STATE OF THE GREAT LAKES 2017

HIGHLIGHTS REPORT

An overview of the status and trends of the Great Lakes ecosystem

EPA

Canada

WHAT ARE THE GREAT LAKES INDICATORS TELLING US?

CAN WE DRINK THE WATER?

YES The Great Lakes remain a source of high quality drinking water.

CAN WE SWIM AT THE BEACHES?

YES But some beaches are unsafe for swimming some of the time due to bacterial contamination.

CAN WE EAT THE FISH?

YES But contaminants in fish require limits to be placed on the amount of fish consumed in order to safeguard human health.

ARE THE LAKES FREE FROM POLLUTANTS AT LEVELS HARMFUL TO HUMAN HEALTH AND THE ENVIRONMENT?

GENERALLY, YES But some pollutants in local areas, including in designated Areas of Concern, remain at problem concentrations.

ARE THE LAKES SUPPORTING HEALTHY WETLANDS AND OTHER HABITATS FOR NATIVE SPECIES?

IN SOME INSTANCES YES, AND IN OTHERS NO Results vary significantly from location to location.

ARE THE LAKES FREE FROM EXCESS NUTRIENTS?

NO Nutrient loadings in Lake Erie and some nearshore areas of Lakes Huron, Michigan and Ontario are causing severe impacts due to the formation of toxic and nuisance algae.

ARE WE WINNING THE BATTLE AGAINST AQUATIC INVASIVE SPECIES?

NO While the introduction of new non-native species has declined, the spread and impacts of aquatic invasive species already in the lakes continues.

IS GROUNDWATER NEGATIVELY AFFECTING THE WATER QUALITY OF THE LAKES?

GENERALLY, NO But some localized areas of contamination exist.

ARE LAND USE CHANGES IMPACTING THE LAKES?

YES Growth, development, and land-use activities stress the waters of the Great Lakes.

OVERALL, THE GREAT LAKES ARE ASSESSED AS FAIR AND UNCHANGING.

While progress to restore and protect the Great Lakes has been made, including the reduction of toxic chemicals, we are still facing challenges with issues such as invasive species and nutrients. In addition, the ecosystem is large and complex and it can take years to respond to restoration activities and policy changes.

ASSESSING THE GREAT LAKES

Why are the Great Lakes Important?

The Great Lakes contain one fifth of the world's fresh surface water supply and are one of the most ecologically diverse ecosystems on earth. They provide drinking water to tens of millions of Canadians and Americans and are important to the economies of both Canada and the United States, supporting manufacturing, transportation, farming, tourism, recreation, clean energy production, and other forms of economic growth.

How are Governments Working Together to Protect the Great Lakes?

2017 marks the 45th anniversary of the signing of the Great Lakes Water Quality Agreement by the Governments of Canada and the United States. The Agreement commits both countries to working cooperatively to restore and protect the water quality and aquatic ecosystem health of the Great Lakes. Through the Agreement, the Governments of Canada and the United States engage the provincial and state governments of Ontario, Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, Tribes, First Nations, Métis, municipal governments, watershed management agencies, other local public agencies, industry and the public in actions to ensure that the Great Lakes remain an important and vibrant natural resource for the benefit and enjoyment of this generation and those to come.

How is the Health of the Great Lakes Assessed?

The Governments of Canada and the United States, together with their many partners in protecting the Great Lakes, have agreed on a set of 9 indicators of ecosystem health. These indicators are in turn supported by 44 sub-indicators, measuring such things as concentrations of contaminants in water and fish tissue, changes in the quality and abundance of wetland habitat, and the introduction and spread of invasive species. To create this report, more than 180 government and non-government Great Lakes scientists and other experts worked to assemble available data to populate the suite of sub-indicators and to agree on what the indicators are telling us. Each indicator was assessed in relation to both status and trend. Status is defined as Poor, Fair or Good. Trend is defined as Deteriorating, Unchanging or Improving.

How is the Assessment of the Great Lakes Used?

Assessments of the Great Lakes help Governments to identify current, new and emerging challenges to Great Lakes water quality and ecosystem health. Assessments also help Governments to evaluate the effectiveness of programs and policies in place to address challenges, and help inform and engage others. We all have a role to play in helping to restore and protect the Great Lakes.

Overall Assessments of the Nine Great Lakes Indicators of Ecosystem Health

Great Lakes Indicator	Status and Trend
Drinking Water	**Status: Good** **Trend: Unchanging**
Beaches	**Status: Fair to Good** **Trend: Unchanging**
Fish Consumption	**Status: Fair** **Trend: Unchanging**
Toxic Chemicals	**Status: Fair** **Trend: Unchanging to Improving**
Habitats and Species	**Status: Fair** **Trend: Unchanging**
Nutrients and Algae	**Status: Fair** **Trend: Unchanging to Deteriorating**
Invasive Species	**Status: Poor** **Trend: Deteriorating**
Groundwater Quality	**Status: Fair** **Trend: Undetermined**
Watershed Impacts and Climate Trends	Watershed Impacts: **Status: Fair** **Trend: Unchanging**
	Climate Trends: **No Overall Assessment**

Drinking Water

Status: Good Trend: Unchanging

Nearly 30 million Americans and the majority of the 11 million Canadians living in the basin get their drinking water from the Great Lakes.

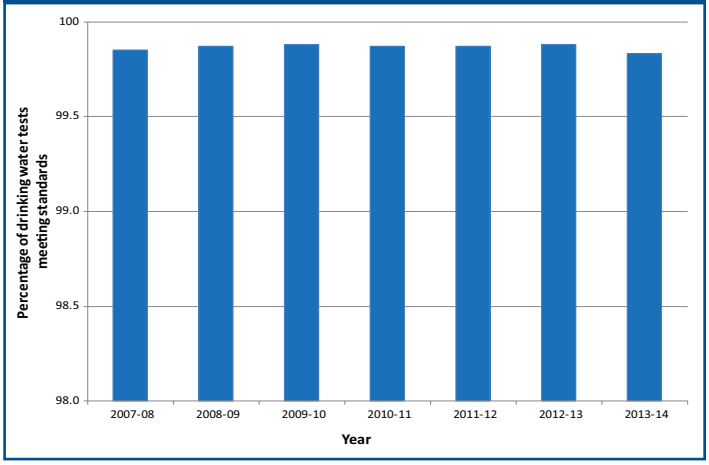
The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should be a source of safe, high-quality drinking water"*

Assessment Highlights

The Drinking Water indicator shows that the status of treated drinking water in both Canada and the U.S. is **Good** and the trend is **Unchanging** since the last report in 2011. This shows that the Great Lakes continue to be a high-quality source of drinking water; however, as with all source waters, water from the Great Lakes must be treated to make it safe to drink.

Ontario and U.S. state agencies have different ways of analyzing and reporting on the quality of treated drinking water, however, both compare microbial, radiological and chemical parameters in treated drinking water to health-based standards. In the Province of Ontario, almost 60% of the population gets their drinking water from the Great Lakes and treated water tests met Ontario Drinking Water Quality Standards 99.83% - 99.88% of the time from 2007 to 2014. In the U.S., 95 - 97% of the U.S. population living within the Great Lakes Basin, or approximately 27 million people, were serviced with drinking water that met all applicable health-based drinking water quality standards from 2012 to 2014.

Percentage of Canadian Drinking Water Tests Meeting Standards



Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Treated Drinking Water	No lake was assessed separately Great Lakes Basin assessment is **Good** and **Unchanging**				

Status:	GOOD	FAIR	POOR	UNDETERMINED

Beaches

Status: Fair to Good Trend: Unchanging

Great Lakes beaches are enjoyed by millions of residents and tourists each year and contribute significantly to local economies; however, some beaches are closed at times due to bacterial contamination caused by overflow of sewage treatment systems, stormwater runoff and other sources.

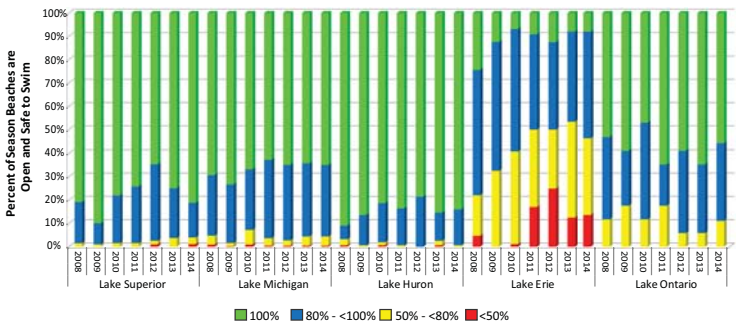
The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should allow for swimming and other recreational use, unrestricted by environmental quality concerns"*

Assessment Highlights

The overall status of Beaches is **Fair** to **Good** and the trend is **Unchanging** since 2011. The Beaches indicator shows that many monitored beaches in the Great Lakes are safe for swimming and recreational use throughout most of the swimming season.

The U.S. and Canada use different bacterial standards or criteria to determine when a beach is unsafe for swimming or other recreational activities. The Ontario standards are more stringent and therefore Ontario often has more beach health advisories issued. Approximately 1,000 beaches along the Great Lakes shoreline are monitored for the fecal bacteria indicator *E. coli* each year. Over the 2011 to 2014 time period, the percentage of days that monitored Canadian Great Lakes beaches met Ontario bacterial standards for swimming averaged 78%. The U.S. Great Lakes beaches monitored during this same time period were open and safe for swimming 96% of the time on average. However, the status of Lake Erie beaches in Canada and the U.S. has deteriorated from the previous 2008 to 2010 reporting period. Sources of *E. coli* for all of the Great Lakes can include wastewater treatment plants, runoff from the land after a heavy rainfall, improperly working septic systems, and even large flocks of gulls.

