Environment and Climate Change Canada
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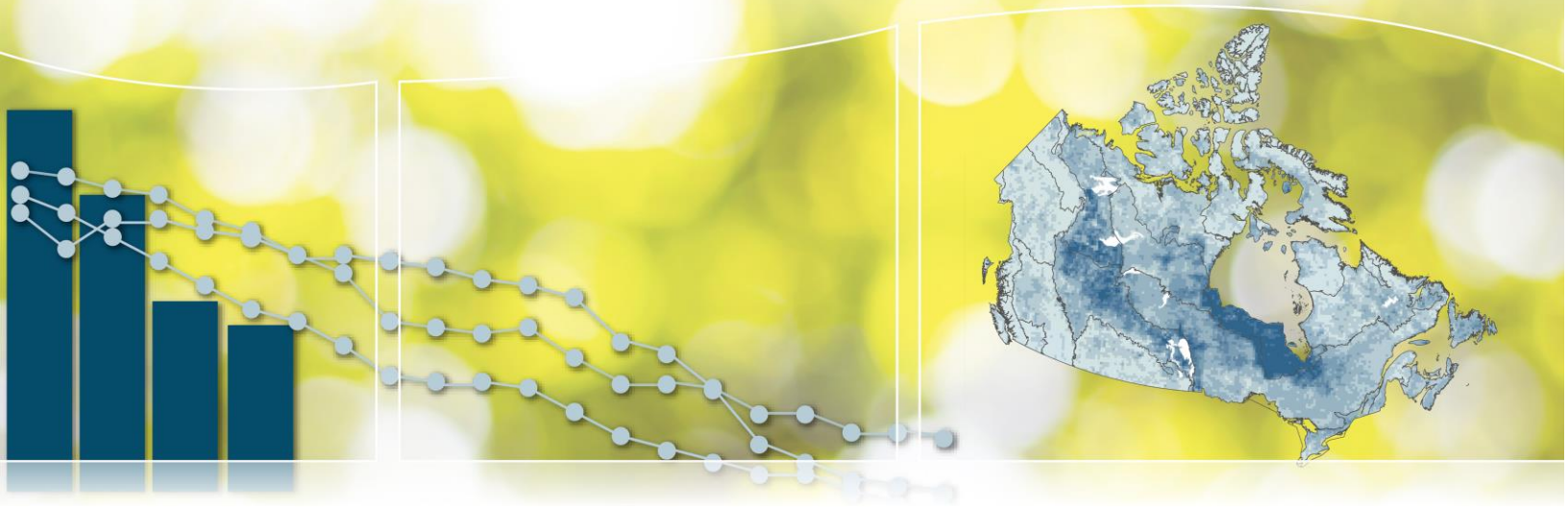
Canadian Environmental Sustainability Indicators

Phosphorus levels in the offshore waters of the Great Lakes



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Phosphorus levels in the offshore waters of the Great Lakes

