



Toxic Chemical Concentrations in Offshore Waters

Indicator #118

Overall Assessment

Status: **Mixed**

Trend: **Undetermined**

Rationale: **Concentrations of most organochlorine compounds are low and many are declining in the open waters of the Great Lakes, indicating progress in the reduction of persistent toxic substances. However, data are not available for all chemicals and changes to field and analytical methodology have made it difficult to discern temporal trends for some compounds.**

Lake-by-Lake Assessment

Lake Superior

Status: Fair

Trend: Undetermined

Rationale: Thirteen of a possible 21 organochlorine pesticide compounds (OCs) were detected in Lake Superior in 2005 and their concentrations were generally very low. Some organochlorines are highest in Lake Superior, due to the lake's susceptibility to atmospheric deposition.

Lake Michigan

Status: Fair

Trend: Undetermined

Rationale: Based on a limited assessment of six stations in 2006, 12 of a possible 21 organochlorine compounds were detected in Lake Michigan water samples. Atrazine concentrations were higher than the upper Great Lakes and within the range observed in Lakes Erie and Ontario.

Lake Huron

Status: Fair

Trend: Undetermined

Rationale: In 2007, 13 of a possible 21 organochlorine compounds were detected in Lake Huron. Of these, 11 were commonly found, including hexachlorocyclohexane (α -HCH), lindane, dieldrin, and g -chlordane. The concentrations were generally low, reflecting historical or diffuse sources. Mercury and PAH concentrations in Lake Huron and Georgian Bay were very low.

Lake Erie

Status: Mixed

Trend: Undetermined

Rationale: In 2006, 14 of a possible 21 organochlorine compounds were detected in Lake Erie. Concentrations of α -chlordane exceeded the strictest water quality guideline in the Great Lakes basin (NYSDEC guideline) at one station. Mercury concentrations in the western basin were the highest observed in the Great Lakes.

Lake Ontario

Status: Mixed

Trend: Undetermined

Rationale: Similar to the other lakes, 13 of a possible 21 organochlorine pesticides were detected in Lake Ontario waters in 2006. Hexachlorobenzene, dieldrin, lindane, a-HCH and DDT compounds were routinely found at levels higher than elsewhere in the basin. Total PCBs were also higher in Lake Ontario compared to the other Great Lakes.

Purpose

- To assess the concentration of priority toxic chemicals in offshore waters
- To infer the potential for impacts on the health of the Great Lakes aquatic ecosystem by comparison to criteria for the protection of aquatic life and human health
- To infer progress toward virtual elimination of toxic substances from the Great Lakes basin

Ecosystem Objective

The Great Lakes should be free from materials entering the water as a result of human activity that will produce conditions that are toxic or harmful to human, animal, or aquatic life (Great Lakes Water Quality Agreement Article III(d), United States and Canada 1987).

State of the Ecosystem

Many toxic chemicals are present in the Great Lakes and it is impractical to summarize the spatial and temporal trends of them all within a few pages. For more information on spatial and temporal trends in toxic contaminants in offshore waters, the reader is referred to Marvin *et al.* (2004), Kannan *et al.* (2006), and *Trends in Great Lakes Sediments and Surface Waters* in Chapter 8 of the Great Lakes Binational Toxics Strategy 2006 Progress report.

Beginning in 1986, Environment Canada has conducted toxic contaminant monitoring in the shared waters of the Great Lakes. Since 2004, Environment Canada has developed new measurement techniques and has invested in an ultra-clean laboratory in order to more accurately measure these trace concentrations of pollutants in the surface waters of the Great Lakes. The data presented here represent the results of this new methodology. Data are available for all of the shared waters, as well as a limited survey of Lake Michigan (six stations) in 2006. The analyte list includes chlorobenzenes, organochlorines, PCBs (as congeners), PAHs, trace metals including mercury, as well as a limited number of in-use pesticides.

Recent (2005 – 2007) water quality testing has found that only a small number of compounds are found ubiquitously in the basin at concentrations above laboratory detection limits. This category comprises a small number of chlorinated benzenes (including pentachlorobenzene (PECB) and hexachlorobenzene (HCB)), organochlorine compounds (g-HCH, dieldrin and heptachlor epoxide), PAHs (fluoranthene) and currently-used pesticides (atrazine and metolachlor). Total PCBs are also routinely found, although at some stations the levels are not significantly above field- and laboratory-blank levels.

