surveys, day/night trawls, otter trawls, shorebird colonies, fish contaminants surveillance, other

Appendix B. Science Workshop - science and monitoring updates submitted by workshop participants

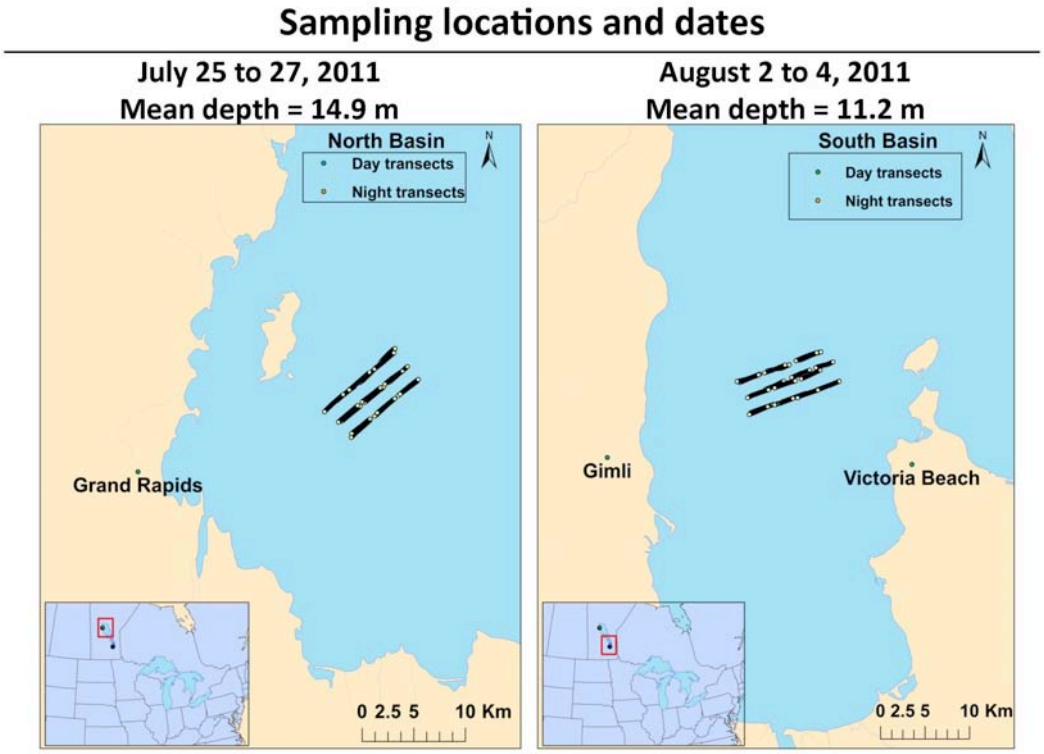
Offshore Surveys of the Fish Community in Lake Winnipeg

Chelsey Lumb and Laura Heuring
Fisheries Branch, Manitoba Conservation and Water Stewardship

Other Collaborators (and affiliations): Doug Watkinson (Fisheries and Oceans Canada); Karen Scott (Lake Winnipeg Research Consortium); Scott Milne (Milne Technologies)

Brief description of your project(s): Status and trend monitoring of fish populations in offshore waters of Lake Winnipeg using midwater trawl surveys conducted lakewide during summer and fall. In the summer of 2012, we hope to compare two independent assessment methods; traditional trawl surveys and large-scale fisheries acoustics, to improve understanding of fish distribution and to compare biomass estimates of prey fishes.

Summary or update of your results, if applicable: I plan to summarize day/night fish biomass estimates from summer 2011 in the next month.



Mean depth (± 1 standard deviation) of trawl depth by basin

Trawl depth	South basin	North basin
Surface	1.5 m ± 0.1 m	1.4 m ± 0.1 m
Midwater	4.9 m ± 0.4 m	6.4 m ± 0.5 m*
Deepwater	7.3 ± 0.6 m	11.0 m ± 0.3 m*

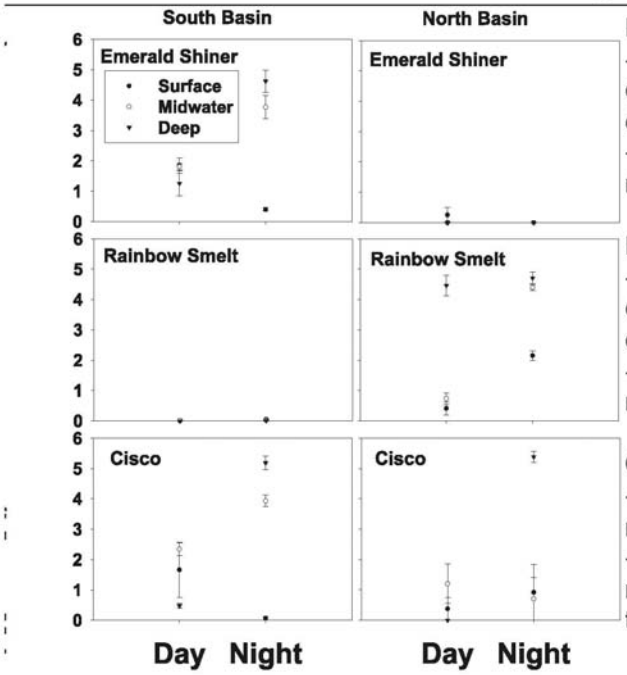
*Denotes trawl depths that were significantly different in the south compared to the north basin ($P < 0.05$)

Total Catch by Fish Species in Day/Night Trawls

Species	South Basin				North Basin			
	Day		Night		Day		Night	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Emerald Shiner *Notropis atherinoides*	859	29.3	3452	34.6	47	3.8	2	0.1
Rainbow Smelt *Osmerus mordax*	3	0.1	13	0.1	1094	89.4	2527	90.1
Cisco *Coregonus artedi*	194	6.6	1434	14.4	20	1.6	185	6.6
Lake Whitefish *Coregonus clupeaformis*	1	0.0	2	0.0	27	2.2	11	0.4
Troutperch *Percopsis omiscomaycus*	0	0.0	50	0.5	0	0.0	19	0.7
Burbot *Lota lota*	0	0.0	0	0.0	0	0.0	2	0.1
Spoonhead Sculpin *Cottus ricei*	0	0.0	5	0.1	0	0.0	0	0.0
White Bass *Morone chrysops*	16	0.5	28	0.3	0	0.0	0	0.0
Yellow Perch *Perca flavescens*	1251	42.6	3706	37.2	1	0.1	1	0.0
Sauger *Sander canadensis*	156	5.3	264	2.6	2	0.2	2	0.1
Walleye *Sander vitreus*	456	15.5	614	6.2	33	2.7	55	2.0
Freshwater Drum *Aplodinotus grunniens*	0	0.0	396	4.0	0	0.0	0	0.0
Total	2936	100.0	9964	100.0	1224	100.0	2804	100.0

Total of nine day trawls, and nine night trawls in each basin completed summer 2011