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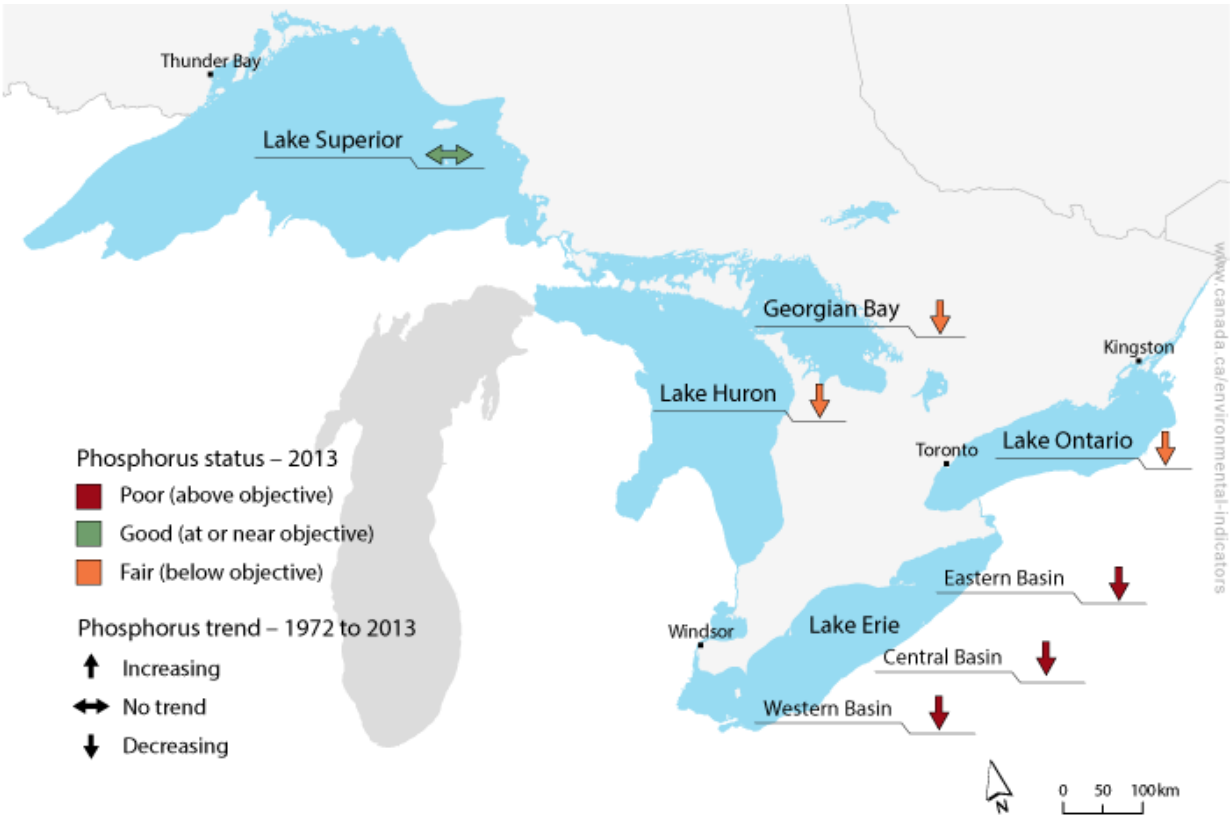
Phosphorus levels in the offshore waters of the Great Lakes indicator

Phosphorus is an essential plant nutrient. When phosphorus levels are too high or too low, they can have harmful impacts on a lake's food web. It is one feature of the health of the offshore waters of the Great Lakes. Conditions may be very different in nearshore areas.

Key results

- Phosphorus levels are too high in the offshore waters of Lake Erie. While there has been an overall decrease in phosphorus levels over the past 40 years, recent levels vary greatly from year to year. They are no longer showing a declining trend.
- Phosphorus levels are too low in the offshore waters of Lake Ontario, Lake Huron and Georgian Bay. Since 1972, levels have decreased to a point where preyfish populations are declining.
- Offshore phosphorus levels in Lake Superior are at the level they should be and not changing.

Figure 1. Status and trends of phosphorus levels in the offshore waters of the Canadian Great Lakes, 1972 to 2013



Data for Figure 1

Note: Water quality in the offshore regions of a lake is considered good when it can support a healthy food web. Lakes where phosphorus levels are below objectives, and negative impacts to the offshore food web have been observed, are given a classification of fair. Where phosphorus levels are above a lake's phosphorus objectives, lakes are classified as poor. Long-

term trends to explore how phosphorus levels in the offshore areas of the lakes have changed since 1972 were assessed using linear regression.
Source: Environment and Climate Change Canada (2016) Great Lakes Surveillance Program.