Surveys conducted between 1992 and 2000 (Marvin *et al.* 2004) and during 2005-2007 (Environment Canada Great Lakes Surveillance Program, unpublished data) have showed that concentrations of most organochlorine compounds are below the most stringent water quality guidelines. One exception is that the NYSDEC guideline for a-chlordane was exceeded at one nearshore station in Lake Ontario and one station in the western basin of Lake Erie in 2006. In some cases (e.g., dieldrin, total PCBs), the laboratory detection limit is not yet sufficiently low to permit a comparison with the most stringent water quality guidelines in the basin.

Many organic compounds (such as PECB, HCB, total PCBs and DDT) show spatial patterns that indicate higher

concentrations near historical, localized sources. Concentrations in offshore waters are lower than nearshore, and concentrations in the upper Great Lakes are lower than the Lakes Erie and Ontario.

Exceptions to this pattern do exist. For example, compounds that are primarily distributed by atmospheric deposition rather than point sources, such as lindane and α -HCH, are found at higher concentrations in the north. In these cases, concentrations are highest in Lake Superior and are lower in the other lakes. The recent distribution of dissolved dieldrin in surface waters (Figure 1) shows an interesting pattern of atmospheric redistribution combined with proximity to historical source areas.

Currently-emitted compounds, such as PAHs, which are released during fossil fuel combustion, also show spatial patterns that are indicative of sources. Concentrations of PAHs are therefore higher in the lower lakes, where usage is greater. The lighter PAHs are also ubiquitous in the upper Great Lakes, but their concentrations are much lower. Concentrations of the heavier PAHs, which are not as subject to atmospheric transport due to their partitioning to particles, are highest in the lower Great Lakes, where human populations are greater.

Mercury concentrations (Figure 2) overall are very low, and concentrations in the open lake areas are currently below the U.S. EPA Great Lakes Initiative (GLI) water quality criterion of 1.3 ng/L (U.S. EPA 2006). However, higher concentrations are observed in the western basin of Lake Erie in particular, and in some harbors and major urban areas as well (e.g., Toledo, Hamilton, Duluth, Cleveland, Rochester, Chicago). Some samples near these urban areas exceed the GLI water quality criterion for the protection of wildlife.

Certain parameters have shown a marked decline over time. Concentrations of pentachlorobenzene (PCB) in Lake Ontario have fallen by 71% since 1993, although the rate of decline appears to have slowed in recent years. Similarly, lindane (γ -HCH) and α -HCH concentrations have declined in Lake Ontario by 68% and 90%, respectively, since 1992. Reductions are largely due to the ban of these compounds and the subsequent control of point sources. The rates of decline appear to be slowing, however, as residual levels are persistent in the environment. For example, the rate of decrease in α -HCH in Lake Ontario from 1992 to 1998 was 0.12 ng/L per year, but the rate from 1998 to 2006 has slowed to 0.04 ng/L per year.

Concentrations of HCB, whose use as a fungicide was discontinued in 1976, but which can be released as a by-product from the manufacture of a variety of organic chemicals and from the incineration or processing of chlorinated solvents and pesticides, have not changed significantly between 1998 and 2006 in Lake Ontario nor Lake Erie. Similarly, no significant change in the concentration of d-BHC is observed in the lakes since 1992.

In contrast, the concentrations of currently-used pesticides atrazine and metolachlor have increased by 57% and 31%, respectively, between 1998 and 2006 in Lake Ontario. Detectable concentrations of these two pesticides are found ubiquitously in all of the lakes, with higher concentrations reflecting source areas primarily in the watersheds of Lakes Ontario, Erie and Michigan.

The best available information for the determination of longer-term temporal trends is bottom sediment quality. This information indicates that concentrations of total PCBs and mercury, among other parameters, have declined markedly over the past 30 years. The concentration of total PCBs in Lake Erie surficial bottom sediments has fallen from a lakewide average concentration of 136 ng/g in 1971 to 43 ng/g in 1997 (Painter et al., 2001), a three-fold decline. Concentrations of mercury in bottom sediments have decreased in all of the Great Lakes since the peak (approximate 1968 – 1975) period with the exception of Lake Superior, where levels approach geologic norms. Reductions in mercury contamination in sediments across the basin, estimated by comparisons of recent and

historical surveys, range from 24% for Lake Ontario to 60% for western Lake Erie and 80% for Lake Huron (Marvin et al., 2004b).

