Our GREAT LAKES

What is *happening* to them,
what it *means* and what *you*
can do to *help* keep them great

Canada

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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A report *to the public*

Under the Great Lakes Water Quality Agreement, the governments of the United States and Canada are working to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes ecosystem.

As Great Lakes citizens, we need a healthy Great Lakes ecosystem to ensure our own health, well-being, and economic security. The lakes were in decline during much of the 1900s, but decades of sustained efforts have been reversing the damage. People in both nations have put a tremendous effort into cleaning up our lakes and protecting them from pollution, habitat destruction, loss of native species, and invasions by non-native creatures. Governments at all levels have spent billions of dollars and assigned thousands of people to the task. Businesses and industry have spent similar sums to change products and production methods to reduce their impacts, and to clean up polluted areas. Community groups and non-governmental organizations have played important roles in the restoration of the Great Lakes.

The governments of Canada and the United States want to keep everyone in the Great Lakes area informed about what is happening to the lakes, why it is happening, what is being done to restore and protect them, and how all of us can reduce our environmental impacts. The federal governments collaborated with state and provincial governments, industry, Tribes and First Nations, and non-governmental organizations in writing this report. It discusses six key indicators of how the lakes are doing. These indicators relate to the questions that people ask most often about the Great Lakes, questions concerning the safety of drinking water and beach water, the edibility of fish, and the health of our fish, birds, and wildlife.

The final section of the report – "What Can You Do to Help?" – suggests some practical ways in which you can help keep our lakes cleaner and healthier. It is hoped that, once you have read this report, you will be inspired to take action to improve our common environment, for our own well-being and as a legacy to our children.

This report draws mainly from the *State of the Great Lakes 2003* report, which resulted from the State of the Lakes Ecosystem Conference (SOLEC)[1] process. Data in this report draws on information available at the time of initial publication. To view the full *State of the Great Lakes 2003* report, visit **http://binational.net.**

1. SOLEC, first held in 1994, is a biennial meeting of scientists, policy makers, academics, and representatives from industry, business, and non-profit organizations to discuss information on the state of the Great Lakes basin ecosystem, as partial fulfillment of the governments' responsibility to report under the Great Lakes Water Quality Agreement. Subsequent to the conference, a State of the Great Lakes report is produced.

About the Great *Lakes*

The Great Lakes basin, including the land that drains into the lakes, is one of the world's great ecological systems. Its unique mix of water, soils, minerals, and climates supports a wide array of plants and animals. This ecosystem sustains the lives of 33 million people, shaping our health, culture, and recreation, and was responsible for our economic development. The region is tremendously diverse, ranging from the wild Lake Superior shorelines in the north to the big cities and industrial centers in the south. The economy of the Great Lakes basin is diverse, ranging from fishing and farming to automotive manufacturing, and from tourism to banking.

The Great Lakes – *some vital statistics*

- The five Great Lakes - Superior, Michigan, Huron, Erie, and Ontario - hold one-fifth of the fresh water on the earth's surface and 80 percent of the lake and river water in North America. Less than 1 percent of the water in the Great Lakes, however, is replaced each year by precipitation.
- The Great Lakes basin, including the water and land area that drains into the lakes, covers 766,000 square kilometers (295,700 square miles). This area is bigger than Texas or any of Canada's three Prairie provinces.
- The shoreline of the five Great Lakes and the connecting rivers stretches for 17,000 kilometers (10,200 miles), long enough to reach nearly halfway around the world.
- The water of the Great Lakes flows from the middle of the continent to the Atlantic Ocean.
- The lakes contain the world's largest system of freshwater islands, some of which are refuges for rare and endangered species.
- The basin includes parts of the province of Ontario and eight states – Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin.
- The region is home to 30 percent of Canadians and 10 percent of Americans.
- About five million people fish in the Great Lakes.
- Close to one million boats, mainly pleasure craft, operate on the Great Lakes.

The Great Lakes *time line*

1850–1880 Primeval forests surrounding the Great Lakes are lost due to widespread logging. Severe erosion follows, resulting in rivers and streams being clogged with sediment. Water temperatures of once shaded rivers and streams increases making them unsuitable for some native fish. In addition, damming of rivers and streams prevents upstream passage of fish to spawning areas.

1900–1960 Settled and industrialized parts of the Great Lakes basin are degraded by pollution. The mix of fish and wildlife begins to change due to heavy fishing, toxic substances, and the impacts of non-native species such as the sea lamprey.

1909 Canada and the United States sign the Boundary Waters Treaty and create the International Joint Commission to help them deal with trans-boundary water issues. In subsequent years, the commission is repeatedly asked to report on the state of the Great Lakes.

1954 The two nations create the Great Lakes Fishery Commission to control sea lamprey and to foster good fisheries management in shared waters.

1959 Opening of the St. Lawrence Seaway allows big ocean-going vessels into the Great Lakes. The result is an increase in trade, but in their ballast water many ships bring invasive, non-native species and discharge them with the water into the lakes.

1960s A series of events focuses attention on the need to clean up the Great Lakes. These events include the "death" of Lake Erie because of phosphorus from detergents and sewage, and a fire on the oily surface of the Cuyahoga River in downtown Cleveland, Ohio.

1970s Toxic chemicals found in Great Lakes fish and wildlife spark concerns for both ecosystem and human health. A number of substances, such as DDT, PCBs, and mercury, are banned or controlled.

1972 First Canada – United States Great Lakes Water Quality Agreement leads to limits on phosphorus in detergents and a major expansion of sewage treatment systems.

1977 Populations of bald eagles and double-crested cormorants start to recover as the levels of some toxic pollutants fall in the Great Lakes.

1978 Second Great Lakes Water Quality Agreement deals more with toxic chemicals and sets a goal of protecting the entire ecosystem.

1980s–90s The sustainable development approach brings governments, industries, and non-governmental organizations together to solve Great Lakes problems. Chemical pollution is reduced, but non-native species, such as the zebra mussel, continue to invade the lakes.

1987 A protocol expands the Great Lakes Water Quality Agreement to cover airborne fallout and contaminated runoff from land. Governments agree to launch Remedial Action Plans to clean up polluted areas and develop indicators of ecosystem health. They also commit to creating Lakewide Management Plans to identify and eliminate critical pollutants, such as mercury, PCBs, and dioxins, that threaten human and ecosystem health.

1994 First SOLEC brings together scientists from around the region to develop reports on the health of the lakes. The first State of the Great Lakes report is published the following year.

1994 Collingwood Harbour on Ontario's Georgian Bay is the first polluted Area of Concern to be cleaned up and taken off the list of such areas, or "delisted."

1997 The Great Lakes Binational Toxics Strategy pledges collaboration among governments, First Nations and Tribes, and industries to work for the virtual elimination of persistent toxic substances resulting from human activities.

2002 Presque Isle Bay on Lake Erie is the first U.S. Area of Concern to be declared in the recovery stage. Spanish Harbour in northern Lake Huron receives a similar status. In both cases, natural processes will deal with the low levels of pollutants that remain.

2002 The governments of Canada and Ontario sign their sixth Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem. The agreement sets out an aggressive five-year action plan to restore and protect the Great Lakes.

2003 Severn Sound, also on Georgian Bay, is the second Area of Concern to be restored and removed from the list.

2004 United States President Bush signs Executive Order 13340, establishing a Cabinet level federal Interagency Task Force and Working Group. An effort to begin a Regional Collaboration of National Significance on the Great Lakes is underway.

2004 The Great Lakes Innovation Committee, a multistakeholder advisory committee formed under the Canada-Ontario Agreement, is created to enhance cooperation and coordination between government and interested parties and bring innovative approaches to overcoming barriers to achieving the agreement's goals and objectives.