U.S. Great Lakes Beaches: Percent of Season Open By Lake



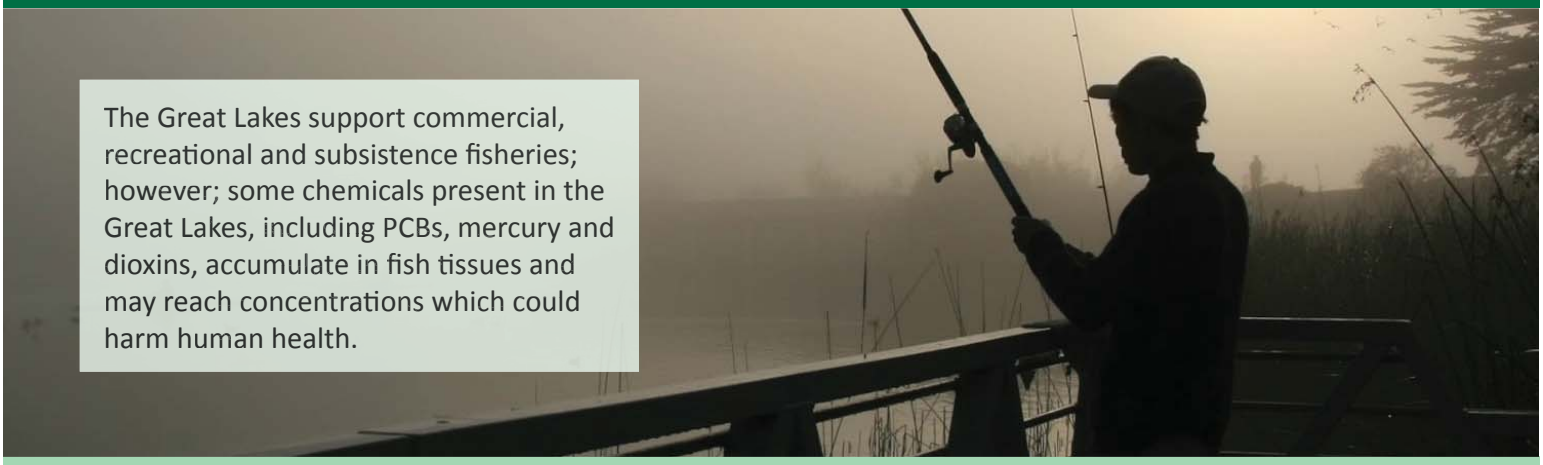
Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Beach Advisories	Unchanging	Unchanging	Unchanging	Deteriorating	Unchanging

Status:	GOOD	FAIR	POOR	UNDETERMINED

Fish Consumption

Status: Fair Trend: Unchanging



The Great Lakes support commercial, recreational and subsistence fisheries; however; some chemicals present in the Great Lakes, including PCBs, mercury and dioxins, accumulate in fish tissues and may reach concentrations which could harm human health.

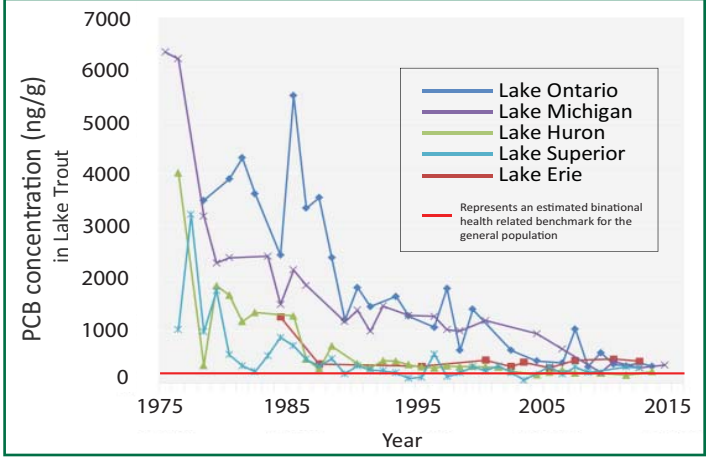
The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants"*

Assessment Highlights

The Fish Consumption indicator reveals that in all the Great Lakes contaminants in edible portions of fish have declined over time. However, in Lakes Erie and Huron, recent concentrations of PCBs and mercury are stable or slightly increasing. The status of contaminants in edible portions of fish is assessed as **Fair** and the trend is **Unchanging** since last reported in 2011.

Contaminants causing consumption restrictions of Great Lakes fish typically include PCBs, mercury, and dioxins. PCBs drive the majority of fish consumption advice in both the U.S. and Canada. PCB levels in edible portions of fish tissue have decreased by 90% in some cases, but are still above consumption benchmarks. Mercury levels have generally declined over the last four decades and, depending on the fish species and lake, are lower than most fish consumption advisory benchmarks. However, in Lakes Erie and Huron, PCBs and mercury have remained stable or are slightly increasing. Non-legacy contaminants, such as Perfluorooctanesulfonic acid or PFOS (a stain repellent), continue to be a monitoring priority and will be included in future State of the Great Lakes reporting as necessary. Additional stressors such as warming waters and invasive species will likely continue to complicate the cycling of contaminants in the Great Lakes and may impact the levels of contaminants in fish.

PCBs in Edible Fish Tissue Have Declined But Are Still Above Guidelines



Sub-Indicators Supporting the Indicator Assessment

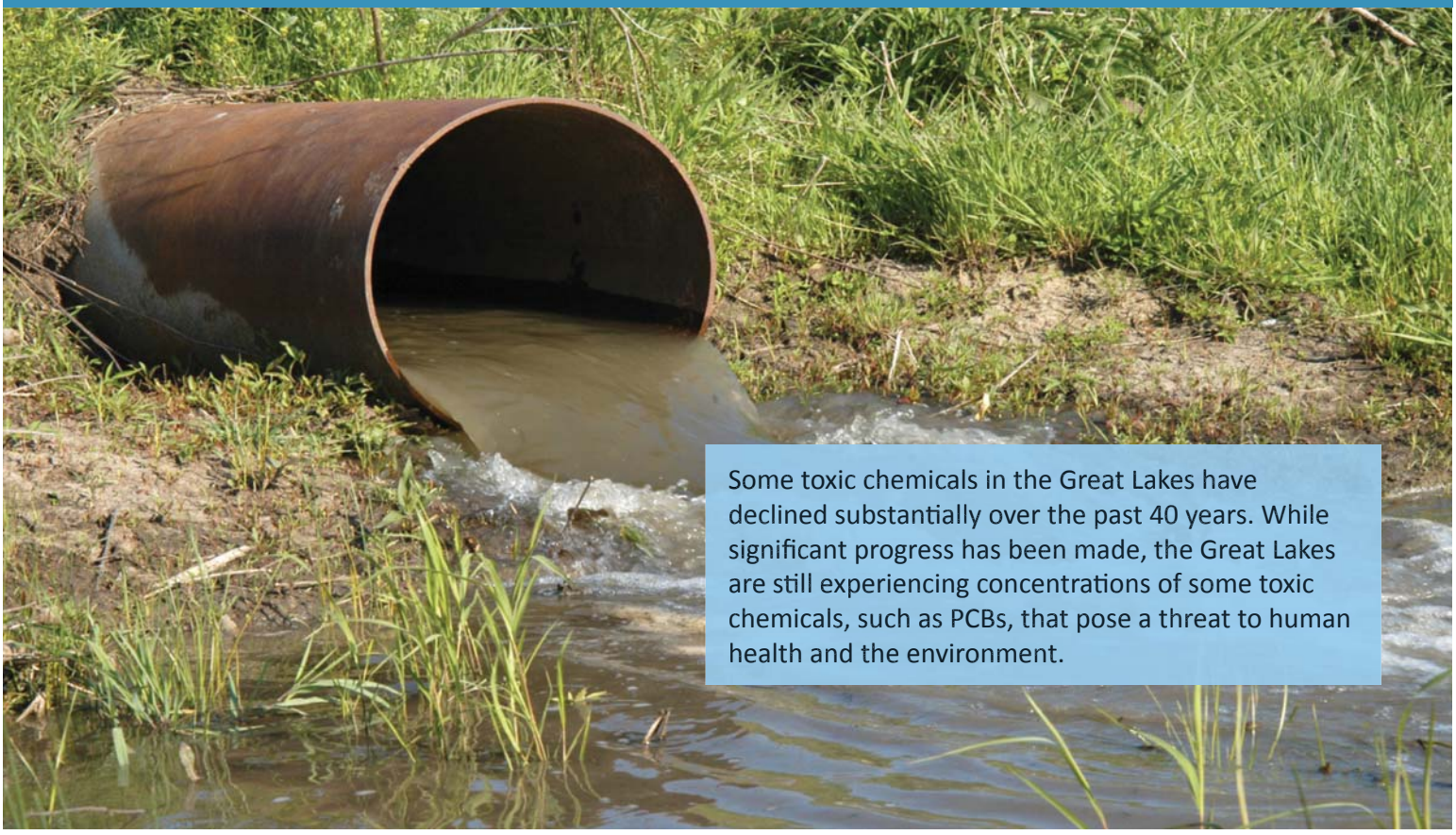
Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Contaminants in Edible Fish	Unchanging	Improving	Unchanging	Deteriorating	Improving

Status:	GOOD	FAIR	POOR	UNDETERMINED

Toxic Chemicals

Status: Fair Trend: Unchanging to Improving

The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain"*



Some toxic chemicals in the Great Lakes have declined substantially over the past 40 years. While significant progress has been made, the Great Lakes are still experiencing concentrations of some toxic chemicals, such as PCBs, that pose a threat to human health and the environment.