Phosphorus levels remain an issue in the offshore areas of 3 of the 4 Canadian Great Lakes. Only in Lake Superior are plankton and preyfish populations healthy, resulting in a good phosphorus status in of the lake's offshore waters.[1,2]

For Lake Superior, spring average phosphorus levels in offshore waters have declined very slowly since 1972. Over the 40-year period, phosphorus levels have remained consistently below the lake's water quality objective of 5 micrograms of phosphorus per litre.

In the offshore waters of Lake Huron and Georgian Bay, phosphorus levels were close to their phosphorus objective of 5 micrograms of phosphorus per litre from 1972 until the late 1990s when they started to decline. For Lake Ontario's offshore waters, levels have declined from very high levels in 1972, dropped below the phosphorus objective of 10 micrograms of phosphorus per litre in the late 1980s, and continue to decline to historic lows. Open-water plankton, algae and preyfish populations in Lake Huron, Georgian Bay and Lake Ontario are showing signs of the impacts of these declines and low phosphorus levels are contributing to this stress.[3,4] These 3 systems are given the fair designation.

In recent years, there has been an increase in toxic and nuisance algae in Lake Erie that may be linked to phosphorus levels. The offshore waters of Lake Erie's eastern, central and western basins continue to have levels exceeding each basin's expected level, giving it a poor status. Phosphorus levels decreased from 1972 to 2013. Recent changes are difficult to identify because of the highly variable nature of the data. For example in 2012, a majority of samples taken from the western basin of the lake met the expected level. In contrast, in 2011 and 2013, samples from the same stations were above the expected level.[5]

While offshore phosphorus levels are reaching unprecedented lows in some lakes, many nearshore regions of the Great Lakes are experiencing nuisance algae problems due to excessive concentrations of nutrients in these areas.[6]

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[1] Barbiero RP (2011) Phytoplankton Populations. Page 372 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

[2] Gorman OT (2011) Preyfish Populations. Page 376 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

[3] Barbiero RP (2011) Phytoplankton Populations. Page 372 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

[4] Gorman OT (2011) Preyfish Populations. Page 376 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

[5] Dove A and Chapra SE (2016) Long-term trends in nutrients and trophic response variables for the Great Lakes. Limnology and Oceanography 60(2): 696–721. Retrieved on May 4, 2017.

[6] Dove A and Chapra SE (2016) Long-term trends in nutrients and trophic response variables for the Great Lakes. Limnology and Oceanography 60(2): 696–721. Retrieved on May 4, 2017..

About the indicator

What does the indicator measure

This indicator reports total phosphorus levels in the offshore waters of the 4 Canadian Great Lakes.

The indicator assumes water in the Great Lakes would never be above phosphorus water quality objectives in the absence of human development. It provides information on how human activity contributes to phosphorus levels in lakes.

A lake's phosphorus status is determined by comparing spring total phosphorus levels to its water quality objectives and the health of the lake's food web. Failure to meet a water quality objective for phosphorus suggests a greater risk to the health of the lake ecosystems.

Why is this indicator important

Clean freshwater is an essential resource. It protects the biodiversity of aquatic plants and animals. We use it for drinking, manufacturing, energy production, irrigation, swimming, boating and fishing. Degraded water quality damages the health of freshwater ecosystems and can disrupt economic activities, such as fisheries, tourism and agriculture. When phosphorus levels in water become too high, aquatic plant growth can become excessive and harmful. The decay of excess plant material can reduce the amount of oxygen available for fish and other aquatic animals. High nutrient levels can also lead to harmful algal blooms, which can kill animals that use the water, and affect human health. Conversely, too little phosphorus can result in not enough plant growth to support a lake's food web, which can result in a collapse of the fishery.

This indicator is used to provide information about the state of the Great Lakes and Canadian environment. It is also used to assess progress towards implementing the 2016–2019 Federal Sustainable Development Strategy.

What are the related indicators

The Restoring the Great Lakes areas of concern indicator assesses progress towards the restoration of Canada's 17 Great Lakes areas of concern.