Definitions:

Biological integrity – *the ability to support and maintain a balanced, integrated, and adaptive biological system having the full range of form and function expected in the natural habitat of an area.*

Ecosystem – *an area of air, land, and water in which living organisms, including humans, interact in a stable relationship. The Great Lakes basin ecosystem is made up of a mosaic of smaller ecosystems.*

Watershed – *a region bounded by heights of land and draining into a watercourse or body of water.*

How the Great Lakes *are doing*

By most measures, the Great Lakes are much healthier than they were a generation ago, particularly when it comes to chemical pollution. The answers to six key questions give a snapshot of how the lakes are doing:

Can we drink the *water?*

The Great Lakes are one of the world's finest sources of water. Treated drinking water from the lakes and the surrounding watershed is safe. We need to keep contaminants, especially bacteria, parasites, and viruses, out of drinking water sources.

Can we swim at the *beach?*

Most Great Lakes beaches are safe for swimming most of the time. Some beaches, however, are at times unfit for swimming because of high bacteria levels in the water. In some areas, particularly around cities and areas of intensive agriculture, beaches may be posted as unfit for swimming. Work to keep human and animal wastes out of the waters is continuing, and better monitoring is providing people with more timely and detailed information about beach conditions.

Can we eat the *fish?*

Pollution levels in Great Lakes fish have been dropping for 30 years due to controls on chemicals, and now more fish are safe to eat. However, a significant proportion of fish are still contaminated enough that they should be eaten in limited amounts or not at all.

How are the *fish doing?*

Some Great Lakes fish species, such as the lake trout, are showing signs of recovery in Lake Superior and parts of Lake Huron, while other species, such as the Lake Erie walleye, have been declining in recent years. Many smaller species that play an important role in the food chain are being affected negatively by non-native species.

How is the *wildlife doing?*

Due to reductions in the use of chemicals that damage their ability to reproduce, bald eagles once again soar over most Great Lakes shorelines. A number of other species are also recovering; in contrast, the black tern, American coot, marsh wren, and other species are declining, largely because of loss of wetlands and other important habitat.

How are *non-native species* affecting the Great Lakes?

More than 160 non-native species live in the Great Lakes, and more continue to arrive. Some are causing serious disruptions among native species, as well as economic damage. The impacts of non-native species range from increased competition for food to habitat destruction to basic changes in the way the lake ecosystems function.

The cleanup and protection of our Great Lakes is an environmental success story even though many challenges remain. In recent decades, governments, businesses and industries, Tribes and First Nations, non-governmental organizations, teachers, and many other concerned individuals have combined their efforts in teams, task forces, and volunteer groups. They have made commitments, passed environmental regulations, reduced pollution, protected valuable wildlife habitat, educated millions of people about the lakes, rehabilitated polluted areas, and worked to keep invasive species out of the region. The job is not finished. Everyone who lives in and benefits from the Great Lakes basin can help protect this unique ecological system. The sections below provide more details about what is happening in the Great Lakes and what has been done so far to improve the situation, as well as some ideas about how you can help make our lakes cleaner and healthier.

Can we Drink the water?

Every day, 24 million people drink water that is drawn from the Great Lakes, treated, and delivered to their taps. Nine million more people rely on rivers, wells, and small inland lakes in the surrounding watershed. Drinking water from public systems is tested thousands of times a year to ensure that it is safe.

What is *happening?*

The greatest threat to drinking water safety comes from tiny microbes, including bacteria, viruses, and parasites, found in human and animal wastes. Human waste from our towns and cities is sent to sewage plants designed to destroy microbes. However, accidents and overflows caused by rainstorms can cause the release of untreated sewage into rivers and lakes. Chemical discharges from industry have been greatly reduced, but sometimes spills or leaks occur during manufacture, shipment, use, or disposal of chemicals. In some cases, people dispose of unwanted paints, chemicals, motor oil, and medicines by pouring them down household or street drains rather than taking them to hazardous waste disposal sites.

Pollution from many diffuse sources is washed into the Great Lakes by rainwater and snowmelt. In urban areas, such pollution includes spilled automotive oils and chemicals, road salt, lawn and garden chemicals, and pet waste. In rural areas, runoff from farm fields can carry manure, fertilizers, and pesticides into surrounding waters.

Modern drinking water treatment systems excel at killing microscopic organisms before the water is sent to our taps. These systems rarely fail, but when they do the consequences can be serious. In 1993, a parasite known as cryptosporidium was in the waters of Lake Michigan off the shores of Milwaukee, Wisconsin. Human error allowed the parasite to get through the city's drinking water treatment system and into tap water. The events that took place in Walkerton, Ontario, in 2000 are worth noting here, although the community's water was not sampled as part of the work done to prepare this report because Walkerton's population is less than 10,000 people. Failure to chlorinate water from Walkerton wells properly allowed E. coli bacteria to contaminate the local drinking water. The incidents at both Milwaukee and Walkerton led to widespread sickness and a number of deaths.

Treated drinking water is also monitored regularly for chemical contaminants. They are rarely found in treated drinking water and, if present, are usually at levels below those that could pose a risk to human health.

What is being *done?*

Governments have built a broad network of protection systems to ensure that treated drinking water is safe. This safety net includes drinking water laws, regulations, and standards, source water protection plans, water quality monitoring systems, and treatment systems for both sewage and drinking water. Various information programs, including the State of the Great Lakes reports and reports from water suppliers, inform the public about the quality of their drinking water.

Protecting water sources reduces the risk of exposing us to harmful contaminants, lowers the costs of treating our drinking water, and results in a healthier ecosystem in which to live. Sewage treatment systems are used to kill harmful microbes before wastewater is discharged into the Great Lakes. In the final line of defense, drinking water treatment plants use a variety of technologies to remove contaminants, for example, adding chlorine to kill bacteria and viruses before sending the water out to our faucets.

The levels of a number of toxic chemicals in the Great Lakes basin have been dropping for years due to cleanups, the imposition and enforcement of regulations, and the pollution reduction approach that many business leaders have taken. Governments, businesses, and associations have developed a range of pollution prevention programs to help companies reduce the entry of chemicals into the environment, and to help farmers keep agricultural wastes out of the water. Many local governments have developed household hazardous waste disposal programs, and many pharmacies accept unwanted medicines and dispose of them safely. Both governments and non-governmental organizations have developed public education programs on waste reduction.

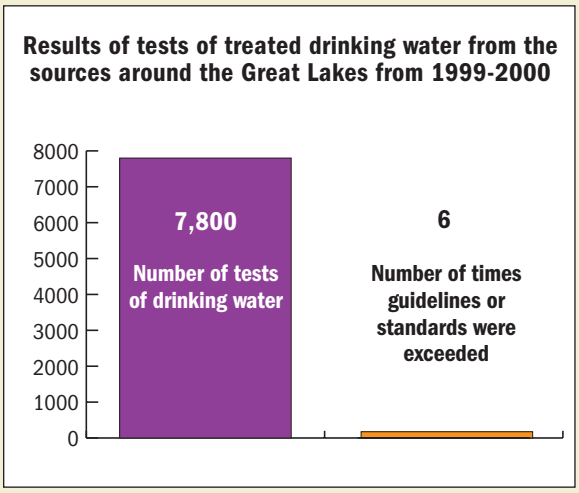


Figure 1:
The water tested came from untreated drinking water sources in the Great Lakes basin or from public treatment plants supplying communities of over 10,000 people. Two exceedances occurred for total coliform, which by itself is not necessarily harmful but which may indicate the presence of harmful bacteria. No exceedances occurred for harmful bacteria, viruses, or parasites. Nitrate, a substance that can signal pollution from such sources as manure and fertilizers, exceeded limits in four instances. None of the exceedances was high enough to pose a risk to human health.