Toxic Chemicals

Assessment Highlights

The Toxic Chemicals indicator shows that nearly all older and regulated or banned chemicals, generally referred to as legacy contaminants and include Polychlorinated Biphenyls (PCBs) and mercury, have decreased over the past 40 years. In general, non-legacy compounds, such as Polybrominated Diphenylethers (PBDEs), have shown slow declines in recent years, although some replacements for these compounds are increasing in the environment. Overall, the status of Toxic Chemicals is **Fair** and the trend is **Unchanging** to **Improving**.

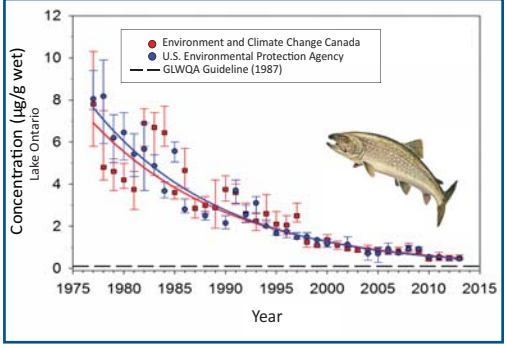
In the offshore waters of the Great Lakes, the long-term trends for many contaminants, such as PCBs and PBDEs, show declines to lower levels and little or no change in the more recent trend, although concentrations are higher in the lower lakes. There are however, occasional exceedances of water quality objectives and criteria for PCBs.

Contaminant levels in Great Lakes whole fish and Herring Gull eggs have decreased significantly since the 1970s. Although declines are being seen, concentrations of some compounds, like PCBs and PBDEs, may still exceed environmental quality guidelines or objectives. Localized areas of highly contaminated sediment in Areas of Concern (AOCs) and hazardous waste sites may continue to act as sources of these and other contaminants to the lakes. Residual sources of PCBs remain in the Great Lakes Basin and throughout the world. PCBs and other chemicals can be carried by air currents from within and outside the basin to the Great Lakes; therefore, atmospheric deposition will remain a significant source of PCBs and other contaminants for decades into the future.

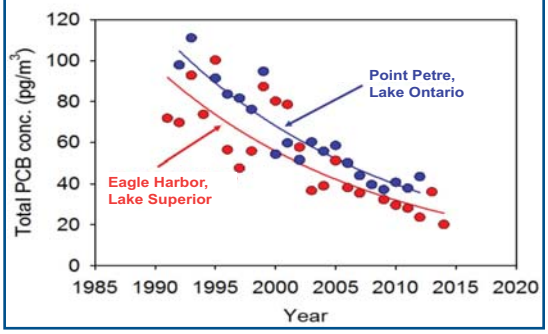
The Toxic Chemicals indicator includes data from several long-term monitoring programs. These programs have been tracking a wide variety of chemicals including mercury, PCBs and PBDEs in the environment for years, and in some cases, decades. The number of substances being monitored is increasing and evolving, thereby improving our base of knowledge to lead to more robust assessments; including chemicals such as current-use pesticides, pharmaceuticals and personal care products.

Refer to the *State of the Great Lakes 2017 Technical Report* for chemicals monitored in the Great Lakes.

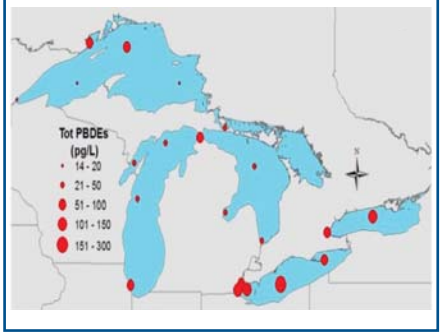
PCBs in Whole Fish are Decreasing



PCBs in Air are Decreasing



PBDEs are Higher in Lakes Erie and Ontario



Sub-Indicators Supporting the Indicator Assessment

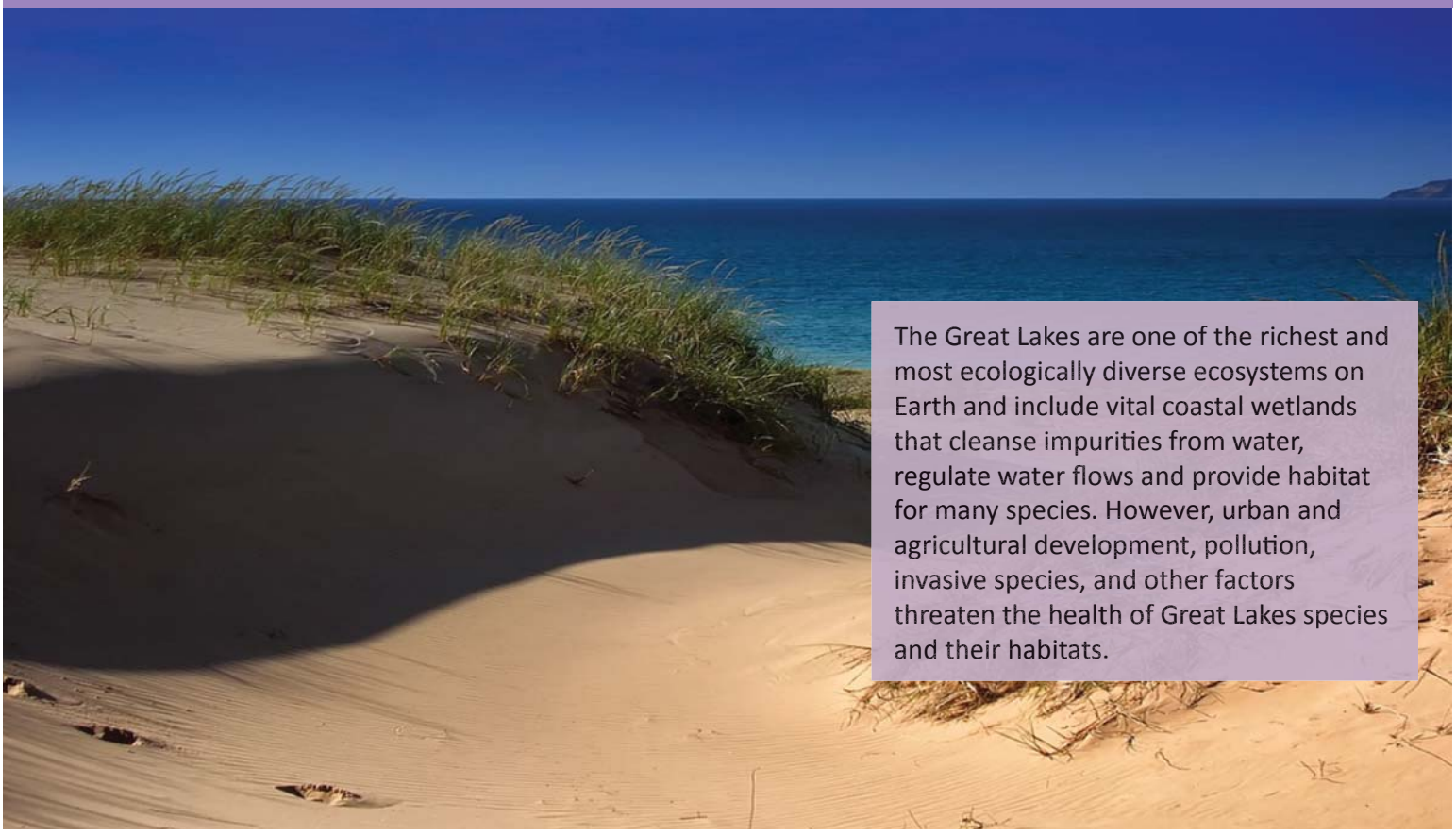
Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Toxic Chemical Concentrations	**Improving**	**Unchanging**	**Unchanging**	**Unchanging**	**Unchanging**
Toxic Chemicals in Sediments	**Unchanging**	**Unchanging**	**Unchanging**	**Improving**	**Improving**
Toxic Chemicals in Great Lakes Whole Fish	**Unchanging**	**Improving**	**Unchanging**	**Unchanging**	**Improving**
Toxic Chemicals in Great Lakes Herring Gull Eggs	**Improving**	**Improving**	**Improving**	**Unchanging**	**Unchanging**
Atmospheric Deposition of Toxic Chemicals	No lake was assessed separately Great Lakes Basin assessment is **Fair** and **Improving**				

Status:	GOOD	FAIR	POOR	UNDETERMINED

Habitat and Species

Status: Fair Trend: Unchanging

The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should support healthy and productive wetlands and other habitats to sustain resilient populations of native species"*



The Great Lakes are one of the richest and most ecologically diverse ecosystems on Earth and include vital coastal wetlands that cleanse impurities from water, regulate water flows and provide habitat for many species. However, urban and agricultural development, pollution, invasive species, and other factors threaten the health of Great Lakes species and their habitats.

Habitat and Species

Assessment Highlights

The Habitat and Species indicator is used to assess habitats, such as wetlands, along with the species that reside in these areas. The Habitat and Species indicator shows that across the basin, the status is quite variable, ranging from good to poor and improving to deteriorating, depending on the lake basin and habitat or species of interest. The health of various species in the Great Lakes is also reflective of the availability and condition of the habitat that they dwell in and need. Overall, the Habitat and Species indicator is assessed as **Fair** and **Unchanging**.

