LAKE ONTARIO

LAKEWIDE MANAGEMENT PLAN

STATUS

APRIL 22, 2006

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

CHAPTER 1 STATE OF LAKE ONTARIO

1.1 Summary 1-1

CHAPTER 2 BACKGROUND

2.1 Summary 2-1
2.2 Introduction to Lake Ontario 2-1

2.2.1 Climate 2-2
2.2.2 Physical Characteristics and Lake Processes 2-2
2.2.3 Aquatic Communities 2-3
2.2.4 Demographics and Economy of the Basin 2-7

2.3 LaMP Background 2-8
2.4 LaMP Structure and Processes 2-9
2.5 References 2-11

CHAPTER 3 ECOSYSTEM GOALS, OBJECTIVES, AND INDICATORS

3.1 Summary 3-1
3.2 Development of Lake Ontario Ecosystem Goals and Objectives 3-1

3.2.1 Ecosystem Goals for Lake Ontario 3-1
3.2.2 Ecosystem Objectives for Lake Ontario 3-1

3.3 Ecosystem Indicators 3-2

3.3.1 Critical Pollutant Indicators 3-3
3.3.2 Lower Foodweb Indicators 3-9
3.3.3 Upper Foodweb Indicators 3-9

3.4 Cooperative Monitoring Progress Towards Meeting LaMP Goals and Indicators 3-15
3.5 Major 2003 Cooperative Monitoring Projects 3-16

3.5.1 Lake Ontario Atmospheric Deposition Study (LOADS) 3-17
3.5.2 Lake Ontario Lower Aquatic Foodweb Assessment (LOLA) 3-17
3.5.3 Interagency Laboratory Comparison Study 3-18

3.6 Other Indicator Initiatives 3-19
3.7 Actions and Progress 3-19
3.8 References 3-19

TABLE OF CONTENTS (Continued)

CHAPTER 4 IDENTIFICATION OF BENEFICIAL USE IMPAIRMENT ASSESSMENTS

4.1 Summary 4-1
4.2 Beneficial Use Impairments Defined by the Great Lakes Water Quality Agreement 4-1
4.3 Beneficial Use Impairment Identification Process and Problem Definition 4-1
4.4 Beneficial Use Impairments in Lake Ontario 4-2

4.4.1 Restrictions on Fish and Wildlife Consumption 4-3
4.4.2 "Degradation of Wildlife Populations" and "Bird or Animal Deformities or Reproduction Problems" 4-6
4.4.3 Loss of Fish and Wildlife Habitat 4-9
4.4.4 Degradation of Benthos 4-12
4.4.5 Degradation of Nearshore Phytoplankton Populations 4-13
4.4.6 Degradation of Fish Populations 4-15

4.5 Unimpaired Lakewide Beneficial Uses in Lake Ontario 4-18

4.5.1 Tainting of Fish and Wildlife Flavor 4-18
4.5.2 Fish Tumors 4-19
4.5.3 Restrictions on Dredging Activities 4-19
4.5.4 Eutrophication or Undesirable Algae 4-20
4.5.5 Restrictions on Drinking Water Consumption, or Taste and Odor Problems 4-21
4.5.6 Beach Closings 4-22
4.5.7 Degradation of Aesthetics 4-23
4.5.8 Degradation of Zooplankton 4-24
4.5.9 Added Costs to Agriculture or Industry 4-24

4.6 Actions and Progress 4-24
4.7 References 4-25

CHAPTER 5 HABITAT ASSESSMENT AND RESTORATION

5.1 Summary 5-1
5.2 Habitat Types of the Lake Ontario Basin 5-1

5.2.1 Habitat Zones and Foodwebs 5-1
5.2.2 Nearshore Habitat 5-1
5.2.3 Offshore Habitat 5-2
5.2.4 Nearshore Wetlands 5-2
5.2.5 Tributaries 5-2

5.3 Current Status of Basin Habitat 5-2
5.4 Ongoing Work 5-4

5.4.1 Binational Activities 5-5
5.4.2 U.S. Activities 5-6
5.4.3 Canadian Activities 5-9

5.5 Actions and Progress 5-10
5.6 References 5-11

TABLE OF CONTENTS (Continued)

CHAPTER 6 SOURCES AND LOADS OF CRITICAL POLLUTANTS

6.1 Summary 6-1
6.2 Identifying Lakewide Problems and Critical Pollutants 6-1
6.3 Lake Ontario Sources and Loadings Strategy 6-2
6.4 Identifying Sources and Loadings of Critical Pollutants 6-3

6.4.1 Data Sources and Limitations 6-3

6.4.1.1 Sources Within the Lake Ontario Basin 6-4
6.4.1.2 Sources and Releases Outside the Lake Ontario Basin 6-5
6.4.1.3 Atmospheric Deposition 6-6

6.4.2 Loadings – General 6-6
6.4.3 Loadings of Critical Pollutants 6-9

6.4.3.1 PCBs 6-9
6.4.3.2 DDT and its Metabolites 6-9
6.4.3.3 Mirex 6-9
6.4.3.4 Dioxins and Furans 6-10
6.4.3.5 Mercury 6-11
6.4.3.6 Dieldrin 6-11

6.5 Actions and Progress 6-11

6.5.1 Binational Activities 6-12

6.5.1.1 Niagara River Toxics Management Plan 6-12
6.5.1.2 Lake Ontario Air Deposition Study (LOADS) 6-12
6.5.1.3 Great Lakes Binational Toxics Strategy 6-17
6.5.1.4 Lake Ontario Mass Balance Models 6-17
6.5.1.5 Binational Sediment Workshop 6-21

6.5.2 U.S. Activities 6-24

6.5.2.1 Contaminant Trackdown 6-24
6.5.2.2 Government Activities 6-27
6.5.2.3 Pollution Prevention Partnerships 6-31

6.5.3 Canadian Activities 6-32

6.5.3.1 Contaminant Trackdown 6-32
6.5.3.2 Government Activities 6-39
6.5.3.3 Pollution Prevention Partnerships 6-40

6.6 References 6-42

TABLE OF CONTENTS (Continued)

CHAPTER 7 HUMAN HEALTH

7.1 Summary 7-1
7.2 Background 7-1
7.3 Human Health and the Lake Ontario LaMP 7-2
7.4 Human Health Pathways 7-2
7.5 Beneficial Use Impacts 7-3

7.5.1 Fish Consumption Advisories 7-4
7.5.2 Drinking Water 7-6
7.5.3 Bathing Beach (Closings) and Recreation 7-6

7.6 Great Lakes Human Health Network 7-7
7.7 Actions and Progress 7-8
7.8 References 7-8

CHAPTER 8 PARTNERSHIPS

8.1 Summary 8-1
8.2 Binational Partnerships 8-1

8.2.1 Lake Ontario Committee 8-1
8.2.2 Lake Ontario-St. Lawrence Water Level Study 8-2
8.2.3 Cooperative Monitoring 8-3
8.2.4 Remedial Action Plans 8-3

8.3 Public Partnerships 8-4
8.4 Actions and Progress 8-4
8.5 References 8-4

CHAPTER 9 PUBLIC INVOLVEMENT AND COMMUNICATION

9.1 Summary 9-1
9.2 Public Involvement Goals 9-1
9.3 Meeting Public Involvement Goals 9-1

9.3.1 Public Meetings 9-1
9.3.2 Publications 9-2
9.3.3 Websites 9-3
9.3.4 Media Events 9-3
9.3.5 Special Projects 9-3
9.3.6 Speaking Engagements 9-4
9.3.7 LaMP Displays 9-4
9.3.8 Information Distribution 9-4

9.4 Information Connections 9-4
9.5 Actions and Progress 9-5
9.6 References 9-5

TABLE OF CONTENTS (Continued)

CHAPTER 10 SIGNIFICANT ONGOING AND EMERGING ISSUES

10.1 Summary 10-1
10.2 Significant Ongoing Issues 10-1

10.2.1 Protection and Restoration of Native Species 10-1
10.2.2 Invasive Species 10-2
10.2.3 Lake Ontario Water Levels 10-6

10.3 Emerging Issues 10-8

10.3.1 Rapid Urbanization of the Canadian Side of Western Lake Ontario 10-8
10.3.2 Emerging Chemicals of Concern 10-9
10.3.3 Other Emerging Chemicals 10-12
10.3.4 Fish and Wildlife Disease 10-12
10.3.5 Type E botulism 10-13
10.3.6 Climate Change 10-14
10.3.7 Harmful Algal Blooms 10-14

10.4 Actions and Progress 10-15
10.5 References 10-19

CHAPTER 11 SUMMARY OF AREA OF CONCERN STATUS

11.1 Summary 11-1
11.2 Background and Current Status 11-1
11.3 Binational Areas of Concern 11-4

11.3.1 Niagara River Area of Concern 11-4

11.3.1.1 Niagara River (U.S. Side) 11-5
11.3.1.2 Niagara River (Canada Side) 11-6

11.3.2 St. Lawrence River Area of Concern 11-7

11.3.2.1 St. Lawrence River at Massena, New York 11-7
11.3.2.2 St. Lawrence River at Cornwall, Ontario 11-9

11.4 U.S. Areas of Concern 11-10

11.4.1 Eighteenmile Creek 11-10
11.4.2 Rochester Embayment 11-11
11.4.3 Oswego River 11-12

11.5 Canada Areas of Concern 11-14

11.5.1 Hamilton Harbour 11-14
11.5.2 Toronto and Region 11-15
11.5.3 Port Hope Harbour 11-16
11.5.4 Bay of Quinte 11-18

TABLE OF CONTENTS (Continued)

11.6 Actions and Progress 11-19
11.7 References 11-19

CHAPTER 12 LaMP WORKPLAN ACTIONS AND PROGRESS

12.1 Summary 12-1

CHAPTER 13 LaMP NEXT STEPS

13.1 Summary 13-1
13.2 Next Steps 13-1
13.3 Research and Monitoring Needs 13-2
13.4 Recommendations 13-2
13.5 References 13-2

Tables

2.1 Basin Land Use (%) 2-8
2.2 Shoreline Land Use (%) 2-8

3.1 Critical Pollutant Concentrations in Lake Ontario Open Waters, 1997 3-4

4.1 Lake Ontario Lakewide Beneficial Use Impairments, Impacted Species and Pollutants 4-4

6.1 Estimates of Critical Pollutant Loadings to Lake Ontario 6-7
6.2 PCB air concentrations, pg/m3 and air temperature. Sampled from Ship and from nearby Land based station. Average of three intensive sampling events (April and September 2002 and July 2003) 6-13
6.3 Total PCBs, DDE and Mirex in Lake Ontario Surface Water dissolved phase, ng/L (Average of 3 intensive sampling events: April and Sept. 2002 and July 2003) 6-14
6.4 Concentrations of Total Gaseous Mercury (TGM) and Reactive Gaseous Mercury (RGM) in Air and filtered Total Gaseous Mercury (TGM) and Dissolved Gaseous Mercury (DGM) in the Water Column of Lake Ontario 6-16
6.5 Total Dioxins / Furans air concentrations (pg/m^3) LOADS three intensive sampling periods 6-16
6.5 Phases of Lake Ontario Trackdown Studies 6-34

10.1 Other non native species threatening Lake Ontario ecosystem, their origin, date and location of first sighting, mechanism of introduction into the Great Lakes, and their current or potential impacts. (Dermot and Legner 2002, Mills et al. 1993, Owens et al. 1998, Ricciardi 2001, Witt et al. 1997, and Zaranko et al. 1997) 10-2
10.2 Summary of Actions and Progress 10-16

11.1 Summary of Beneficial Use Impairments for Lake Ontario Lakewide, Nearshore, and Areas of Concern (Based on the 14 IJC Use Impairment Indicators) 11-2

12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities 12-1

TABLE OF CONTENTS (Continued)

Figures

2.1 Lake Ontario Drainage Basin 2-1
2.2 Sedimentation Basins in Lake Ontario (Thomas, 1983) 2-3

3.1 PCB Concentrations in Herring Gull Eggs from Lake Ontario Colonies, 1970-1999 3-5
3.2 DDE Levels in Herring Gull Eggs from Kingston Harbour, 1974-2001 3-6
3.3 Dioxin Levels in Herring Gull Eggs from Toronto Harbour, 1987-2001 3-6
3.4 Total PCB Levels in 50 cm Coho Salmon from the Credit River, 1976-2001 3-8
3.5 Mirex Levels in 50 cm Coho Salmon from the Credit River, 1976-2001 3-8
3.6 Mercury Levels in 50 cm Coho Salmon from the Credit River, 1976-2001 3-8
3.7 Total DDT Levels in 50 cm Coho Salmon from the Credit River, 1976-2001 3-8
3.8 Number of Gull, Tern and Cormorant Nests on Lake Ontario, 1976-1999 3-11
3.9 Indicator: Bald Eagle Measure: Eaglets Produced Per Nest 3-14
3.10 Indicator: Bald Eagle Measure: Number of Nesting Territories. 3-15

4.1 Phytoplankton Densities from Toronto-based Lake Ontario Water Treatment Plant Intakes, 1923-1998 4-14

5.1 Lake Ontario Habitat Restoration Projects 5-5

6.1 Variations in flows and loads of mercury in US Tributaries 6-5
6.2 Total PCB comparison of IADN (1998-2000) and Sterling (2002-2003) 6-14
6.3 PCB air sampling at Sterling for the period April 2002 – March 2003 showing direct relationship between air temperature and amount of PCBs measured 6-14
6.4 Model Confirmation 1998 - 2001 6-20
6.5 Output for Lake Trout PCB Concentrations under Baseline and Other Loading Scenarios 6-20
6.6 Lake Ontario PCB Mass Balance for the Year 2000. 6-21
6.7 Ontario Tributary Source Trackdown locations 6-33

10.1 Greenbelt Plan Area 10-9

11.1 Lake Ontario Areas of Concern (AOCs) 11-4

Appendices

A Glossary and List of Acronyms
B Lake Ontario Letter of Intent
C LaMP Management Team
D 5-Year Binational Workplan for the Lake Ontario Lakewide Management Plan

Photo Credits

Cover Bald Eagle – U.S. Environmental Protection Agency (USEPA)
Aerial Shot - Cootes Paradise – Environment Canada (EC)
Salmon - Canadian Department of Fisheries and Oceans (DFO)

Executive Summary – USEPA *

Chapter 1 – DFO
Chapter 2 – EC
Chapter 3 – USEPA *
Chapter 4 – New York State Department of Environmental Conservation (NYSDEC)
Chapter 5 – DFO
Chapter 6 – EC
Chapter 7 – Ontario Ministry of Environment (OMOE)
Chapter 8 – USEPA
Chapter 9 – OMOE
Chapter 10 – USEPA *
Chapter 11 – EC
Chapter 12 – USEPA
Chapter 13 – USEPA

* Photos for the Executive Summary and chapters 3 and 10 are taken from USEPA's web site Visualizing the Great Lakes which contains images from a variety of contributors.

EXECUTIVE SUMMARY (LAMP 2006)

Introduction

This Lake Ontario Lakewide Management Plan Status 2006 is the latest, comprehensive compilation of existing LaMP reports, and replaces the 2004 Status. The document contains new/updated information on the current status of beneficial use impairments, sources and loads of critical pollutants, public involvement and communication and significant ongoing and emerging issues. The report also provides an update on LaMP workplan actions and progress and next steps. Most of the chapters in this document have been updated and other chapters will be updated at a later date, as new information becomes available.

Background

In 1987, the governments of Canada and the United States made a commitment, as part of the Great Lakes Water Quality Agreement (GLWQA), to develop a Lakewide Management Plan (LaMP) for each of the five Great Lakes.

The Lake Ontario LaMP is a binational, cooperative effort to restore and protect the health of Lake Ontario by reducing chemical pollutants entering the lake and addressing the biological and physical factors impacting the lake.

Building on the Lake Ontario Toxics Management Plan (1989, 1991, 1993), the Lake Ontario LaMP focuses on:

- Restoring lakewide beneficial use impairments, as defined in the GLWQA (Annex 2) and described in Chapter 4 of this LaMP;
- Virtually eliminating critical pollutants that due to their toxicity, persistence in the environment, and their ability to accumulate in organisms are likely to contribute to these impairments despite past application of regulatory controls; and
- Resolving physical and biological problems caused by human activities.

LaMP 2006

The LaMP 2006 Status for Lake Ontario has been developed by Region 2 of the US Environmental Protection Agency (USEPA), Environment Canada (EC), the New York State Department of Environmental Conservation (NYSDEC), The Ontario Ministry of the Environment (OMOE), the Ontario Ministry of Natural Resources (OMNR), Fisheries and Oceans Canada (DFO), and the US Fish and Wildlife Service (USF&W). The document incorporates all relevant information/commitments from: the Lake Ontario Toxics Management Plan (1989, 1991, 1993), the Lake Ontario LaMP Stage 1 Report (1998), the Lake Ontario LaMP 2002 Biennial Report, and the Lake Ontario LaMP 2004 Status. In addition, the following chapters of the LaMP have been updated:

- Chapter 2 Background
- Chapter 4 Identification of Beneficial Use Impairment Assessments
- Chapter 6 Sources and Loads of Critical Pollutants
- Chapter 9 Public Involvement and Communication
- Chapter 10 Significant Ongoing and Emerging Issues
- Chapter 12 LaMP Workplan Actions and Progress
- Chapter 13 LaMP Next Steps

The primary audience for this document is government agencies and their partners who are involved directly in restoration and protection activities around the Lake. LaMP Status also responds to the reporting requirement to the IJC under the Great Lakes Water Quality Agreement (GLWQA). *Update* newsletter is prepared annually by the LaMP Agencies to inform the public about developments and progress on LaMP Program activities.

LaMP 2006 Highlights

Background (Chapter 2)

- In 2004, the membership of the LaMP was expanded to include Fisheries and Oceans Canada (DFO), the US Fish and Wildlife Service (USF&W) and the Ontario Ministry of Natural Resources (OMNR). The participation of these agencies has allowed better integration of fish and wildlife objectives and indicators into the LaMP.
- Information on the demographics and economy of the basin, and the status of aquatic communities of Lake Ontario has been updated to reflect current conditions.

Identification of Beneficial Use Impairment Assessments (Chapter 4)

- Status reports for each of 14 Beneficial Use Impairments (BUI) identified in the Great Lakes Water Quality Agreement (1987) have been updated including a brief account of the LaMP's original determination of their status.
- In 2005, the status of the Degradation of Fish Populations BUI was reviewed, as recent data and scientific interpretation clearly showed the offshore to be impaired due primarily to the impacts of non-native species. Research into the re-introduction of Atlantic salmon and deep water ciscos, as well as food quality issues including thiamin deficiency, are key action items currently underway that directly address the impaired fish population BUI.
- No previously impaired beneficial uses have changed status. Benthos and phytoplankton (nearshore) are deemed impaired mainly due to the impacts of non-native species. Several projects on the lower foodweb and benthos status have been completed or are continuing in order to assess the impacts of these non-native species on the near and offshore ecosystems. The LaMP directly participated in the Lake Ontario Lower Aquatic Foodweb Assessment project (LOLA) and results of this project should be available in 2006.
- Contaminant levels have declined in bald eagles, colonial waterbirds, mink, otter and snapping turtles, and healthy populations of these animals exist around much of Lake Ontario where habitat is suitable. The exception is in the Golden Horseshoe area (western end of Lake Ontario) where contaminant issues still exist for mink and snapping turtles. For most species, physical habitat quality and loss are now greater concerns, however, disease issues like botulism may also have a negative impact on fish and wildlife.
- The zooplankton BUI (which is listed as not impaired) is currently under review by the LaMP member agencies.

Sources and Loads of Critical Pollutants (Chapter 6)

- The sources and loadings of critical pollutants (i.e. bioacumulative and persistent toxic substances that are known or suspected to be responsible for lakewide impairments of beneficial uses) to Lake Ontario were updated, based on the best data available. For Lake Ontario, these substances, which include, DDT and its metabolites, dieldrin, dioxins/furans, mercury, mirex and PCBs, are the focus of LaMP source reduction activities.