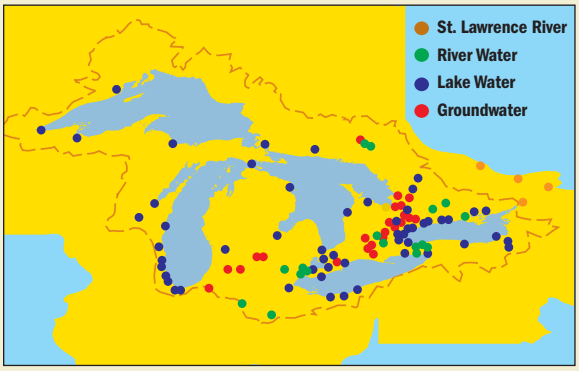


Figure 2:
Locations of public water systems in the Great Lakes and the source from which the water is drawn.

Can we Swim *at the beach?*

Every summer, the long, sandy beaches that ribbon Great Lakes shorelines draw millions of people seeking relief from the heat and a chance to be closer to nature. We want to be able to swim without worrying about getting sick from the water.

What is *happening?*

The water along most Great Lakes beaches is safe for swimming most of the time. But, at some times and places beach water is too contaminated for safe swimming. High bacteria levels in the water can give swimmers a number of illnesses, including skin rashes, intestinal upsets, and ear and eye infections. When bacteria levels rise beyond government standards, beaches are closed to swimming or warnings are posted.

The causes of bacterial problems on beaches are much the same as those in drinking water. Malfunctioning or overloaded sewage treatment plants, leaking septic tanks, and untreated discharges from boats all lead to human waste entering the environment. Runoff may become contaminated by pet droppings and droppings from geese and gulls in urban areas, and by animal waste from pastures and farms. In towns and cities, rainstorms can send too much water into sewage systems, particularly those that combine sanitary system and storm sewer pipes. The sanitary sewers take wastes away from our homes, while storm sewers carry rainwater and snowmelt from roofs, yards, parking lots, and streets.

When these systems are overloaded by stormwater, sewage treatment plants release untreated or partially treated wastes to avoid being flooded. This water is discharged into the Great Lakes and can pollute nearby beaches. Storm sewers that are separate from the sanitary system have traditionally discharged untreated water into lakes and rivers. In recent years, we have come to realize that this water carries contaminants from urban runoff.
As a general rule, the farther a beach is from settled areas or from intensive livestock farming, the lower the risk of bacterial contamination on that beach.

What is being *done?*

Sewage treatment systems are being built or upgraded to capture and treat polluted water. The biggest challenge is to further reduce the amount of untreated stormwater that flows into the Great Lakes. A number of strategies to control this source of pollution have been developed. They include building holding ponds and underground storage tanks to keep polluted water from rushing into the lakes so that it can be processed at sewage treatment plants after the storm has passed. Wetlands are being reintroduced in some urban areas to filter pollutants out of the water naturally.

Individuals can play an important role in reducing stormwater. Homeowners are encouraged to disconnect downspouts from municipal sewer systems and let water from their roofs flow into rain barrels or directly onto lawns and gardens. Diverting water in this way takes pressure off sewer systems and reduces the risk of sewer water backing up into basements. People can use porous materials for walkways, driveways, and patios so that rain and snowmelt will seep into the ground rather than draining into the sewer systems. These measures also reduce the need for lawn watering.

To give swimmers better warnings of beach contamination, federal, state, provincial, municipal, and Tribal and First Nations governments have increased the number of tests of swimming water quality. Governments are using tougher standards for acceptable bacterial levels in water and are improving sampling and testing methods. As a result of more stringent tests, some beaches may appear to be more polluted than they were in the past, but they are simply better monitored. Governments are enhancing the communication of beach contamination information. Through the BEACH Act grants administered under the Environmental Protection Agency, additional funding has helped communities develop public notification programs at coastal beaches, including signs in multiple languages, beach status web-sites, telephone hotlines, and brochures that inform beach goers about the risks of swimming in contaminated water.

The sounds of water lapping on a sandy beach and children playing in the shallows are part of the pleasure of living around the Great Lakes.

One of the problems facing public health officials is that it takes time to sample and analyze water, which means that a contaminated beach may remain open for a day or two while tests are being done. By the time the beach is posted as unsafe for swimming, the bacterial levels in the water may have dropped. Officials are testing rapid sampling technologies that will enable them to spot problems earlier. Since rainfall is closely linked to a rise in bacterial levels along many beaches, officials are trying to predict the need for beach closings on the basis of both the amount of rain that falls in a storm and mathematical models that predict the likelihood of unsafe coliform levels.

To further improve swimming conditions, the United States has set a goal that, by 2010, 90 percent of monitored high-priority beaches around the Great Lakes will meet standards for bacteria (E. coli and fecal coliform) for more than 95 percent of the swimming season. In Canada, the City of Toronto is adopting the Blue Flag approach to certifying beaches as safe. Other communities are expected to follow this example.

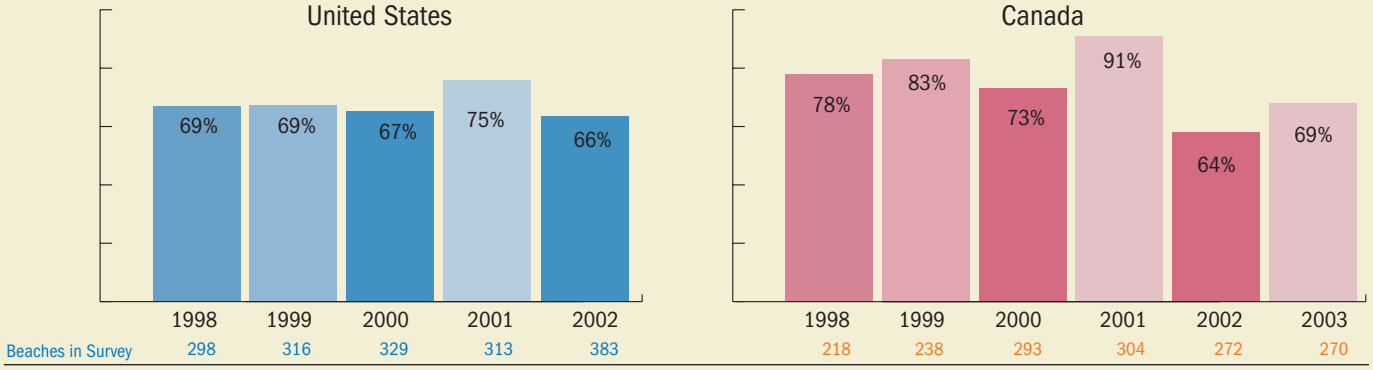
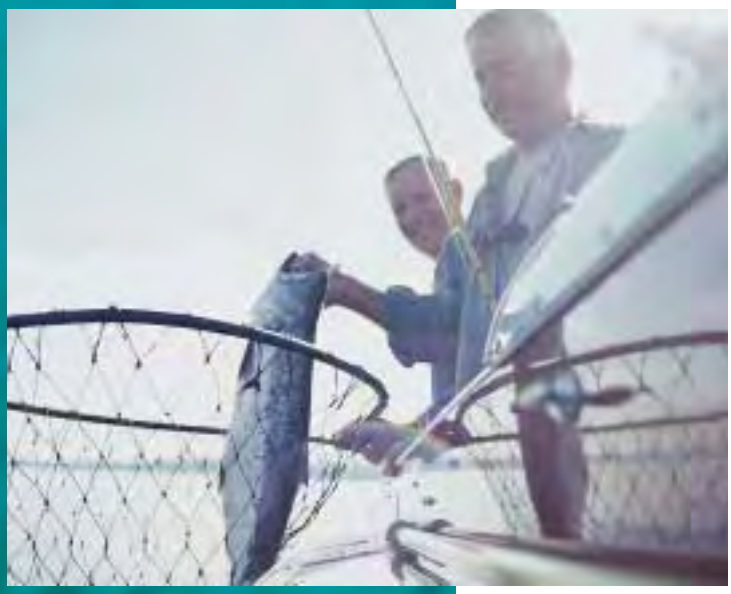


Figure 3:
Percentage of the swimming season when reported Great Lakes beaches were not closed or posted with elevated bacteria levels. While six years of data are presented, trends over time are difficult to accurately interpret because measurement techniques have changed, monitoring has increased, different beaches are included in each survey, pollution levels and annual rainfall, which affects pollution, vary.

