Contaminants in Whole Fish

Indicator #121

Overall Assessment

Status: **Mixed**

Trend: **Improving**

Rationale: **Over time, concentrations of historically regulated contaminants have generally declined in most monitored fish species. The concentrations of other contaminants, currently regulated and unregulated, vary in selected fish communities. The changes are often lake-specific and relate both to the characteristics of the substances involved and the biological composition of the fish community.**

Lake-by-Lake Assessment

PCB and DDT levels are measured in lake trout and walleye while only smelt samples have recent mercury trend data available.

Lake Superior

Status: Fair

Trend: Improving

Rationale: Concentrations of ∑ PCBs show little change, ∑ DDT shows fluctuating concentrations, while mercury concentrations continue to decline. ∑ PCB concentrations remain above GLWQA criteria while ∑ DDT and mercury remain below. Contaminants in Lake Superior are typically atmospherically-derived. The dynamics of Lake Superior allow for the retention of contaminants much longer than in any other Great Lake

Lake Michigan

Status: Fair

Trend: Improving

Rationale: Concentrations of ∑ PCBs and ∑ DDT are declining. ∑ PCB levels remain above GLWQA criteria and ∑ DDT levels remains below. Food web changes are critical to Lake Michigan contaminant concentrations. Aquatic invasive species such as Asian carp are also of major concern to Lake Michigan due to the connection of Chicago Sanitary and Ship Canal and the danger the carp pose to the food web.

Lake Huron

Status: Fair

Trend: Improving

Rationale: Both ∑ PCBs and DDT show general declines in concentrations while mercury displays a flux in concentration. ∑ PCB concentrations remain above GLWQA criteria while ∑ DDT and mercury remain below. Contaminant loading to Saginaw Bay continues to be reflected in fish tissue contaminant levels.

Lake Erie

Status: Fair

Trend: Improving

Rationale: ∑ PCBs and DDT concentrations show a pattern of annual increases linked to changes in invasive species populations, such as zebra and quagga mussels. Aquatic invasive species are of major concern to Lake Erie. Mercury concentrations are the highest ever recorded in Lake Erie. ∑ PCB concentrations remain above GLWQA criteria while ∑ DDT and mercury remain below.

Lake Ontario

Status: Fair

Trend: Improving

Rationale: Both ∑ PCBs and DDT concentrations show a pattern of decline while mercury concentrations show little change. ∑ PCB concentrations remain above GLWQA criteria while ∑ DDT and mercury remain below. Historic point sources of mirex and OCS have resulted in higher concentrations in Lake Ontario than any other Great Lake. Contaminants of emerging concern, such as PBDEs and PFOS, continue to raise alarm in Lake Ontario.

Purpose

- To describe temporal and spatial trends of bioavailable contaminants in representative open water fish species from throughout the Great Lakes
- To infer the effectiveness of remedial actions related to the management of critical pollutants
- To identify the nature and severity of emerging problems

Ecosystem Objective

Great Lakes waters should be free of toxic substances that are harmful to fish and wildlife populations and the consumers of this biota. Data on status and trends of contaminant conditions, using fish as biological indicators, support the requirements of the Great Lakes Water Quality Agreement (GLWQA, United States and Canada 1987) Annexes 1 (Specific Objectives), 2 (Remedial Action Plans and Lakewide Management Plans), 11 (Surveillance and Monitoring), and 12 (Persistent Toxic Substances).

State of the Ecosystem

Background

Long-term (greater than 25 yrs), basin-wide monitoring programs that measure whole body concentrations of contaminants in top predator fish (lake trout and/or walleye) and in forage fish (smelt) are conducted by the U.S. Environmental Protection Agency (U.S. EPA) Great Lakes National Program Office (GLNPO) through the Great Lakes Fish Monitoring Program, and Environment Canada, through the Fish Contaminants Surveillance Program, to determine the effects of contaminant concentrations on wildlife and to monitor trends. Environment Canada reports annually on contaminant burdens in similarly aged lake trout (4+ - 6+ year range), walleye (Lake Erie), and in smelt. GLNPO annually monitors contaminant burdens in similarly sized lake trout (600-700 mm total length) and walleye (Lake Erie, 400-500 mm total length) from alternating locations by year in each lake. Details of the program can be found at, http://www.epa.gov/glnpo/glindicators/fish.html. Differences between the U.S. and Canadian programs, including collection site differences and varying species collections, inhibit the direct comparison of results from the two programs.

In 2006, Environment Canada assumed responsibilities for the Fish Contaminant Surveillance Program from the Department of Fisheries and Ocean (DFO). All data, prior to 2006 in this indicator report were produced by DFO.

Also in In 2006, the Great Lakes Fish Monitoring Program was granted to a new principal investigator. Data from 2004 and beyond was provided by Clarkson University.

Chemical Concentrations in Whole Great Lakes Fish

Since the late 1970s, concentrations of historically regulated contaminants such as PCBs, DDT and mercury have generally declined in most monitored fish species. The concentration of other contaminants, currently regulated and unregulated, have demonstrated either slowing declines or, in some cases, increases in selected fish communities. The changes are often lake-specific and relate both to the characteristics of the substances involved and the biological composition of the fish community.

The GLWQA, first signed in 1972, renewed in 1978, and amended in 1987, expresses the commitment of Canada and the United States to restore and maintain the chemical, physical and biological integrity of the Great Lakes basin ecosystem. When applicable, contaminant concentrations are compared to GLWQA criteria.

Total PCBs

Total PCB concentrations in Great Lakes top predator fish have continuously declined since their phase-out in the 1970s (see figures 1 – 4). However, rapid declines are no longer observed and concentrations in fish remain above the U.S. EPA wildlife protection value of 0.16 ppm and the GLWQA criteria of 0.1 ppm. Concentrations remain high in top predator fish due to the continued release of uncontrolled sources and their persistent and bioaccumulative nature.

Total DDT

Total DDT concentrations in Great Lakes top predator fish have continuously declined since the chemical was banned in 1972. However, large declines are no longer observed. Rather, very small annual percent declines are seen, indicating near steady state conditions (see figures 5 – 8). It is important to note that the concentrations of this contaminant remain below the GLWQA criteria of 1.0 ppm. There is no U.S. EPA wildlife protection value for total DDT because the PCB value is more protective.

Mercury

Concentrations of mercury are similar across all fish in all lakes. It is assumed that concentrations of mercury in top predator fish are atmospherically driven. It is important to note that current concentrations in GLNPO top predator fish in all lakes remain above the GLWQA criteria of 0.5 ppm (see figure 9) as do the majority of Environment Canada lake rout (see figure 10). It is also important to note that Canadian smelt have never been observed to be above the GLWQA criteria (see figure 11).

Total Chlordane

Concentrations of total chlordane have consistently declined in whole top predator fish since the U.S. EPA banned it in 1988 (see figures 12 – 13). Total chlordane is composed of cis- and trans-chlordane, cis- and trans-nonachlor, and oxychlordane, with trans-nonachlor being the most prevalent of the compounds. While trans-nonachlor was one of the five components of the technical chlordane mixture, it is the least metabolized and predominates within the food web (Carlson and Swackhamer 2006).

Mirex

Concentrations of mirex are highest in Lake Ontario top predator fish and smelt due to its continued release from uncontrolled historic sources near the Niagara River (see figures 16 – 19).

Dieldrin

Concentrations of dieldrin in lake trout appear to be declining in all Great Lakes and are lowest in Lake Superior and highest in Lake Michigan (see figures 20 – 24). Concentrations in Lake Erie walleye were lower than those in lake trout from the other Great Lakes. Aldrin is readily converted to dieldrin in the environment. For this reason, these two closely related compounds (aldrin and dieldrin) are considered together by regulatory bodies.

Toxaphene

Decreases in toxaphene concentrations have been observed throughout the Great Lakes in all media following its ban in the mid-1980s. However, concentrations have remained the highest in Lake Superior due to its longer retention time, cold temperatures, and slow sedimentation rate. It is assumed that concentrations of toxaphene in top predator fish are atmospherically driven (Hites 2006).

PBDEs

The more toxic penta and octa formulations of PBDE were discontinued in 2004 in the United States while the less toxic and more stable deca formulation continued to be produced. Both U.S. EPA and Environment Canada analyze for polybrominated diphenylethers (PBDE) in whole top predator fish. Retrospective analyses of archived samples demonstrated an increase in concentrations of PBDEs and continued through the early 2000s. More recent samples display a decline in total PBDEs (see figure 25). Ongoing research indicates that some species of Great Lakes fish are capable of debrominating the deca formulation.

Other Contaminants of Emerging Interest

One of the most widely used brominated flame retardants (BFR) is hexabromocyclododecane (HBCD). Based on its use pattern as an additive BFR, it has the potential to migrate into the environment from its application site. Recent studies have confirmed that HBCD isomers do bioaccumulate in aquatic ecosystems and do biomagnify as they move up the food chain. Recent studies by Tomy *et al*. (2004) confirmed the food web biomagnification of HBCD isomers in Lake Ontario (Table 1).

