Great Lakes Mercury Connections

The findings from a binational scientific study indicate that while efforts to control mercury pollution in the Great Lakes region have resulted in substantial progress, mercury pollution remains a major concern in this region and the scope and intensity of the problem is greater than had been previously recognized.

The Extent and Effects of **Mercury Pollution** in the Great Lakes Region—*A Summary*

Mercury pollution is a local, regional, and global environmental problem that adversely affects human and wildlife health worldwide. As the world's largest freshwater system, the Great Lakes are a unique and extraordinary natural resource providing drinking water, food, recreation, employment, and transportation to more than 35 million people.

Mercury has been released into the air and waterways of the Great Lakes region since the early to mid-1800s from human activities such as fossil fuel combustion, waste incineration, metal smelting, chlorine production, mining, and discharges of mercury in wastewater.

The widespread loading of mercury into the Great Lakes environment is responsible for mercury-related fish consumption advisories in the eight U.S. states and the province of Ontario that border the lakes. Past and present inputs of mercury pollution have created a substantial recovery challenge for the region.

To inform policy efforts and to advance public understanding, the Great Lakes Commission, in 2008, sponsored a scientific synthesis of information on mercury in air, water, fish, and wildlife through its U.S. EPA-funded Great Lakes Air Deposition (GLAD) program. The results of this scientific collaboration have been published in a series of 35 papers in the journals *Ecotoxicology* and *Environmental Pollution*.

The full summary report, *Great Lakes Mercury Connections: the Extent and Effects of Mercury Pollution in the Great Lakes Region*, has been published by the Biodiversity Research Institute in partnership with the Great Lakes Commission and the University of Wisconsin-La Crosse.

The report is available at:
www.briloon.org/mercuryconnections/GreatLakes

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Why is Mercury Pollution a Problem in the Great Lakes Region?

The Great Lakes region is an internationally significant freshwater resource that is widely contaminated with mercury largely due to atmospheric emissions and deposition.

- Historic records show that mercury levels in lake sediment, fish, birds, and mammals have been declining in recent decades in response to pollution controls on large industrial point-source discharges of mercury to surface waters and decreased air emissions from regional and U.S. sources.
- Emissions of mercury to the air are now the primary source of mercury pollution to the Great Lakes region. Coal-fired utility boilers (power plants) are the largest source of mercury emissions in the region (Figure 1).
- The amount of mercury that is deposited annually to the landscape varies due to changes in climatic conditions and appears to be highest in areas near large air emission sources in the region.
- The eight states that border the Great Lakes and the province of Ontario have issued consumption advisories for mercury in fish.
- Among 15 local fish species consumed by people and wildlife, six have average mercury concentrations in fillet above 0.30 parts per million (ppm)(the U.S. EPA human health criterion) and above risk threshold for fish-eating wildlife of 0.27 ppm in the inland waters of the region.

