CHAPTER 1 LAKE ONTARIO STATUS

1.1 Summary

This chapter provides a status of the Lake Ontario ecosystem measured against the objectives and indicators of the Lake Ontario Lakewide Management Plan (Chapter 3). In addition, the status of contaminant in sediment cores has been provided. This is an indicator under development.

1.2 Linking Lake Ontario's Ecosystem Goals, Objectives, and Indicators

The Lake Ontario LaMP adopted ecosystem goals to provide a vision for the future of Lake Ontario. Subsequently, ecosystem objectives and indicators were developed to provide a practical approach for monitoring progress towards achieving the LaMP's ecosystem goals. Ecosystem objectives were identified for aquatic communities, wildlife, human health and stewardship. Eleven indicators, approved in 2001, are designed to track progress towards ecosystem objectives in three categories: critical pollutants, lower food web, and upper food web.

The LaMP's indicators will be reviewed periodically to ensure that they continue to measure the status of the Lake Ontario ecosystem relative to LaMP goals and objectives, and that they are supported by the monitoring agencies. The LaMP work group and management committees are developing new indicators to address elements not yet measured such as habitat, contaminated sediments, and stewardship. As these are developed, they will be available to the Lake Ontario community for review and comment. Once new indicators are finalized, indicator descriptions will be incorporated into Chapter 3 and the indicator status will be reported in Chapter 1.

More detailed information on the development of the LaMPs goals, objectives and indicators can be found in Chapter 3.

1.3 Lake Ontario Status

Overall Lake Ontario's ecosystem is improving. All the critical pollutant indicators, the bald eagle indicator, and the mink and otter indicators are showing progress towards achieving the Lake Ontario LaMP Objectives. Lower food web indicators and the lake trout population indicator are indicating challenges that appear to be linked to nearshore nutrient levels, invasive exotic species, and human affects on habitat.

The discussion presented here is summarized into three categories of indicators: critical pollutants, lower food web and upper food web. An overview of the status of each of these categories is followed by more details on each of their constituent indicators. More detailed information about the status of each of these indicators, including tables, figures, and references, is provided in Chapter 3.

1.3.1 Critical Pollutant Indicators

Critical pollutant indicators measure concentrations of critical pollutants in water, young of the year fish, herring gull eggs, and sport fish (lake trout and coho salmon). A brief status of the critical pollutant indicators is provided here.

<u>Summary</u>: Overall, critical pollutants are continuing to decline in all indicators presented although many are still present at levels above criteria. Fish advisories are still in effect due to PCBs, dioxins, mirex and mercury, however concentrations are declining.

<u>Details</u>: The most recent data available (2004) show concentrations in the open waters of many organic compounds and metals present in only trace amounts, with some below available water quality objectives. PCB and dieldrin levels are declining over the last two decades (Figure 1.1).

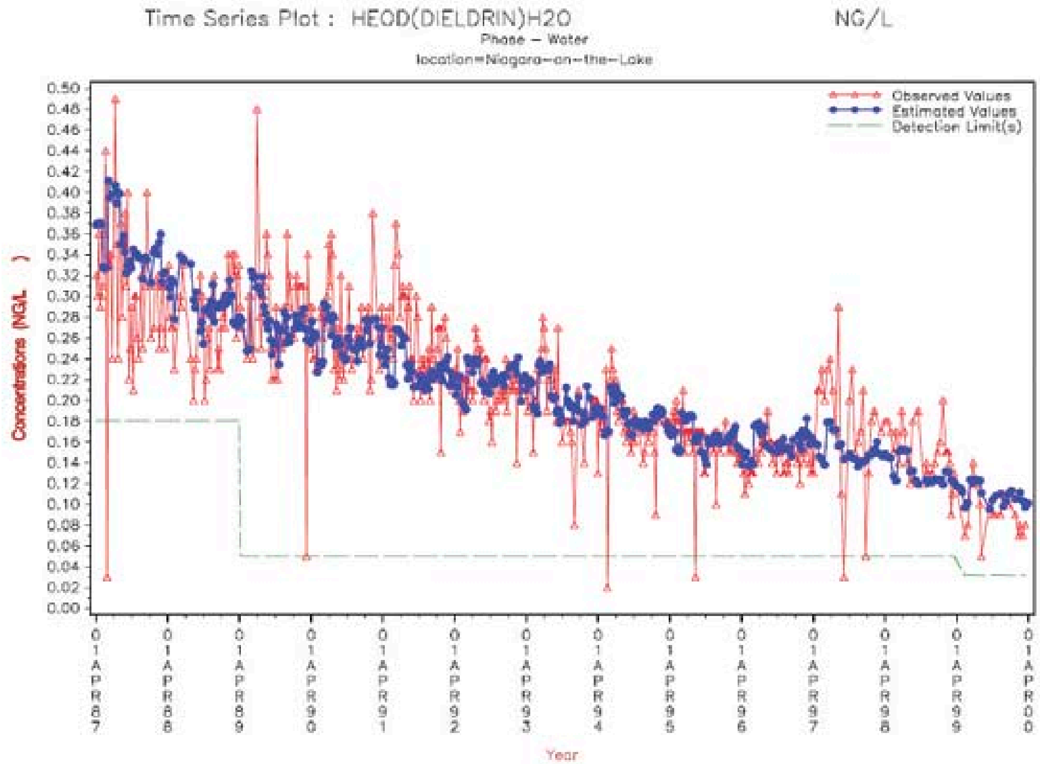

Figure 1.1: Dieldrin dissolved phase trends in Niagara River surface water at Niagara-on-the-Lake 1987-2000.