- Previously, the LaMP reported that, based on the very limited loadings data available, it appeared that the most significant source of critical pollutants to Lake Ontario come from outside the Lake Ontario basin, specifically the Niagara River Basin and upstream lakes. Based on the current, although still very limited loadings data available, it appears that the upstream Great Lakes are still a significant source of critical pollutants and are now equaled in magnitude by atmospheric deposition from emissions both within and outside the Lake Ontario basin.
- The chapter also describes the status of selected actions taken by LaMP Parties to address known and potential sources of critical pollutants throughout the Lake Ontario basin, in keeping with the LaMP's sources and loadings strategy. Updates are provided on the following binational activities: the Niagara River Toxics Management Plan (NRTMP); the Lake Ontario Air Deposition Study (LOADS); the Great Lakes Binational Toxics Strategy; the Binational Sediment Workshop; and Lake Ontario Mass Balance Models.
- U.S. government activities which have been undertaken to address sources of critical pollutants include: contaminant trackdown; NYSDEC's Comprehensive Watershed Restoration and Protection Action Strategies (WRAPS); implementation of the Great Lakes Water Quality Guidance; and development of a watershed-based, pollutant management tool known as 'total maximum daily load" (TMDL). In addition many pollution prevention partnership activities have been implemented on the U.S. side such as: mercury reduction projects in hospitals and dental offices; and agricultural pesticide clean sweeps.
- Canadian government activities have focused on: contaminant trackdown in three pilot watersheds, Twelve Mile Creek, Etobicoke Creek, and Cataraqui River, where elevated PCB levels were found to exist; and screening level surveys of all Lake Ontario tributaries. Pollution prevention partnership activities that were undertaken on the Canadian side include: burn barrel and household garbage burning community education programs; mercury "switch-out" project with auto recyclers; a pilot mercury appliance switch collection program; launching of a mercury-dental clean sweep; and agricultural pesticide clean sweeps.

Public Involvement and Communication (Chapter 9)

- In June 2005 the LaMP hosted a public information session at the Marine Museum of the Great Lakes in Kingston, Ontario, timed to coincide with the International Joint Commission (IJC) Biennial Meeting. The theme topic of the meeting was stewardship and included presentations by the LaMP and from the "Centre for Sustainable Watersheds" and the "Finger Lakes - Lake Ontario Watershed Protection Alliance." In 2006 the LaMP will host a joint public meeting with the Niagara River Toxics Management Plan. The meeting will be held on October 26, 2006 in Niagara Falls, New York.
- Providing the public with a sound understanding of the complex problems facing the Lake is the first step in gaining public support and participation in achieving the LaMP's goals. Ongoing and planned activities include opportunities to meet with existing groups, forming partnerships locally to assist in LaMP projects and providing information when requested and regularly through the LaMP website and mailings. Stewardship of the Lake will be emphasized at future partnership meetings. The LaMP will continue to inform the public through reporting and public meetings, and will participate in other meetings such as SOLEC and the International Joint Commission (IJC) biennial sessions.

Significant Ongoing and Emerging Issues (Chapter 10)

- Significant ongoing issues facing Lake Ontario include: the protection and restoration of native species (lake trout and American eel); the prevention of introduction of new non-native species like Asian carp; the continuing colonization of the lake and connected waterbodies by non-native

species like zebra and quagga mussels, fishhook / spiny waterfleas, and round gobies; and artificial control of Lake Ontario water levels.

- Emerging issues (i.e., issues that are relatively new to Lake Ontario and may warrant the LaMP's attention) include: the rapid urbanization of the western end of Lake Ontario (the "Golden Horseshoe); emerging chemicals of concern (flame retardants (PBDEs, HCBD), perfluorinated compounds (PFOS, PFOA), polychlorinated naphthalenes (PCNs), and other emerging chemicals including endocrine disrupting compounds, pharmaceuticals and personal care products); fish and wildlife diseases; type E botulism; and harmful algal blooms.

LaMP Workplan Actions and Progress (Chapter 12)

- In January 2005 the LaMP Parties developed a new 5-year binational workplan for the Lake Ontario LaMP. The workplan outlines binational efforts to restore and protect Lake Ontario and its biological resources. Table 12.1 summarizes the actions and progress made in all the workplan activities as of December 31, 2005. The full 5-year workplan can be found in Appendix D of this report.

LaMP Next Steps (Chapter 13)

- The LaMP Parties will continue their cooperative efforts towards the restoration and protection of Lake Ontario and its ecosystem. In the upcoming years, special attention will be concentrated on the following activities:
  - Coordination of binational monitoring efforts and programs to better assess the health of Lake Ontario and its ecosystem. Planning is underway to continue the data analysis from the binational monitoring efforts, to disseminate this information and evaluate the management implications and follow-up next steps that will evolve from these efforts.
  - Reducing critical pollutant loadings to the lake. Contaminant trackdown efforts in the U.S. and Canada will continue so that contaminant sources can be identified and addressed.
  - Reporting on the status of the LaMP's ecosystem indicators, and adopting new indicators.
  - Assessing the current status of the lower food web and the fisheries. Since the lower food web has been irreversibly modified by invasive species, work is planned on further assessing the biological aspects of the Lake and investigating the development of new biological indicators to establish well-defined endpoints for the LaMP's restoration efforts.
  - Re-evaluating the status of the Lake's beneficial use impairments, as needed.
  - Developing a binational habitat conservation strategy. A binational data base and strategy for conservation will be developed drawing information from the Canadian habitat assessment, NYS's Comprehensive Wildlife Conservation Strategy, the U.S. Lake Ontario Coastal Initiative, and other relevant habitat efforts.
  - Conducting public outreach and promoting LaMP partnerships and stewardship of the Lake and its watershed.

The LaMP agencies are looking forward to continuing efforts to improve Lake Ontario and its ecosystem. The updated workplan and relevant documents can be found on the web at www.binational.net.

CHAPTER 1 STATE OF LAKE ONTARIO

1.1 Summary

The State of the Lake chapter is intended to provide up-to-date information on the conditions present in Lake Ontario. Since one of the key chapters, Chapter 3, Ecosystem Goals, Objectives, and Indicators will not be finalized until later this year, Chapter 1 will not be included in this Spring 2006 status report. A revised version of the status report will be provided later this year which will include revised Chapters 1 and 3.

CHAPTER 2 BACKGROUND

2.1 Summary

This chapter presents background information on the climate and physical characteristics of the Lake Ontario basin including lake processes and aquatic communities. It goes on to discuss the demography and economy of the basin. It then describes the history of the Lake Ontario LaMP, including its beginnings under the Lake Ontario Toxics Management Plan (LOTMP). The chapter lists the goals of the LOTMP which were adopted as the goals of the LaMP and records the objectives that were developed to achieve the goals. The LaMP *Structure and Processes* section describes the management structure of the LaMP and goes on to present the scope of activities and the methods the agencies intend to use to address the objectives as described. The Background chapter concludes with an outline of the reporting process that the LaMP has taken on over the past number of years.

2.2 Introduction to Lake Ontario

Lake Ontario is last in the chain of Great Lakes that straddle the Canada/United States border. Its shoreline is bordered by the Province of Ontario on the Canadian side and New York State on the US side (see Figure 2.1). Lake Ontario is the smallest of the Great Lakes, with a surface area of 18,960 km^2 (7,340 square miles), but it has the highest ratio of watershed area to lake surface area. It is relatively deep, with an average depth of 86 meters (283 feet) and a maximum depth of 244 meters (802 feet), second only to Lake Superior. Approximately 80 per cent of the water flowing into Lake Ontario comes from Lake Erie through the Niagara River (USEPA et al., 1987). The remaining flow comes from Lake Ontario basin tributaries (14 per cent) and precipitation (7 per cent). About 93 per cent of the water in Lake Ontario flows out to the St. Lawrence River; the remaining 7 per cent leaves through evaporation. Since Lake Ontario is the downstream Great Lake, it is impacted by human activities occurring throughout the Lake Superior, Michigan, Huron, and Erie basins.

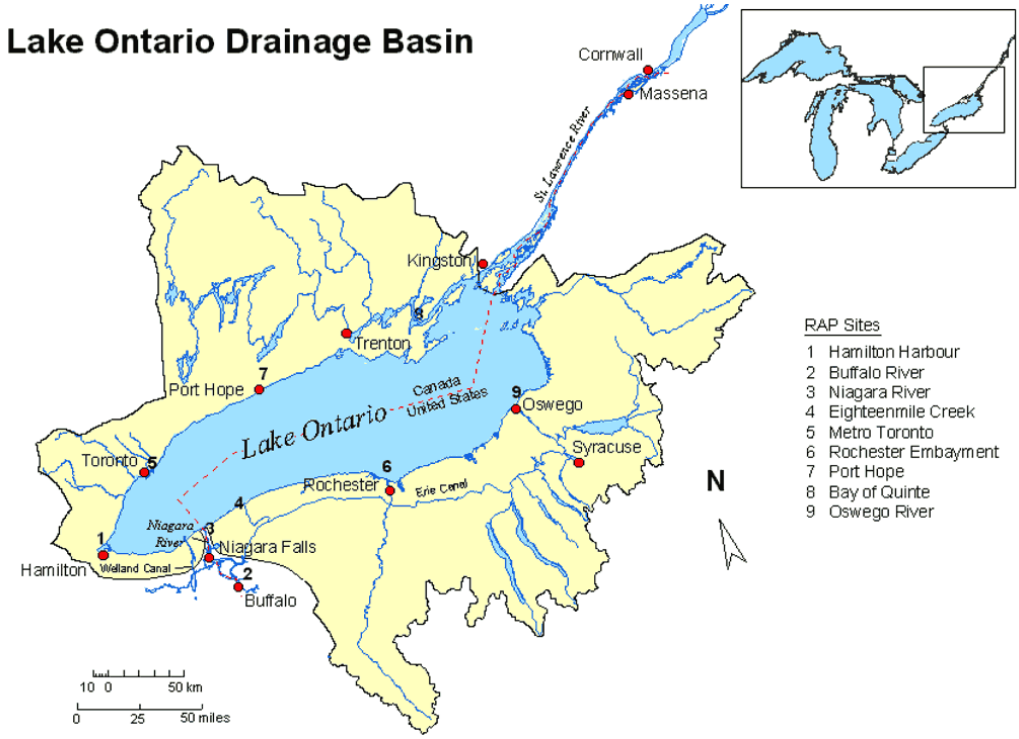


Figure 2.1 Lake Ontario Drainage Basin

2.2.1 Climate

The climate of the entire Great Lakes basin is characterized as humid and temperate (USEPA et al., 1987). The position and size of each lake, together with the effects of outside air masses, further influence climate. Each lake acts as a heat sink, absorbing heat when the air is warm and releasing it when the air is cold. This results in more moderate temperatures at nearshore areas than other locations at the same latitude. The influence of external air masses varies seasonally. In the summer, the Lake Ontario basin is influenced mainly by warm humid air from the Gulf of Mexico, whereas in winter the weather is influenced more by Arctic and Pacific air masses.

2.2.2 Physical Characteristics and Lake Processes

There are two major sedimentary basins within Lake Ontario: 1) the Kingston Basin, which is a shallow basin located northeast of Duck-Galloo Island; and 2) a deeper main basin that covers the rest of the lake (see Figure 2.2). Within the main basin there are three deep sub-basins: the Rochester, Mississauga, and Niagara Basins. These basins are bordered by a shallow inshore zone that extends along the perimeter of the main basin.

Lake Ontario has a seasonally dependent pattern of both horizontal and vertical thermal stratification. In the spring, nearshore water warms more quickly than the deep offshore waters. The density of water varies with temperature, resulting in little mixing between these waters. The lake becomes stratified horizontally between the nearshore and the offshore zones (except in the Kingston Basin which is shallow throughout). This thermal stratification lasts until around the middle of June when offshore waters warm and mixing occurs between offshore and nearshore waters. For the rest of the summer, there is vertical stratification between the warm surface waters (epilimnion) and cool deeper waters (hypolimnion). The depth of the thermocline varies between sub-basins. Summer water temperatures are generally warmer in the southeast end of the lake and cooler in the northwest end. Mixing of the waters in the epilimnion and the hypolimnion begins during September, when the surface waters have cooled, and continues until isothermal conditions occur. During the winter months, inshore areas freeze (including Kingston Basin) but deep waters remain open.

The prevailing west-southwest winds combined with the eastward flow of water from the Niagara River are the most important influences on lake circulation resulting in a counter-clockwise motion (Sly, 1991). Circulation of water generally occurs along the eastern shore and within sub-basins of the main lake. There is very little net flow along the north inshore zone. Lake Ontario's resultant circulation consists of a dominant counter clockwise gyre in the main basin of the lake that connects or causes a smaller clockwise gyre in the northwest portion of the lake (Schertzer, 2003).

Circulation patterns, sedimentation rates, and thermal stratification influence the effects of human activities on the lake. Although water retention time in the lake is estimated to be about seven years, based on inflow and outflow rates it may take much longer for substances such as toxic chemicals to leave the lake (Sly, 1991). Contaminants may bind to sediments on the lake floor, be covered over, and remain indefinitely. Alternatively, contaminants may be resuspended to the water column or ingested by benthic organisms and be introduced to the food chain. In the summer when the lake is stratified, only water from the epilimnion flows out into the St. Lawrence River, but during the winter months when the water is thoroughly mixed, water from the deeper parts of the lake reaches the St. Lawrence.

The trophic status of the lake has been influenced by human activities. Prior to European settlement, Lake Ontario was oligotrophic. In the 1960s and 1970s, excess nutrients in the form of phosphorus (from household detergents, for example) caused excess algal growth. The trophic status of the main basin

changed from oligotrophic to mesotrophic, and many nearshore areas became eutrophic. Phosphorus controls were implemented in the 1970s and have been successful in reducing the amount of nutrients entering the lake. Phosphorus levels, which were over 20 µg/L in the 1970s, have dropped to less than 10 µg/L since 1986 (Neilson et al., 1994) indicating that the lake is returning to its original oligotrophic condition.

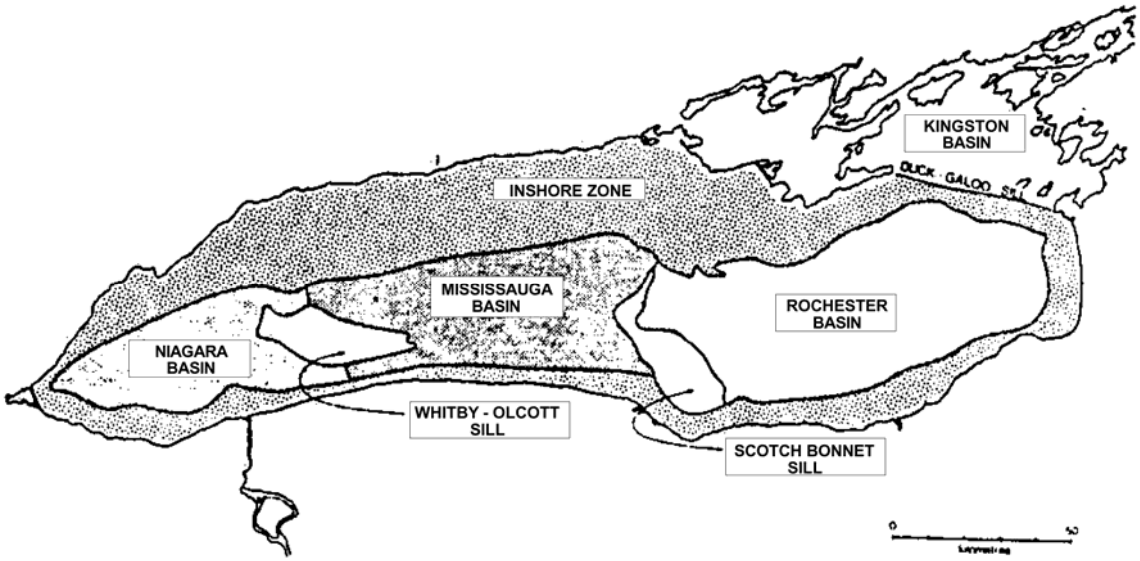


Figure 2.2 Sedimentation Basins in Lake Ontario (Thomas, 1983*)*

2.2.3 Aquatic Communities

The aquatic communities of Lake Ontario are dynamic and under continuous stress from environmental drivers and human activity. Anthropogenic stress increased rapidly following the colonization of Ontario by non-aboriginal peoples and subsequent industrialization (Christie, 1972, 1973; Smith, 1972). In the last 200 years the biodiversity of the lake changed from one dominated by native cold and warm water species to one with many non-native species and fewer native species. This rate of change increased with time. The introduction of non-native species is not the only driver causing change because climate, habitat modification, and direct exploitation are other factors to consider. A major anthropogenic driver of ecosystem change was eutrophication followed by oligotrophication as a result of the implementation of phosphorus control under the Great Lakes Water Quality Agreement (GLQWA 1972). The following is a brief history of how the aquatic community became what it is today.

As was discussed in the previous section, Lake Ontario's offshore main and Kingston basins were oligotrophic prior to the early 1900s (Ryder, 1972). The near shore, places like the Bay of Quinte, Frenchman's Bay, and Chaumont Bay were more likely mesotrophic. One can directly relate the oligo (meaning few) and meso (meaning moderate) prefix to the biodiversity in the lake too. Towards the end of the 19th century, Lake Ontario had a different and arguably less complex offshore food web than it does now (Christie, 1973; Mills et al, 2004). Invertebrate biodiversity offshore was composed only of native species including a variety of mollusks such as freshwater clam and fingernail clam (*Sphaerium* spp.) as well as several snail species (Mills et al, 2004). Amphipods like *Diporeia hoyi* and crustaceans like *Mysis relicta* were the most abundant invertebrates in the offshore. Fish species included Atlantic salmon (*Salmo salar*) as the top pelagic predator, a host of cisco (*Coregonus* spp.) species throughout the offshore water column and lake trout (*Salvelinus namaycush*), burbot (*Lota lota*) and sculpins (deepwater, *Myoxocephalus thompsoni* and slimy, *Cottus cognatus*) at the bottom of the lake (Christie, 1973).

Atlantic salmon were extirpated by the late 1800s, lake trout and blue pickerel (*Stizostedion vitreum glaucum*) were extirpated by the 1960s, deep water sculpin and all ciscoes except one shallow water form of lake herring found in eastern Lake Ontario were also virtually, if not completely, extirpated from Lake Ontario. In the first half of the 20th century, alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*) and white perch (*Morones americana*) were introduced or invaded Lake Ontario. Due to the extirpation of native species, and eutrophication of the nearshore, these three species increased in numbers dramatically. The cumulative effects of these non-native species, severe habitat degradation, and continued exploitation were permanent changes to the near and offshore food webs.

The restoration of native species to provide fishing opportunities began very early in Lake Ontario with attempts to culture and stock Atlantic salmon but these failed for a variety of reasons. The lack of offshore predators allowed alewife to become very abundant during the mid-1900s and huge die offs were causing a real pollution concern along Lake Ontario's shoreline. During this build up of alewife, rainbow smelt, became very abundant as well. During the late 1960s and early 1970s, lake trout became a focus for restoration on Lake Ontario but any restoration efforts were hampered because of both increased mortality of their young of the year and competition for food between young lake trout and alewife and smelt (Jones et al., 1995; Mills et al. 2004). Both smelt and alewife needed to be reduced before any restoration effort would work. As a result, both New York and Ontario explored a wide variety of species and strains of non-native salmonids as potential alewife control options.

In conjunction with stocking of non-native species came the implementation of the very effective sea lamprey (*Petromyzon marinus*) control program. This predator of many cold water fish species has a preference for lake trout and induced heavy mortality on them. In the late 1950s, both Canada and the United States of America signed the Convention of Great Lakes Fisheries and the Great Lakes Fishery Commission was established (Stewart et al, 1999). Lake Ontario's sea lamprey population was significantly reduced in size during the early 1980s. Shortly thereafter, the stocked non-native and native salmonids really started to show increases in the number of fish surviving to adults.

As was described earlier in this status report, the Great Lakes Water Quality agreement (1972) resulted in significant reductions in phosphorus loadings in all of the Great Lakes. There were rapid and substantial impacts in the Lake Ontario near and off shore ecosystem as the lake became more oligotrophic (Mills et al, 2004). For example, many native species of fish that used the near shore for spawning and early life had been negatively impacted by the eutrophication occurring there. Shortly after phosphorus abatement was instituted, many of these species, particularly walleye (*Zander vitreus*) and lake whitefish (*Coregonus clupeaformis*) rebounded.