Management Implications

Management efforts to control inputs of organochlorine pesticides have resulted in decreasing concentrations in the Great Lakes. Historical sources for some compounds, however, still appear to affect ambient concentrations in the environment. Further reductions in the input of OC pesticides are dependent, in part, on controlling indirect inputs such as atmospheric deposition and surface runoff. Monitoring programs should increase measurement of the major in-use pesticides, of which currently only half are monitored. The additive and synergetic effects of pesticide mixtures should be examined more closely, since existing water quality criteria have been developed for individual pesticides only (Kannan *et al.* 2006).

Efforts need to be maintained to identify and track the remaining sources and explore opportunities to accelerate their elimination (e.g., via the Great Lakes Binational Toxics Strategy). Targeted monitoring to identify and track down local sources of LaMP critical pollutants is being conducted in Great Lakes watersheds. However, an expansion of the track-down program should be considered to include other priority chemicals whose distributions suggest localized influences.

Compounds that are included in Canada’s Chemical Management Plan and the BTS surveillance for compounds of emerging concern, as well as other chemicals that act as endocrine disruptors, in-use pesticides and pharmaceuticals, are emerging issues. Surveillance and monitoring for parameters of emerging concern is being prioritized by discussions with risk assessors and managers, in order to first address substances that are most likely to be persistent, bioaccumulative, and/or inherently toxic in the aquatic environment and is providing an early warning system to help anticipate possible future toxic substance problems.

Comments from the author(s)

Data are for Lake Superior (2005), Lake Huron and Georgian Bay (2007), Lake Erie (2006) and Lake Ontario (2005 and 2006) as well as limited survey data for Lake Michigan (2006).

Assessing Data Quality

Insert “x” under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization	X					
2. Data are traceable to original sources	X					
3. The source of the data is a known, reliable and respected generator of data	X					
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin	X					
5. Data obtained from sources within the U.S. are comparable to those from Canada						X

6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report	X					
Clarifying Notes: Comparable data have not been generated by the US during the time frame of the data presented here (2005-2007). Data presented here have not been compared with older US data.						

Acknowledgments

Authors:

Alice Dove, Environment Canada, Water Quality Monitoring and Surveillance, Burlington, ON (2008)

Sources

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List of Figures

Figure 1. Great Lakes 2005-2007 Spring, Surface Water Concentrations of Dieldrin (ng/L).

Source: Environment Canada’s Great Lakes Surveillance Program, Burlington, Ontario. Data for Lakes Superior and Ontario are from 2005, Lakes Michigan and Erie are from 2006, and Lake Huron and Georgian Bay are 2007.

Figure 2. Great Lakes 2005-2007 Spring, Surface Water Concentrations of Total Mercury (ng/L).

Source: Environment Canada’s Great Lakes Surveillance Program, Burlington, Ontario. Data for Lake Superior are

from 2005, Lakes Michigan, Erie and Ontario are from 2006, and Lake Huron and Georgian Bay are 2007.