Contaminant concentrations in young-of-the-year fish from New York State (1997) showed that mercury, dioxin, total DDT and dieldrin concentrations were below their respective criteria at all sampled locations; in fact dieldrin was not detected at any location. However PCBs and mirex were found to exceed their respective criteria at some locations (Figure 1.2). PCB levels in New York Areas of Concern were below the GLWQA 100 ng/g criteria, the fish collected from the Black River, Salmon River and Sodus Bay exceeded it. Mirex was above the GLWQA criteria of "non-detect" at all locations except at the Black River and Sodus Bay. Mirex concentration trends through time were mixed depending on where sampling occurred. Eighteenmile Creek, NY showed no significant change in concentrations, whereas the Oswego River site levels dropped from 2.0 and 4.7 parts per billion in 1984 and 1987 respectively to not detected in 1997. A small increase of 2-4 parts per billion in 1984-1986 changes to 8.5 parts per billion in 1997 at the Salmon River. Five sites (Twelve Mile Creek, Burlington Beach, Bronte Creek, Credit River, and Humber River) along the Ontario shoreline of the lake showed total PCBs and DDT levels declining but still above guidelines. Mirex levels are at or below guidelines (SOLEC 2007).

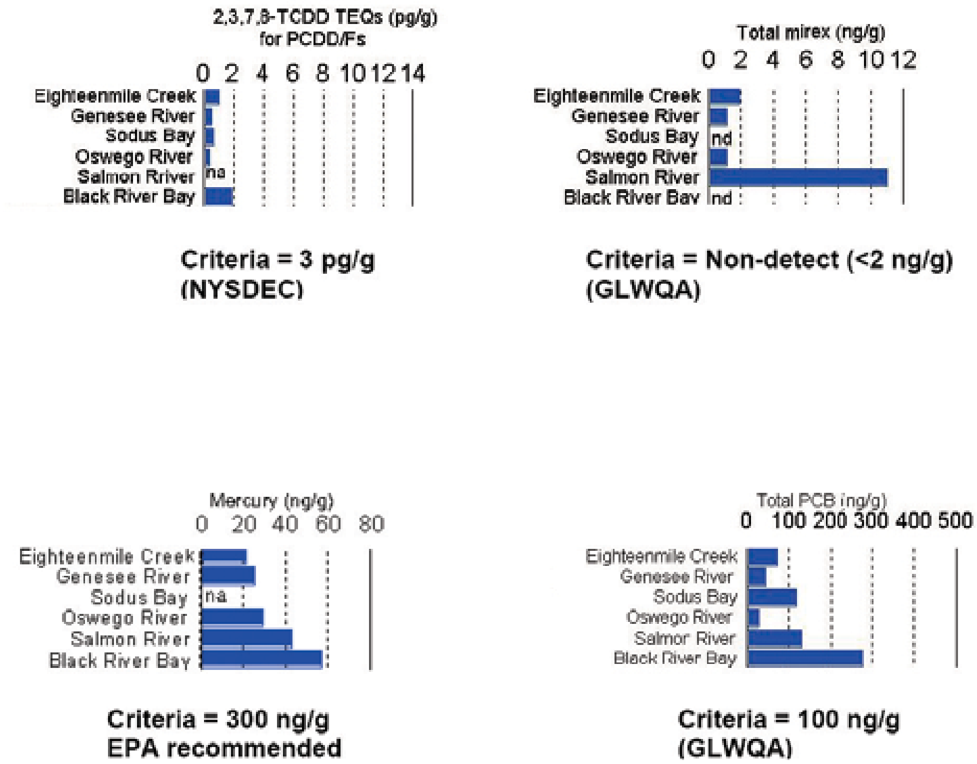

Figure 1.2: Contaminants in Young-of-the-Year Fish from Nearshore Areas of New York's Lake Ontario Basin, 1997.

PCBs, dioxins, mirex and mercury are still responsible for a number of lakewide fish consumption advisories. Overall, the proportion of the piscivorus fish community assessed has experienced a dramatic reduction in contaminant levels since the mid-1970s (Figure 1.3). The U.S. EPA monitoring program shows PCB concentrations have declined from >6 µg/g in 1978 to <2 µg/g in 2000. Annual reports from the Canadian federal fish contaminants program show concentrations of PCBs, DDT and mercury in similarly aged fish have generally declined in most monitored fish species. After a period of consistent decline total PCB levels have remained virtually unchanged since 1998 at a level of 1.27 µg/g. Total DDT concentrations continued a pattern of a steady decline since 1994. Whole fish concentrations of DDT have been consistently less than the Great Lakes Water Quality Agreement objective of 1.0 µg/g since 1995.

