The Lake Winnipeg Research Consortium Inc.

Research, Education and Outreach Activities
April 1st, 2007 – March 31st, 2008

June 2008

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Chronology of LWRC Research, Education/Outreach &Communications
1999 to 2007

From its inception in August 1998, the Lake Winnipeg Research Consortium Inc. (LWRC) has facilitated research, education, and outreach activities on Lake Winnipeg that have stimulated further scientific investigations, enhanced public awareness, and prompted government action to restore Manitoba's Great Lake Winnipeg.

Since the first LWRC Lake Winnipeg survey in August 1999, when it became evident that the condition of Lake Winnipeg had deteriorated to the point where science and policy were essential to reverse ecosystem degradation, many initiatives by various agencies, both government and non-government have taken place. Not only have scientists and politicians responded to the need for research and regulation, respectively, but also public and private institutions, foundations, universities, environmental associations, service clubs, students and artists have accepted the challenge to raise awareness, assume responsibility and creatively change behavior so that the lake will be restored and sustained for future generations. Lake Winnipeg's plight is now engrained in the fabric of Manitoba and has also engaged neighbors to the west, south and east, as a living example, so expansive as to be visible from space, of the many pressing environmental issues faced by society today.

Following the 1997 Red River Flood and the 1998 International Joint Commission study of flooding impacts on Lake Winnipeg's south basin, a handful of researchers at the Freshwater Institute, Department of Fisheries and Oceans (DFO) and the University of Manitoba (UM) reached a consensus that flooding impacts on the entire lake needed study. They agreed that the lack of a scientific understanding required a research plan similar to the long-term programs established for the Laurentian Great Lakes. Not since the Lake Winnipeg surveys in 1969 by the Fisheries Research Board of Canada had any intensive limnological studies been undertaken in spite of considerable economic development occurring throughout the watershed over the intervening 30 years. The LWRC 1999 survey, enabled by funding cobbled from Manitoba Hydro and provincial and federal sources, revealed that the Lake Winnipeg ecosystem had changed substantially since 1969, particularly its north basin phytoplankton community which had become dominated by surface-forming cyanophyte (bluegreen algae) blooms. New exotic biota had entered the lake and their impacts on the food web were unknown. The 1999 survey findings were followed by several media reports and government deliberations. In February 2003 the Lake Winnipeg Action Plan was announced by Manitoba Water Stewardship.

During 2000 and 2001, the LWRC assembled its membership and further developed its organization; however, because a dedicated research vessel was not available, it did not undertake Lake Winnipeg surveys. Following incorporation in 2001 with 28 member agencies, it began to operate the Coast Guard vessel *Namao* as a research platform on a cost-recovery basis to conduct spring, summer and fall surveys of Lake Winnipeg in 2002, 2003 and 2004. Funding for these surveys came from Manitoba

Hydro (all 3 years), Natural Resources Canada, Canadian Space Agency, DFO, Manitoba Conservation, and some LWRC members (Fish Futures and Manitoba Pork). Each year, all funds were depleted for vessel fuel, ship crew (9) salaries, maintenance and a 5-year recertification reserve. LWRC management and science program coordination was provided through in-kind part-time support by a number of DFO employees. In these initial years, research (mainly monitoring of chemical and biological parameters) was undertaken by a small group of university and DFO scientists who had participated in the 1969 Lake Winnipeg study and retained interest in eutrophication and food-web issues. A formal Lake Winnipeg research program was never adopted by DFO. Consequently, the few scientists who worked on the lake did so essentially in their discretionary time. However, in 2005 the Canadian Coast Guard arm of DFO transferred ownership of the *Namao* to the LWRC, thereby ensuring that a safe, dedicated vessel would be available for the lake research program.

In February 2003, the Lake Winnipeg Stewardship Board (LWSB) was established under the provincial Lake Winnipeg Action Plan and the LWRC was represented on the Board. The Final LWSB report (December 2006) offered several recommendations for Lake Winnipeg remediation that included a call for science-based policy and lake management, acknowledgement of the important role of the LWRC in filling knowledge gaps and educational opportunities, and the need for the provincial and federal governments to develop and implement a long-term, collaborative science plan for Lake Winnipeg. A federal Lake Winnipeg research program actually began in September 2005 when scientists from Environment Canada's (EC) National Water Research Institute (Burlington) and National Hydrology Research Centre (Saskatoon) made preliminary observation on the lake during the fall survey. The spring and summer lake surveys in 2005 were not undertaken because of record high Red River water levels that delayed vessel maintenance in dry dock. Funding for ship operation for the fall survey was provided by Manitoba Hydro and Environment Canada.

In May 2005, the Lake Winnipeg Implementation Committee (LWIC) was formed as a joint initiative of the Province of Manitoba and the Government of Canada with the purpose of identifying and advising on mechanisms of federal and provincial co-operation about Lake Winnipeg. The LWIC fulfilled its mandate with the November 2005 release of its report that concluded "science is lacking and funding for the science has been sporadic at best". LWIC organized the recent (May 28, 2008) Lake Winnipeg Leaders Forum attended by community and opinion leaders from Canadian provinces and American States within the lake's watershed who were exploring the possibility of adopting a broader basin-wide approach to lake health restoration.

Under the leadership of the Thomas Sill Foundation, seven Manitoba charities (Westshore Community Foundation, Selkirk and District Community Foundation, Brandon Area Community Foundation, Dauphin and District Community Foundation, Community Foundation of Portage and District, Lake Winnipeg Foundation, The Winnipeg Foundation) and the Lake of the Woods Sustainability Foundation in Northwestern Ontario, united to provide funding towards LWRC

administration in 2008 as a sign of leadership within the Lake Winnipeg watershed. The Lake Winnipeg Foundation (LWF), incorporated in August 2005, is a grassroots charity committed to restoring and maintaining the health of Lake Winnipeg and its watershed. It is supporting LWRC *Namao* operation with a 5-year grant of $1,000.00 annually. The LWF has organized benefit concerts and walkathons to raise money for graduate student research on the lake. It is organizing and co-hosting with the University of Winnipeg a Public Forum on Lake Winnipeg issues in October 2008.