Meanwhile in the offshore, almost all stocked salmonids showed substantial increases in survival and also increases in wild reproduction were observed particularly for rainbow trout (*Onchorhynchus mykiss*), Coho salmon (*Onchorhynchus kisutch*)and lake trout. A premier sport fishery developed and is now a primary driver for continuing stocking of non-native species of salmon and trout. During this period contaminant levels in fish tissue declined (reference). By the late 1980s, Lake Ontario was showing signs of improvement not only of native species but also of ecosystem function even though the food webs had become, inarguably, much more complex with respect to the variety of top predators and other non-native species (see Chapter 4).

Unfortunately, these improvements were short lived. In the early 1990s, a Ponto-Caspian species called the zebra mussel (*Dreissena polymorpha*) was introduced into Lake Ontario probably from both natural flow of water and also from inter-lake shipping having first been introduced to Detroit River/Lake St. Clair. This benthic organism had immediate impacts on benthic habitat and physical qualities of water. As well, it was predicted that this mussel would create severe changes in biodiversity and it did. Many

native mollusks and the amphipod, *Diporeia hoyi* showed significant declines since 1972 (Lozano and Nalepa, 2004). *Diporeia* was extirpated from areas less than 100 m deep by 1997 (Lozano et al, 2001; Mills et al., 2004). While zebra mussels were colonizing the lakes near shore, quagga mussels (*D. bugensis*) were also introduced and began out-competing zebra mussels and colonizing far into the offshore causing further benthic habitat change and perhaps, further shrinking of the distribution of *Diporeia hoyi*.

The loss of Diporeia hoyi from a large area of the offshore meant a loss of a critical component of the offshore food web. This amphipod is rich in fat and was the primary component of the diet of lake whitefish and probably lake herring (*Coregonus artedii*), and an important component of the diet of young lake trout, slimy sculpin, deep water sculpin, alewife and smelt. Concurrent with the rapid decline of this amphipod came the precipitous decline in lake whitefish reproductive success (6 out of the last 7 years), poor wild reproduction among lake trout and a decline in both alewife and rainbow smelt. The alewife was also subject to heavy predation because it is an important diet component of all salmonids and walleye as well as double crested cormorants (*Phalacrocorax auritus*). The double crested cormorant benefited greatly from the reductions in contaminants and later improvements in water clarity and is now an important fish predator in much of the near shore of Lake Ontario (Johnson, 2002).

Today, *Diporeia hoyi* is found only at the deepest survey sites in Lake Ontario main basin (Dermott 2001). Many benthic communities are now dominated by zebra and quagga mussels (reference see Project Quinte). In some nearshore areas, particularly those near urban development, oligochaete worms dominate, reflecting the eutrophic status of these areas. Zooplankton communities are dominated by cladocerans (water fleas) and cyclopoid copepods. Diatoms and green algae are the most common types of phytoplankton. *Mysis relicta*, the opossum shrimp, is a very important part of the pelagic offshore food web. The exotic cladoceran, *Cercopagis pengoi* (the fish hook water flea), has become a persistent and important component of the summer zooplankton community. *Bythotrephes longiminus*, (spiny water flea) was introduced into Lake Ontario several years ago (Johannsson, 2003) and is showing a resurgence of late.

The prey fishes are dominated by non-native species particularly alewife which is the central vertebrate prey item in the offshore food web of all of Lake Ontario (Mills et al, 2004; OMNR, 2005) . Alewife status is difficult to assess as the older alewife in the lake are in very good body condition (they are fat for their length) but there are virtually no younger alewife being captured. Smelt and slimy sculpin are doing poorly. The offshore has some surprising peculiarities being observed as threespine stickleback (*Gasterosteus aculeatus*), a nearshore spawning fish and usually lifelong inhabitant is being found throughout the offshore. In 2005, several deep water sculpin were found.

If one considers the recreational fishery catch on Lake Ontario to be an index of relative abundance, then its most abundant top predators, in descending order are Chinook salmon (*Oncorhynchus tshawytscha*), brown (*Salmo trutta*) and rainbow trout, lake trout, Coho salmon, and Atlantic salmon with Chinook representing about 65 per cent of the catch or about five times more fish than either brown or rainbow trout (NYSDEC, 2005; OMNR 2005). One benthic top predator that is not well assessed is the burbot, a native species; its status is uncertain. All of the salmonids are maintained primarily through stocking programs (Crawford, 2001; Mills et al, 2004). However, natural reproduction of these species has been documented in a number of tributary systems and is the focus of some intense research (see Chapter 4, Degradation of Fish Populations BUI).

In the nearshore areas of Lake Ontario, the food web has undergone a shift too. The nearshore was first colonized by zebra mussels and then replaced by quagga mussels. The amphipod *Gammarus fasciatus* became more abundant as a result but the non-native amphipod *Echinogammarus ischnus* creates some uncertainty (Mills et al. 2004). Non-native fish species like white perch, alewife and smelt are less

abundant in the nearshore allowing for better survival of some native species (Mills et al, 2004). But, the reduction of abundance of alewife and smelt further supports the offshore observations of reduced production of alewife and rainbow smelt. The increase in abundance of cormorants has further increased demands on the prey base (Mills et al, 2004).

Fishes like the largemouth bass (*Micropterus salmoides*), sunfishes (*Lepomis* sp.), yellow perch (*Perca flavescens*), common carp (*Cyprinus carpio*), catfishes (*Ameiuruss* spp.) and the newest non-native species the round goby (*Neogobius melanostomus*) have shown marked increases in abundance, particularly since the establishment of Dreissenid mussels. But some native species like walleye, smallmouth bass and rock bass have not adapted well to the rapid changes in the nearshore. Walleye abundance has declined dramatically but the population remains stable at about half the size it was in the late 80s and early 90s (OMNR, 2005).

The round goby (*Neogobius melanostomus*) is clearly becoming an important diet item of many fish species (Lake Ontario Management Unit, OMNR, RR#4 Picton, ON, unpublished data). Its range extends to the offshore in association with quagga mussels. It is a very territorial fish that is displacing native benthic fishes. Larger gobies feed primarily on *Dreissena* spp. but they are suspected to be voracious egg and larval fish predators, too. The re-direction of energy and contaminants from the benthos by the addition of round goby in the food chain will be of particular interest in the future.

During the 1990s invasion of Lake Ontario by *Dreissena* spp., double crested cormorants showed exponential increases in abundance. Their success was in large part due to the reduction of persistent bioaccumulative chemicals in the lake. Their impact on fish communities is currently being investigated but this top predator has the potential to consume a large biomass of both forage and sport fish. Their negative impacts on other colonial water birds and coastal/riparian habitat are well documented.

Although the nearshore is dynamic and has undergone some rapid perturbations, it still supports many healthy populations of native species. But there are some disturbing trends. The worst would be the trends observed for the American eel (*Anguilla rostrata*). It was once a common species throughout the lake, especially in the Kingston basin and all of the St. Lawrence River where it supported a large commercial fishery. This near shore piscivore was an important component of the food web. Since the early 1990s, this species has shown a rapid and catastrophic decline in abundance in Lake Ontario. There are many factors affecting the survival of eels during their migration into Lake Ontario to live and grow, and then back to the Atlantic Ocean to spawn. The future of the American eel in Lake Ontario is grave. (see also Chapter 10)

Another factor affecting many fish species is contaminants. Many of the contaminants found in the fishes of Lake Ontario bioaccumulate reaching restrictive concentrations in larger older fish and at higher trophic levels. Walleye, channel catfish and common carp all have elevated levels of persistent toxic substances as indicated in fish consumption guides in both New York and Ontario. In Ontario, some restrictions on the commercial sale of fish are in place due to contaminants. While long-term trends in the reduction of persistent contaminants in lake trout are promising, the recent, dramatic increase in polybrominated diphenyl ethers (PBDE's) in lake trout is of concern. See also 2004 SOLEC Indicators report: Indicator #121 - Contaminants in Whole Fish.

Not all chemical compounds causing health problems for fish are man-made. An enzyme called thiaminase is also present in many prey fish such as alewife, rainbow smelt and gizzard shad. It is also found in some invertebrates like *Diporeia hoyi*. Chinook and Coho salmon as well as lake trout and Atlantic salmon eat these prey fishes. For the latter two species this enzyme causes increased mortality of their young soon after hatching, hence the disease is named early mortality syndrome. Recent research has shown this enzyme to cause secondary non-lethal effects including lethargy in salmonids, making

young salmonids more vulnerable to predators, and giving them a lack of migratory ability, and reduced growth (Honeyfield et al, 2005; Ketola et al. 2005). Thiaminase induced mortality and secondary effects are a high priority for the Lake Ontario Technical Committee of the Great Lakes Fishery Commission because both are major impedances to the restoration of Atlantic salmon and lake trout.

Lake Ontario has been the recipient of many exotic species and has been subject to several recent and rapid ecological changes due to the invaders. Our awareness of future invaders is heightened and as such it is important to note that a variety of species of Asian carp are set to invade Lake Ontario. Grass carp have been reported in the watershed and bighead carp have been captured in Lake Erie. The impact of these and other large omnivorous fish is uncertain but they have the reproductive capacity to become well established quickly.

As part of their shared responsibility to the Great Lakes Fishery Commission, the NYSDEC and the OMNR review fisheries management direction for the lake every five years. This review involves fisheries professionals and stakeholders. The results of the review are Fish Community Goals and Objectives (FCOs) for Lake Ontario, which should be available for review in early 2007.

2.2.4 Demographics and Economy of the Basin

The present day demographics of Lake Ontario are a result of the historical patterns of settlement which were closely tied to the physical and environmental features of the basin. Native people have lived along the shores of the Great Lakes for over 10,000 years. They fished the waters, grew crops on the land, and used the rivers for transportation. Europeans first settled along the shores of Lake Ontario in the 1700s. Cities and towns sprung up near tributaries because of the abundant water supply and transportation opportunities. The mixed hardwood forests provided a rich resource. Logging became a major activity, both for the valuable timber and to clear the land for agriculture. The Lake Ontario basin has an ideal climate and soil types for agriculture. Some areas, such as the Niagara region, are highly specialized in the growing of fruit and vegetable crops.

Shipping is a major activity on the lake and has led to the growth of manufacturing and population increases in port communities. Major steel mills that rely on shipping were established at Hamilton. In the 1900s, the chemical industry was established near Niagara Falls due to the abundant supply of hydroelectric power generated by the Niagara Falls.

Commercial fishing yields in Lake Ontario were never as high as more productive lakes such as Lake Erie. In the Canadian waters of Lake Ontario the commercial fishery had been worth about $1.5 million (CDN) during the late 1980s. Since then, the fishery has dwindled down to about $250,000 (CDN) as a result of reduced abundance and value of lake whitefish, the removal of American eel from the commercial fishery in 2004 and lower harvests of all other species (OMNR, 2005). The American eel was removed from the commercial fishery in 2004 as part of the Ontario government's effort to maintain this species in Lake Ontario and ensure its survival worldwide (OMNR, 2005). The US commercial fishery for Lake Ontario was valued at $68,000 (US) in 1995 and in 2004 was about $46,000 (US) (Cluett, 1995; NYSDEC, 2005). The recreational fishery is based primarily on salmon and trout species in the open lake and tributaries, walleye in the eastern lake, and smaller numbers of perch, smallmouth and largemouth bass, and panfish species in embayments. The economic value of recreational fishing to local communities is estimated to range from $100 million to over $200 million per year (USEPA et al., 1987; Kerr and LeTendre, 1991).

The Lake Ontario basin, its major sub-basins, and communities are shown in Figure 2.1. At the present time, over 5.4 million people live on the Canadian side of the basin (Statistics Canada, 1994). The northwestern part of the shoreline is a highly urbanized and industrialized area referred to as the "Golden

Horseshoe." This area extends from Cobourg in the east, around the western end of Lake Ontario to Niagara Falls. The US side of the lake is not as heavily populated, with approximately 2.2 million residents (NYSDED, 1991). There are, however, concentrated areas of urbanization at Rochester, Syracuse, and Oswego, New York.

Land use in the basin and along the shoreline is presented in Tables 2.1 and 2.2, respectively. Forested areas are mainly in the northernmost and southernmost areas of the watershed. Nearer to the lake, forest habitat is highly fragmented.

Table 2.1 Basin Land Use (expressed as percentages of Canadian basin, US basin, and total basin)

	Agriculture	*Residential*	*Forest*	*Other*
Canada	49	6	42	3
U.S.	33	8	53	6
Total	39	7	49	5

Table 2.2 Shoreline Land Use (expressed as percentages of Canadian and US basins)

	Residential	*Recreational*	*Agricultural*	*Commercial*	*Other*
Canada	25	15	30	18	12
U.S.	40	12	33	8	7

Rural and urban land use activities in the watershed influence the environmental health of Lake Ontario. Herbicides, pesticides, and excess nutrients from agricultural runoff are types of non-point source contaminants. Sources of pollution from urban areas include stormwater runoff from paved streets, effluent from sewage treatment plants, and combined sewer overflows (CSOs).

2.3 LaMP Background

In 1987, the governments of Canada and the United States made a commitment, as part of the Great Lakes Water Quality Agreement (GLWQA), to develop a Lakewide Management Plan for each of the five Great Lakes. The purpose of a Lakewide Management Plan (LaMP) is to identify the actions necessary to restore and protect the lake. There are a number of important principles that guide the development of LaMPs. According to the 1987 Agreement, "LaMPs shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in ... open lake waters," including consultation with the public. LaMPs will also provide an important step towards the virtual elimination of persistent toxic substances and the restoration of "physical, chemical, and biological integrity" (IJC, 1987) of the lakes. Through a LaMP, efforts are to be coordinated among governmental agencies to reduce amounts of contaminants entering the lake and address causes of lakewide environmental problems. LaMPs also identify the progress seen to date in the lake as a result of actions already implemented and propose future actions that the agencies can take, individually or jointly, to address identified problems.

For Lake Ontario, one of the challenges of the LaMP is to understand the state of the lake as it exists today and how it may change in the near future and over the long term. Concentrations of toxic substances in water, sediment, fish, and wildlife respond at different rates to changes in loadings and changes in biological or physical conditions. Programs in place today which have already reduced critical

pollutant loadings may not have an impact on environmental levels for decades, particularly in fish and wildlife. This time lag must be considered when evaluating data which were often collected several years before being reported on and which reflect loadings which occurred many more years before data collection. Organisms accumulate chemicals or metals that have been in the ecosystem for long periods of time, either in sediment or in organisms which are lower on the food chain. Estimating if current programs will eventually resolve some of these ecosystem issues and over what time frame is an important step in understanding what additional measures are necessary to accelerate the cleanup of Lake Ontario.

The LaMP for Lake Ontario was originally developed by Region 2 of the US Environmental Protection Agency (USEPA), Environment Canada (EC), the New York State Department of Environmental Conservation (NYSDEC), and the Ontario Ministry of the Environment (OMOE) (the Four Parties) in consultation with the public.

In response to an identified toxics problem in the Niagara River and Lake Ontario, a Niagara River Declaration of Intent was signed on February 4, 1987, by the Four Parties. This document included a commitment to develop a Lake Ontario Toxics Management Plan (LOTMP). The main purpose of the LOTMP was to define the toxics problem in Lake Ontario and to develop and implement a plan to eliminate the problem through both individual agency and joint agency actions. The Four Parties developed a draft Toxics Management Plan which was presented for public review in 1988. The completed LOTMP was published in 1989 (LOTMP, 1989). Updates of the LOTMP were completed in 1991 (LOTMP, 1991) and in 1993 (LOTMP, 1993).

Goals of the Lake Ontario Toxics Management Plan:

- Drinking water and fish that are safe for unlimited human consumption
- Natural reproduction, within the ecosystem, of the most sensitive native species, such as bald eagle, osprey, mink, and river otter

To achieve the goals, four objectives were developed:

- Reductions in Toxic Inputs Driven by Existing and Developing Programs
- Further Reductions in Toxic Inputs Driven by Special Efforts in Geographic Areas of Concern
- Further Reductions in Toxic Inputs Driven by Lakewide Analyses of Pollutant Fate
- Zero Discharge

The LOTMP identified 11 priority toxic chemicals in the lake and provided information regarding ongoing load reduction efforts. This program has been the primary binational toxic substances reduction planning effort for Lake Ontario. As such, it serves as a foundation for the development of the Lake Ontario LaMP, which incorporates an ecosystem approach through the assessment of beneficial uses. In May of 1996, the Four Parties signed a Letter of Intent (see Appendix B) agreeing that the LaMP should provide the binational framework for environmental protection efforts in Lake Ontario. The Four Parties have reviewed and incorporated all relevant LOTMP commitments into this plan.

2.4 LaMP Structure and Processes

In 2004 the membership of the LaMP expanded to include Fisheries and Oceans Canada, the United States Fish and Wildlife Service and the Ontario Ministry of Natural Resources. The participation of these agencies will allow better integration of fish and wildlife objectives and indicators into the LaMP.

The agencies have the responsibility for developing the Lake Ontario LaMP and have approved a LaMP management structure that consists of a Coordination Committee, a Management Committee, and a Lake Ontario Workgroup.

The Lake Ontario LaMP focuses on resolving:

- Lakewide beneficial use impairments as defined in the Great Lakes Water Quality Agreement (Annex 2) and described in Chapter 4 of this report;
- Critical pollutants contributing to, or likely to contribute to, these impairments despite past application of regulatory controls, due to their toxicity, persistence in the environment, and/or their ability to accumulate in organisms; and
- Physical and biological problems caused by human activities.

The LaMP addresses sources of lakewide critical pollutants, which are those substances responsible, either singly or in synergistic or additive combination, for beneficial use impairments in the open lake waters of both countries, as well as those substances that exceed criteria and are therefore likely to impair such uses, which require binational actions for resolution. This plan is to be coordinated with Remedial Action Plans within the Lake Ontario drainage basin and other localized efforts which are best suited to address issues of local concern. In addition, this Plan is to utilize linkages to other natural resource management activities, such as the development of Lake Ontario fish community objectives by the Great Lakes Fishery Commission and the Lake Ontario Committee of fisheries managers. The LaMP addresses impairments found in open waters of the lake and nearshore areas, without duplicating the efforts of localized remedial action plans. Tributaries, including the Niagara River, are treated as inputs to the lake. The St. Lawrence River is treated as an output from the lake.

The LaMP will provide an assessment of the physical and biological problems after these objectives and indicators have been completed. Recognizing that the development of ecosystem objectives may require a considerable amount of time, the LaMP has been moving forward with the development of a critical pollutants reduction strategy rather than waiting until all physical and biological problems have been defined.

In addition to the Lake Ontario LaMP, there are a number of other environmental planning efforts upstream and downstream of the Lake Ontario basin. Plans are being implemented for the Niagara River, including Remedial Action Plans in both Canada and the US and a binational Toxics Management Plan. The major sources of pollutants within the downstream St. Lawrence River are being addressed through three ongoing planning efforts: Canadian and US Remedial Action Plans for the St. Lawrence River at Cornwall and Massena, respectively, and a St. Lawrence River Action Plan for the section of the river located in the Province of Quebec.

The LaMP Stage 1 Report, released in 1998, identified the problems existing lakewide in Lake Ontario, and the chemical, physical, and biological causes of these impairments. It also included information on progress made to date, monitoring results, and a three-year binational work plan that identified the activities the LaMP partners would undertake to restore beneficial uses of the Lake. The work plan identified activities to further reduce inputs of critical pollutants to Lake Ontario, reassess beneficial use impairments in open lake waters, manage biological and habitat issues, and develop ecosystem objectives and indicators. The binational work plan has since been revised and updated.

In July 1999, the Great Lakes Binational Executive Committee (BEC), which is the group of senior government representatives to the Great Lakes Water Quality Agreement, adopted a resolution that called for the reporting on all elements of LaMPs every two years. In 2002, the Lake Ontario LaMP presented

its first biennial LaMP report. The 2002 LaMP Report provided a summary of actions taken and progress made by the LaMP since the LaMP Stage 1 Report.

The LaMP 2004 report was the first report in binder layout for the Lake Ontario LaMP and it represents the format that will be utilized over the coming years. Every two years the binder will be reviewed and, where appropriate, chapters will be replaced with updated versions. Where there is no new information, the chapter will remain unchanged.

In addition to the binder, a brochure titled *Update* is to be produced, which will inform the public of the progress of the LaMP, as described in the binder.