Perfluoroctanesulfonate (PFOS) has also been detected in fish throughout the Great Lakes and has also demonstrated the capacity for biomagnification in food webs. PFOS is used in surfactants such as water repellent coatings (e.g., Scotchguard ™) and fire suppressing foams. It has been identified in whole lake trout samples from all the Great Lakes at concentrations from 3 to 139 ng/g wet weight (Stock *et al*. 2003). In addition, retrospective analyses of archived lake trout samples from Lake Ontario have identified a 4.25-fold increase (43 to 180 ng/g wet weight, whole fish) from 1980 to 2001 (Martin *et al*. 2004).

Pressures

Current

The impact of invasive nuisance species on toxic chemical cycling in the Great Lakes is still being investigated. The number of non-native invertebrates and fish species proliferating in the Great Lakes basin continues to increase, and they continue to spread more widely. Changes imposed on the native fish communities by non-native species will subsequently alter ecosystem energy flows. As a consequence, the pathways and fate of persistent toxic substances will be altered, resulting in different accumulation patterns, particularly at the top of the food web. Each of the Great Lakes is currently experiencing changes in the structure of the aquatic community, hence there may be periods of increases in contaminant burdens of some fish species.

A recently published, 15-year retrospective Great Lakes study showed that lake trout embryos and sac fry are very sensitive to toxicity associated with maternal exposures to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and structurally related chemicals (Cook *et al*. 2003). The increase in contaminant load of TCDD may be responsible for declining lake trout populations in Lake Ontario. The models used in this study can be used in the other Great Lakes.

Future

Additional stressors in the future will include climate change, with the potential for regional warming to change the availability of Great Lakes critical habitats, change the productivity of some biological communities, accelerate the movement of contaminants from abiotic sources into the biological communities, and effect the composition of biological communities. Associated changes in the concentration of contaminants in the water, critical habitat availability and reproductive success of native and non-native species are also factors that will influence trends in the quantity of toxic contaminants in the Great Lakes basin ecosystem.

Management Implications

Much of the current, basin-wide, persistent toxic substance data that is reported focuses on legacy chemicals whose use has been previously restricted through various forms of legislation. There are also a variety of other potentially harmful contaminants at various locations throughout the Great Lakes that are reported in literature. A comprehensive, basin-wide assessment program is needed to monitor the presence and concentrations of these recently identified compounds in the Great Lakes basin. The existence of long-term specimen archives (greater than 25 years) in both Canada and the United States could allow retrospective analyses of the samples to determine if concentrations of recently detected contaminants are changing. Further control legislation might be needed for the management of specific chemicals.

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:						

Acknowledgments

Authors: (2008)

Elizabeth Murphy, U.S. Environmental Protection Agency, Great Lakes National Program Office

Sean Backus, Environment Canada

Sources

Carlson, D.L., and Swackhamer D.L. 2006. Results from the U.S. Great Lakes Fish Monitoring Program and Effects of Lake Processes on Contaminant Concentrations. *Journal of Great Lakes Research.* 32(2):370 – 385.

Cook, P.M., Robbins, J.A., Endicott, D.D., Lodge, K.B., Guiney, P.D., Walker, M.K, Zabel, E.W., and Peterson, R.E. 2003. Effects of Aryl Hydrocarbon Receptor-Mediated Early Life Stage Toxicity on Lake Trout Populations in Lake Ontario during the 20th Century. *Environ. Sci. Technol.*37(17):3878-3884.

Hites R.A, (ed). 2006. *Persistent Organic Pollutants in the Great Lakes*. Heidelberg, Germany: Springer.

Martin, J.W., Whittle, D.M., Muir, D.C.G., and Mabury, S.A. 2004. Perfluoroalkyl Contaminants in the Lake Ontario Food Web. *Environ. Sci. Technol.* 38(20):5379-5385.

Stock, N.L., Bonin J., Whittle, D.M., Muir, D.C.G., and Mabury, S.A. 2003. Perfluoronated Acids in the Great Lakes. SETAC Europe 13th Annual Meeting, Hamburg, Germany.

Tomy, G.T., Budakowski, W., Halldorson T., Whittle, D.M., Keir, M., Marvin, C., MacInnis, G., and Alaee, M. 2004. Biomagnification of α and γ-Hexabomocyclododecane in a Lake Ontario Food Web. *Environ. Sci. Technol.* 38:2298-2303.

United States and Canada. 1987. *Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987*. Ottawa and Washington.

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Source: Tomy *et al*. (2004)

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Lake Trout = 600-700 mm size range. *Fish collected between 1972 and 1982 were collected at even year sites only. Walleye = 450-550 mm size range.
Source: U.S. Environmental Protection Agency

Figure 2. Total PCBs in Odd Year whole EPA Lake Trout composites (Walleye in Lake Erie), 1991 – 2005 µg/g wet weight +/- 95% C.I., composite samples. Lake Trout = 600-700 mm size range. Walleye = 450-550 mm size range.
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Figure 6. Total DDT in Odd Year whole EPA Lake Trout composites (Walleye in Lake Erie), 1991 - 2005 µg/g wet weight +/- 95% C.I., composite samples. Lake Trout = 600-700 mm size range. Walleye = 450-550 mm size range
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Figure 15. Total Chlordane in composite Environment Canada rainbow smelt, collected 1977 through 2005, µg/g wet weight.
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Figure 22. Dieldrin in 4 to 6 year old individual whole Environment Canada Lake Trout, collected 1977 through 2005, µg/g wet weight.
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Figure 23. Dieldrin in composite Environment Canada rainbow smelt, collected 1977 through 2005, µg/g wet weight.
Source: Fisheries and Oceans Canada

Last Updated
State of the Lakes Ecosystem Conference (SOLEC) 2008

Species	ΣHBCD (α+γ isomers) (ng/g wet wt ± S.E.)
Lake Trout	1.68 ± 0.67
Sculpin	0.45 ± 0.10
Smelt	0.27 ± 0.03
Alewife	0.13 ± 0.02
Mysis	0.07 ± 0.02
Diporeia	0.08 ± 0.01
Plankton	0.02 ± 0.01

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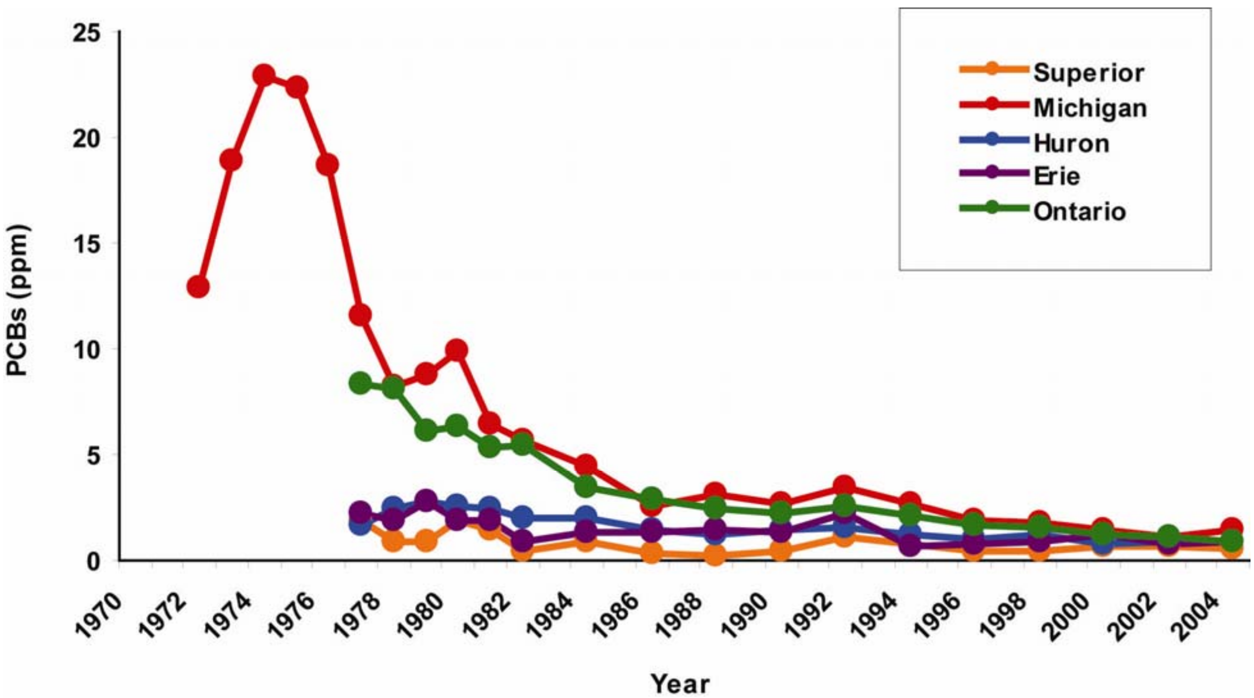