In 2006, EC scientists began in earnest to study the physical nature of Lake Winnipeg by measuring several meteorological and hydrological parameters and to identify nutrient sources by evaluating water chemistry and stable isotopes in various compounds in the lake. As well, EC and Manitoba Hydro committed to three and five years, respectively, of funding for vessel operation. Manitoba Water Stewardship (MWS) and the City of Winnipeg also provided assistance to support the operation of the *Namao*. The three surveys in each of 2006 and 2007 brought the number of lake-wide samplings to a total of 17 (5- spring, 6-summer, and 6-fall) since 1999.

In response to the LWSB call for federal-provincial collaboration to restore Lake Winnipeg, MWS and EC established the Joint Federal-Provincial Lake Winnipeg Basin Committee and a Science Sub-Committee in November 2007. Several researchers affiliated with the LWRC are members of the Science Sub-Committee whose mandate is to provide scientific and technical advice and input to the Federal-Provincial Lake Winnipeg Basin Committee to ensure the long-term sustainability of Lake Winnipeg and its basin including actions to implement the LWSB's recommendations.

In addition to operating the *Namao* for Lake Winnipeg research surveys, the LWRC organizes an annual Science Workshop where participating scientists meet to present and discuss previously collected data, evaluate and refine the research program, and develop research plans for the upcoming field season. Workshop proceedings are made available to researchers and LWRC members and a report on LWRC field and workshop activities is prepared annually for Manitoba Hydro, a major supporter of the LWRC. The 5th Annual Science Workshop was held March 17th to 19th, 2008 at the Freshwater Institute, and was attended by 50 government and university researchers and students.

The LWRC co-operative approach for studying complex ecosystems has attracted attention and recognition throughout Canada and internationally. In 2007, the LWRC received a Canadian Environmental Award sponsored by Canadian Geographic Enterprises, Shell Canada, and the Government of Canada. Lake Winnipeg and the LWRC were also featured in the December 2006 issue of Canadian Geographic. In addition, the International Association for Great Lakes Research invited the LWRC to present a Plenary Address on the Consortium research model at their 2008 meeting at Trent University, Peterborough, Ontario.

Education and public awareness are important elements of the LWRC agenda and, thanks largely to private donations from the general public, a number of achievements have been made since 2002. The LWRC *Education & Field Program* for schools has evolved from an 'education component' of the Science Program, whereby students simply came aboard and watched scientists at work, to a full-fledged Education Program, introduced in 2008, where students undertake their own sampling and analyses on board the *Namao*. Over 30 schools and universities have, thus far, participated in the programming.

In 2006, as part of the LWRC *Special Projects Program,* a group of young students from Cecil Rhodes School produced a documentary on Lake Winnipeg that won three national awards. The LWRC also took part in the International Canon Envirothon when several hundred student competitors from across Canada and the USA visited the *Namao* and listened to a presentation on Lake Winnipeg. In 2007, the LWRC was on the technical advisory team to develop Lake Winnipeg curriculum material for grade 8, as recommended by the LWSB (Rec. 2.0). In addition, the LWRC took part in discussions with the Ministry of Education to promote science in the classroom, and presented at the Special Area Group conference of the Science Teachers Association of Manitoba.

Contributions by the general public have also allowed the LWRC to purchase a laptop computer, projector and portable tabletop display for its *Outreach Program*. Public awareness of Lake Winnipeg and LWRC science activities has grown with each annual *Namao* Open House held in Gimli when hundreds of visitors tour the vessel and speak with scientists about the lake. The LWRC has also developed a number of printed communications products in an effort to share research findings and raise awareness about Lake Winnipeg. Materials include a series of postcards, a nutrient poster, pamphlet, and a hand-out entitled "What you can do". To raise funds and spread the word, the LWRC has produced t-shirts and a tote bag with the slogan "Be part of the solution". The LWRC also produced its first 7-page newsletter in 2008. The LWRC website has improved greatly since its inception, and this is reflected in the steady increase in traffic that now includes hits from around the globe. Recognizing the internet as a powerful communication tool, effort will be made to further improve the site. The LWRC website will also serve as the hub for the web-based resource materials developed as part of the Education Program.

Since 1998, LWRC program administrators have accepted over 100 invitations from universities, schools, national and international research institutes, service clubs, environmental groups, municipalities, conservation districts, and community foundations for presentations on Lake Winnipeg. LWRC collaborating scientists have related the Lake Winnipeg story at several national and international scientific conferences and symposia where the security and sustainability of our freshwater supplies are discussed. The state of Lake Winnipeg, as an example of the health of the global environment, is a grim reminder of how natural ecosystems can be impacted by human negligence and how important it will be to act responsibly and collectively to ensure its sustainability.

LWRC 2007 Research, Education & Outreach Activities

Research

Field Activities

In 2007, the Lake Winnipeg Research Consortium facilitated three scientific surveys of Lake Winnipeg, conducted a Science Workshop, provided field and classroom training in Lake Winnipeg science, held an Open House and presented a variety of seminars to community organizations.

The scientific surveys of Lake Winnipeg took place from May 25 to June 15, July 19 to August 10, and September 12 to October 5. Researchers from Environment Canada (EC), Manitoba Water Stewardship (MWS), University of Manitoba (UM), Department of Fisheries and Oceans (DFO), and graduate students were onboard during the surveys and collected a suite of samples at 56, 51, and 53 sites in the spring, summer and fall surveys, respectively, Of particular significance to understanding the mixing process in Lake Winnipeg, EC scientists from the National Water Research Institute in Burlington deployed instruments at fixed moorings throughout the lake (Appendix) to measure several variables. Currents, water temperatures, winds, solar radiation, waves and some water quality parameters were recorded, the thermal structure and exchange processes during stratification were measured, and the circulation within and between the South and North basins were studied. EC researchers from the National Hydrology Research Centre in Saskatoon continued their studies to identify chemical and isotope patterns in the lake that could be linked to individual nutrient sources. They also furthered evaluation, using isotope and other techniques, of Lake Winnipeg's food web and nutrient pathways in the Red River. With funding assistance from the EC Science Horizon Fund, the LWRC was able to hire a field technician to oversee all sampling operations and to be the liaison between the ship crew and scientists.