The Nutrients in Lake Winnipeg and the Nutrients in the St. Lawrence River indicators report the status of total phosphorus and total nitrogen levels in those two ecosystems.

The Freshwater quality in Canadian rivers indicators rank water quality at monitoring sites across Canada where human activity is likely to impair water quality in its ability to support aquatic life.

Pristine lakes and rivers

This indicator supports the measurement of progress towards the following 2016–2019 Federal Sustainable Development Strategy long-term goal: Clean and healthy lakes and rivers support economic prosperity and the well-being of Canadians.

Data sources and methods

What are the data sources

Environment and Climate Change Canada's Great Lakes Surveillance Program collects the total phosphorus data used to calculate the status and trends in the offshore waters of the four Canadian Great Lakes. The indicator is calculated using the most recent data available for each lake.

More information

Total phosphorus ratings reported in the indicator are based on measurements taken in 2012 for Lake Huron and Georgian Bay and in 2013 for Lake Superior, Lake Ontario and the western, central and eastern basins of Lake Erie.

The total phosphorus objectives used in this indicator are the interim substance objectives for total phosphorus concentration in open waters published in the 2012 Great Lakes Water Quality Agreement.

For the trend analysis, total phosphorus data from 1972 to 2012 are used for Lake Huron and Georgian Bay. All other lakes use total phosphorus data from 1972 to 2013.

Each lake is monitored by Environment and Climate Change Canada every two years with several monitoring cruises typically conducted within that year. There are gaps in the data collected since the 1970s because of program changes, weather and mechanical problems with the ships used to collect the data.

How is this indicator calculated

Average open-water, spring-time total phosphorus concentrations in each lake are compared to water quality objectives. The status of phosphorus levels in the offshore waters of the Great Lakes were categorized as good (at or near the objective), fair (below the objective) or poor (above the objective).

For the trend analysis, linear regression was used to examine changes in mean total phosphorus levels over the entire length of the data record.

More information

Calculation of phosphorus status for the Great Lakes

Spring (late March to late May) phosphorus concentrations are compared to water quality objectives because they represent the annual maximum concentration of phosphorus in the lakes.

The status categories for this indicator are determined by comparing the most recent average spring total phosphorus concentration to:

- the water quality objectives as the maximum acceptable level
- the long-term trends for phosphorus levels in the lake
- the trends for related State of the Great Lakes indicators, especially abundance trends for algae[7] and prey fish[8]

Phosphorus levels categories are defined as:

- Good (at or near objective), if concentrations are below or close to the lake's objective, and no long-term changes to the lake ecosystems are observed

[7] Barbiero RP (2011) Phytoplankton Populations. Page 372 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

[8] Gorman OT (2011) Preyfish Populations. Page 376 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

- Fair (below objective), if concentrations are below the lake's objective and recent deterioration in algal, zooplankton and prey fish populations caused by low phosphorus concentrations are observed
- Poor (above objective), if concentrations are above the lake's objective

Trend Analysis

To calculate the long-term trends, the data are restricted to water samples collected at offshore locations because offshore waters are less influenced by local pollutant discharges than nearshore, shallow waters. For Lake Huron and Georgian Bay, these samples are taken from stations with depths greater than or equal to 50 metres. Samples taken from stations with depths greater than or equal to 100 metres are used for Lake Ontario and depths greater than or equal to 150 metres for Lake Superior. Lake Erie is shallow relative to the other lakes and is divided into three basins. Least squares regression was used to examine changes in mean phosphorus concentrations over the entire length of the data record.[9]

There are gaps in the data collected since the 1970s because of program changes, weather and mechanical problems with the ships used to collect the data. These data gaps have no major impact on the statistical trend analysis because of the length of the phosphorus monitoring record for the Great Lakes.

What has recently changed

Since this indicator was last published in 2011, the starting year for the trend analysis changed from 1970 to 1972 due to uncertainty in the early laboratory results. As well, 1972 corresponds to the date when the first Canada-U.S. Great Lakes Water Quality Agreement was signed.