For information on beach conditions around the lakes, please see the BeachCast web site at **http://www.great-lakes.net/beachcast.**

Can we Eat *the fish?*



Many people love to grab a fishing pole and catch their dinner or at least enjoy time spent dipping a line in the water. About five million people fish in the Great Lakes every year. While many people fish for recreation, some depend on fish for food or for their livelihood in the sport and commercial fishing industries. Some Great Lakes fish are safe to eat and the situation is improving. Nevertheless, people who fish for or eat Great Lakes fish should be aware of published guidelines about how to avoid contaminated fish.

What is *happening?*

Over the years, the Great Lakes have been polluted by a wide range of heavy metals and chemicals. Some of these substances are persistent and do not break down readily in the environment. Several of them also build up in the food chain and can end up in the fish we like to eat.

Therefore, while fish are a good source of healthy food, you should avoid those whose tissues are too contaminated. The chemicals found in fish do not cause immediate sickness, but they can accumulate in our bodies over time and affect our health and that of our children. Some chemicals pose a considerable risk to a developing fetus, and their effects can include developmental problems in children. Women of child-bearing age, pregnant women, nursing mothers, and children under age 15 all face greater risk of harm from toxic substances and should be careful to follow guidelines on what fish are safe for them to eat.

The Food and Drug Administration and the Environmental Protection Agency have issued a joint advisory to women who may become pregnant, pregnant women, nursing mothers and young children to avoid some types of fish and eat fish and shellfish that are lower in mercury.

The good news is that since the 1970s, levels of many toxic chemicals in the Great Lakes ecosystem have declined and many sport consumption advisories have been eased. Despite these encouraging trends, advisories still exist about limiting or avoiding consumption of some fish from parts of all five Great Lakes.

Consult official fish consumption advisories for local conditions. Advisories are available from state, provincial, and Tribal and First Nations agencies dealing with Great Lakes fish issues, or online at **http://www.great-lakes.net/humanhealth/fish/advisories.html.**

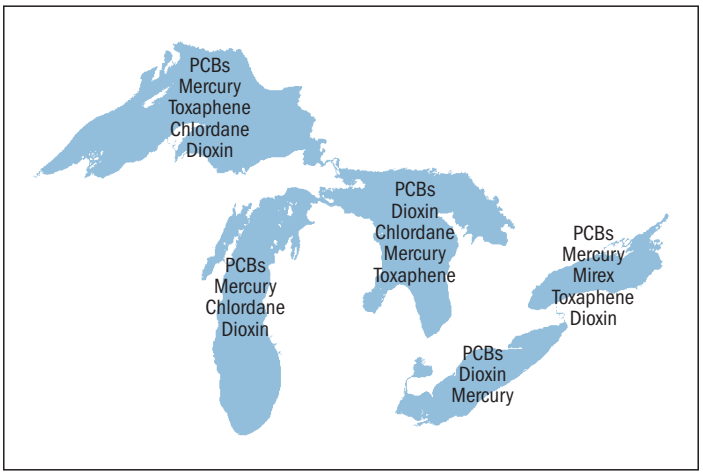


Figure 4:
Contaminants that cause fish advisories in Canada and the United States.

What is being *done?*

We cannot smell, taste, or otherwise detect toxic chemicals in fish, so for decades governments around the Great Lakes have been testing fish in laboratories. Governments then advise the public about which fish are safe or unsafe to eat. Recommendations range from unlimited consumption to avoiding all fish of certain species in certain areas. The Ontario government monitors contaminants in fish in Ontario waters, including the Great Lakes and provides consumption information to the public through *The Guide to Eating Ontario Sport Fish*. Species at the top of the aquatic food chain, such as trout, salmon, and walleye, can build up higher levels of pollutants than fish that are not top predators. Generally, bigger and older fish accumulate more chemicals in their flesh than do smaller and younger fish. In addition to publishing information about contaminant levels, various organizations are helping people understand how to minimize exposure to pollution through their choice of fish and removal of fat before consuming it. Women of childbearing age and children are most sensitive to food borne contaminants.

Since 1970, governments have restricted or banned outright a number of key pollutants, such as PCBs and the pesticide DDT. Industries have also voluntarily reduced or eliminated releases of several substances into the environment. Many individuals have reduced their use of hazardous products and are safely disposing of unwanted amounts of such products. As a result, toxic chemical levels have been falling because, once the pollution flows are stopped, natural processes can begin to cleanse the environment.

The cleansing process, however, is being slowed down by some continued emissions of toxic substances from some sources. Contaminants from industrial smokestacks, power plants, and incinerators, as well as some pesticide sprays, are picked up from nearby – and even from halfway around the globe – and carried by winds, eventually to settle on the Great Lakes basin. Scientists are also monitoring potential risks from other chemicals that are turning up in the Great Lakes food chain. These include fire retardants containing polybrominated diphenyl ethers (PBDEs), a group of chemicals suspected of being able to disrupt the endocrine system, a regulator of many of the processes in our bodies.

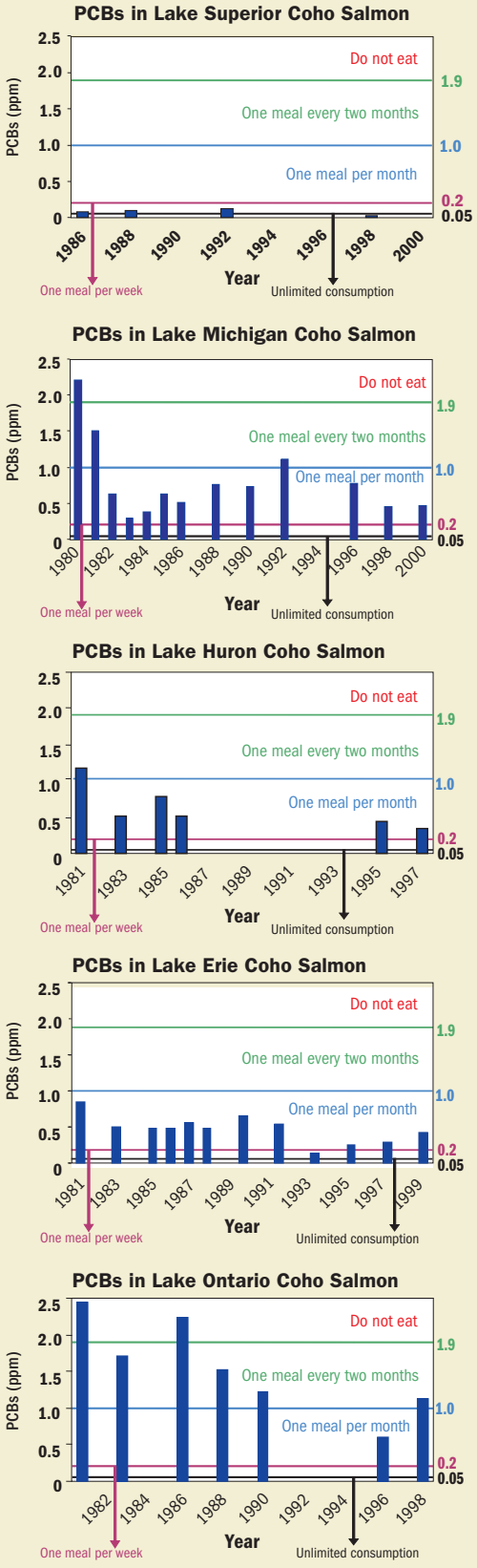


Figure 5:
These salmon are high on the food chain and tend to accumulate such chemicals, so this indicator gives a good sense of trends in Great Lakes sport fish. The graphs show averages for each lake. Contaminant levels in coho and other fish may be higher or lower in different parts of a lake.