Fish Biomass Density Estimates

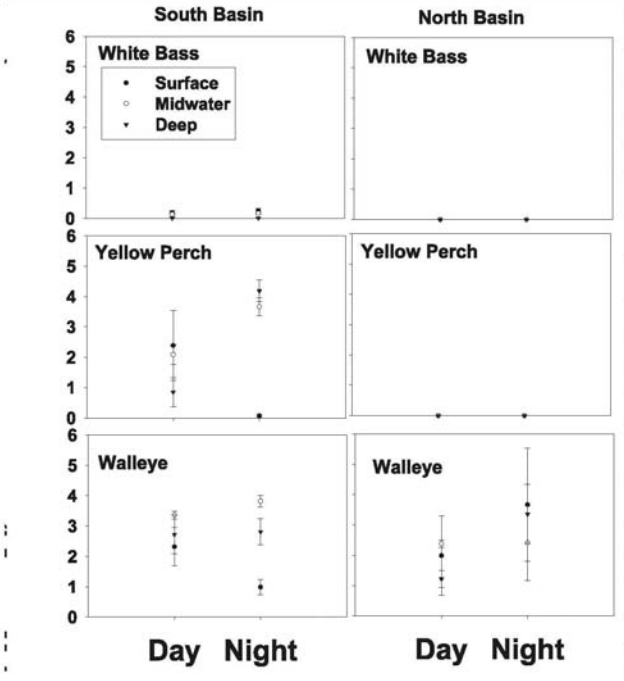


Emerald shiner, south basin:
- greater biomass in midwater and deep trawls in night compared to day
- less biomass in surface trawls in night compared to day

Rainbow smelt, north basin:
- greater biomass in midwater and deep trawls in night compared to day
- no difference in deep trawls in night compared to day

Cisco, south and north basin:
- greater biomass in deep trawls in night compared to day
- no differences in surface or midwater trawls in night compared to day

Fish Biomass Density Estimates



White bass, south basin:
- interaction of main effects not significant, so results interpreted at level of main effects
- no effect of diel period
- greater biomass in surface trawls compare to deep trawls

Yellow perch, south basin:
- greater biomass in deep trawls in night compared to day
-no differences in surface or midwater trawls in night compared to day

Walleye, south basin:
- interaction of main effects not significant, so results interpreted at level of main effects
- no effect of diel period
- greater biomass in midwater and deep trawls compared to surface

Growth, Condition and Diet Variation in Walleye (*Sander vitreus*) and Sauger (*Sander Canadensis*) in Lake Winnipeg

Katie Sheppard (M.Sc. Student), Drs. B. Hann and G. Davoren (Supervisors)
Department of Biological Sciences, University of Manitoba

Other Collaborators (and affiliations): Manitoba Hydro funded project

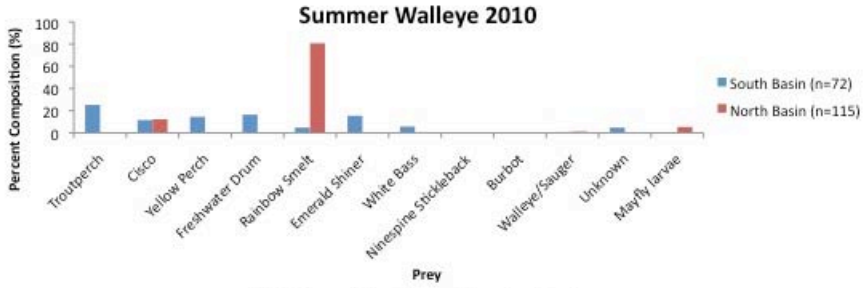
Brief description of your project(s): The objective is to determine if there are spatial differences in growth and condition based on diet variation throughout the lake. I will be using energy density of prey to determine reasons for any determinable preference in prey selection. Gut content analysis, to determine any possible prey selection, makes up a large portion of this study.

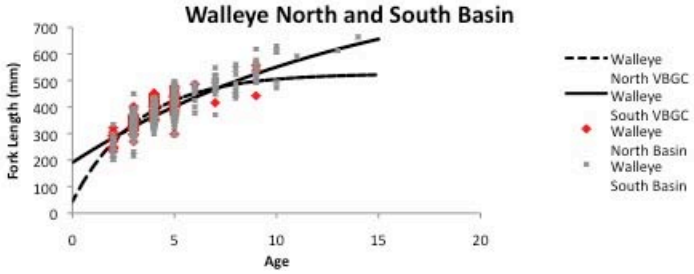
Summary or update of your results, if applicable: Nothing at this time. I will have reportable results soon.

Katie Sheppard – M.Sc. Student with Dr. Hann and Dr. Davoren, U of M

Diet, growth, condition and bioenergetics of Walleye, Sauger and their prey in Lake Winnipeg

- Diet: Species, season, basin and sex differentiation
- Growth: Species, basin and sex differentiation
- Condition: Species (incl. prey), season, basin and sex differentiation
- Bioenergetics: Interactions of walleye (normal and dwarf morphotype), sauger and their prey





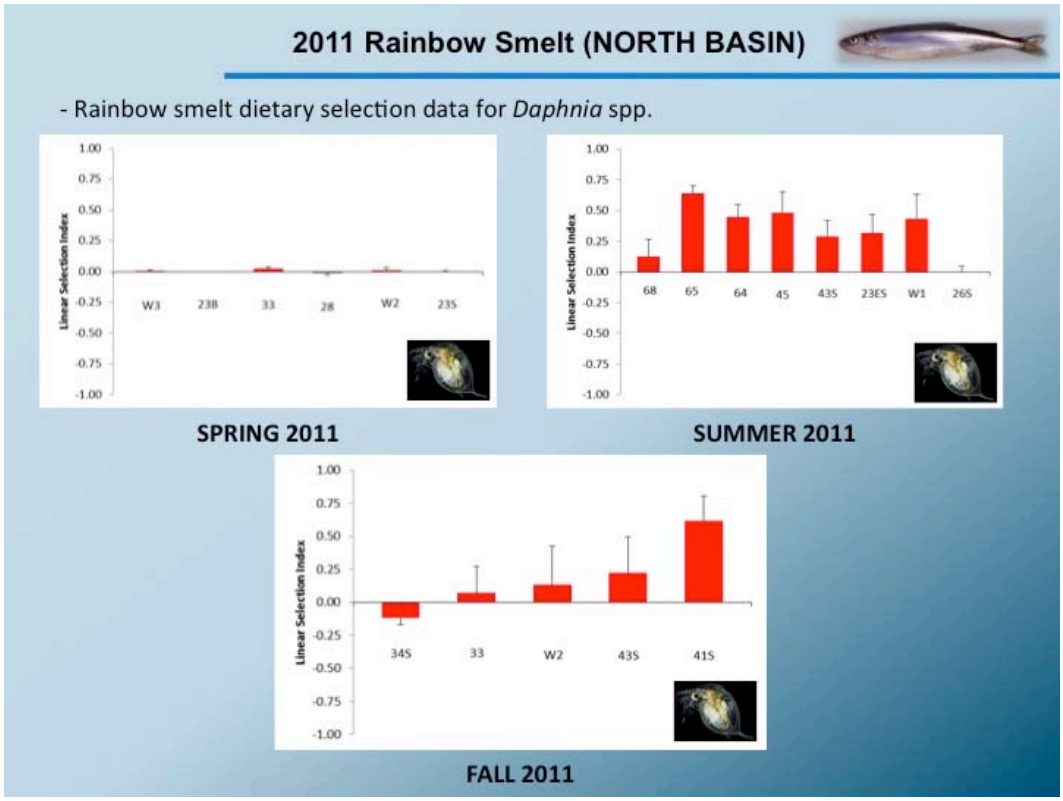
Seasonal variation in diet of invasive Rainbow Smelt (*Osmerus mordax*) and native Cisco (*Coregonus artedi*) in Lake Winnipeg, MB

