INDICATOR: Status of the Great Lakes Ecosystems

Startegic Direction: Enhanced Resilience

Target: N/A

Theme: State of Ecosystems and Species

Background Information

The Great Lakes – Erie, Huron, Michigan, Ontario and Superior - and their surrounding watershed make up a rich and diverse system that supports a wide variety of aquatic and terrestrial life. The Great Lakes contain nearly 20 per cent of the fresh surface water on the planet and there are over 4,000 species of plants, fish and wildlife that call this area their home. The Lakes also provide food and recreational opportunities, as well as supply the province with numerous economic advantages (Environment Canada and the US Environmental Protection Agency 2014). They provide drinking water to 48 million Canadians and Americans (Great Lakes Commission 2020) and are important to the economies of both countries (Environment and Climate Change Canada and the US Environmental Protection Agency 2017).

The Great Lakes ecosystem has undergone significant and sometimes rapid ecological change associated with a long history of intensive human use. During the 1970s it became clear that pollution and other pressures were taking their toll on the Lakes. In the mid-1980s, 42 Great Lakes Areas of Concern (AOCs) were designated along with a 43rd in 1991. The Great Lakes Restoration Initiative (GLRI) was launched in 2010, which helped to accelerate protection and restoration efforts, resulting in the clean-up of polluted harbours. Legal and conservation efforts have been initiated to reduce emission of toxic chemicals, clean-up of over 40 polluted harbours, bays and waterfronts; restore habitat for fish and wildlife; and reduce phosphorus loading to Lake Erie which cause algae problems. Though efforts have been ongoing, algal blooms remain a problem in the Great Lakes. In 2016, Ontario adopted a target to reduce phosphorus loading by 40 percent for the western and central basin of Lake Erie by (Government of Ontario 2020). Agal blooms have become a regular occurrence in all or parts of each of the Great Lakes. Actions to meet phosphorus reduction targets, reduce algal blooms, and help restore Lake Erie include better management of wastewater and stormwater impacts, reducing run-off from agriculture and supporting wetland restoration in the Lake Erie watershed.

Despite some successes, the cumulative impacts of many pressures continue to threaten the Great Lakes. Toxic contaminants, invasive species, excessive amounts of nutrients, shoreline and land use changes, and hydrologic modifications are all impacting the Great Lakes ecosystem. An understanding of ecosystem conditions and whether these conditions are improving, or declining is necessary to determine the impacts of these threats. This indicator provides a lake-by-lake summary of the state of the Great Lakes based on information provided in the State of the Great Lakes 2017 Report and examines changes between the 2011 and 2017 analysis.

Data Analysis

Information for this indicator was assembled from data provided in the State of the Great Lakes 2017 Report (ECCC and USEPA 2017); which provides science-based trend information on the state of the health of the Great Lakes Basin. The State of the Great Lakes 2017 Report was developed with the involvement of more than 180 scientists and experts from the Great Lakes community within Canada and the United States. The data are based on indicator reports and presentations from the Great Lakes Public Forum, which provides opportunity for US and Canada to discuss and seek public comment. Some indicator reports have also been augmented with more recent information. More information about Great Lakes indicators can be found through the final published State of the Great Lakes 2017 Technical Report.

Reporting on a suite of Great Lakes indicators provides a big picture perspective of the complex Great Lakes ecosystem. The State of the Great Lakes 2017 Technical Report contains indicator reports that assess trends in water quality, aquatic-dependent life and landscapes and natural processes. In the 2017 report the status of 44 indicators (full list of indicators can be found on page 5) is also assessed on a Lake-by-Lake basis. The framework for the status assessment is defined in Table 1.

Table 1. Indicator assessment criteria in the State of the Great Lakes 2017 Report.

Status	Description
Good	Most or all ecosystem components are in acceptable condition otherwise in acceptable condition.
Fair	Some ecosystem components are in acceptable condition.
Poor	Very few or no ecosystem components are in acceptable condition.
Undetermined	Data are not available or are insufficient to assess the condition of the ecosystem component.