Manitoba Water Stewardship continued to monitor their long-term stations (increased to 14), for general chemistry, nutrients, bacteria, benthos, chlorophyll-a, pesticides, trace metals, phytoplankton diversity, and microcystin-LR when algal blooms were evident. MWS Fisheries Branch staff carried on the trawl net sampling program initiated by DFO in 2002 to examine the distribution and abundance of small fishes in the south, narrows and north regions of the lake.

The Canadian Space Agency continued to fund Dr. Greg McCullough (UM), who in collaboration with Mike Stainton (DFO) is using satellite surveillance to assess algal blooms with spatial and temporal coverage unobtainable by other methods. Satellites such as MERIS can estimate chlorophyll within +/-10 mg/cu m.

Benthic community samples were collected from the lake-wide station network in each survey and archived for Dr. Brenda Hann (UM) for future processing. Zooplankton samples were also collected from the same stations and samples archived for future analyses.

Science Workshop

The Annual Lake Winnipeg Research Consortium (LWRC) Science Workshop on March 17th to 19th, 2008 at the Freshwater Institute brought government and university scientists together to discuss research findings from the 2007 Lake Winnipeg surveys, to consider LWRC science program objectives, and to develop 2008 field season plans.

Day 1 (Agenda in Appendix) - reports on provincial and federal initiatives on Lake Winnipeg provided a context for discussions on evolving research program plans. A review of existing physical, chemical and biological data acquired on Lake Winnipeg since 1999 helped to define existing knowledge of the lake. Discussion of the need for a Lake Winnipeg ecosystem model suggested that (a) it could be a useful tool to identify research gaps and provide a collaborative research framework and pathway, and (b) modelling must be coupled with monitoring, experimentation and experience to inform a sustainable nutrient management strategy, Assessment of available models is now underway and will rely on the experience of the LWRC modelling committee, available data, and funding support to fill ecosystem model parameter gaps. A basic bio-monitoring program to accompany the physical and chemical measurements being gathered on Lake Winnipeg is now under consideration by EC.

Day 2 - LWRC researchers presented their preliminary findings from the 2007 field season on Lake Winnipeg and some of the highlights include: (Abstracts in Appendix).

- Important new data on water temperatures, currents, waves, wind, solar radiation and dissolved oxygen levels from Environment Canada (EC) *in-situ* instrumentation will improve understanding of the mixing of sediments, chemicals and plankton in Lake Winnipeg. Evidence of an extended period (~ 25 days) of temperature stratification was found during August in the North Basin.
- Stable isotope (^{2}H, ^{18}O, ^{13}C, and ^{15}N) studies by EC are identifying water and nutrient sources, water masses, primary productivity, energy flow and changes in food web structure related to eutrophication and exotic species. Preliminary results indicated that contributing rivers had unique isotopic "fingerprints", water "patches" with distinct qualities were found in different areas, bottom waters in the northern half of the North Basin were only half saturated with oxygen during August, and relatively high nitrate levels at lake stations near Gimli and Winnipeg Beach appeared to be associated with human and animal wastes. Initial analyses of the Lake Winnipeg food web revealed large isotopic differences between the North and South basins possibly related to variability in nutrient inputs.
- A synthesis of long-term nutrient and hydrological data by Fisheries & Oceans (DFO) provided information crucial to a nutrient management strategy and stressed the importance of understanding the relative impacts of natural (climate and hydrology) and anthropogenic stressors on Lake Winnipeg sustainability. It also called for development of an ecosystem

model to examine and understand nutrient and food web relationships to ensure that fishery productivity remains high.

- A preliminary EC study on nutrient bioavailability in the Red River, undertaken to assist decisions on local actions and methods of nutrient reduction, indicated high riverine phosphorous and nitrogen levels from Emerson to Lake Winnipeg.
- A study, funded by the Canadian Space Agency (CSA) to develop methods for measuring algal blooms from orbiting satellites, found that a portable, onboard, online analyzer performed as well as lab-based chlorophyll determinations as an indicator of algal biomass in Lake Winnipeg. Reflectance spectra detected by MERIS satellites enabled chlorophyll estimates within +/-10 mg/m^3 and provided whole lake coverage unattainable by any other method.
- Reports on the three components of the Lake Winnipeg food-web, the phytoplankton, zoobenthos, and forage fish communities, currently under investigation were presented. Long-term studies indicate that phytoplankton biodiversity has declined, previously rare taxa have become dominant, diatom diversity has fallen, and nitrogen-fixing, toxin-producing cyanophytes have become widespread, and more frequently dominate the algal community. Trends were also evident in the benthic community as abundances rose from mesotrophic values in 1969 to eutrophic levels during 2002 to 2006. During the latter period, in the North Basin, sludge worms (tubificids), fingernail clams (sphaeriids) and chironomids increased substantially but freshwater shrimp (Diporeia) declined. Trawl net sampling for forage fish in 2007 revealed that the South Basin had the highest number of species. The Lake Winnipeg fish community continues to consist mainly of emerald shiner, rainbow smelt, cisco, trout perch, white bass and walleye. Rainbow smelt accounted for the highest densities of forage fish biomass in the North Basin, surpassing that for small (20 – 60 mm Fork Length) walleye and emerald shiner. Densities of the smallest sized walleye (20 – 40 mm FL) were lowest in the North Basin which may indicate predation by rainbow smelt on young walleye.

Day 3 - scientists convened to discuss plans for the 2008 field season. EC will install a new portable control room and lab facility on the *Namao* for a water sampling system that includes a Seabird rosette, sensors, and electronic winch. Consensus was reached to continue with three lake-wide 50 to 60 station surveys and to provide the necessary effort to sample the region west of Reindeer Island extending south of Long Point to Sturgeon Bay. As in 2007, EC meteorological buoys and instrumentation will be installed throughout the lake to evaluate meteorological conditions, physical mixing processes, sedimentation rates, river plume mixing and water quality. Continuous analyses of pH, conductivity, surface oxygen, chlorophyll fluorescence, turbidity, and pCO_2 (partial pressure of gaseous carbon dioxide) will again be done. Other research activity objectives for 2008 reported at the workshop included:

1. Develop a bio-optical model specific to Lake Winnipeg to predict water quality parameters from the detected water colour spectrum (EC)
2. Use MERIS satellite to identify and quantify Harmful Algal Bloom (EC, CSA).
3. Study role of river & lake sediments as sources of biologically active P and N (EC)
4. Continue multi-year isotopic analysis of food web, including fish scales (EC).
5. Complete interpretation of fish age structures collected in 2007 (MC)
6. Continue trawling and fix and preserve collected walleye and sauger (MC)
7. Confirm fish species identification and examine gonad condition (MC)

Numerous biological (benthos, zooplankton and phytoplankton) samples collected during 2006 and 2007 field survey remain archived. Until these samples are processed, data gaps will hinder development of a Lake Winnipeg ecosystem model. EC is in the process of developing and implementing a bio-monitoring program for the lake.