Mercury Emission Sources in the Great Lakes Region from Human Activities

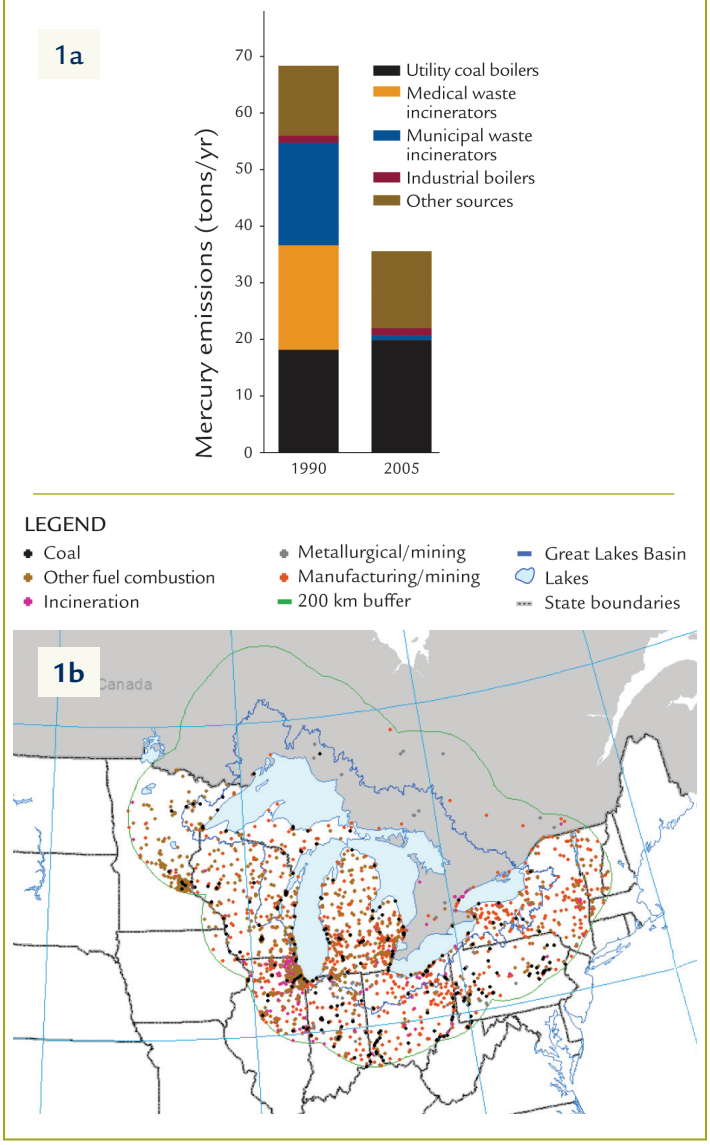


Figure 1: (a) Mercury emissions by source category in the Great Lakes states; (b) locations of inventoried emission sources (2005) in the Great Lakes basin and an adjacent 200 km buffer area. Note that the U.S. mercury emissions inventory includes more source categories than the Canadian inventory used here.

What Risks Does Mercury Pollution Pose in the Great Lakes Region?

The scope and intensity of the impact of mercury on fish and wildlife in the Great Lakes region is much greater than previously recognized. Mercury concentrations exceed human and ecological risk thresholds in many areas, particularly in inland waters.

- Mercury pollution is ubiquitous across the Great Lakes region. Elevated mercury levels have been detected in many animal groups (e.g., birds, fish, mammals), at all levels of the food web in lakes (e.g., plankton, fish, loons), and across many different habitat types (e.g., lakes, wetlands, streams, forests) throughout the region.
- Expanding research shows that the number of documented wildlife species with mercury levels of concern has increased substantially. For example, over the past two decades the number of bird species cited in the scientific literature as adversely affected by mercury has increased by a factor of six.
- During recent decades, research on the toxicological impacts of mercury pollution has demonstrated that effects on fish and wildlife occur at lower mercury concentrations than previously reported.
- A screening analysis for mercury in the Great Lakes region illustrates that risks to fish, wildlife, and people who consume fish in the region can be substantial, particularly in inland waters (see sidebar on page 3).

