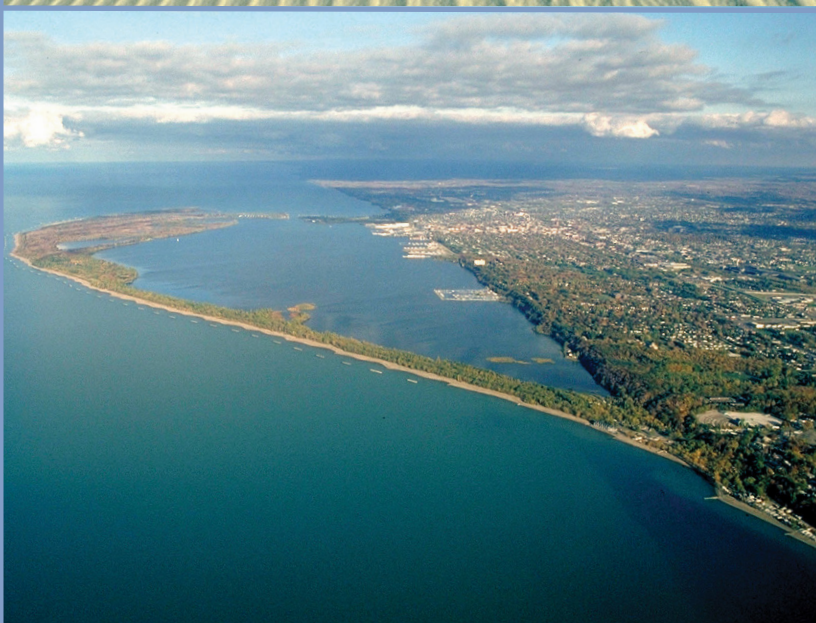


State of the Great Lakes

2011 Highlights



An overview of status and trends in the Great Lakes ecosystem



Assessing the Great Lakes Ecosystem

The Great Lakes are a global environmental and economic wonder. Lakes Superior, Huron, Michigan, Erie and Ontario contain 84% of North America's fresh surface water, the source of drinking water for more than 24 million people. Millions of jobs are dependent on Great Lakes basin fisheries, forests, farmland, industry and recreation.

Ongoing and emerging problems such as invasive species, chemical contaminants, and climate change impact the Great Lakes ecosystem. An understanding of ecosystem conditions and whether conditions are getting better or worse is necessary to address these problems. Using status and trend assessments, this report summarizes the health of the Great Lakes to answer the question, "How are the Great Lakes doing?"

About this Report

The goal of the Great Lakes Water Quality Agreement (GLWQA) is "to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes." In accordance with this goal, the United States Environmental Protection Agency and Environment Canada coordinate regular assessments of the conditions of the Great Lakes ecosystem.





Indicators

An indicator is a signal that informs us about current environmental conditions. Indicators are a useful and accepted approach for assessing large, complex ecosystems. Great Lakes indicators are used to:





- Assess conditions and track changes in the ecosystem;
- Understand existing and emerging issues and possible solutions;
- Guide programs and policies needed to prevent or address environmental problems; and,
- Set priorities for research and program implementation.

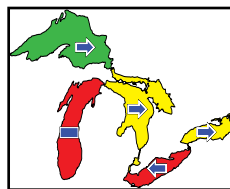
More than 125 scientists and experts from Canada and the United States authored or provided the most up-to-date information for the indicator reports on which this Highlights report is based. Authors assessed ecosystem status and trends. Where possible, the authors used applicable objectives and guidelines found in the GLWQA, as amended in 1987, and other supporting programs to inform their assessments.

The status for each indicator is defined as follows:

-  **GOOD** - Meeting GLWQA or other ecosystem objectives or otherwise in acceptable condition.
-  **FAIR** - Exhibiting minimally acceptable conditions, but not meeting established GLWQA or other ecosystem objectives.
-  **POOR** - Severely negatively impacted and not displaying even minimally acceptable conditions.
-  **UNDETERMINED** - Data are not available or are insufficient to assess the status of ecosystem components.

The trend for each indicator is defined as follows:

-  **IMPROVING** - Metrics show a change toward more acceptable conditions.
-  **DETERIORATING** - Metrics show a change away from acceptable conditions.
-  **UNCHANGING** - Metrics show no change.
-  **UNDETERMINED** - Metrics indicate a balance of both improving and deteriorating conditions, or data are not available to report on a trend.



Accompanying each of the 20 indicator summaries is a lake-by-lake assessment map that provides status and trend information according to the above definitions. The lake trout assessment map is shown here as an example.

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State of the Great Lakes - Summary and Findings

Water quality is in fair condition and is deteriorating.

- Harmful and nuisance algae in nearshore areas and coastal bays, particularly in the western Lake Erie basin, Green Bay, Saginaw Bay, and parts of Lake Ontario are impacting human and ecosystem health. Algal trends are worsening.
- Low oxygen levels in the central Lake Erie basin are causing seasonal “dead zones” for aquatic life.
- Increasing water clarity is accelerating the proliferation of nuisance algae along some shorelines and signifies a lack of food for fish offshore.
- Levels of many legacy chemicals are declining in offshore waters; however, while declining, levels in fish and waterbird eggs still exceed guidelines in some areas. Mercury levels in fish have been slowly increasing since 1990.
- New substances of concern are being detected in the environment.



Credit: U.S. Environmental Protection Agency

Aquatic-dependent life is in fair condition and is deteriorating.

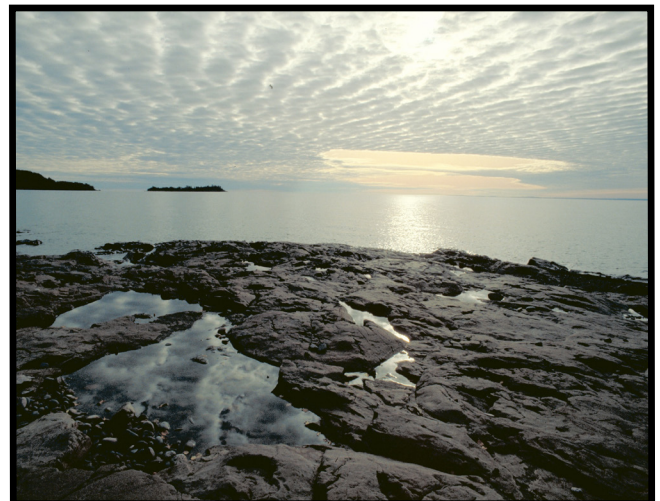
- No new non-native species have been detected in the lakes since 2006, but earlier invaders continue to impact the ecosystem.
- In some areas, native species are struggling to survive in an ecosystem where invasive species have altered the food web and habitats have been lost or degraded.
- Coastal wetland plant and animal communities are diminishing due to loss of habitat; however, protection and restoration of wetland habitats have begun.



Credit: U.S. Fish and Wildlife Service

The landscapes (and landscape-related natural processes) that influence the Great Lakes are in fair condition and are improving.

- Dams and other barriers prevent fish access to spawning and nursery habitats, but access is improving through dam removals and riparian restoration.
- Human uses can transform and stress Great Lakes watersheds. However, some positive signs in watersheds include marginal increases in forest cover and better land management.
- Water levels in Lakes Superior, Huron and Michigan have been below average since the 1990s, and there are concerns that climate change will cause greater fluctuations and possibly lower water levels.

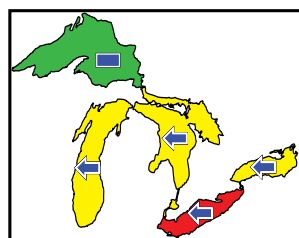


Credit: Dave Hansen

Water Quality: Four Key Indicators

The overall status for water quality in the Great Lakes is fair. There are currently low concentrations of toxic chemicals in offshore waters, and a decreased concentration of some legacy chemicals, such as PCBs and DDT, in fish. However, not all water quality guidelines are being met. Despite a mix of trends for the various monitored contaminants, the overall water quality trend is deteriorating. Nearshore symptoms of nutrient enrichment persist and algal trends are worsening in some areas of the Great Lakes. Phosphorus concentrations in offshore waters are becoming too low in some lakes to support productive food webs. Increasing mercury concentrations in fish are being observed in some areas of the lakes, after years of steady decline.