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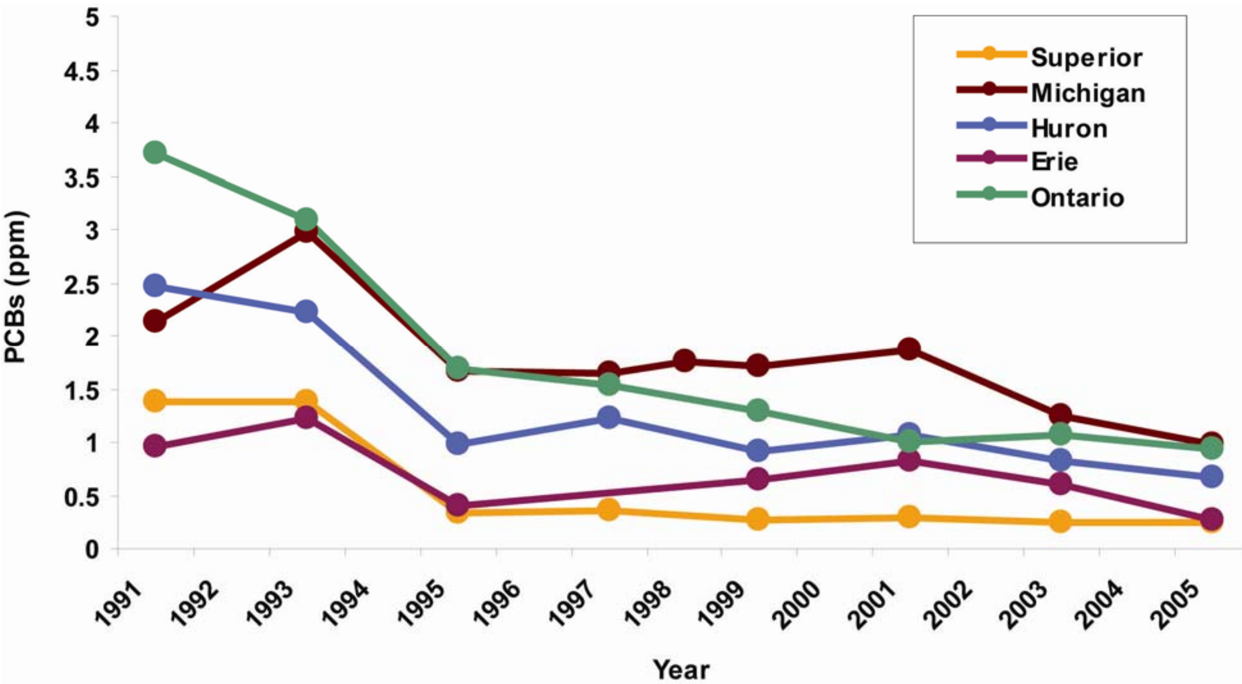

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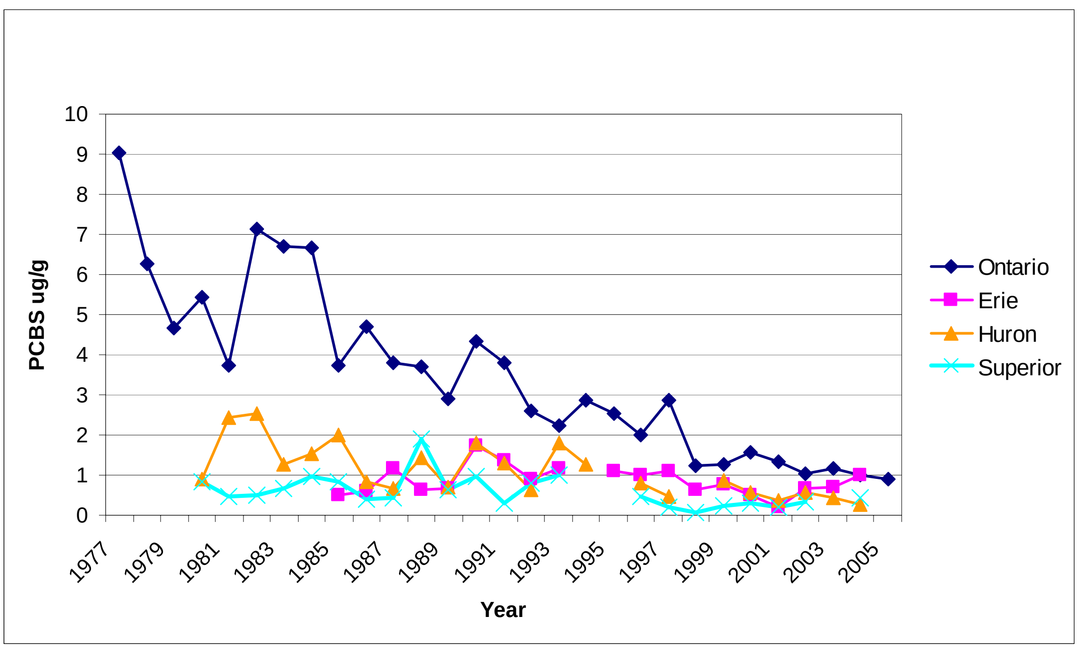

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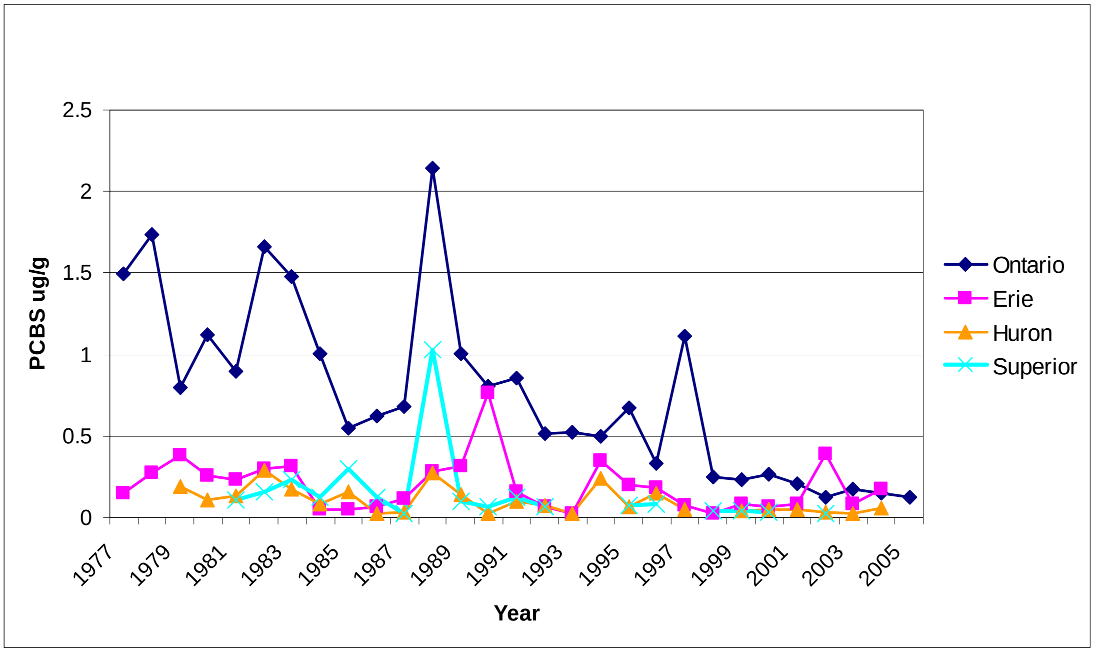

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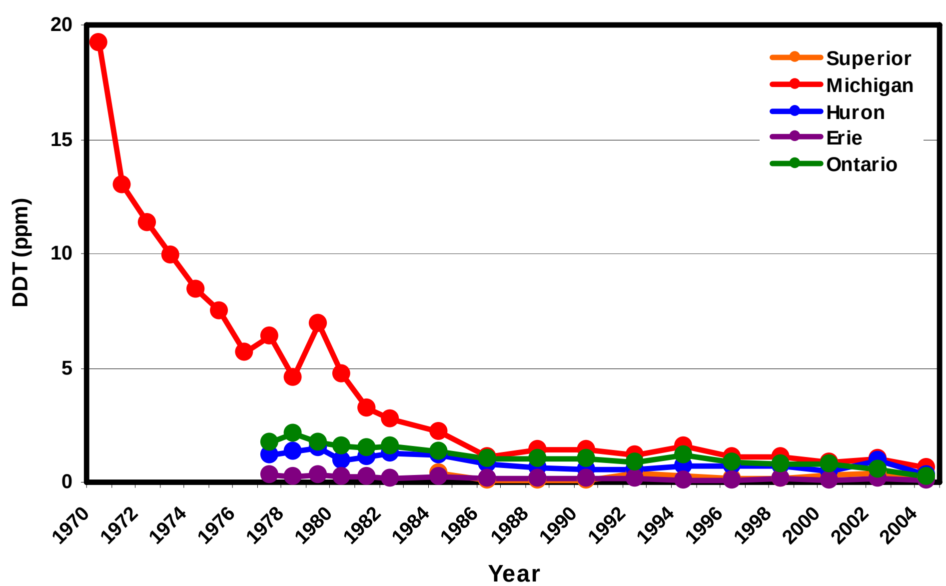