Coastal Wetlands

Despite the fact that coastal wetland restoration and protection efforts have improved specific areas, wetlands continue to be lost and degraded. Efforts to better track and determine the extent and rate of this loss are currently underway. In the southern lakes region, almost all coastal wetlands are degraded by nutrient enrichment, sedimentation, or a combination of both. In Lake Ontario, water-level regulation also limits natural variation in wetlands, though work is underway to address this situation. A more recent concern in the southern lakes region and Lake Huron is the expansion of the invasive Frog-bit, a floating plant that forms dense mats capable of eliminating native submergent plants in coastal wetlands. Of similar concern, the invasive Water Chestnut is expanding rapidly in Lake Ontario.

Coastal wetland habitats in some regions of the Great Lakes, in particular in the northern parts, are intact and show fewer signs of impairment. Across the basin, improvements have also been seen in the diversity of coastal wetland fish species with recent data showing an average of 10 to 13 species per coastal wetland, with some wetlands having as many as 28. Although many invertebrates, birds and plants have experienced long-term declines, some birds and amphibians are showing a more recent unchanging trend. These stable populations may be preliminary indications of some progress in the rehabilitation and restoration of coastal wetlands.

Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Coastal Wetland Amphibians	**Unchanging**	**Unchanging**	**Unchanging**	**Unchanging**	**Unchanging**
Coastal Wetland Birds	**Unchanging**	**Unchanging**	**Unchanging**	**Deteriorating**	**Improving**
Coastal Wetland Fish	No lake was assessed separately Great Lakes Basin assessment is **Fair** and **Improving**				
Coastal Wetland Invertebrates	No lake was assessed separately Great Lakes Basin assessment is **Fair** and **Deteriorating**				
Coastal Wetland Plants	**Undetermined**	**Undetermined**	**Deteriorating**	**Deteriorating**	**Unchanging**
Coastal Wetlands: Extent and Composition	No lake was assessed separately Great Lakes Basin assessment is **Undetermined**				
Aquatic Habitat Connectivity	**Improving**	**Improving**	**Improving**	**Improving**	**Improving**

Status:	GOOD	FAIR	POOR	UNDETERMINED

Habitat and Species

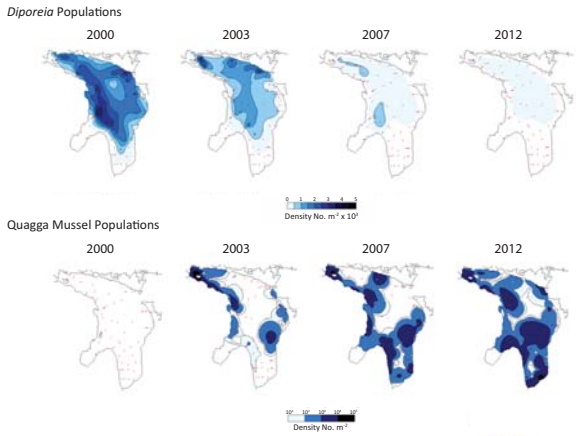
Aquatic Food Web

The Great Lakes aquatic food web is made of many important species, ranging from tiny plants and animals (phytoplankton and zooplankton) to top predator fish. Zooplankton communities in all lakes except Lake Huron are generally in good condition, although changes in quantity, density and type are occurring in Lakes Michigan and Ontario. Changes that are occurring in zooplankton communities are consistent with decreasing nutrient concentrations in offshore waters. Low nutrients levels result in a loss of algae for zooplankton to feed on. Also, *Diporeia*, a small bottom-dwelling shrimp-like species and an important source of food for fish, has severely declined in all the lakes except Lake Superior. The invasive dreissenid mussels (specifically Zebra and Quagga Mussels) have likely compounded this problem. Dreissenid mussels graze on phytoplankton and small zooplankton as well as filter and store nutrients which can prevent the movement of nutrients into the open waters of the lake. The situation is complex and the exact mechanisms causing these changes in *Diporeia* and zooplankton have yet to be fully determined.

Zooplankton and phytoplankton communities are the main source of food for prey fish and are essential to sustaining a healthy food web. Prey fish communities across the Great Lakes continue to change, although the direction and magnitude of those changes vary. The prey fish community is considered fair overall based on the diversity and the proportion of native prey fish species in the Great Lakes despite fluctuations in population levels. The abundance of prey fish is influenced by food availability and the abundance of predator fish, such as Lake Trout and Walleye, which eat prey fish to survive. A balance between the numbers of top predator fish and the available prey fish in the lakes is important.

The status of populations of native predator fish, such as Walleye and Lake Trout, is variable; however, populations of these fish are improving in some cases. Lake Trout populations, for example, are improving in some areas of the Great Lakes with support from stocking and rehabilitation efforts. In fact, natural reproducing populations of Lake Trout are now routinely detected in southwestern Lake Michigan, and wild Lake Trout make up over 50% of the population in Lake Huron. While changes in Lake Sturgeon status will take a long time to manifest, activities such as habitat improvements, dam removals, and stocking efforts indicate an improving trend for this species.

Diporeia Are Declining - Quagga Mussels are Increasing



Sub-Indicators Supporting the Indicator Assessment

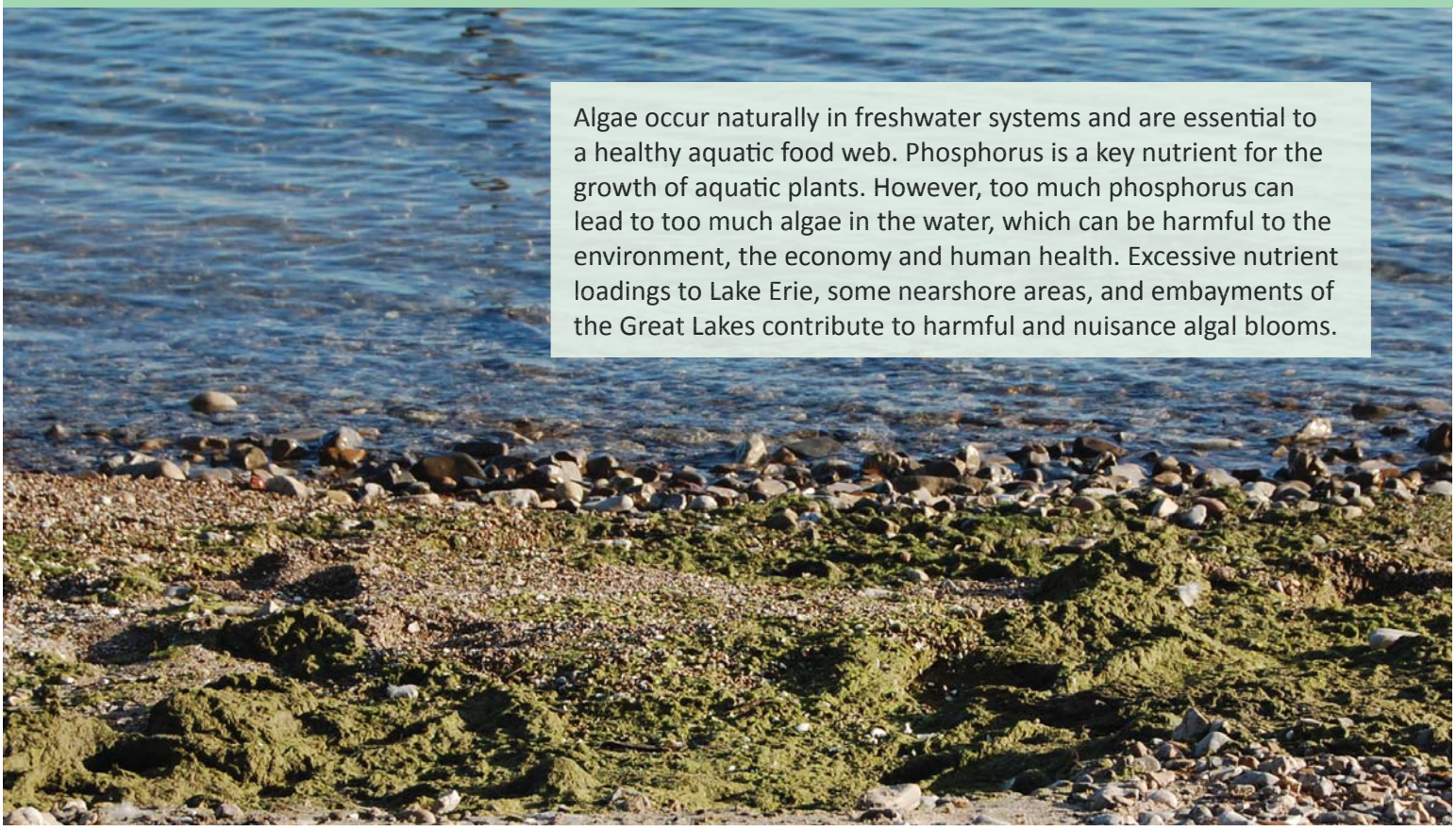
Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Phytoplankton	Unchanging	Deteriorating	Deteriorating	Deteriorating	Unchanging
Zooplankton	Unchanging	Unchanging	Unchanging	Unchanging	Unchanging
Benthos	Unchanging	Unchanging	Unchanging	Deteriorating	Unchanging
Diporeia	Unchanging	Deteriorating	Deteriorating	Deteriorating	Deteriorating
Prey fish	Unchanging	Deteriorating	Undetermined	Improving	Deteriorating
Lake Sturgeon	Improving	Improving	Improving	Improving	Improving
Walleye	Unchanging	Unchanging	Unchanging	Improving	Unchanging
Lake Trout	Unchanging	Improving	Improving	Improving	Improving
Fish Eating and Colonial Nesting Waterbirds	Unchanging	Unchanging	Unchanging	Unchanging	Unchanging

Status:	GOOD	FAIR	POOR	UNDETERMINED

Nutrients and Algae

Status: Fair Trend: Unchanging to Deteriorating

The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and cyanobacteria that interfere with aquatic ecosystem health, or human use of the ecosystem"*



Algae occur naturally in freshwater systems and are essential to a healthy aquatic food web. Phosphorus is a key nutrient for the growth of aquatic plants. However, too much phosphorus can lead to too much algae in the water, which can be harmful to the environment, the economy and human health. Excessive nutrient loadings to Lake Erie, some nearshore areas, and embayments of the Great Lakes contribute to harmful and nuisance algal blooms.

