

# State of the Great Lakes 2007

## Highlights






This Highlights report is based on environmental indicator reports that were prepared for the State of the Lakes Ecosystem Conference (SOLEC) in Milwaukee, Wisconsin, 1-3 November 2006. Many experts on various components of the Great Lakes basin ecosystem contributed to the process. Data sources and contact information for each indicator are included in the technical report, *State of the Great Lakes 2007*.

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## Assessing Status and Trends of the Great Lakes Ecosystem

### Indicator Category Assessments and Management Challenges:

- Contamination
- Human Health
- Biotic Communities
- Invasive Species
- Coastal Zones and Aquatic Habitats
- Resource Utilization
- Land Use-Land Cover
- Climate Change

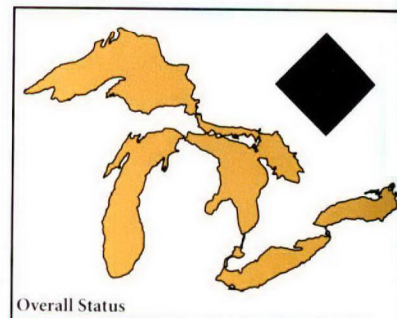
What is Being Done to Improve Conditions

State of the Lakes Ecosystem Conference

## Assessing Status and Trends of the Great Lakes Ecosystem

*In 2006, the overall status of the Great Lakes ecosystem was assessed as mixed because some conditions or areas were **good** while others were **poor**. The trends of Great Lakes ecosystem conditions varied: some conditions were **improving** and some were **worsening**.*

Since 1998, the U.S. Environmental Protection Agency and Environment Canada have coordinated a biennial assessment of the ecological health of the Great Lakes ecosystem using a consistent set of environmental and human health indicators. This assessment is in accordance with the Great Lakes Water Quality Agreement (GLWQA). Each indicator report is supported by scientific information collected and assessed by Great Lakes experts from Canada and the United States, along with a review of scientific papers and use of best professional judgment.



Indicators are organized into nine categories: **Contamination, Human Health, Biotic Communities, Invasive Species, Coastal Zones, Aquatic Habitats, Resource Utilization, Land Use-Land Cover, and Climate Change**. Overall assessments and management challenges were prepared for each category to the extent that indicator information was available. This *State of the Great Lakes 2007 Highlights* report is derived from a more detailed *State of the Great Lakes 2007* report. The *2007 Highlights* report also includes information on "What is Being Done to Improve Conditions," which outlines some examples of actions taken by the Great Lakes community in response to environmental conditions.

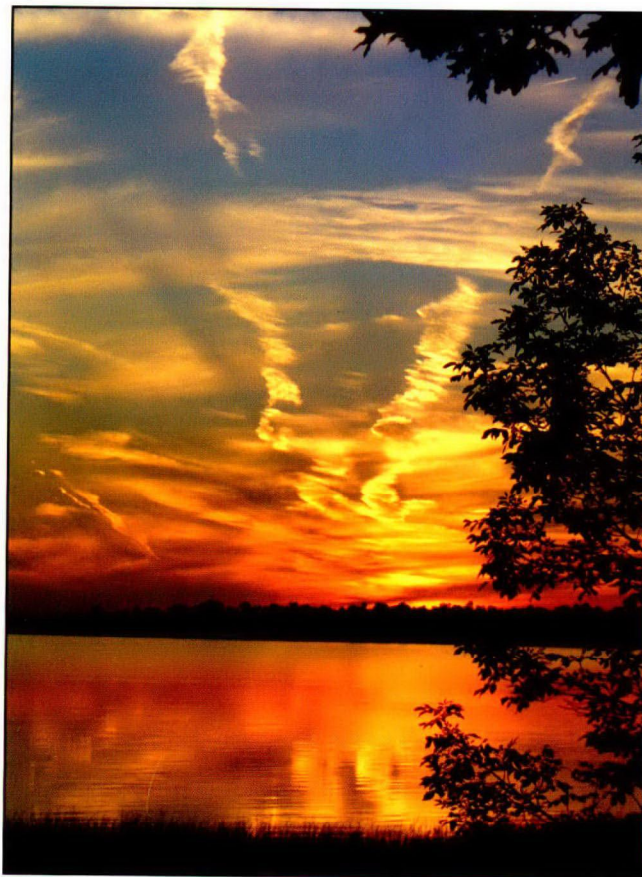











Photo credit: Paul Best



Authors of the indicator reports assessed the status of ecosystem components in relation to desired conditions or ecosystem objectives, if available. Five status categories were used (coded by color in this Highlights report):

-  **GOOD.** The state of the ecosystem component is presently meeting ecosystem objectives or otherwise is in acceptable condition.
-  **FAIR.** The ecosystem component is currently exhibiting minimally acceptable conditions, but it is not meeting established ecosystem objectives, criteria, or other characteristics of fully acceptable conditions.
-  **POOR.** The ecosystem component is severely negatively impacted and it does not display even minimally acceptable conditions.
-  **MIXED.** The ecosystem component displays both good and degraded features.
-  **UNDETERMINED.** Data are not available or are insufficient to assess the status of the ecosystem component.

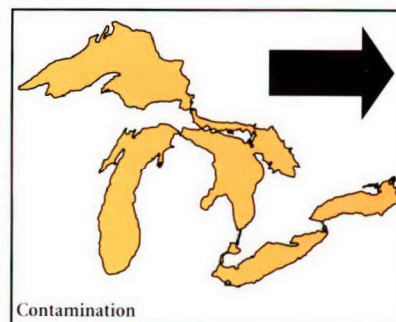
Four categories were also used to denote current trends of the ecosystem component (coded by shape in this Highlights report):

-  **IMPROVING.** Information provided shows the ecosystem component to be changing toward more acceptable conditions.
-  **UNCHANGING.** Information provided shows the ecosystem component to be neither getting better nor worse.
-  **DETERIORATING.** Information provided shows the ecosystem component to be departing from acceptable conditions.
-  **UNDETERMINED.** Data are not available to assess the ecosystem component over time, so no trend can be identified.

For many indicators, ecosystem objectives, endpoints, or benchmarks have not been established. For these indicators, complete assessments are difficult to determine.

## Indicator Category Assessments and Management Challenges

### CONTAMINATION

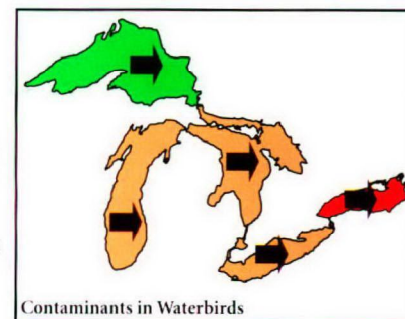


Contamination

*The transfer of natural and human-made substances from air, sediments, groundwater, wastewater, and runoff from non-point sources is constantly changing the chemical composition of the Great Lakes. Over the last 30 years, concentrations of some chemicals or chemical groups have declined significantly.*

*There is a marked reduction in the levels of toxic chemicals in air, water, biota, and sediments. Many remaining problems are associated with local regions such as Areas of Concern. However, concentrations of several other chemicals that have been recently detected in Great Lakes have been identified as chemicals of emerging concern.*

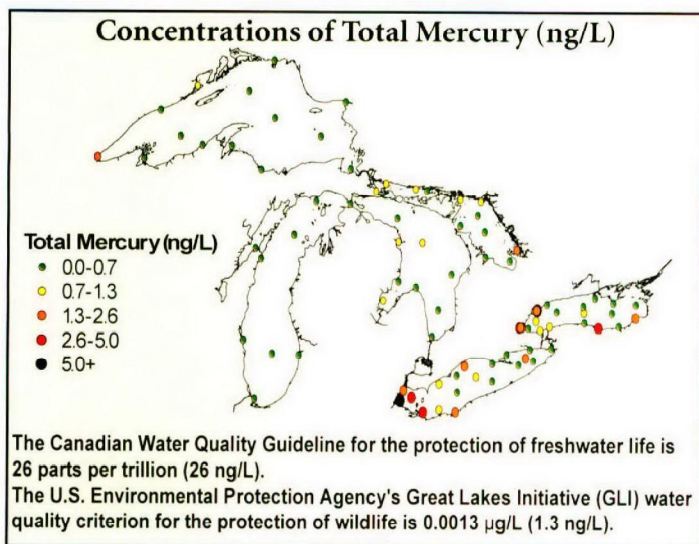
Levels of most contaminants in **herring gull eggs** continue to decrease in all the Great Lakes colonies monitored, although concentration levels vary from good in Lake Superior, to mixed in Lake Michigan, Lake Erie and Lake Huron, to poor in Lake Ontario. While the frequency of gross effects of contamination on wildlife has subsided, many subtle (mostly physiological and genetic) effects that were not measured in earlier years of sampling remain in herring gulls. Concentrations of flame-retardant polybrominated diphenyl ethers (PBDEs) are increasing in herring gull eggs.



Contaminants in Waterbirds

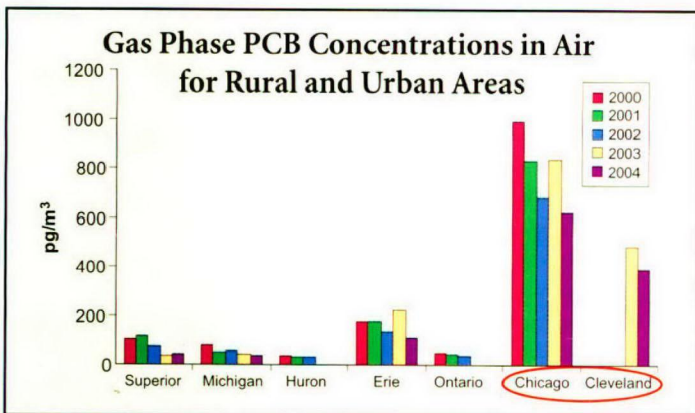
Concentrations of most **organic contaminants** in the **offshore waters** of the Great Lakes are low and are declining, indicating progress in the reduction of persistent toxic chemicals. Indirect inputs of in-use organochlorine pesticides are most likely the current source of entry to the Great Lakes. Continuing sources of entry of many organic contaminants to the Great Lakes include indirect inputs such as atmospheric deposition, agricultural land runoff, and resuspension of contaminated sediments. Overall, **mercury** concentrations in offshore waters are well below water quality guidelines. Mercury concentrations in waters near major urban areas and harbors, however, exceed water quality criteria for protection of wildlife. The spatial distribution of **polycyclic aromatic hydrocarbons (PAHs)** reflects the major source from the burning of fossil fuels. Concentrations of PAHs are therefore higher in the lower lakes, where usage is greater.