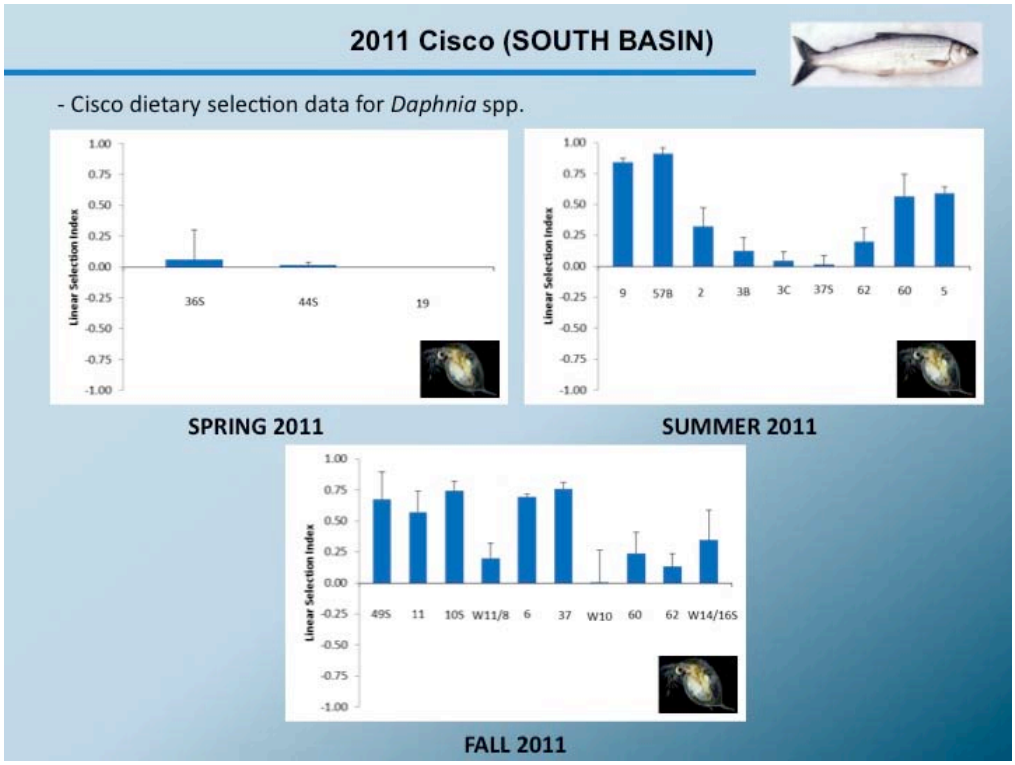
Andrew Olynyk (M.Sc. Student), Dr. Brenda Hann & Dr. Gail Davoren (supervisors)
Department of Biological Sciences, University of Manitoba

Other Collaborators (and affiliations): N/A

Brief description of your project(s): The objective of this study is to investigate the effects of the invasive rainbow smelt (*Osmerus mordax*) on the food web of Lake Winnipeg, with particular emphasis on current interactions between smelt and the zooplankton prey community. In addition, the interactions of smelt with cisco (*Coregonus artedi*), a native fish species occupying a similar trophic niche, will be considered. Overall, this project aims to broaden the knowledge of smelt dietary characteristics in Lake Winnipeg and explore the impacts to both the fish and zooplankton community. This will serve to increase knowledge on the energy flow in Lake Winnipeg as well as help in making food web predications based on smelt's continued presence in the lake.

Summary or update of your results, if applicable: Preliminary analysis of 2010 and 2011 gut contents for both cisco and rainbow smelt indicate an overall preference for large cladocerans (i.e *Daphnia* spp. and *Eubosmina* sp.) in summer and fall. Spring gut contents show higher amounts of dietary variation, with greater preference for copepods (calanoids and cyclopoids) present than in the other seasons. Further analysis of gut contents (statistical testing, mean size of prey groups in gut contents, etc.) and environmental zooplankton data (mean size of prey groups, densities, etc.) is ongoing.





Survey of Zoobenthos (seasonal and spatial)

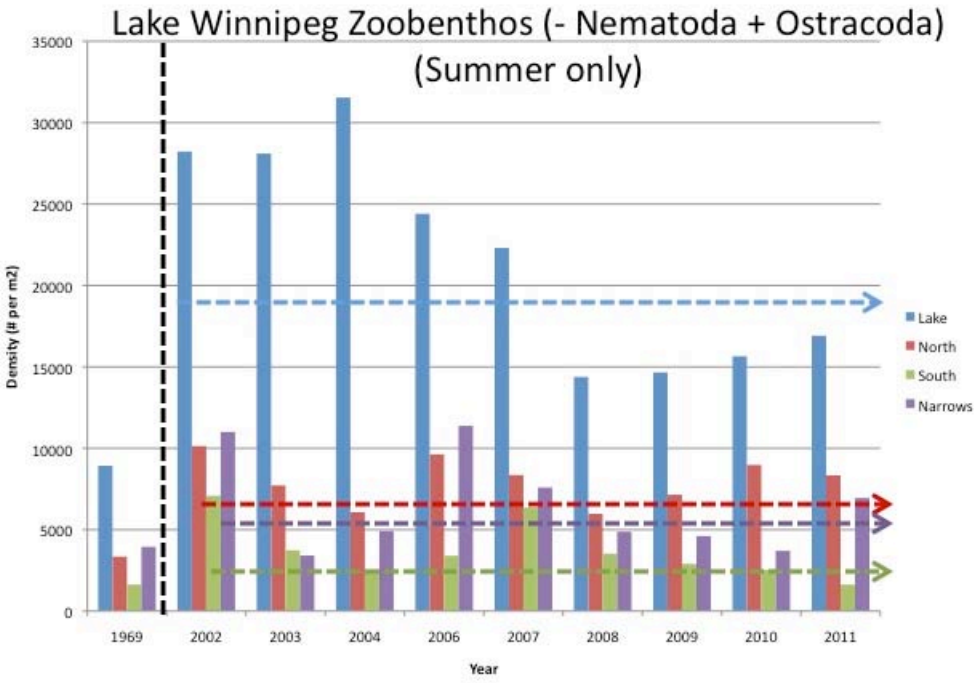
Dr. Brenda Hann
Department of Biological Sciences, University of Manitoba

Other Collaborators (and affiliations): Mirna Wishart, contractor funded by EC, working in my lab; Matthew Bryan, MSc student, Department of Biological Sciences, UM