How are the Fish *doing?*

For many years, Great Lakes fish populations have been subject to severe pressures from overfishing, pollution, and invasions by non-native species. Governments have sought to compensate by setting fishing quotas, reducing pollution, and trying to control invasive species. As a result, some native fish are making a comeback. Pike are once again swimming in Toronto Harbour now that pollution levels have dropped. An artificial reef off Detroit's shoreline is being built to facilitate the return of the sturgeon, whose rocky habitat was previously dredged for use as building material.

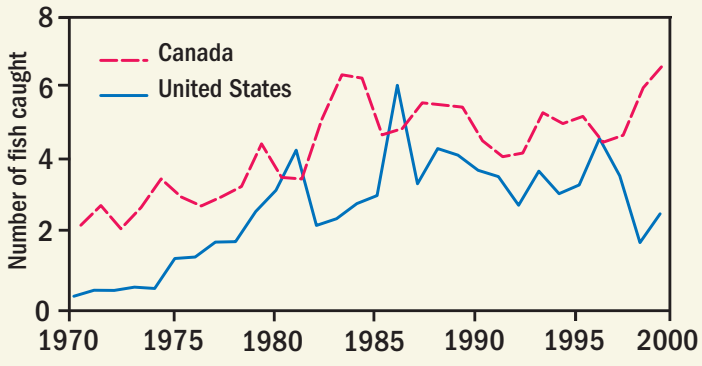


Figure 6:
Trends in abundance of lake trout in the Great Lakes. The graph uses a series of different measures but give a sense of the health of lake trout populations. Only Lake Superior and parts of Lake Huron have self-sustaining populations. In the other lakes, lake trout populations are not yet self-sustaining.

What is *happening?*

Native fish species of the Great Lakes range from the little emerald shiner to the huge lake sturgeon, and telling their story is like trying to piece together a giant jigsaw puzzle. It is useful to look at how top predators such as the lake trout and walleye are doing. Like the wolf on land, these big fish are a major force in shaping the lives of smaller species around them. The health of the predators acts as a barometer of the stability and resilience of the whole community of Great Lakes fish.

The swift, sleek lake trout was virtually king of the waters for hundreds of years, but its numbers declined drastically during the 20th century due to a combination of predation by the sea lamprey and overfishing. After nearly being wiped out in much of the Great Lakes, and surviving only in pockets in Lake Superior and Georgian Bay, the lake trout is now able to survive through natural reproduction in Lake Superior and parts of Lake Huron. They were starting to reproduce again in Lake Ontario, but the young may now be falling prey to another invasive species, the round goby. In most other areas of the Great Lakes, hatchery-reared lake trout are needed to keep the species going. It still faces a range of threats, including declines in its prey fish, competition from non-native species that have invaded the lakes, and pressure from humans.

The big-finned, sharp-toothed walleye is another ruler of its waters. Walleye (also known as pickerel) are found in all five Great Lakes, but in Lake Erie they are the dominant predator. This species is also the basis of important sport and commercial fisheries. The population fluctuations of the Lake Erie walleye indicate that this species is in difficulty. After soaring to historic highs in the 1980s, the walleye population plummeted by more than half in a decade. The reasons for the decline are not fully known but include years of poor reproduction, due in part to weather patterns and temperature variations, and changes in the food supply caused by non-native species such as zebra mussels. Fisheries around the lake are being significantly scaled back in recognition of the reduced capability of the walleye population to support fishing.

Farther down the food chain are smaller fish - a mix of native and non-native species such as perch, shad, sculpin, bloater, herring, burbot, alewife, and rainbow smelt. Some are themselves sport or commercial fish and all serve as prey for bigger species. Many of these prey fish are in decline, so predators higher up in the food chain have difficulty surviving.

We can learn a lot from the fate of *Diporeia*, a tiny freshwater shrimp that swims sideways and that most people rarely see. These fat little crustaceans, also known as scud, feed on algae and other organic matter in deep waters and form an important part of the base of the food chain. Many species of forage fish in turn feed on scud. Scud populations are in dramatic decline in four of the five Great Lakes and have vanished from some regions. This species appears to be losing the competition for food to the invasive zebra and quagga mussels.

What is being *done?*

In the Great Lakes basin, states, Ontario, Tribes and First Nations, and two federal governments manage the fisheries to meet a wide range of needs, including food, recreation, cultural heritage, employment, and the health of the aquatic ecosystem. The United States and Canada cooperate on fisheries management through such organizations as the Great Lakes Fishery Commission. This group coordinates fisheries research, controls sea lamprey, and helps coordinate fishery management among the state, provincial, Tribal and First Nations, and federal agencies. Fishing rates must be adjusted to the ability of various species to reproduce. Habitat must also be considered. It is key to the survival of all species. Governments at all levels, often in collaboration with non-profit organizations and industry, have been working to protect and restore habitat, often by creating conservation areas, parks and protected areas, and even artificial reefs. Pollution reductions in recent decades have promoted the survival and reproduction of fish.

Controls on pollution and predators were rewarded by the come-back of native species. Once the lamprey was brought under control through the introduction of coho and chinook salmon (745 million salmon were released into the Great Lakes between 1966 and 1998), native lake trout were reintroduced to a number of areas. The constant arrival of non-native species, however, continues to disrupt the Great Lakes ecosystem and put new pressures on native species.

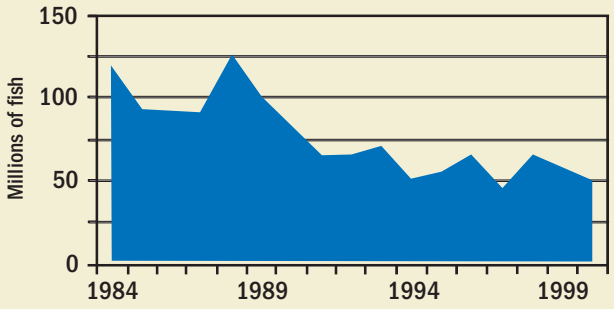


Figure 7:
Trends in abundance of Lake Erie walleye. This fish is the top predator in Lake Erie, and its reproduction and survival provides information about the health of that lake's ecosystem.

How is the Wildlife *doing?*

Like fish populations, wildlife populations on land and in the air around the Great Lakes basin are subject to severe external pressure such as pollution and habitat loss. Controls on pollutants have enabled the bald eagle to make a comeback, but the little marsh wren is declining, along with its wetland habitat.

What is *happening?*

The health of any top predator, particularly a long-lived one, reveals a lot about the state of the entire ecosystem in which we all live. The bald eagle sits high up on the Great Lakes food chain, so it is a good indicator of environmental quality.

Not too long ago, spotting one of these big birds, especially in the southern Great Lakes, was a rarity. As farmers cleared the land of large trees, habitat for eagles disappeared. These magnificent birds were also hunted as "vermin" and their numbers dropped dramatically. Finally, the eagle's ability to reproduce was impaired by the persistent bioaccumulative chemicals found in the fish and wildlife that were staples of its diet.