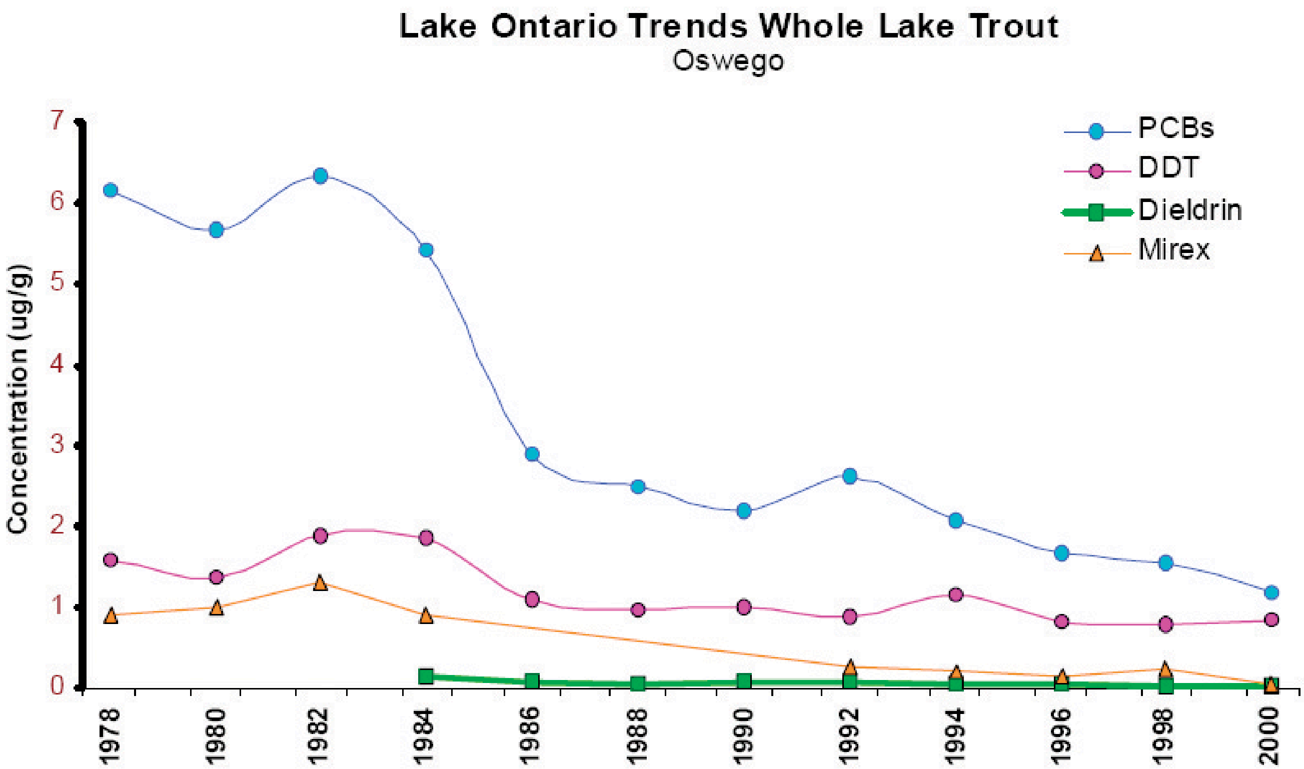

Figure 1.3 Contaminant trends in Lake Ontario lake trout.

Concentrations of total PCB, mirex, mercury, and total DDT in Credit River Coho salmon have been decreasing steadily since monitoring commenced in the late-1970s. Total PCB concentrations have decreased from greater than 1.5 ppm in late-1970s to approximately 0.5 ppm in 2000. Over the same time period, concentrations of mirex have decreased from greater than 0.1 ppm to less than 0.05 ppm (Figure 1.5). Similar trends have been observed for mercury and DDT, as can be seen in Figures 1.6 and 1.7, respectively.

Contaminant levels in herring gull eggs have continued to decline since the 1970s when monitoring first began. Change-point regression analysis continues to show that most contaminant levels at most sites (72.4%) are declining as fast as or faster now than they did in the past. This is particularly evident for dieldrin and DDE. The rates of decline have slowed for some compound-site comparisons particularly PCBs and mirex. There has been only one Lake Ontario site where temporal data is available on the emerging chemical PBDE. Results showed concentrations increased dramatically from 1981 through 1999 but appear to have declined slowly since then, possibly due to the manufacturer ceasing production in December 2003 (Figure 1.4).