A tentative date, Monday, May 26, was set for commencement of the Spring 2008 survey of Lake Winnipeg. The *Namao* will be accessible for loading of equipment and supplies on May 19.

Education & Outreach

Education

This year marked a significant turning point for the LWRC as it was the first year that funds were available to pay administrative staff, including a part-time Education Coordinator. Prior to 2007/2008, all annual funding went to the operation and maintenance of the *Namao*.

In 2007, 9 schools and university classes participated in the LWRC Education Program. In addition, the Education Coordinator was on the technical advisory team to develop Lake Winnipeg curriculum material for grade 8 as recommended by the LWSB (Rec. 2.0) and participated in early discussions for grade 12. In addition, she took part in discussions with the Ministry of Education to promote science in the classroom, and presented at the Special Area Group conference of the Science Teachers Association of Manitoba. A proposal was also developed and submitted to support further development of education programming.

Currently, the Education Field Program integrates well with a number of the advanced grade 11 and 12 courses, such as Aquatic Sciences, Environmental Sciences and Advanced Placement Biology; in addition it supports recommendation 1.5 as advocated by the Lake Winnipeg Stewardship Board. Additional changes and improvements to the Education Program are being introduced in 2008 so it will ultimately support many of the existing units from grades 6 to 10 from the Manitoba science curriculum. The Field Program is also being enhanced and a limited number of dedicated ship days will be allocated for schools to allow students to conduct

their own sampling and analyses of lake samples. A student award is also being introduced to the programming.

Outreach

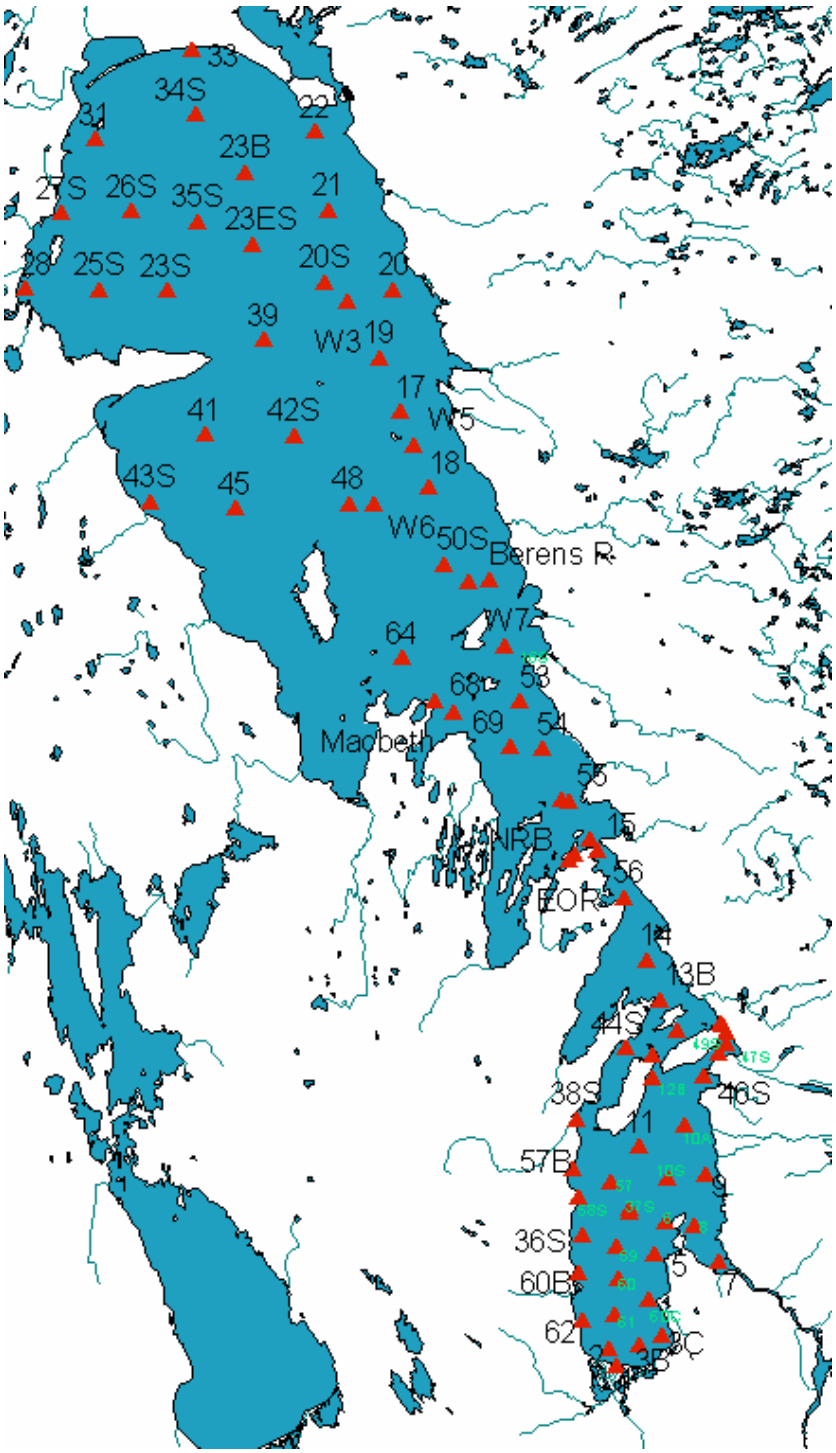
The LWRC held its Annual Open House on Monday, August 6 when 800 visitors toured the *Namao* during the Gimli Icelandic Festival long weekend. Scientists were on hand to answer questions on the LWRC research program and the status of Lake Winnipeg health. Posters on recent science findings, demonstrations of limnological sampling methods and conducted tours of the vessel grabbed the interest of visitors. Souvenir LWRC T-shirts or grocery bags were available for purchase to raise funds for the Education and Outreach Program.