Last Updated

State of the Lakes Ecosystem Conference (SOLEC) 2008

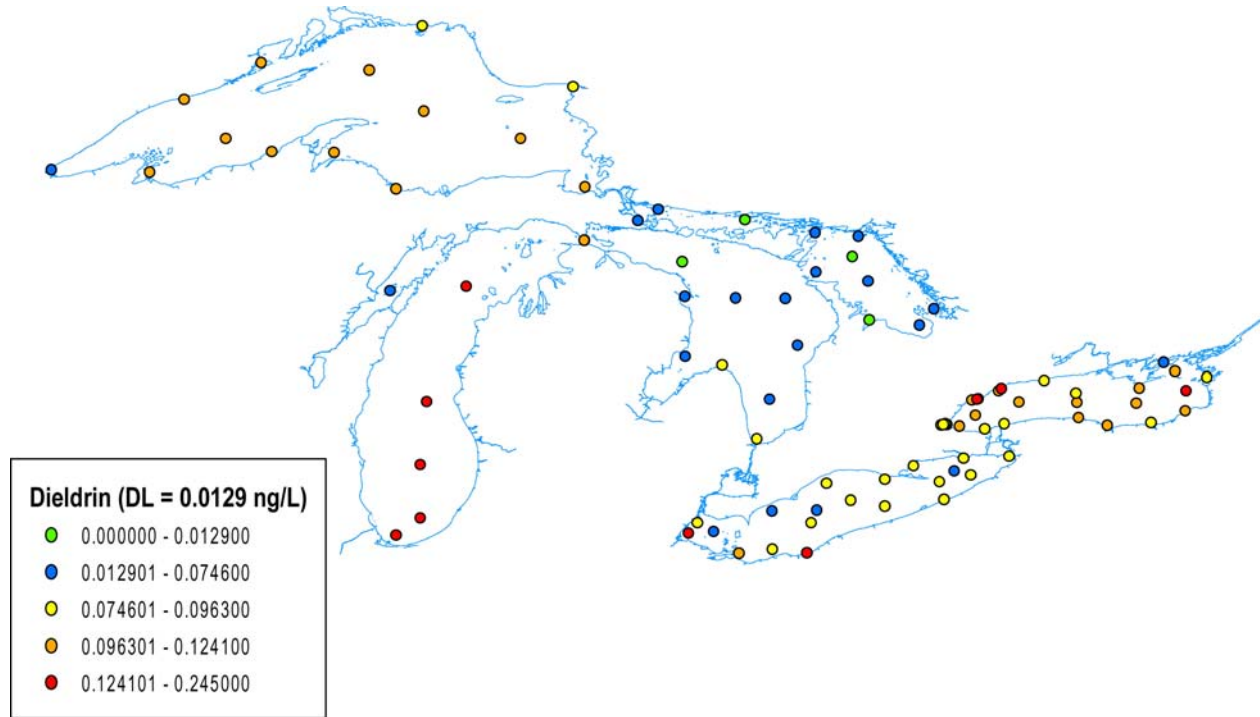


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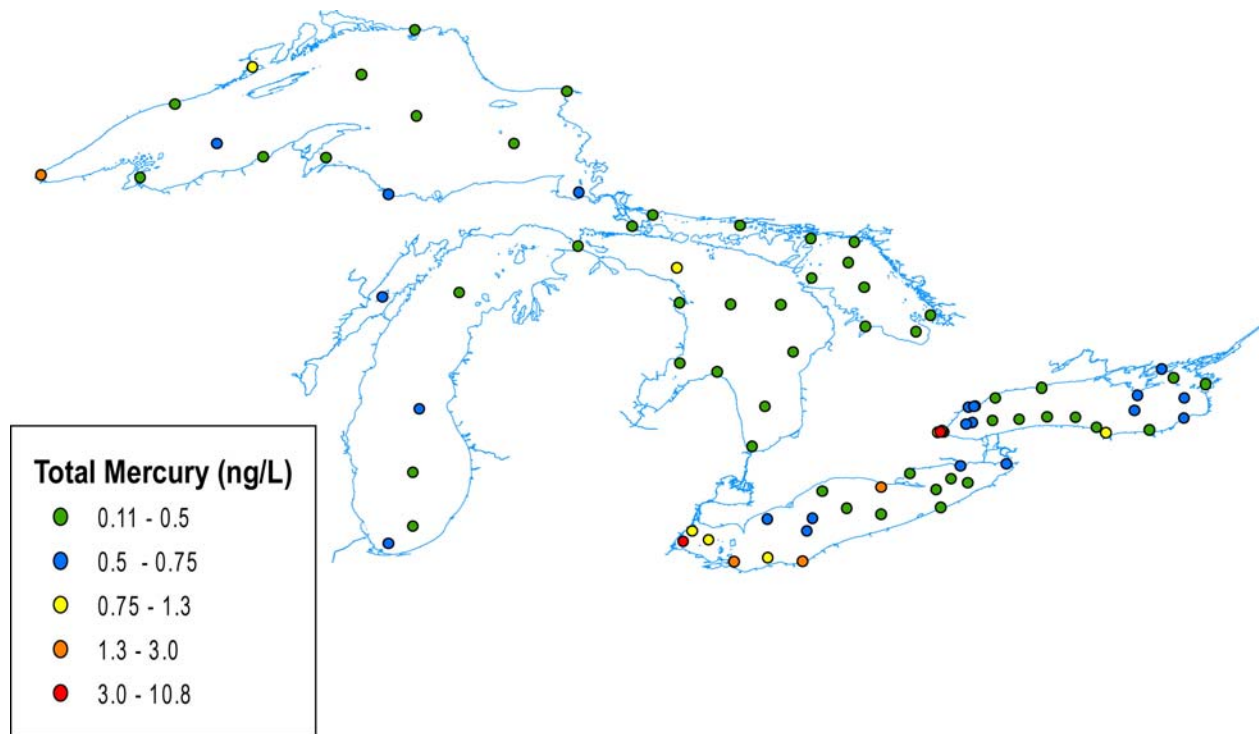


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