Temporal trends of legacy and current persistent organic pollutants of concern are reported for a Lake Ontario sediment core from two Lake Ontario stations; one station is located 16 km north of Fort Niagara (near the mouth of the Niagara River) and the other from the offshore of Lake Ontario near its centre. This study aims to assess historical inputs of legacy and current-use persistent compounds into Lake Ontario, examining progress towards virtual elimination of priority pollutants and providing information for setting lake-wide management priorities on chemicals of emerging concern. These studies provide a baseline of information for assessing management of these compounds in Lake Ontario

The offshore site showed trends of legacy contaminants such as polychlorinated biphenyls (PCBs) and dioxins/furans (PCDD/Fs) slowing their rates of declines in recent years after significant reductions, while perfluorinated compounds show considerable increases. Persistent organic pollutants of current concern, such as polybrominated diphenylether (PBDE) concentrations, dominated by BDE-209, peaked in the two most recent slices. Polychlorinated naphthalenes (PCNs) exhibited a similar trend to PBDEs, peaking only in recent years. The recent peak of PCN concentration is unexplained, and requires further assessment[1].

The core taken near offshore of Fort Niagara showed reduced loadings to this area for all contaminants analyzed in the top 2 cm of the core. Only four of eight metals examined have guidance values which were found at concentrations greater than respective Toxic Equivalent Concentration (TEC) levels and total PCB was below the TEC. The trend indicates that since 1964 significant reductions have taken place for the conventional pollutants measured in this study[2].

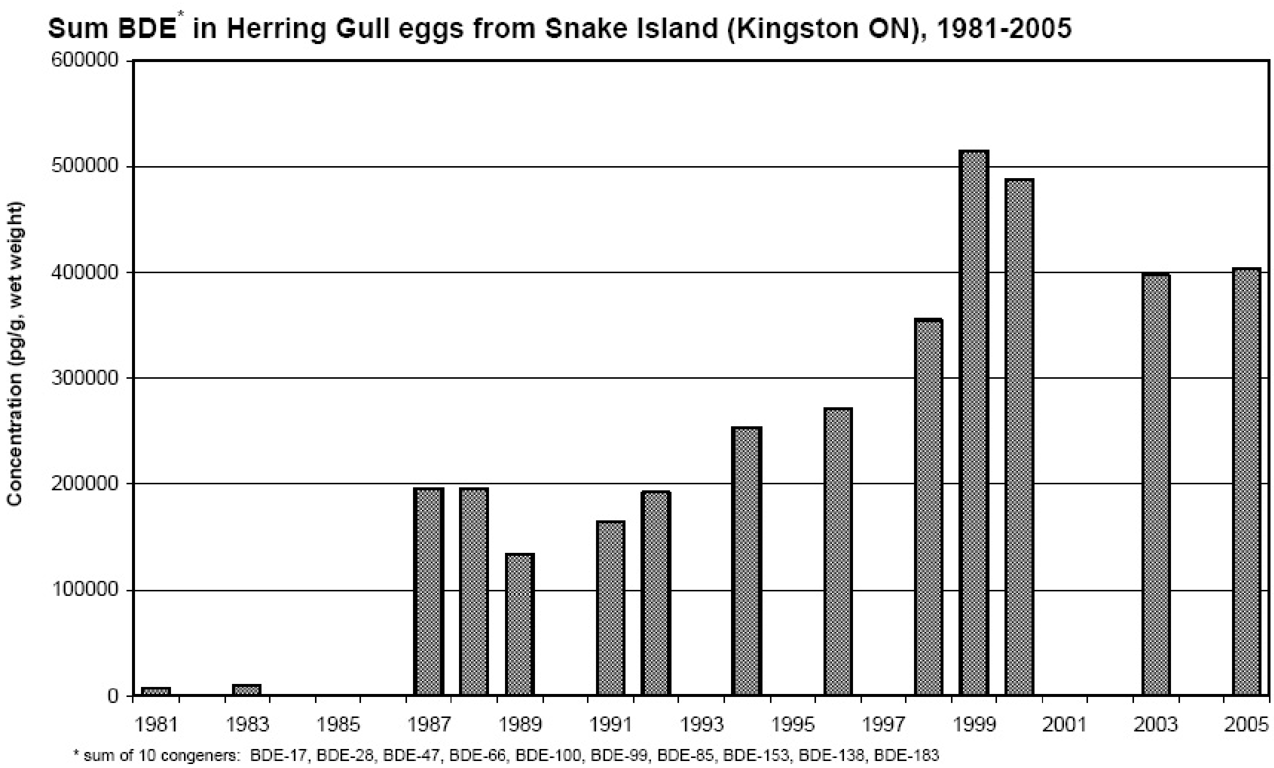

Figure 1.4 Polybrominated Diphenyl Ether (PBDE) Trends in Lake Ontario Herring Gull Eggs. Totals reflect the sum of 10 congeners: PBDE-17, PBDE-28, PBDE-47, PBDE-66, PBDE-100, PBDE-99, PBDE-85, PBDE-153, PBDE-138 and PBDE-183.

1.3.2 Lower Food Web Indicators

Lower food web indicators track the status of nutrients in open waters (total phosphorus, chlorophyll a, and secchi disc depth), zooplankton populations (mean individual size and biomass), and prey fish populations (abundance, age and size distribution of deepwater ciscoes, sculpin, lake herring, rainbow smelt and alewife). They reflect the ability of the ecosystem to support higher level organisms (such as lake trout and waterbirds).