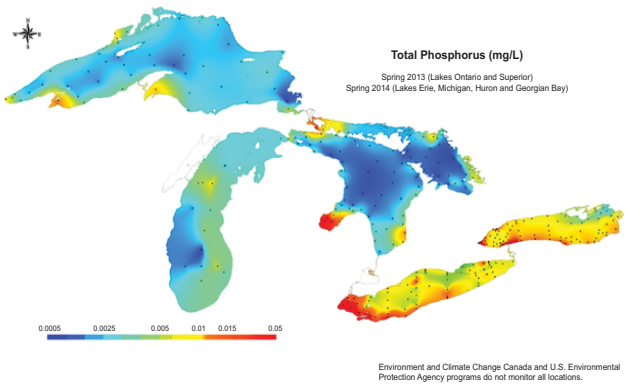
Nutrients and Algae

Assessment Highlights

The 1972 GLWQA focused on phosphorus reductions. In the 1980s and early 1990s, basin-wide restoration efforts were successful in reducing nutrient-related runoff and conditions in the lakes improved. These efforts included the regulation of phosphorus concentrations in detergents, investments in sewage treatment, and the implementation of best management practices on agriculture lands and in expanding urban areas. Despite these efforts, there is a nutrient imbalance in the Great Lakes. With the recent resurgence of the nearshore algal problem in some areas and with other changes in the ecosystem, the problem has become more complicated. Overall, the conditions result in a status of **Fair** and a trend of **Unchanging** to **Deteriorating** for this indicator.

Many offshore regions of some of the Great Lakes have nutrient levels below desired concentrations. In fact, concentrations may be too low in some areas, resulting in insufficient growth of key phytoplankton species which form the base of the food chain. Only in Lake Superior are offshore phosphorus concentrations considered in acceptable condition. Conversely, there are excess nutrients in many nearshore areas. While a certain level of nutrients is good, too much may lead to the development of nuisance and harmful algal blooms (HABs) and hypoxic zones (areas with low oxygen levels). This issue is primarily a concern in Lake Erie, parts of Lake Ontario, Saginaw Bay and Green Bay, along with other nearshore areas that experience elevated nutrient levels. Algal blooms can be harmful to both ecosystem and human health. The western basin of Lake Erie and some parts of Lake Ontario have experienced a resurgence of HABs since 2008, adversely impacting ecosystem health as well as commercial fishing, municipal drinking water systems and recreational activities. Algal blooms are particularly harmful when they are dominated by cyanobacteria (or "blue-green" algae) which can produce toxins such as microcystin. These toxins can impact drinking water safety or can cause gastrointestinal upsets, skin rashes and at elevated levels can be fatal to many organisms.

Total Phosphorus Concentrations in the Great Lakes



Cladophora is a nuisance algae that is broadly distributed over large areas of the nearshore regions of Lakes Erie, Ontario, Huron and Michigan. Large mats of *Cladophora* give the impression that nutrient concentrations are high in the nearshore. However, in some areas, these mats of nuisance algae persist despite low nutrient concentrations in the surrounding water, which is why the management of *Cladophora* has become such a challenge. Excessive *Cladophora* poses many problems including beach and shoreline fouling, clogging of municipal water intakes and unpleasant aesthetics, as well as tourism and recreational fishing impacts. There are also significant ecological impacts of excessive *Cladophora* growth and, when washed up on the shoreline, *Cladophora* may harbour pathogens and create an environment conducive to the development of botulism outbreaks which pose a risk for fish and wildlife.

Warmer temperatures, higher frequency and intensity of precipitation events, and invasive species, in particular Zebra and Quagga Mussels, are confounding factors in the cycling and uptake of nutrients in the lakes. These factors may lead to increased frequency, distribution and severity of HABs, hypoxic zones and *Cladophora*.

Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Nutrients in Lakes	Unchanging	Deteriorating	Deteriorating	Deteriorating	Deteriorating
Cladophora	Unchanging	Undetermined	Undetermined	Undetermined	Undetermined
Harmful Algal Blooms	Undetermined	Undetermined	Undetermined	Deteriorating	Deteriorating
Water Quality in Tributaries	Unchanging	Undetermined	Unchanging	Unchanging	Unchanging

Status:	GOOD	FAIR	POOR	UNDETERMINED

Invasive Species

Status: Poor Trend: Deteriorating

The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should be free from the introduction and spread of aquatic invasive species and free from the introduction and spread of terrestrial invasive species that adversely impact the quality of the Waters of the Great Lakes"*

The number of new invasive species entering the Great Lakes has been significantly reduced; however, those invasive species already in the Great Lakes such as Sea Lamprey, Zebra Mussels and Purple Loosestrife continue to cause more than $100 million annually in economic impacts in the U.S. alone.

Invasive Species

Assessment Highlights

The Invasive Species indicator highlights that the spread and impact of aquatic and terrestrial invasive species continues to be a significant stress to biodiversity in the Great Lakes region. As such, the Invasive Species indicator is assessed as **Poor** and the trend is **Deteriorating**.

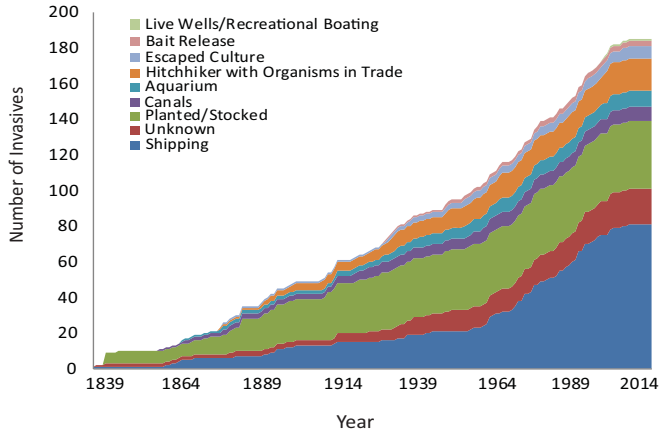
To date, over 180 aquatic non-native species have become established in the Great Lakes Basin. Only **one** new non-native species has been discovered since 2006, a zooplankton called *Thermocyclops crassus*. This tremendous success in reducing the introduction of invasive species is largely due to the regulation of ballast water from trans-oceanic ships. Additionally, the Asian carp species established in the Mississippi River, which are threatening the Great Lakes, have not become established. This success is attributed to the important prevention efforts in both countries, including the U.S. Army Corps of Engineers electrical barrier on the Chicago Sanitary and Ship Canal.

Despite the significant slowdown in recent introductions, the impacts of established invaders persist and their ranges within the lakes are expanding. It is believed that at least 30% of the aquatic non-native species found in the Great Lakes have significant environmental impact.

For several decades, Sea Lamprey have been causing severe ecological impacts. However, Sea Lamprey abundance has been reduced significantly in the five lakes through active, on-going, and basin-wide control measures. But, native fish such as Lake Trout, Walleye and Lake Sturgeon are still subject to Sea Lamprey predation. Sea Lamprey remain an impediment to achieving critical fish community and ecosystem objectives and therefore continuation of and improvements to Sea Lamprey control are required.

Dreissenid mussels, also known as Zebra and Quagga Mussels, are prominent invasive species in the Great Lakes as well. In many offshore regions, Zebra Mussels have been displaced by increasing populations of Quagga Mussels. While in some nearshore regions, populations of both species seem to be stable or declining. Overall, dreissenids are a dominant component of the bottom-dwelling community. Consequently, they have played an instrumental role in the alteration of the zooplankton and phytoplankton communities as well as disrupting the nutrient cycle and increasing water clarity.

Aquatic Invasive Species - Establishments Have Slowed Down



On the land, terrestrial invasive species have a significant impact and continue to spread throughout the Great Lakes Basin. Five terrestrial invasive species were assessed collectively—*Phragmites*, Purple Loosestrife, Garlic Mustard, Emerald Ash Borer and Asian Long-horned Beetle. These species are widely distributed and their ranges appear to be expanding. All five of these species have a detrimental impact on the surrounding ecosystem, including degrading habitat and water quality.

Limiting the impact of existing invaders is critical. However, binational prevention efforts, including continuing early detection and rapid response programs, are where the biggest difference can be made to ensure the Great Lakes are healthy, safe and sustainable.

Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Impacts of Aquatic Invasive Species	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Deteriorating
Dreissenid Mussels	Unchanging	Deteriorating	Deteriorating	Improving	Deteriorating
Sea Lamprey	Improving	Improving	Improving	Improving	Unchanging
Terrestrial Invasive Species	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Deteriorating

Status:	GOOD	FAIR	POOR	UNDETERMINED

Groundwater

Status: Fair Trend: Undetermined

Groundwater can enhance surface water quality and quantity and provide essential aquatic habitats. Groundwater can also transmit contaminants and excessive loads of nutrients to the Great Lakes.

