Lake Winnipeg Research Consortium Inc.
Science Workshop 2011

Lake Winnipeg - State of the Science

What is the Scientific Basis for Understanding and Protecting Lake Winnipeg?

Siobhan Field Station
Fort Whyte Nature Centre
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EXECUTIVE SUMMARY

The purpose of the 2011 LWRC Science Workshop was to evaluate the progress made on the science priorities and research needs identified in the 2004 Federal-Provincial Science Workshop, with an emphasis on synthesizing and evaluating existing knowledge about the lake ecosystem. In essence, this report describes the *state of the science* on Lake Winnipeg.

The 2004 proposals and recommendations were intended to aid the discussions between Manitoba and Canada to identify the individual and joint roles of these governments concerning Lake Winnipeg. Acting on those proposals was expected to be the first step in the development of an ongoing comprehensive science program for Lake Winnipeg. Much has been accomplished, especially in terms of nutrient loading estimates and model development. It is apparent, however, that research and monitoring activities remain loosely organized and a comprehensive science program on Lake Winnipeg was never fully realized. Consequently, much knowledge remains dispersed among agencies and until very recently, unpublished. A regular, comprehensive synthesis of information would aid in defining new research that is based on addressing the knowledge gaps that meet management needs.

Below is a brief summary of the salient scientific findings in recent years and research gaps that were identified during Discussions at the 2011 Science Workshop.

Nutrient Loading

Nutrient loading estimates to Lake Winnipeg have improved through an increased and coordinated monitoring effort between Manitoba Water Stewardship and Environment Canada, as well as independent research. Among the more important research findings were:

- The onset of large cyanobacterial blooms in Lake Winnipeg was driven almost entirely by an abrupt increase of 70% (compared to the 1970s) in phosphorus loading to the lake in the mid-1990s;
- This abrupt increase in loading is explained by a doubling in the flow of the Red River in the last 20 years relative to its previous history (1971 to 1980), which mobilize nutrients from land enriched by a growing population and ever more intensive land use practices;
- Annual runoff and the frequency and extent of flooding within the Red River Basin is a major determinant of the magnitude of this phosphorus loading;
- Other tributaries had either comparatively little (Winnipeg and Dauphin rivers) or a negative (Saskatchewan River) effect on this loading.

Thus, contrary to previous assumptions, most of Lake Winnipeg's enormous watershed is currently not an important contributor of nutrients to the lake, and phosphorus abatement

efforts should be aimed largely at the Red River Basin. Furthermore, future climate scenarios determining the amount of rain (and run-off) occurring in the Red River Basin will have very important implications for the remediation of Lake Winnipeg. Water quantity, therefore, is as critical as water quality to the management of productivity in the lake.

Internal Nutrient Cycling

Within the lake, the contribution of a number of processes to the nutrient budgets remains largely unknown. For the nitrogen cycle, nitrogen fixation rates require further refinement. Moreover, no measures of denitrification have been made, despite the possibility that this microbial process could represent an important loss of nitrogen from the system. Phosphorus retention estimates in the sediment of the lake range from 60 to 70%. Due to the increased nutrient load, the net sedimentation (loading – outflow flux) is estimated to have nearly doubled (from roughly 3,200 to 5,500 Mg P/a). Consequently, there is potentially an enormous reservoir of phosphorus being stored in the lake that could significantly prolong remediation efforts. This will in part depend on the extent to which this phosphorus is remobilized by various means (internal loading, re-suspension) into the water column, and on its bioavailability, two very important unknowns for Lake Winnipeg.