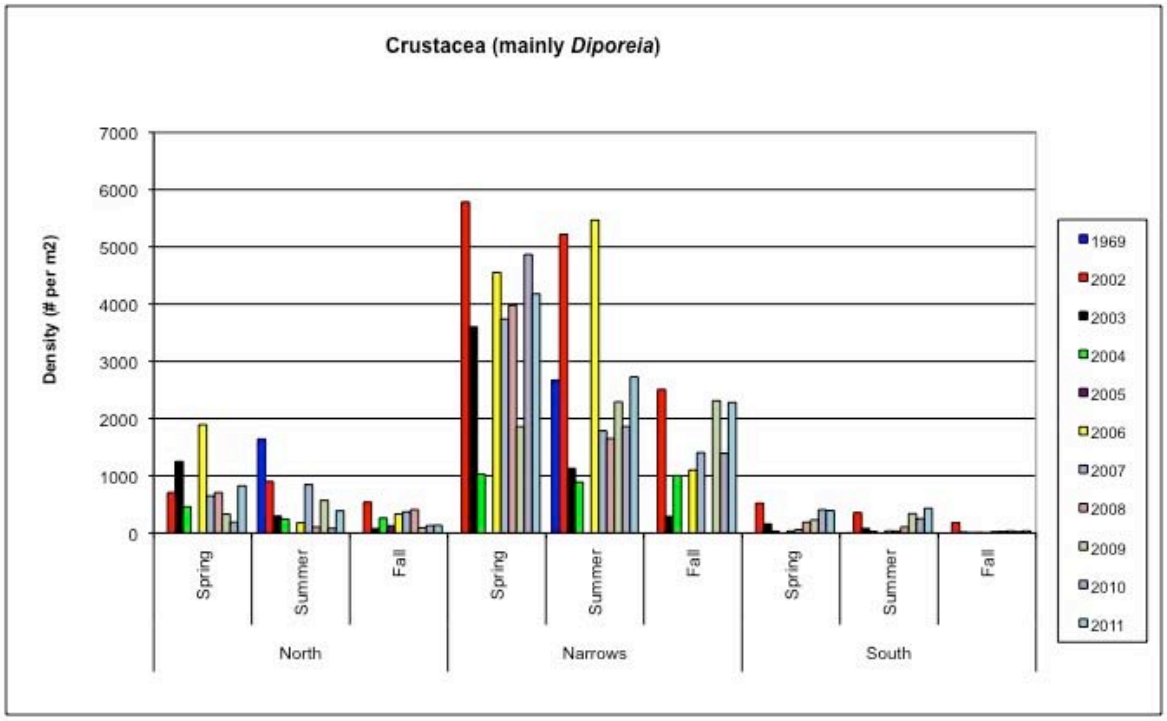
Status: ongoing, contingent on EC funding for benthos analysis

Brief description of your project(s): (1) Sampling and analysis of zoobenthos to examine seasonal and spatial variation to compare with previous years with the goal of assessing the impact of eutrophication and climate change on the benthic community. (2) Impact of cyanobacteria and cyanotoxins on zoobenthos.

Summary or update of your results, if applicable:



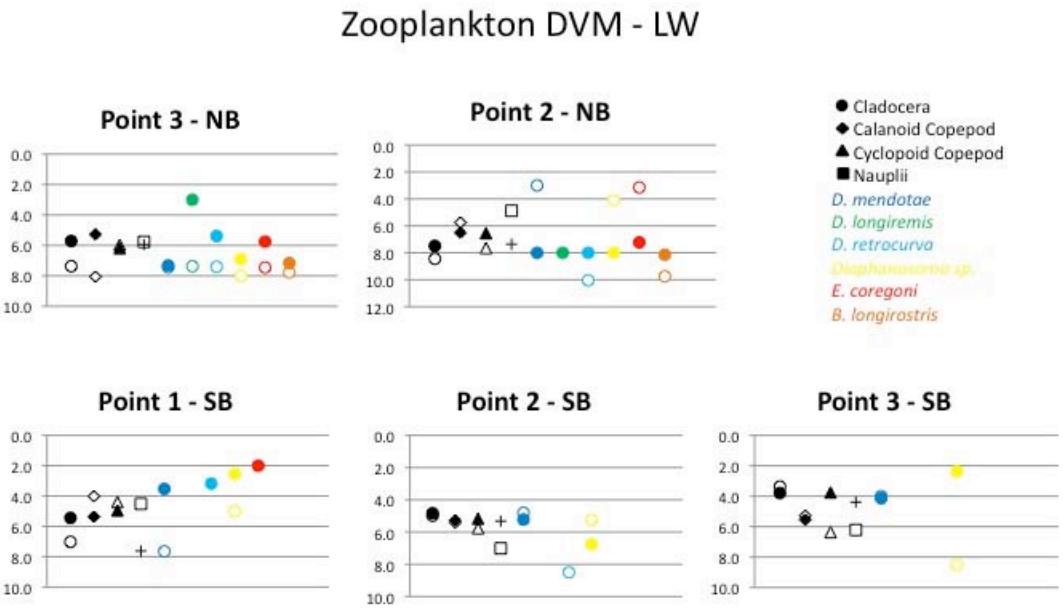
Note: 1. Mean 2X increase in zoobenthos lakewide; 2-3X increase in North Basin
2. Nematoda and Ostracoda were not counted in 1969



Response of Zooplankton Community of Lake Winnipeg to Environmental Changes

Daigo Kamada (M.Sc. student), Dr. Brenda Hann (Supervisor)
Department of Biological Sciences, University of Manitoba

No synopsis submitted



Mean Residence Depth (Baryanai *et al.*, 2011) of Zooplankton in LW. Filled circles = Night
Empty symbols = Day.

Characterize the physical, chemical and biological nature of Lake Winnipeg to better understand the balance of nutrient enrichment to the lake and its productivity in relation to algal/cyanobacterial blooms and toxicity

Drs. Sue Watson, Jay Guo, Ram Yerubandi
Environment Canada - Burlington

Other Collaborators (and affiliations): Hedy Kling, Len Hendzel, Mike Stainton, Greg McCullough, Lewis Molot, Brenda Hann, Alex Salki

Status: ongoing and completed

Brief description of your project(s): This overall objective has been addressed with a series of river/lake based research projects

I) *Origins, status and trends of the nutrient loading from the LWPG drainage basin and in-lake processing (P, N).*

i) bioavailability and levels of inorganic and organic P and N loads and potential sources in major rivers and their role in promoting in -lake cyanobacteria blooms

ii) sediment loads and nutrient content/availability in major tributaries and in-lake resuspension/internal loading

II) *Increased knowledge of the status, origins and trends of the biological community in LWPG and major tributaries:*

i) extent, intensity and trends in algal/cyanobacterial blooms, spatial and temporal dynamics, physiological status, indigenous and invasive species and major toxins in LW and major drainage

ii) biological community at key trophic levels (primary, secondary, detrivore, heterotrophic), and the impact of nutrient enrichment and invasive species on this foodweb to provide benchmarks for target setting and remediation policy

Tributaries:

1. Between 2007-2011, the Red and other major rivers were sampled for sediment and nutrient studies from 3-5 stations under spring melt, summer low flow, fall and winter flow regimes. During 2009 and 2010, major tributaries (Red River (4 stations), Assiniboine River (2 stations), Winnipeg River (2 stations) were sampled in spring, summer and fall for water quality, plankton and suspended sediment using an improved method for *in situ* filtering of large volume samples. Where possible, bottom sediments were also collected (with the exception of rocky riverbeds). Dissolved and particle-bound fractions were processed for nutrients, biota and water chemistry and indicators/bioassays for nutrient deficiency (Guo, Watson et al)
2. The bioavailability of P and N fractions in Red and Assiniboine were assessed at sites near and away from agricultural or industrial/urban influences (including at 3 long-term provincial monitoring sites) using bioassays were performed with species

representative of the N-fixing cyanobacteria dominating LW blooms. (Watson, Hendzel, Stainton, Kling et al.)

3. Future work could integrate these measures with hydrological data to model river channelization and discharge, and in-lake circulation and sedimentation/resuspension.