Today, however, this majestic bird, with its distinctive white head and brown-feathered body, can once again be seen soaring high overhead or perched in a tall tree. But the eagle is not totally out of danger. While more eagles inhabit the area now than did a few years ago, they still carry elevated levels of some contaminants, such as PCBs, DDE (a residue of the pesticide DDT), and the heavy metals lead and mercury. Although DDT was banned in North America in the 1970s, it persists in the environment, and PCBs are still used in some old electrical equipment, which periodically leaks. Lead is used in hunting and fishing equipment, and mercury is released into the environment from a number of sources. In Canada, mercury releases have been reduced by 83 percent, compared to 1988 levels. Canada's goal is to reach a 90 percent reduction by 2010.

In the United States, mercury emissions have decreased by almost 100 tons (approximately 40 percent) between 1990 and 1999, according to best estimates from the National Emissions Inventory. Additional reductions will come from the first ever proposed mercury emission regulations for coal-fired plants. The Bush Administration has set a goal of finalizing these regulations by March 2005.

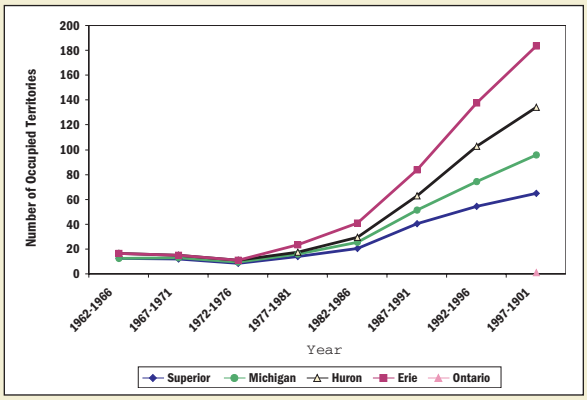


Figure 8:
Average number of occupied nesting areas by lake.

Figure 9:
The bald eagle is a not just a powerful cultural symbol. Its recovery around the Great Lakes is a measure of our ability to repair environmental damage. The graph shows that bald eagles now are nesting extensively throughout the Great Lakes. The map shows bald eagle nesting areas along Great Lakes shorelines in 2000.

Habitat change is a major factor in the survival of species. In some areas around the Great Lakes, wetlands and forests are increasing where farms are abandoned and reclaimed by nature or landowners and set aside land for wildlife. In other parts of the basin, habitat is decreasing as industrial, agricultural, and residential expansion overtakes woods, pastures, and wetlands.

While the species just mentioned are on the rebound, populations of other birds, such as the black tern, American coot, and marsh wren, are declining, apparently due to loss of the healthy wetlands that they need. Some species of frogs and toads are also in decline. In parts of the Great Lakes, snapping turtles are contaminated with chemicals, which negatively affect the reproduction of this species.

What is being *done?*

The bans and controls on pollutants over the past three decades have improved the health of wildlife. Generally, wildlife populations, except in highly polluted areas, are reproducing normally.

Habitat has been increasing. Governments and non-governmental organizations, as well as a number of businesses and private industry, have been creating parks and nature reserves. Around the Great Lakes, the amount of land protected by land trusts and conservancies has been growing steadily and is an important sign of citizen and community stewardship. Today, about one-fifth of the remaining Lake Ontario wetlands is protected. In the Lake Michigan watershed, the gray wolf, bald eagle, Kirtland's warbler, and Piping Plover have benefited from habitat protection and restoration.

In an effort to help nature recover, governments have committed to protection and recovery plans for endangered species. Such plans include habitat protection and reintroduction of species.

The double-crested cormorant, a fish-eating bird high on the food chain, also experienced a population surge around the Great Lakes, mainly because of lower pollution levels and more available habitat. The phenomenal increase in the cormorant population provides an important lesson about what can happen once we begin to rehabilitate an ecosystem. Decades ago, cormorants could not reproduce because of the effects on them of toxic chemicals, but, as pollution levels fell, the cormorant population boomed. In some areas, these birds have become so numerous that they have displaced other waterbirds, and cormorant droppings have destroyed some vegetation. Wildlife managers are now trying to control some cormorant populations to limit their impact on the environment.

How are non-native Species affecting the *Great Lakes*?

Humans have deliberately or accidentally introduced more than 160 new species – from alewives to zebra mussels – into the Great Lakes basin, forever changing the species mix in it. Non-native species range from tiny plankton that float in the water to shellfish and fish. Some, like coho and chinook salmon and rainbow and brown trout, were released intentionally to provide sportfishing fun and to keep alewife populations under control. Most, like the spiny water flea, zebra mussel, and sea lamprey, entered the lakes unobserved and are wreaking havoc on native species. Usually the conflict takes place underwater, and we see only small signs of it: we may find a beach covered with tiny, striped zebra mussel shells, or we notice that a native species, such as lake trout, is not where it used to be.

What is *happening?*

Non-native species are one of the most serious threats to the natural balance of life in the Great Lakes. The newcomers can displace native species by either eating them or outcompeting them for food.

One of the most dramatic invasions began in the early 1800s when the eel-like sea lamprey moved into Lake Ontario from the Atlantic Ocean and later, using shipping canals, upstream past Niagara Falls. The parasitic lamprey, which feeds on the body fluids of other fish, clinging to its victim with a suction cup mouth and rasping though the scales and skin with a sharp tongue, devastated many native fish populations. A series of control measures are holding the lamprey in check, but invasions by other species continue.

Since zebra mussels were discovered in Lake St. Clair in the late 1980s, the small, fast-breeding shellfish have spread throughout the Great Lakes and into surrounding inland lakes and rivers. In the process, this species has displaced most native freshwater mussels and may also be causing the disappearance of the small, freshwater shrimp known as scud, a key part of the Great Lakes food chain. Historically, parts of the lakes had several thousand scud for every square meter of lake bottom. A decade after zebra mussels arrived, some areas are devoid of scud.

The effects of invasive species are unpredictable. Lake Erie's increasing clarity has been attributed to billions of zebra mussels gobbling up algae that normally cloud the water. There is also concern that zebra mussels are fostering an abundance of toxic blue-green algae by eating only the other algae. As well, the mussels are thought to play a role in the creation of a "dead zone" of low oxygen found in parts of the bottom of Lake Erie. These actions are changing living conditions for a wide range of other species. Another invader, a small fish called the round goby, is suspected of being involved in increased outbreaks of type E botulism, which has killed thousands of fish and birds, including ducks, gulls, mergansers, and loons, that live in or migrate through the Lake Erie region.

Invasive species are not confined to the water. Purple loosestrife, a flowering plant, is displacing many native plants in wetlands. Two insects, the emerald ash borer and the Asian longhorned beetle, threaten to devastate forests around the Great Lakes.

Invasive species impose an economic toll, as well as an ecological one. It costs municipalities and industries tens of millions of dollars a year just to keep zebra mussels from clogging up water intake pipes around the Great Lakes. Governments currently spend more than $12 million a year on sea lamprey controls. Invasive species threaten a sport and commercial fishing industry that is valued at almost $4.5 billion annually and that supports more than 80,000 jobs.

Stopping the invasions is no easy task. At least one-third of the new species arrived in ballast water carried by the more than 500 ocean-going ships that enter the lakes each year. While in a foreign port, a ship draws water into its ballast tanks to give it stability for an ocean crossing, and in doing so often takes in local species. That water, along with its imported species, is discharged into the Great Lakes when the ship takes on cargo or navigates through shallow waters. Since the Great Lakes basin is an international destination, new organisms from around the world keep invading. Although not all species arriving in ballast water flourish in local conditions, successful invaders tend to be fast-breeding and voracious eaters. Once established, they are virtually impossible to eradicate.