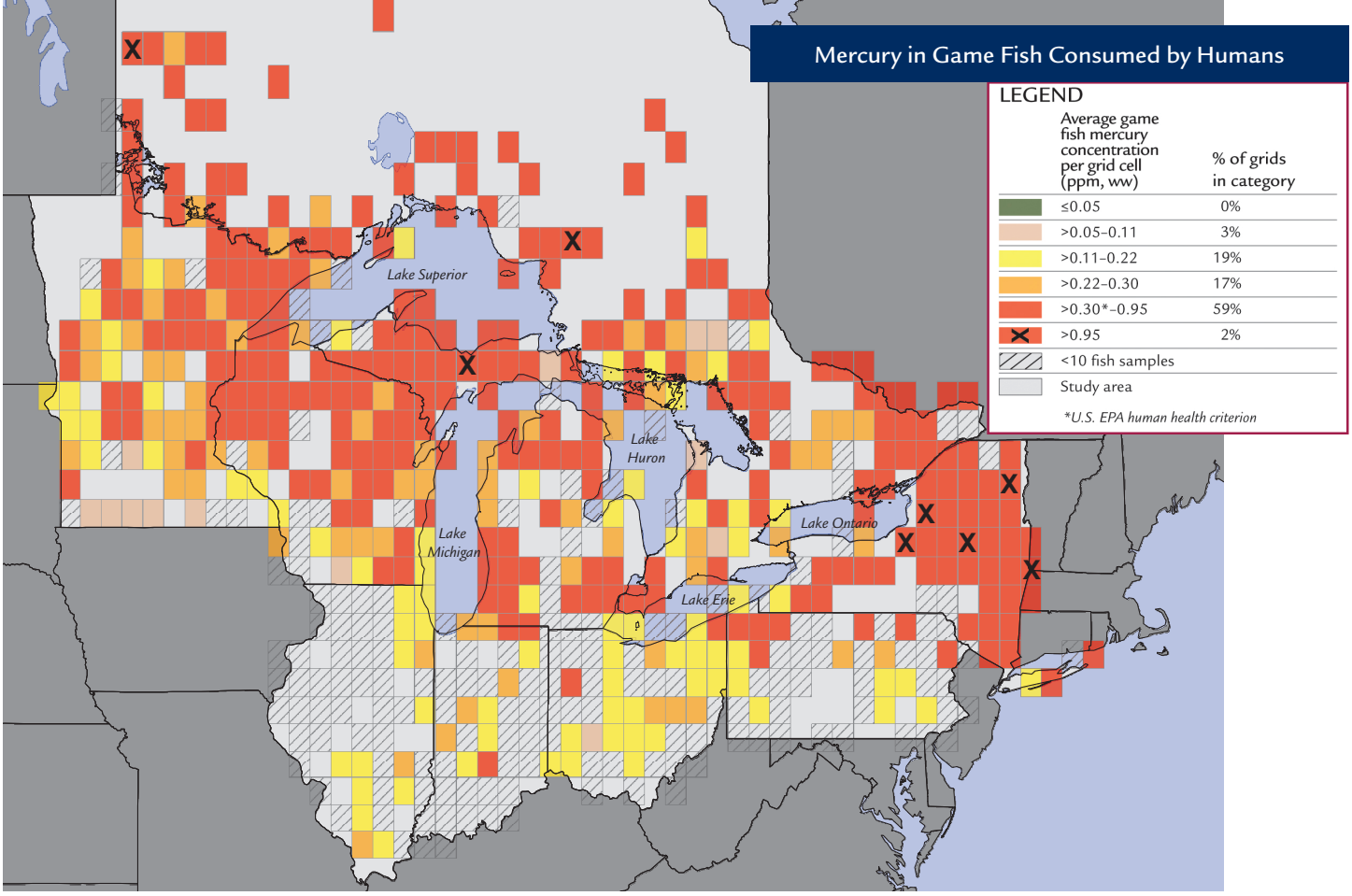



Photo: OakleyOriginals

Figure 2: The mean mercury concentration in 30 x 30 minute grid cells (approximately 35 x 25 miles) for six fish species: lake trout, largemouth bass, muskellunge, northern pike, small-mouth bass, and walleye. A total of 25,177 fish samples were included.

Screening analysis for mercury specifically showed:

- Average mercury concentrations in four top predator fish exceeded the adverse effects threshold for fish of 0.20 ppm in 8 percent (largemouth bass) to 53 percent (walleye) of the study grid cells.
- Twenty-four percent of the study grid cells had average estimated blood mercury levels in common loons equal to or exceeding 2.0 ppm, a threshold associated with at least a 22 percent decrease in the number of fledged young.
- Average mercury concentrations in six commonly eaten fish species were above the U.S. EPA human health criterion (0.30 ppm) in 61 percent of the study grid cells. All study grid cells exceeded the Great Lakes Fish Advisory Workgroup recommended threshold for unrestricted consumption of fish by sensitive populations (0.05 ppm).

Where are Mercury Levels Highest in the Great Lakes Region?

The northern Great Lakes region is particularly sensitive to mercury pollution. The impact of mercury emissions and deposition is exacerbated by watershed and lake characteristics in areas with abundant forests and wetlands that result in higher mercury inputs, transport, methylation, and uptake to elevated concentrations in aquatic food webs.

- Walleye and largemouth bass sampled from water bodies in the region show higher mercury concentrations from south to north and from west to east. Consistent with these broad geographic patterns of fish mercury concentrations, areas of high mercury concentrations in fish are positively correlated with areas of high forest cover and wetland area.
- The forested areas in the northern reaches of the region receive higher dry deposition of mercury and have other watershed features that produce mercury sensitive conditions and exacerbate the impacts of mercury emissions and deposition.
- Mercury concentrations in walleye and largemouth bass are 55 and 25 percent lower, respectively, in the Great Lakes than in nearby inland lakes, which may reflect differences in the food web structure, land-water linkages, and methylating potential between the large Great Lakes and smaller inland waters.

How is Mercury Contamination Changing Over Time in the Great Lakes Region?

Mercury levels in the Great Lakes region have declined over the last four decades, concurrent with controls on large industrial point-source discharges of mercury to surface waters throughout the region and decreased air emissions from regional and U.S. sources. After initial declines, however, concentrations of mercury in some fishes and birds from certain locations have increased in recent years—revealing how trajectories of mercury recovery can be complex.