Lake Winnipeg:

Between 2008-2011 the following activities were carried out on the spring summer and fall Namao lake surveys

1. **Nutrient deficiency and N-fixation:** Spring/summer/fall in-lake bioassays coupled with nutrient enrichment experiments and measures of nutrients, sestonic stochiometry and biomass (chl*a*, biovolume, taxa) were carried out to address N:P issue in lake integration into previous data and publication (Watson, Hendzel, Stainton, Kling et al.)
2. **Cyanobacterial toxins:** summer/fall samples were collected and analysed for microcystins and other toxins for integration into previous data and publication (Watson, Kling Herbert Boyer Kotak, et al) Archived fish samples will be analyzed for toxin content, resources permitting. In 2010, beach samples were collected for toxins and major cyanobacterial taxa (with MWS and Health Canada).
3. **Evaluation of application of fluorescence-based measures:**
    i) Spring/summer/fall deployment of algal online analyser and FluoroProbe profiling were combined with taxonomic analyses, pigment concentrations and remote imagery for integration into previous data and publication (McCullough, Stainton, Watson, Kling)
    ii) PAM based measures were taken in parallel with nutrient-deficiency and other measures to assess physiological status of major plankton groups
4. **Lake Winnipeg lower trophic levels:** collection, flow cytometric and taxonomic analysis and initial reporting were carried out on river and lake samples (for selected years and samples) collected and archived since 1999 -present by ATEI (Kling, Salki, Wichart, Hann).
    i) Picoplankton (<2um) and heterotrophic bacteria; 2010-2011
    ii) Phytoplankton and microzooplankton; current and historical trends in phytoplankton species and biomass and relationship with other records (core/satellite/toxin imaging data).
    iii) Macrozooplankton, from current and archived samples
    iv) Major zoobenthos taxa; collected between 2009-2011 spring, summer, fall lake surveys; analysis up to 2009-10
5. In addition, sediment core samples were analyzed for sediment chemistry, algal (diatoms, non-siliceous cyanobacterial cells) and zooplankton fossils to assist in a robust evaluation of long-term trends in the aquatic foodweb.
6. Collection and analyses of spring/fall 2008-10 surficial sediment composition, particle size and nutrient bioavailability; these data will be combined with i) analysis

of material collected from deployed sediment traps ii) analysis of archived surficial sediments from previous years to extend the evaluation of seasonal/spatial/inter-annual patterns in surficial sediments, relationship with water column nutrients and seston levels and implications for resuspension and internal nutrient recycling (Guo, Watson, Stainton, Ramcharan, Yerubandi)

7. Collection and incubation of sediment cores from 5 sites between 2010-2011 to evaluate the potential for anoxic P release and the role of iron. Surficial sediments (0-5 cm) from a 2nd set of cores sequentially fractionated for P, Fe and Al (Molot, Watson, Stainton and Guo). This and further lake based work will address the potential for internal P loading from areas prone to the development of anoxic bottom layers in the N basin

Summary or update of your results, if applicable:

Tributaries:

- Major differences in water quality and nutrients among sites along the Red and Assiniboine rivers, with a decrease in turbidity downstream of the US-Canada border towards the outflow to the lake. Estimates show the Red River as major source (>60%) of P to Lake Winnipeg. Current levels of TP in the river often exceed 500ug/L; approximately half of this as SRP.
- Total dissolved N showed differences in chemistry among sites with the highest NO_3 at Emerson and influxes of NH_4 near municipal sewage treatment plants (STPs). TON represented a high proportion of the TDN at all sites
- No evidence of significant N or P deficiency in the river but bioassays during summer and fall periods indicate localized differences in nutrient bioavailability. Upstream at Emerson the river showed relatively higher levels dissolved organic P (DOP) which is less immediately available to the plankton but supports sustained growth of taxa which can utilize this fraction, including cyanobacteria found in LWP. Near STP discharge there was a local pulse in nutrient bioavailability which supported rapid but short growth but was rapidly dissipated downstream.. Variable, but high levels of chla and plankton at some sites (dominated by diatoms, and N-fixing Cyanobacteria)

Lake Winnipeg:

Nutrient deficiency and N-fixation

- Initial assessment of data indicated little N or P deficiency across the lake in the spring, but an increase in P and to a lesser extent N deficiency from summer though to fall in both basins. PAM measures indicated that cyanobacteria had a superior physiological status than diatoms and other taxa as the season progressed. These data will be combined with those from earlier years (Hendzel, Herbert, Stainton) to evaluate short and long term nutrient status in relationship with water chemistry and other factors and to recalibrate an earlier model for N-fixation and cyanobacterial heterocyst frequency developed by Hendzel et al.

Toxins

- MC-producing cyanobacteria are present but not predominant in blooms. The risk of toxins increases dramatically, however, in dense surface or shoreline scums which commonly occur as a result of wind and currents.
- Pelagic zones often show low or undetectable MC levels, but concentrated net hauls and surface scums can show elevated levels and there is some indication that nutrient status affects toxin production. The (provisional) recreational guideline (~20ug MC/L) is periodically far exceeded in the public beaches and nearshore mats of bloom material. Other toxins were undetected.

Lower Foodweb:

Final results are pending completion of analyses for this funding cycle and will be integrated with water quality data and with taxonomic analyses from earlier periods in a co-authored manuscript on a comprehensive temporal and spatial analysis of lower foodweb. Initial results show:

- Spring blooms initially under ice are dominated almost solely by *Aulacoseira islandica.* after ice out in both S and N basins and the blooms are a mixed population of primarily centric diatoms (*Aulacoseira islandica, A. ambigua and A. granulata*, (the last two can grow at higher temperatures than the former) and often there are also *Stephanodiscus binderanus*, small *Stephanodiscus minutulus* and *S. hantzschii* and the larger, *Stephanodiscus niagarae*, *S. agassiziensis*, and *Cyclostephanos dubuis* some areas of the lake) Summer/fall blooms are dominated by N-fixing cyanobacteria, with early summer dominance by *Anabaena lemmermannii*, *A. flos-aquae/ A. spiroides, A. mendotae*, some years *A. ellipsoidea* (all planktonic *Anabaena* are now in the genus *Dolichospermum*) succeeded and by strains of the *Aphanizomenon flos-aquae* complex which dominate by late summer-fall. *Aphanizomenon* blooms are often accompanied by low abundance *Pseudanabaena rutilis-viridis* especially in the north basin around Berens River, and by several strains of non-fixing *Microcystis* spp. the strains of which are known microcystin (MC) toxin producers. Over the past few years in LWPG samples show year to year variation and a high degree of morphological variance among the dominant LWPG cyanobacteria (especially in the *Aphanizomenon flos- aquae* complex) - all or only some of which may be different species which may vary in toxicity - and which are difficult to resolve using traditional methods
- Comparing LWPG South Basin zooplankton community in 1969 (moderate Red River flows) with 1998 (1997 flood impacts still visible) and 2003 (low RR flows), Red River hydraulic variability appears to have a strong influence on species structure in the South Basin. Widening of the cut through the Netley Marsh area at the mouth of the Red River allows more flow through the marsh which in turn probably flushes littoral inhabitants, including zooplankton and some bait fish, into the lake. Inclusion of additional years of Red River and zooplankton data from archived samples will improve this assessment and allow a better evaluation of this mechanism, which has significant implications both for the resilience of the marsh foodweb and LW blooms and fisheries.

- Preliminary comparison of 2010 and 2011 spring surveys in the North and South Basins showed distinct differences in abundances and species richness of four major zoobenthos families. In the North Basin, there was an increase in chironomid and haustoriid (*Diporeia* sp.) abundance, especially near Grand Rapids, while in the South Basin and Narrows these two groups decreased slightly together with Sphaeriids. Tubificid worms decreased considerably throughout the lake between the two years.
- Water levels in the lake were quite different in 2001 from the previous year (2010) and samples showed more evidence of fine decomposed organic debris. Late in summer 2010, a channel was dug from Lake Manitoba to Lake Winnipeg to relieve exceptionally high water levels in Lake Manitoba (as a consequence of diversion of the Assiniboine River). This might have caused changes in the number and diversity in the zoobenthos of LWPG. Completion of samples from 2011-12 surveys will allow us to better evaluate these and other changes in the zoobenthos.