The first LWRC e-newsletter was developed and the LWRC pamphlet was updated and re-printed.

During 2007, LWRC coordinators gave numerous presentations on Lake Winnipeg research at national and international scientific conferences, government assemblies, university lectures, service clubs dinners and community club meetings.

Appendix

Lake Winnipeg Sampling Stations



Mooring Locations (2007 – 2008)

STATION NUMBER	MOORING NUMBER	LATITUDE N.	LONGITUDE W.	INST./DEPTH
500	2007-10S-01A	50° 47’ 00”	96° 45’ 00”	TEMP/ADCP (1, 3, 4, 6, 8, 10, 11, 12m)
501	2007-10M-02A	50° 55’ 00”	96° 35’ 00”	MET
502	2007-10T-03A	51° 41’ 00”	96° 47’ 00”	TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18m)
	2007-10C-04A			ADCP (18m)
503	2007-10T-05A	52° 20’ 00”	97° 30’ 00”	TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16m)
504	2007-10T-06A	52° 37’ 00”	98° 09’ 00”	TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18m)
505	2007-10S-07A	53° 23’ 00”	98° 30’ 00”	YSI/ OPTICAL DO/ TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18m)
	2007-10C-08A			ADCP (18m)
506	2007-10S-09A	53° 18’ 00”	97° 40’ 00”	YSI/ TEMP (1, 3, 4, 6,
	2007-10C-10A			8, 10, 11, 12m)
	2007-10A-11A			ADCP (12m)
				SEQ. SED. TRAP(m)
George Island	2007-10M-12A	52° 49’ 00”	97° 40’ 00”	MET

Abstracts of Scientific Presentations

Lake Winnipeg Basin Initiative

Malcolm Conly and John Lawrence
Environment Canada

For several years water quality in Lake Winnipeg has been deteriorating dramatically. The chief concern is nutrient loading (phosphorous and nitrogen) mainly from agricultural run-off and municipal wastewater effluent leading to advanced eutrophication of the Lake. While the primary responsibility for most aspects of water management in Canada rests with the provinces and territories, the federal government has a significant role to play in protecting water by providing science and information, regulating toxic substances, promoting pollution prevention and as a facilitator in inter-jurisdictional matters. Watersheds that cross political boundaries often present unique challenges for provinces, particularly when a significant contributor to the source of a given problem may lie beyond their jurisdictional boundaries. An example of this type of inter-jurisdictional challenge is manifest in the issues affecting Lake Winnipeg (LW), which is located entirely within the province of Manitoba. As the world's10th largest lake, Lake Winnipeg's contributing basin covers approximately 1,000,000 km^2 extending across four provinces and four states. The broader basin is home to six million Canadians and comprised of three major sub-basins – Saskatchewan River Basin, Red River Basin and Winnipeg River/Lake of the Woods Basin, which flow into Lake Winnipeg. Activities outside of Manitoba's borders, but within the larger basin, directly impact the health of Lake Winnipeg. As a large proportion of the nutrient loading to Lake Winnipeg originates from beyond the Manitoba border the problem and solution are both inter-provincial and international in scope, involving a myriad of stakeholders. This presentation will discuss Environment Canada's contributions to the remediation of Lake Winnipeg within the context of the Lake Winnipeg Basin. Specifically this presentation will outline the federal government's actions relative to facilitating inter-jurisdictional governance; supporting science and monitoring; and encouraging stewardship activities in the context of improving the sustainability of Lake Winnipeg.

Physical Processes and Modelling of Lake Winnipeg

Ram Yerubandi, Jun Zhao, Len Wassenaar & Sue Watson
Water S&T Directorate, Environment Canada

Lake Winnipeg is experiencing significant changes in water transparency, biological species composition, productivity, and sedimentary chemistry. This indicates that the lake is on a trajectory of progressive eutrophication and approaching a state of deterioration that may affect ecosystem sustainability. Because of these reasons new research projects are initiated to study the relative roles of physical, chemical, and biological factors on the ecology of Lake Winnipeg at various space and time scales. Currents, water temperature, winds, solar radiation, waves and some water quality parameters were recorded at several fixed moorings in Lake Winnipeg during 2007. Circulation within and between the basins were studied. The thermal

structure and exchange processes during summer stratification in the lake have also been examined using a time series data of horizontal velocity profiles from broadband Acoustic Dopler Continuous Profilers and temperature profiles at the moorings. A three dimensional model (ELCOM) has been used to model the water circulation and temperature in the lake. Conservative tracers such as conductivity and TSS are used to study the impact of major rivers flowing into the lake.

Optical Properties, Water Colour, and Water Quality of Lake Winnipeg

J. H. Jerome, C. E. Binding, R. P. Bukata – Environment Canada,
M. P. Stainton, Fisheries & Oceans
G. K. McCullough, CEOS, University of Manitoba

Analyses of the optical measurements performed on 2 research surveys of Lake Winnipeg in July and September, 2007 are given. Profiles of the beam attenuation are used to monitor the vertical structure of the water column. Beam attenuation also determines the average pathlength between photonic interactions in the water.

The spectral irradiance attenuation is calculated for each station. It can be employed in solar heating models to estimate of absorption of solar radiation with depth, and in photosynthetic models to estimate the depth of the photic zone. Also, the thickness of the surface layer monitored by satellites is calculated from the irradiance attenuation. K PAR is estimated from the spectral irradiance attenuation and compared with measurements collected by the province. Other methods of obtaining K PAR are also discussed.

Spectral reflectance measurements are shown, and a bio-optical model to obtain water quality parameters from the reflectance is discussed. From the reflectances at the wavelengths corresponding to MERIS bands, algorithms are developed to estimate chlorophyll concentration and to separate blue-green algal blooms from non blue-green algal blooms.

Stream Nutrient Assessment Update

Sue Watson
Environment Canada

(Not Available)

Changes in precipitation and runoff patterns as a cause of recent increases in productivity in Lake Winnipeg: Implications for establishing ecologically relevant nutrient targets.