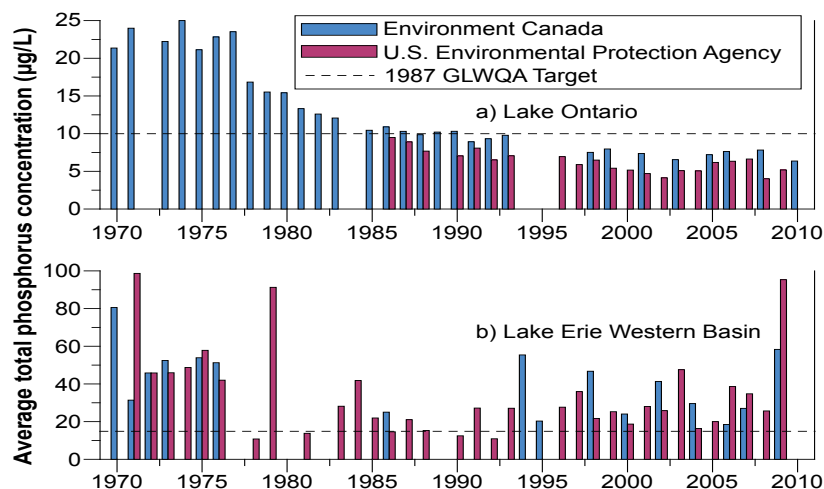
NUTRIENTS IN LAKES



In Lakes Michigan, Huron and Ontario, offshore total phosphorus concentrations are currently below 1987 GLWQA targets but

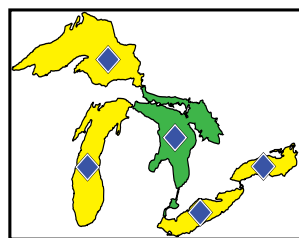
may be too low to support healthy levels of lake productivity. In Lake Erie, targets are frequently exceeded and conditions are deteriorating. Only in Lake Superior are offshore nutrient targets being met and conditions acceptable. The assessment for nutrients in lakes in offshore waters is fair and deteriorating. Nearshore symptoms of nutrient enrichment persist and are getting worse in some areas of the Great Lakes resulting in greater extent and duration of nuisance and harmful algal blooms.

Nutrients in Lakes



Trends in total phosphorus in offshore waters of Lake Ontario and the western basin of Lake Erie (µg/L). *Source: U.S. Environmental Protection Agency and Environment Canada.*

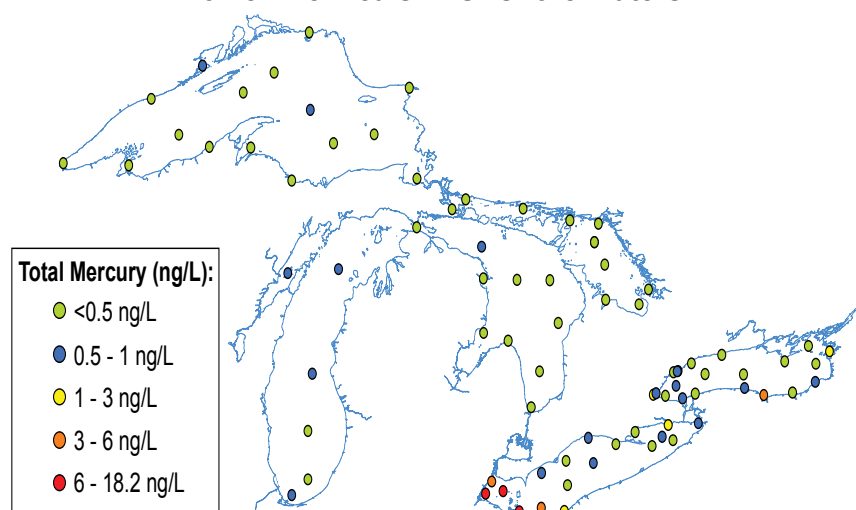
TOXIC CHEMICALS IN OFFSHORE WATERS



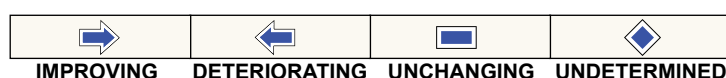
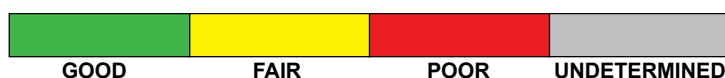
Concentrations of many compounds are still detected in offshore waters, although they are at very low concentrations, so the status of this indicator

is considered fair. Overall, the trends of toxic chemicals in offshore waters are undetermined because there is a mixture of trends observed. Trends for the majority of organochlorine compounds are improving, while trends for PAHs and in-use pesticides vary. The highest concentrations of total mercury in Great Lakes surface waters are observed in the western basin of Lake Erie; however, there have been no observed exceedances of the Canadian Council of Ministers of the Environment water quality guideline.

Toxic Chemicals in Offshore Waters

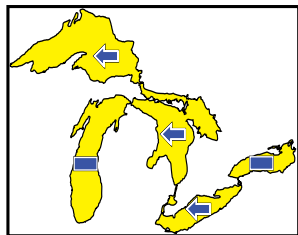


Total mercury in surface waters from 2006 - 2009 surveys. *Source: Environment Canada.*



Water Quality: Four Key Indicators

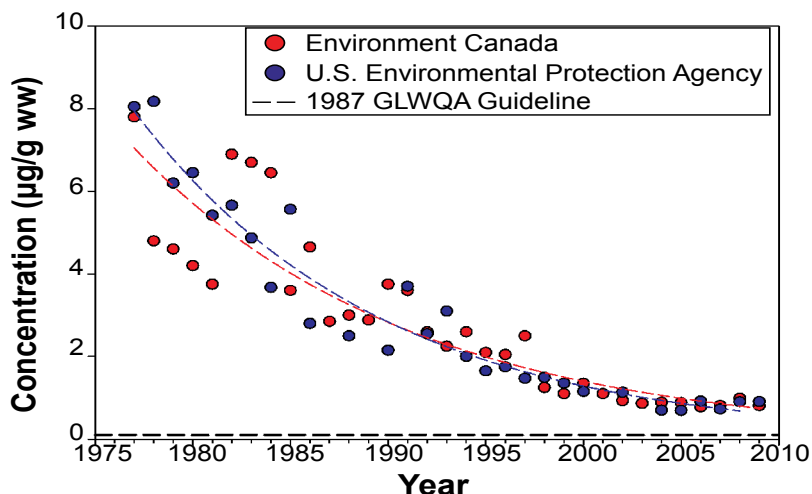
CONTAMINANTS IN WHOLE FISH*



Total mercury concentrations in fish are below the 1987 GLWQA guidelines in all lakes. However, concentrations appear to be

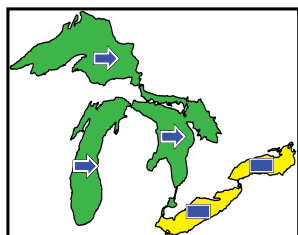
increasing in Lakes Superior, Huron and Erie. Concentrations of pentaPBDEs are currently above the Federal Environmental Quality Guidelines developed by Environment Canada in lake trout and walleye in all the Great Lakes, but are declining in most monitored fish. Total PCB concentrations in fish are above 1987 GLWQA guidelines in all lakes.

Contaminants in Whole Fish



Total PCB concentrations for whole lake trout collected from Lake Ontario by U.S. EPA (Total Arochlor 1254) and Environment Canada (Total PCB congeners). Dashed red and blue lines show the annual trend based on a statistical analysis. *Source: U.S. Environmental Protection Agency and Environment Canada.*

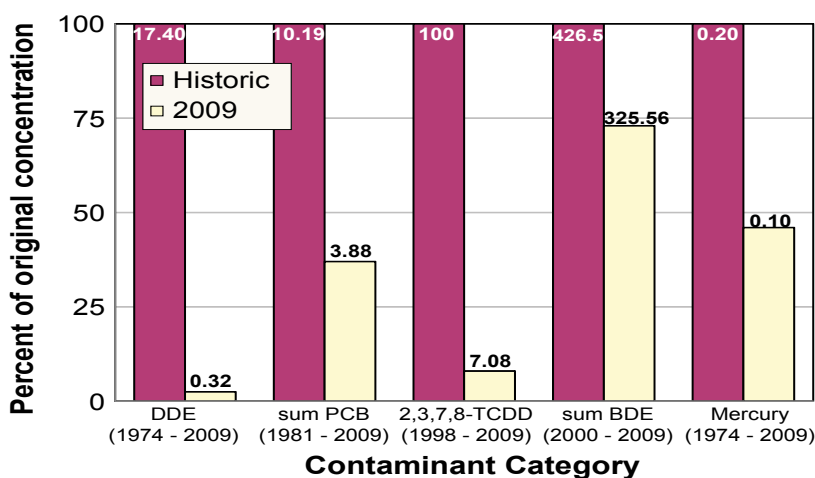
CONTAMINANTS IN WATERBIRDS*



Concentrations of contaminants that have been managed and monitored since the 1970s and 1980s have decreased in herring gull eggs, including

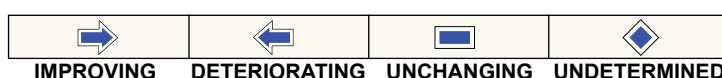
significant declines in DDE (a breakdown product of DDT) and other banned pesticide-related compounds. However, over the last decade there has been a mixture of chemical concentration trends in herring gull eggs, with some contaminant trends showing continuing improvements but other contaminant trends showing no significant change. The overall assessment is good with an improving trend.