2.5 References

Christie, W.J. 1972. Lake Ontario: effects of exploitation, introductions and eutrophication on the salmonid community. Journal of the Fisheries Research Board of Canada. 29:913-929.

Christie, W.J. 1973. A review of the changes in fish species composition of Lake Ontario. Great Lakes Fishery Commission Technical Report No. 23, 65 pp.

Cluett, S. 1995. Summary of the Reported 1995 Commercial Fish Harvest in New York Waters of Lake Ontario. NYSDEC Lake Ontario Annual Report. 1995. Cape Vincent, New York 13618.

Crawford, S.S. 2001. Salmonine introductions to the Laurentian great lakes: an historical review and evaluation of ecological effects. Canadian Special Publication of Fisheries and Aquatic Sciences 132: 205 pp.

Dermott, R. 2001. Sudden disappearance of the amphipod *Diporeia* from eastern Lake Ontario. J. Great Lakes Research 27(4):423-433)

Honeyfield, D.C., Hinterkopf, J.P., Fitzsimons, J.D., Tillitt, D.E., Zajicek, J.L. and S.B. Brown. 2005. Development of thiamin deficiencies and early mortality syndrome in Lake Trout by feeding experimental and feral fish diets containing thiaminase. J. Aquatic Animal Health 17:4-12

Hoyle, J.A. and Harvey. 1997. Commercial Fisheries, Part II, Resource Use. 1996 Annual Report. Lake Ontario Fisheries Unit. OMNR.

Hoyle, J. A. 2005. Status of lake whitefish (Coregonis clupeaformis) in Lake Ontario and the response to the disappearance of Diporeia spp. In Proceedings of a workshop on the dynamics of lake whitefish (Coregonis clupeaformis) and the amphipod Diporeia spp. In the Great Lakes. Edited by L.C. Mohr and T. F. Nalepa. Great Lakes Fishery Commission Technical Report 66. pp. 47-66.

IJC. 1987. Revised Great Lakes Water Quality Agreement of 1978, International Joint Commission, United States and Canada, November 18, 1987.

Johannsson, O.E. 2003. A history of changes in zooplankton community structure and function in Lake Ontario: responses to whole-lake remediation and exotic invasion. *in* M. Munawar (Ed.), The State of Lake Ontario (SOLO), Past, Present and Future. Ecovision World Monograph Series. Aquatic Ecosystem Health Management. p. 220-256.

Johannsson, O.E., M.T. Arts, K.L. Bowen, R. O'Gorman, T. Schaner and R.E.H. Smith. 2003. Mysis relicta: Is it also in decline in Lake Ontario? Abstract in International Association for Great Lakes Research 46th Annual Conference and International Lake Environment Committee 10th World Lakes Conference, June 22-26,2003.

Johnson, J.H. Ross., R.M. and McCullough, R.D. 2002. Little Galloo Island, Lake Ontario: a review of nine years of double crested cormorant diet and fish consumption information. Journal of Great Lakes Research 28: 182-192.

Jones, M., Eck, G.W., Evans, D.O., Fabrizio, M.C., Hoff, M.M., Hudston, P.L., Janssen, J., Jude, D., O'Gorman, R., and Savino, J.F. 1995. Limitations to lake trout (*Salvelinus namaycush*) rehabilitation in the Great Lakes imposed by biotic interactions occurring at early life stages. Journal of Great Lakes Research 21(Supp. 1): 505-517.

Kerr, S.J. and G. LeTendre. 1991. The state of the Lake Ontario fish community in 1989. Special Publication No. 91-3, Great Lakes Fishery Commission, 1451 Green Road, Ann Arbor, MI 48105, November 1991, 38 pp.

Ketola, G et al. 2005, Thiamine Status of Cayuga Lake Rainbow Trout and Its Influence on Spawning Migration). North American Journal of Fisheries Management 25:1281–1287

LOTMP. 1989. Lake Ontario Toxics Management Plan, A report by the Lake Ontario Toxics Committee, Environment Canada, US Environmental Protection Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation. February 1989.

LOTMP. 1991. Lake Ontario Toxics Management Plan, 1991 Update. A report by the Lake Ontario Secretariat, Environment Canada, US Environmental Protection Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation. September 1991.

LOTMP. 1993. Lake Ontario Toxics Management Plan, 1993 Update. A report by the Lake Ontario Secretariat, Environment Canada, US Environmental Protection Agency, Ontario Ministry of Energy and the Environment, New York State Department of Environmental Conservation. November 1993.

Lozano. S.J. and T.P. Nalepa. 2003. Disruption in the benthic community in Lake Ontario. *in* M. Munawar (Ed.), The State of Lake Ontario (SOLO), Past, Present and Future. Ecovision World Monograph Series. Aquatic Ecosystem Health Management. pp. 305-322.

Lozano, S.J. Scharold, J.V., and Nalepa T.F. 2001. Recent declines in benthic macroinvertebrate densities in Lake Ontario. Canadian Journal of Fisheries and Aquatic Sciences 58: 518-529.

Mackay, D. 1989. Modeling the Long-Term Behavior of an Organic Contaminant in a Large Lake: Application to PCBs in Lake Ontario. Journal of Great Lakes Research 15(2):283-297.

Mills, E.L., J.H. Leach, J. T. Carlton and C.L. Secor. 1993. Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19(1): 1-54.

Mills, E.L., J.M. Casselman, R. Dermott, J.D. Fitzsimons, G. Gal, K.T. Holeck, J.A. Hoyle, O.E. Johannsson, B.F. Lantry, J.C. Makarewicz, E.S. Millard, I. F. Munawar, M. Munawar, R. O'Gorman, R. W. Owens, L.G. Rudstam, T. Shaner, and T. J. Stewart. 2003. Lake Ontario: food web dynamics in a changing ecosystem (1970-2000). Canadian Journal of Fisheries and Aquatic Science 60: 471-490.

Neilson, M., S. L'Italien, V. Glumac, and D. Williams. August 1994. Nutrients: Trends and System Response. SOLEC Working Paper presented at State of the Lakes Ecosystem Conference. EPA 905-R-95-015. Chicago, Ill: US Environmental Protection Agency.

NYSDED. 1991. Summary Population Characteristics for New York Areas. Prepared by New York State Department of Economic Development, State Data Center, March 6, 1991.

Ontario Ministry of Natural Resources (OMNR). 2005. Lake Ontario Fish Communities and Fisheries: 2004 Annual Report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, ON. 72p.

Ryder, R.A. 1972. The limnology and fishes of oligotrophic glacial lakes in North America (about 1800 A.D.). Journal of Fisheries Research Board of Canada 29:617-628

Schertzer, W.M. Physical limnology and hydrometeorological characteristics of Lake Ontario with consideration of climate impacts. *in* M. Munawar (Ed.), The State of Lake Ontario (SOLO), Past, Present and Future. Ecovision World Monograph Series. Aquatic Ecosystem Health Management. p. 3-57

Schneider, C. P., D.P. Kolenosky, and D. B. Goldthwaite. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario, the Lake Trout Subcommittee of the Lake Ontario Committee, Great Lakes Fishery Commission.

Sly, P.G. 1991. The Effects of Land Use and Cultural Development of the Lake Ontario Ecosystem since 1750. Hydrobiologia 213:1-75.

Smith, S.H. 1972. Factors of ecologic succession in oligotrophic fish communities of the Laurention great lakes. Journal of Fisheries Research Board of Canada 29: 717-730

Statistics Canada. 1994. Human Activity and the Environment. National Accounting and Environment Division.

Thomas, R. L. 1983. Lake Ontario Sediments as indicators of the Niagara River as a primary source of contaminants. J. of Great Lakes Research. 9(2): 118-134.

USEPA, Environment Canada, Brock University, and Northwestern University. 1987. The Great Lakes: An Environmental Atlas and Resource Book.

CHAPTER 3 ECOSYSTEM GOALS, OBJECTIVES AND INDICATORS

3.1 Summary

This chapter summarizes information from earlier reports on Lake Ontario LaMP ecosystem objectives and indicators describing how these indicators are to be used. Future LaMP reports will provide an assessment of each indicator. Information is also provided on other measures of the status of Lake Ontario's ecosystem collected by a variety of monitoring programs.

3.2 Development of Lake Ontario Ecosystem Goals and Objectives

After several years of work, the LaMP has adopted ecosystem goals, objectives and indicators that will be used to measure progress in restoring and maintaining the health of the Lake Ontario ecosystem. The selected ecosystem indicators reflect lakewide conditions and are sensitive to a number of stressors. For example, healthy populations of bald eagles and lake trout, both top-level native predators, indicate the presence of suitable habitat, healthy populations of prey organisms, and low levels of environmental contaminants. Healthy populations of eagles and trout also reflect our society's commitment to responsible stewardship in protecting habitat, limiting harvests and reducing levels of contaminants in the environment.

3.2.1 Ecosystem Goals for Lake Ontario

Work first began on Lake Ontario ecosystem goals, objectives and indicators as part of the Lake Ontario Toxics Management Plan (LOTMP) in the late 1980s. U.S. and Canadian monitoring experts brought together by LOTMP developed ecosystem goals and objectives for the lake. The LaMP has adopted these goals, which provide a vision for the future of Lake Ontario and the role human society should play:

- The Lake Ontario ecosystem should be maintained and, as necessary, restored or enhanced to support self-reproducing and diverse biological communities.
- The presence of contaminants shall not limit uses of fish, wildlife and waters of the Lake Ontario basin by humans, and shall not cause adverse health effects in plants and animals.
- We, as a society, shall recognize our capacity to cause great changes in the ecosystem and we shall conduct our activities with responsible stewardship for the Lake Ontario basin.

3.2.2 Ecosystem Objectives for Lake Ontario

The LaMP also adopted the LOTMP's five ecosystem objectives that describe the conditions necessary to achieve LaMP ecosystem goals:

- Aquatic Communities: The waters of Lake Ontario shall support diverse and healthy reproducing and self-sustaining communities in dynamic equilibrium, with an emphasis on native species.
- Wildlife: The perpetuation of a healthy, diverse and self-sustaining wildlife community that utilizes the lake habitat and/or food shall be ensured by attaining and sustaining the waters,

coastal wetlands, and upland habitats of the Lake Ontario basin in sufficient quantity and quality.

- Human Health: The waters, plants and animals of Lake Ontario shall be free from contaminants and organisms resulting from human activities at levels that affect human health or aesthetic factors, such as tainting, odour and turbidity.
- Habitat: Lake Ontario offshore and nearshore zones surrounding tributary, wetland and upland habitats shall be of sufficient quality and quantity to support ecosystem objectives for the health, productivity and distribution of plants and animals in and adjacent to Lake Ontario.
- Stewardship: Human activities and decisions shall embrace environmental ethics and a commitment to responsible stewardship.

3.3 Ecosystem Indicators

Annex 11 of the Great Lakes Water Quality Agreement (GLWQA) describes the surveillance and monitoring activities that the parties will carry out in order to assist in evaluating the attainment of specific water quality objectives listed in Annex 1 of the GLWQA. These activities include the development of ecosystem health indicators for each of the Great Lakes.

Indicators proposed by the LOTMP and the State of the Lakes Ecosystem Conferences (SOLEC) served as a starting point for the LaMP's selection process. SOLEC has provided a forum for Great Lakes monitoring and ecosystem indicator issues. Data collected and reported by U.S. and Canadian monitoring programs were reviewed to identify what types of information, collected on a regular basis, could be used to measure long-term trends. The LaMP used six criteria to select appropriate ecosystem indicators that are:

- well-recognized by monitoring experts;
- supported by historical data available for comparison purposes;
- consistent with SOLEC and LOTMP indicator recommendations;
- easily understood by the general public;
- supported by data available from existing monitoring programs; and
- reflective of general "ecosystem health" on a lakewide scale.

The eleven indicators selected provide a good characterization of ecosystem health across the foodweb. The selected indicators can be divided into three groups:

(1) Critical Pollutant Indicators: which measure concentrations of critical pollutants in water, young of the year fish, herring gull eggs and lake trout, and compare this information against existing guidelines;

(2) Lower Foodweb Indicators: which track the status of nutrients, zooplankton and prey fish (such as alewife and smelt). These indicators reflect the ability of the ecosystem to support higher level organisms (such as lake trout and waterbirds); and

(3) Upper Foodweb Indicators: which monitor the health of herring gull, lake trout, bald eagle, mink and otter populations. These top level predators are dependent on quality habitat and sufficient prey populations, free of problematic contaminant levels.

The indicators were presented at SOLEC, RAP meetings, the Finger Lakes-Lake Ontario Watershed Protection Alliance Conference and in the LaMP 2001 Update Report. In general, the indicators have been well received by the public. The LaMP adopted the indicators in 2001.

The process of fine tuning and reporting on these indicators will foster closer working relationships between U.S. and Canadian monitoring programs and will promote better binational coordination. Additional indicators will be considered, as necessary, to help guide LaMP restoration activities. A brief overview of each of the selected indicators is provided below.

3.3.1 Critical Pollutant Indicators

Critical pollutant indicators measure concentrations of critical pollutants in water, young of the year (YoY) fish, herring gull eggs and lake trout, and compare this information against existing guidelines.

Critical Pollutants in Offshore Waters

Objective: critical pollutants in open waters should not pose a threat to human, animal and aquatic life ***Measure:*** concentration of critical pollutants in offshore waters
Purpose: to measure priority toxic chemicals in offshore waters and to assess the potential impacts of toxic chemicals on human health and the aquatic ecosystem and the progress of contaminant reduction efforts
Target: concentrations of critical pollutants in offshore waters are below standards and criteria designed to protect the health of human, animal and aquatic life

Critical pollutant levels in Lake Ontario have generally declined over the last 20 to 25 years. Nevertheless, critical pollutants are still detected at extremely low concentrations in open waters at levels that exceed the most stringent surface water criteria designed to protect wildlife and humans who consume fish (Table 3.1).

With proper treatment, regular monitoring of Lake Ontario water supplies shows that water quality meets public health standards for drinking water supplies.

The most recent data available (collected by NYSDEC in 1997) suggest that DDE levels are now slightly above the open water standard, while PCB and dieldrin levels are approximately 100 times higher than their respective standards. Water sampling results from the Niagara River and the St. Lawrence River suggest that mirex and mercury levels also exceed standards in open waters (although information on mirex and mercury was not collected in the 1997 study).

Canadian and U.S. monitoring programs are continually improving sampling and analytical methods with the goal of achieving lower detection limits. The results of U.S. open lake water critical pollutant sampling conducted in 1999 are now being finalized and will be summarized in future LaMP

reports. Environment Canada measured open lake water critical pollutant concentrations in 2003. The LaMP will continue to monitor critical pollutant levels and trends in open waters and report on the results.

Table 3.1 Critical Pollutant Concentrations in Lake Ontario Open Waters, 1997

	NYS WQS	Measured	
Critical Pollutant	*Standard (pg/L)*	*Concentration(pg/L)*	*Exceeds WQS*
PCBs	1	110	Yes
Dioxins + Furans	0.0006	0.0046	Yes
p,p' - DDE	7	10	Yes
p,p' - DDD	80	13	No
p,p' - DDT	10	2.6	No
Dieldrin	0.6	51	Yes
Mirex	1	R	NA
Dissolved Mercury	700	NS	NA

pg/L = parts per quadrillion
R - Data rejected due to lab problems
NS - Not sampled
NA - Data not available for this time period
NYS WQS - New York State Water Quality Standard for pollutants in open water

Source: Litten & Donlon 1998.

Critical Pollutants in Young-of-the-Year (YoY) Fish

Objective: critical pollutants should not pose a risk to fish-eating wildlife
Measure: concentration of critical pollutants in YoY fish
Purpose: to measure persistent toxic chemicals in YoY fish and to evaluate and measure potential harm to fish-eating wildlife
Target: concentrations of critical pollutants in YoY fish are below standards and criteria designed to protect fish-eating wildlife

Critical Pollutants in Herring Gull Eggs

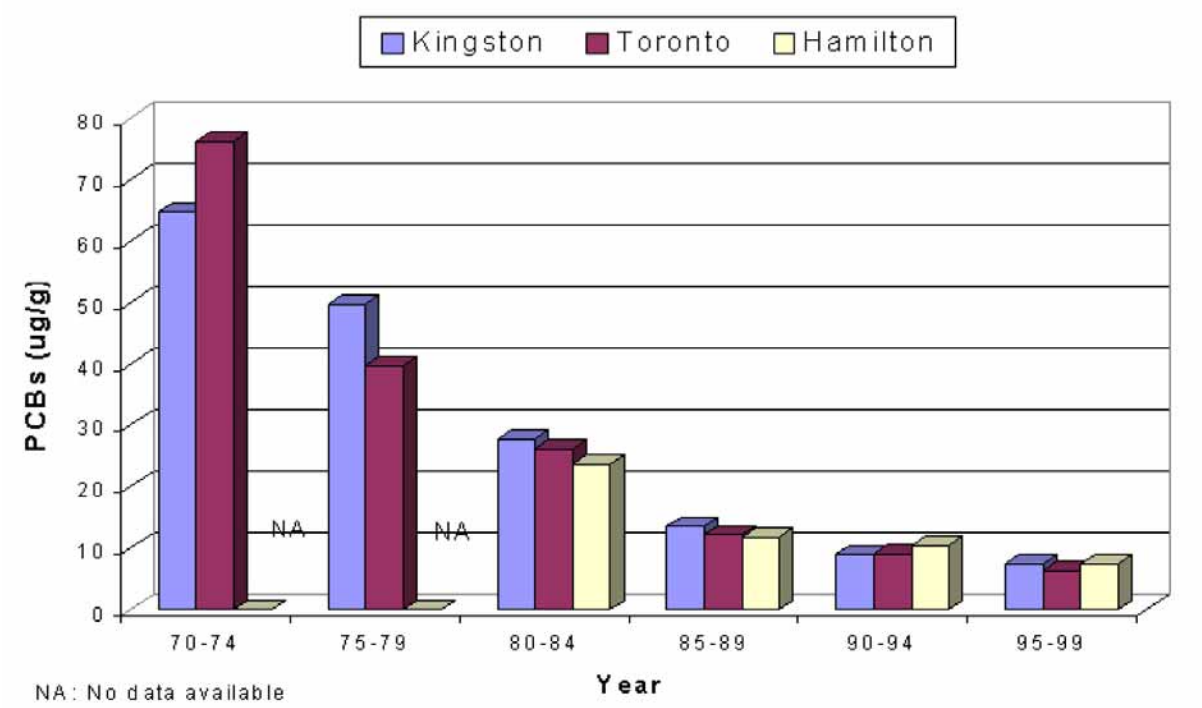
Objective: the health and reproductive success of waterbirds should not be impaired by contaminants present in the aquatic foodweb
Measure: annual concentrations of persistent toxic chemicals in herring gull eggs from colonies
Purpose: to measure critical pollutants in herring gull eggs from colonies that reflect general lakewide conditions and to compare contaminant concentrations to criteria designed to protect waterbirds
Target: contaminant levels in colonial nesting waterbird eggs are similar to those of unaffected reference sites or are below existing standards or criteria designed to protect colonial waterbirds

Fish-eating birds, such as gulls, terns, cormorants and night herons, have been used as bio-indicators of contamination on Lake Ontario and throughout the Great Lakes for more than 30 years. In the 1970s, fish-eating birds in the Great Lakes, including Lake Ontario, were found to have very high levels of contaminants such as PCBs, DDE and mirex in their eggs. At that time some species of

colonial waterbirds exhibited much thinner eggshells than normal, elevated rates of embryonic mortality and deformities, total reproductive failure, and declining population levels. Eggshell thickness has returned to normal or, at least, is not a problem for any of the species. Today Lake Ontario colonial waterbirds are reproducing normally due in part to controls and bans placed on persistent toxic chemicals such as DDT more than two decades ago.