To understand the overall state of each Great Lake, the percentage of indicators that were assessed as good, fair, poor or undetermined are presented (Fig. 1). As well, a narrative describing the state of each Great Lake, including ongoing and emerging stressors is included. While Lake Michigan is located entirely within the United States, it is included in this analysis as these waters are part of a larger shared system and the state of the Lake has impacts on the entire Great Lakes Basin, including the province of Ontario.

State of Ecosystems and Species

Results

Trend: Fair **Data Confidence:** High **Geographic Extent:** Great Lakes

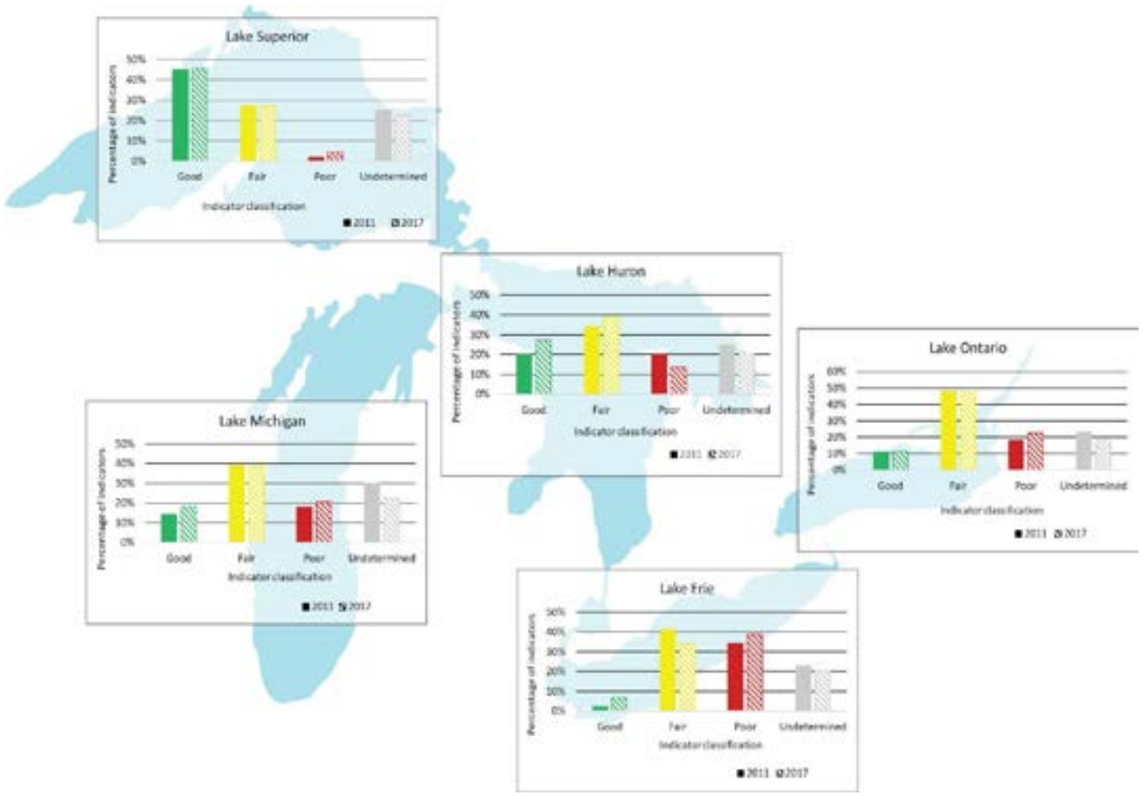

Figure 1. Percentage of indicators that were classified as good, fair, poor or undetermined for each of the Great Lakes in the State of the Great Lakes 2017 Report compared to 2011 analysis (n = 44).

Status

- Lake Superior is in generally good condition, with almost half of the indicators assessed as good (45%) and two indicators (Lake sturgeon and impacts of aquatic invasive species) considered poor.
- The largest proportion of indicators for Lake Michigan (39%), Lake Huron (39%) and Lake Ontario (48%) were assessed as fair.
- The largest proportion of indicators for Lake Erie were assessed as poor (39%), this has changed from the last assessment in 2011 which assessed most indicators as fair (41%). Three of Lake Erie's indicators were assessed as good (zooplankton, walleye, and treated drinking water), which has improved from only one in 2011.