Summary: In Lake Ontario the offshore waters have changed from a mesotrophic system towards an oligotrophic system. This has come at a time when demands for a salmonid sport fishery have increased, non-native species such as the alewife have exhibited highly variable population dynamics, oligotrophic fish stocks are recovering, and exotics such as the zebra mussel, quagga mussel and currently the predatory zooplankton, such as *Bythotrephes cederstromi* and *Cercopagis pengoi*, have become established and may be impacting food web dynamics. Complicating the lower food web is the reoccurrence of nearshore algal blooms, resulting in problems such as beach closures, drinking water quality concerns, and added costs to industry. The sources of these problems are uncertain. This will be the focus of an intensive binational monitoring effort in 2008.

Details: In response to binational phosphorus control programs, open lake phosphorus concentrations declined from a peak of about 25 µg/L in 1971 to the 10 µg/L concentration recommended to achieve the GLWQA target load to the lake by the mid 1980s. Offshore phosphorus levels continued to decline through the 1990s and are now at approximately 5 – 7 µg/L (Fig 1.5). However, nearshore areas are now suffering from increased occurrences of the filamentous algae *Cladophora* similar to the 1970s. Chlorophyll data from Environment Canada's Surveillance Program showed the trophic status of Lake Ontario has changed from a mesotrophic system in the 1970s and is now bordering on oligotrophic. Monitoring will assist in determining if this trend is continuing.

Water clarity, as measured by secchi disc depth, has increased dramatically in Lake Ontario over time (Figure 1.6). Some of the improvements occurred concurrently with improved phosphorus discharge controls and the accompanying decline in nuisance algal biomass. However, the most dramatic changes in offshore waters have been apparent since about 1989, indicating that water clarity has increased due to influences other than phosphorus discharge controls.

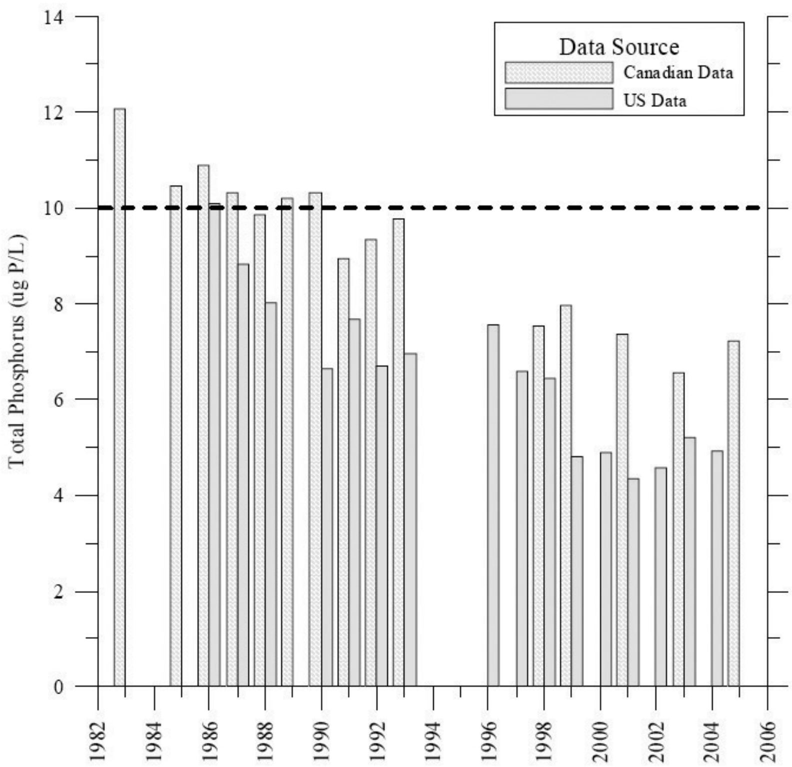

Figure 1.5 Mean spring total phosphorus concentration in the open waters of Lake Ontario. (Dashed line represents concentration recommended to achieve GLWQA target loads)

Mean zooplankton length can be used as an indicator of the balance between plankton eating fish and fish predators. Offshore crustacean zooplankton body size had a mean of 0.74 mm, close to the 0.8 mm target. Future Status reports will provide more information on this indicator.

The prognosis is poor for Lake Ontario alewife and rainbow smelt populations, the non-native mainstays of the offshore food web for most pelagic predators. Both species have been affected by changes in the food web and declines in productivity in the open lake. Alewife abundance has been declining during recent years, but a stronger 2005 year-class suggests a small rebound may occur. Smelt abundance continues to decline to record low levels. The recent invading round goby continues to increase in abundance and to expand its range into the offshore in association with quagga mussels. Gobies continue to increase in importance as diet items for fish like lake trout. Slimy sculpin populations have declined for all size categories except the largest during recent years, but this observation may be affected by changes in sampling gear. Specific indicators for prey fish populations are needed, but the rapid pattern of change has defied efforts to define future abundance targets.