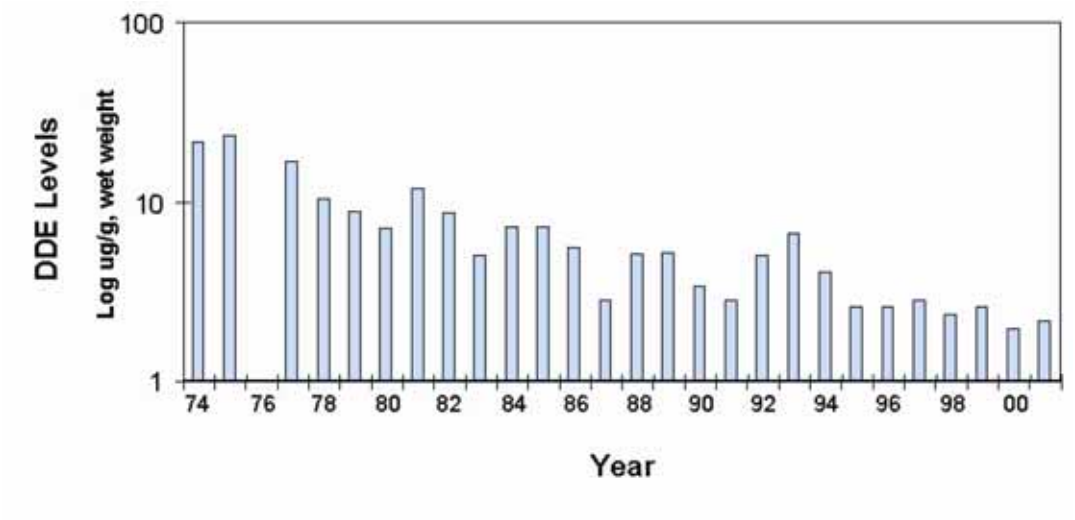
The herring gull is the most widespread colonial waterbird nesting on the Great Lakes. As a native, non-migratory species that relies heavily on aquatic prey organisms the herring gull provides an excellent indicator species. The Canadian Wildlife Service's herring gull egg contaminant monitoring program has provided an excellent way to track environmental trends in persistent toxic chemicals. PCBs and DDE levels have declined dramatically in eggs of herring gulls (Figures 3.1 and 3.2) although other contaminants such as dioxin appear to be declining more slowly (Figure 3.3). Although many of the obvious signs of toxic contamination are no longer apparent, the Canadian Wildlife Service is continuing its research to better understand the potential for more subtle effects of environmental contaminants on fish-eating birds and other wildlife on Lake Ontario. The direct correlation of load reduction activities and ecosystem improvements is further illustrated in the reduced levels of contaminants in herring gull eggs.

Figure 3.1 PCB Concentrations in Herring Gull Eggs from Lake Ontario Colonies, 1970 - 1999



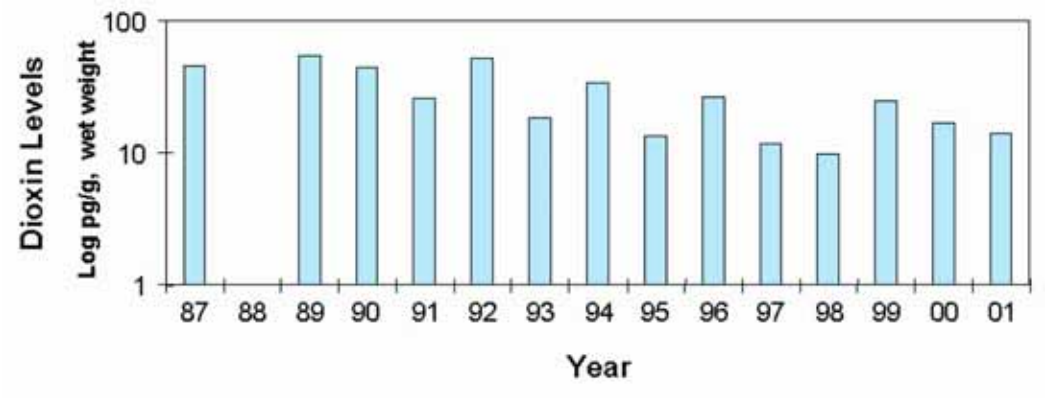
Sources: Bishop et *al*. (1992), Pettit et *al*. (1994), Pekarik et *al*. (1998) and D.V. Weseloh (Unpublished).

Figure 3.2 DDE Levels in Herring Gull Eggs from Kingston Harbour, 1974-2001



Source: Bishop et *al.*, 1992; Pettit et *al.*, 1994; Canadian Wildlife Service, Unpublished data.

Figure 3.3 Dioxin Levels in Herring Gull Eggs from Toronto Harbour, 1987-2001



Source: Bishop et *al.*, 1992; Pettit et *al.*, 1994; Canadian Wildlife Service, Unpublished data.

Critical Pollutants in Lake Trout Tissue

Objective: consumption of fish should not be restricted due to contaminants of human origin
Measure: concentrations of pollutants in edible fish tissue responsible for advisories
Purpose: to measure critical pollutants in fish and to evaluate the potential exposure of humans to these substances through fish consumption
Target: contaminants in fish tissue are below the existing standards and criteria designed to protect human health, as shown by the elimination of fish advisories

The Lake Ontario LaMP has identified a number of critical pollutants that have impaired beneficial uses on a lakewide basis. These persistent contaminants (i.e., PCB, DDT, mirex, dioxin/furans, mercury, dieldrin) tend to bioaccumulate in biological tissue (of fish, animals and humans). Monitoring contaminant levels in tissue, therefore, facilitates the assessment of spatial and temporal trends in water quality and contaminant availability.

Overall, the fish community has experienced a dramatic reduction in contaminant levels since the mid-1970s. Concentrations of PCBs, DDT and mirex in lake trout tend to be higher in the western basin of Lake Ontario than the eastern basin. This reflects the magnitude of contaminant inputs from the upper lakes and the Niagara River and the industrialized nature of the western end of the lake.

In addition to lake trout, contaminant trends monitored in other fish species can also provide useful indicators of current contaminant trends. Long-term trends in contaminant concentrations are illustrated using data collected by the Ontario Ministry of Environment (OMOE) for 50-centimetre coho salmon from the Credit River spawning run (Figures 3.4 to 3.7). Coho salmon data are well suited to analysis of trends over time since they spend most of their time in the Lake and different individuals of similar age return to the same location each year to spawn. In the mid-1990s, coho salmon stocks in the Credit River were low and no samples were obtained. 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 (Figure 3.4). Over the same time period, concentrations of mirex have decreased from greater than 0.1 ppm to less than 0.05 ppm (Figure 3.5). Similar trends have been observed for mercury and DDT, as can be seen in Figures 3.6 and 3.7, respectively.

Figure 3.4 Total PCB Levels in 50 cm Coho Salmon from the Credit River, 1976-2001

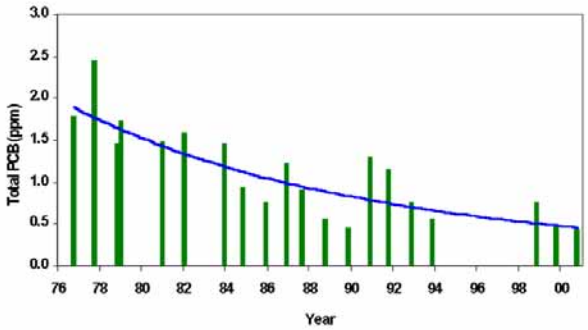


Figure 3.5 Mirex Levels in 50 cm Coho Salmon from the Credit River, 1976-2001

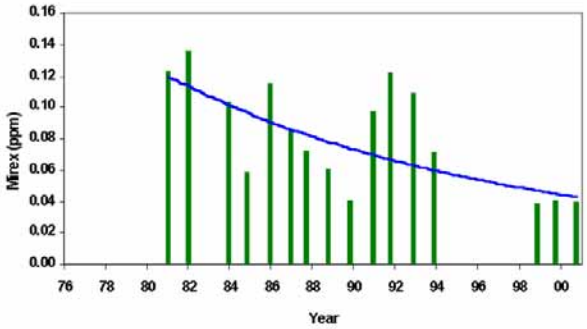


Figure 3.6 Mercury Levels in 50 cm Coho Salmon from the Credit River, 1976-2001

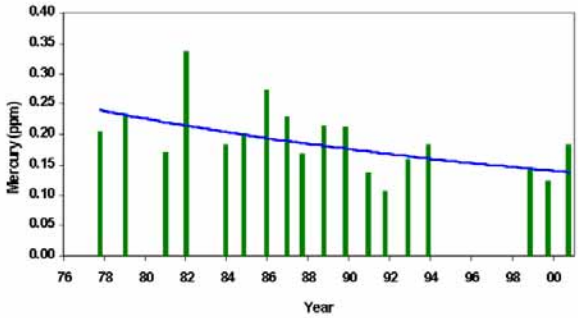
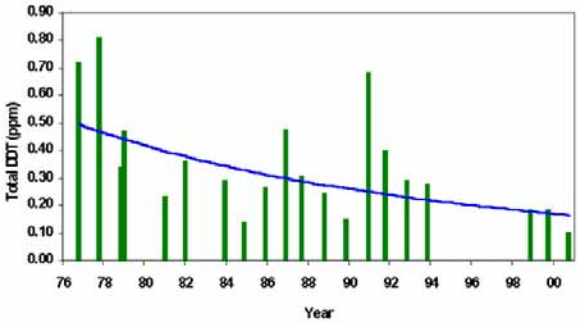


Figure 3.7 Total DDT Levels in 50 cm Coho Salmon from the Credit River, 1976-2001



3.3.2 Lower Foodweb Indicators

Lower foodweb indicators track the status of nutrients, zooplankton and prey fish (such as alewife and smelt). These indicators reflect the ability of the ecosystem to support higher level organisms (such as lake trout and waterbirds).

Nutrients in Open Waters

Objective: nutrient levels should be sufficient to support aquatic life without causing persistent water quality problems (such as the depletion of dissolved oxygen in bottom waters, nuisance algal blooms or accumulations, and decreased water clarity)
Measures: total spring phosphorus levels (micrograms per litre), chlorophyll-a, and water clarity
Purpose: to follow trends in open lake nutrients
Target: nutrient levels allow attainment of fishery management objectives without exceeding the GLWQA phosphorus-loading target for Lake Ontario

Zooplankton Populations

Objective: zooplankton populations should be sufficient to support a healthy and diverse fishery
Measures: (1) mean individual size, and (2) biomass
Purpose: to directly measure changes in mean individual size and biomass of zooplankton populations in order to indirectly measure changes in food-web dynamics due to: changes in vertebrate or invertebrate predation, changes in system productivity, the type and intensity of predation, and energy transfer within a system
Targets: zooplankton populations are sufficient to maintain prey and predator fish at levels consistent with existing binational fishery objectives; mean individual size of approximately 0.8 millimeters (mm) is generally considered an optimal size when the water column is sampled with a 153 micron mesh net; specific biomass targets will be developed as the state of knowledge permits

Preyfish

Objective: a diverse array of preyfish populations should be sufficient to support healthy, productive populations of predator fishes
Measures: abundance, age and size distribution of preyfish species (such as deepwater ciscoes, sculpins, lake herring, rainbow smelt and alewives)
Purpose: to directly measure the abundance and diversity of preyfish populations and to indirectly measure the stability of predator species necessary to maintain biological integrity
Target: given the rapid changes that have occurred in the Lake Ontario foodweb, a specific target in terms of average annual biomass cannot be set at this time; a specific target will be set once fishery managers have a better understanding of preyfish dynamics

3.3.3 Upper Foodweb Indicators

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

Herring Gull

Objective: Lake Ontario should support healthy populations of colonial waterbirds
Measure: total number of active herring gull nests counted per year (with additional species counted, as necessary)
Purpose: to directly measure numbers of breeding gulls on Lake Ontario in order to detect changes in population status that may reflect stresses due to contaminants, disease or insufficient food supply
Target: reproduction and fledging rates of herring gulls are normal (that is, similar to unaffected background areas)

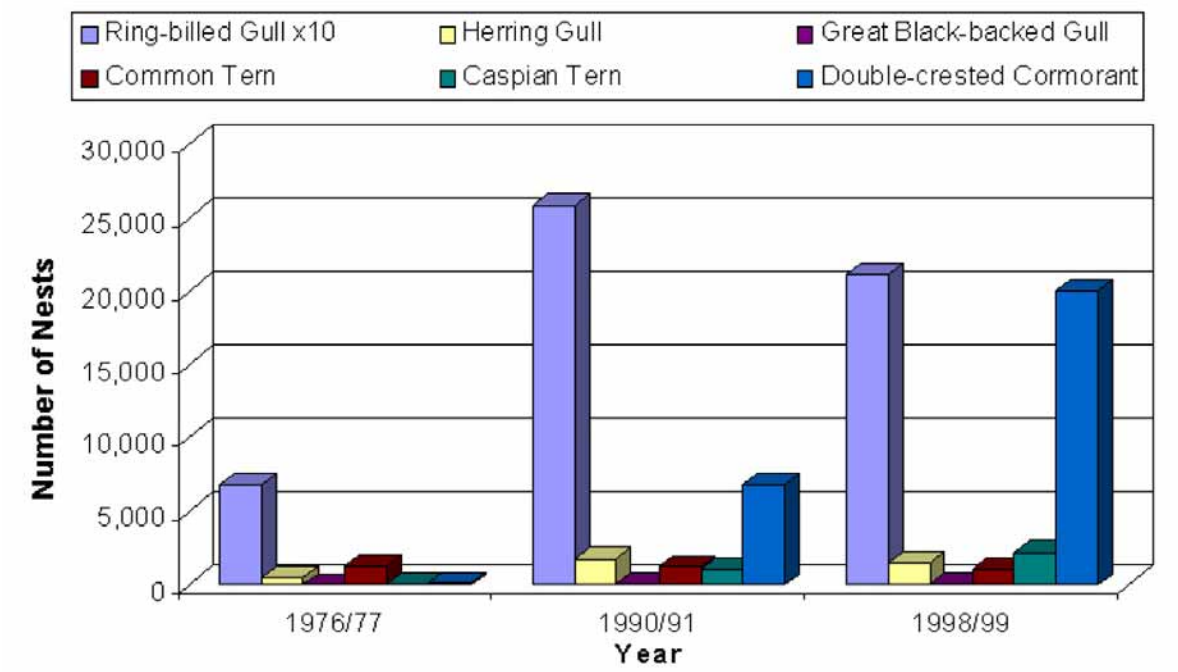
The herring gull is the most widespread colonial waterbird nesting on the Great Lakes. As a native, non-migratory species that relies heavily on aquatic prey organisms the herring gull provides an excellent indicator species. In 1998-99 it nested at 18 different locations on Lake Ontario, with a population of almost 1,500 nests. In 1990-1991, 21 colonies were counted, with about 1,800 nests. In 1976-77 there were 448 nests on 13 colonies. After growing at an average annual rate of 11 percent from 1976-77 to 1990, this population also declined by two percent per year overall between 1990 and 1999.

Lake Ontario is home to hundreds of thousands of colonial nesting water birds. Biologists from the Canadian Wildlife Service, the Ontario Ministry of Natural Resources and the New York State Department of Environmental Conservation completed the third Lake Ontario-wide census of nesting colonial water birds in 1999, a survey that is conducted approximately once every ten years.

Information collected from these surveys, along with the results of other studies carried out over a number of years in the Lake Ontario basin, is summarized here to provide an indication of improvements to the ecosystem. Surveys have shown that: Caspian tern numbers are increasing; common terns, though their numbers are declining, are adapting to man-made sites in the face of large ring-billed gull populations; both herring and ring-billed gull populations appear to have leveled off during the last decade; cormorant populations have greatly expanded; and black-backed gulls represent a new nesting species on Lake Ontario.

Lake Ontario-wide surveys of colonial waterbirds were conducted in 1976-1977, 1990-1991 and 1998-1999 for six species of colonial water birds: double-crested cormorant, ring-billed gull, herring and great black-backed gulls, and common and Caspian terns (Figure 3.8).

Figure 3.8 Number of Gull, Tern and Cormorant Nests on Lake Ontario, 1976 - 1999



Note: Numbers pertain only to colonies in Canadian waters.
^Ring-billed Gull numbers have been divided by ten for sake of graphical representation.
Data for 1976/77 and 1990/91 from: Blokpoel & Tessier. 1996. "Atlas of colonial waterbirds nesting on the Canadian Great Lakes, 1989-1991. Part 3. Cormorants, gulls and island-nesting terns on the lower Great Lakes system in 1989. Technical Report Series No. 225. Canadian Wildlife Service, Ontario Region".
Data for 1998/99 from: Canadian Wildlife Service, Unpublished.

Double-crested cormorants have increased tremendously on Lake Ontario during the last quarter-century. As cormorant populations increased so did public concerns that cormorants were depleting nearshore fish populations and reducing fishing opportunities. In 1977, there was one cormorant colony on Lake Ontario, which contained 96 nests. In 1999, there were over 20,000 nests on 17 colonies. The two largest colonies, each with more than 4,500 cormorant nests, were located in the eastern half of the lake.

NYSDEC completed a detailed diet assessment of Little Galloo cormorants in 1999 that determined that cormorant predation on smallmouth bass had significantly reduced numbers of smallmouth bass large in eastern Lake Ontario. In response to this threat to smallmouth bass and other nearshore fish populations, a large scale, sanctioned cormorant control program was initiated on Little Galloo Island in 1999. All cormorant eggs in ground nests were sprayed with non-toxic corn oil to prevent them from hatching and to eliminate any production of young. Reducing the number of cormorants is also desired because of their potential impact on other species of colonial birds with which they nest, especially the blackcrowned night heron.

The ring-billed gull is the most numerous colonial waterbird on Lake Ontario and the Great Lakes. During 1998-99, over 200,000 nests were tallied on 18 colonies on Lake Ontario. Between the first

two census periods, the population grew by ten percent per year, but between 1990-1991 and 1998-99 it declined by two percent per year. By 1999, ring-billed gulls had also completely abandoned seven colony sites that were active in 1990-1991. Natural habitat change and gull control activities were responsible for some of this decline, but nesting cormorants and great black-backed gulls also may be exerting an influence.

Of the six species of colonial waterbirds discussed here, the great black-backed gull is the least numerous. During the 1976-77 census, it was not found nesting on Lake Ontario. In 1990, there were 15 nests on three sites and in 1998-99, there were 33 nests on six sites. This large gull, which has only started nesting on Lake Ontario regularly since the early 1980s, may be a serious competitor and predator with some of the other species of colonially nesting birds.

Since 1990, the lakewide population of common terns has declined by 11 percent. However, it is encouraging that the number of nesting sites in Canadian waters increased from 6 to 14 between 1990 and 1998. Most of these sites were located on man-made islands, shoals or "tern rafts", and two were re-established colonies at sites that had been abandoned. Artificial nest sites seem to be an attractive alternative for this species. Average annual growth rates of Caspian tern populations were 24 percent for 1976-77 to 1990-1991 and eight percent for 1990-1991 to 1997-98. Substantial cormorant colonies do not seem to be having a negative impact on the growth of the Caspian tern colonies with which they are located. For example, on Little Galloo, nests increased from 4,072 to 7,591 during the same period. However, the large black-backed gull may be preying on terns; in 1995, 21 fresh Caspian tern carcasses were found within black-backed gull nesting territories. The results of the recent population surveys are mixed but encouraging; contaminants do not appear to be limiting any of the colonial bird populations.

Lake Trout

Objective: lake trout populations should be sustained through natural reproduction
Measures: (1) abundance of naturally produced fish, (2) number of mature females, and (3) number harvested
Purpose: to measure progress and identify obstacles to the successful rehabilitation of naturally reproducing populations of lake trout
Targets: abundance of at least 2.0 mature female lake trout larger than 3,000 grams per standard gillnet; abundance of naturally-produced mature females greater than 0.2 in U.S., and 0.1 in Canadian waters per standard gillnet; harvest not to exceed 30,000 fish per nation; and abundance of naturally produced age 2 fish of at least 26 juveniles from July bottom trawls in U.S. waters and increased over current levels in Canadian waters

Mink and River Otter

Objective: naturally reproducing populations of mink and river otter should be established throughout the Lake Ontario basin
Measure: number of tributaries and wetlands with established mink and river otter populations
Purpose: to evaluate mink and otter populations in the Lake Ontario basin
Target: all suitable habitats have established, healthy and naturally reproducing populations

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.

Mink live on a diet of fish, muskrats, mice and other small creatures, while otters consume fish almost entirely. Given the position of mink and otter – high in the foodweb - their health could be impacted if the fish they rely on are highly contaminated. The presence of sufficient quality and quantity of habitat is also essential to their successful reproduction and survival. These qualities make them a good indicator of Lake Ontario ecosystem health. While increasing populations would be a positive sign of a recovering ecosystem, decreasing populations would indicate a negative change in the biological, chemical or physical status of the ecosystem.