Sediment:

- Significant differences in sediment nutrient and organic composition were observed between sites and in particular, between spring and fall samples both in 2008 and 2009. There was a marked increase in TP levels in fall surficial sediments in both basins, N showed less distinctive patterns. BAP concentrations ranged between 10-20% of the total P content of the surficial sediments
- Fe and P release rates from incubated LWPG cores were relatively high compared to release rates from other lakes, attributed to differences in sulphate concentrations, and organic carbon, P and Fe content in the sediments.

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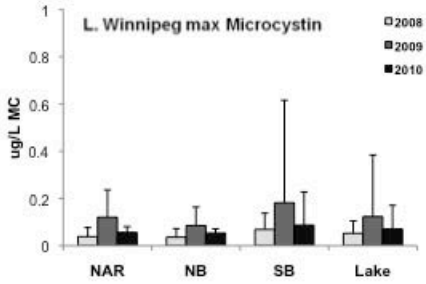
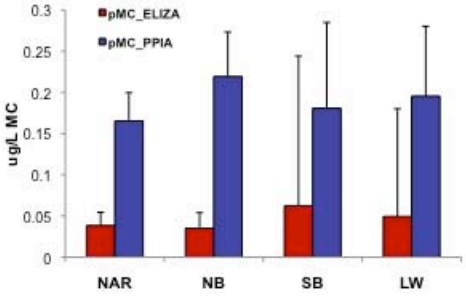
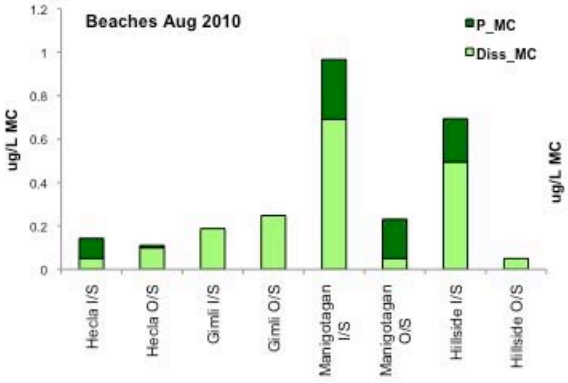
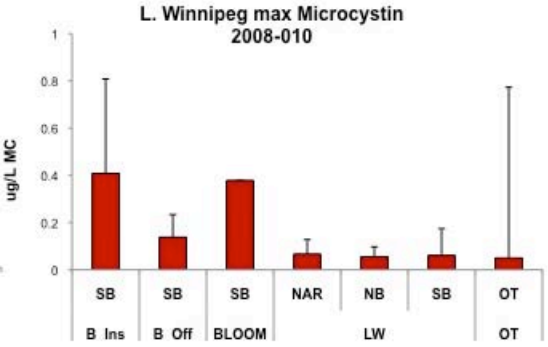
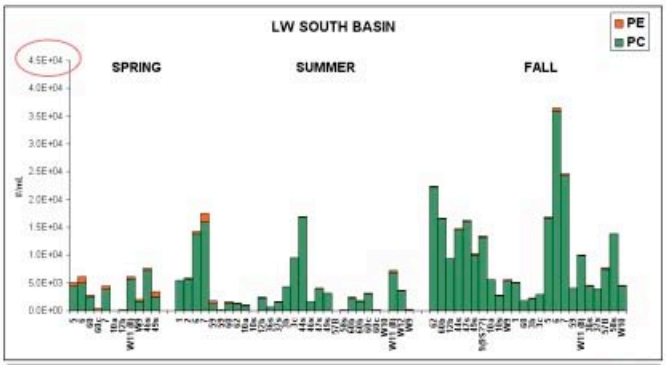
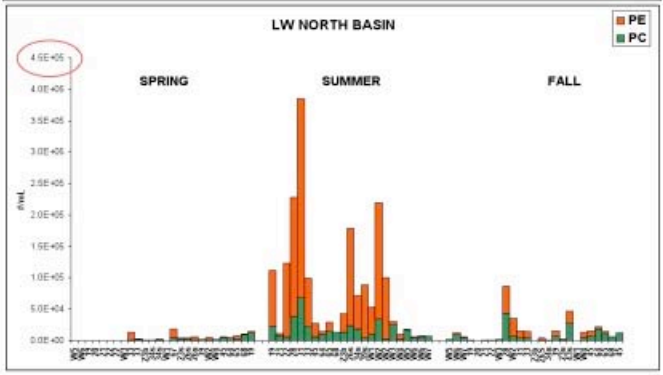






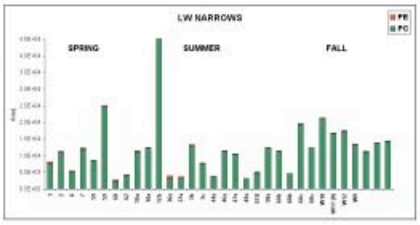


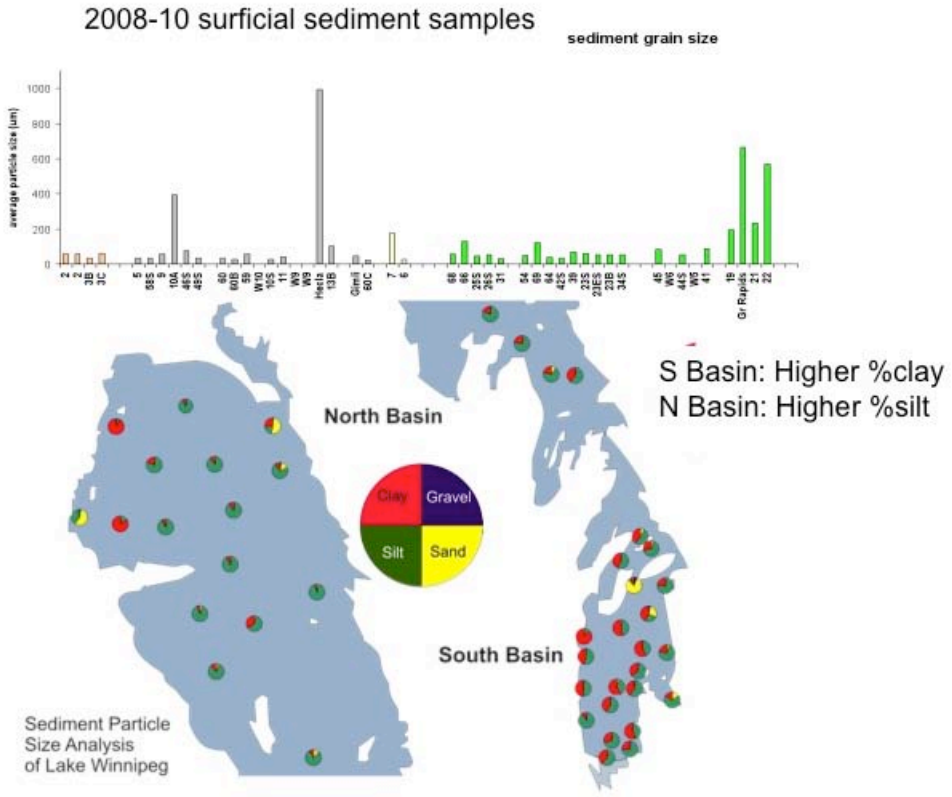


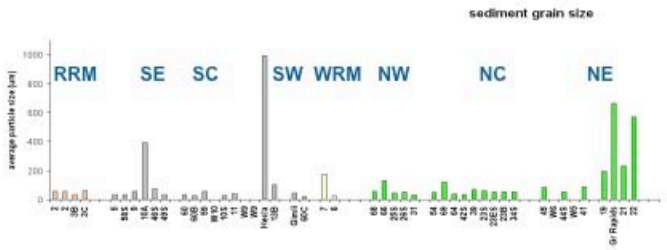


Picoplankton (<2um)