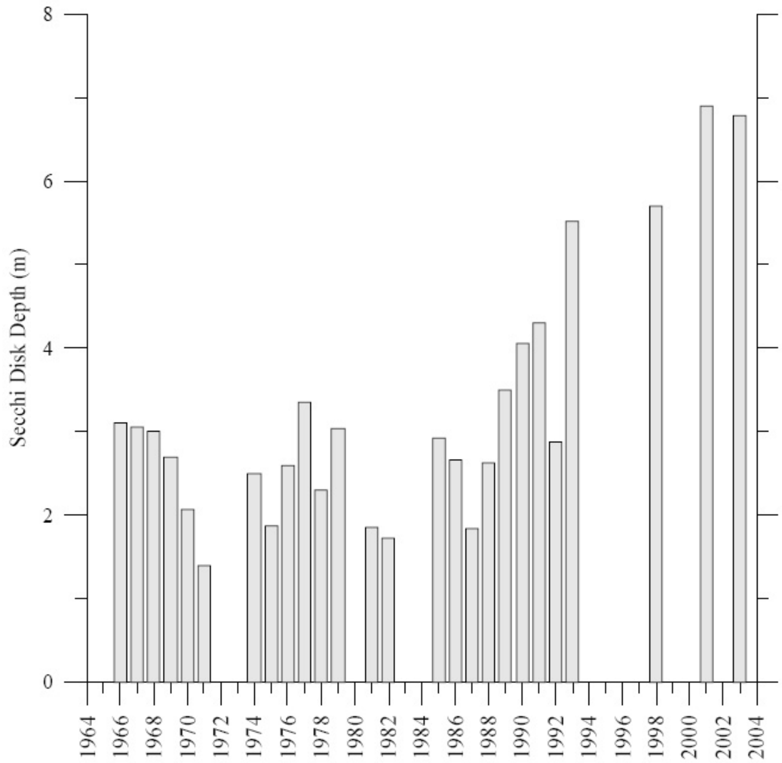

Figure 1.6: Summertime Secchi disc depths in Lake Ontario offshore waters (depth ≥ 100 m) 1966 – 2004.

Reductions in non-native alewife and smelt may have positive effects on other native species in the lake. The number of deepwater sculpin caught in trawls has continued to increase during recent years, from 1 fish caught during 2004 to 16 fish observed during 2006. Prior to 1998, the last documented record of a deepwater sculpin being captured in U.S. waters of Lake Ontario was over 50 years ago. Future monitoring will determine if a recovery of deepwater sculpin is occurring. Assessments suggest that lake herring abundances may be increasing. Currently sampling has not found any deepwater cisco in Lake Ontario; plans are underway for the re-introduction of this critical element of the offshore food web.

1.3.3 Upper Food Web Indicators

Upper food web indicators monitor the health of lake trout, herring gull, bald eagle, mink and otter populations. These top level predators are dependent on quality habitat and sufficient prey populations, free of problematic contaminant levels.

Summary: Restoration of naturally reproducing population of lake trout is the focus of a major international effort in Lake Ontario coordinated by the Lake Ontario Committee of the Great Lakes Fisheries Commission. While natural reproduction of lake trout is occurring, their abundance is well below target and adult numbers of adult fish are declining. Only one of the five lake trout restoration targets were met during the most recent sampling period 2006. The numbers of fish stocked has declined and the survival of stocked young fish continues to be low. New strategies to improve this restoration effort are being developed. Changes to the offshore food web may be having effects on this effort. The Lake Ontario Committee is revising the Lake Trout Rehabilitation Plan to include new strategies for restoration and revised indicators of success. The Lake Ontario LaMP will review this document and consider how the current LaMP objectives and indicator targets may need to be adjusted.

Contaminants do not appear to be limiting herring gull or other colonial bird populations. Double-crested cormorant populations are expanding. Herring gull populations are stable but may be in flux possibly due to nesting competition with double-crested cormorants. Great black-back gulls are in decline having suffered severely from a botulism outbreak in 2005. Mink are located throughout the basin and their populations are stable. River otter, found around the eastern end of Lake Ontario, in central Ontario and along the St. Lawrence River, are now moving into western and central New York as more and more abandoned agricultural land returns to natural conditions. The number of bald eagle nesting territories within the Lake Ontario basin continues to increase. During 2007 there were two additional shoreline nests established for a total of 3. The 2004 fledging rate was above the one eaglet per nest target.

Details: Only one of the five lake trout restoration targets were met during the most recent sampling period 2006. Harvest by the fisheries on the lake remains below the target level for restoring the population. The rate of wounding by sea lampreys on lake trout, a measure of mortality caused by this parasite, is much lower than pre-1985 levels, but has increased during recent surveys to more than the target level, suggesting that the low host density is affecting wounding rates. Despite low harvest rates, and until recently, low sea lamprey attack rates, the abundance of adult lake trout, including mature females, is below targets and declining. Reduced numbers of lake trout stocked into the lake, especially since 2004, are contributing to the decline in abundance. Stocked fish are not surviving as well as they did in the past as evidenced by very low catches of young lake trout in assessment programs in recent years. Small numbers of naturally produced lake trout have been produced from 1993 to 2004, but the number of these wild juveniles caught in trawls is below target. A final and key indicator of the success of restoration will be an abundance of wild adult lake trout, but the assessment captures of wild adults remain rare and well below the target.