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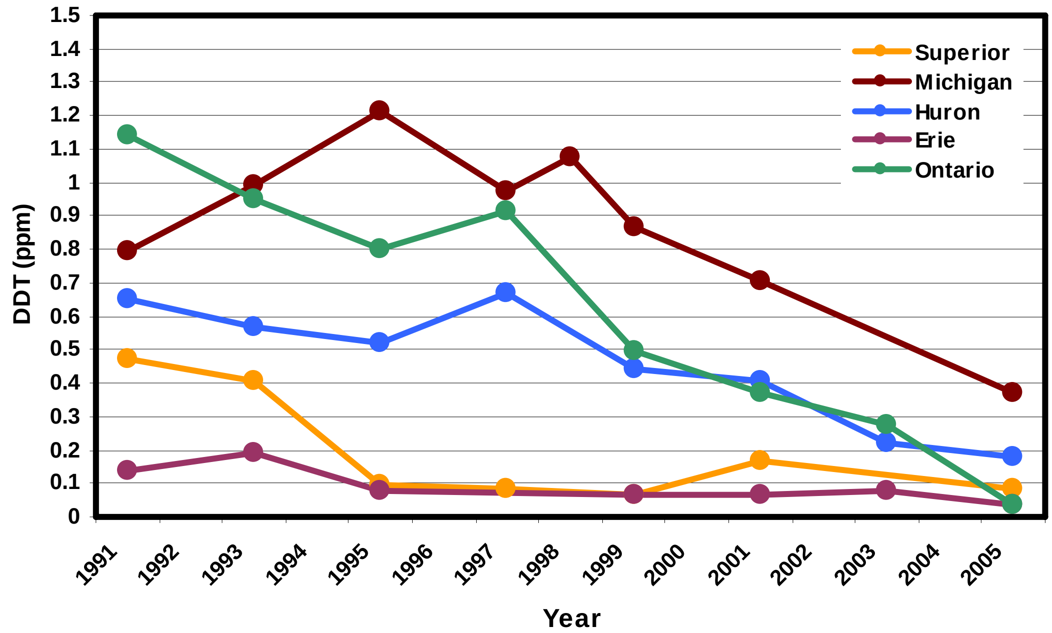

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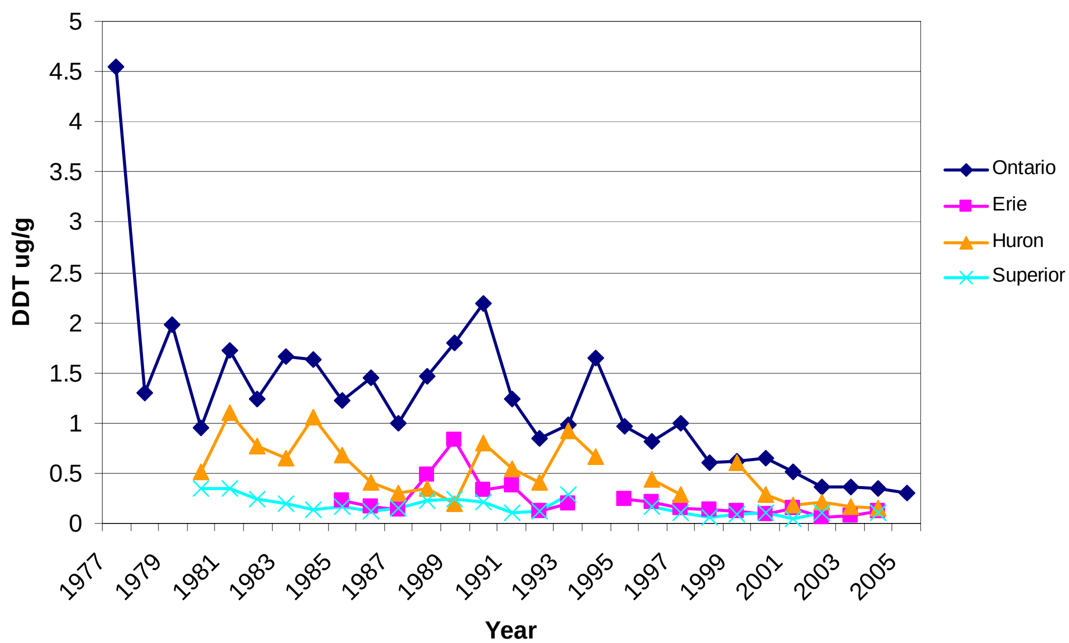

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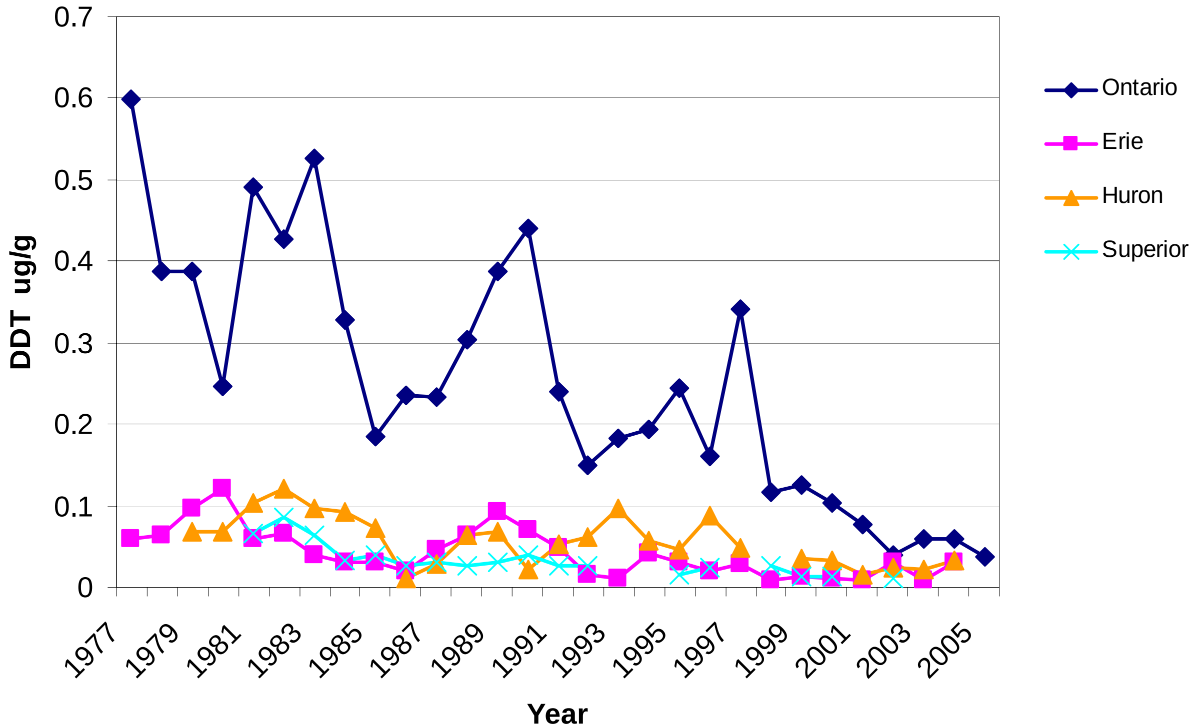