Contaminants in Waterbirds



Decline of contaminant concentrations in Great Lakes herring gull eggs in Lake Huron. Values within and above each bar represent the concentration (µg/g wet weight, except for 2,3,7,8-TCDD and sum BDE which are pg/g wet weight) of the contaminant. *Source: Canadian Wildlife Service.*

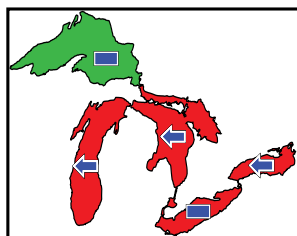
* These indicators are highlighted in the Water Quality assessment because long-term trends of contaminants in aquatic biota provide valuable insight into how chemicals get into and move throughout the food web.



Aquatic-Dependent Life: Nine Key Indicators

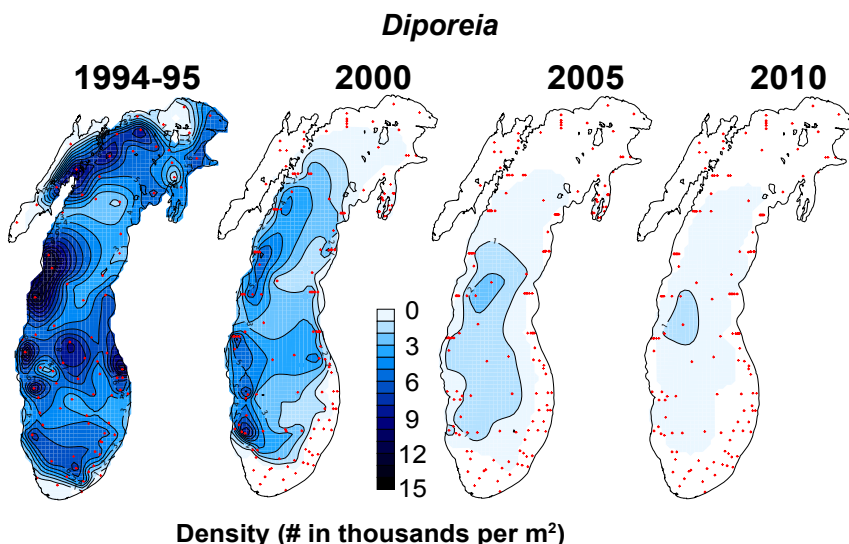
The overall status of aquatic-dependent life in the Great Lakes is fair because many locations support self-sustaining fish populations and a healthy food web; however, other areas are degraded. Predatory fish populations are being fairly well maintained through stocking programs, and in some cases natural reproduction, but most populations do not meet target levels. The overall deteriorating trend for aquatic-dependent life is a result of decreasing preyfish populations, the declining population of *Diporeia* (a source of food for small fish), and the declining populations of many coastal wetland species. The food web has been drastically altered. No new non-native species have been detected since 2006; however, the impacts of established invasive species continue to harm the ecosystem.

DIPOREIA



Populations of the small, native, shrimp-like *Diporeia* have declined for more than a decade and this indicator species is almost completely

gone in Lakes Michigan, Ontario and Huron. *Diporeia* has been virtually gone from Lake Erie since 1998. The population in Lake Superior, although highly variable, remains good and unchanging.

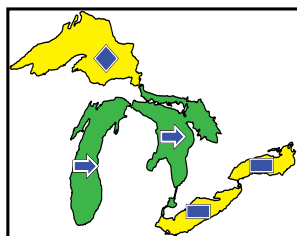


Density (# in thousands per m²)

Drastic declines in *Diporeia* density in Lake Michigan from 1994 - 2010. Small red dots represent sampling locations.

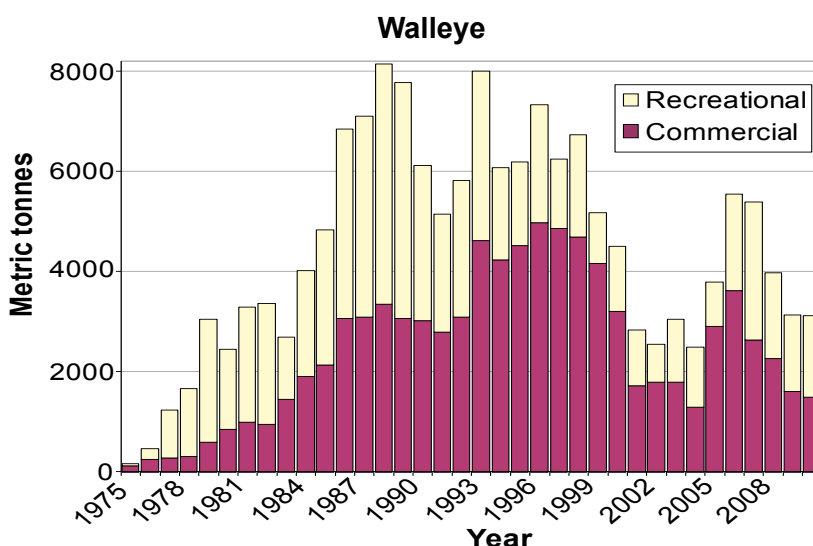
Source: National Oceanic and Atmospheric Administration.

WALLEYE

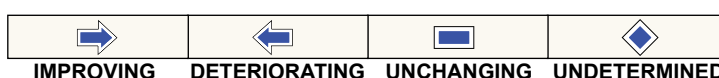
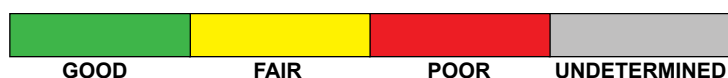


Walleye populations in Lakes Huron and Michigan are good, with improving trends since approximately 2003 and 2007, respectively. Populations in Lake

Ontario have stabilized or increased slightly compared to declines observed in the 1990s. Lake Erie populations are lower than the highs experienced in the 1990s and early 2000s. Lake Superior populations are lower than historical levels, with healthy self-sustaining populations only in the St. Louis and Kaministiquia rivers.

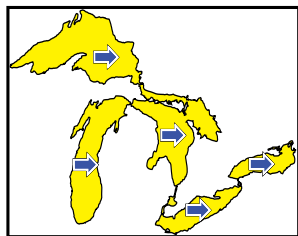


Walleye harvest from recreational and commercial fisheries in Lake Erie. Source: Ohio Department of Natural Resources and Ontario Ministry of Natural Resources.



Aquatic-Dependent Life: Nine Key Indicators

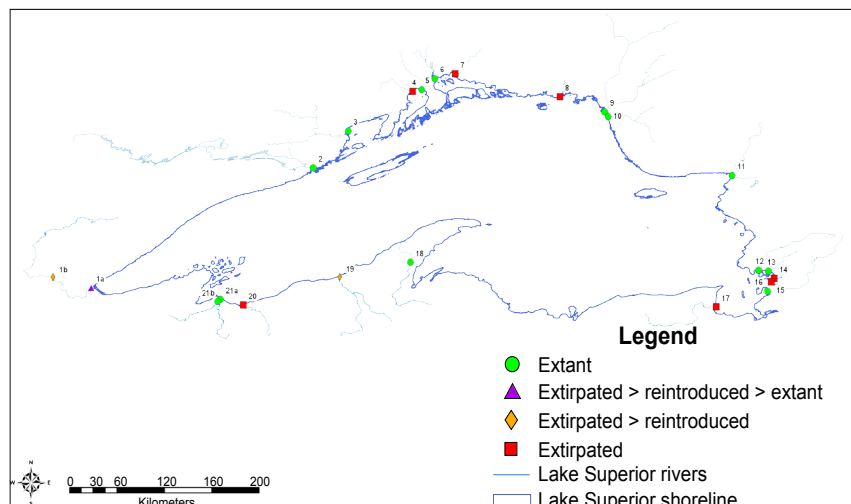
LAKE STURGEON



Once an important commercial species, only remnant populations of lake sturgeon remain in each of the Great Lakes. Populations

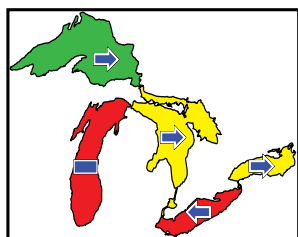
have been considered fair and slowly increasing in all lakes over the last decade, with stocking programs and habitat restoration contributing to the increased abundance.

Lake Sturgeon



Lake sturgeon population status in Lake Superior in 2011.
Source: Lake Superior Lake Sturgeon Work Group.