M. P. Stainton, R. Hesslein, S. Page - Fisheries and Oceans
G. McCullough, CEOS, University of Manitoba

The past decade has seen a significant increase in the size and frequency of cyanophyte blooms in Lake Winnipeg along with consequent hypoxia, algal toxins, fowled beaches and general changes in the food web. While these changes have for the most part been attributed to increased anthropogenic loading from municipal and agricultural sources, climate related events appear to have had a greater and

more immediate impact. In this presentation we report on observed and modeled changes to lake surface temperature, precipitation patterns in the basin and consequent modeled changes in riverine loadings of P and N to Lake Winnipeg. The nutrient loading model used to estimate in lake concentrations is also used to demonstrate the effectiveness of various initiated and proposed nutrient management strategies.

While there are doubtless anthropogenic impacts on Lake Winnipeg's trophic status, we conclude that the dominant event driving recent changes in the water quality of Lake Winnipeg has been extraordinary levels of precipitation in the Red River basin and the consequent disproportionate contribution of the P rich waters of the Red River to the lake. Historic Catch Per Unit Effort data indicates a strong correlation with P loading. Modeled relationship between P loading and fish productivity suggest that proposed P management strategies could have a negative impact on the stocks in periods of low Red River flow. Current nutrient management strategies are brought into question.

Mapping total chlorophyll concentrations and cyanophyte biomass using satellite-borne sensors over Lake Winnipeg.

G. K. McCullough (CEOS, UM), H.J. Kling (Algal Taxonomy and Ecology Inc.), M.P. Stainton (DFO) and D.G. Barber (UM)

Remote sensing is a relatively inexpensive means of mapping algal concentrations to monitor the response of Lake Winnipeg to planned watershed management action. Several satellites designed for measuring water quality variables now pass over the region daily, so that coverage is limited only by cloud-cover frequency. Since 2001, we have measured remote sensing reflectance spectra on Lake Winnipeg in order to simulate data from selected satellites to test algorithms for determination of chlorophyll and algal biomass. Blue/green band ratios traditionally used in chl mapping in the open ocean are very poor predictors of chl in the turbid and DOC-coloured waters characterizing Lake Winnipeg. More recently developed chlorophyll indicators, including the maximum chlorophyll index and fluorescence line height (FLH) measured by the Medium Resolution Imaging Spectrometer on Europe's Envisat satellite, are better predictors of chlorophyll, with r^2=0.84 & 0.75 respectively. FLH operates by measuring a chlorophyll fluorescence peak at 685 nm. This peak is characteristic of Lake Winnipeg phytoplankton in general, but not of cyanobacteria, which contain phycoeritherin pigment which re-absorbs the fluoresced light. This difference weakens the general power of FLH to predict chl in Lake Winnipeg, but it also suggests a technique to distinguish cyanobacteria from other plankton in the lake, and potentially to predict developing blooms by remote sensing. We are currently analyzing our database of remote sensing and water quality observations on Lake Winnipeg to assess this potential.

Isotope studies of water balance, O_2 status, nutrient sources and cycling, and food web – study progress update

Leonard I. Wassenaar, Keith A. Hobson, Veronique Hiraert-Baer, Ram Yerubandi
Environment Canada, Science and Technology Branch

Here we present a progress report and presentation of preliminary data results from an interdisciplinary research program by Environment Canada that primarily uses stable isotopes to examine:

- Water balance hydrologic modeling of lake Winnipeg using isotope tracers
- Dissolved oxygen status in Lake Winnipeg (primary productivity & dead zones)
- Key nutrient sources and cycling (NOx, PO_4)
- Lake chemical evolution and spatial distribution
- Aquatic food web dynamics (eutrophication, invasive species)

The above studies were initiated in 2006/07-2007/08 and are in various stages of data collection and analysis. Preliminary results from some of the more complete projects will be presented. These projects are expected to continue over the next several years in order to improve spatial and temporal coverage of Lake Winnipeg.

Lake Winnipeg Phytoplankton: a summary and Update

Hedy Kling (Algal Taxonomy and Ecology Inc.), Mike Stainton (DFO),
Greg McCullough (CEOS, UM), Claire Herbert (Parks Canada)

The Lake Winnipeg phytoplankton update presented a summary of historic conditions including the spatial and temporal variations observed in 1969 with a small (<10,000ug/L biomass) isolated bloom off Grand Rapids. Cyanobacteria were important components of the phytoplankton community at a few stations into October of that year. Core studies as well as satellite images showed an increase in the presence of Cyanobacteria blooms in the recent lake history. The increase appeared to be more prevalent during the last 10-15 years, with blooms increasing in size and magnitude. The blooms were composed primarily of various morphological forms of the heterocystous nitrogen fixing species in the *Aphanizomenon flos-aquae* complex (mainly morphotypes comparable to *A. flos aquae*, *A. klebahnii*, *A. yesoense, A. cf flexuosum*, and *A. hungaricum*), as well as non colonial *Aphanizomenon* such as *A. gracile* and *A. issatchenkoi* and other heterocystous types such as *Anabaena lemmermannii*, *A. spiroides, A. mendotae,* and *A. flos-aquae)*. Some of these taxa produced neurotoxins as well as hepatotoxins. More recently there appeared to have been an increased occurrence of non nitrogen fixing cyanobacteria species, particularly *Microcystis* species such as *M. botrys, M. flos aquae, M. novacekii*, as well as the oscillatoriales *Pseudanabaena catenata*, epiphytic *Pseudanabaena* species and *Planktothrix* in the lake. In addition to this increased cyanobacterial presence, changes have been noticed in other algal classes (especially noticeable in diatoms and cryptophytes) with considerable year-to-year variability. Under ice diatom populations were discussed related to their potential contribution in determining the open water spring phytoplankton community. The biomass comparisons indicated an increase in predominance of the cyanobacteria

community especially in the summer and fall periods as well as increase in average biomass. The plankton community of Lake Winnipeg is a very dynamic entity with rapid response to climate and watershed changes. The seasonal and spatial variability in the phytoplankton community is high and in order to understand it and its contribution to the lake the entire plankton community needs to be evaluated in an ecosystem approach.