Lake Ontario is home to nearly 1,000,000 colonially nesting waterbirds. Biologists from the Canadian Wildlife Service, the Ontario Ministry of Natural Resources and the New York State Department of Environmental Conservation have completed three Lake Ontario-wide census of nesting colonial water birds, a survey that is conducted approximately once every 10 years. Although herring gulls are the selected LaMP waterbird indicator, this section also includes information on species of colonial waterbirds in order to provide additional information on waterbird issues. Lake Ontario-wide surveys were conducted in 1976-1977, 1990-1991 and 1998-1999 for six species of colonial water birds: double-crested cormorant, ring-billed gull, herring gull, great black-backed gulls, common tern and Caspian tern. Selected species are monitored more frequently; their recent numbers are discussed and updated below.

Herring Gull - The herring gull is the most widespread colonial waterbird nesting on the Great Lakes[26]. As a native non-migratory species that relies heavily on aquatic prey organisms, the herring gull serves as an excellent indicator species. From 1976/77 to 1990, the number of nests (breeding pairs) of Herring Gulls on Lake Ontario increased from 522 to nearly 1800, a 242% increase. The number of nesting sites increased from 14 to 21. However, more recently, from 1990 to 2003, the number of breeding pairs decreased to approximately 1400 (when adjusted for uncensused sites), a decline of approximately 22%. Declines in the numbers of breeding Herring Gulls have been most noticeable at sites where cormorants also nest. However, a cause and effect relationship has yet to be established.

Double-crested Cormorant – From 1977 to 1999 the Lake Ontario population of breeding cormorants increased from 96 pairs to over 20,000. In response to this increase and the cormorant's potential impacts to vegetation and co-occurring tree/shrub-nesting species, management actions were begun on Little Galloo Island (NY) in 1999 and at Presqu'ile Provincial Park (ON) in 2003. These actions appear to have stabilized the number of nesting cormorants in the eastern basin of Lake Ontario (at approximately 9,000 pairs) and decreased it in the central basin to just over 5,000 (Figure 1.7). However, the number of nesting pairs in Lake Ontario's western basin is now the greatest (9,000+ pairs) and appears to be still growing. Cormorants are reproducing very well.

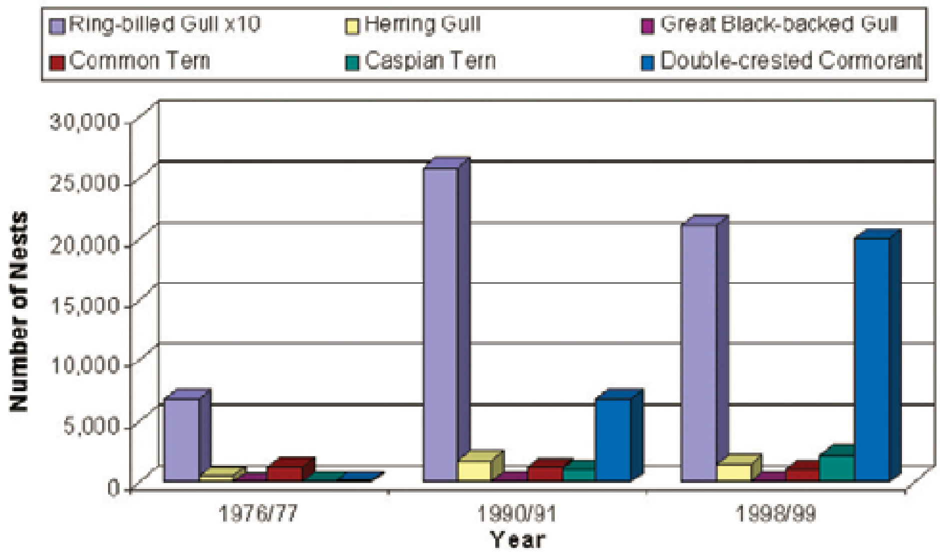

Figure 1.7: Numbers of Gull, Tern and Cormorant Nests on Lake Ontario, 1976 – 1999

Great Black-backed Gull - Of the gulls and terns which commonly nest on Lake Ontario, the great black-backed gull is the least numerous. During the 1976-77 census, it was not found nesting anywhere on Lake Ontario. In 1990, a total of 15 nests were found on 3 sites and by 2004 this number had grown to 40 pairs. However, there was a severe botulism-induced die-off of various colonial waterbirds in Lake Ontario in the summer-fall of 2004 and several Lake Ontario-banded black-backed gulls were found dead. In the spring of 2005, the breeding numbers had declined to only 12 pairs.