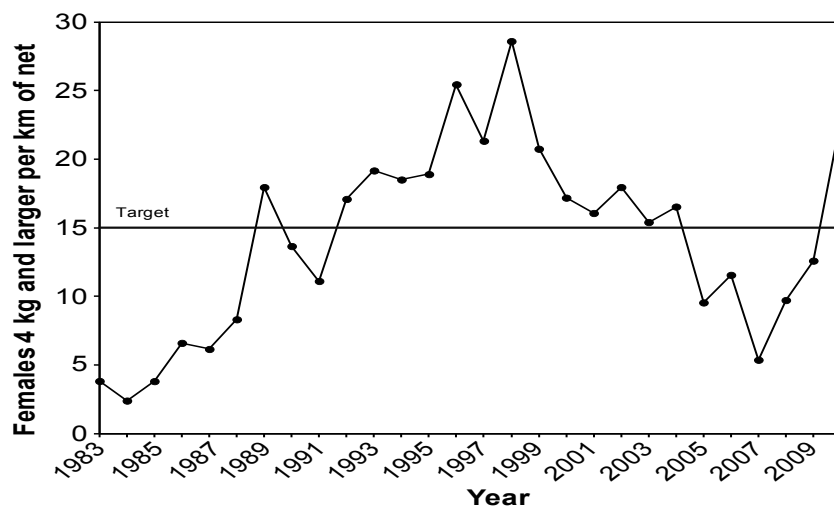
LAKE TROUT



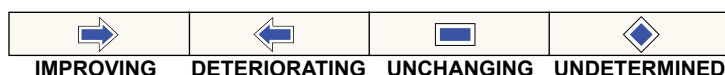
Lake Trout, historically the top predator fish of the Great Lakes, now only have self-reproducing populations throughout Lake Superior and

many smaller populations in Lake Huron. Populations in Lakes Michigan, Erie and Ontario are mostly below Great Lakes Fishery Commission Lake Committee target levels for relative abundance and natural reproduction is low. Although populations remain low in Lake Ontario, there was a sharp recovery in adult lake trout numbers in 2010. Some population increases are being observed with support of stocking and other restoration efforts.

Lake Trout

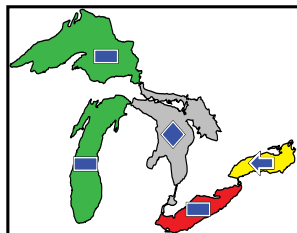


Relative abundance of stocked lake trout in Lake Ontario from 1983 - 2010. Source: New York Department of Environmental Conservation, Ontario Ministry of Natural Resources and U.S. Geological Survey.



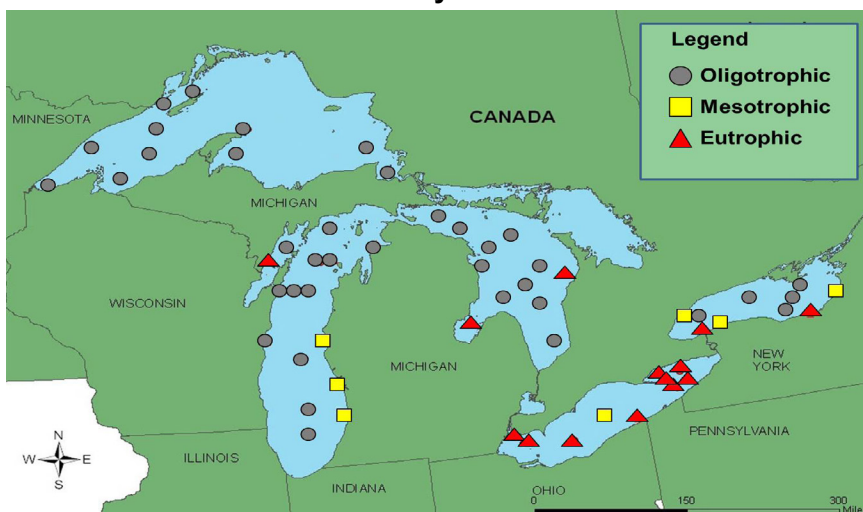
Aquatic-Dependent Life: Nine Key Indicators

BENTHOS DIVERSITY AND ABUNDANCE



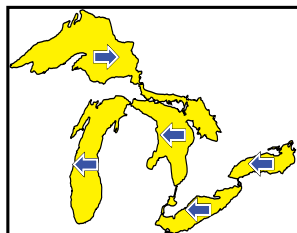
Changes in the benthic (or bottom-dwelling) community, as measured by the tolerance of certain freshwater benthic worm communities to nutrient enrichment, are indicating that some nearshore sites in Lake Ontario and Lake Michigan have become more rich in nutrients. This nutrient enrichment promotes the proliferation of plant life (i.e. more eutrophic). The majority of offshore sites in Lake Huron have seen a reduction in nutrient levels (i.e. increasingly oligotrophic), potentially causing problems for the aquatic ecosystem since there is a lack of food. Lake Erie is consistently and significantly more eutrophic than the other lakes while Lake Superior is oligotrophic.

Benthos Diversity and Abundance



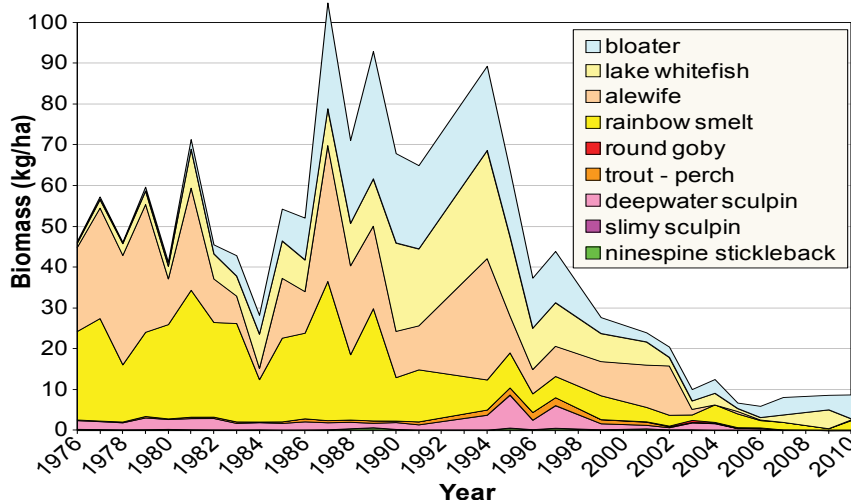
Trophic status at each benthic sampling site calculated for 2009. Source: U.S. Environmental Protection Agency.

PREYFISH POPULATIONS

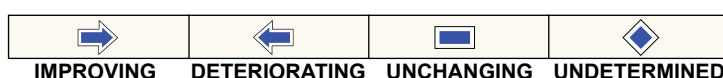


Basinwide, preyfish biomass (total weight) has been decreasing since 1988. A combination of pressures is causing the decline, including salmonid predation and the compounding impacts resulting from the expansion of zebra and quagga mussels and other invasive species. However, the Lake Superior preyfish community is considered improving because of an increase in the proportion of native species comprising the assemblage and the prey base's ability to support the recovery of the wild lake trout population.

Preyfish Populations

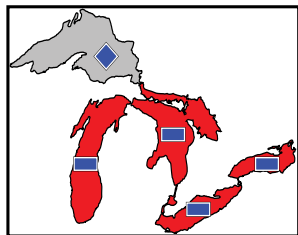


Preyfish trends based on annual bottom trawl surveys in Lake Huron. Source: U.S. Geological Survey.



Aquatic-Dependent Life: Nine Key Indicators

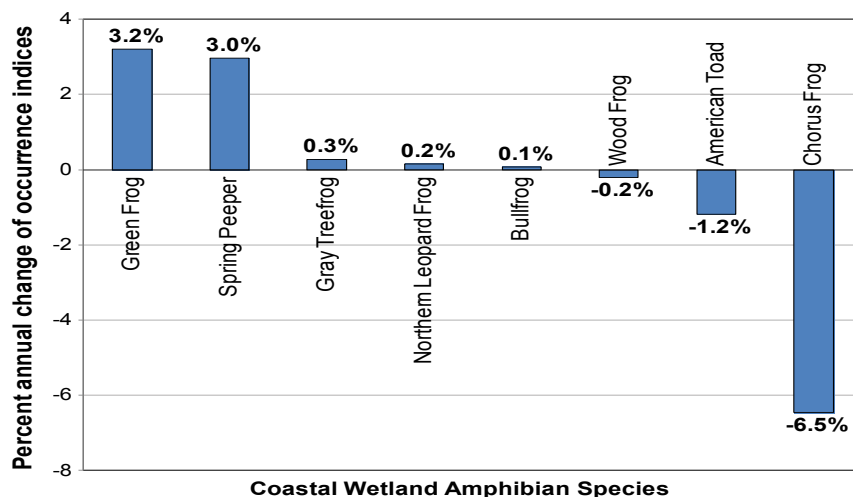
COASTAL WETLAND AMPHIBIANS



Between 1995 and 2010, the occurrence of five species was stable, two species increased and one decreased. Indices of relative occurrence for these eight species are below proposed targets established by the Marsh Monitoring Program.