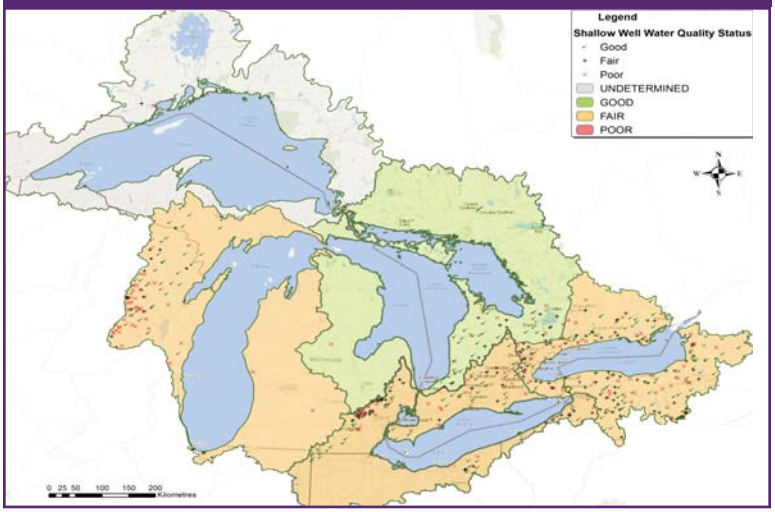
The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should be free from the harmful impact of contaminated groundwater"*

Assessment Highlights

The Groundwater Quality indicator is assessed as **Fair** but the trend is **Undetermined** due to insufficient long-term data. The concentrations of nitrate, primarily from agricultural practices, and chloride, mainly from the urban use of de-icing salt, are being used to assess groundwater quality. Elevated concentrations of both of these constituents in water can have detrimental impacts to ecosystem and human health.

Portions of the Great Lakes Basin with more intense development, such as areas within the basins of Lakes Michigan, Erie and Ontario, are generally assessed as fair. Groundwater quality is generally assessed as good in the less developed areas, such as portions of the Lake Huron basin. A better understanding about the impacts of contaminated groundwater and its interaction with the waters of the Great Lakes is needed, particularly for the nearshore zone.

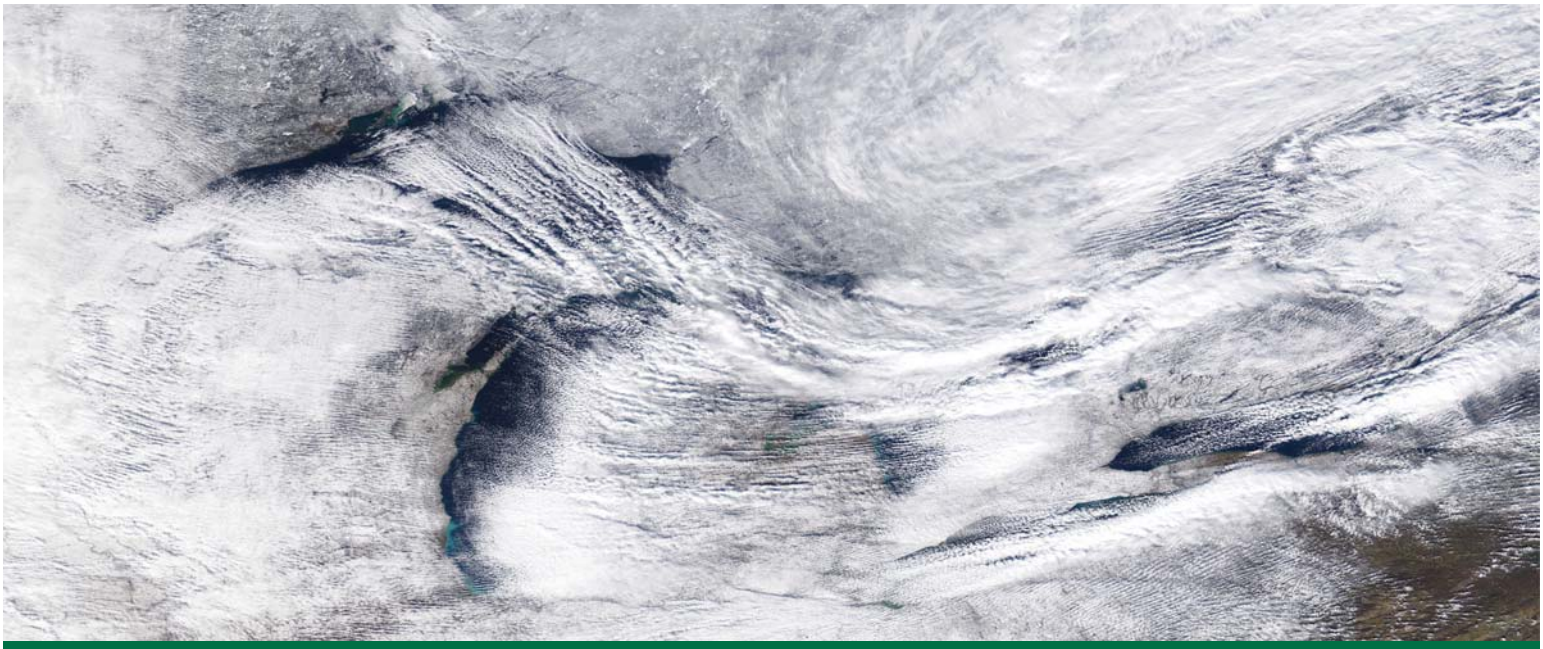
Groundwater Quality Assessment by Lake Basin



Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Groundwater Quality	Undetermined	Undetermined	Undetermined	Undetermined	Undetermined

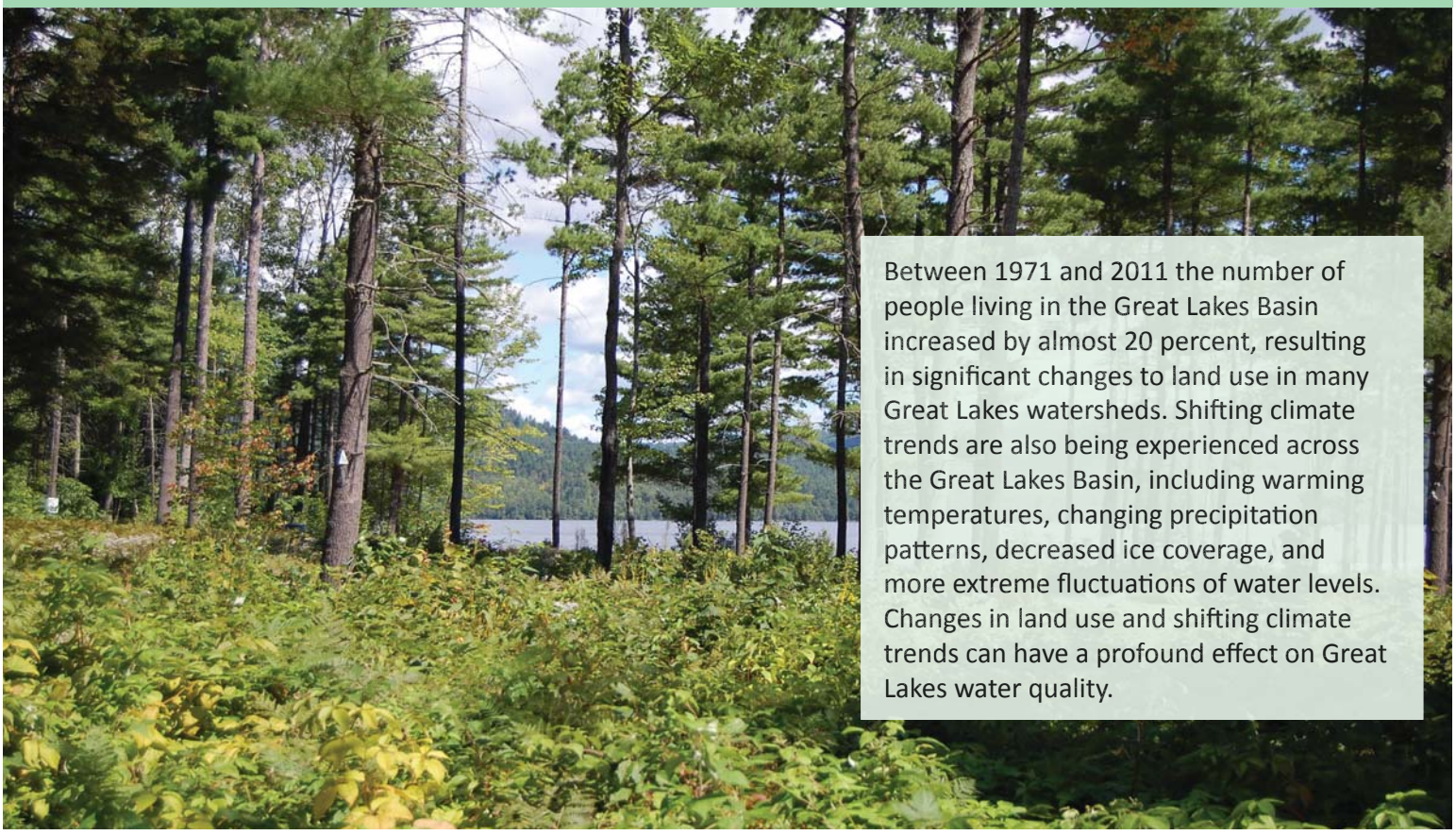
Status:	GOOD	FAIR	POOR	UNDETERMINED



Watershed Impacts and Climate Trends

Status: Fair Trend: Unchanging

The 2012 Great Lakes Water Quality Agreement states that *"the Waters of the Great Lakes should be free from other substances, materials or conditions that may negatively impact the chemical, physical or biological integrity of the Waters of the Great Lakes"*



Between 1971 and 2011 the number of people living in the Great Lakes Basin increased by almost 20 percent, resulting in significant changes to land use in many Great Lakes watersheds. Shifting climate trends are also being experienced across the Great Lakes Basin, including warming temperatures, changing precipitation patterns, decreased ice coverage, and more extreme fluctuations of water levels. Changes in land use and shifting climate trends can have a profound effect on Great Lakes water quality.