Mink and river otter are making a comeback in the Lake Ontario basin. Their populations were severely reduced in the 1800s due to habitat loss, water pollution and excessive trapping. Prior to these changes the river otter had the largest geographic range of any North American mammal. A review of trapping data showed that more than 5,000 mink were trapped during the 1999-2000, harvest season. Although otter trapping is illegal in a large portion of the basin, over 1,200 otter were trapped in the remaining areas in the 1999-2000 seasons (Fig. 1.8). There were also a number of otter sightings in the portion of the Lake Ontario basin that is closed to otter trapping. The harvest counts found in the trapping records represent only a small percentage of the total populations of mink and otter in the Lake Ontario basin. This provides good evidence that significant numbers of these animals are present in the basin.

The bald eagle is considered by many to be one of the premier ecological indicators of the Great Lakes. In the 1970s there were no active bald eagle nesting territories in the Lake Ontario basin. Two eagle nesting territories were artificially established in the basin during the 1980s through the introduction of adult eagles captured in Alaska. Since that time the number of nesting territories has steadily increased. There are now 23 established nesting territories in the basin. The 2004 average successful reproduction rates for these nests was ~1.5 eaglets per nesting attempt. A minimum reproduction rate of 1.0 eaglet per occupied nesting territory is generally believed to be necessary to maintain stable bald eagle populations.

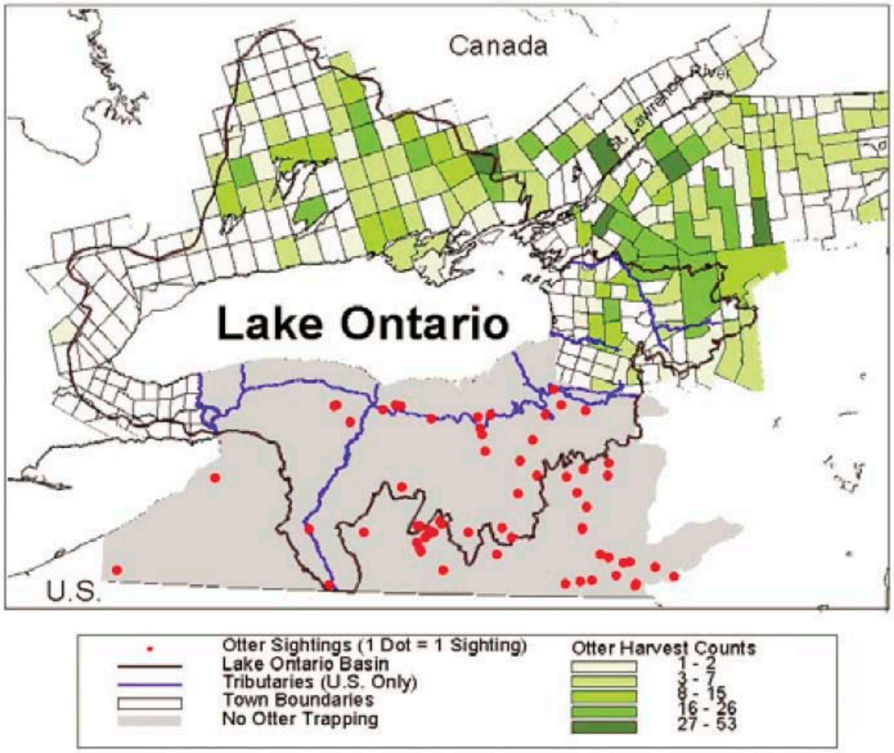

Figure 1.8: Otter sightings and harvests in the Lake Ontario basin 1999-2000.

Although good to excellent bald eagle nesting habitat exists along the eastern shoreline of the lake, there were no shoreline or island nests until recently. In 2000 the first shoreline nesting territory was established and has successfully fledged each year since. Two additional nests were established during 2007 for a new total of 3 shoreline nesting territories. The result of successful nests and reproduction rates has been 18 young eagles fledged from known shoreline territories since 2000. More eagles are expected to occupy shoreline nesting sites as their numbers steadily increase. Human disturbance has slowed the return of eagles to the shoreline. Restoration of shoreline nesting territories will depend in part on protection of eagle nesting habitats and preventing further human disturbance. As well as nesting habitat, Lake Ontario provides considerable overwintering habitat with increasing numbers of eagles being observed during the winter in the eastern basin and the Thousand Islands.

1.4 References:

1 Crozier, Patrick, Rocsana, Lega, Terry Kolic, Karen Macpherson, Sarah Gewurtz, Li Shen1, Paul Helm, Eric Reiner, Ian Brindle, Chris Marvin. Temporal Trends of Legacy and Emerging Persistent Organic Pollutants in a Sediment Core from Lake Ontario. Poster Session, SETAC Conference 2006.

2 New York State Department of Environmental Conservation, 2007. Results from core collected in Lake Ontario, April 2007. NYS Department of Environmental Conservation. Division of Water. October 2007, 42 pages.

3 SOLEC, 2007. State of the Lakes Great Lakes 2007 (Draft). State of the Lakes Ecosystem Conference (SOLEC). June 2007. 534 pages.