Lake Winnipeg zoobenthos: Are any patterns or trends emerging from the mud?

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

Lake Winnipeg is influenced by multiple stressors: nutrient loading leading to eutrophication, contaminants, hydrologic modification, invasive species, and increasing climate warming and variability. Many factors make study of zoobenthos in Lake Winnipeg very challenging: large size of the lake; wind-driven hydrodynamics; complex lake morphometry (sub-basins with different mean depths, currents); patchiness of sediment characteristics (particle sizes, chemistry); diversity of biota (taxonomy, functional roles, feeding types, life history, life span, body size).

From 2002-2006, >50 stations in all basins of L. Winnipeg have been routinely sampled to study the zoobenthos and determine what are the major responses of the zoobenthic community to these environmental stressors. The most clearcut pattern is substantially higher density of all zoobenthic organisms in the North basin relative to both Narrows and South basin densities. Densities in all basins have increased greatly since 1969, but again most noticeably in the North basin. Mollusca (mainly Sphaeriidae, fingernail clams), Chironomidae (midge larvae), and Oligochaeta (mainly Tubificidae worms), in particular, occurred at higher densities in the North basin, with increasing abundance from spring through summer to fall across all years. Amphipoda (mainly *Diporeia*) remained concentrated in the Narrows.

It appears that increased organic matter sedimentation from the pelagic zone may drive the acceleration of eutrophication by the benthic community. In the North basin, zoobenthos benefits from sedimentation of cyanobacterial blooms that are inedible and/or toxic to zooplankton grazers. In the South basin (light-limited), fewer algal blooms occur, with less organic matter sedimentation and lower abundance of zoobenthos.

2007 Distribution and Abundance of Small-Bodied Fishes in Lake Winnipeg

Lumb, C.E. Manitoba Water Stewardship, Watkinson, D.A. DFO), Franzin, W.G. (DFO)

Lake Winnipeg is the tenth largest freshwater lake in the world, by surface area, and the third largest lake completely within Canada. It is a shallow, turbid lake that does not typically thermally stratify. The lake is divided into two distinct basins: the North Basin has a larger surface area and greater mean depth (13.3 m) than the South Basin (9.7 m). While the lake supports important subsistence, recreational and commercial fisheries and despite its ecological, social and economic importance, dynamics of the fish community are not well understood. To describe seasonal

distribution and abundance of small-bodied fishes in open waters of Lake Winnipeg, the current trawling program was started in 2002. Additional objectives of data collection in 2007 were to graphically represent geographic patterns of density of small walleye in Lake Winnipeg during spring, summer and fall and to describe length distribution of walleye. In 2007, trawling was conducted near long term monitoring stations during seasonal research cruises using a 3-meter square beam trawl. Biomass density ($g/1000m^3$) was calculated for species by basin and by season. The largest number of species was found in the South Basin, followed by the Channel and the North Basin. Species assemblage was composed of emerald shiner, rainbow smelt, cisco, troutperch, white bass and walleye. The largest number of species was caught during the summer, followed by the fall and the spring. Overall, biomass density was greatest in the summer when young of the year fishes were caught in trawls. The greatest biomass densities of walleye by station were found in the South Basin and in the Channel, during the summer. Finally, in the summer, greater frequency of small walleye (20 to 60 mm fork length) was observed in the Channel compared to South Basin in 2007.

Phosphorus reduction by cattail (*Typha*) harvest in Netley Libau Marsh

Joe Ackerman (UM)

The majority of phosphorus (P) entering Lake Winnipeg is via the Red River, which flows through Netley Libau Marsh. A portion of this P is retained by the marsh and provides good conditions for emergent macrophyte growth. Annual harvest of this biomass would potentially provide a way to remove P from the system, along with other benefits. However, it is not known if *Typha* biomass P is derived from the water column, (thereby reducing P loading on the lake), or from the sediment (and having a less immediate impact of Lake nutrients). This presentation summarizes the work conducted in a Masters thesis addressing this question. Water, plant and sediment sampling was conducted over a growing season and revealed sediment P levels at 50 g/m^2 and P uptake by *Typha* of totaled 5 g/m^2. Dramatic seasonal changes were found within sediment P fractions and a large portion of "stored" P was in organic forms. Over the growing season *Typha* sourced the majority of its P needs from sediment sources, perhaps reducing the stored fraction(s). Of particular interest to other researchers was the variability of many aspects of sample collection over the season. These included bulk density, P fractions, and *Typha* morphology

Impacts of climate change on the biological, cultural, and economic sustainability of the Lake Winnipeg commercial fishery

Bruce Maclean, Centre for Indigenous Environmental Resources Inc.

Climate change is increasing as an important and diverse issue facing First Nations and northern communities. Typically, within these groups reliance on natural resources for many benefits is great due to the high level of participation within traditional pursuits and subsistence activities. One activity maintaining high interest from Manitoba First Nations relates to the fisheries within Lakes Manitoba,

Winnipeg, and the other numerous freshwater bodies contained within the province.

CIER collaborated with the Fisher River Cree Nation (FRCN) to conduct research on the impacts of climate change on the biological, social, cultural, and economic sustainability of freshwater fisheries in Lake Winnipeg, and provides potential adaptations to these. To obtain FRCN fishers' knowledge about climate change, CIER completed thirteen interviews in January 2007. In addition to the Indigenous Knowledge collected, CIER gathered Western scientific information on commercial, subsistence, and recreational fish species and the present and potential climate change impacts. Collectively, these activities identified potential climate change risks while identifying possible adaptation and risk management measures.

Fishers communicated that climate change, pollution, hydropower development, exotic species, and commercial fishing pressures affect the lake. These pressures interact with each other making it difficult to isolate those specifically attributed to climate change. Changes observed in the walleye populations are extreme, but it is not clear if this is due to warmer water, or the increase in rainbow smelt or a combination of factors. New species of fish such as the longnose gar, expected by fisheries scientists to eventually enter Lake Winnipeg, have already been positively identified by one Fisher River fisherman near McBeth Point.