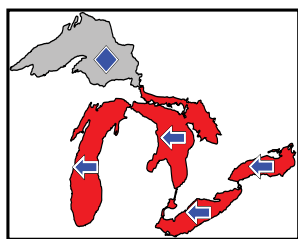
Indices of relative occurrence for these eight species are below proposed targets established by the Marsh Monitoring Program.

Coastal Wetland Amphibians



Percent annual change of occurrence indices for some wetland-breeding amphibian species from 1995 - 2010. *Source: Marsh Monitoring Program.*

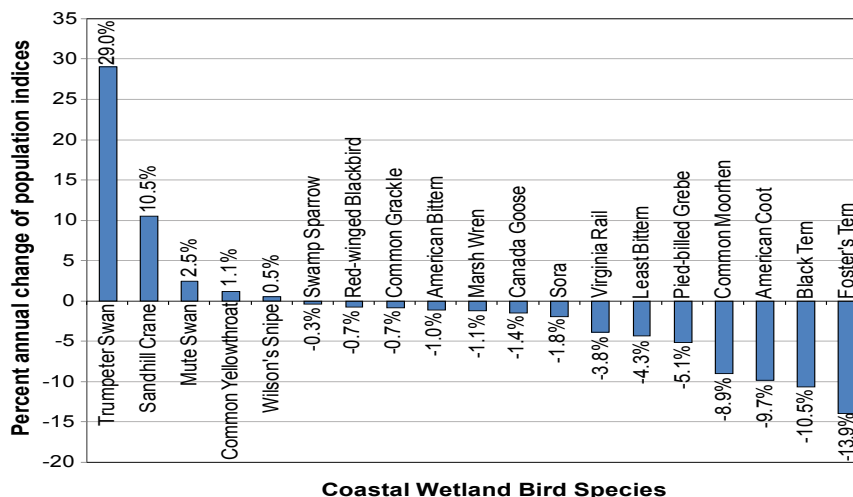
COASTAL WETLAND BIRD COMMUNITIES



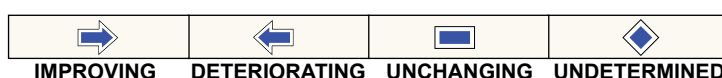
The abundance of half the species that regularly or always nest in Great Lakes wetlands declined significantly between 1995 and 2010 and

was below proposed targets established by the Marsh Monitoring Program. However, the abundance of trumpeter swan, sandhill crane and common yellowthroat increased.

Coastal Wetland Bird Communities

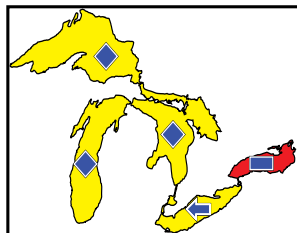


Percent annual change of population indices for some wetland-nesting bird species from 1995 - 2010. Note: Mute Swan is an invasive species. *Source: Marsh Monitoring Program.*



Aquatic-Dependent Life: Nine Key Indicators

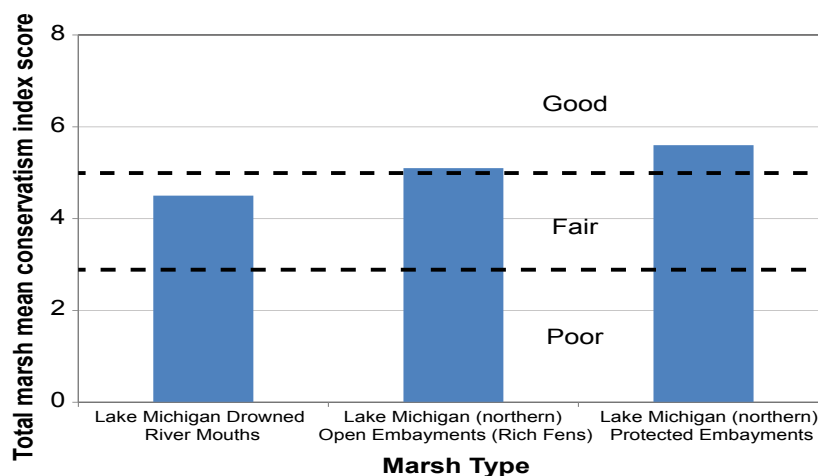
COASTAL WETLAND PLANT COMMUNITIES



The conditions of the plant community in coastal wetlands naturally differ across the Great Lakes basin due to differences in underlying geomorphic

and climatic conditions. Some individual wetlands have healthy plant communities, as indicated by their conservatism index score and other measures. The conservatism index score measures the specificity of a particular plant species to a specific habitat. Overall, the status for Lake Ontario coastal wetland plant communities is poor, and the other lakes are in fair condition. Note that the overall lake assessments can mask the good, fair, or poor conditions observed in individual wetland marsh types within a lake basin.

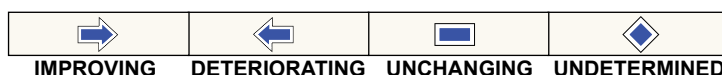
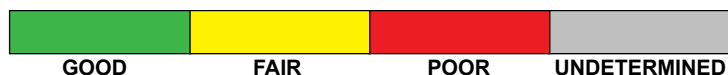
Coastal Wetland Plant Communities



Mean conservatism index scores by marsh type in 2008 for Lake Michigan. *Source: Central Michigan University and Oregon State University.*



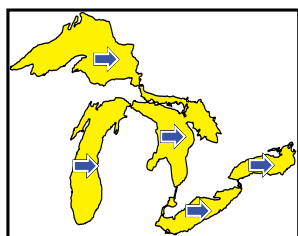
Credit: David Riecks



Landscapes and Natural Processes: Four Key Indicators

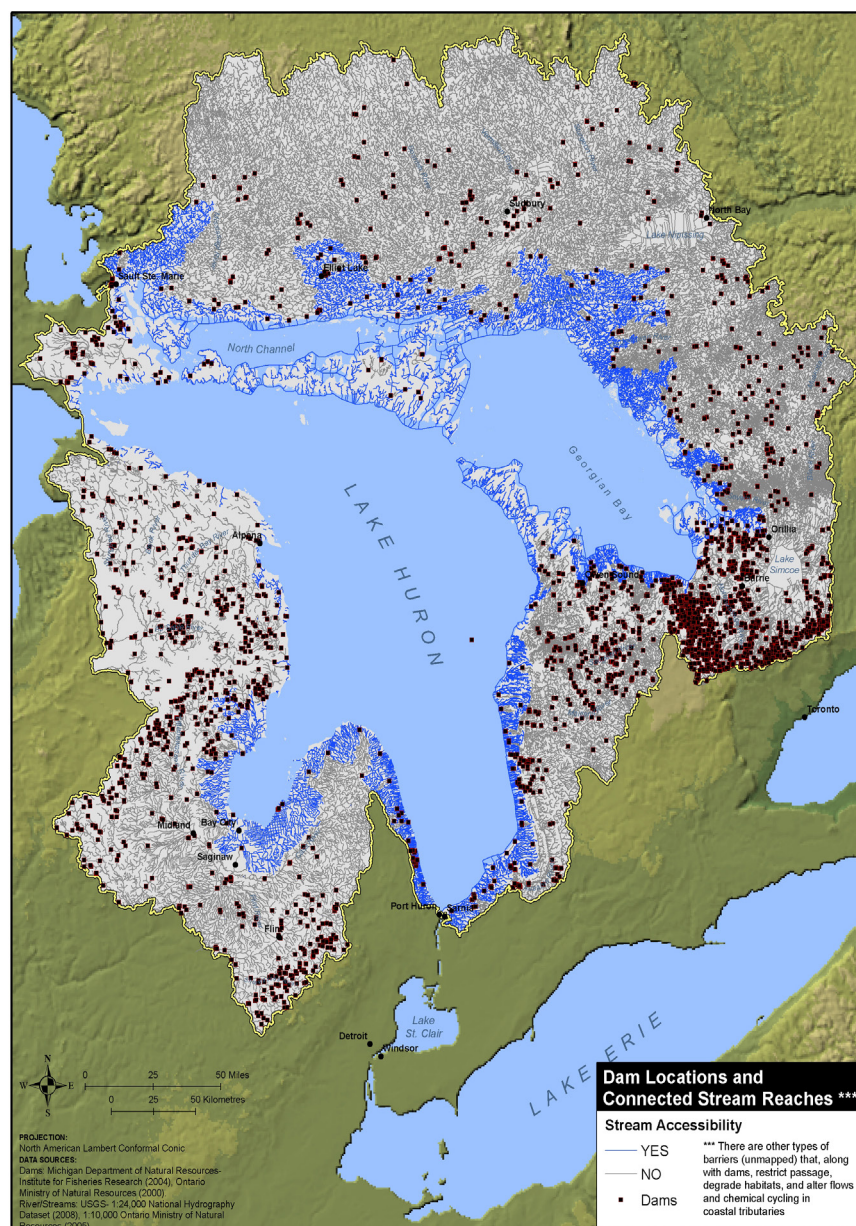
The overall status of landscapes and natural processes of the Great Lakes is fair. Despite degradation in some areas, many watersheds and tributaries continue to serve as important spawning or nursery habitat for Great Lakes fish and continue to provide important functions such as water purification. The overall trend is improving because dam mitigation and barrier removal projects are increasing habitat connectivity for fish; forested lands in Lakes Superior, Huron, and Michigan basins are increasing slightly; and some rivers and streams are exhibiting more stable streamflow conditions. Climate change impacts on natural processes of the Great Lakes, such as water level fluctuations and ice cover, are being observed.