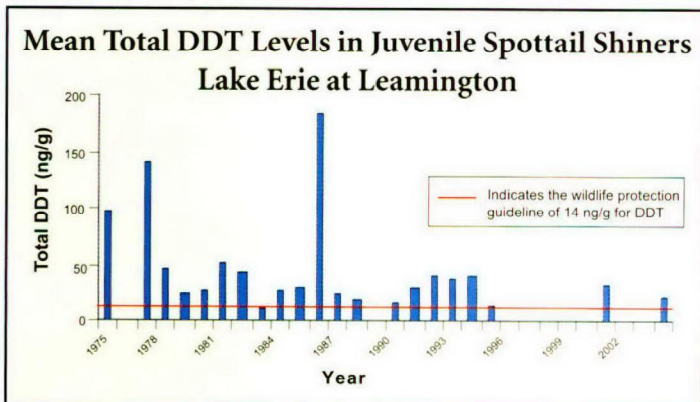
Source: State of the Great Lakes 2007 report

The status of **atmospheric deposition of toxic chemicals** is mixed and improving for polychlorinated biphenyls (PCBs), banned organochlorine pesticides, dioxins, and furans, but mixed and unchanging or slightly improving for PAHs and mercury across the Great Lakes. For Lake Superior, Lake Michigan, and Lake Huron, atmospheric inputs are the largest source of toxic chemicals due to the large surface areas of these lakes. While atmospheric concentrations of some substances are very low at rural sites, they may be much higher in some urban areas.



Source: State of the Great Lakes 2007 report

**Juvenile spottail shiner**, an important preyfish species in the Great Lakes, is a good indicator of **nearshore contamination**



Source: State of the Great Lakes 2007 report

because the species limits its distribution to localized, nearshore areas during its first year of life. Total dichlorodiphenyltrichloroethane (DDT) in juvenile spottail shiner has declined over the last 30 years but still exceeds GLWQA criteria at most locations. Concentrations of PCBs in juvenile spottail shiner have decreased below the GLWQA guideline at many, but not all, sites in the Great Lakes.



Photo credit: U.S. Environmental Protection Agency

The status of contaminants in lake trout, walleye and smelt as monitored annually in the open waters of each of the Great Lakes is mixed and improving for PCBs, DDT, toxaphene, dieldrin, mirex, chlordane, and mercury.

Concentrations of PBDEs and other chemicals of emerging concern such as perfluorinated chemicals, however, are increasing. Both the United States and Canada continue to monitor for these chemicals in whole fish tissues and have over 30 years of data to support the status and trends information.

**Phosphorus** concentrations in the Great Lakes were a major concern in the 1960s and 1970s, but private and government

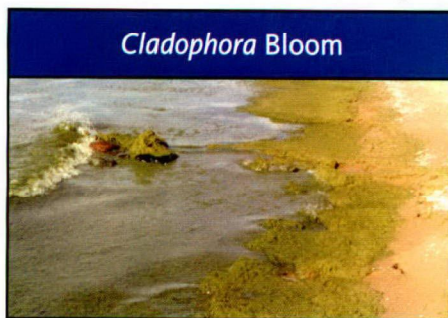


Photo credit: Tip of the Mitt Watershed Council

actions have reduced phosphorus loadings, thus maintaining or reducing phosphorus concentrations in open waters. However, high phosphorus concentrations are still measured in some embayments, harbors, and nearshore areas. Nuisance growth of the green alga *Cladophora* has reappeared along the shoreline in many places and may be related, in part, to increased availability of phosphorus.

### Management Challenges:

- Presently, there are no standardized analytical monitoring methods and tissue residue guidelines for new contaminants and chemicals of emerging concern, such as PBDEs.
- PCBs from residual sources in the United States, Canada, and throughout the world enter the atmosphere and are transported long distances. Therefore, atmospheric deposition of PCBs to the Great Lakes will still be significant at least decades into the future.
- Assessment of the capacity and operation of existing sewage treatment plants for phosphorus removal, in the context of increasing human populations being served, is warranted.



Monitoring of tributary, point source, and urban and rural non-point source contributions of phosphorus will allow tracking of various sources of phosphorus loadings.

- Investigating the causes of *Cladophora* reappearances will aid in the reduction of its impacts on the ecosystem.

## Chemical Integrity of the Great Lakes-What the Experts are Saying

*In addition to the ecosystem information derived from indicators, six presentations on the theme of "Chemical Integrity of the Great Lakes" were delivered at SOLEC 2006 by Great Lakes experts. The definition of Chemical Integrity proposed by SOLEC is "the capacity to support and maintain a balanced, integrated and adaptive biological system having the full range of elements and processes expected in a region's natural habitat." James R. Karr, 1991 (modified)*

*The presentations focused on the status of anthropogenic (man-made) contaminants and imbalances in naturally-occurring chemicals in the Great Lakes basin. The key points of each presentation are summarized here.*

### **Anthropogenic Chemicals**

Ron Hites, Indiana University: While concentrations of **banned or regulated toxic substances** such as PCBs and PAHs have decreased over the past 30 years, the rate of decline has slowed considerably over the past decade. Virtual elimination of most of these chemicals will not occur for another 10 to 30 years despite restrictions or bans on their use. Further decreases in the environmental concentrations of PCBs, PAHs, and some pesticides may well depend on emission reductions in cities.

Derek Muir, Environment Canada: Some 70,000 commercial and industrial compounds are now in use, and an estimated 1,000 new chemicals are introduced each year. Several chemical categories have been identified as **chemicals of emerging concern**, including polybrominated diphenyl ethers (flame retardants), perfluorooctanyl sulfonate (PFOS) and carboxylates, chlorinated paraffins and naphthalenes, various pharmaceutical and personal care products, phenolics, and approximately 20 currently-used pesticides. **PBDEs, siloxanes and musks** are now widespread in the Great Lakes environment. Implementation of a more systematic program for monitoring new persistent toxic substances in the Great Lakes will require significant investments in instrumentation and researchers.

Joanne Parrot, Environment Canada: Some **pharmaceuticals and personal care products** appear to cause negative effects in aquatic organisms at very low concentrations in laboratory experiments. Some municipal wastewater effluents within the Great Lakes discharge concentrations of these products within these ranges. There is some evidence that fish and turtles show developmental

effects when exposed to municipal wastewater effluent in the laboratory. Whether these effects appear in aquatic organisms including invertebrates, fish, frogs, and turtles, in environments downstream of municipal wastewater effluent is not known, indicating the need for more research in this area.

### **Naturally-occurring Chemicals**

Harvey Bootsma, University of Wisconsin-Milwaukee: Changes in levels of **nitrate, chloride and phosphorus** in Great Lakes waters are attributed to human activities, with potential effects on phytoplankton and bottom-dwelling algae. Changes in lake chemistry, shown through variations in **calcium, alkalinity**, and even **chlorophyll**, are linked to the biological activity of non-native species. Non-native species also appear to be altering nutrient cycling pathways in the Great Lakes, by possibly intercepting nearshore nutrients before they can be exported offshore and transferring them to the lake bottom.

Susan Watson, Environment Canada: The causes and occurrences of **taste and odor impairments** in surface waters are widespread, erratic, and poorly characterized but are likely caused by volatile organic compounds produced by species of plankton, benthic organisms, and decomposing organic materials. In recent years, there has been an increase in the frequency and severity of **nuisance algae** such as *Cladophora* outbreaks in the Great Lakes, particularly in the lower Great Lakes. Type E **botulism** outbreaks and resulting waterbird deaths continue to occur in Lake Michigan, Lake Erie and Lake Ontario.

David Lam, Environment Canada: **Models and supporting monitoring data** are used to predict Great Lakes water quality. A post-audit of historical models for Great Lakes water quality revealed the general success of setting target phosphorus loads to reduce open water phosphorus concentrations.



## HUMAN HEALTH

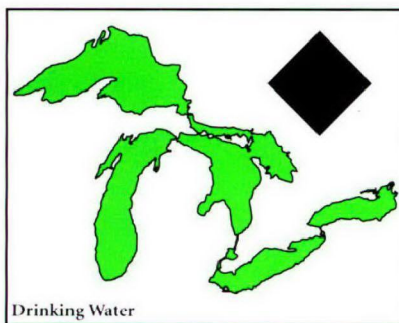


Human Health

Levels of PCBs in sportfish continue to decline, progress is being made to reduce air pollution, beaches are better assessed and more frequently monitored for pathogens, and treated drinking water quality continues to be assessed as good. Although concentrations of many

organochlorine chemicals in the Great Lakes have declined since the 1970s, sportfish consumption advisories persist for all of the Great Lakes.

The quality of municipally-treated **drinking water** is considered good. The risk of human exposure to chemicals and/or microbiological contaminants in treated drinking water is generally low. However, improving and protecting source water quality (before treatment) is important to ensure good drinking water quality.



Drinking Water

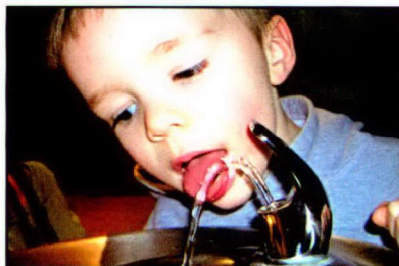
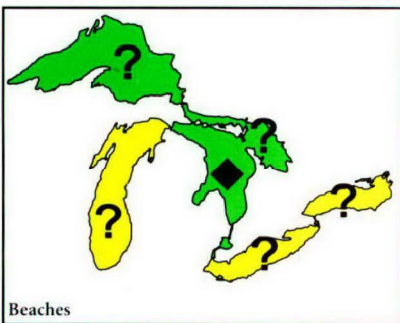


Photo credit: Environment Canada



Beaches

In 2005, 74 percent of monitored Great Lakes beaches in the United States and Canada remained open more than 95 percent of the swimming season. Postings, advisories or closures were due to a variety of reasons,

including the presence of *E. coli* bacteria, poor water quality, algae abundance, or preemptive beach postings based on storm events and predictive models. Wildlife waste on beaches can be more of a contributing factor towards bacterial contamination of water and beaches than previously thought.