The secretive nature of these animals makes them difficult to study in the wild. American and Canadian trapping statistics have been the primary source of information on mink and otter. The LaMP, working closely with wildlife experts, collected these statistics and reviewed trapping records, sighting reports and other information to develop a basinwide picture of their distribution and relative abundance.

The review showed that more than 1200 river otters and 5000 mink were trapped during the 1999-2000, harvest season, providing good evidence that significant numbers of these animals are present in the basin. Mink are located throughout the basin and their populations are stable. River otter populations are increasing, expanding into areas where they have not been seen in decades.

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. Their expansion has been aided by initiatives like the New York River Otter project that released nearly 300 river otters at several locations in central and western NewYork.

The LaMP will continue to work with its partners to protect habitat and water quality to ensure that mink and otter continue to call the Lake Ontario basin home. For more information on efforts to restore river otter populations, see www.nyotter.org/.

Bald Eagle

Objective: shoreline and inland bald eagle nesting territories should be established and sustained through natural reproduction throughout the basin
Measures: (1) total number of established bald eagle nesting territories within the Lake Ontario basin, (2) total number of established shoreline nesting territories, and (3) average number of eaglets per nest successfully produced
Purpose: to measure trends in the recovery and reestablishment of bald eagles within the basin
Targets: all suitable habitat for bald eagle nesting is successfully utilized; average basinwide fledging rates per occupied territory are one eaglet per nest or greater; and shoreline nesting territories are defined as those less than seven kilometers from the lake.

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 increased at a rate of approximately 20% a year. There are now eight established nesting territories in the basin (New York tributaries of Lake Ontario). The combined long term average successful reproduction rates for these nests is 1.4 eaglets per nesting attempt. A reproduction rate of 1.0 eaglets per occupied nesting territory is generally believed to be necessary to maintain stable Bald Eagle populations.

Although good to excellent bald eagle nesting habitat exists along the eastern shoreline of the lake, there are as yet no shoreline or island nests. The eagles are expected to occupy shoreline nesting sites as their numbers steadily increase. Human disturbance has already slowed the return of eagles to the shoreline. A few years ago a young hunter shot and killed the female of a Bald Eagle pair engaged in nest building behavior along the lake shore west of Oswego, New York. Restoration of shoreline nesting territories will depend in part on protection of eagle nesting habitats and preventing further human disturbance.

Examples of the data collected to assess whether targets for ecosystem objectives are being met are presented in Figures 3.9 and 3.10. These figures show the average number of eaglets produced per nest and the number of nesting territories in the Lake Ontario basin, respectively. Since the 1980s, a positive trend has been observed in both categories.

Figure 3.9 Indicator: Bald Eagle Measure: Eaglets Produced Per Nest.

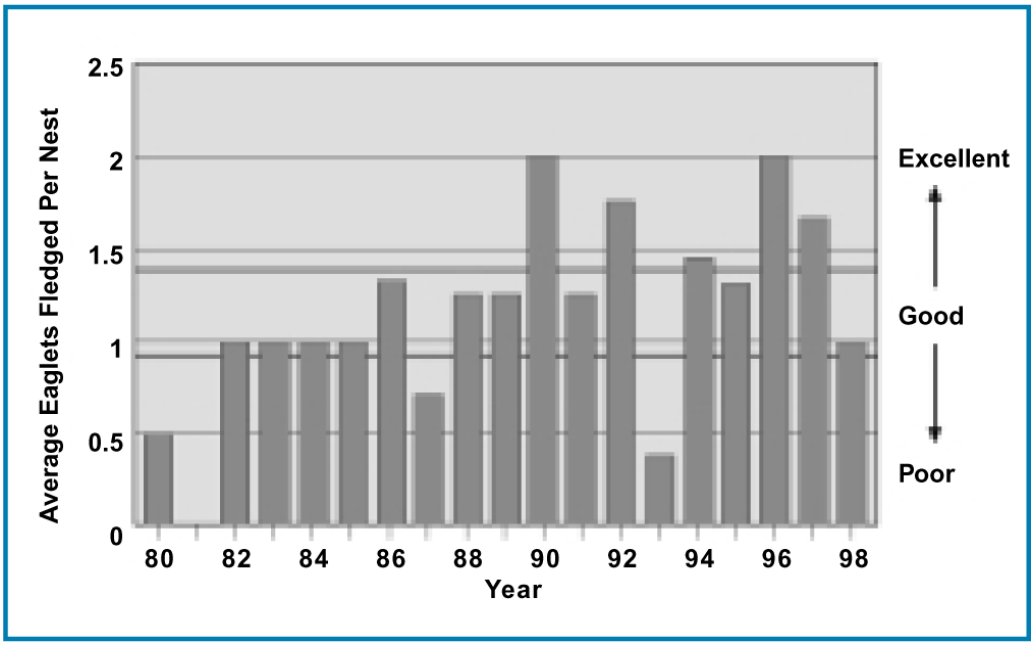
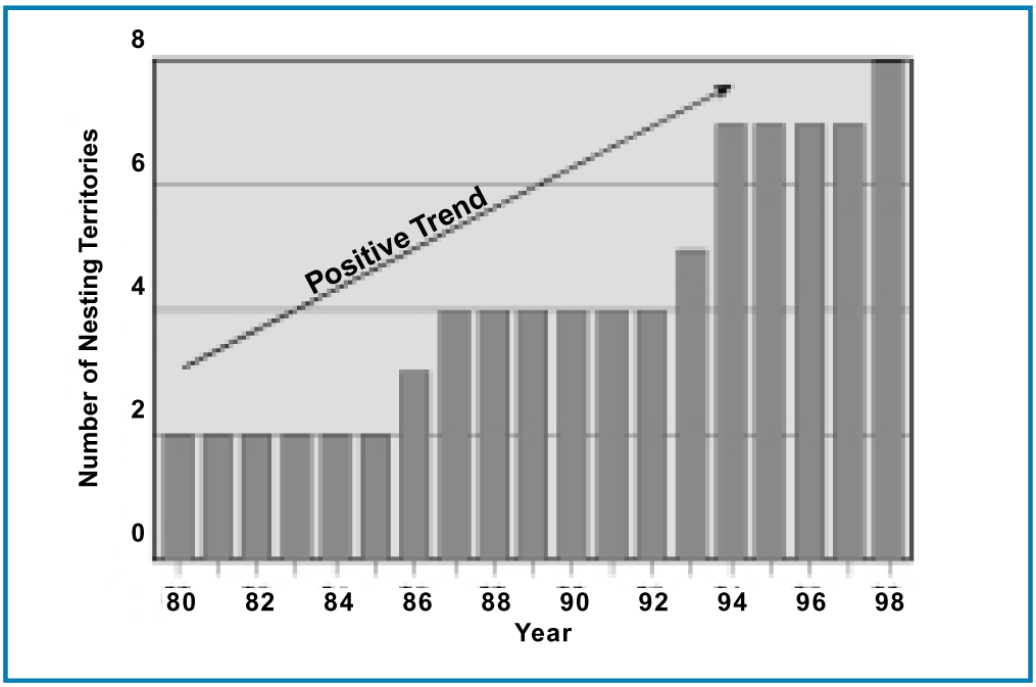


Figure 3.10 Indicator: Bald Eagle Measure: Number of Nesting Territories.



3.4 Cooperative Monitoring Progress Towards Meeting LaMP Goals and Indicators

With the adoption of this initial suite of ecosystem indicators, attention now shifts to data collection and synthesis. Fortunately, much of this work is already being done through existing federal, state and provincial Great Lakes water quality, biomonitoring and fisheries programs and organizations, such as the Great Lakes Fishery Commission's Lake Ontario Lake Committee, consisting of New York and Ontario fishery managers.

Although the LaMP's primary focus is the development of strategies and actions designed to restore impaired lakewide uses, effective monitoring is required to track progress in achieving its goals. Whenever possible, the LaMP promotes cooperative U.S.-Canadian monitoring efforts in Lake Ontario's open waters, nearshore areas and tributaries. Increased communication and coordination of existing programs are encouraged. The LaMP's cooperative monitoring approach has three components: (1) promoting increased communication and coordination among monitoring programs; (2) developing special monitoring projects to answer specific LaMP-related questions; and (3) building on existing monitoring initiatives.

The LaMP is working to better coordinate U.S and Canadian monitoring related to LaMP beneficial uses and ecosystem indicator data needs. The LaMP's information needs can be classified into four general categories:

- evaluating the status of beneficial use impairments;
- monitoring environmental levels of critical pollutants;

- measuring progress through the use of ecosystem indicators; and
- providing input to mass balance modeling.

Existing U.S. and Canadian monitoring programs meet most of the LaMP's beneficial use and ecosystem indicator monitoring needs. The findings of these programs are highlighted in LaMP reports and will be used in reporting on selected ecosystem indicators. The LaMP is now working to promote and encourage existing U.S. and Canadian programs to coordinate their efforts, and where possible, expand their efforts as needed to develop a more complete lakewide assessment of current conditions. The LaMP will support these efforts by identifying available equipment, boats and other resources that can support these activities. Additional information regarding U.S. and Canadian tributary monitoring and sediment sampling is provided in Chapter 6.

Lake Ontario fishery researchers have a well-developed binational approach to monitoring and reporting through the efforts of the Great Lakes Fishery Commission's binational Lake Ontario Committee. NYSDEC and OMNR conduct joint hydro-acoustic surveys at key times of the year to evaluate the status of alewife and smelt populations. Binational investigations of eel populations are also being conducted. The findings of these studies, as well as other individual agency studies (such as warm water fish population monitoring and lake trout restoration) are presented at annual Lake Ontario Committee meetings. The Lake Ontario Technical Committee (LOTC) of U.S. and Canadian fishery researchers maintains close contact through an informal network that allows them to efficiently address monitoring issues.

Monitoring programs are often impacted by equipment failure, staffing and budgetary cuts, and/or severe weather events all of which can derail sampling plans. Similar to the LOTC, the LaMP is developing an informal network of contacts involved in monitoring critical pollutants in water, sediment and biota that may be able to assist each other when problems arise. Increased communication will also lead to a better understanding of each other's sampling methods and recognition of opportunities to collaborate. Binational reporting on LaMP ecosystem indicators will further promote communication between various monitoring programs.

Much of the monitoring done in Lake Ontario would not be possible without the support of U.S. and Canadian research vessels. Cooperative monitoring projects in 2003 were supported by:

- ***Lake Guardian*** (180 ft / 54 m)
  U.S. EPA Great Lakes National Program Office
- ***CCGS Limnos*** (148 ft / 45 m)
  DFO vessel operated by the Canadian Coast Guard
- ***Great Lakes Guardian*** (45 ft / 14 m)
  Ontario Ministry of the Environment
- ***Lake Explorer*** (82 ft / 25 m)
  U.S. EPA Office of Research & Development

3.5 Major 2003 Cooperative Monitoring Projects

The Lake Ontario Lakewide Management Plan (LaMP) coordinated a number of binational cooperative monitoring efforts in 2003 to improve our understanding of the Lake Ontario ecosystem. In addition to promoting projects that address key LaMP information needs, emphasis has been placed on improving communication and data sharing between US and Canadian monitoring programs. Often the hardest part of this type of work is pulling together key researchers to interpret the data and to effectively communicate the "big picture" to stakeholders. This type of coordination and data synthesis takes time and effort and the LaMP is committed to making this happen.

In promoting cooperative monitoring the LaMP has broadened its base of partners to help support and strengthen existing efforts. For example, the LaMP's partnership with the Great Lakes Fishery Commission (GLFC) has brought together water quality and fishery managers. The LaMP and the GLFC have identified common information needs that helped guide the development of this year's projects. This may be the first step in developing a long-term binational strategy for Lake Ontario that meets the needs of both water quality and fishery managers.

Three major binational cooperative monitoring projects are summarized in the following sections.

3.5.1 Lake Ontario Atmospheric Deposition Study (LOADS)

Understanding Sources of Atmospheric Contaminants

Atmospheric deposition is one of the important sources of critical pollutants entering Lake Ontario. This project is developing a more detailed understanding of atmospheric deposition processes within the Lake Ontario basin and may provide information on the relative importance of local and long distance sources of atmospheric contaminants. The results of this study will support the development of contaminant loading mass balance models that are being used to predict how changes in contaminant loadings will impact contaminant levels in fish tissue.

The partners involved in this study include:

- Clarkson University
- EC Meteorological Services Canada
- U.S. EPA Region 5
- U.S. EPA Great Lakes National Program Office
- U.S. EPA Office of Research & Development
- Fredonia College
- State University of New York, Oswego
- University of Michigan
- Lake Ontario LaMP Four Parties (EC, EPA R2, OMOE, NYSDEC)

PCBs, pesticides, dioxins/furans and mercury are being measured in air and wet and dry precipitations samples collected from sampling platforms on land and on the lake. Lake water samples are also being collected. This work will give the LaMP a better understanding of how contaminants enter and leave the lake via atmospheric processes.

Some of the major questions to be addressed by this study include:

- How important are the amounts of contaminants entering the lake via atmospheric deposition compared to other sources, such as upstream lakes and in-basin tributaries?
- Does the nature or rates of atmospheric contaminant deposition differ between land & lake sampling locations?
- How significant are urban sources of atmospheric contamination?

3.5.2 Lake Ontario Lower Aquatic Foodweb Assessment (LOLA)

Understanding Changes in a Post-Zebra Mussel Foodweb

This project is developing a better understanding of the changes that are occurring in Lake Ontario's lower aquatic foodweb and its ability to support fish populations. The introduction of exotic species such as zebra & quagga mussels have changed the way nutrients and energy are cycled through Lake Ontario's foodweb impacting the productivity of fisheries and threatening efforts to restore naturally reproducing populations of native fish. Recently introduced exotic zooplankton, namely *Cercopagis pengoi*, may also negatively impact native zooplankton communities. The LaMP recently listed two new lakewide impairments, degraded benthos and degraded nearshore phytoplankton, probably related to the disruption of the foodweb by zebra & quagga mussels. The LaMP and the GLFC both agree that the need for better information on the lower foodweb is a high priority.

Partners involved in this project include:

- Great Lakes Fishery Commission
- Ontario Ministry of Natural Resources
- Department of Fisheries & Oceans Canada
- National Oceanic & Atmospheric Administration
- Cornell University
- U.S. EPA Great Lakes National Program Office
- U.S. EPA Office of Research & Development, Duluth
- University of Toronto
- State Univ. of New York, Environmental Sciences & Forestry
- Lake Ontario LaMP Four Parties (EC, EPA R2, OMOE, NYSDEC)

Four sampling cruises (April, August, September & October) were conducted with the assistance of U.S. EPA's vessel Lake Guardian and the Canadian Coast Guard's vessels CCGS Limnos and CCGS Simcoe. Approximately 30 stations per cruise were sampled along four north-south transects. Nutrient, phytoplankton, zooplankton, mysid (a type of freshwater shrimp) and benthic samples were collected in order to characterize the status of Lake Ontario's lower foodweb. The use of optical plankton counters, a new remote sensing technology, is also being explored as a tool to collect information on the status of zooplankton communities. Data interpretation and report writing will be coordinated among U.S. & Canadian partners. Pre-zebra mussel lower aquatic foodweb surveys conducted in the 1980s will provide a historical point of comparison for these results.

Some of the questions to be addressed by this projects are:

- What types of organisms make-up the lower aquatic foodweb?
- Have exotic species had negative impacts on native benthic organisms and zooplankton?

- Can the lower aquatic foodweb continue to support existing recreational and sport fisheries?

3.5.3 Interagency Laboratory Comparison Study

Understanding Differences in Analytical & Sampling Methods
Accurately measuring extremely low, parts per trillion, concentrations of critical pollutants is very difficult. The use of different sampling methods and laboratory techniques may provide different results for the same sample due to slight differences in the ability of various methods to capture and measure contaminants. This project was designed to give the LaMP a better understanding of how well the analytical results produced by U.S. and Canadian monitoring programs compare with each other and will allow the Four Parties to combine their data sets with confidence to better characterize the lakewide environmental conditions.

Partners involved in this project include:

- Environment Canada
- U.S. EPA Region 2
- Ontario Ministry of the Environment
- New York State Dept. of Environmental Conservation

Samples containing PCBs, pesticdes and PAHs were carefully prepared in the lab and split four ways and analyzed by laboratories that perform analytical work for the Four Parties. The results are now being carefully reviewed to identify any data comparability issues. Later stages of this study will include the collection and analysis of actual field samples at Niagara-on-the-Lake.

Some of the major questions to be addressed through this study include:

- How well do analytical results produced by U.S. and Canadian laboratories compare?
- Does the use of different sampling methods produce similar results?

3.6 Other Indicator Initiatives

This section will be updated as information becomes available.

3.7 Actions and Progress

The information contained in this chapter has been compiled based on documents produced up to January 2003. Additional input from technical experts and the public will be considered over the years to come. Further study will be necessary to define specific targets for zooplankton populations and prey fish. In the meantime, data collection and reporting on basic measures for these populations will provide some measure of how well these components of the ecosystem are faring.

The status of these indicators will be reported on in future LaMP reports and public meetings.
The need for any additional indicators will be considered as part of the data collection and reporting process.

3.8 References

No references were identified for inclusion in this section.

CHAPTER 4 IDENTIFICATION OF BENEFICIAL USE IMPAIRMENT ASSESSMENTS

4.1 Summary

This chapter provides status reports for each of 14 Beneficial Use Impairments (BUI) identified in the Great Lakes Water Quality Agreement (1987) including a brief account of the LaMP's original determination of their status. Some of this material was taken from the 1998 LaMP Stage 1 report and updated using various sources of information as shown in the references. In 2005, the status of the Degradation of Fish Populations BUI was reviewed as recent data and scientific interpretation clearly showed the offshore to be impaired. No previously impaired beneficial uses have changed status. The Zooplankton component of the Phytoplankton and Zooplankton BUI is currently under review and no recommendation for change was made at the time this chapter was revised.

The information contained in this chapter has been compiled based on documents produced up to March 31, 2005 for sections 4.4, 4.5, and 4.6. All others are virtually identical to that printed in LaMP Status Report April 2004. Information on current environmental conditions and issues is provided in Chapter 3, Ecosystem Indicators.

4.2 Beneficial Use Impairments Defined by the Great Lakes Water Quality Agreement

Significant changes have occurred in the Great Lakes over the last century due to the effects of toxic pollution, changes in nutrient input, fishing, and habitat loss resulting from water level regulation, power generation, rapid agricultural, industrial, and urban development within the Great Lakes watersheds and also by accidental and intentional introductions of non-native species. In 1972, Canada and the United States took actions to ban and control contaminants entering the Great Lakes, and, in 1987, renewed the Great Lakes Water Quality Agreement (GLWQA) with the goal to restore and maintain the chemical, physical, and biological integrity of the Great Lakes ecosystem.

The GLWQA (1987) provides fourteen indicators of beneficial use impairments (identified in the text box below) to help assess the impact of chemical, biological and physical factors on the Great Lakes ecosystem. These indicators provide a systematic way to identify impacts on the entire ecosystem, ranging from phytoplankton to birds of prey and mammals, including humans.

These impairments reflect those beneficial uses of the Great Lakes which cannot presently be realized because the physical, chemical, and/or biological integrity of the ecosystem has been compromised. These impairments are continuously evaluated on the other Great Lakes and in Areas of Concern (AOC). Given the rapid environmental changes that have occurred over the last 20 years, emphasis was placed on using the most recent information available at the time to identify problems facing the Lake Ontario ecosystem. Local impairments found in Lake Ontario AOCs and other nearshore areas are also discussed.

4.3 Beneficial Use Impairment Identification Process and Problem Definition

In preparing the Stage I binational problem assessment, Canada and the United States first independently evaluated 13 of the Lake Ontario beneficial use impairments for those geographic areas within their jurisdictions (Rang et al., 1992; USEPA and NYSDEC, 1994). The agencies proceeded to integrate their separate evaluations into the binational assessment of the status of beneficial use impairments in Lake Ontario. The fourteenth beneficial use impairment, loss of fish and wildlife habitat, was evaluated using Lake Ontario habitat reports compiled by the United States Fish & Wildlife Service (USF&WS) as part of the LaMP evaluation process (Busch et al., 1993) and others (Whillans et al., 1992). The LaMP recognizes the importance of appropriate linkages to other natural resource management initiatives such as the Great Lakes Fishery Commissions Fish Community Goals and Objectives, provincial and state

fishery management plans, International Joint Commission's lake-level management plan, wetlands protection, watershed management plans, and control strategies for exotic species.

