Preface to special theme, part 1

Toward a better understanding of Lake Simcoe through integrative and collaborative monitoring and research

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This special section of Inland Waters features the first of numerous papers that highlight trends and insights emerging from decades of ecological monitoring and research activities on Lake Simcoe, Canada. Lake Simcoe is the largest lake in southern Ontario after the Laurentian Great Lakes. Like most large lakes, Simcoe has been negatively impacted over the past century by human activities, which accelerated dramatically around the 1930s (Hawryshyn et al. 2012). Phosphorus (P) loading from point and nonpoint sources caused excessive growth of plants and algae that consume hypolimnetic oxygen during decomposition, which limited coldwater fish habitat and contributed to the recruitment failure of popular sportfish such as lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*; Evans et al. 1996). The establishment in recent decades of invasive fish, invertebrates, and plants is changing lake habitat, food webs, and native species dynamics (Evans et al. 2011, Ginn 2011, Ozersky et al. 2011). Increasing air temperature associated with climate change has prolonged thermal stratification and shortened the period of ice cover (OMOE et al. 2009, Stainsby et al. 2011). Metals and organic pollutants originating from urban and industrial sources have accumulated in lake and tributary sediments (Helm et al. 2011, Landre et al. 2011), potentially affecting aquatic biota and increasing the risk associated with human fish consumption (Gewurtz et al. 2011, Lembcke et al. 2011). Additionally, the cumulative effects of these and other stressors have drastically altered aquatic communities (Depew et al. 2011, Ginn 2011, Jimenez et al. 2011, Winter et al. 2011).

In response to public concern about the ecological health of the lake, the Lake Simcoe Protection Act was approved by the Government of Ontario in 2008 with a mandate to protect and restore the Lake Simcoe watershed (Government of Ontario 2008). The Act established the Lake Simcoe Protection Plan (LSPP; OMOE et al. 2009) that identifies a number of targets and indicators to characterize environmental health in the Lake Simcoe watershed and details 119 policies and actions to achieve these targets. Scientific monitoring and research play an integral role in the success of the LSPP, which supports an ecosystem approach to informing policies and actions, taking into account the interconnectedness of the lake and watershed. The LSPP mandates the enhancement of current monitoring programs, development of new monitoring programs, and the promotion and implementation of research projects that build upon existing science to continually update management decisions as part of an adaptive management approach.

The challenges posed by the LSPP necessitate collaborative research efforts and sharing of responsibilities, resources, and knowledge among federal, provincial, and local governments, academics, conservation authorities, agricultural, commercial, and industrial sectors, First Nations communities, the general public, and other stakeholders. The collection of papers shows the value of a collaborative approach and demonstrates how strong partnerships can facilitate integrative approaches to scientific monitoring and research efforts being used to protect Lake Simcoe.

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Introduction to Lake Simcoe and the special issue

Lake Simcoe (44º25´N; 79º20´W) has a surface area of 722 km^2 and is moderately shallow (mean depth 16 m; maximum depth 42 m). The lake has 6 islands, the largest of which (Georgina Island) is 15 km^2, and 2 prominent bays: Kempenfelt Bay and Cook's Bay (surface areas of 34 and 44 km^2, respectively) to the west and southwest of the 643 km^2 main basin. The lake receives water from 35 tributaries within a catchment area of 2899 km^2 spread across 23 municipalities, and empties through a single outflow to the north. Land use in the Lake Simcoe watershed is largely agricultural (47%), although urban land use (12%, including roads) is becoming increasingly important as some of the fastest growing communities in North America are located in the watershed (OMPIR 2006, Winter et al. 2007). The watershed is also home to First Nations communities including the Chippewas of Georgina Island First Nation.

Lake Simcoe provides watershed residents with valuable socioeconomic services, such as drinking water and wastewater assimilation, and supports tourism as well as recreational and agricultural activities, which contribute an estimated C$700 million annually to Ontario's economy (LSEMS 2008). In addition, Lake Simcoe is part of the Trent Severn Waterway, historically an industrial transportation corridor connecting Lake Ontario to Lake Huron, now maintained for recreational travel.