Watershed Impacts and Climate Trends

Assessment Highlights

Overall, the Watershed Impacts and Climate Trends indicator is assessed as **Fair** and **Unchanging**. This indicator includes all "other substances, materials or conditions" that are not highlighted in the eight other indicators noted on page 2, but are important with respect to the state of the Great Lakes. The indicator currently includes an array of land-based conditions which can affect water quality as well as climate trends which can impact all parts of the ecosystem.

Watershed Impacts

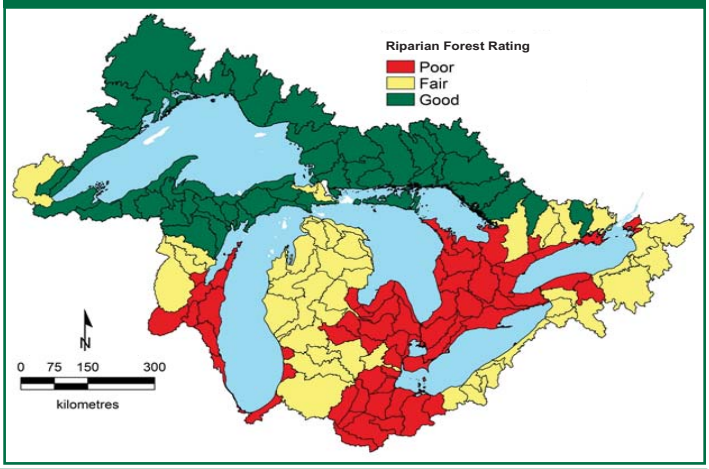
Population, development, agriculture and road density can cause land-based pressures on the Great Lakes ecosystem, especially in areas with larger population centres. Although urban and agricultural lands are important to the Great Lakes region because they help support people and the economy, the water quality in these areas, in particular the lower lake basins, is more susceptible to impairments or threats. Conversely, the northern part of the Great Lakes Basin has lower relative amount of stress since it remains largely undeveloped and is dominated by natural cover.

Across the entire basin, almost 400 square kilometres (154 square miles) or 40,000 hectares of natural lands were converted to developed land cover between 2001 and 2011. The latest analysis shows a growing trend of increasing development, resulting in a loss of agricultural, forested and natural lands.

Research has shown that an increase in forest cover improves water quality. In particular, forest cover within a riparian zone (i.e. land along a lake, river or stream), plays a key role in stabilizing soil and can help reduce the amount of runoff from the land and reduce nutrient loadings and other non-point source pollutants. Forest cover in the riparian zones varies with the Lake Superior watershed having the highest amount at 96% and the Lake Erie watershed having the least with 31%. With half of the Great Lakes Basin currently in agricultural or developed land use, and with much less forest cover in the more southern parts of the Great Lakes Basin, it is evident that land-based pressures can significantly impact water quality.

Agricultural Lands in the Southern Parts of the Great Lakes Basin

Forest Cover Helps to Improve Water Quality



Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Forest Cover	Unchanging	Unchanging	Unchanging	Improving	Deteriorating
Land Cover	Unchanging	Unchanging	Unchanging	Unchanging	Unchanging
Watershed Stressors	Unchanging	Unchanging	Unchanging	Unchanging	Unchanging
Hardened Shorelines	Undetermined	Undetermined	Undetermined	Undetermined	Deteriorating
Tributary Flashiness	No lake was assessed separately Great Lakes Basin trend is **Unchanging**				
Human Population	Decreasing	Increasing	Increasing	Increasing	Increasing

Status:	GOOD	FAIR	POOR	UNDETERMINED

Watershed Impacts and Climate Trends

Climate Trends

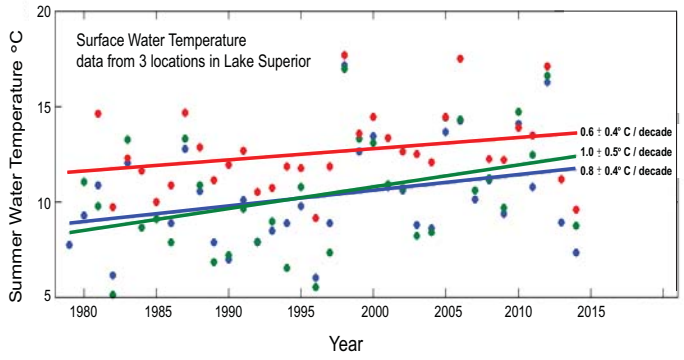
Data collected over the past 30-40 years in the Great Lakes Basin show increases in the amount of precipitation, increases in summer surface water temperature and a reduction in ice cover. Lake levels have also generally decreased, although there has been a recent rebound in water levels in the past few years. It is not yet possible to say with any certainty, however, if changes in water levels are due to human activity or natural long-term cycles.

These changes can affect the health of the Great Lakes Basin including impacts to spawning and other habitats for fish species, the amount and quality of coastal wetlands and changes in forest composition. Shifts in climate trends can also lead to the northward migration of invasive species and alter habitat in a way that favours some invaders over native species. An extended growing season, increases in runoff and nutrient loads and changes to contaminant cycling could also result from a shift in climate trends.

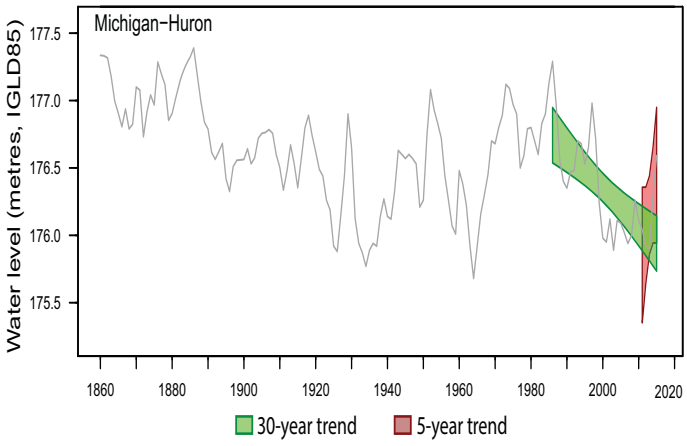
Assessing Climate Trends

Climate information is not assessed in the same manner as other indicators in this report. For example, the ecosystem has adapted to and needs both high and low water levels and neither condition can be assessed as **Good** or **Poor**. However, prolonged periods of high or low water levels may cause stress to the ecosystem. Therefore, climate trends are simply assessed as **Increasing**, **Unchanging** or **Decreasing** over a defined period of time.

Surface Water Temperatures are Increasing



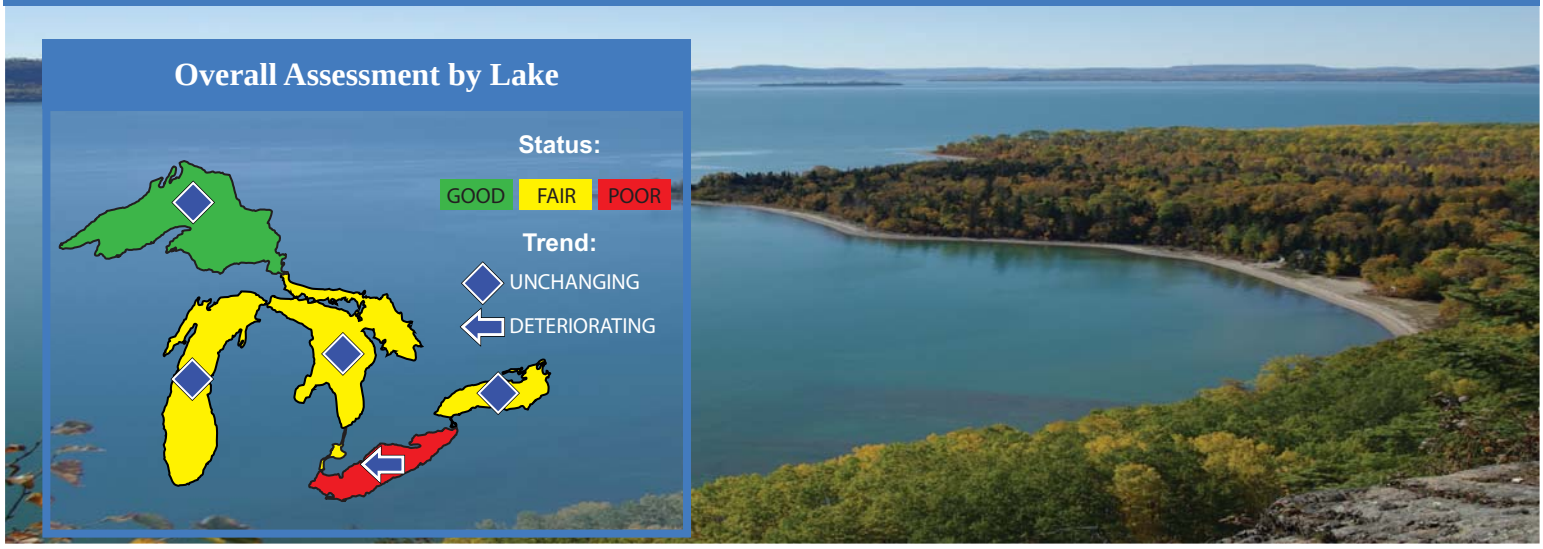
Water Levels Fluctuate



Sub-Indicators Supporting the Indicator Assessment

Sub-Indicator	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Precipitation Amounts (1948-2015)	No lake was assessed separately. Great Lakes Basin trend is ↑				
Surface Water Temperature (1979/1980-2014)	↑	↑	↑	**Undetermined**	**Undetermined**
Ice Cover (1973-2015)	↓	↓	↓	↓	↓
Water Levels (1985-2015)	↓	↓	↓	↓	**No significant change**
Baseflow Due to Groundwater	No lake was assessed separately. Great Lakes Basin trend is **Undetermined**				