The Great Lakes Water Quality Agreement definition of "impairment of beneficial use(s)" is a change in the chemical, physical, or biological integrity of the Great Lakes System sufficient to cause any of the following:

1. Restrictions on fish and wildlife consumption
2. Tainting of fish and wildlife flavor
3. Degradation of fish and wildlife populations
4. Fish tumors or other deformities
5. Bird or animal deformities or reproductive problems
6. Degradation of benthos
7. Restrictions on dredging activities
8. Eutrophication or undesirable algae
9. Restrictions on drinking water consumption, or taste and odor problems
10. Closing of beaches
11. Degradation of aesthetics
12. Added costs to agriculture or industry
13. Degradation of phytoplankton and zooplankton populations
14. Loss of fish and wildlife habitat

4.4 Beneficial Use Impairments in Lake Ontario

In the 1800s and early 1900s, much of Lake Ontario's watershed was deforested, its tributaries were dammed, and non-native species were introduced both purposely and accidentally. In the 1900s, rapid development of the Lake Ontario basin was accompanied by further habitat loss, unregulated harvest of fish, and the release of excessive nutrients and toxic pollution that caused major changes in the Lake Ontario ecosystem. Also during this time, sea lamprey became very abundant adding to the declines in native species like lake trout. From 1900 to 1960, Atlantic salmon, deep water ciscoes, deep water sculpin and lake trout were extirpated as a result of many or all of the above reasons. By the 1960s and 1970s, Lake Ontario's near shore waters were choked with algae and colonial water birds experienced nearly total reproductive failure due to the presence of high levels of toxic contaminants in the food chain. Similarly, near shore production of several species of fish including walleye and lake whitefish also declined significantly, allowing populations of non-native species like white perch and alewife to increase dramatically.

The reduction of contaminant and phosphorus loadings beginning in 1972 resulted in a major turn of ecological events in Lake Ontario most of which seemed to provide a promising positive outlook. The 1987 revision of the GLWQA focused on remediation, restoration and maintenance of the chemical, physical and biological integrity of the waters of the Great Lakes Basin ecosystem and provided a set of impairments by which to evaluate the state of the lake.

Today, as a result of these actions, levels of toxic contaminants in the Lake Ontario ecosystem have decreased significantly. Colonial waterbird populations have recovered and are reproducing normally. However, bioaccumulative toxics persist in sediment, water and biota at levels of concern for higher order predators (such as bald eagles, snapping turtles, mink, otters and humans).

Polychlorinated biphenyls (PCBs), DDT, mirex, dieldrin, mercury and dioxins/furans have been identified as critical pollutants linked to lakewide impairments in Lake Ontario. In addition to the historical loss of

significant habitats, artificial lake level controls were identified as a significant cause of degraded habitats. (Refer to the 1998 "Lakewide Management Plan for Lake Ontario - Stage 1 Report" for a detailed discussion on the evaluation of these lakewide impairments.) Although there have been positive changes related to these impairments, their overall status of "impaired" remains unchanged.

The following is a summary of the technical basis for the beneficial use impairment assessment and the identification of the chemical, physical, and biological factors contributing to these impairments. A general list of references is provided in Section 4.7. Detailed references for information sources are provided in the individual United States and Canadian assessment reports that were used for this evaluation. In the development of the LaMP, the lakewide impairment status (impaired, degraded, insufficient information, or unimpaired) was determined after consideration of the Ecosystem Goals for Lake Ontario (see Section 3.2.1) and the preliminary ecosystem objectives.

Since the LaMP 1998 report, 7 lakewide beneficial use impairments related to persistent toxic substances, food web disruption from non-native species and habitat degradation/loss have been identified:

1. restrictions on fish and wildlife consumption;
2. degradation of wildlife populations;
3. bird or animal deformities or reproductive problems; and
4. loss of fish and wildlife habitat.
5. degradation of benthos; and
6. degradation of nearshore phytoplankton populations
7. degradation of fish populations (primarily off shore).

The factors responsible for these impairments are identified in Table 4.1. PCBs, DDT, dioxins, and mirex are the critical pollutants associated with one or more of these lakewide impairments. Loss of fish and wildlife habitat is due primarily to physical and biological factors rather than toxic contaminants. The LaMP Management Committee and Working Group reviewed the status of degradation of fish populations BUI and changed it to impaired in 2005. The primary reasons were impacts of non-native species on the off shore food web and not meeting ecological objectives as stated in Chapter 3 for lake trout and prey fishes. The status of zooplankton remains unchanged but is currently under review.
The Lake Ontario AOCs, with the exception of the Port Hope AOC, also list some or all of these impairments as local concerns. The St. Lawrence River AOC shows only fish and wildlife consumption restrictions as impaired at this time. The LaMP process will be coordinated with the continuing activities of the local Remedial Action Plan councils to ensure the development of effective strategies for lakewide critical pollutants and other lakewide issues. The LaMP process will also support and provide integration of other existing programs that address these lakewide issues.

4.4.1 Restrictions on Fish and Wildlife Consumption

The LaMP Management Committee agreed that fish and wildlife consumption advisories due to PCBs, dioxins and furans, and mirex made this beneficial use impaired lakewide. Most human exposure to many persistent and bioaccumulative contaminants is through eating fish and other aquatic organisms, which far outweighs contaminant exposures related to drinking water, air, or other terrestrial sources. Consumption advisories are developed to help protect people from the potential health impacts associated with long term consumption of contaminated fish and wildlife.

Table 4.1 Lake Ontario Lakewide Beneficial Use Impairments, Impacted Species and Causes

Lakewide Impairments	Impacted Species	Lakewide Critical Pollutants and Other Factors
Restrictions on Fish and Wildlife Consumption	Trout, Salmon, Channel catfish, American eel, Carp, White sucker	PCBs, dioxins, mirex,
	Walleye[1], Smallmouth bass[1]	Mercury
	All Waterfowl[2]	PCBs, dioxin and Mirex
	Snapping Turtles[2]	PCBs
Degradation of Wildlife Populations	Bald Eagle[3] Mink and Otter[3]	PCB, dioxin, and DDT PCBs
Bird or Animal Deformities or Reproductive Problems	Bald Eagle[3] Mink and Otter[3]	PCB, dioxin, and DDT PCBs
Loss of Fish and Wildlife Habitat	A wide range of native fish and wildlife species	Lake level management Non-native species Physical loss, modification and destruction of habitat
Degradation of Benthos	*Diporeia hoyi* populations	Non-native species and unknown causes prior to introduction of zebra mussels
Degradation of Phytoplankton Populations	Nearshore phytoplankton	Non-native species and other factors to be confirmed
Degradation of Fish Populations	Lake trout	Poor survival of eggs and young lake trout caused by predation and early mortality syndrome as well as continued exploitation of adult fish
	Prey fishes	Imbalanced predator prey ratios in food web, poor survival or reproduction of non-native prey base, very low abundance of native prey fishes, low prey fish diversity, and nutritional factors
	Lake whitefish	Loss of *Diporeia hoyi*, nutritional factors, fishing

1. Canadian advisories only.
2. U.S. advisories only
3. Indirect evidence only (fish tissue contaminant levels)

Notes: The term "DDT" includes all DDT metabolites. The term "dioxin" includes furans. Dieldrin, although identified as a critical pollutant, is not linked to a beneficial use impairment.

For New York State Guidelines www.health.state.ny.us and Ontario Ministry of Environment Guidelines www.ene.gov.on.ca .

Fish Consumption Advisories

In general, consumption advisories are based on contaminant levels in different species and ages of fish. Both Ontario and New York fish consumption advisories account for the fact that contaminant levels are generally higher in older, larger fish. There are some differences in the fish tissue monitoring processes of the two governments; for example, New York State analyzes entire fillets which include belly-flap and skin (catfish, bullhead, and eels are exceptions since skin is removed before analysis) and Ontario

analyzes muscle fillets. These two types of fish samples are not directly comparable. Muscle fillets have lower fat content. Since organochlorine chemicals, such as PCBs and DDT, tend to concentrate in fatty tissue, muscle fillet samples will generally show lower levels of these contaminants than the levels found in the fattier fillets.

Although not responsible for consumption advisories on a lakewide basis, mercury in larger smallmouth bass and walleye was considered likely to exceed Ontario's 0.5 ppm criteria for human consumption and was therefore considered a factor in listing this beneficial use as impaired (Table 4.1).

In Ontario, a Sports Fish Contaminant Monitoring Program is administered by the Ontario Ministry of the Environment (OMOE) and the Ontario Ministry of Natural Resources (OMNR). New York State operates a statewide fish tissue monitoring program. USEPA's Great Lakes National Program Office coordinates a fish tissue monitoring effort as part of a long term contaminant trends monitoring project. Fish tissue samples are also collected by the Canadian Food Inspection Agency (CFIA) term contaminant trends monitoring program.

In Ontario, sportfish advisories are published every two years in the Guide to Eating Ontario Sport Fish, which includes tables for the Great Lakes. Various consumption advisories were reported for 19 species: salmon (Chinook, Coho), trout (rainbow, brown, lake), white bass, yellow and white perch, whitefish, rainbow smelt, freshwater drum, channel catfish, white and redhorse suckers, brown bullhead, American eel, black crappie, gizzard shad, and carp. The contaminants responsible for advisories are PCBs (61%), dioxins and furans (32%), and mercury (7%). The regular evaluation of commercial catches by the CFIAs fish inspection program has led to some restrictions on the commercial harvest of bowfin, lake trout, carp, large walleye, and channel catfish. In 2005, OMOE published new guidelines that use a new tolerable daily intake approach to assessing risk from contaminants in sport fish.

The New York State Department of Health issues annual fish consumption advisories for New York State waters which include specific and general advisories for Lake Ontario. NYSDEC collects and analyzes fish for contaminants. "Eat none" advisories are in place for Lake Ontario American eel, channel catfish, carp, and lake trout >25", Chinook salmon, brown trout over 20 inches, and white perch (west of Point Breeze). "Eat no more than one meal per month" advisories are in effect for Lake Ontario white sucker, Coho salmon over 25 inches, brown trout less than 20", smaller lake trout, rainbow trout, and white perch (east of Point Breeze). "Eat no more than one meal per week" advisories are in effect for many Lake Ontario fish species not listed above. In addition, an "Eat none" advisory, which applies to all Lake Ontario fish, is in effect for all women of childbearing age and children under the age of 15. This stringent advisory is designed to protect these sensitive human populations from any increased exposure to toxic contaminants.

In addition to these lakewide consumption advisories caused by organic contaminants, it is worth noting that a considerable number of local advisories have existed in Canadian waters due to mercury. Mercury advisories were reported for nine species of fish, including walleye, in fourteen locations. Walleye is an important recreational fishery in the eastern end of Lake Ontario. Fish consumption advisories are periodically reconsidered if new information suggests that more restrictive advisories are necessary to fully protect human health or if contaminant levels have dropped below guidelines.

The effect of any one or all contaminants on the fish species described is discussed in the degradation of fish and wildlife section.

Wildlife Consumption Advisories

Diving ducks, such as mergansers, feed on fish and other aquatic organisms and, as a result, tend to be the most heavily contaminated waterfowl. New York has a statewide advisory recommending that mergansers not be eaten and that the consumption of other types of waterfowl be limited to no more than two meals per month. The New York State Health Department also advises that wild waterfowl skin and fat should be removed before cooking and that stuffing be discarded. The contaminants of concern for Lake Ontario mergansers in New York are PCBs, DDT, and mirex.

Snapping turtles are another example of a high level predator that is near the top of the food chain. Over their relatively long life span, snapping turtles can accumulate significant levels of persistent toxic substances in their fatty tissues. New York's statewide advisory recommends that women of childbearing age, and children under the age of 15, "eat no" snapping turtles, and recommends that others who choose to consume snapping turtles should reduce their exposure by trimming away all fat and discarding the fat, liver, and eggs prior to cooking the meat or preparing the soup. This advisory is based on PCBs, as the primary contaminants of concern.

Studies conducted by the Canadian Wildlife Service of Environment Canada have shown contaminant levels in ducks to be below guidelines. Snapping turtle eggs from a number of locations in Lake Ontario exceed the PCB minimum consumption guidelines for sport fish. Although there has been no direct assessment of turtle muscle, turtle muscle with all fat removed would likely be below consumption guidelines. There are no consumption advisories for wildlife species in the Canadian portion of the Lake Ontario basin.

4.4.2 "Degradation of Wildlife Populations" and "Bird or Animal Deformities or Reproduction Problems"

The two impairments, "degradation of wildlife populations" and "bird or animal deformities or reproduction problems," are addressed together in this section since past declines in some wildlife populations have been directly related to contaminant-related reproduction problems. Wildlife population and reproduction impairments are lakewide impairments caused by PCBs, dioxin equivalents, and DDT. Wildlife used in the evaluation of this beneficial use indicator included mink, otter, bald eagles, and colonial water birds. These species were chosen because of historical, documented problems associated with contaminants or other non-chemical stressors. These species are useful indicators of environmental conditions because of their high level of risk due to being at or near the top of the food chain or requiring special habitat in order to reproduce successfully.

At the time of the BUI determination, there was indirect evidence that bald eagle, mink, and otter populations remained degraded along the Lake Ontario shoreline. Levels of PCBs, dioxins, and DDT and its metabolites in the food chain were thought to be important factors limiting the recoveries of these wildlife populations. There was no indication at that time that existing levels of contaminants in the open waters were degrading fish populations.

Bald Eagles

Bald eagle populations began to decline in the early 1900s due to hunting and loss of habitat. In the decades following the introduction of DDT in 1946, contaminant-induced eggshell thinning lowered reproductive success throughout North America, including the Lake Ontario basin. During the 1980s, after DDT and other pesticides were banned, two successful bald eagle nesting territories were reestablished in the Lake Ontario basin using adult eagles captured in Alaska. By 1995, bald eagles had

recovered to the point that they were moved from the U.S. endangered species list to the threatened species list. They retain their endangered status in Ontario.

In 1995 there were at least six successful bald eagle nesting territories in the Lake Ontario basin which have fledged more than sixty eaglets since 1980 (Nye, 1979, 1992). Since then the number of nesting territories has steadily increased in the basin and each territory has fledged on average one or more eaglets per nest. Chapter 3 provides details on the most recent information on the numbers of bald eagle nesting territories and eaglets successfully fledged.

In 1992, a survey of the entire Lake Ontario shoreline (both Canadian and U.S. sides) for suitable breeding habitat for bald eagles was conducted by Environment Canada, the Ontario Ministry of Natural Resources, and U.S. bald eagle experts. A more quantitative GIS study was completed throughout the basin in 2005, involving USEPA, NYSDEC, Environment Canada, Ontario Ministry of Natural Resources and Bird Studies Canada, with the objectives of identifying and ultimately protecting prime bald eagle nesting habitat over the next 10 years.

There was indirect evidence that bald eagle reproduction in the Lake Ontario basin was impacted by persistent toxic contaminants. Studies of bald eagles nesting on other Great Lakes shorelines in the 1980s suggested that levels of PCBs, dioxins, and DDT in the Lake Ontario food web may have caused lowered reproductive success, increased eaglet deformities, and early adult mortality (Best, 1992; Bowerman et al., 1991). Bald eagles as fish consumers, as well as scavengers of bird carcasses on islands and shorelines, may be at risk from direct and secondary exposure to botulism (see Chapter 10); however, at this time botulism has not been identified as the cause for the death of any bald eagles.

Colonial Waterbirds

Colonial waterbirds have a long history of being used as indicators of contaminant effects and ecosystem health on Lake Ontario and throughout the Great Lakes (Gilbertson, 1974; Mineau et al., 1984). In the 1970s, Gilbertson (1974, 1975) and Postupalsky (1978) found highly elevated contaminant levels in eggs, severe eggshell thinning, elevated embryonic mortality, high rates of deformities, declining population levels, and total reproductive failure among several species of colonial waterbirds on Lake Ontario. Many of these conditions had improved substantially at the time of the BUI determination, [e.g., concentrations of PCBs, dieldrin, total DDT, mirex, mercury, and dioxins had declined significantly in herring gull eggs and, to a lesser extent, in cormorants and common and Caspian terns (Weseloh et al., 1979, 1989; Ewins and Weseloh, 1994; Bishop et al., 1992; Pettit et al., 1994). Additionally, eggshell thickness had returned to normal (Price and Weseloh, 1986; Ewins and Weseloh, 1994), and population levels had increased (Price and Weseloh, 1986; Blokpoel and Tessier, 1996)]. The status of some of these conditions was unknown at that time and some new issues had arisen (physiological biomarkers, endocrine disruption, structural deformities) in birds as well as other classes of wildlife (G.A. Fox, Canadian Wildlife Service personal communication)

Since the assessment of the BUI, Weseloh et al. (2003) have shown that contaminant levels in herring gull eggs continued to decline and for all of the contaminants monitored since the beginning of the project levels had declined between 89 and 98% by 2000. In reference to a wide variety of colonial waterbirds, notable gulls, terns, egrets and cormorants, they concluded “Contaminant induced biological effects do not appear to be limiting factors at the population level.” This conclusion was based on the number of fledglings produced, colony size, and number of colonies. Yet to be addressed, however, are issues of recruitment, survival, or duration of breeding, all of which could be affected by contaminants. Documented cases of decreased embryo viability, immunosuppression, altered stress response, alterations in thyroid function, and metabolic abnormalities on Lake Ontario herring gull colonies located at Hamilton Harbor, Toronto and at Kingston suggest that demographic parameters such as survival and

recruitment could be affected in this population (C. Hebert, L. Shutt, G. Fox, Canadian Wildlife Service unpublished data).

A recent development in the health of Lake Ontario's nesting colonial waterbirds and migratory waterbirds concerns die-offs of large numbers of cormorants, terns, gulls and long-tailed ducks, in the late summer and autumn. During 2004 and 2005, over 4,000 dead birds were found washed up on shorelines or found dead on roosting islands, mainly in eastern Lake Ontario (from Pres'quile east through to Kingston area on Canadian side) (Pekarik et al. 2005, CWS unpublished data). Post-mortem examination indicated that the most likely cause of death was type E Botulism. The die-offs may have effects on populations of colonial waterbirds, in particular populations whose numbers are small or geographically restricted. For example, with the great black-backed gull, a species whose main breeding area on the Great Lakes is located in eastern Lake Ontario on islands and shoals surrounding Prince Edward County, the number of individuals found dead exceeds the known breeding population (Weseloh et al. 2003). Over the last 5 years there has been a nearly 70% decline in the number of breeding pairs of black-back gulls on the Canadian side of Lake Ontario (L. Shutt, CWS unpublished. data). Continued monitoring for bird deaths along Lake Ontario's shorelines and islands should provide the Lake Ontario LaMP and its partner agencies with updates on their status and an assessment of biodiversity.

Mink & River Otter

Settlement, trapping, and habitat losses during the eighteenth century are believed to have contributed to major population declines for both species. Prior to these changes, the river otter had one of the largest geographic ranges of any North American mammal and was found in all major U.S. and Canadian waterways. As with the bald eagle, there was indirect evidence at the time of the BUI determination which suggested that reproduction of Lake Ontario mink in nearshore areas was affected by persistent toxic contaminants. In the 1960s, reproductive failures of ranch mink that had been fed Great Lakes fish led to the discovery that mink are extremely sensitive to PCBs (Hartsough, 1965; Aulerich and Ringer, 1977). Laboratory experiments had shown that a diet of fish with PCB or other dioxin-like contaminant levels comparable to those found in some Lake Ontario fish can completely inhibit mink reproduction. However, the fact that mink are highly opportunistic and may rely on muskrat, rabbits, and mice for the bulk of their diet in some locales made it difficult to estimate the impact that environmental contaminants were having on the populations of this species. Otters, on the other hand, rely almost exclusively on fish for their diet, but there was little information on the sensitivity and exposure of otters to PCBs and other contaminants. Laboratory studies corroborated that levels of PCBs and dioxin-like contaminants in the food chain may have been limiting the natural recovery of both mink and otter populations.