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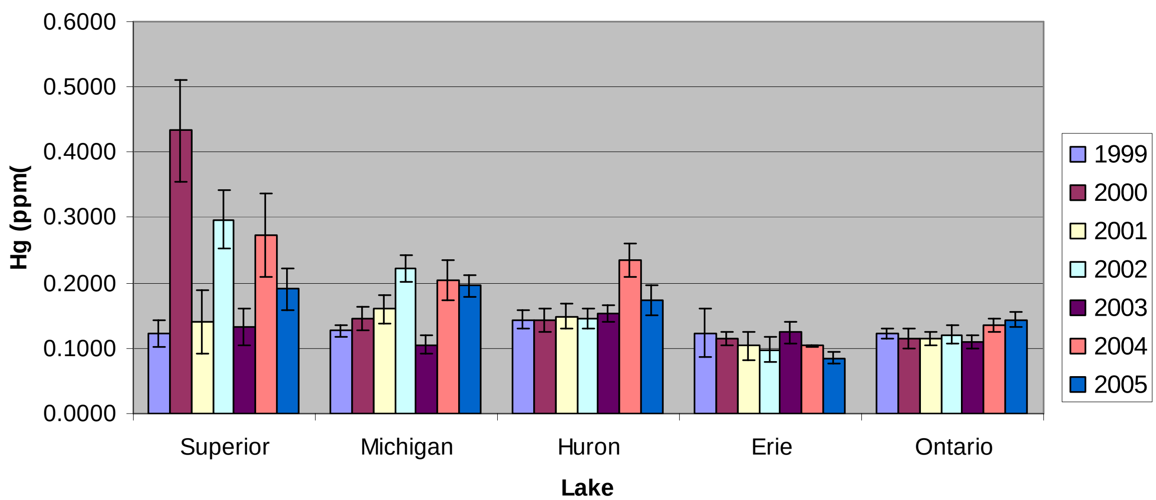

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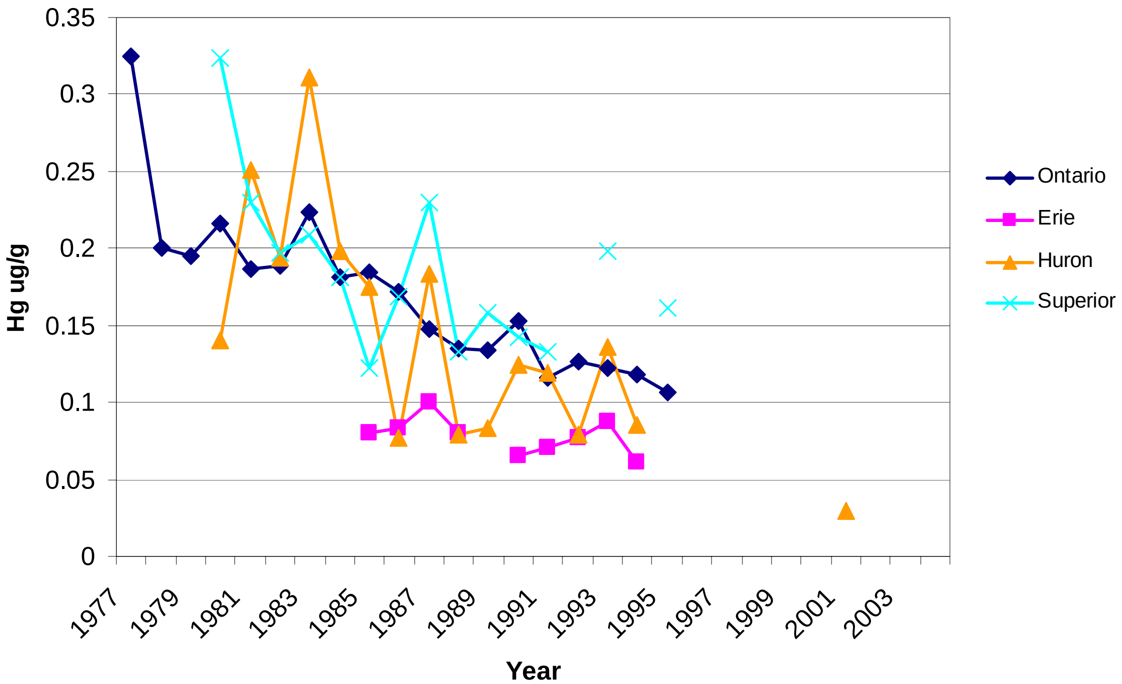

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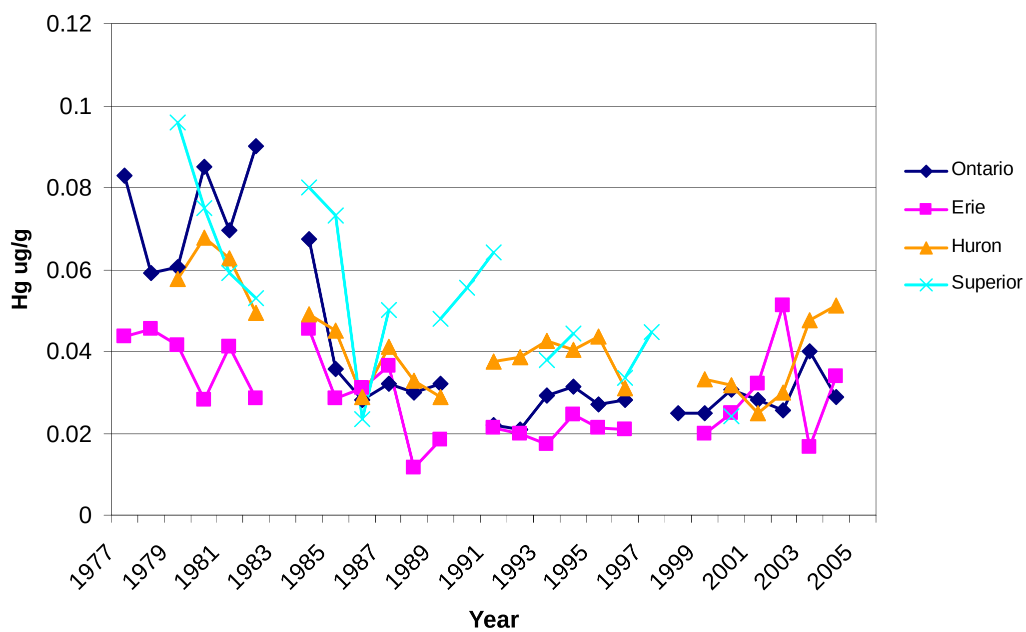

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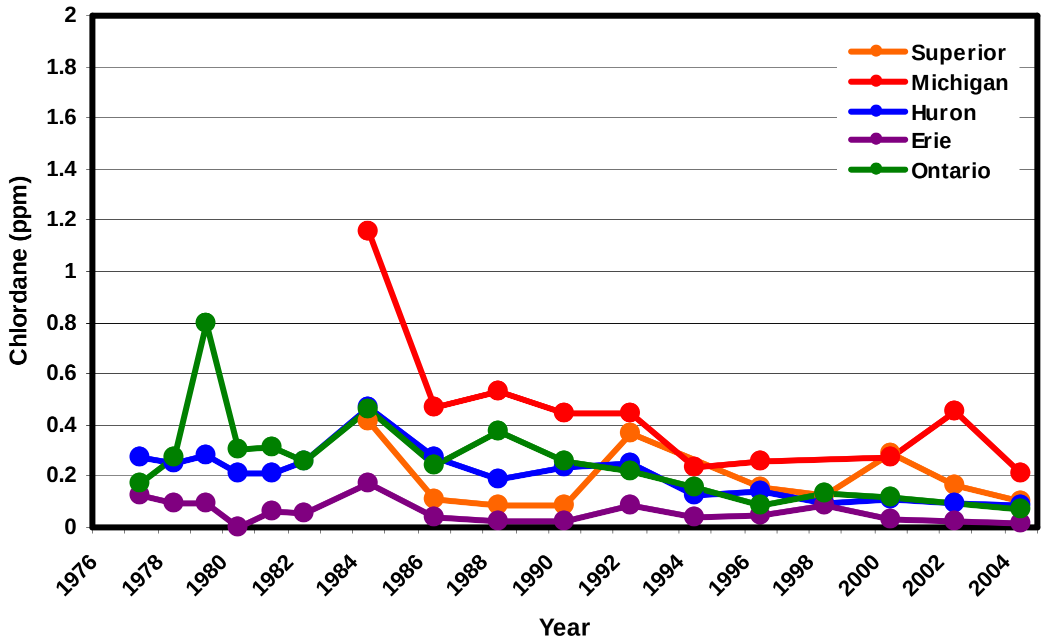