AQUATIC HABITAT CONNECTIVITY



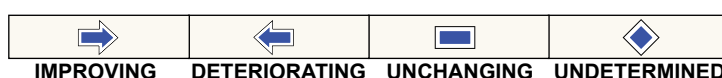
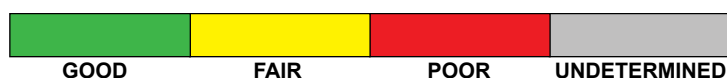
Thousands of dams are found on Great Lakes tributaries and are a key factor in the decline of several species of fishes. Many dams are near the end of their functional life. Several dam mitigation projects occurring throughout the basin are restoring connectivity between aquatic habitats.

Aquatic Habitat Connectivity



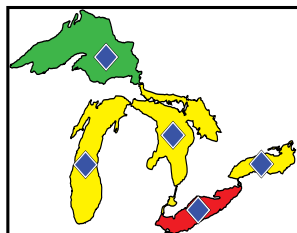
Location of dams and accessible tributaries in Lake Huron.

Source: Sweetwater Sea, An International Biodiversity Strategy for Lake Huron.



Landscapes and Natural Processes: Four Key Indicators

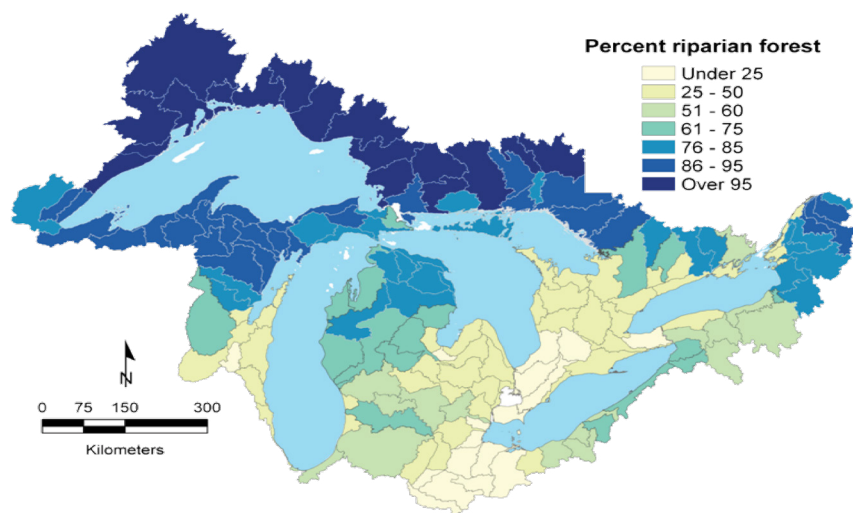
FOREST COVER



Forested cover in the riparian zone of water bodies is high in the Lake Superior basin, moderate in the Lake Michigan, Lake Huron and Lake Ontario

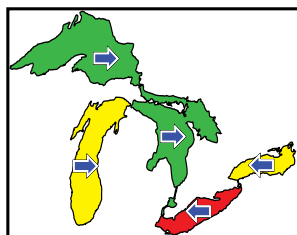
basins and low in the Lake Erie basin. Trends are undetermined as data are not available.

Forest Cover (% of Forested Lands within Riparian Zones by Watershed)



Percentage of riparian zones with tertiary watersheds identified as forested. *Source: U.S. National Land Cover Database 2006 and Ontario LandCover 2008.*

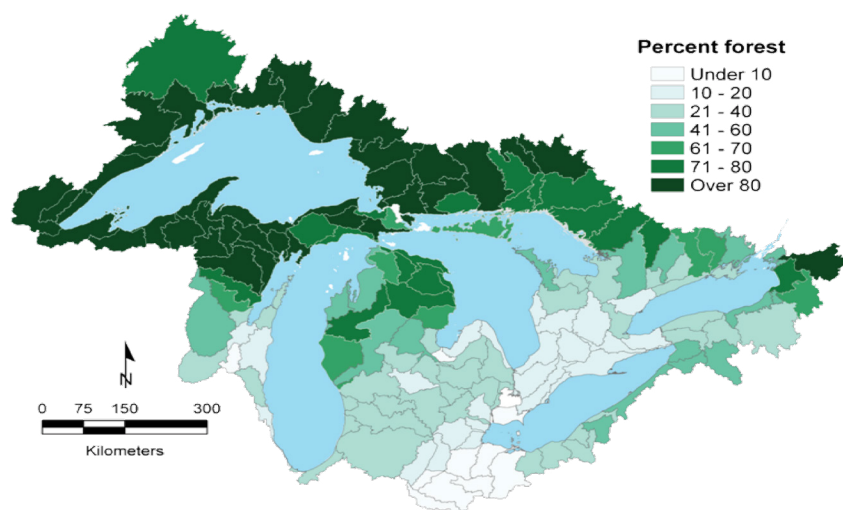
FOREST COVER



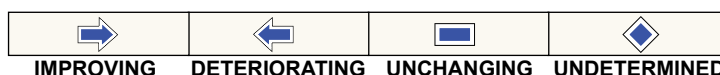
Forested lands, as measured by satellite imagery, cover a large percentage of land area within the Lake Superior and Lake Huron basins, a

moderate amount in the Lake Michigan and Lake Ontario basins and a low percentage in the Lake Erie basin. Recent data for basin-wide trends indicate that forest cover for Lakes Superior, Michigan and Huron is increasing, but is decreasing overall for Lakes Erie and Ontario. However, it is important to note that the forest cover trends being seen in the Great Lakes basin are quite small. Changes in forest types, composition and localized decreases in forest cover remain a concern.

Forest Cover (% of Forested Lands within a Watershed by Lake Basin)



Percentage of forest cover in tertiary watersheds (HUC 8 in U.S. and 4 digit in Ontario). Forest cover was estimated from satellite imagery and includes a variety of forest type and treed wetlands. *Source: U.S. National Land Cover Database 2006 and Ontario LandCover 2008.*

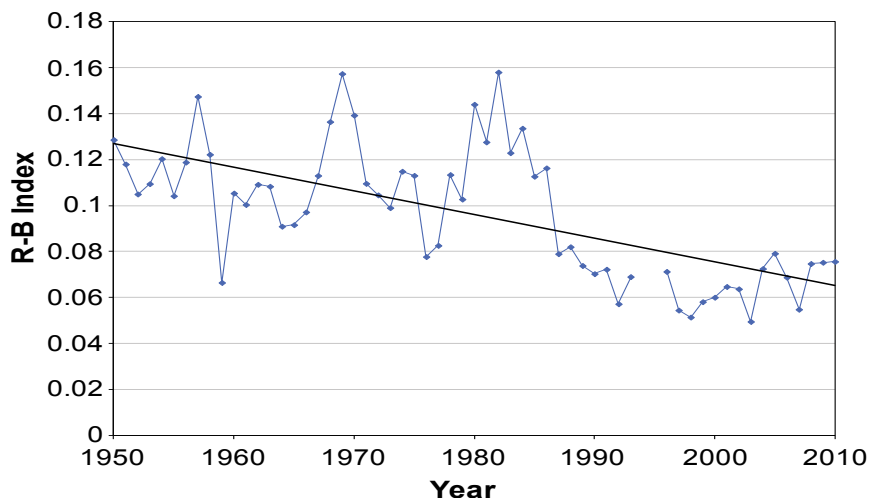


Landscapes and Natural Processes: Four Key Indicators

TRIBUTARY FLASHINESS

Tributary flashiness is a measure that reflects the frequency of short-term changes in streamflow; the flow of a flashy stream increases and decreases dramatically in hours or a few days in response to rainfall. On average, tributary flashiness has significantly decreased in five out of 11 selected tributaries over a 10-year period, meaning flow conditions are becoming more stable. Flashiness in one of the tributaries (the Maumee River) has significantly increased, while flashiness in the remaining five tributaries studied did not exhibit significant trends. Periodic changes in flow rates are natural in streams and rivers and organisms that live in these systems adapt to them. However, changes in hydrologic regimes, either reductions or increases in flashiness, can lead to displacement of native biotic communities. Status and trends in tributary flashiness have not been analyzed for each lake basin.