This extensive human use of the Lake Simcoe watershed has impacted the ecological health of the lake. Recognizing the ongoing deterioration of the lake and the critical need for scientific data to elucidate the causes and consequences of human actions on the state of the lake, the Ontario Ministries of the Environment and Natural Resources began monitoring lake water quality and biota in the 1970s. Monitoring and research on the lake were expanded in the 1980s under the Lake Simcoe Environmental Management Strategy (LSEMS), a partnership among government, the Lake Simcoe Region Conservation Authority, the Chippewas of Georgina Island First Nation, and other stakeholders. A primary goal of LSEMS was to quantify and reduce sources of P to Lake Simcoe, and it supported more than 500 nutrient reduction projects between 1990 and 2008 (LSEMS 2008). The breadth of monitoring and research on Lake Simcoe was further enhanced through various sources, including LSPP funds, Ontario Ministry of the Environment Best in Science awards, Natural Sciences and Engineering Research Council of Canada awards, and the Government of Canada's C$30 million Lake Simcoe Clean-Up Fund, which was administered between 2007–2012 and supported 160 projects in areas such as P reduction, implementation of best management practices, improvement of information and monitoring for decision making, and emerging stressors. With the January 2013 announcement of another 5 years of funding under the C$29 million Lake Simcoe/South-eastern Georgian Bay Clean-Up Fund, we can expect productive and collaborative initiatives like those described here to continue into the future. For further reference, a wealth of information exists on Lake Simcoe and monitoring in the watershed (LSEMS 2008, OMOE et al. 2009, Young et al. 2010, Palmer et al. 2011).

The tremendous amount of science underway in the Lake Simcoe watershed was the impetus for a 2011 special issue on Lake Simcoe in the Journal of Great Lakes Research (Palmer et al. 2011). Many of the papers in that first special issue documented long-term ecological changes that have occurred in Lake Simcoe and investigated the stressors potentially driving these changes. The four papers published here, in combination with the collection of papers planned for Inland Waters Volume 3, Issue 2, focus on Lake Simcoe and continue this line of investigation. In addition, these studies make significant advances in the integration of knowledge across multiple fields of research to increase understanding of the function of the lake and its watershed and to better inform conservation actions in Lake Simcoe. This integrative approach is exemplified by North et al. (2013), the first paper of the current special issue, which provides the first comprehensive evaluation of the state of the lake. North et al. (2013) assess trends and abrupt temporal shifts over the past 3 decades in water quality and biological communities across multiple trophic levels in an integrated fashion to identify multiple stressors and their impacts in Lake Simcoe.

The current series of papers also delves into new areas of research and emerging issues that have not been addressed previously in Lake Simcoe. For example, Kelly et al. (2013) describe the population dynamics and environmental controls on the invasive spiny water flea, *Bythotrephes longimanus*, while Khan et al. (2013) examine the prevalence and potential sources of bacteria at recreational beaches around the lake. The latest research also compares Lake Simcoe to other systems, as demonstrated by Loh et al. (2013) who develop and compare models to predict sediment release of P and iron among Lake Simcoe and other large lakes that have experienced cyanobacterial blooms.

Collectively, this series of papers showcase current Lake Simcoe research. We hope this work will not only inform management of the Lake Simcoe watershed, but also act as a model for other ecosystems impacted by human activities. The collaborative, adaptive approach to long-term monitoring, research, and management of Lake Simcoe has been extremely productive, and a number of

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achievements have been reached; however, more work is needed to ensure the future health of this valuable resource. Ontario's Lake Simcoe Protection Act and LSPP, as well as renewed Clean-Up funding by the Government of Canada, demonstrate that both provincial and federal governments are committed to protecting Lake Simcoe for future generations, an endeavor that will require continual monitoring and research that is both collaborative and integrative.

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