Oxygen Dynamics – Water Column and Sediment-Water Interface

The oxygen dynamics in Lake Winnipeg are key to understanding a number of these in-lake processes. Effort thus far has been directed at understanding water column oxygen levels only. Since 2002, low oxygen in bottom waters has been measured in 2003, 2006 and 2007 in the central north basin. The south basin had no hypoxic events in any year with the exception of one station, and no dissolved oxygen concentrations below 5.5 mg/L were recorded in either basin between 2008 and 2010. Due to the size of the lake, the spatial and temporal extent of low oxygen events remains poorly understood; however, based on the current findings, it appears that Lake Winnipeg does not experience persistent and frequent low oxygen events. Thus, the tendency of the popular press and others who describe “dead zones” in Lake Winnipeg, or that the lake is “dying”, is scientifically unfounded to date. Given the seemingly fleeting episodes of hypoxia in the central north basin, mortality of fishes due to low oxygen is likely extremely rare.

Whereas stratification is a pre-condition for hypoxia and anoxia in the water column, the amount of organic material is critical for sustaining bacterial respiration and fermentation at and within the sediments. Given the shallow depth of the lake, which limits the probability of stratification, as well as the development of extensive algal blooms, which often descend to the bottom of the lake to decompose, it is at the sediment/water interface that oxygen studies should also be aimed. Within the microzone of the sediment/water interface, anoxic conditions could promote the mobilization of phosphorus from the

sediment to the water column (internal loading) and enhance rates of denitrification. Low oxygen levels in the sediment also impact the benthic community, even without water column oxygen depletion. As nothing is currently known about oxygen dynamics at the sediment/water interface, it remains an extremely important knowledge gap for Lake Winnipeg.

Food Web Dynamics

Food web dynamics, especially who is eating whom, remains an important information gap with potential economic consequences. Ultimately, knowledge of the quantity, nutritional quality, and spatial distribution of dietary resources is necessary to understand the flow of energy from nutrients to fish and how that flow is being redirected or disrupted in response to changing nutrient regimes (including abatement), climate change, and exotic species. The importance of the microbial loop in this energy transfer must not be overlooked, nor should the potential disruption to the synchronies of life stages and dietary resources. Some salient studies could include:

- The role of temperature and ice transparency on the early succession of diatom to cyanobacterial dominance;
- Nutritional value of cyanobacteria to benthos and zooplankton and of *Bythotrephes* to forage fishes;
- The relative importance of heterotrophs, notably protozoa, in the transfer of energy to consumers;
- Tagging studies to establish movement and feeding patterns of fishes; and
- Sentinel whitefish data (diet, length, weight and age) as a means to evaluate the potential impacts of zebra mussels.

Clearly, this effort will require a very broad interrogation and collaborative effort in terms of how these dynamics are examined.

Commercial Fishery

The impacts of eutrophication, whether negative or positive, on the productivity of the commercial fishery have not been established. Thus, conclusions by the media and others describing a thriving or threatened fishery due to eutrophication are currently not supported by scientific data. As the highest priced commercial species, most emphasis has thus far been placed on walleye. Results from the index-netting program describe a walleye fishery that is supported by a very large 2001-year class, which is providing a massive peak, followed by a smaller 2006-year class. Moreover, most of the increased yield in walleye has occurred in the channel and the south basin, not in the north basin. The estimated rate of mortality of walleye is high; unheard of in most walleye fisheries, and it is not known if it is sustainable. No mortality estimates have been made for sauger or whitefish. Indeed, lake whitefish is not sampled in the index-netting program and,

therefore, very little is known in terms of its population dynamics. This is most unfortunate because as a bottom feeder, it might be among the first species to be affected by changes in the benthic community. Moreover, lake whitefish is one of the species that exotics like zebra mussels and *Bythotrephes* will occur in large numbers in their gut contents. As a sentinel species of sorts, good pre-invasion lake whitefish diet and condition data would help discern changes resulting from a seemingly increasing number of stressors. It is critical at this juncture, when potentially aggressive phosphorus abatement measures will be undertaken, that a more adequate understanding of the relationship between phosphorus loading, the surge in algal production and the impacts on the fishery be sought to ensure that the productive capacity of the fishery is not compromised. Sustainable management targets and end points will be difficult to define without this knowledge.