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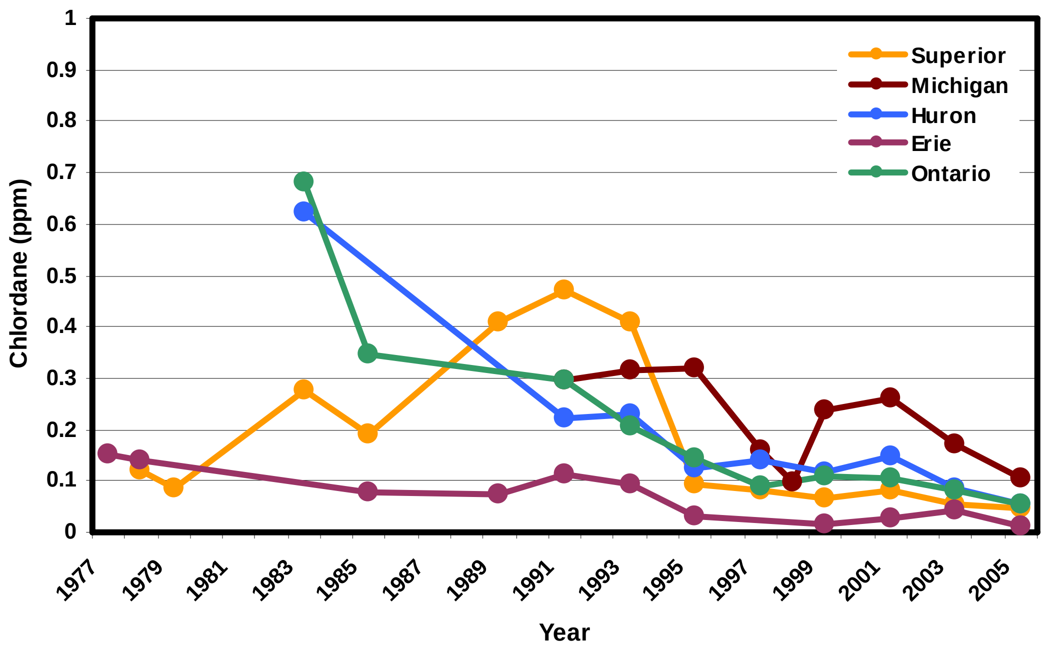

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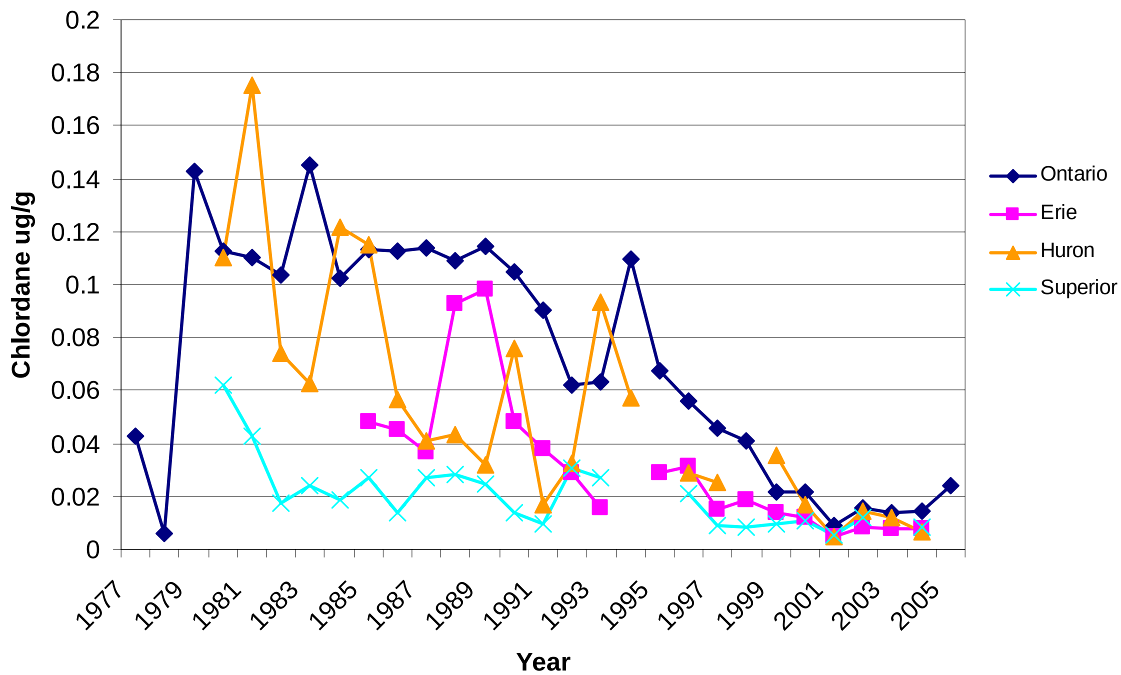

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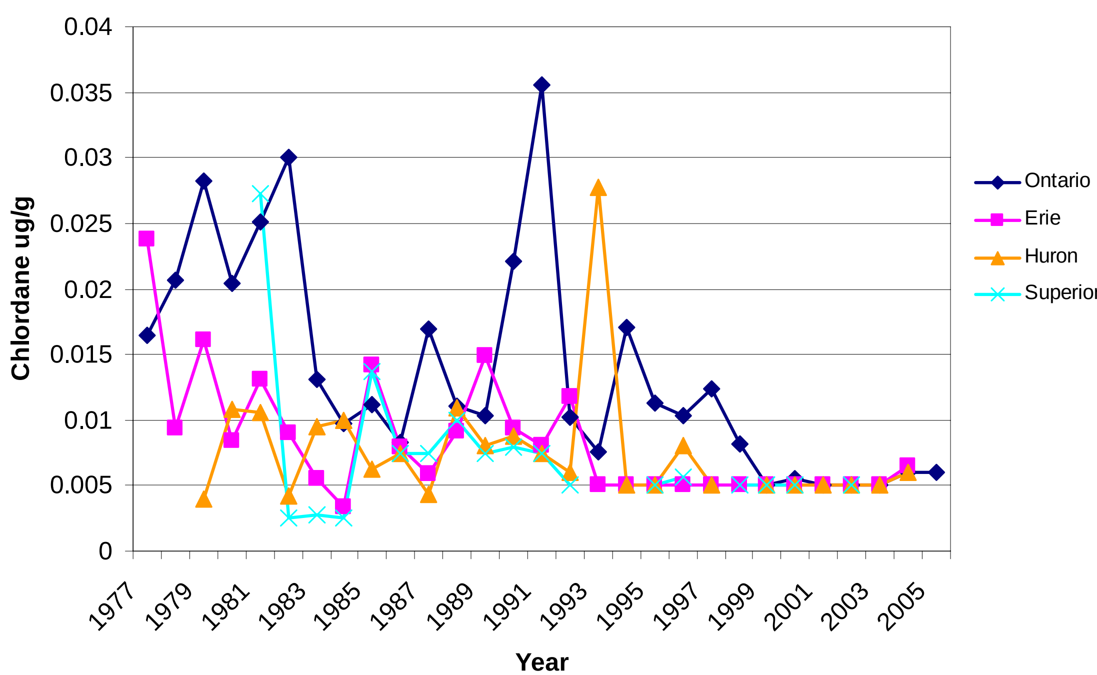

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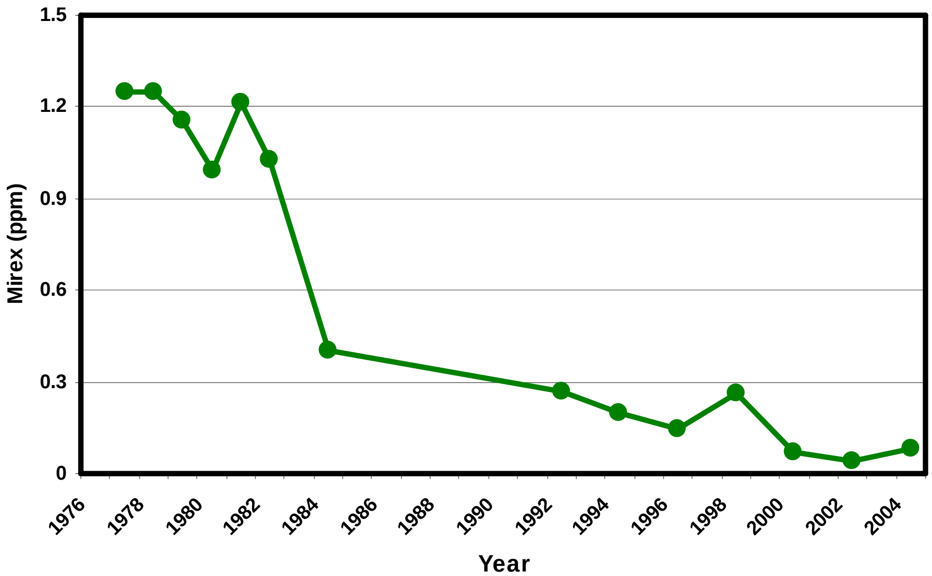