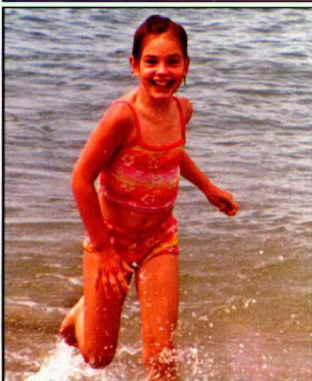
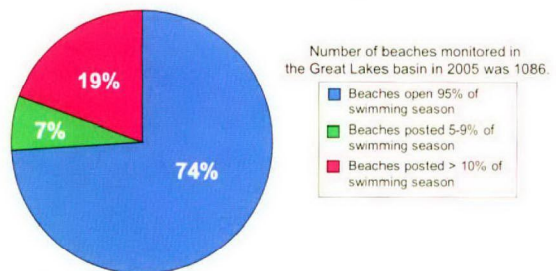


Photo credit: Environment Canada

## Beach Postings and Closures for 2005 Great Lakes Swimming Season



Source: State of the Great Lakes 2007 report

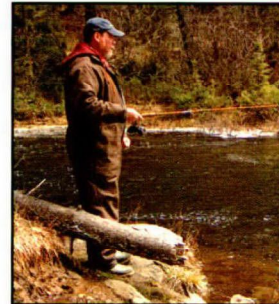
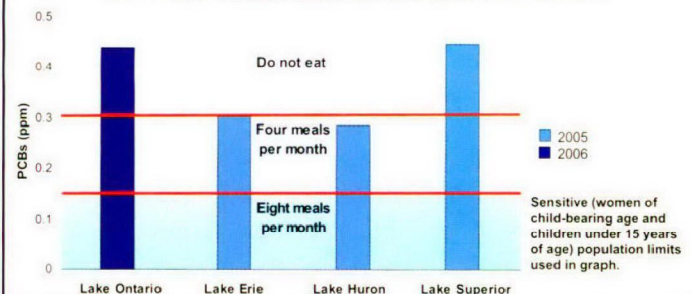


Photo credit: Environment Canada

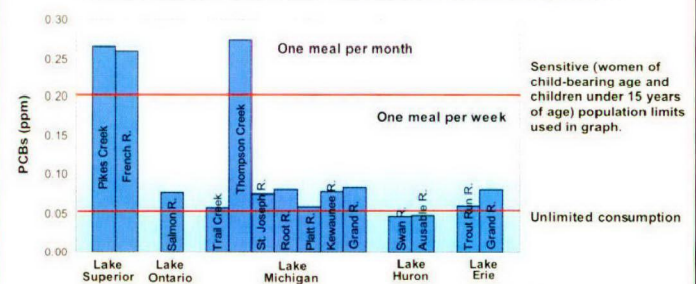
Concentrations of organochlorine contaminants in Great Lakes sportfish are generally decreasing. However, in the United States, PCBs drive consumption advisories of Great Lakes sportfish. In Ontario, most of the consumption advisories for Great Lakes sportfish are driven by PCBs, mercury, and dioxins. Toxaphene also contributes to consumption advisories of sportfish from Lake Superior and Lake Huron. Monitoring for other contaminants, such as PBDEs, has begun in some locations.

## Guide to Eating Ontario Sportfish for PCB Concentrations in Lake Trout



Source: State of the Great Lakes 2007 report

## Application of a Uniform Fish Consumption Advisory for PCB Concentrations in Chinook Salmon, 2003



Source: State of the Great Lakes 2007 report





Overall, there has been significant progress in reducing **air pollution** in the Great Lakes basin. However, regional pollutants, such as ground-level ozone and fine particulates, remain a concern, especially in the Detroit-Windsor-Ottawa corridor, the Lake Michigan basin, and the Buffalo-Niagara area. Air quality will be further impacted by population growth and climate change.

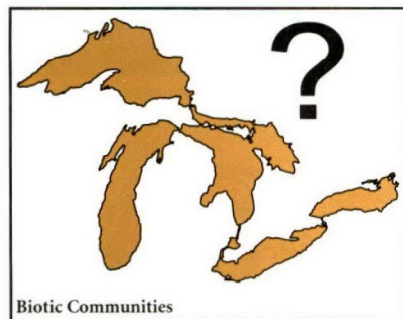
## Management Challenges:

- Maintenance of high-quality source water will reduce costs associated with treating water, promote a healthier ecosystem, and lessen potential contaminant exposure to humans.
- Although the quality of treated drinking water remains good, care must be taken to maintain water treatment facilities.
- One-fourth of monitored beaches still have beach postings or closures.
- A decline in some contaminant concentrations has not eliminated the need for Great Lakes sportfish consumption advisories.
- Most urban and local air pollutant concentrations are decreasing. However, population growth may impact future air pollution levels.



Photo credit: City of Toronto

## BIOTIC COMMUNITIES



Despite improvements in levels of contaminants in the Great Lakes, many biological components of the ecosystem are severely stressed. Populations of the native species near the base of the food web, such as *Diporeia* and species of zooplankton, are in decline in some of the Great Lakes.

Native preyfish populations have declined in all lakes except Lake Superior. Significant natural reproduction of lake trout is occurring in Lake Huron and Lake Superior only. Walleye harvests have improved but are still below fishery target levels. Lake sturgeon are locally extinct in many tributaries and waters where they once spawned and flourished. Habitat loss and deterioration remain the predominant threat to Great Lakes amphibian and wetland-dependent bird populations.

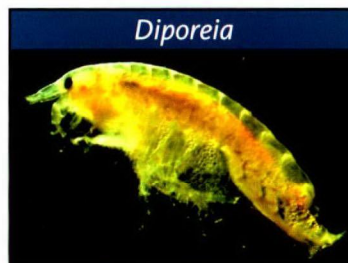
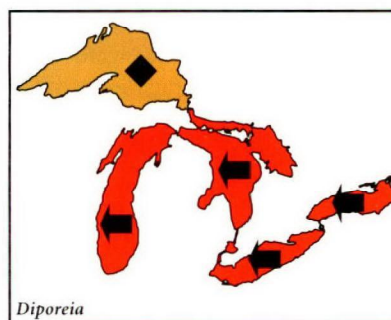
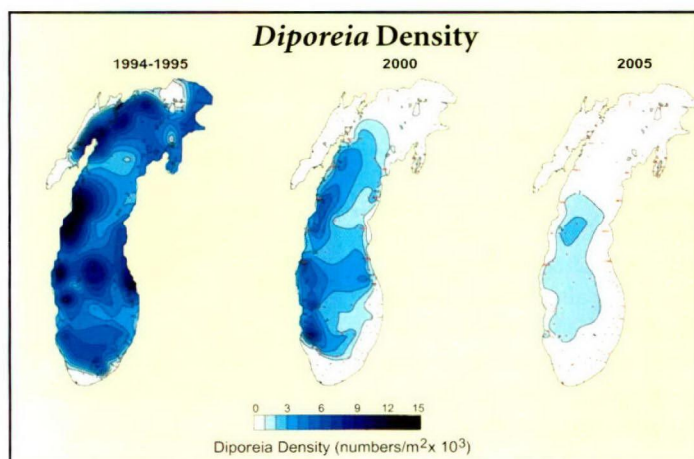


Photo credit: National Oceanographic and Atmospheric Administration

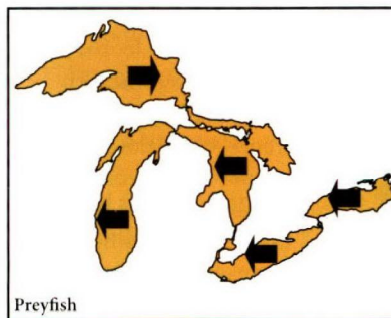
The aquatic food web is severely impaired in all the Great Lakes with the exception of Lake Superior. **Zooplankton** populations have declined dramatically in Lake Huron, and a similar decline is occurring in Lake Michigan.

Populations of *Diporeia*, the dominant native benthic (bottom-dwelling) invertebrate in offshore waters, continue to decline in Lake Huron, Lake Michigan, and Lake Ontario, and they may be locally extinct in Lake Erie.

The decline of *Diporeia* coincides with the introduction of non-native zebra and quagga mussels. Both zooplankton and *Diporeia* are crucial food sources for many other species, so their population size and health impact the entire system.



Source: State of the Great Lakes 2007 report

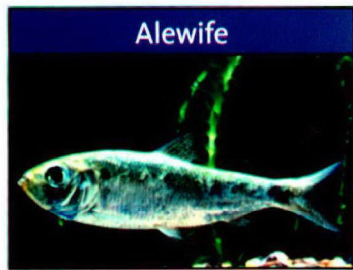


The current mix of native and non-native (stocked and naturalized) prey and predator fish species in the system has confounded the natural balance within most of the Great Lakes. In all but Lake Superior, native **preyfish** populations have deteriorated.

However, the recent decline of non-native preyfish (alewife and smelt) abundance in all Great Lakes except Lake Superior could have positive impacts on other preyfish populations. Preyfish populations are important for their role in supporting predator fish populations, so the potential effects of these changes will be a significant factor to be considered in fisheries management decisions.



Despite basin-wide efforts to restore **lake trout** populations that include stocking, harvest limits, and sea lamprey management, lake trout have not established self-sustaining populations in Lake Michigan, Lake Erie, and Lake Ontario. In Lake Huron,

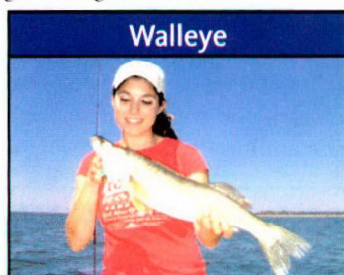


**Alewife**

Photo credit: (c) Shedd Aquarium/  
www.fishphotos.org

substantial and widespread natural reproduction of lake trout was observed starting in 2004 following the near collapse of alewife populations. This change may have been due to the reduced predation on juvenile lake trout by adult alewives and the alleviation of a trout vitamin deficiency problem caused by trout consuming alewives. In Lake Superior, lake trout stocks have recovered such that hatchery-reared trout are no longer stocked.

Reductions in phosphorus loadings during the 1970s substantially improved spawning and nursery habitat for many fish species in the Great Lakes. **Walleye** harvests have improved but are still below target levels. **Lake sturgeon** are now locally extinct in many tributaries and waters where they once spawned and flourished, although some remnant lake sturgeon populations exist throughout the Great Lakes. Spawning and rearing habitats have been destroyed, altered or access to them blocked. Habitat restoration is required to help re-establish vigorous lake sturgeon populations.



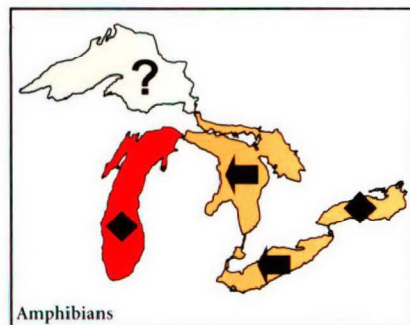
**Walleye**

Photo credit: Ohio Sea Grant



**Lake Sturgeon**

Photo credit: (c) Shedd Aquarium/  
www.fishphotos.org

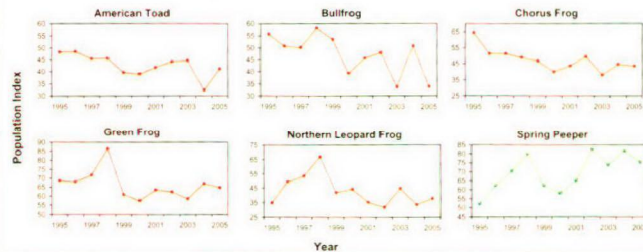


**Amphibians**

From 1995 to 2005, the American toad, bullfrog, chorus frog, green frog, and northern leopard frog exhibited significantly declining population trends while the spring peeper was the only amphibian species that exhibited a significantly increasing population

trend in Great Lakes coastal wetlands. For this same time period, 14 species of wetland-dependent birds exhibited significantly declining population trends, while only six species exhibited significantly increasing population trends.

## Trends of Amphibian Species from 1995–2005

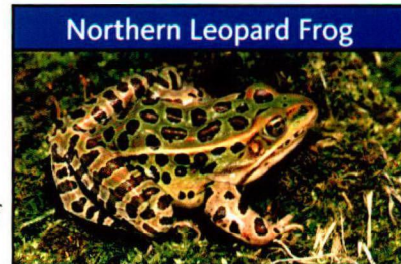


Source: State of the Great Lakes 2007 report

The Great Lakes are now facing a challenge from viral hemorrhagic septicemia (VHS). This virus has affected at least 37 fish species and is associated with fish kills in Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario, and the St. Lawrence River.