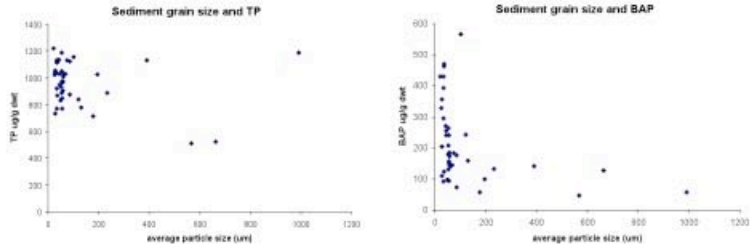
- **NB>>SB**
- NB: PE (red), summer
- SB: PC (blue-green), fall



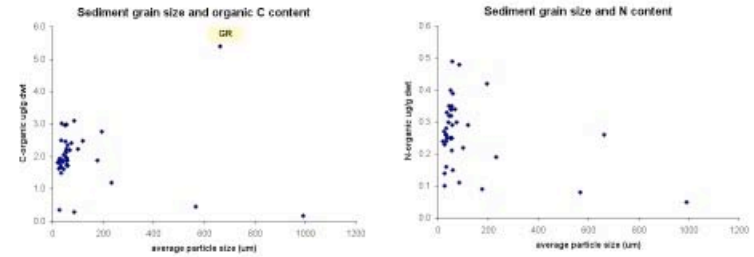




Particle size
N→S
E → W
Inshore→offshore



Particle size
→ organic nutrients



Nutrient Sequestration Study & Physical limnology of Lake Winnipeg (light and temperature profiles)

Dr. Brian Parker
Environment Canada - Winnipeg

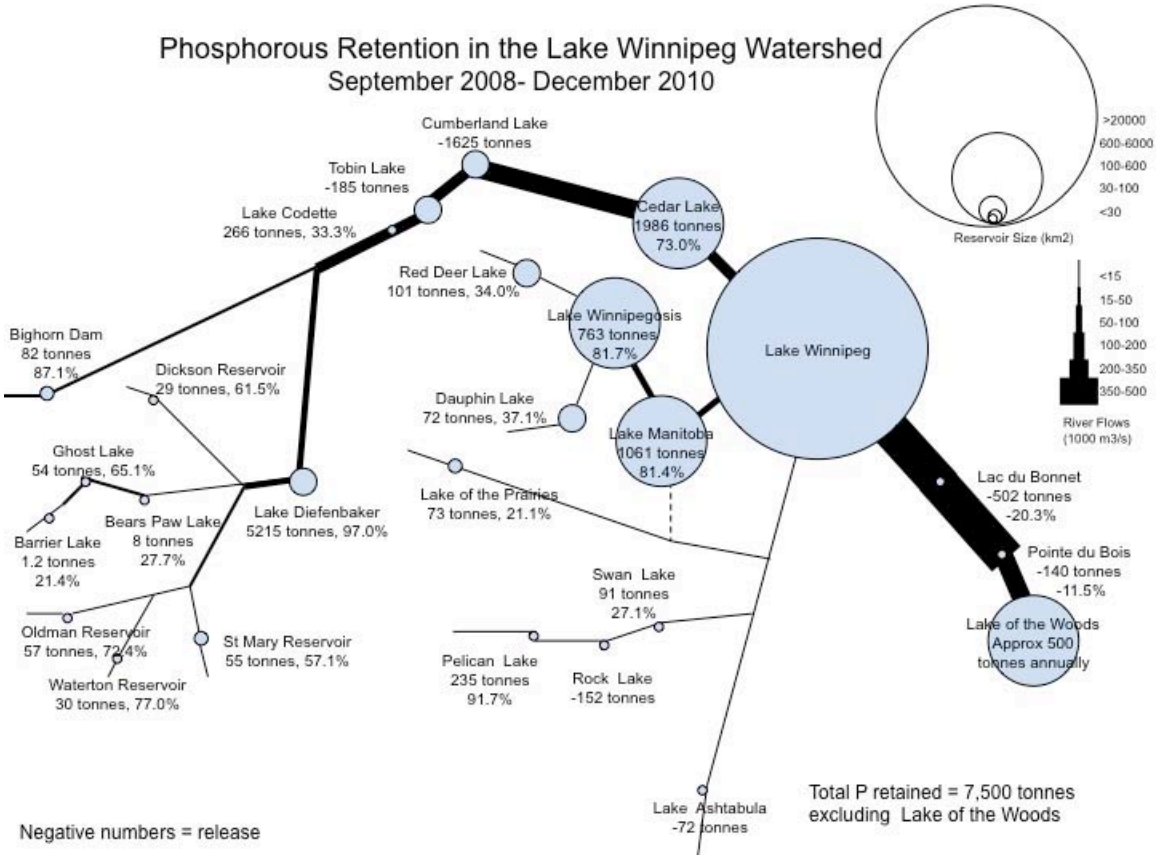
Other Collaborators (and affiliations): Nil

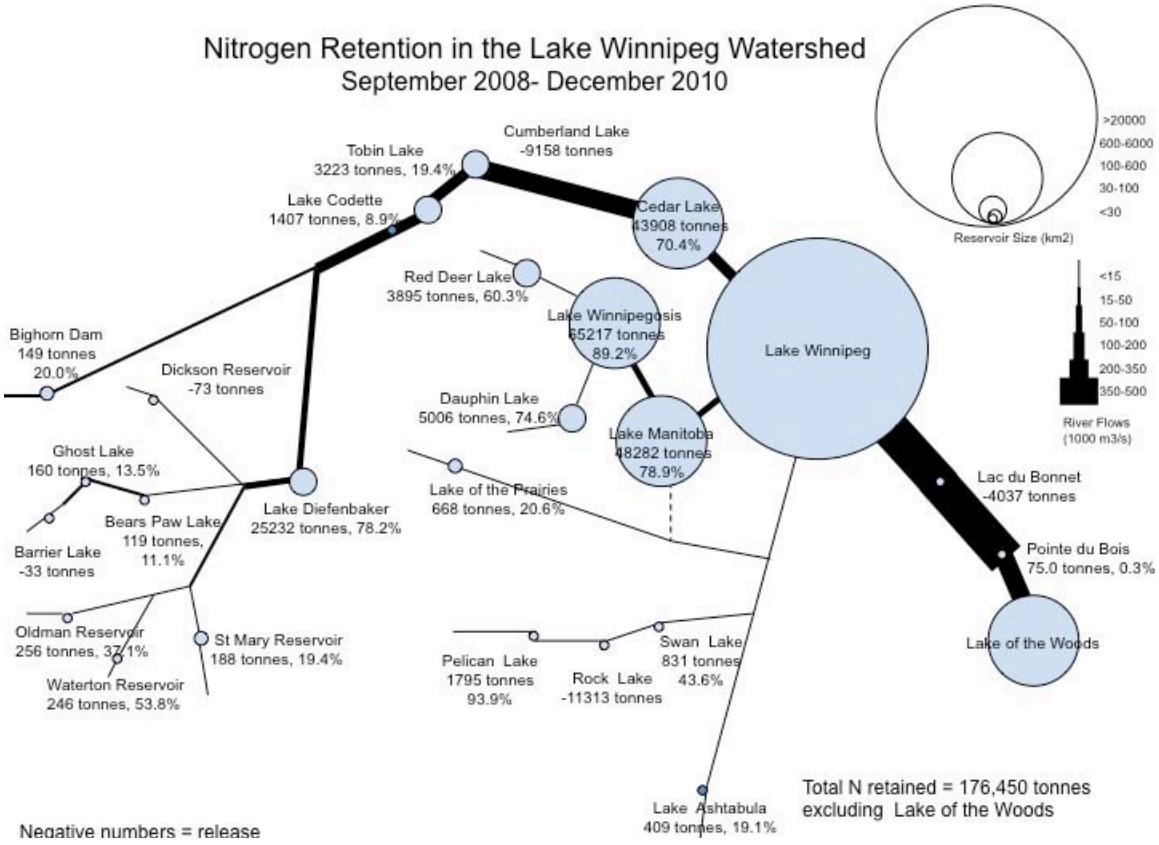
Status: Nutrient sequestration – near completion, physical limnology - ongoing