Lake Superior

Lake Superior is in generally good condition due to its larger size and relatively low development pressure. The fisheries are healthy, the lower food web is strong and toxic chemicals are largely decreasing or remaining stable. There are self-sustaining populations of Lake Trout and increasing abundance of Lake Sturgeon. Ongoing and emerging stressors include fluctuating water levels, invasive species, and increasing concentrations of contaminants in whole fish. Water levels in Lake Superior have been below average since the 1990s, however in 2013 and 2014 levels rose very quickly and continue to be above long-term average values. The high rate of variability in climate conditions and the regional hydrologic cycles makes it difficult to determine whether these changes are expected to continue in the future. There is also concern that climate change will cause greater fluctuations in water levels. From an ecological perspective, short and long-term lake level fluctuations are critical to maintain healthy coastal habitats, especially wetlands. However, dramatic or sustained long-term changes can degrade these important habitats. Concentrations of toxic chemicals (e.g. PCBs and PeBDEs) in Lake Trout and Walleye continue to be above guidelines. Total mercury concentrations, although still below the target, have returned to levels observed in the 1980s and appear to be stable in recent years.

Lake Michigan

Lake Michigan is located entirely within the United States; however, these waters are part of a larger shared system and the state of the Lake has impacts on the entire Great Lakes Basin, including the Province of Ontario. In general, Lake Michigan is in a fair state with both positive and negative trends. The removal of dams, restoration of wetland habitat and riverine spawning habitat, and continued decline of contaminants such as PCBs in fish have resulted in improvements. PCB levels from fish in Lake Michigan have historically been the worst among the Great Lakes, but substantial declines show levels are nearing the other Great Lakes. However, the aquatic food web is under stress because *Diporeia*, a small crustacean that is an important food for many fish species, has almost disappeared. Several invasive species such as Sea Lamprey, Round Goby, Zebra Mussel and Quagga Mussel continue to cause significant changes in water clarity and fertility, resulting in major changes to Lake Michigan's ecosystem. Both Zebra and Quagga mussels have contributed significantly to the decline of *Diporeia*. Invasive species continue to expand their range causing environmental impacts, including widespread algal growth which is suspected of playing a role in Type E Botulism outbreaks that have caused the death of large numbers of fish-eating birds. Viral Hemorrhagic Septicemia (VHS) has also become established and has caused significant fish die-offs.

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Lake Huron

Lake Huron has been called "the lake in the middle" both geographically and in terms of its environmental quality. In general, Lake Huron has good water quality with low concentrations of toxic chemicals in offshore waters and though chemical pollutants have declined significantly since the 1970s, in recent years PCBs and mercury levels appear to be stable and fish and wildlife consumption advisories remain in effect. Development, dams, non-point source pollution, invasive species and climate change are major stressors on the ecosystem and are resulting in habitat degradation and loss. In particular, Lake Huron has suffered due to the invasion and spread of Zebra Mussel and Quagga Mussel and the disappearance of Diporeia, which impact on the Lake's nutrient cycling and food web dynamics. Offshore prey fish populations continue to decline since 2003 and predator fish species, such as Salmon have also decreased in number and total biomass. In contrast, near shore nutrient concentrations have increased and populations of Walleye, Yellow Perch and Smallmouth Bass seem to be rebounding. Harmful algal blooms linked to botulism are a problem in the southern portion of the lake. Massive fall die-offs of migrating loons and diving ducks are reported annually in the lower Great Lakes including the southern portion of Lake Huron and Georgian bay, due to botulism.