## Management Challenges:

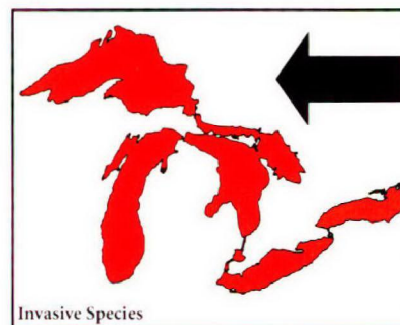
- Management actions to address the decline of *Diporeia* may be ineffective until the underlying causes of the declines are identified.
- The decline of *Diporeia* coincides with the spread of non-native zebra and quagga mussels. Cause and effect linkages between non-native species in the Great Lakes and ecological impacts may be difficult to establish.
- Identification of remnant lake sturgeon spawning populations should assist the selection of priority restoration activities to improve degraded lake sturgeon spawning and rearing habitats.
- Protection of high-quality wetland habitats and adjacent upland areas will help support populations of wetland-dependent birds and amphibians.



**Northern Leopard Frog**

Photo credit: Lang Elliot, NatureSound Studio

## INVASIVE SPECIES



**Invasive Species**

Activities associated with shipping are responsible for over one-third of the aquatic non-native species introductions to the Great Lakes. Total numbers of non-native species introduced and established in the Great Lakes have increased steadily since the 1830s. However, numbers of ship-introduced aquatic species have increased exponentially





during the same time period. High population density, high-volume transport of goods, and the degradation of native ecosystems have also made the Great Lakes region vulnerable to invasions from terrestrial non-native species. Introduction of these species is one of the greatest threats to the biodiversity and natural resources of this region, second only to habitat destruction.

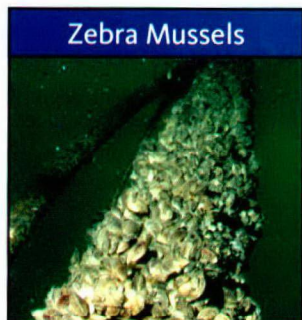


Photo credit: Environment Canada, Technical Operations

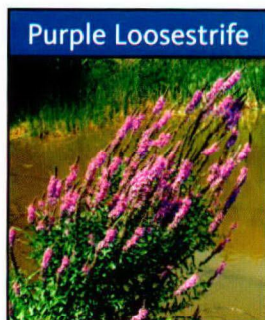
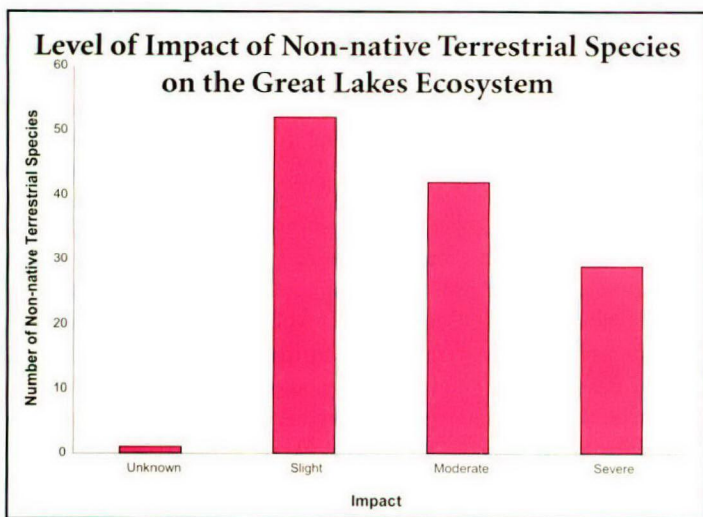
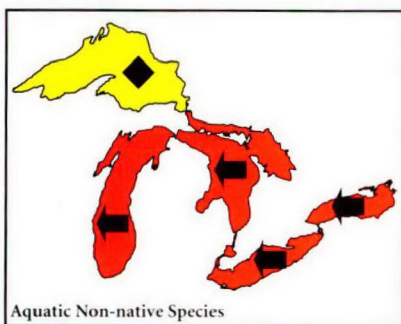


Photo credit: Michigan Sea Grant



Source: State of the Great Lakes 2007 report



Aquatic Non-native Species

There are currently 183 known aquatic and 124 known terrestrial **non-native species** that have become established in the Great Lakes basin. Non-native species are pervasive throughout the Great Lakes basin, and they continue to exert impacts on native species

and communities. Approximately 10 percent of aquatic non-native species are considered invasive and have an adverse effect, causing considerable ecological, social, and economic burdens.

Both aquatic and terrestrial wildlife habitats are adversely impacted by invasive species. The terrestrial non-native **emerald ash borer**, for example, is a tree-killing beetle that has killed

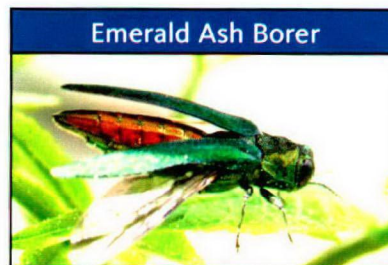
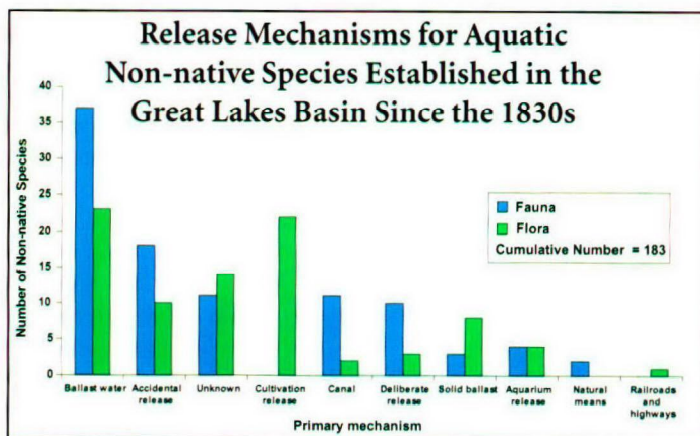


Photo credit: Dave Cappaert, Michigan State University

more than 15 million trees in the state of Michigan alone as of 2005. The emerald ash borer probably arrived in the United States on solid wood packing material carried in cargo ships or airplanes originating from its native Asia.

Introductions of non-native invasive species as a result of world trade and travel have increased steadily since the 1830s and will continue to rise if prevention measures are not improved. The Great Lakes basin is particularly vulnerable to non-native invasive species because it is a major pathway of trade and is an area that is already disturbed.



Source: State of the Great Lakes 2007 report

## Management Challenges:

- A better understanding of the entry routes of non-native invasive species would aid in their control and prevention.
- Prevention and control require coordinated regulation and enforcement efforts to effectively limit the introduction of non-native invasive species.
- Prevention of unauthorized ballast water exchange by ships will eliminate one key pathway of non-native aquatic species introductions to the Great Lakes.
- The unauthorized release, transfer, and escape of introduced aquatic non-native species and private sector activities related to aquaria, garden ponds, baitfish, and live food fish markets need to be considered.

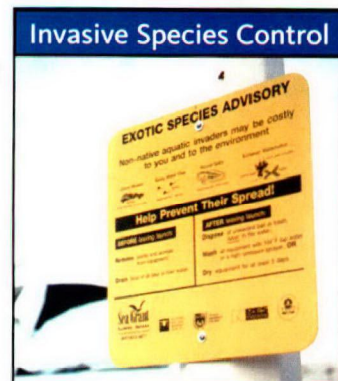


Photo credit: P. Charlebois, Illinois Natural History Survey/Illinois-Indiana Sea Grant



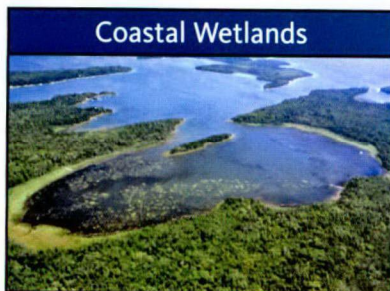
## COASTAL ZONES AND AQUATIC HABITATS



*Coastal habitats are degraded due to development, shoreline hardening and establishment of local populations of non-native invasive species. Wetlands continue to be lost and degraded. In addition to providing habitat and feeding areas for many*

*species of birds, amphibians and fish, wetlands also serve as a refuge for native mussels and fish that are threatened by non-native invasive species.*

The Great Lakes coastline is more than 17,000 kilometers (10,563 miles) long. Unique habitats include more than 30,000 islands, over 950 kilometers (590 miles) of cobble beaches, and over 30,000 hectares (74,131 acres) of sand dunes. Each **coastal zone** region is subject to a combination of human and natural stressors such as agriculture, residential development, point and non-point sources of pollution, and weather patterns. The coastal zone is heavily stressed, with many of the basin's 42 million people living along the shoreline.

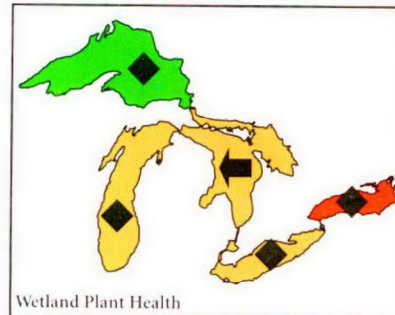


**Coastal Wetlands**

Photo Credit: Ted Cline

Wetlands are essential for proper functioning of aquatic ecosystems. They provide a refuge for native fish and mussels from non-native predators and competitors. The Great Lakes coastline includes more than 200,000 hectares (494,000 acres) of **coastal wetlands**, less than half of the amount of wetland area that existed prior to European settlement of the basin. An inventory of Great Lakes coastal wetlands in 2004 demonstrated that Lake Huron and Lake Michigan still have extensive wetlands,

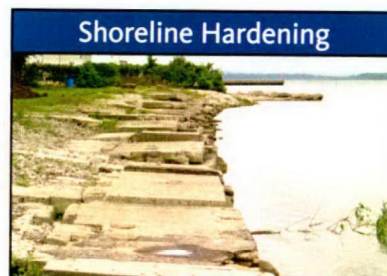
especially barrier-protected wetlands. Reductions in wetland area are occurring, however, due to filling, conversion to urban, residential, and agricultural uses, shoreline modification, water level regulation, non-native species invasions, and nutrient loading. Stressors, such as these, may also impact the condition of remaining wetlands and can threaten their natural function.



Coastal wetland plant community health, which is indicative of overall coastal wetland health, varies across the Great Lakes basin. In general, there is deterioration of native plant diversity in many wetlands as shoreline alterations may cause habitat degradation

and allow for easier invasion by non-native species.