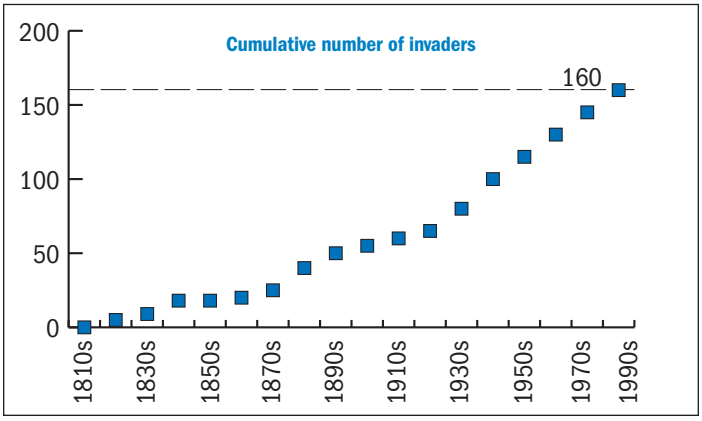


Figure 10:
Since the 1830s, more than 160 species of non-native fish, animals, and plants have entered the Great Lakes basin.

Nonindigenous Animals Established in the Great Lakes Drainage Basin Since the mid-1980s

Common Name	Year of Discovery	Endemic Region	Mode of Transfer	Probable Donor Region
Ruffe	1986	Ponto-Caspian	Ballast water	Danube River
Zebra mussel	1988	Ponto-Caspian	Ballast water	Baltic Sea
Quagga mussel	1989	Ponto-Caspian	Ballast water	Black Sea
Rudd	1989	Eurasia	Bait release	---
Round goby	1990	Ponto-Caspian	Ballast water	Black Sea
Tubenose goby	1990	Ponto-Caspian	Ballast water	Black Sea
New Zealand mudsnail	1991	New Zealand	Ballast water	Baltic Sea
Blueback herring	1995	Atlantic N.A.	Canal	Atlantic N.A.
Echinogammarus (amphipod)	1994	Ponto-Caspian	Ballast water	Baltic Sea
Acineta noticrae (ciliate)	1997	Eurasia	Ballast water	Black Sea
Cercopagis (waterflea)	1998	Ponto-Caspian	Ballast water	Baltic Sea
Daphnia lumholtzi	1999	Africa, Asia, Aust	Boat?	Ohio Reservoirs
Schizopera borutzkyi	1999	Ponto-Caspian	Ballast water	Danube River
Heteropsyllus nr. nunni	1999	Atlantic N.A.	?	Atlantic N.A.

Ricciardi and MacIsaac, 2000.

Sea lampreys, primitive eel-like fish native to the Atlantic Ocean, were found in Lake Ontario in the 1830s and spread to the rest of the Great Lakes system through shipping canals during the early 1900s. They have been held in check for years by a series of measures, but the species continues to pose a risk to Great Lakes fish, especially in northern Lake Huron.

Some invasive species are released into the lakes when people dump the contents of aquariums, water gardens, and bait buckets, not realizing that doing so can disrupt the environment. Sometimes invaders have escaped from fish farm ponds where they were being used in food production for people.

What is being *done?*

Governments use a combination of regulations and guidelines requiring ships entering the Great Lakes to first exchange their ballast in open salt water, where there should be no organisms that can survive in fresh water. However, even a change of water is not guaranteed to purge everything because ballast tanks retain a certain amount of sludge that can hide foreign organisms.

In 2002, an underwater electric barrier was installed in the Chicago Sanitary and Ship Canal, which links Lake Michigan with the Des Plaines, Illinois, and Mississippi rivers. The barrier was designed to keep non-native carp that escaped into the Mississippi River system from moving north into the Great Lakes, and to prevent the invasive ruffe from moving from the lakes into the Mississippi.

The long struggle against the sea lamprey shows that the fight to control even a single invader can be extremely costly and probably never finished. For more than half a century, Great Lakes fishery managers have been using barriers, traps, the release of sterile males, and, mainly, the pesticide known as TFM to hold the sea lamprey in check. Even this barrage of measures cannot eliminate the lamprey from the lakes, but it has reduced them to less than 10 percent of their previous numbers. If we want native fish such as the lake trout to make a comeback, the fight against the lamprey must continue. In Hamilton Harbour, Lake Ontario, a carp barrier was built at the entrance to the Cootes Paradise Marsh. This barrier keeps carp out of the marsh, allowing marsh vegetation, no longer uprooted by carp, to regenerate.

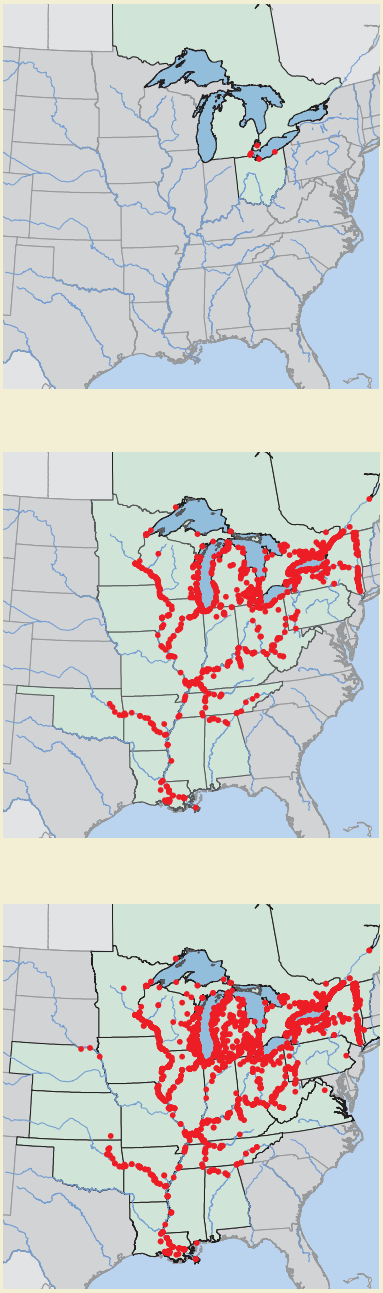


Figure 11:

First discovered in Lake St. Clair in 1988, zebra mussels rapidly spread throughout the Great Lakes basin. The thumbnail-sized shellfish probably entered the lakes in ballast water discharged by a European freighter. The striped mollusk attaches itself to boat hulls, thereby being spread further. The maps here show the spread of zebra mussels from 1988 through to 2003.

What can You do *to help?*

The choices we make every day affect the quality of our environment. These are decisions about where and how we build homes, factories, and offices, our transportation, the products we buy, and how we use and dispose of them. Our decisions affect air and water quality and the state of fish and wildlife. Making the right choices will lead to cleaner waters and a healthier Great Lakes ecosystem. Wise choices will reduce the risk of contaminating our drinking water and polluting the waters off our beaches, and will result in more fish that are safe to eat.

To make wise choices, we need to be well informed about our environmental impacts and the options we have to live more sustainably. As individuals, we can reduce our use of toxic substances, buy environmentally friendly products, and use them responsibly. We can also choose to dispose of them safely. We can tell elected officials what kind of environment we want to live in. Collectively, we can become involved in community programs, including those to protect the environment and clean up past damage. All of us have a role to play in keeping the Great Lakes great. The following sections contain some suggestions about what you can do to help.

At *home* and *play*

Keep hazardous materials out of the water

Sometimes we pour wastes such as old paints and pesticides into our drains. Sewage treatment systems were designed to deal with human waste, not to remove toxic chemicals. They can pass through the sewage plant and into our rivers and lakes. If a product carries a hazard warning, you should not dispose of it in drains or sewers. Pesticides, fertilizers, household chemicals, and runoff from washing a car can drain directly into waterways or reach them through storm drains. These materials can harm wildlife and pollute our sources of drinking water.