Brief description of your project(s): Nutrient sequestration: evaluation of nutrient sequestration and release in 30 larger lakes and reservoirs in the Lake Winnipeg Basin.

Physical limnology: collection of light and temperature profiles and water samples from the Namao via operation of the Seabird

Summary or update of your results, if applicable:





Portage Diversion – Lake Manitoba

	2009	2010	2011
Average Inflow Rate (m^3/sec)	472.4	390.1	1258.9
% inflow to lake from Portage diversion	41%	14%	42%
P Input (tonnes) from diversion	826	399	3869
% TDP	9%	7%	6%
TP Retained (tonnes) in Lake Manitoba	710 (86%)	307 (77%)	3598 (93%)

P=Phosphorous

TDP=Total Dissolved Phosphorous

TP=Total Phosphorous

Pharmaceutical Contaminants in Lake Winnipeg and Surrounding Watersheds

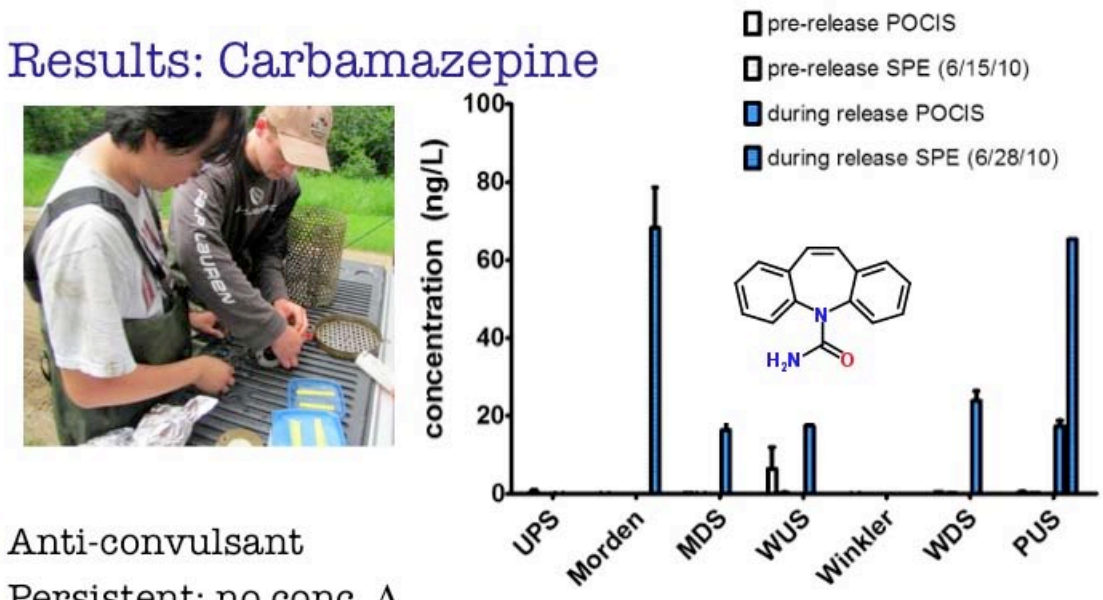
Mark Hanson[1], Jules Carlson[1,2], Jonathan Challis[1,2], and Charles Wong[2]
[1]Department of Environment and Geography, University of Manitoba; [2]Richardson College for the Environment, University of Winnipeg

Other Collaborators (and affiliations):

Status: Ongoing (POCIS on Lake Winnipeg)

Brief description of your project(s): Using Dead Horse Creek as a model watershed. 1. Characterize the quantities and types of pharmaceuticals entering aquatic environments in Manitoba. 2. Examine the efficacy of treatment wetlands to remove pharmaceutical contaminants. 3. Characterize the role of ecological mechanisms in removing antibiotic resistant gene-containing organisms from the aquatic environment.

Summary or update of your results, if applicable:



- Anti-convulsant
- Persistent; no conc. Δ
- Generally only present in DHC during discharge
- Similar to surface water: North Sask. River, AB ≈30 ng/L
  (MacLeod et al. (2007) Environ Toxicol Chem 26, 2517-2529.)
- And other sewage lagoons: Lac la Biche, AB ≈70 ng/L
  (MacLeod and Wong (2010) Wat Res 44, 2757-2766.)

Appendix C. Science Workshop participants and affiliations.

Name	Agency
Armstrong, Nicole	Manitoba Water Stewardship
Artuso, Christian	Manitoba Breeding Bird Atlas
Bibeault, Jean-Francois	Environment Canada, Montreal
Binding, Caren	Environment Canada, Burlington
Bryan, Matthew	University of Manitoba
Challis, Jonathon	University of Manitoba
Chaze, Ainslie	Manitoba Hydro
Clark, Heather	Manitoba Fisheries Branch
Hann, Brenda	University of Manitoba
Hansen, Mark	University of Manitoba
Hesslein, Ray	Independent
Higgins, Scott	Fisheries and Oceans Canada
Howard-Scott, Zander	Independent (audio)
Janjua, Yamin	Fisheries and Oceans Canada
Kamada, Daigo	University of Manitoba
Kline, Geoff	Manitoba Fisheries Branch
Kling, Hedy	Algal Taxonomy and Ecology, Inc.
Kristofferson, Al	Lake Winnipeg Research Consortium Inc.
Lawrence, John	Environment Canada, Burlington
Lumb, Chelsey	Manitoba Fisheries Branch
Olynyk, Andrew	University of Manitoba
Page, Elaine	Manitoba Water Stewardship
Ramlal, Patricia	Fisheries and Oceans Canada
Rennie, Mike	Fisheries and Oceans Canada
Richmond, Dan	Lake Winnipeg Research Consortium (Ship operations)
Salki, Alex	Salki Consultants
Scott, Karen	Lake Winnipeg Research Consortium Inc.
Shead, Justin	Manitoba Water Stewardship
Sheppard, Katie	University of Manitoba
Stainton, Mike	Fisheries and Oceans Canada
Swanson, Gary	Manitoba Hydro
Tipples, Mo	Lake Winnipeg Research Consortium Inc. (Board Member)
Watchorn, Elise	Manitoba Water Stewardship
Watson, Sue	Environment Canada, Burlington