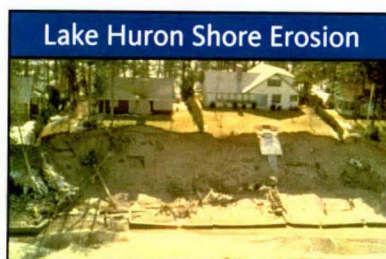
Naturally fluctuating **water levels** are essential for maintaining the ecological health of Great Lakes shoreline ecosystems, especially coastal wetlands. Wetland plants and biota have adapted to seasonal and long-term water level fluctuations, allowing wetlands to be more extensive and more productive than they would be if water levels were stable. In 2000, Great Lakes water levels were lower than the 140-year average water level measured from 1860-2000. Furthermore, many climate change models predict lower water levels for the Great Lakes. Coastal wetlands that directly border the lakes and do not have barrier beaches may be able to migrate toward the lakes in response to lower water levels. Inland and enclosed wetlands would likely dry up and become arable or forested land.



**Shoreline Hardening**

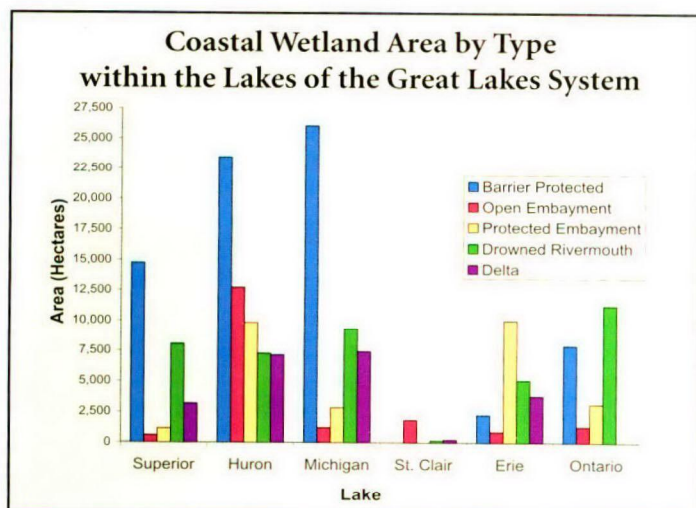
Photo credit: Environment Canada

**Shoreline hardening**, primarily associated with artificial structures that attempt to control erosion, can alter sediment transport in coastal regions. When the balance of accretion and erosion of sediment carried along the shoreline by wave action and lake currents is disrupted, the ecosystem functioning of coastal wetlands is impaired. The St. Clair, Detroit, and Niagara Rivers have a higher percentage of their shorelines hardened than anywhere else in the basin.



**Lake Huron Shore Erosion**

Photo credit: Environment Canada



Source: State of the Great Lakes 2007 report





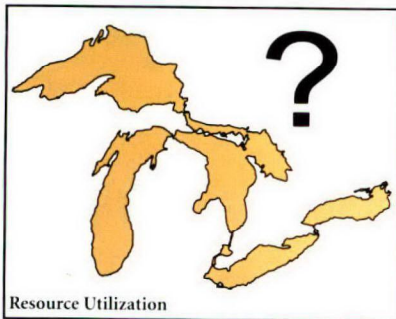
Of the five Great Lakes, Lake Erie has the highest percentage of its shoreline artificially hardened, and Lake Huron and Lake Superior have the lowest percentages artificially hardened.

**Groundwater** is critical for maintaining Great Lakes aquatic habitats, plants and animals. Human activities such as groundwater withdrawals for municipal water supplies and irrigation, and the increased proportion of impervious surfaces in urban areas, have detrimentally impacted groundwater. On a larger scale, climate change could further contribute to reductions in groundwater storage.

## Management Challenges:

- Despite improvements in research and monitoring of coastal zones, the basin lacks a comprehensive plan for long-term monitoring of these areas. Long-term monitoring should be an important component of a comprehensive plan to maintain the condition and integrity of the coastal zones and aquatic habitats.
- An educated public is essential to ensuring wise decisions about the stewardship of the Great Lakes basin ecosystem.
- Protection of groundwater recharge areas, conservation of water resources, informed land use planning, raising of public awareness, and improved monitoring are essential actions for improving groundwater quality and quantity.

## RESOURCE UTILIZATION



*Although water withdrawals have decreased, overall energy consumption is increasing as population and urban sprawl increase throughout the Great Lakes basin. Human population growth will lead to an increase in the use of natural resources.*

The population of the Great Lakes basin is approximately 42 million. Growth forecasts for the western end of Lake Ontario (known as the Golden Horseshoe) predict that this portion of the Canadian population will grow by an additional 3.7 million people by 2031. **Population size**, distribution, and density are contributing factors to resource use in the basin, although many trends have not been adequately assessed. In general, resource use is connected to economic prosperity and consumptive behaviors.

Although the Great Lakes and their tributaries contain 20 percent of the world's supply of surface freshwater, less than one percent of these waters is renewed annually through

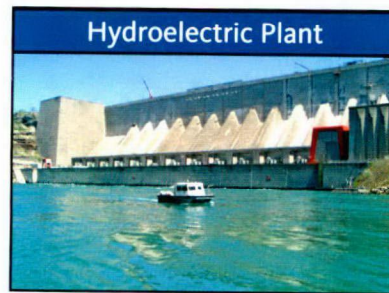
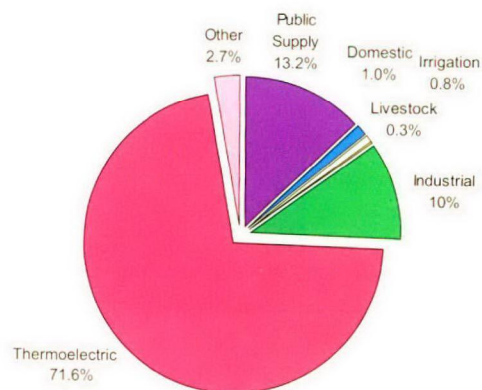


Photo credit: Environment Canada

precipitation, run-off and infiltration. The net basin water supply is estimated to be 500 billion liters (132 billion gallons) per day. In 2000, water from the Great Lakes was used at a rate equal to approximately 35 percent of the available daily supply. The majority of **water withdrawn** is returned to the basin through discharge or run-off. However, approximately seven percent is lost through evapo-transpiration or depleted by human activities. Due to the shutdown of nuclear power facilities and improved water efficiency at thermal power plants, water use in Canada and the United States has decreased since 1980. In the future, increased pressures on water resources are expected to come from population growth in communities bordering the basin, and from climate change.

## Water Withdrawals in the Great Lakes Basin, by Sector Category as a Percentage of Total, 2000



Note: The majority of the water withdrawn is returned to the basin.

Source: State of the Great Lakes 2007 report

Population size, geography, climate, and trends in housing size and density all affect the amount of **energy consumed** in the basin. Electricity generation was the largest energy-consuming sector in the Great Lakes basin due to the energy required to convert fossil fuels to electricity.

## Total Secondary Energy Consumption in the Great Lakes Basin, in Megawatt-hours (MWh)

Sector	U.S. Basin Total Energy Consumption - 2000	Canadian Basin Total Energy Consumption - 2002
Residential	478,200,000	127,410,000
Commercial	314,300,000	107,800,000
Industrial	903,900,000	206,410,000
Transportation	714,000,000	184,950,000
Electricity Generation	953,600,000	303,830,000

Source: State of the Great Lakes 2007 report



# State of the Great Lakes 2007

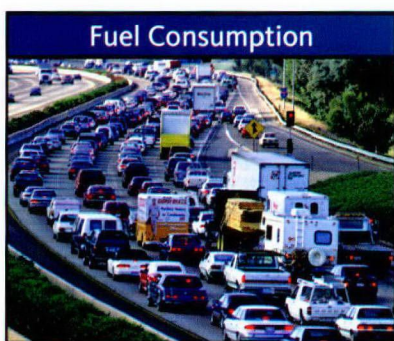
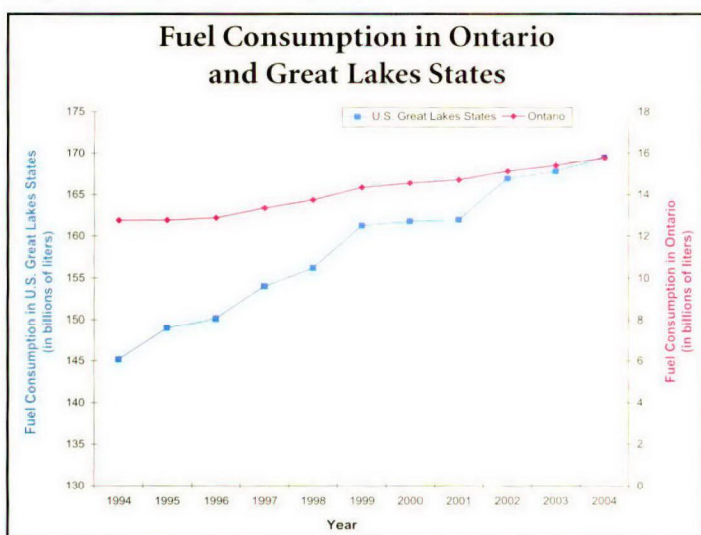


Photo credit: Microsoft Office Clipart

Population growth and urban sprawl in the basin have led to an increase in the number of **vehicles on roads, fuel consumption, and kilometers/miles traveled**. Over a ten year period (1994-2004) fuel consumption increased by 17 percent in the U.S. states bordering the Great Lakes

and by 24 percent in the province of Ontario. Kilometers/miles traveled within the same areas increased 20 percent for the United States and 56 percent for Canada. The increase in registered vehicles continues to outpace the increase in licensed drivers.



Source: State of the Great Lakes 2007 report

## Management Challenges:

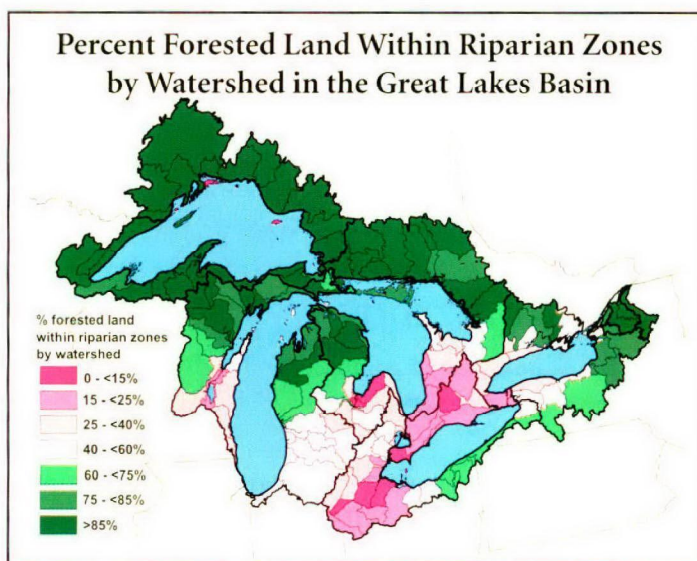
- Increasing requests for water from communities bordering the basin where existing water supplies are scarce or of poor quality will require careful evaluation.
- Energy production and conservation need to be carefully managed to meet current and future energy consumption demands.
- Population growth and urban sprawl are expected to challenge the current and future transportation systems and infrastructures in the Great Lakes basin.