Contaminants

It is apparent that the research and monitoring effort for contaminants in Lake Winnipeg is not receiving the same level of attention as other initiatives on the lake. The monitoring efforts of the provincial and federal governments are limited both spatially and in terms of the range of contaminants being monitored. Furthermore, datasets remain dispersed as does the interpretation and discussion of results. Of the little research conducted to date, there appear to be important differences in the magnitude and sources of some contaminants between basins: the south basin has experienced higher loadings largely from riverine sources, whereas the north basin had lower total loadings with a higher fraction derived from atmospheric deposition. The importance of the Red River Basin as a source of contaminants derived from agricultural and urban activities should be actively investigated, especially given the extent to which phosphorus has been mobilized in the last decades. To improve upon the current situation, future State of the Lake reports should include the status of contaminant monitoring in Lake Winnipeg. Furthermore, the inclusion of contaminants data collected by the Province of Manitoba and EC (FCMSP) in the Lake Winnipeg Basin Information Portal would be of value in increasing the visibility and accessibility of such data, and in acknowledging the importance of contaminants as a potentially serious water quality concern.

Algal Toxins

Microcystin-LR is the only algal toxin that is routinely monitored in Lake Winnipeg. Results indicate that this toxin is more frequently detected in samples collected from the near-shore areas of the lake and has been elevated above recreational water quality guidelines on occasion. However, it has remained low or undetectable in most algal bloom samples collected from the offshore areas. The tendency of the popular press and others to describe all algal blooms as toxic is unfortunate, as that assumption is not supported by the available data. That said, much remains to be understood in the area of algal toxin production, notably which toxins are being produced and what species are producing them. Moreover, few studies have been carried out to evaluate the

accumulation of algal toxins in fish or other biota in Lake Winnipeg, and it is not known whether any toxins are impacting higher organisms. To manage this potential water quality issue more effectively, a comprehensive, coordinated analysis of a broad spectrum of toxins, as well as a thorough, consistent approach to assessing the threat of algal toxins in Lake Winnipeg to humans and other biota would be of value.

Suggested Additions to Field Programs - Near-Shore and Under Ice

Most of the data on Lake Winnipeg were acquired using the M.V. *Namao* as a research platform, and are representative of the pelagic area of the lake. Consequently, knowledge of the near-shore area is lacking, despite its importance in the lake's metabolism. Furthermore, in the Great Lakes, the predominant effects of zebra mussels were near-shore, yet that was where the least historical sampling effort took place. Given the proximity of zebra mussels to Lake Winnipeg, characterizing the near-shore areas of the north basin of Lake Winnipeg is of utmost importance. In an effort to address this need, the LWRC will introduce a North Basin Near-Shore Sampling Program in 2012 to facilitate access to the near-shore for the various science agencies working on the lake. The M.V. *Namao* will serve as the staging and launch platform for this work using smaller vessels to access the shallows.

Knowledge of the under ice environment is also lacking. Winter conditions, such as low snow cover, are believed to have an important effect on the timing of the under ice diatom growth, which in turn can have consequences on the algal succession, notably to cyanobacteria, and subsequent energy transfer to lower level consumers up to fish. A sampling program that includes both the open water season and entire winter period for at least one year would be necessary to adequately understand food web and oxygen dynamics in Lake Winnipeg.

Modeling Efforts

Much progress has been made in the development of models that can be used for various purposes including in the refinement of nutrient targets for Lake Winnipeg. All models require data inputs, and the process itself of building models is a valuable exercise in identifying data deficiencies and in helping guide future research and monitoring. Addressing the above research gaps would greatly benefit the development, refinement, and predictive capacity of a Lake Winnipeg whole ecosystem model. The development of models has a unifying function in that it can serve as a common goal among agencies with differing mandates, priorities, levels of funding, and commitment to Lake Winnipeg.