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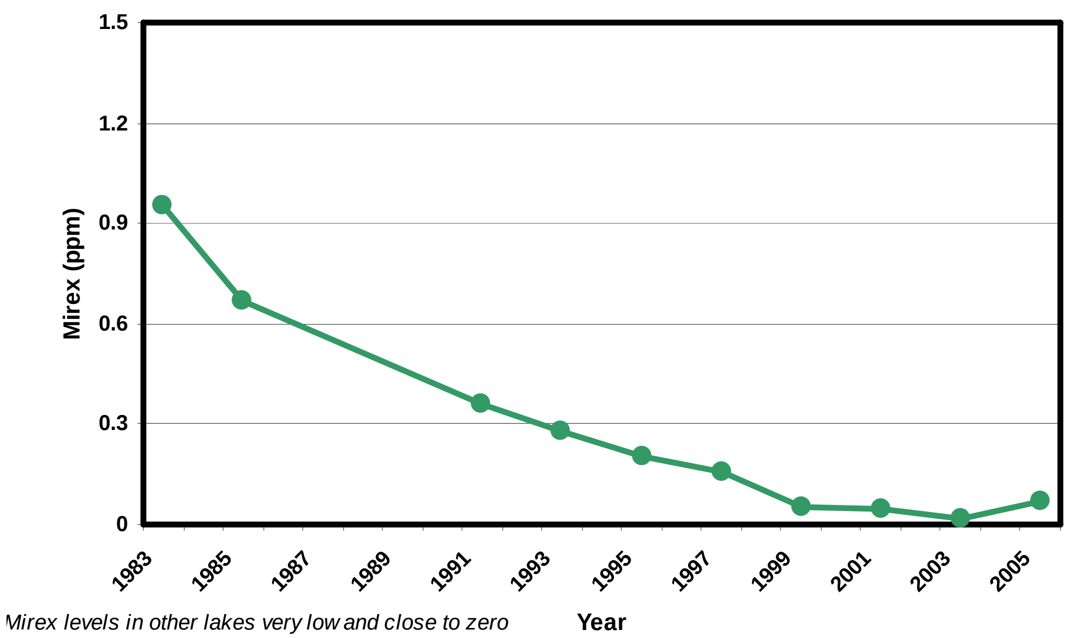

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Source: U.S. Environmental Protection Agency

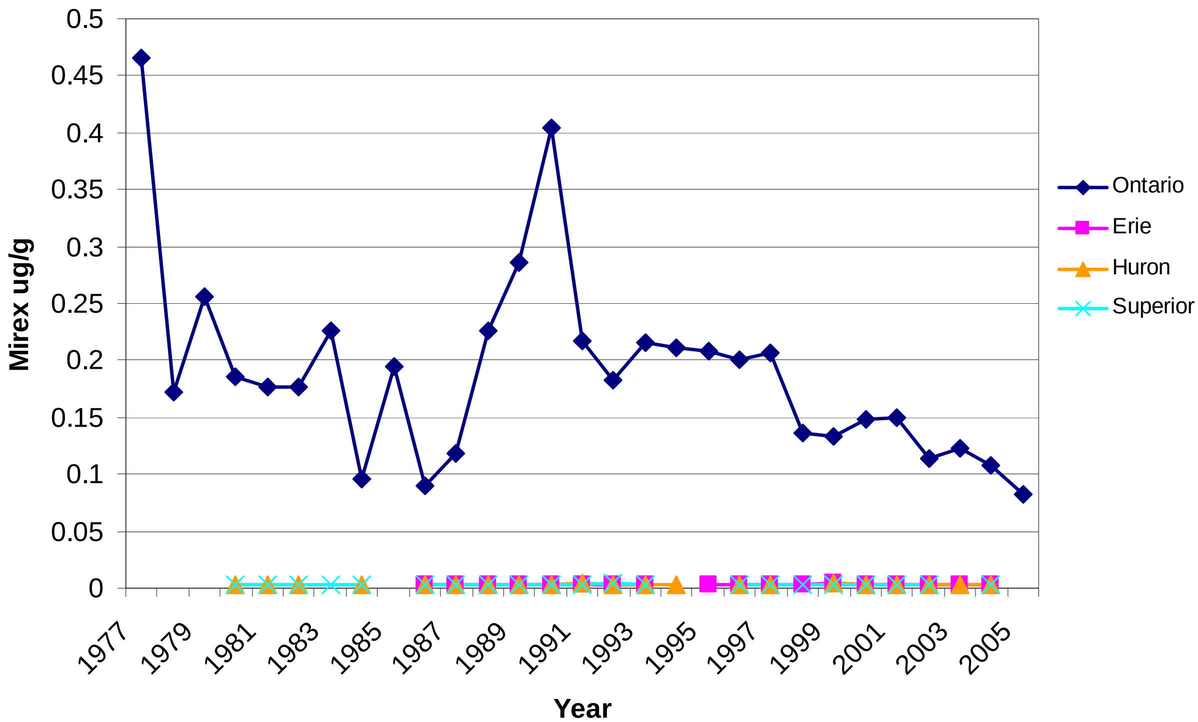

Figure 18. Mirex in 4 to 6 year old individual whole Environment Canada Lake Trout, collected 1977 through 2005, µg/g wet weight.
Source: Fisheries and Oceans Canada

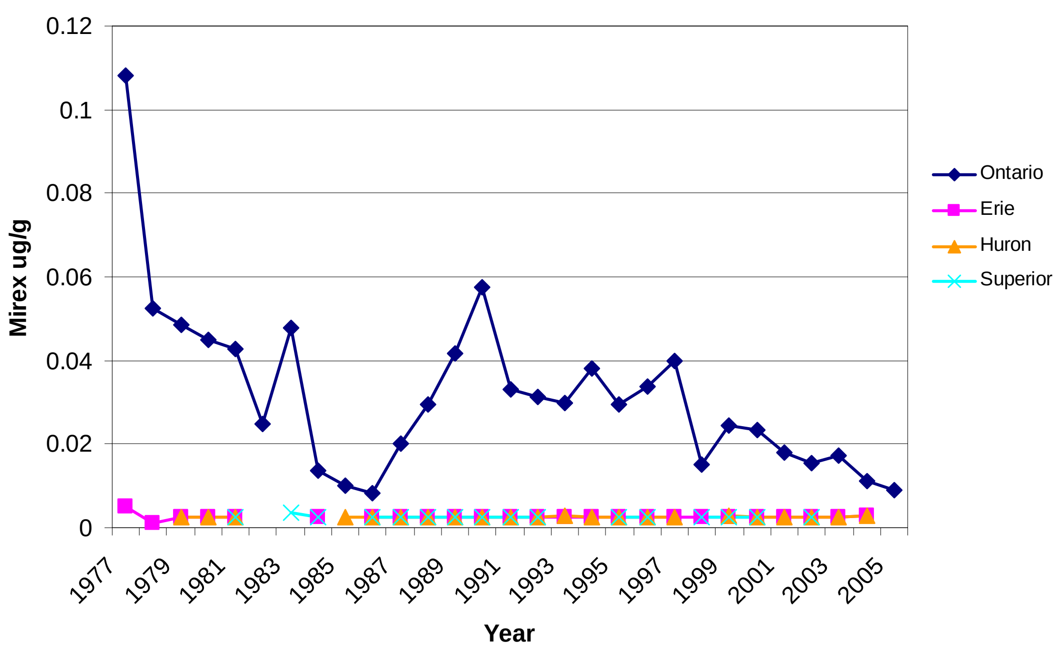

Figure 19. Mirex in composite Environment Canada rainbow smelt, collected 1977 through 2005, µg/g wet weight.
Source: Fisheries and Oceans Canada

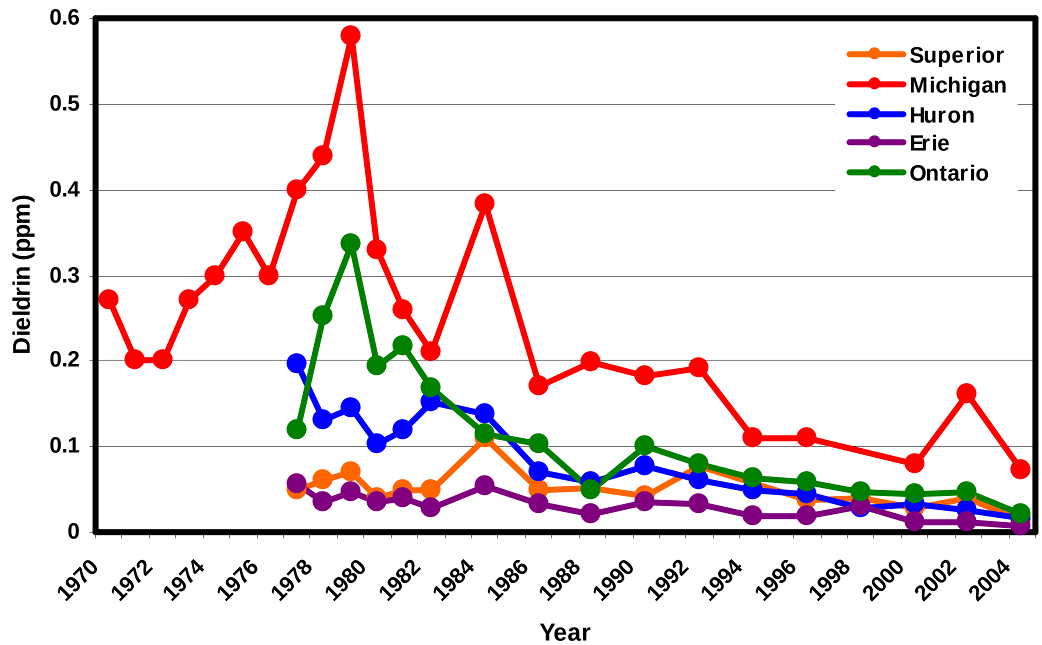

Figure 20. Dieldrin in Even Year whole EPA Lake Trout composites (Walleye in Lake Erie), 1972 - 2004 µg/g wet weight +/- 95% C.I., composite samples.
Lake Trout = 600-700 mm size range. *Fish collected between 1972 and 1982 were collected at even year sites only. Walleye = 450-550 mm size range.
Source: U.S. Environmental Protection Agency