## LAND USE-LAND COVER



The Great Lakes basin encompasses an area of more than 765,000 square kilometers (295,000 square miles). How land is used impacts not only water quality of the Great Lakes, but also biological productivity, biodiversity, and the economy.

Data from 1992 and 2002 indicate that **forested land** covered 61 percent of the Great Lakes basin and 70 percent of the land immediately buffering surface waters, known as riparian zones. The greater the forest coverage in a riparian zone, the greater the capacity for the watershed to maintain biodiversity, store water, regulate water temperatures, and limit excessive nutrient and sediment loadings to the waterways. Urbanization, seasonal home construction, and increased recreational use are among the general demands being placed on forest resources nationwide. Additional disturbances caused by lumber removal and forest fires can also alter the structure of Great Lakes basin forests. However, the area of forested lands certified under sustainable forestry programs has significantly increased in recent years, exemplifying continued commitment from forest industry professionals to practices that help protect local ecosystem sustainability. Continued growth in these practices will lead to improved soil and water resources and increased timber productivity in areas of implementation.



Source: State of the Great Lakes 2007 report

Under the pressure of rapid population growth in the Great Lakes region, **urban development** has undergone unprecedented growth. Sprawl is increasing in rural and urban fringe areas of the Great Lakes basin, placing a strain on infrastructure and consuming habitat in areas that tend to have healthier environments than those that remain in urban areas. This trend is expected to continue, which will exacerbate other problems, such as longer commute times

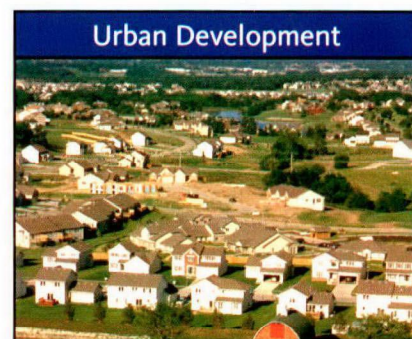


Photo Credit: Lynn Betts, courtesy of the Natural Resources Conservation Service





from residential to work areas, increased consumption of fossil fuels, and fragmentation of habitat. For example, at current development rates in Ontario, residential building projects are predicted to consume some 1,000 square kilometers (386 square miles) of the countryside, an area double the size of Toronto, by 2031. Also, vehicle gridlock could increase commuting times by 45 percent, and air quality could decline due to an estimated 40 percent increase in vehicle emissions.

In 2006, The Nature Conservancy Great Lakes Program and the Nature Conservancy of Canada Ontario Region released the *Binational Conservation Blueprint for the Great Lakes*. The Blueprint identified 501 areas across the Great Lakes that are a priority for biodiversity conservation. The Blueprint was developed by scientifically and systematically identifying native species, natural communities, and aquatic system characteristics of the region, and determining the sites that need to be preserved to ensure their long-term survival.

## Management Challenges:

- As the volume of data on land use and land conversion grows, stakeholder discussions will assist in identifying the associated pressures and management implications.
- Comprehensive land use planning that incorporates “green” features, such as cluster development and greenway areas, will help to alleviate the pressure from development.
- Managing forest lands in ways that protect the continuity of forest cover can allow for habitat protection and wildlife species mobility, therefore maintaining natural biodiversity.
- Policies that favor an economically viable forestry industry will motivate private and commercial landowners to maintain land in forest cover versus conversion to alternative uses such as development.

## CLIMATE CHANGE

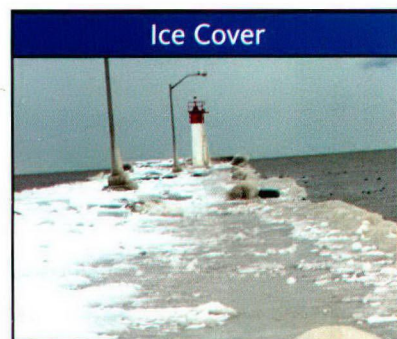


Photo credit: Environment Canada

*A qualitative assessment of the indicator category Climate Change could not be supported for this report because the indicators are incomplete at this time. Some observed effects in the Great Lakes region, however, have been attributed to changes in climate. Winters are getting shorter; annual average temperatures are*

*growing warmer; extreme heat events are occurring more frequently; duration of lake ice cover is decreasing as air and water temperatures are increasing; and heavy precipitation events, both rain and snow, are becoming more common.*



Photo credit: National Aeronautics and Space Administration Goddard Space Flight Center, MODIS Rapid Response

Continued declines in the duration and extent of ice cover on the Great Lakes and possible declines in lake levels due to

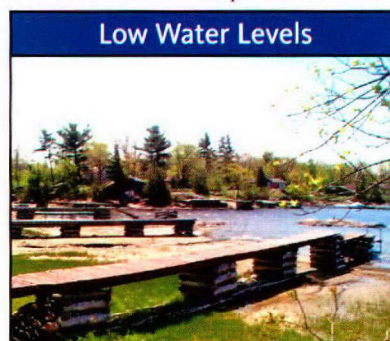


Photo credit: Environment Canada

evaporation during the winter are expected to occur in future years. If water levels decrease as predicted with increasing temperature, shipping revenue may decrease and the need for dredging could increase. Northward migration of species naturally found south of the Great Lakes region and invasions by warm water, non-native aquatic species will likely increase the stress on native species. A change in the distribution of forest types and an increase in forest pests are expected. An increase in the frequency of winter run-off and intense storms may deliver more non-point source pollutants to the lakes.

## Management Challenges:

- Increased modeling, monitoring, and analysis of the effects of climate change on Great Lakes ecosystems would aid in related management decisions.
- Increased public awareness of the causes of climate change may lead to more environmentally-friendly actions.



## What is Being Done to Improve Conditions

*In an effort to restore and preserve the Great Lakes, legislators, managers, scientists, educators and numerous others are responding to environmental challenges with multifaceted solutions. The responses and actions referenced here are intended to serve as examples of positive strides being taken in the Great Lakes basin to improve ecosystem conditions. Examples from both Canada and the United States and from each of the Great Lakes are included. There are many more actions that could have been recognized in this report. Each is an important part of our collective commitment to a clean and healthy Great Lakes ecosystem.*

Canada and the United States implement numerous **actions** across the basin at national, regional and local scales. For example, in Ontario, the City of Toronto is addressing water pollution through the Wet Weather Flow Management Master Plan, a long-term solution to reduce pollution from stormwater and combined sewer overflows.

Communities, states, the U.S. Environmental Protection Agency and local industry are working together to remediate contaminated sediments in U.S. Areas of Concern (AOCs) with funding provided through the U.S. Great Lakes Legacy Act. Since inception of the Act in 2002, sediment remediation has been completed at three U.S. AOC sites (Ruddiman Creek and Ruddiman Pond in Michigan, Black Lagoon in Michigan, and Newton Creek and Hog Island Inlet in Wisconsin).

The Oswego River AOC on Lake Ontario was delisted in 2006, the first removal of an AOC designation in the United States. In Canada, two AOCs have been delisted, both on Lake Huron (Collingwood Harbour in 1994 and Severn Sound in 2003). Delisting of an AOC occurs when environmental monitoring has confirmed that the remedial actions taken have restored the beneficial uses in the area and that locally derived goals and criteria have been met.

Forestland Group (a limited partnership), collaborated in a sale and purchase agreement that created the largest conservation project in Michigan's history. This purchase will protect more than 110,000 hectares (271,000 acres) through a working forest easement on 100,362 hectares (248,000 acres) and acquisition of 9,445 hectares (23,338 acres) in the Upper Peninsula of Michigan. By connecting approximately one million hectares (2.5 million acres), the project curbs land fragmentation and incompatible development by establishing buffers around conservation sites such as the Pictured Rocks National Lakeshore and Porcupine Mountains Wilderness State Park.

### Electronic Waste Collection



Photo credit: Superior Watershed Partnership

Lake Superior **communities** have embraced a goal of zero discharge of critical chemical pollutants by engaging in a number of actions to remove contaminants. Efforts to reach this goal have included electronic and hazardous waste collection events run by Earth

Keepers, a faith-based environmental initiative, which is based in the Upper Peninsula of Michigan. On Earth Day 2006, over 272 metric tons (300 U.S. tons) of household hazardous waste, primarily household electronics, were collected and properly disposed or recycled. In Canada, through Ontario's mercury Switch Out program, more than 11,500 mercury switches from scrap automobiles were collected in 2005.

### Water Sampling



Photo credit: U.S. Environmental Protection Agency Great Lakes National Program Office

**Research, monitoring and assessment** efforts operating at various geographic scales are the backbone of management actions and decisions in the basin. Coordinated monitoring among Canadian and United States federal, provincial, state, and university groups began in 2003 to focus on

monitoring physical, biological, and chemical parameters with monitoring occurring on a five-year rotation of one Great Lake per year. A binational Great Lakes Monitoring Inventory has been established that currently provides information on 1,137 monitoring programs in the basin. The International Joint Commission maintains a Great Lakes – St. Lawrence Research Inventory of the many funded projects that help increase our knowledge about the structure and function of the Great Lakes ecosystem.

**Strategic planning** occurs at basin-wide, lake-wide and local scales. An example of strategic planning is the Canada-Ontario Agreement, a federal-provincial agreement that supports the

### Varrick Dam North, Oswego River

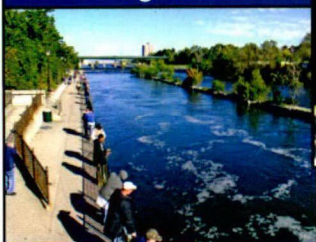


Photo credit: U.S. Environmental Protection Agency, Great Lakes National Program Office

### EnviroPark, Collingwood

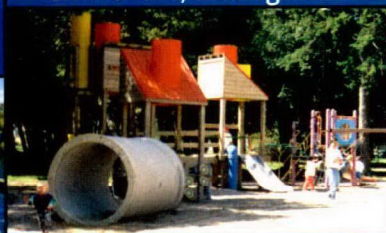


Photo credit: Environment Canada

### Wye Marsh, Severn Sound



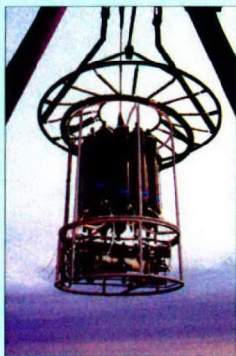
Photo credit: Environment Canada

Effective actions are often based on **collaborative work**. In 2005, The Nature Conservancy, the State of Michigan and The



## Monitoring the Pulse of the Great Lakes

# Sampling Equipment used aboard the R/V Lake Guardian



### Rosette Sampler

The rosette sampler is used to collect water samples for chemical and biological parameters (nutrients, phytoplankton, chlorophyll *a*, and dissolved oxygen) and physical parameters (temperature, total suspended solids, turbidity, specific conductance, and pH). Attached to the sampling apparatus is the Seabird

multiparameter sensor array that records depth, temperature, dissolved oxygen, optical transmittance, photosynthetically active radiation (PAR), pH, electrical conductivity, chlorophyll fluorescence, and distance from bottom. The latitude, longitude, date, time, and number of water samples collected are also recorded automatically.