- Seek out products that have and are produced in ways that have a low impact on the environment. Choose less toxic or non-toxic substitutes whenever possible.
- Take advantage of programs that dispose properly of mercury thermometers.
- Use safe disposal methods for your hazardous wastes, such as insect and weed killers, paints, solvents, used motor oil, and other auto fluids. Do not pour them into sinks, toilets, storm sewers, or drains or dump them on the ground. Take them to local household hazardous waste centers for disposal. If your community does not have such a center, ask your local government to establish one. Take used motor oil to a service station for recycling.
- Do not flush old medicines down the drain. Take them to a pharmacy for safe disposal.
- Keep litter, pet waste, leaves, and debris out of street gutters and storm drains. Pet waste can be disposed of with human waste. Avoid hosing dirt into storm sewers because it can reduce flow in them and be carried into lakes and rivers. Sweep walks instead of washing them down with water.
- Clean up spilled brake fluid, oil, grease, and antifreeze. Do not hose these materials into the street where they can drain into streams and lakes.
- Use low-phosphate or phosphate-free detergents.
- Apply pesticides such as insecticides and herbicides carefully if you must use them. When using pesticides in or around your home, purchase only the amount needed and follow the instructions on the package carefully. Whenever possible, use natural pest-control methods rather than chemical pesticides. Reduce runoff by maintaining ample grass cover and shrubs.

- Control soil erosion by planting ground cover and stabilizing erosion-prone areas.
- Disconnect your downspouts (check municipal bylaws and instructions first) and direct rainwater into a barrel or onto your lawn or garden, not onto the pavement.
- Use separate stones and porous materials instead of concrete for walkways, driveways, and patios so that water will seep into the ground rather than draining into the sewer systems.
- If you wash your car at home, try to avoid allowing detergents to run into the storm sewers.
- Support service businesses that use environmentally friendly processes, such as car washes that treat or recycle their wastewater and dry cleaners that are using new “green” processes.

- Check septic systems every three years, and pump out tanks before they overflow.
- If you are a boater, ensure that you have waste holding tanks, go to pump-out stations regularly, and never discharge untreated wastewater overboard.
- Do not use burn barrels or burn refuse in your backyard, as doing so can release a number of air pollutants that may enter our water.

Help stop invasive species

We can avoid introducing non-native species and help control their spread, particularly to inland lakes and rivers. Many species are tiny and can cling to boats and trailers or ride in water carried in boats and motors.

- Learn how to identify non-native species, and take steps to eliminate them by hosing down your boat on land and cleaning your equipment away from open water.
- Do not dump bait species into areas where they are not native.
- Do not release non-native aquarium fish or plants into the Great Lakes or their tributaries.

Conserve water

Each of us uses about 340 liters (90 gallons) of water a day indoors. We flush 30 percent down the toilet and use another 35 percent for showers and baths. Demand goes up in the summer when half to three-quarters of municipally treated water is sprayed onto lawns. Reducing the amount of water that has to be treated, and thereby the amount of equipment needed to purify and deliver it, can save money and energy.

- Turn off taps, showers, and hoses when you do not need running water.
- Fix leaky taps or toilets.
- Install low-flush toilets.
- Install low-flow or attach flow-reducing mechanisms to faucets and showerheads. Take short showers instead of baths.
- Run washing machines and dishwashers only when full, and conserve energy too by using the coolest cycle that will do the job.
- Reduce lawn watering to a minimum. Plant native grasses and flowers that are adapted to the local climate and need less water than non-native species. Native species are also more resistant to local pests.
- Do not use a hose to sweep sidewalks, patios, and driveways.

At *work*

You can carry many of the ideas for action at home right into the workplace. Most companies can reduce demands for energy and materials, both saving money and reducing wastes. Here are some other actions you can take:

- Handle, use, and dispose of hazardous materials safely, following guidelines from governments and industry associations. Clean up any chemical and oil spills immediately and dispose of hazardous materials safely.
- Encourage your company to adopt a green purchasing policy that favors clean and efficient equipment and processes.
- Check your company's recycling policy to see if it can be improved.
- Reduce polluted runoff. On construction sites, cover dirt to reduce erosion. On farms, keep livestock away from stream banks by providing animals with a water source away from waterways. Do not store or apply manure near water bodies.

Conserve and protect habitat

- Encourage plant growth along shorelines and riverbanks to reduce erosion.
- Avoid dredging or filling wetlands.
- Participate in and support conservation organizations involved in protecting aquatic and wildlife habitat.

Enjoy and respect the resource

- Encourage your children to enjoy and respect clean water, wild places, and wild creatures. Set an example for your children by taking personal responsibility to leave the Great Lakes just a little bit better than you found them when you were a child.

The following websites provide more information about what you can do to help:

What You Can Do
http://www.ec.gc.ca/eco/main_e.htm

Where You Live
http://www.epa.gov/epahome/citizen.htm

Environment Canada

Pollution Prevention Fact Sheets
http://www.ec.gc.ca/nopp/docs/fact/en/index.cfm

Water Efficiency/Conservation
http://www.ec.gc.ca/water/en/manage/effic/e_weff.htm

What can I do to improve water quality?
http://www.ec.gc.ca/water/en/manage/qual/e_can_i.htm

U.S. Environmental Protection Agency

Watershed Information Network
http://www.epa.gov/win/active.html

Polluted Runoff (Nonpoint Source Pollution)
http://www.epa.gov/nps

National Pollutant Discharge Elimination System
http://cfpub.epa.gov/npdes/index.cfm

Environmentally Preferable Purchasing
http://www.epa.gov/oppt/epp/index.htm

Information Resources About the Great Lakes

WEBSITES

State of the Lakes Ecosystem Conference (SOLEC)
http://www.binational.net
http://www.on.ec.gc.ca/solec/intro.html
http://www.epa.gov/glnpo/solec/index.html

U.S. Environmental Protection Agency
The Great Lakes of North America (Great Lakes National Program Office)
http://www.epa.gov/glnpo/
Great Lakes Areas of Concern
http://www.epa.gov/grtlakes/aoc

Environment Canada
Our Great Lakes (Great Lakes Program)
http://www.on.ec.gc.ca/water/greatlakes/intro-e.html
Canadian Remedial Action Plans
http://www.on.ec.gc.ca/water/raps

Great Lakes Fishery Commission
http://www.glfc.org

Human health and the Great Lakes
http://www.great-lakes.net/humanhealth/index.html

Fish consumption in the Great Lakes
http://www.great-lakes.net/humanhealth/fish/index.html

Fish consumption advisories for the Great Lakes (state-and province-specific advice)
http://www.great-lakes.net/humanhealth/fish/advisories.html

Great Lakes Directory
http://www.greatlakesdirectory.org

Great Lakes Information Network
http://www.great-lakes.net

The Great Lakes: An Environmental Atlas and Resource Book
http://www.epa.gov/glnpo/atlas

International Joint Commission (a binational body on boundary waters, particularly the Great Lakes)
http://www.ijc.org

Zebra Mussels in the Great Lakes
http://nas.er.usgs.gov/zebra.mussel/

PRINTED REPORTS

Governments of the United States of America and Canada. State of the Great Lakes, report published biennially.

Government of Canada and United States Environmental Protection Agency. The Great Lakes: An Environmental Atlas and Resource Book, third edition, Toronto and Chicago, 1995.

Sources

The information contained in Our Great Lakes comes mainly from the State of the Great Lakes 2003 report, which is jointly produced by the governments of the United States and Canada. This report draws from the 2002 biennial SOLEC, where experts review information from hundreds of individuals, ranging from government scientists to representatives of non-governmental organizations to hunters and fishers. From their expertise comes a set of indicators for measuring the health of the lakes and our progress in restoring them.

You can obtain a copy of the State of the Great Lakes 2003 report at http://www.binational.net. Information on SOLEC is available at the following websites:

http://www.on.ec.gc.ca/solec/intro.html
http://www.epa.gov/glnpo/solec/index.html

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