According to fishers, blue-green algae blooms have become more frequent, larger, and deeper. This adversely affects the industry due to time lost while cleaning nets and distances travelled to avoid the blooms. Fishers have also noted irritation to skin, eyes and lungs from cleaning nets.
However, according to fishers the most notable change on Lake Winnipeg is an increase in dangerous and unpredictable weather. Lake Winnipeg has always had dangerous weather, but the ability to read the Lake and have sufficient time to get off safely is changing according to FRCN fishers.

CIER was able to assess the observed and predicted climate change impacts to identify adaptation measures specific to the freshwater fishery on Lake Winnipeg. These adaptation measures relate to the following three areas: economic, social, and fishers' health and safety. These include the importance of continued planning activities, especially in relation to social impacts. Other measures included working with federal and provincial governements to establish a more accurate weather monitoring system and increase safety measures.

CIER predicts changes to the social fabric of FRCN, as fewer fishers perceive commercial fishing as a viable profession to pass on to their children. Some of the causes for this shift relate to climate change. As the many climate change impacts become more apparent, the need for First Nations to become informed of the issues will increase. FRCN and other FN with similar economic and social makeup will need to plan to meet the expected challenges.

W. Lyle Lockhart
Lake Winnipeg Foundation

Lake Winnipeg has received limited research attention in the past but some growth in attention is anticipated over the next few years as a result of a new commitment by Environment Canada. The lake has provided a number of benefits to Manitobans (fish, recreation, inspiration, hydroelectricity, waste disposal, habitat, carbon storage etc.) but it is not clear what Manitobans expect from the lake in the future. Diverse expectations cannot be maximized at the same time and some difficult value judgments will be required to derive some optimum blend of management objectives. While the derivation of objectives for management is not entirely a scientific process, after clear objectives are in hand, the best scientific insights into the way the lake works will be needed to guide management choices. As a "grass-roots" organization we are in frequent touch with groups such as service clubs, church groups, associations etc., and we have developed a list of about thirty-five issues that people ask about. Usually the answers involve a deeper understanding than we possess about the ways in which the lake and its watershed work. We look to the scientists for answers. As improved scientific insights become available, they may lead to conflict with existing management policies within or across jurisdictions. However, the best science is closest to the truth and it must be interpreted and applied to management decisions. We hope to help provide ongoing opportunities for the best science to be presented and explained to the Public.

AGENDA - LAKE WINNIPEG RESEARCH CONSORTIUM SCIENCE WORKSHOP
Developing an Ecosystem Model for Lake Management
Freshwater Institute Seminar Room
March 17th – 19th, 2008

DAY 1 (Monday March 17th, 13:00 – 17:00)
Defining Research Targets
(Open to LWRC Science Team Only)

13:00	Welcome by LWRC Managing Director	Al Kristofferson
13:10	Introduction 2007 Research Team Participants	
13:15	Overview 2007 LWRC Activities	Alex Salki
	Lake Winnipeg Provincial- Federal Initiatives	
13:25	Manitoba Water Science and Management – Dwight Williamson Manitoba Water Stewardship	
13:40	The Lake Winnipeg Basin Initiative – Malcolm Conly & John Lawrence Environment Canada	
	Lake Winnipeg Science Pathway	
13:55	Current understanding of the Lake Winnipeg ecosystem - Alex Salki	
14:15	Formulating an Integrated Research Model for Lake Winnipeg Remediation – Alex Salki	
14:20	Physical and hydrological model parameters – LWRC Modeling Committee – Steve Page	
14:40	Chemical and biological model parameters – LWRC Science Committee – Alex Salki, Brenda Hann	
15:00	**Coffee**	
15:15	Open Discussions on Science Pathway - Research Targets, Model Development, Integration	
17:00	Adjournment Day 1	

DAY 2 (Tuesday, March 18th, 8:45 – 16:30)
Lake Winnipeg Research Activities 2007 - Scientific Presentations
(Open to all LWRC members, students)

8:45	Welcome and Announcements
9:00	Physical Limnology and Modelling of Lake Winnipeg. R. Yurebandi, EC – NWRI, CCIW
9:25	Optical properties, water colour and water quality of Lake Winnipeg. J. Jerome, EC – NWRI,CCIW
9:50	Stream nutrient assessment update. S. Watson, EC – NWRI, CCIW
10:15	***Coffee***
10:45	Changes in precipitation and runoff patterns as a cause of recent increases in productivity in Lake Winnipeg: Implications for establishing ecologically relevant nutrient targets. M.Stainton (FWI), G. McCullough, (CEOS) R. Hesslein, (FWI) S. Page (FWI)
11:10	Mapping total chlorophyll concentrations and cyanophyte biomass using satellite-borne sensors over Lake Winnipeg. G. McCullough (CEOS), H. Kling (AET), M.Stainton (FWI), & D. Barber (CEOS)
11:35	Isotope studies of water balance, O2 status, nutrient cycling, foodweb update L. Wassenaar and K. Hobson, EC – NWRI, NHRI
12:00	***Lunch***
13:15	Phytoplankton in Lake Winnipeg. H. Kling. Algal Ecology and Taxonomy
13:40	Lake Winnipeg zoobenthos: Are any patterns or trends emerging from the mud? B. Hann, U. of Manitoba
14:05	2007 distribution and abundance of small-bodied fishes in Lake Winnipeg. C. Lumb (MWS), D. Watkinson (FWI), W. Franzin (FWI)
14:30	Environmental aspects of a proposed Hydro Cable under Lake Winnipeg. J. Ryan, retired U of W
14:55	***Coffee***
15:15	Phosphorus reduction by cattail (*Typha*) harvest in Netley Libau Marsh. J. Ackerman U of Manitoba
15:40	Impacts of climate change on the biological, social, cultural, and economic sustainability of the Lake

	Winnipeg fishery. Bruce Maclean, Centre for Indigenous Environmental Resources Inc.
16:05	The Lake Winnipeg Foundation Initiatives. Lyle Lockhart. Lake Winnipeg Foundation
16:30	Adjournment

DAY 3 (Wednesday, March 19th, 9:00 – 12:00)
2008 Science Program Planning Discussion
(Open to LWRC Science Team Only)

9:00	Discussions on 2008 field program, coordination, equipment, schedule, station network,
	graduate student research proposals
10:15	**Coffee**
10:30	Discussions on data sharing and database, publications, website and education
12:00	Adjournment

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