### Plankton Nets

Plankton nets are used to collect the small organisms that form the base of lake food webs: phytoplankton (algae) and zooplankton (small animals). Plankton are evaluated for their abundance, diversity, and overall health, since the base of the food web supports the entire lake ecosystem.



### Sediment Grabs and Cores

The PONAR grab sampler and the box core (shown here) are two devices used to collect bottom sediment. The PONAR grab sampler retrieves a small amount of surface sediment and is used to collect benthic (bottom-dwelling) invertebrates. The box core collects a much larger and deeper section of sediment without disrupting the sediment surface. Box core subsamples are used for analysis of contaminants in the sediment and collection of benthic invertebrates.



### Mysis & Diporeia Sled

The sled with its large mesh bag is towed along the lake bottom to collect two of the larger crustaceans present in the Great Lakes: *Mysis* and *Diporeia*. Both animals are crucial components of the food

web, therefore their population size and health impact the entire Great Lakes ecosystem.



### Air Samplers

High volume air samplers are used to collect air pollutants in the particle and gas forms. A vacuum pump pulls air through a filter and then through an adsorbent. The filter captures particles and the adsorbent captures

pollutants in the gas form. The adsorbent and filter are sent to a separate laboratory for analyses. The air samplers are mounted on a boom that is extended over the bow of the ship. Scientists measure the concentrations of pollutants in air to determine the amount of pollutants deposited from the air to the Great Lakes.

Educational materials like these are available from Illinois-Indiana Sea Grant at [www.iisgcp.org](http://www.iisgcp.org). This poster series was produced in cooperation with the Illinois-Indiana Sea Grant College Program.

Photo credits:

U.S. EPA Great Lakes National Program Office

IISG-05-21

**Sea Grant**  
ILLINOIS-INDIANA





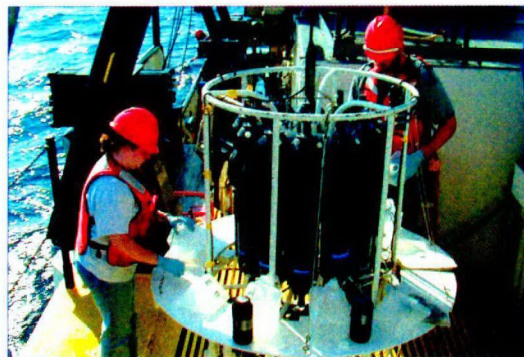
# U.S. EPA Great Lakes National Program Office Limnology Program

## Monitoring Great Lakes Water Quality

Clean water and a healthy food web are fundamental to the health of the Great Lakes. The U.S. EPA Great Lakes National Program Office (GLNPO) Limnology Program monitors the status of key environmental parameters that influence water quality, the food chain, and fish of the Great Lakes. Water is collected annually from sampling stations in each lake in the spring and summer. The EPA research vessel *Lake Guardian* is used to conduct the monitoring surveys.

The objectives of the GLNPO Limnology Program are to:

- Monitor the water quality in the lakes.
- Evaluate trends and annual changes in chloride, nitrogen, silica, phosphorus, chlorophyll *a*, and water clarity.
- Provide data for water quality models.
- Calculate the trophic state of each lake. The trophic state is indicative of the amount of living material supported within a lake, primarily in the form of algae.



Scientists use a rosette sampler to collect water from the Great Lakes.



The U.S. EPA R/V Lake Guardian.



GLNPO's Open Lake Water Quality Survey sampling stations.

Educational materials like these are available from Illinois-Indiana Sea Grant at [www.iisgcp.org](http://www.iisgcp.org). This poster series was produced in cooperation with the Illinois-Indiana Sea Grant College Program.

Photo credits:

U.S. EPA Great Lakes National Program Office

IISG-06-08

Sea Grant  
ILLINOIS-INDIANA

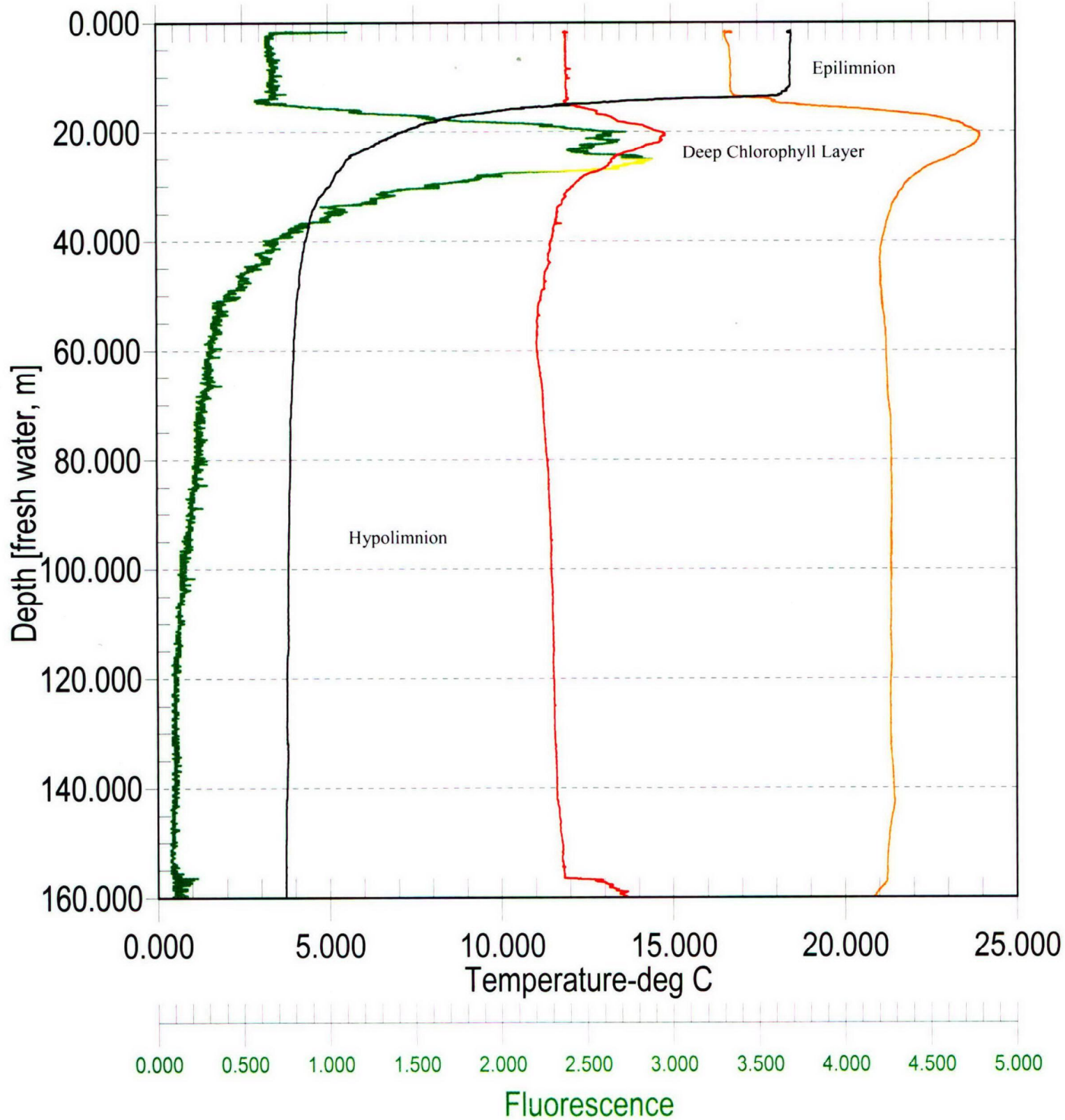




# Lake Michigan Deep Station - Summer

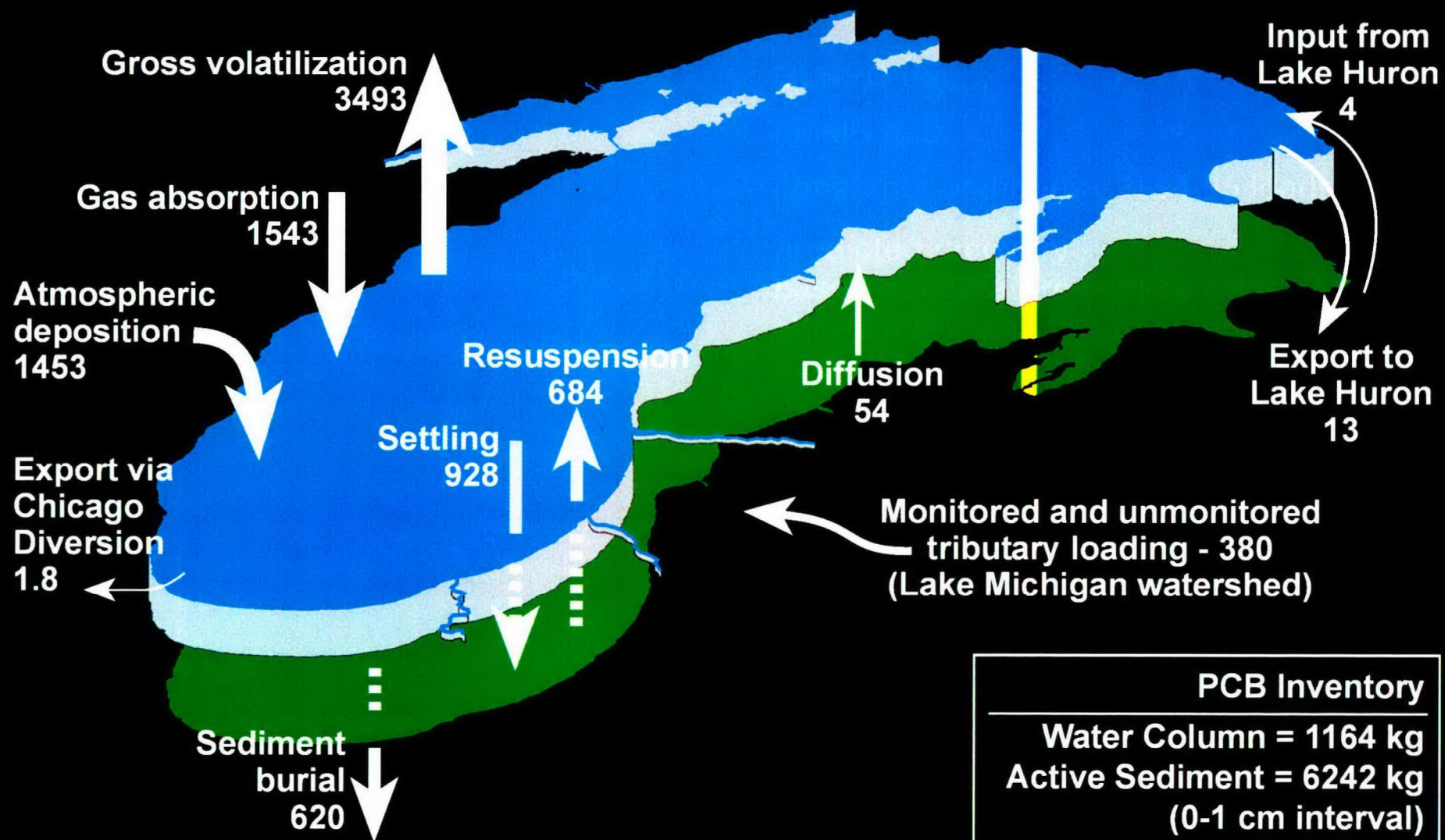
Oxygen-mg/l  
0.000 3.000 6.000 9.000 12.000 15.000