Lake Erie

Despite early successes in reducing phosphorus loads to the Lakes after the 1972 Great Lakes Water Quality Agreement was implemented, Lake Erie continues to be threatened by excessive nutrient inputs from non-point sources such as urban and rural run-off. Algal blooms have become a regular occurrence throughout Lake Erie and Lake St. Clair during summer months and Cladophora growth continues to be a problem in near shore areas. Lake Erie's western basin also experiences blooms dominated by toxic microcystis. These algal blooms impact drinking water treatment systems and recreational activities. Compounding this problem, in-lake nutrient cycling has changed due to the spread of invasive Zebra Mussel and Quagga Mussel that became established in the 1980s. This alteration of nutrient flow is contributing to greater nuisance algal growth in the near shore regions, while deeper offshore waters are deprived of oxygen causing "dead zones" for aquatic life. Other changes contributing to the resurgence of algae include the significant loss of wetlands and riparian vegetation that once trapped nutrients. The loss of millions of ash trees across Ontario increased amounts of stormwater runoff and has led to more pollutants and sediments going into the waters. Shifting communities of phytoplankton, increased water clarity and climate issues such as warmer waters and extreme precipitation events also play a role. As a result of these ecological changes, the fish community in Lake Erie has also suffered. Some fish have been extirpated (e.g., Blue Pike, Shortnose Cisco). Progress has been made to increase aquatic connectivity through dam removal and mitigation projects helping to increase Walleye across the lake as well as lake sturgeon in the St. Clair-Detroit river system. *Diporeia*, an important cold-water species, is likely extirpated from the eastern basin where it has not been seen since 1998.

Lake Ontario

Although Lake Ontario is the smallest of the Great Lakes, its drainage basin is the most densely populated and provides ecosystem services to over 10 million people. Past and current pressures on this ecosystem have led to drastic changes in nutrient dynamics, altered hydrology, loss of coastal habitats, and the introduction of invasive species, all with serious consequences to native species, food webs, and quality of life. Many of these changes have occurred rapidly and the Lake continues to respond in unpredictable ways. Progress has been made to reduce these

stressors including decreasing the amount of nutrients and toxic chemicals entering the lake and restoration of degraded habitats. These improvements have led to the return of Osprey and Bald Eagle to the shores of Lake Ontario, and have supported initiatives to restore native Lake Trout and Atlantic Salmon to the region, and native deepwater sculpin, a species once thought extirpated, has recovered, while stocking efforts to restore other native prey fish show some signs of success. In contrast, a number of fish, bird and wildlife populations have declined in Lake Ontario, due in part, to destruction of habitat, overfishing, the introduction and spread of invasive species and toxic contaminants. In particular, the invasion of Zebra Mussel and Quagga Mussel and the disappearance of *Diporeia* continue to impact the Lake's nutrient cycling and food web dynamics. Parts of Lake Ontario have seen a resurgence of harmful algal blooms (HABs) since 2008 which are caused by a combination of elevated nutrient levels, invasive species, warmer temperatures, and higher frequency of precipitation.

Links

Related Targets: N/A

Related Themes: N/A

Web Links:

Great Lakes Commission https://www.glc.org/lakes/#:~:text=The%20system%20is%20invaluable%20as,found%20nowhere%20else%20on%20Earth.

State of the Great Lakes 2011 Technical Report https://binational.net//wp-content/uploads/2014/11/sogl-2011-technical-report-en.pdf

State of the Great Lakes 2011 Highlights Report https://binational.net/wp-content/uploads/2014/11/SOLEC2011Highlights_e.pdf

State of the Great Lakes 2017 Technical Report https://binational.net/wp-content/uploads/2017/09/SOGL_2017_Technical_Report-EN.pdf

State of the Great Lakes 2017 Highlights https://binational.net/wp-content/uploads/2017/06/SOGL_17-EN.pdf

Ontario's Great Lakes Strategy https://www.ontario.ca/page/ontarios-great-lakes-strategy

Great Lakes Biodiversity Conservation Strategies https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/wholesystems/greatlakes/basin/biodiversity/Pages/default.aspx

References

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Environment and Climate Change Canada and the U.S. Environmental Protection Agency. 2017. Government of Ontario. 2012. Ontario's Great Lakes Strategy. Queen's Printer for Ontario. Toronto, ON. Available at: https://www.ontario.ca/environment-and-energy/ontarios-great-lakes-strategy]

State of the Great Lakes 2017 Technical Report. Cat No. En161-3/1E-PDF.EPA 905-R-17-001. Available at http://binational.net]

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Ontario Biodiversity Council. 2019. State of Ontario's Biodiversity [web application]. Ontario Biodiversity Council, Peterborough, Ontario. [Available at: http://ontariobiodiversitycouncil.ca/sobr (Updated: May 19, 2021)].