Concentrations of Contaminants in Sediment Cores
Indicator #119

Overall Assessment

Status:	**Mixed**
Trend:	**Improving/Undetermined**
Rationale:	**There have been significant declines over the past three decades in concentrations of many contaminants including PCBs, DDT, lead, and mercury. Knowledge is lacking regarding the occurrence of many new contaminants including brominated flame retardants and fluorinated surfactants.**

Lake-by-Lake Assessment

Each lake was categorized with a mixed *status and an* improving/undetermined *trend, indicating that assessments were not made on an individual lake basis.*

Purpose
- To infer potential harm to aquatic ecosystems from contaminated sediments by comparing contaminant concentrations to available sediment quality guidelines
- To infer progress towards virtual elimination of toxic substances in the Great Lakes by assessing surficial sediment contamination and contaminant concentration profiles in sediment cores from open lake and, where appropriate, Areas of Concern index stations
- To determine the occurrence, distribution, and fate of new chemicals in Great Lakes sediments

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 health, animal, or aquatic life (Great Lakes Water Quality Agreement (GLWQA), Article III(d), United States and Canada 1987). The GLWQA and the Great Lakes Binational Toxics Strategy both state the virtual elimination of toxic substances to the Great Lakes as an objective.

State of the Ecosystem
Sediment Quality Index

A sediment quality index (SQI) has been developed that incorporates three elements: scope – the percent of variables that did not meet guidelines; frequency – the percent of failed tests relative to the total number of tests in a group of sites; and amplitude – the magnitude by which the failed variables exceeded guidelines. A full explanation of the SQI derivation process and a possible classification scheme based on the SQI score (0 to 100, poor to excellent) is provided in Grapentine *et al*. (2002). Generally, the Canadian federal probable effect level (PEL) guideline (Canadian Council of Ministers of the Environment (CCME) 2001) was used if available. Otherwise, the Ontario lowest effect level (LEL) guideline was used (Persaud *et al*. 1992). Application of the SQI to Lake Erie and Lake Ontario was reported in Marvin *et al.* (2004). The SQI ranged from fair in Lake Ontario to excellent in eastern Lake Erie. Spatial trends in sediment quality in Lake Erie and Lake Ontario reflected overall trends for individual contaminant classes such as mercury and polychlorinated biphenyls (PCBs).

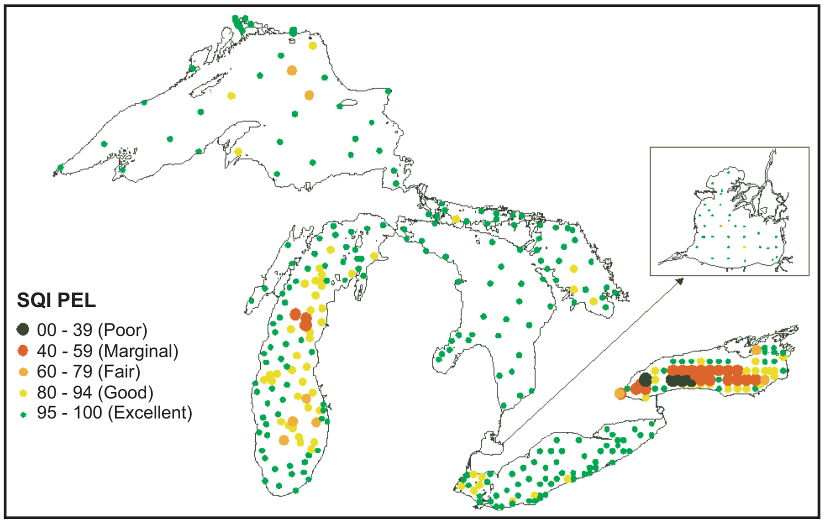

Figure 1. Site Sediment Quality Index (SQI) based on lead, zinc, copper, cadmium and mercury.
Source: Chris Marvin, Environment Canada (1997-2001 data for all lakes except for Lake Michigan); Ronald Rossmann, U.S. Environmental Protection Agency (1994-1996 data for Lake Michigan)