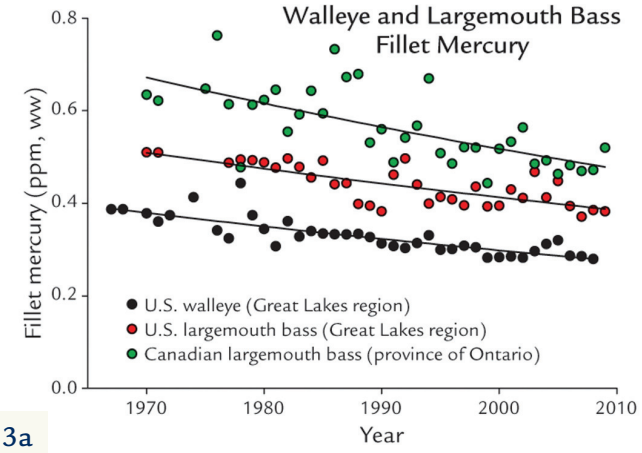
- Sediment cores from inland lakes within the Great Lakes region indicate that declines in local and regional mercury emissions have decreased mercury delivery to inland lakes across the region by about 20 percent since the mid-1980s.
- Mercury concentrations in walleye, largemouth bass, lake trout, and herring gull eggs in the Great Lakes region show downward trends in recent decades, consistent with declines in regional emissions and sediment accumulation in inland lakes.
- In certain areas within the region, mercury concentrations in some fish and wildlife species have been trending upward in the last 10 to 15 years.
- The challenge of interpreting patterns and change in mercury contamination and methylmercury in fish and wildlife underscores the need for comprehensive mercury monitoring at multiregional or national scales and over decadal time scales.

In Summary

Efforts to control mercury pollution in the Great Lakes region have resulted in substantial progress, but have not yet addressed the full scope of the problem. The findings from this binational scientific synthesis indicate that mercury pollution remains a major concern in the region and that the scope and intensity of the problem is greater than previously recognized.

While many measurements show declining mercury concentrations in fish and wildlife for decades, some observations indicate recent increases in mercury concentrations in particular species in certain areas. Mercury research in the Great Lakes region underscores the benefits of policy advances such as decreases in mercury emissions regionally and nationally. The general trends observed in this study indicate that controlling air emission sources should lower mercury concentrations in aquatic food webs yielding multiple benefits to fish, wildlife, and people in the region. It is expected that these improvements will be greatest for inland lakes and will be roughly proportional to declines in mercury deposition, which most closely track trends in regional and U.S. mercury air emissions.

Long-Term Mercury Trends in Fish and Wildlife (1967-2009)



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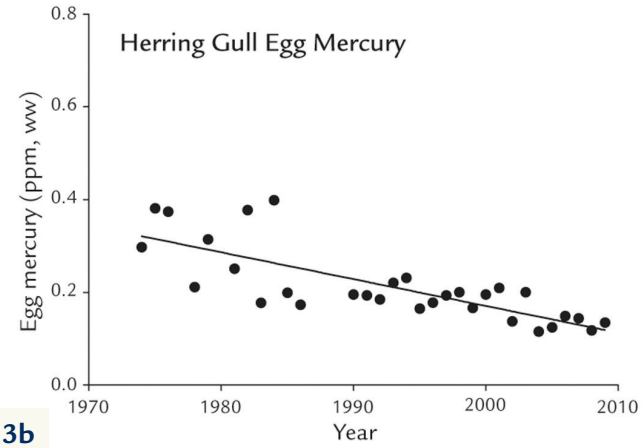

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Figure 3: Trends in (a) fillet (walleye and largemouth bass) and (b) herring gull egg mercury concentrations (averaged by year across multiple sites). Much of this decrease has been attributed to reductions in regional mercury emissions, although other factors may contribute.

For More Information:

The content for this report was distilled from 35 peer-reviewed papers published as special issues in the journals *Ecotoxicology* and *Environmental Pollution*.

Guest editors for the *Ecotoxicology* special issue include:
David C. Evers, Ph.D. (Biodiversity Research Institute)
James G. Wiener, Ph.D. (University of Wisconsin-La Crosse)
Niladri Basu, Ph.D. (University of Michigan)
Drew Bodaly, Ph.D. (University of Manitoba)
Heather Morrison, Ph.D. (Environment Canada)
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Guest editors for the *Environmental Pollution* special issue include:
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Heather Morrison, Ph.D. (Environment Canada)
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The full 40-page report can be found at:
www.briloon.org/mercuryconnections/GreatLakes