Lake-by-Lake Snap Shot



Lake Superior's ecosystem is in good condition and the trend is unchanging. Fisheries in the open waters are in good condition, supported by a robust lower food web including small, shrimp-like species *Diporeia* and *Mysis*. There are self-sustaining populations of Lake Trout and increasing abundance of Lake Sturgeon. Most major habitats are in good condition on a lakewide scale, including coastal wetlands. Concentrations of legacy contaminants in the environment, such as PCBs, are generally decreasing or remaining stable. However, fish consumption advisories continue to be in effect due to pollutants such as mercury and PCBs. Aquatic invasive species, in particular Sea Lamprey, are still causing harm. In addition, warming waters are stressing some cold-water species, such as Brook Trout. Areas of degraded habitat or impaired habitat connectivity between the tributaries and the lake are impacting native species. Contaminants of emerging concern, such as microplastics, have been detected.

Lake Superior alone has 11.4 quadrillion litres (3 quadrillion gallons) of water - enough to submerge North and South America under 30 centimetres (1 foot) of fresh water.

Lake Michigan's ecosystem is in fair condition and the trend is unchanging. Removal of contaminated sediment and habitat improvement are occurring in AOCs; White Lake has been formally removed from the list of designated AOCs and management actions have been completed at three other AOCs. Chemical pollutants have declined significantly since the 1970s; however, fish and wildlife consumption advisories remain in place. In some nearshore areas, elevated phosphorus concentrations are observed, while offshore phosphorus concentrations are below objectives and continue to decrease. *Diporeia* have almost disappeared, and filter-feeding by invasive

Lake Michigan is home to the world's largest freshwater sand dunes, attracting millions of visitors annually.

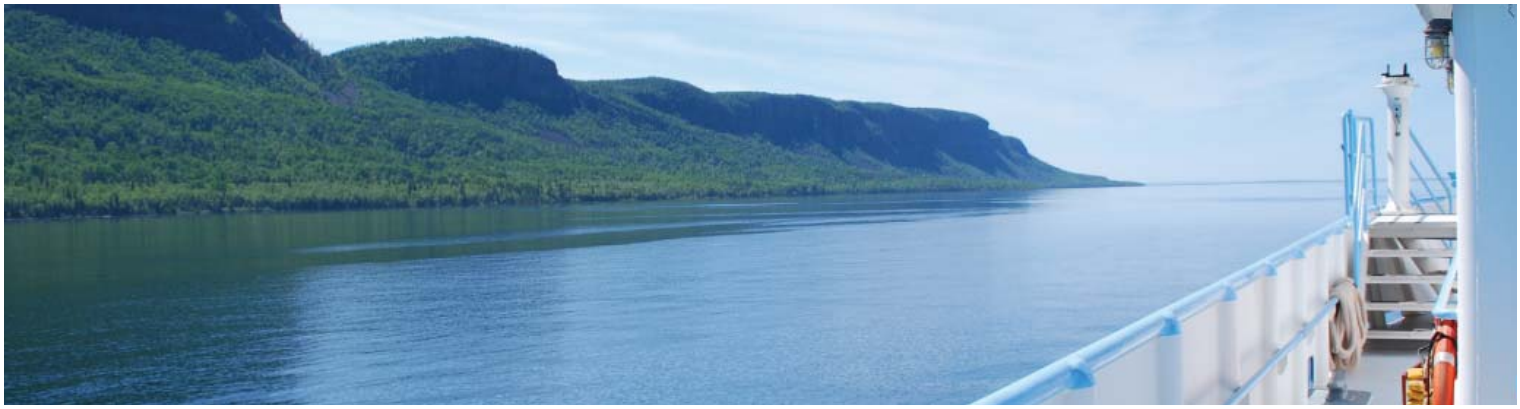
Lake-by-Lake Snap Shot

Quagga Mussels has reduced the food available for prey fish and the juveniles of economically important sport fish (e.g. Yellow Perch) and commercial species (e.g. Lake Whitefish). Record low abundance estimates for most prey fish populations, combined with increased natural reproduction of predator fish, have prompted stocking reductions for salmon and trout, cornerstone species for the multi-billion dollar sport fishing industry. However, in a few places, Lake Trout, the top native predator fish, has shown signs of natural reproduction for the first time in decades, due in part to the successful control of Sea Lamprey.

More than 75,000 cubic metres (100,000 cubic yards) of contaminated sediment were removed from White Lake resulting in improved water quality and the return of fish and wildlife populations in Lake Michigan.

Lake Huron's ecosystem is in fair condition and the trend is unchanging. It has extensive beaches and its nearshore areas provide excellent opportunities for swimming and recreation. Chemical pollutants have declined significantly since the 1970s; however, fish and wildlife consumption advisories remain to protect human health. The majority of nearshore waters are of high quality, but areas of the southeast shore, Saginaw Bay, and parts of eastern Georgian Bay experience periodic harmful or nuisance algal blooms. Nutrient and algae levels in the offshore are variable, but largely below targets. Zebra and Quagga Mussels are associated with decline in nutrient levels and nutrient availability to other aquatic organisms, increased water clarity, nuisance algae growth and are suspected to facilitate episodic botulism outbreaks in parts of the basin. *Diporeia*, a major food source for prey fish, are declining, resulting in negative consequences for recreational and commercial fisheries. However, Walleye have largely recovered in Michigan waters of Lake Huron and, in the absense of the invasive Alewife, Lake Trout populations are approaching reproduction targets.

Lake Huron has the longest shoreline, including islands, of the Great Lakes extending 6,159 km (3,827 miles).



Lake-by-Lake Snap Shot

Lake Erie's ecosystem is in poor condition and the trend is deteriorating. Harmful algal blooms resulting from excessive nutrient inputs occur regularly in the western basin and Lake St. Clair during summer, and have impacted drinking water treatment systems. Beach closures, habitat loss and degradation, and beach fouling in the eastern basin continue to be major concerns. Increased amounts of decaying algae exacerbate seasonal anoxia (*depleted dissolved oxygen conditions*) and hypoxia (*low oxygen conditons*) in bottom waters of the central basin. Despite the challenges, there are positive ecosystem trends, including increased Walleye across the lake and Lake Sturgeon in the St. Clair-Detroit River System; increased aquatic habitat connectivity due to dam removal and mitigation projects; and declines in Sea Lamprey wounding of fish since 2010. Since 2009, the western Lake Erie Cooperative Weed Management Area partners in Ohio and Michigan have treated more than 13,000 acres of invasive *Phragmites*, resulting in a 70% decrease in live *Phragmites* in Ohio and a resurgence of native plants in Michigan and Ohio.

Lake Erie is the most biologically productive Great Lake, and it also has the biggest sport fishing industry of all the lakes.

Lake Ontario's ecosystem is in fair condition and the trend is unchanging. Contaminants in fish, such as PCBs, have steadily decreased, leading to less restrictive consumption advisories. Bald Eagles and Lake Sturgeon populations are recovering. Native deepwater sculpin, a species once thought extirpated, has recovered, while stocking efforts to restore other native prey fish show some signs of success. As a result of two years of poor alewife reproduction, reductions in salmon and trout stocking are needed to address the potential imbalance between predators and prey. Offshore phosphorus concentrations are below the objective and declining nutrient levels may significantly reduce the overall productivity of the lake and change the structure of the lower food web, impacting fish production. In the nearshore waters, despite long-term lake-wide nutrient declines, mats of *Cladophora* are causing problems in some areas due to high phosphorus levels and/or increased water clarity and changes in nutrient cycling following the arrival of the invasive dreissenid mussels.

The St. Clair River is home to the largest remaining Lake Sturgeon spawning population in the Great Lakes Basin.

Nearly 7.5 million Canadians live in the Lake Ontario watershed, making up almost 20% of the entire Great Lakes Basin population.

Participating Organizations

Many people have been involved with development of the *State of the Great Lakes 2017 Highlights and Technical Reports*. Thank you to the authors and advisory committee members for their continued support.

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The *State of the Great Lakes 2017 Highlights Report* is a summary of science-based information from 44 sub-indicator reports. These sub-indicator reports are included in their entirety in the *State of the Great Lakes 2017 Technical Report*. For more information about the state of the Great Lakes reporting and to access the reports, visit the following websites:

www.binational.net
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