Beam Attenuation/Particles  
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000 4.500 5.000



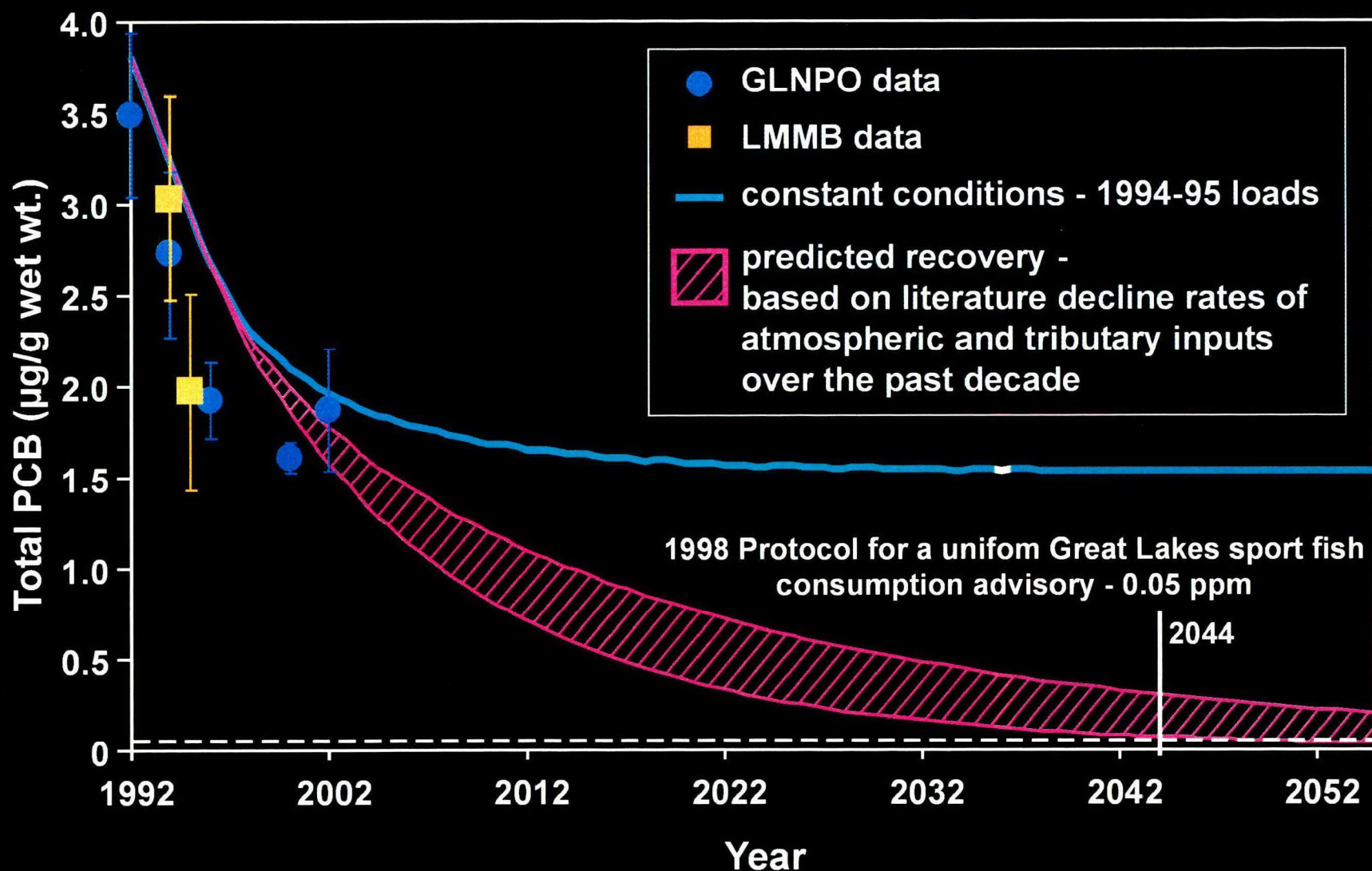


# PCB Mass Balance (kg/yr) for 1994-1995





# Predicted PCB Concentrations in Age 5.5 Lake Michigan Lake Trout at Saugatuck





restoration, protection, and conservation of the Great Lakes basin ecosystem. To achieve the collective goals and results, Canada and Ontario work closely with local and regional governments, industry, community and environmental groups. In the United States, more than 140 different federal programs help fund and implement environmental restoration and management activities in the basin. The Great Lakes Water Quality Agreement, Great Lakes Regional Collaboration and Federal Task Force, Great Lakes Binational Toxics Strategy, Lakewide Management Plans, Binational Partnerships, and Remedial Action Plans are other examples of strategic planning in the Great Lakes basin.

In many cases management and conservation actions are based on or supported by federal, state, provincial, or local **legislation**. For example, Ontario's Greenbelt Act of 2005 enabled the creation of a Greenbelt Plan to protect about 728,437 hectares (1.8 million acres) of environmentally-sensitive and agricultural land in the Golden Horseshoe region from urban development and sprawl. The Plan includes and builds upon approximately 324,000 hectares (800,000 acres) of land within the Niagara Escarpment Plan and the Oak Ridges Moraine Conservation Plan.

Proving that some **legislation** effectively crosses national borders, in December, 2005, the Great Lakes Governors and Premiers signed the *Annex 2001 Implementing Agreements* at the Council of Great Lakes Governors Leadership Summit that will provide unprecedented protection for the Great Lakes–St. Lawrence River basin. The agreements detail how the states and provinces will manage and protect the basin and provide a framework for each state and province to enact laws for its protection, once the agreement is ratified.

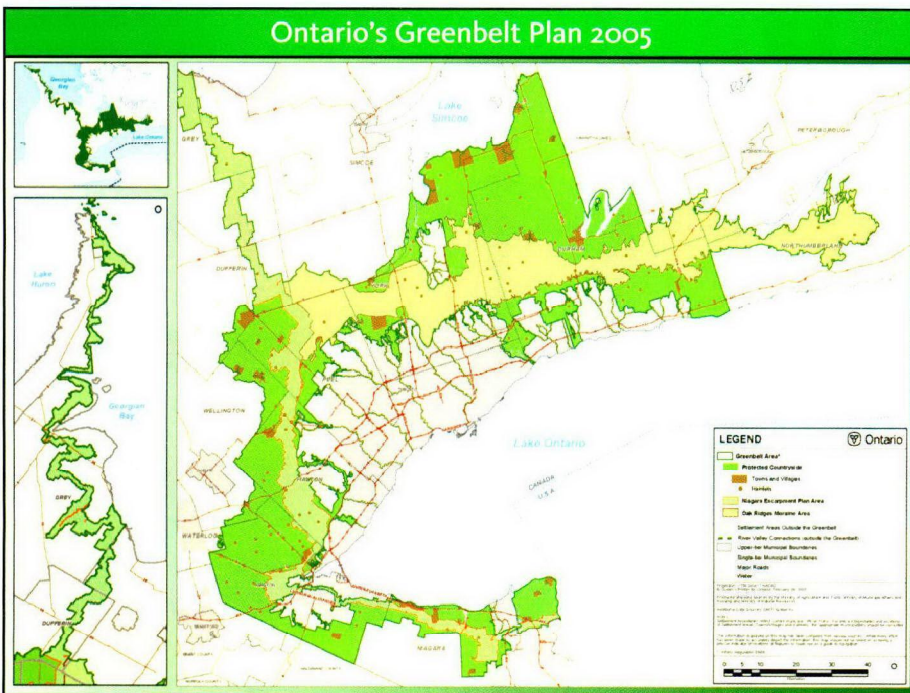
**Education and outreach** about Great Lakes environmental issues are essential actions for fostering both a scientifically-

literate public as well as informed decision-makers. The Lake Superior Invasive-Free Zone Project involves community groups in the inventorying and control of non-native invasive terrestrial and emergent aquatic plants through education. The project combines Canadian and United States programs at federal, state, provincial, municipal, and local levels and has the goal of eliminating non-native plants within a designated 291 hectare (720 acre) area.

A shoreline stewardship manual developed for the southeast shore of Lake Huron and promoted through workshops and outreach programs encourages sustainable practices to improve and maintain the quality of groundwater and surface water and the natural landscape features that support them. The Lake Huron Stewardship Guide is a collaborative effort by the Huron County Planning Department, the University of Guelph, the Huron Stewardship Council, the Ausable Bayfield Conservation Authority, the Lake Huron Centre for Coastal Conservation, and the Friends of the Bayfield River, and a high level of community engagement has been instrumental in its success.

The Great Lakes Conservation Initiative of the Shedd Aquarium in Chicago aims to draw public attention to the value and vulnerabilities of the Great Lakes. With collaboration by Illinois-Indiana Sea Grant and the U.S. Fish and Wildlife Service, the Shedd Aquarium opened a new exhibit in 2006 which features many of the invasive species found in the Great Lakes. This exhibit provides public audiences with the opportunity to see many of these live animals and plants, and is also highlighted in teacher workshops.

As these examples show, there is much planning, information gathering, research and education occurring in the Great Lakes basin. Much more remains to be done to meet the goals of the GLWQA, but progress is being made with the involvement of all Great Lakes stakeholders.



Source: Ontario Ministry of Municipal Affairs and Housing



## State of the Lakes Ecosystem Conference

The State of the Lakes Ecosystem Conferences (SOLEC) are hosted by the U.S. Environmental Protection Agency and Environment Canada every two years in response to the reporting requirements of the Great Lakes Water Quality Agreement.

The conferences and reports provide independent, science-based reporting on the state of the health of the Great Lakes basin ecosystem. Four objectives for the SOLEC process include:

- To assess the state of the Great Lakes ecosystem based on accepted indicators
- To strengthen decision-making and environmental management concerning the Great Lakes
- To inform local decision makers of Great Lakes environmental issues
- To provide a forum for communication and networking amongst all the Great Lakes stakeholders

The role of SOLEC is to provide clear, compiled information to the Great Lakes community to enable environmental managers to make better decisions. Although SOLEC is primarily a reporting venue rather than a management program, many SOLEC participants are involved in decision-making processes throughout the Great Lakes basin.

For more information about Great Lakes indicators and the State of the Lakes Ecosystem Conference, visit:

[www.binational.net](http://www.binational.net)  
[www.epa.gov/glnpo/solec](http://www.epa.gov/glnpo/solec)  
[www.on.ec.gc.ca/solec](http://www.on.ec.gc.ca/solec)

# State of the Great Lakes 2007 Highlights

*by the Governments of*  
**Canada**  
*and*  
**The United States of America**

*Prepared by*  
**Environment Canada**  
*and the*  
**U.S. Environmental Protection Agency**