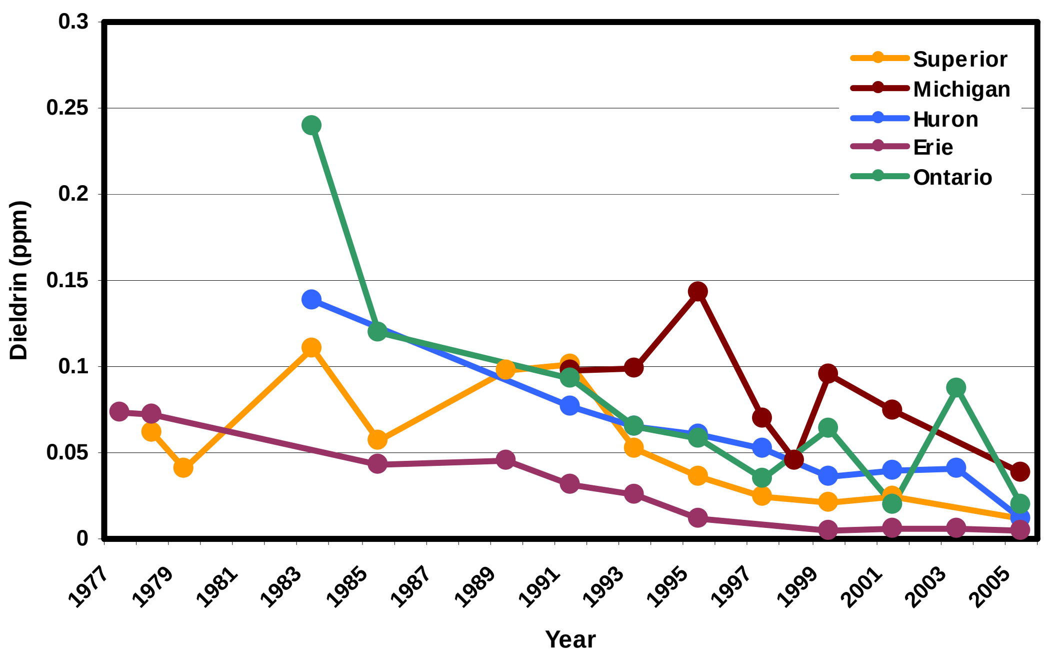

Figure 21. Dieldrin in Odd Year whole EPA Lake Trout composites (Walleye in Lake Erie), 1991 – 2005 µg/g wet weight +/- 95% C.I., composite samples.
Lake Trout = 600-700 mm size range. Walleye = 450-550 mm size range.
Source: U.S. Environmental Protection Agency

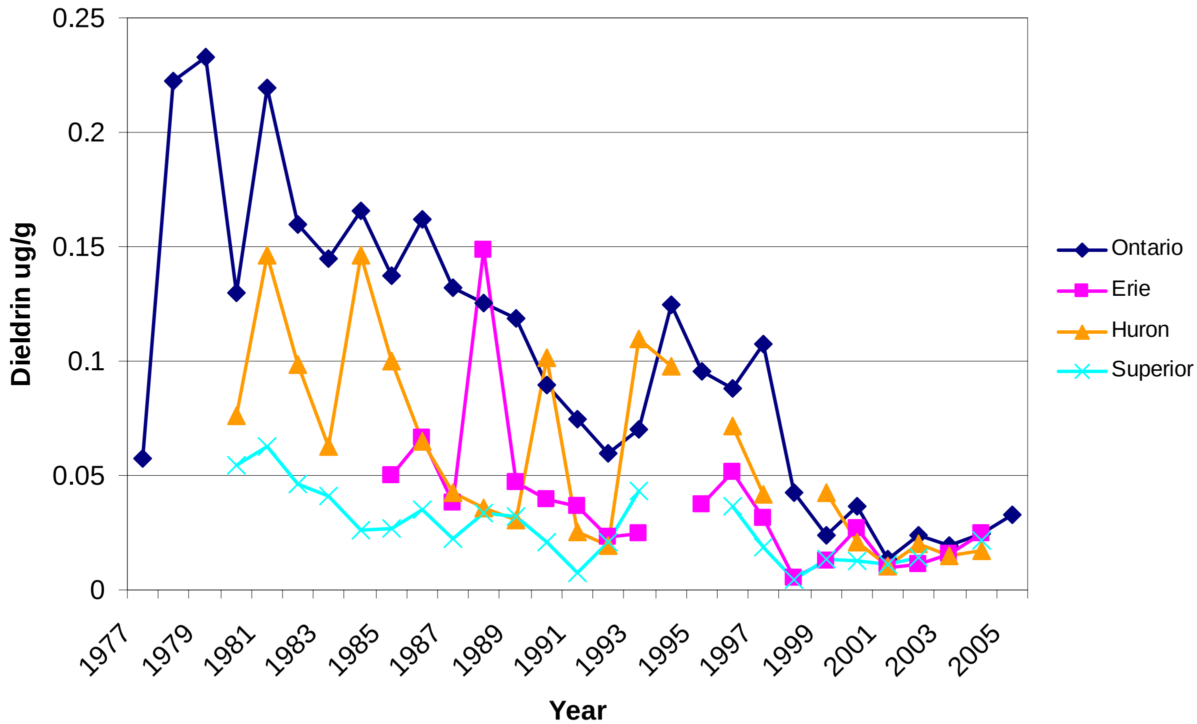

Figure 22. Dieldrin in 4 to 6 year old individual whole Environment Canada Lake Trout, collected 1977 through 2005, µg/g wet weight.
Source: Fisheries and Oceans Canada

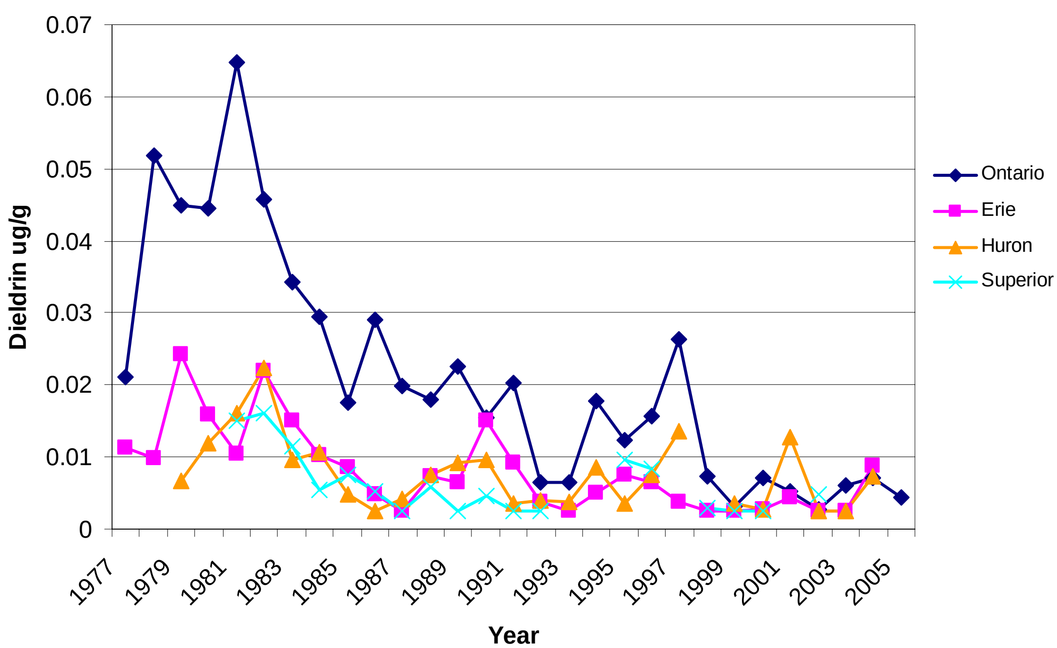

Figure 23. Dieldrin in composite Environment Canada rainbow smelt, collected 1977 through 2005, µg/g wet

weight.
Source: Fisheries and Oceans Canada