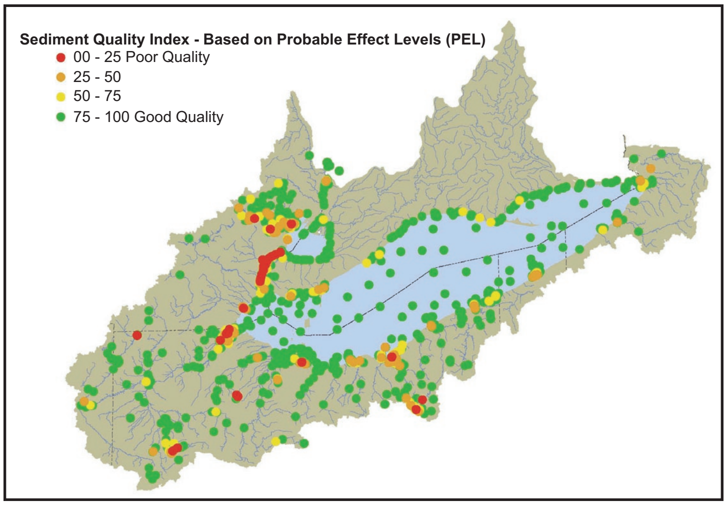

Figure 2. Sediment Quality Index (SQI) for the Lake Erie-Lake St. Clair drainages. More detailed information on contaminants in sediments in the Lake Erie-Lake St. Clair drainages has been reported by the USGS (2000).
Source: Dan Button, U.S. Geological Survey

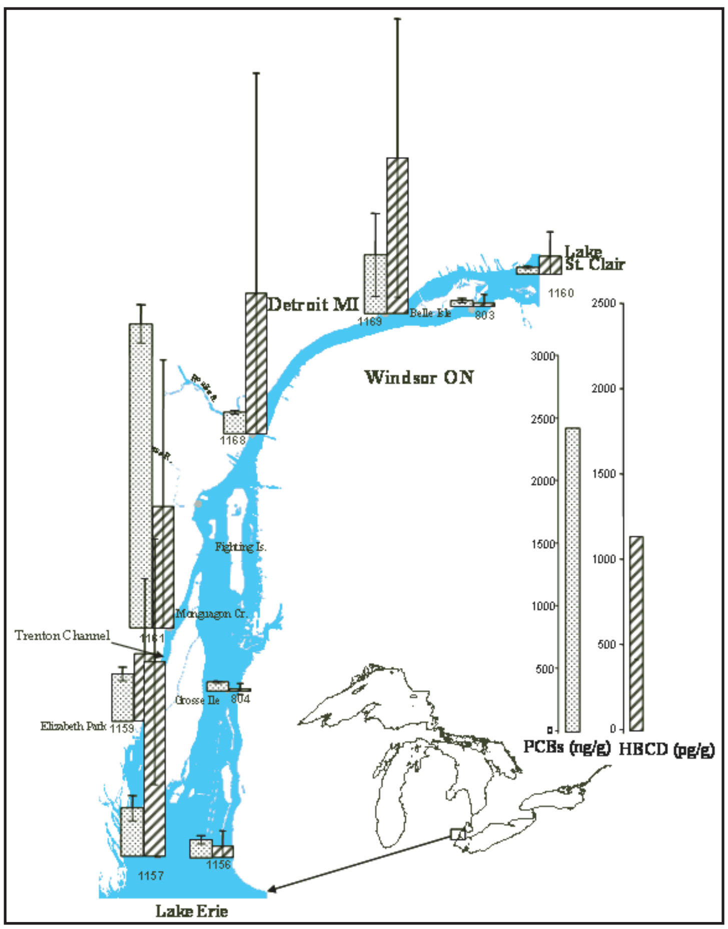

Figure 3. Distribution of HBCD and PCBs in suspended sediments in the Detroit River.
Source: Marvin *et al.* (2006)

Environment Canada and the U.S. Environmental Protection Agency integrated available data from the open waters of each of the Great Lakes. To date, data on lead, zinc, copper, cadmium, and mercury have been integrated. The site-by-site SQI results for Great Lakes sediments based on these metals are illustrated in Figure 1. The general trend in sediment quality across the Great Lakes basin for the five metals is generally indicative of trends for a wide range of persistent toxic substances. Areas of Lake Erie, Lake Ontario and Lake Michigan show the poorest sediment quality as a result of historical urban and industrial activities.

Application of the SQI has been expanded to include contaminants in streambed and riverine sediments for whole-watershed assessments. The SQI map for the Lake Erie – Lake St. Clair drainages is shown in Figure 2. Poorest sediment quality is primarily associated with Areas of Concern where existing multi-stakeholder programs (e.g., Remedial Action Plans) are in place to address environmental impairments related to toxic chemicals.

Pressures

Management efforts to control inputs of historical contaminants have resulted in decreasing contaminant concentrations in the Great Lakes open-water sediments for the standard list of chemicals. However, additional chemicals such as brominated flame retardants (BFRs) and current-use pesticides may represent emerging issues and potential future stressors to the ecosystem.