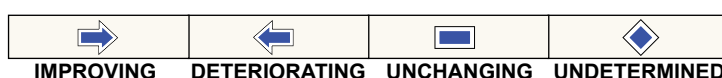
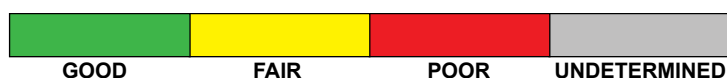
Tributary Flashiness



Richards-Baker (R-B) tributary flashiness index for the Muskegon River at Newaygo from 1950 - 1993 and Croton, Michigan from 1996 - 2010. A declining index means less flashiness. *Source: Heidelberg University.*



Credit: Dave Hansen

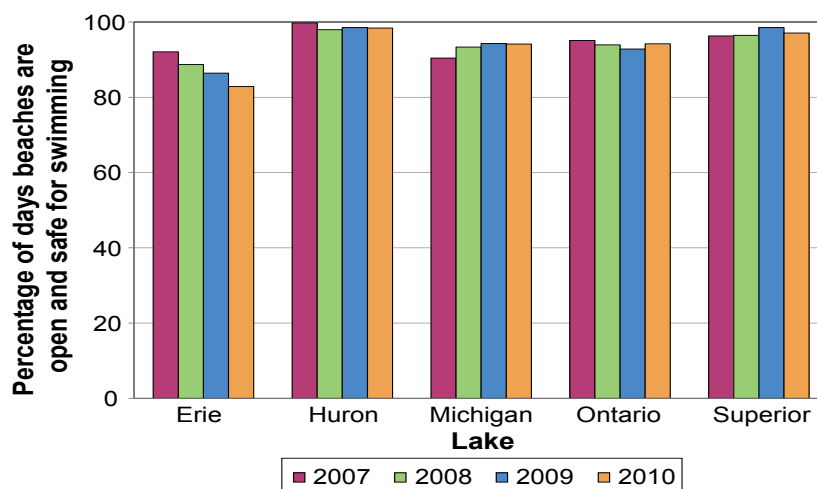


Swimming, Fishing and Drinking: Three Key Indicators

SWIMMING AT GREAT LAKES BEACHES

Most Great Lakes beaches are safe for swimming most of the time. On average, 93 percent of monitored U.S. beaches were open for swimming during the 2008 to 2010 swimming seasons. In Canada, Great Lakes monitored beaches were open for swimming an average of 79 percent of the 2008 to 2010 swimming seasons. Differences between the United States and Canada during 2008 to 2010 reflect different criteria for determining when a beach is safe for swimming. Swimming in waters with fecal bacterial pollution can cause gastrointestinal, eye, ear, skin and upper respiratory infections, so the public should heed current public health information regarding beach advisories. The identification of pollution sources at beaches, reductions in algae, improved wastewater treatment, and improved management of stormwater runoff help to increase the number of beach days that are safe for swimming. Improved monitoring is also providing people with more timely and detailed information about beach conditions.

Beach Advisories



Percentage of Beach Days that U.S. Great Lakes Beaches are Open and Safe for Swimming. *Source: U.S. Environmental Protection Agency.*

EATING GREAT LAKES FISH

Overall, Great Lakes fish are safe to eat. However, PCBs, dioxin, mercury, chlordane, mirex and toxaphene concentrations continue to drive fish consumption advisories. Some contaminants, such as PCBs, have declined substantially over the last 30 years but can persist for a long time in the environment and some contaminants are still being released into the environment. Therefore, fish consumption advisories are likely to persist for many years and the public, in particular women of child-bearing age and children, should follow fish consumption advisories published by the states and provinces regarding cautionary restrictions for certain types of fish.

Fish Consumption Advisories

Lake	State/Province	PCB	Dioxin	Mercury	Chlordane	Mirex	Toxaphene
Superior	Michigan	x	x	x	x		
	Wisconsin	x		x			
	Minnesota	x		x			
	Ontario	x	x	x			x
Huron	Michigan	x	x	x			
	Ontario	x	x	x			
Erie	New York	x					
	Ohio	x		x			
	Pennsylvania	x					
	Michigan	x	x	x			
	Ontario	x	x	x			
Ontario	New York	x	x			x	
	Ontario	x	x	x			
Michigan	Illinois	x			x		
	Michigan	x	x	x	x		
	Indiana	x		x			
	Wisconsin	x		x			

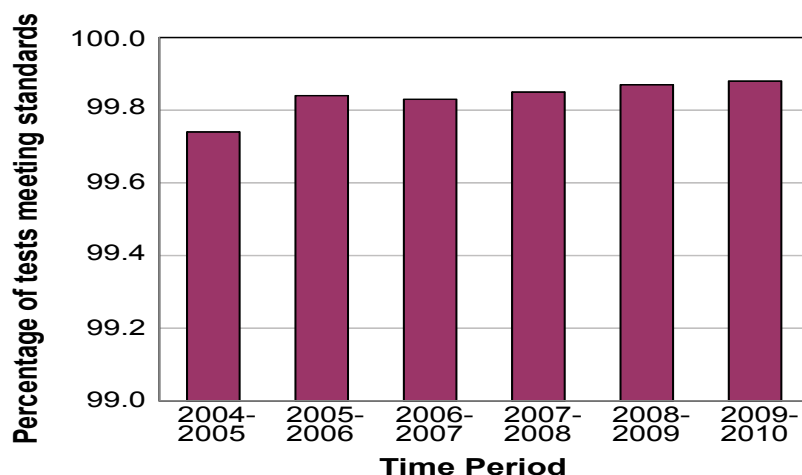
Contaminants listed in state/province fish consumption advisories. Not all states/provinces issue advisories for all of the listed contaminants. *Source: Great Lakes states and Ontario Ministry of the Environment.*

Swimming, Fishing and Drinking: Three Key Indicators

DRINKING GREAT LAKES WATER

The overall quality of municipally-treated Great Lakes drinking water is considered good. The potential risk of human exposure to chemical and/or microbiological (such as bacteria or viruses) contaminants, and any associated health effect, is low. Steps to ensure high quality drinking water include protecting and improving water quality at the source, regular testing of drinking water, ensuring effective treatment when needed, and providing information to the public.

Drinking Water Quality



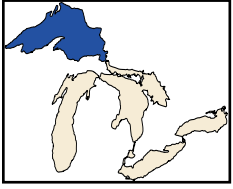
Percentage of treated drinking water tests meeting standards (municipal residential drinking water systems) in Ontario. *Source: Ontario Ministry of the Environment.*



Credit: Stacey Cherwaty-Pergentile

Conditions in Individual Great Lakes and the St. Lawrence River

LAKE SUPERIOR

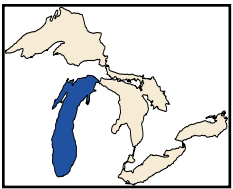


The Lake Superior ecosystem continues to be in good to very good condition. The fisheries are healthy, the lower food web is robust and priority chemical substances are largely decreasing or remaining stable. On the U.S. side, forest cover continues to increase, although the species composition is changing. Ongoing and emerging stressors and threats include chemical contaminants that cause fish advisories and exceedances of water quality guidelines, increasing levels of chemicals of emerging concern (e.g., flame retardants) and impacts from mining. In particular, increased mining activity and hydropower dams in the basin could potentially degrade fish and wildlife habitat, increase mercury emissions, lead to wetland and habitat loss and affect water quality. The impacts from climate change, the spread of existing invasive species, and some land uses including shoreline development are also stressing the ecosystem. Perhaps the greatest challenge to the Lake Superior ecosystem is protection and prevention. The protection of an ecosystem that is still relatively intact and unspoiled is imperative.



Isle Royale Moose
Credit: John Vucetich

LAKE MICHIGAN



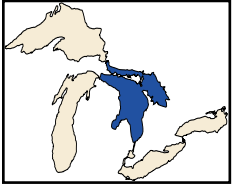
Lake Michigan is in a state of change with both positive and negative trends. Dam removals, restoration of wetland habitat and riverine spawning areas, and the continued decline of contaminants such as PCBs in fish have resulted in the return of bird, mammal and aquatic species and the improvement of the migratory flyway for millions of birds. The lake provides quality drinking water for 12 million residents, and beach advisory days indicate water contamination continues to decline. However, the aquatic food web is under great stress because a key food web species, *Diporeia*, has almost disappeared. The invasive quagga mussel is contributing to a change in the food web by filtering water, thereby increasing water clarity and sunlight penetration in the nutrient-rich nearshore waters, resulting in dense, widespread algal growth which is suspected of playing a role in Type E botulism outbreaks. These outbreaks have resulted in significant numbers of deaths of fish-eating birds. Water levels and winter ice cover remain below average.