What are the caveats and limitations

The indicator reflects the overall state of phosphorus levels in the offshore waters of the Great Lakes and only includes data collected by Environment and Climate Change Canada.

The indicator reflects the state of water quality in the Great Lakes based on total phosphorus concentrations. These concentrations do not show the effects of spills or other transient events, unless these are frequent or long-lasting.

Comparing this indicator with similar indicators for rivers requires a degree of caution.

More information

The indicator excludes nearshore phosphorus levels because there are currently no nearshore water quality objectives.

Offshore data from the United States are not included in this indicator; however, data collected by Environment and Climate Change Canada in United States waters have been included for all lakes.

In lakes, suspended particles tend to settle out. Water quality for each Great Lake is determined by comparing average, spring-time offshore total phosphorus concentrations to the lake's water quality objective. This differs from assessing water quality for a river system, where total phosphorus concentrations are influenced by suspended particles in the water that increase during high-flow events. It is still reasonable to compare lake and river systems as long as the methods to determine the classifications are clear.

[9] Dove A and Chapra SE (2016) Long-term trends in nutrients and trophic response variables for the Great Lakes. Limnology and Oceanography 60(2):696–721. Retrieved on May 4, 2017.

Resources

References

Barbiero RP (2011) Phytoplankton Populations. Page 372 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

Dove A and Chapra SE (2016) Long-term trends in nutrients and trophic response variables for the Great Lakes. Limnology and Oceanography 60(2): 696–721. Retrieved on May 4, 2017.

Environment and Climate Change Canada (2015) Phosphorus in Canada's aquatic ecosystems. Retrieved on May 4, 2017.

Gorman OT (2011) Preyfish Populations. Page 376 in State of the Great Lakes 2011 (PDF; 19.8 MB). Retrieved on May 4, 2017.

Hinderer JM, Murray MW and Becker T (2011) Feast and famine in the Great Lakes: how nutrients and invasive species interact to overwhelm the coasts and starve offshore waters. Retrieved on May 4, 2017.

Related information

Great Lakes Nutrient Initiative

Great Lakes Surveillance Program

Annex

Annex A. Data tables for the figures presented in this document

Table A.1. Data for Figure 1. Status and trends of phosphorus levels in the offshore waters of the Canadian Great Lakes, 1972 to 2013

Lake	Phosphorus water quality objective (micrograms of phosphorus per litre)	Spring phosphorus level (micrograms of phosphorus per litre)	Year of most recent measurement	Status for offshore waters	Long-term trend (1972 to 2013)
Superior	5	2.1	2013	Good	No trend
Huron	5	4.2	2012	Fair	Decreasing
Georgian Bay	5	2.0	2012	Fair	Decreasing
Erie – western basin	12[A]	25.4	2013	Poor	Decreasing[B]
Erie – central basin	6[A]	15.8	2013	Poor	Decreasing[B]
Erie – eastern basin	6[A]	13.4	2013	Poor	Decreasing[B]
Ontario	10	6.0	2013	Fair	Decreasing

Note: Water quality in the offshore regions of a lake is considered good when it can support a healthy food web. Lakes where phosphorus levels are below objectives and negative impacts to the offshore food web have been observed are given a classification of fair. Where phosphorus levels are above a lake's phosphorus objectives, lakes are classified as poor. Long-term trends to explore how phosphorus levels in the offshore areas of the lakes have changed since 1972 were assessed using linear regression.
[A] Expected phosphorus level in the lake based on achieving Lake Erie's phosphorus loading targets.
[B] Phosphorus levels in the offshore waters of Lake Erie decreased between 1972 and 2013. However, recent levels vary greatly from year to year and do not show a declining trend.
Source: Environment and Climate Change Canada (2016) Great Lakes Surveillance Program.

www.ec.gc.ca

Additional information can be obtained at:

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