The distribution of hexabromocyclododecane (HBCD) in Detroit River suspended sediments is shown in Figure 3. This compound is the primary flame retardant used in polystyrene foams, and is the third-most heavily produced BFR. Elevated levels of HBCD were associated with heavily urbanized/industrialized areas of the watershed. The HBCD distribution differs from PCBs, which are primarily associated with areas of contaminated sediment resulting from historical industrial activities including steel manufacturing and chlor-alkali production. These results corroborate observations made globally, which indicate that large urban centers act as diffuse sources of chemicals that are heavily used to support our modern societal lifestyle.

The temporal trend in the Niagara River of another class of BFRs, polybrominated diphenyl ethers (PBDEs), is shown in Figure 4. Prior to 1988, PBDEs were generally detected at low (parts per billion) concentrations, but showed a trend toward increasing concentrations over the period 1980 to 1988. After 1988, PBDE concentrations in the Niagara River showed a more rapidly increasing trend. PBDE concentrations in suspended sediments of the Niagara River are comparable to, or lower than, concentrations in sediments in other industrialized/urbanized areas of the world. The Niagara River watershed does not appear to be a significant source of PBDEs to Lake Ontario, and concentrations appear to be indicative of general contamination from a combination of local, regional, and continental sources.

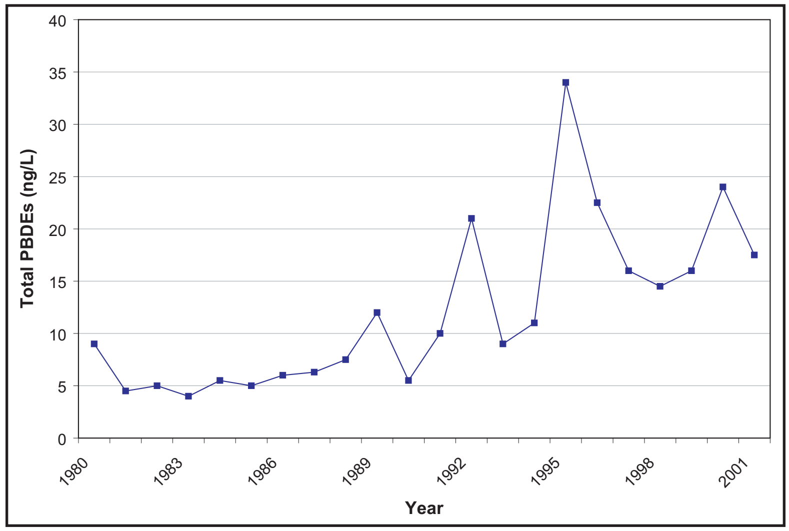

Figure 4. Temporal trend in PBDEs in Niagara River suspended sediments.
Source: Marvin *et al.* (2006)

Management Implications

The Great Lakes Binational Toxics Strategy needs to be maintained to identify and track the remaining sources of contamination and to explore opportunities to accelerate their elimination. In addition targeted monitoring to identify and track down local sources of pollution should be considered for those chemicals whose distribution in the ambient environment suggests local or sub-regional sources. Ongoing monitoring programs in the Great Lakes connecting channels (e.g., Detroit River, Niagara River) provide invaluable information on the success of binational management actions to reduce or eliminate discharges of toxic substances to the Great Lakes. These programs also provide important insights into pathways of new chemicals entering the Great Lakes.

Acknowledgments

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Sources

Canadian Council of Ministers of the Environment (CCME). 1999, (updated 2001). *Canadian Environmental Quality Guidelines*. Canadian Council of Ministers of the Environment. Winnipeg, MB, Canada.

Grapentine, L., Marvin, C., and Painter, S. 2002. Development and evaluation of a sediment quality index for the Great Lakes and associated Areas of Concern. *Human and Ecological Risk Assess.* 8(7):1549-1567.

Marvin, C., Grapentine, L., and Painter, S. 2004. Application of a sediment quality index to the lower Laurentian Great Lakes. *Environ. Monit. Assess*. 91:1-16.

Marvin, C., Tomy, G.T., Alaee, M., and MacInnis, G. 2006. Distribution of hexabromocyclododecane in Detroit River suspended sediments. *Chemosphere*. 64:268-275.

Persaud, D., Jaagumagi, R., and Hayton, A. 1992. *Guidelines for the protection and management of aquatic sediment quality in Ontario.* Water Resources Branch, Ontario Ministry of the Environment and Energy. June 1992.

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

U.S. Geological Survey (USGS). 2000. *Areal distribution and concentrations of contaminants of concern in surficial streambed and lakebed sediments, Lake Erie – Lake St. Clair drainages, 1990-97.* Water Resources Investigations Report 00-4200.

Last Updated

State of the Great Lakes 2007