Piping Plover
Credit: John Van de Graaff

Conditions in Individual Great Lakes and the St. Lawrence River

LAKE HURON



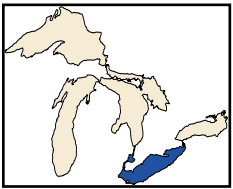
Lake Huron's biological diversity is in fair condition based on an assessment of the open waters, nearshore, coastal wetlands, native migratory fish, islands, and coastal terrestrial ecosystems. Development, dams and barriers, nonpoint source

pollution, invasive species, and climate change are major stressors on the ecosystem and are resulting in habitat degradation and loss. In open waters of Lake Huron, nutrient levels have declined significantly; spring chlorophyll blooms and the abundance and diversity of zooplankton have decreased. For reasons that are still unclear, populations of *Diporeia* have crashed throughout the lake, removing a major food source from the fishery. The observed decline in *Diporeia* correlates with the expansion of invasive quagga mussels into the deeper waters. *Mysis*, the other small, shrimp-like crustacean found in the offshore region, does not appear to be filling the *Diporeia* niche, and may be declining as well. Preyfish populations have dramatically decreased since 2003. Predator fish species, such as salmon, have also decreased and remaining fish appear to have lower mean body weights. The recovery of native lake trout may be limited by changes in the quantity and quality of the prey base as well as by non-native species. In contrast, nearshore nutrient concentrations have increased, and populations of walleye, yellow perch, and smallmouth bass appear to be rebounding.



Georgian Bay
Credit: Parks Canada

LAKE ERIE



Lake Erie's unique ecosystem is under threat from excess algal blooms that have become a regular occurrence throughout the Western basin of the lake during summer months, leading to poor aesthetics, recreational beach closures and

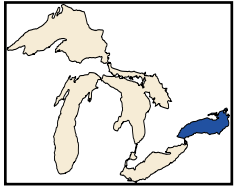
reduced tourism revenue. The blooms are attributed to excessive nutrient inputs. Note that because of a regional drought, algal blooms were significantly reduced in the summer of 2012. *Cladophora* continues to foul beaches in the eastern basin. In the western basin, blue-green algal blooms sometimes produce toxins known as microcystins that pose potential human health risks. Seasonal anoxia (absence of oxygen in the water) and hypoxia (low oxygen in the water) are exacerbated in the central basin by increased amounts of decaying algae. Aquatic invasive species continue to impact the aquatic food web, and have been implicated in nearshore algal problems. Yellow perch populations have increased and there are indications that lake sturgeon populations may be improving. However, lamprey wounding rates are well above target levels, and this continues to suppress adult lake trout numbers.



Put-in-Bay, Lake Erie
Credit: Ohio Sea Grant

Conditions in Individual Great Lakes and the St. Lawrence River

LAKE ONTARIO

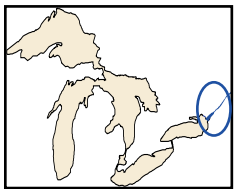


Lake Ontario is in a state of change with both positive and negative trends. Lake Ontario continues to support a diversity of recreational and commercial fisheries. Continuing efforts to restore populations of native lake trout and Atlantic salmon through stocking and habitat improvements have resulted in an abundant population of lake trout and a small population of Atlantic salmon. Adults of both species are spawning successfully, but survival of wild offspring remains low. Changes to the ecosystem, such as the invasion of zebra and quagga mussels and the disappearance of *Diporeia*, continue to have an impact on the lake's nutrient cycling and food web dynamics. Nutrient loadings and the cycling of nutrients will be further investigated through the Lake Ontario Cooperative Science and Monitoring Initiative's 2013 sampling year. A priority for Lake Ontario is conserving and restoring biological diversity, with a strong focus on implementing the Lake Ontario Binational Biodiversity Conservation Strategy, updating fisheries management plans, and developing a binational monitoring program for coastal wetlands.



Lake Ontario Shoreline
Credit: Nancy Stadler-Salt

INTERNATIONAL SECTION OF THE ST. LAWRENCE RIVER



The overall health of the St. Lawrence River is in fair to good condition. The Great Lakes - St. Lawrence region contains about a quarter of the Earth's freshwater reserves and is an important part of the physical and cultural heritage of North America. The St. Lawrence

River is the primary navigational access route for trade and commerce in and out of the Great Lakes basin. The condition of the St. Lawrence River ecosystem is impacted greatly by the quality of water flowing out of the Great Lakes; however the St. Lawrence River can also have an impact on the Great Lakes ecosystem. Habitat fragmentation is a major physical impairment in the St. Lawrence River. Dams and other barriers, such as culverts at road stream crossings, also alter hydrologic rhythms that sustain riparian and coastal habitats, restrict fish access to spawning and nursery habitats, alter the thermal regime of streams, and interrupt movement of sediments. Turbines in power dams kill fish. In the International Section of the St. Lawrence River, like elsewhere in the Great Lakes, tributaries and tributary mouths create important refuges and spawning areas for fish and other aquatic wildlife. However, poor water quality and shoreline alterations affect the quality of the habitat. In the International Section, strong currents ensure shoreline discharges remain close to shore resulting in marked water quality gradients between nearshore and main channel waters. As a result, nearshore waters typically contain much higher chlorophyll *a* and nutrient concentrations than those found in the main channel. Restoration work on tributaries, such as that carried out in Sutherland Creek since 1994, has resulted in marked improvements in water quality and fish habitat.



St. Lawrence River Shoreline
Credit: MR Twiss

Shared Understanding, Cooperative Work

Participating Organizations

Agriculture & Agri-Food Canada	Nature Conservancy of Canada
Bird Studies Canada	NY Dept. of Environmental Conservation
Chippewa Ottawa Resource Authority	NY Sea Grant
Computer Sciences Corporation	OH Department of Natural Resources
Cornell University	OH State University
Council of Great Lakes Industries	ON Min. of Agric. Food & Rural Affairs
Environment Canada	ON Min. of the Environment
Fisheries & Oceans Canada	ON Min. of Natural Resources
Fond du Lac Band of Lake Superior Chippewa	PA Dept. of Environmental Protection
Geological Survey of Canada	St. Lawrence River Inst. of Env. Sciences
Great Lakes Fishery Commission	State University of NY
Great Lakes Indian Fish & Wildlife Comm.	The Nature Conservancy
Heidelberg Univ. Water Quality Research Ctr.	University of MI
IL-IN Sea Grant	University of MN-Duluth
International Joint Commission	University of WI-Madison/Superior
Loyola University	University of Windsor
MI Department of Environmental Quality	U.S. Army Corps of Engineers
MI Dept. of Natural Resources	U.S. Environmental Protection Agency
MI State University – Extension	U.S. Fish & Wildlife Service
MI Technical Research Institute	U.S. Geological Survey
MN Pollution Control Agency	U.S. National Park Service
National Oceanic & Atmospheric Admin.	USDA Forest Service
Natural Resources Canada	WI Department of Natural Resources

For more information about the state of the Great Lakes and government-supported actions to protect the Great Lakes, please visit the following websites:

**www.glri.us
www.epa.gov/greatlakes
www.epa.gov/solec
www.binational.net
www.ec.gc.ca/greatlakes**

What's So *Great* About the Great Lakes?

The Great Lakes basin:

- contains **84%** of North America's surface freshwater and **18%** of the world's surface freshwater
- holds **22.7 quadrillion liters of water** (6 quadrillion gallons), of which **210 billion liters** (56 billion gallons) are used daily for municipal, agricultural and industrial use
- is home to **40 million people**, roughly 10% of the U.S. population and more than 30% of the Canadian population
- provides **24 million people** with drinking water that is drawn from the Great Lakes, treated, and delivered to their taps
- has **16,000 kilometers** (10,000 miles) of **coastline**, which is almost half the earth's circumference
- includes **217,000 hectares** (536,000 acres) of **coastal wetlands** and **31,000 islands**
- contains the **world's largest collection of freshwater sand dunes** and the world's largest freshwater estuary - Green Bay
- hosts the **largest freshwater protected area** in the world - Lake Superior National Marine Conservation Area of Canada
- sustains over **350 species of fish**, including lake sturgeon which colonized the lakes after the last glacial period (approximately 10,000 years ago!)
- maintains a shipping industry that has transported over **2.5 billion tons of cargo** since 1959, a value in excess of **\$375 billion**