A recent review, funded by the Lake Ontario LaMP, was done on trapping and sighting data (Bouvier 2002). This review did not have a contaminants component. However, harvest statistics from trappers although biased by pelt prices and the number of trappers, clearly showed that mink and otter populations in the Lake Ontario basin are healthy. Sighting data in both New York and Ontario supported the trapping data. Although data was lacking for urbanized areas, the author concluded that the Lake Ontario basin supports healthy populations of both mink and otter. The author also concluded that healthy mink and otter populations suggest that habitat for mammals is in a healthy state too. These conclusions suggest that the mink and otter indicator objective has been met.

A different survey about contaminants in trapper-caught mink was conducted by Canadian Wildlife Service in 2000-2005 in Lake Ontario. Results indicated that animals collected from coastal wetlands or tributaries within 4 km of Lake Ontario in Kingston, Bay of Quinte, Port Hope and Hamilton contained concentrations of PCBs and other chlorinated hydrocarbons and mercury well below those associated with negative reproductive effects (P. Martin, CWS unpublished data). .

Snapping Turtles

Although there has been no evidence of snapping turtle declines in Ontario due to persistent organic contaminants, hatching mortality and deformities were higher at some Lake Ontario populations in the late 1980s. There was indirect evidence that depressed hatching mortality and deformities were associated with PCBs and dioxin-like compounds (Bishop et al. 1991), although direct linkages were not made. Liver enzymes consistent with exposure to PCBs and similar compounds were elevated in hatchlings from more contaminated sites along the north shore of Lake Ontario (Bishop et al. 1998). A more recent assessment by the Canadian Wildlife Service (2003-2004) suggests that deformities rates and hatching success of turtles from some of the same sites assessed in the late 1980's did not differ from inland reference sites (K. Fernie, CWS in published data). However, subtle health effects have not been fully evaluated.

4.4.3 Loss of Fish and Wildlife Habitat

Fish and wildlife habitat is a lakewide impairment caused by artificial lake level management, the introduction of non-native species, and physical loss, modification, or destruction, such as deforestation and damming of tributaries. Binational evaluations were initiated to evaluate potential options to mitigate these impacts. An evaluation of habitat conditions from 1980 to 1990 did not identify persistent toxic substances as a significant cause of lakewide habitat loss or degradation.

Physical Habitat

The early colonists began to alter the seasonal flows of Lake Ontario tributaries by clearing land. As the land was cleared, water temperatures began to rise, siltation increased, and aquatic vegetation (which provides cover for young fish) was lost. Further, the damming of Lake Ontario tributaries and streams impeded migration of salmon and other native species to their spawning and nursery grounds. The combined impacts of all these factors were devastating to nearshore, tributary, and wetland habitats. Wetlands provide vital habitat to many species of Lake Ontario's wildlife. It has been estimated that about 50 percent of Lake Ontario's original wetlands throughout the watershed has been lost. Along the intensively urbanized coastlines, 60 to 90 percent of wetlands have been lost. These losses are a result of the multiple effects associated with urban development and human alterations, such as draining wetlands to establish agricultural land, marina construction, dyking, dredging, and disturbances by public utilities. Natural processes, such as erosion, water level fluctuations, succession, storms, and accretion, contribute to the loss of wetlands as well.

At the time of the BUI assessment, approximately 80,000 acres of Lake Ontario's wetlands remained. The largest expanses are still located in the eastern portion, along the coastline of Presque'ile Bay's Provincial Park in Ontario and in Mexico Bay in New York. The pressures of urban and agricultural development continue to threaten wetlands as the public wishes to locate along the lakeshore, have larger marinas in river mouths, achieve more efficient stormwater removal from streets and properties, or till marginal wetlands in the watershed during dry years. Major government initiatives, including education and regulatory controls, have done much to reduce or prevent the loss of wetlands. More than 20 percent of Lake Ontario's wetlands are fully protected (parks) while additional areas are subject to a variety of municipal, state/provincial, or federal rules, regulations, acts, or programs. Stemming continued losses of wetlands requires action at the most efficient level of organization, and opportunities to protect, restore, or replace these valuable habitats need to be explored.

Artificial Lake-Level Management

There is considerable evidence that the management of lake levels has inadvertently reduced the area, quality, and functioning of some Lake Ontario nearshore wetlands. Nearshore wetlands are important to the ecology of the lake because they provide habitat necessary for many species of fish and wildlife to successfully live and reproduce. These wetlands may be unique or of limited quantity in the number and types (diversity) of plants and soil benthic type (i.e., rocks, sand, or silt). Without wetlands of suitable quality and quantity, many species of fish and wildlife would be at risk. There is also significant concern among the citizens living along the shoreline of Lake Ontario that lake level management is causing increased erosion and property loss. High lake levels are associated with accelerated rates of erosion and property loss in areas susceptible to lake-induced erosion.

Lake level management was first recommended to limit flooding and erosion in the Lake Ontario basin and to prevent flooding of major metropolitan areas along the St. Lawrence River, such as Montreal. Lake Ontario level and St. Lawrence River flow regulations are also used to benefit commercial navigation and hydropower production. The International Joint Commission (IJC) was established in 1909 by the Boundary Waters Treaty to serve as an impartial group with jurisdiction over boundary water uses. The IJC consists of three U.S. members appointed by the President of the United States and three Canadian members appointed by the Prime Minister of Canada. Plans to artificially manage Lake Ontario water levels began in 1952 when the IJC issued an Order of Approval to construct hydropower facilities in the international reach of the St. Lawrence River at Cornwall, Ontario and Massena, New York. The hydropower facilities were completed in 1960. The IJC amended its order in 1956 to include regulation criteria designed to reduce the range of lake levels and to protect riparian and other interests downstream in the Province of Quebec. This amended order also established the International St. Lawrence River Board of Control to ensure compliance with provisions of the Orders. The St. Lawrence Board consists of ten members chosen by the IJC for their technical expertise.

Lake levels are currently regulated by Plan 1958-D. This plan sets maximum and minimum flow limitations which change week to week to provide adequate hydropower production and, at the same time, maximize depths for navigation and provide protection against flooding in the St. Lawrence River. Authorization may be requested by the Board to deviate from Plan 1958-D when supplies are greater or less than those upon which the plan was developed. During the development of this plan, environmental and recreational factors were not considered. As recommended by the IJC's Levels Reference Study Board, the St. Lawrence Board has been investigating the possibility of changing the current plan and/or procedures to better address environmental and recreational concerns (see Section 10.2.3).

Several environmental issues have been identified in studies completed by the Levels Reference Study Board in 1993. As a result of lake level management, Lake Ontario wetlands are no longer experiencing the same range of periodic high and low water levels. This reduction in range has resulted in some wetlands becoming a monoculture of cattails -- a greatly reduced biodiversity of nearshore areas. In addition, the current four foot range in fluctuation for Lake Ontario is too narrow to preclude cattail overpopulation by modifying the timing of water level highs and lows from their natural cycle. This can have a devastating effect on wetlands, often resulting in too little water for fish and wildlife reproduction purposes, but has provided benefits to recreational and commercial boating.

Regulation of lake levels is difficult because changes in precipitation rates and winter ice cover are unpredictable and limit our ability to manage water levels. Shoreline erosion is a natural occurrence caused by the energy present in water at the shoreline. The nature of erosion that may occur is related to the soil type and elevation, wind, current, and water level at the time. Where the energy in the water can be absorbed, erosion will be slow, but where the makeup of the shoreline is unstable, the effects of

erosion take place more quickly. Erosion of certain areas of Lake Ontario's shoreline is a natural process that will inevitably occur.

Non-native Species

It is difficult to predict some of the more subtle interactions that might develop between newly introduced non-native species, naturalized non-native species, and native species. This evaluation is further complicated by other chemical and physical changes that are taking place in the basin concurrently. It was clear, however, at the time of the 1997 BUI assessment, that non-native species were having a significant impact on the Lake Ontario ecosystem and continue to do so. The Lake Ontario ecosystem has experienced several significant impacts by non-native species some of which are discussed in degradation of fish populations (section 4.4.6). The designation of the sea lamprey as a non-native species in Lake Ontario is questionable. Nevertheless, the sea lamprey has clearly had a negative impact on some native species. Currently it is being controlled at or near levels targeted by the Lake Ontario Committee of the Great Lakes Fishery Commission (NYSDEC 2005; OMNR 2005). Although not considered a major limiting factor, lamprey predation on lake trout may add to the cumulative mortality currently hampering lake trout restoration efforts.

Other non-native species have become important components of the Lake Ontario food chain forever altering the biological component of fish and wildlife habitat. These species include smelt and alewife, which are now the dominant forage fish in the offshore (see Chapter 2, and section 4.4.6 in this Chapter). The round goby is very quickly becoming an important component of the nearshore food web and there is lake trout diet information from the east and west ends of Lake Ontario that show goby to be important to their diets (OMNR, unpublished data; Clark et al, Great Lakes Fishery Commission, Lake Ontario Committee Meeting 2005). The Dreissenids have become very important diet items for lake whitefish, freshwater drum and probably most zooplanktivores ingest their veligers. They are also clearly important to some waterfowl.

Some species like the rudd (uncommon in Bay of Quinte) and the blueback herring (observed near Oswego) have not become well established in Lake Ontario. The ruffe has not been observed in Lake Ontario yet but is found in Lake Superior and Lake Huron. Asian species like grass carp have been seen in the lake near Toronto. Five bighead carp have been observed in Lake Erie (Morrison et al, 2004). The impact of these rarer non-native species on the nearshore food webs is not known but Asian carp like bighead and silver carp can displace other native fishes in the nearshore and in rivers should they be introduced into Lake Ontario.

Zebra and quagga mussels have altered the bottom of Lake Ontario. Their presence on the bottom surface of the lake has dramatically altered the habitat, making it less suitable for some native invertebrates. Their ability to increase water clarity in nearshore areas has increased the area for and amount of macrophyte and attached algae growth. Their washed up shells are also negatively impacting beach use. In addition, there are increased maintenance costs associated with keeping drinking water and cooling water intakes free of these mussels. It is exceedingly difficult and costly to control non-native species after they have been introduced to an ecosystem, so control programs have concentrated on preventing new introductions and inhibiting the spread of existing species.

An important component of these control programs is the US federal regulation that requires ocean-going ships to exchange their ballast water at sea before entering the St. Lawrence Seaway. This requirement seeks to ensure that any exotic species present in the ballast water will not be released into the Great Lakes. It is believed that zebra mussels, the round goby, and the ruffe were all introduced to the Lakes in this way. Stopping the initial introduction by ocean going vessels is critical as, once in the Great Lakes, Great Lakes vessels (that are not recognized in this legislation) can move non-native species throughout

the system. The goby and *Dreissena* mussels probably arrived in eastern Lake Ontario via a Great Lakes vessel.

The United States and Canadian Coast Guards are working to limit the introduction of non-native species through transoceanic shipping. In addition to the ballast water exchange requirement, chemical treatment measures may be necessary to deal with any organisms that may be left in the tanks after ballast water exchange.

4.4.4 Degradation of Benthos

Degradation of benthos is a lakewide impairment caused by the introduction of zebra and quagga mussels. Benthic macroinvertebrates, often called benthos are small insect-like organisms that live in the bottom sediments of the lake and are an important food source for many types of fish. Dramatic changes have occurred within Lake Ontario's benthic community since the 1950s due primarily to significant reductions in nutrient loadings and changes in the numbers and types of fish that feed on benthic organisms. These impacts may have overshadowed any past or present lakewide impacts from toxic contaminants.

Studies completed shortly before the second BUI assessment in 2002 have given us a better picture of the potential impacts of contaminants in Lake Ontario sediment on benthic communities. Sediment samples were collected throughout Lake Ontario in 1997. Pollution sensitive benthic organisms were then exposed to these sediments under laboratory conditions to evaluate sediment toxicity. Results showed that contaminant concentrations in lake bottom sediments posed little to no acute toxic threat to these sensitive test organisms. Additional information will be needed to assess the potential for contaminants to have long-term chronic impacts on these organisms.

Although contaminant-related impacts on benthos are not a concern for the open lake, localized toxic contaminant impacts on benthic organisms have been documented in some Lake Ontario Areas of Concern with elevated levels of sediment contamination. These problems are being addressed through local Remedial Action Plans.

It is clear that the introduction of the zebra mussel in the late 1980s has had a detrimental impact on Lake Ontario benthos. The Quagga mussel, which arrived in Lake Ontario with the zebra mussels, is capable of living in colder, deeper waters than the zebra mussel. These mussels filter water to feed on microscopic phytoplankton and other organic material, thereby reducing the amount of food available to other benthic organisms. The filtering action of the mussels also contributed to the dramatic increase in water clarity. At the same time, populations of some important native benthic organisms have generally declined. Section 10.2.2 provides further information regarding the zebra and Quagga mussels.

Prior to the arrival of the zebra mussel, populations of the small shrimp-like *Diporeia* were the dominant benthic organisms in the lake. Typically, a few thousand of these organisms were present in a square meter of lake bottom and provided an important source of food for fish. A decade after the zebra mussel invasion, as few as ten of these organisms can be found per square meter in waters up to 200 meters deep, while the *Diporeia* had disappeared from most locations in less than 80 m depth. Although the mussels are suspected to be the cause of these declines, a clear cause-effect relationship has yet to be established.

Some less important nearshore native benthic species have benefited from the zebra mussel invasion. Populations of some shallow water (less than 10 meters-deep) native benthic organisms that prefer the habitat created by zebra mussel shells and can feed on the mussel's waste products have increased. Nearshore fish, such as perch, smallmouth bass and introduced goby that feed on these organisms, are benefiting from the increase in these benthic populations.

Following the 2002 BUI assessment, additional studies of Lake Ontario benthic organisms, phytoplankton, and zooplankton were initiated to develop a better understanding of the rapid changes occurring in Lake Ontario's food web.

4.4.5 Degradation of Nearshore Phytoplankton Populations

Degradation of nearshore phytoplankton populations is a lakewide impairment caused by the introduction of zebra and quagga mussels. Healthy and balanced communities of phytoplankton and zooplankton are essential components of all normal aquatic ecosystems. Without these microscopic plants and animals, there would be no fish in lakes. Lake Ontario phytoplankton and zooplankton data have been collected during the past few decades as part of Canadian and U.S. monitoring programs. Changes in the structure of plankton communities and their relationship to nutrient levels have been examined in nearshore, offshore, and embayment habitats in order to better understand whole-lake processes.

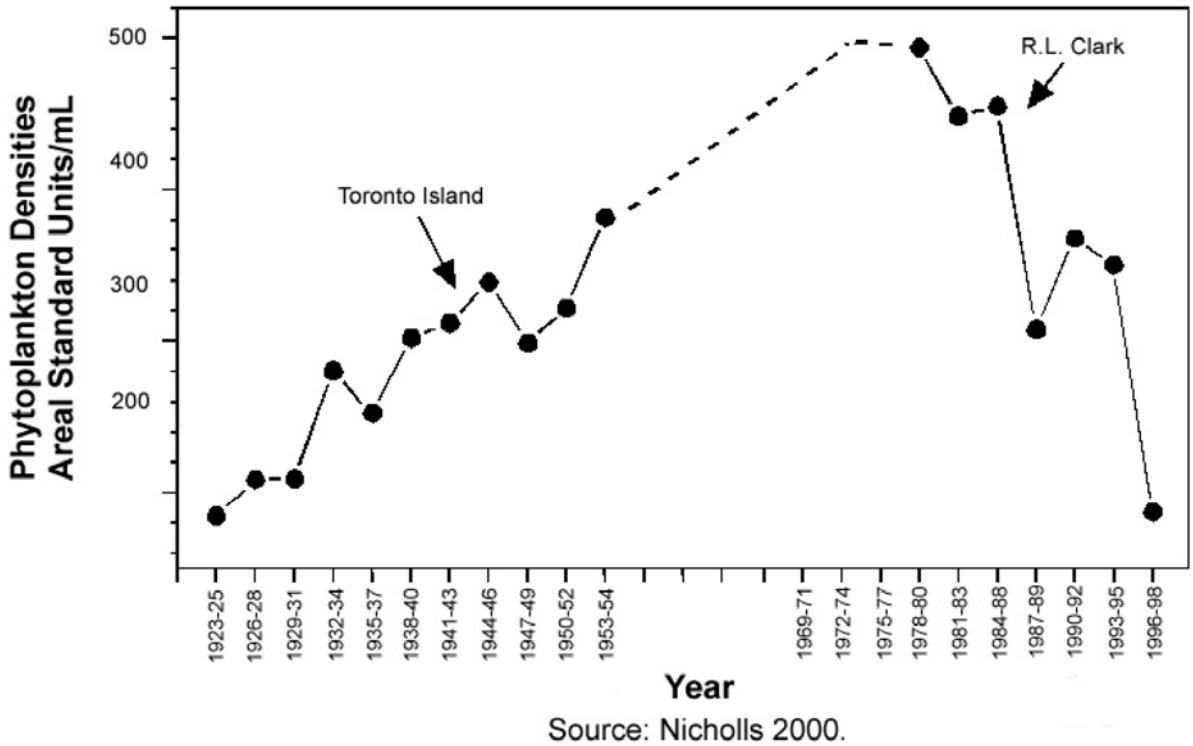
In recent decades in Lake Ontario, these communities have been influenced by reductions in inputs of phosphorus from municipal waste treatment facilities, invasions by exotic species and changes in fish communities. As with the benthic community, these changes may have overshadowed any impacts that contaminants may have had on phytoplankton and zooplankton populations in the past. There is no indication that current levels of contaminants pose a concern for phytoplankton and zooplankton populations. However, through bioaccumulation, even low concentrations of contaminants in phytoplankton and zooplankton can pose concerns for higher level predators such as fish and waterbirds. At the time of the 2002 BUI assessment, the potential impacts of exotic mussels and predatory zooplankton were recognized as the greatest threat to these native populations.

Phosphorus and Phytoplankton

The Lake Ontario phytoplankton community is controlled by both nutrient supply, typically measured in terms of total phosphorus, and by the size of zooplankton populations that feed on phytoplankton. During the 1940s to the 1970s excessive discharges of nutrients from agriculture and wastewater discharges resulted in abnormally high Lake Ontario phosphorus levels. The result was an explosion in the growth of phytoplankton and algae creating severe water quality problems. The U.S. and Canada implemented phosphorus controls at wastewater treatment plants beginning in the 1970s and reduced total phosphorus levels in the open lake by 30 percent over a 15-year period. Nearshore waters that had the highest nutrient levels saw declines in phosphorus levels well over 50 percent.

Several long-term studies have documented changes in phytoplankton. Collections of phytoplankton samples from Toronto drinking water intakes provide a historical perspective on long-term trends and their response to changing nutrient levels (Figure 4.1). These collections show that phytoplankton densities doubled between the 1920s and the 1950s in response to increasing and excessive nutrient levels. Beginning about 1980, this trend was reversed, reflecting the success of phosphorus controls which have maintained open lake total phosphorus concentrations at or below a level designed to prevent nuisance growths of algae.

Figure 4.1 Phytoplankton Densities from Toronto-based Lake Ontario Water Treatment Plant Intakes, 1923 – 1998



Source: Nicholls 2000.

Since the arrival of the zebra and quagga mussels, there has been concern that this species could alter the Lake Ontario food web in a number of ways. The impacts of the filtering action of Dreissenid mussels on nearshore phytoplankton densities were seen as early as 1992. By 1998, zebra mussel feeding apparently had reduced phytoplankton densities by more than 90 percent in some inshore areas. The composition of phytoplankton communities also changed, with edible types of algae decreasing and less edible forms increasing.

Normally, chlorophyll a concentrations are directly proportional to nutrient levels. However, at the time of the 2002 BUI assessment, an apparent "decoupling" of chlorophyll a and nutrients was observed in some nearshore waters where increases in nutrients were not accompanied by expected increases in chlorophyll a. It was suspected that this decoupling reflected grazing activity by zebra and quagga mussels.

Research continues to provide a better understanding of seasonal changes in phytoplankton populations in nearshore and offshore waters and embayments. Studies undertaken in the mid-1990s in Canadian waters found that nearshore spring phytoplankton densities were six to eight-times higher than summer densities at the eastern end of the lake. Offshore stations showed much less difference between spring and summer phytoplankton biomass. Spring phytoplankton density peaks were confined to April and May at eastern Lake Ontario nearshore sampling locations, but often extended into June at western sampling sites, indicating higher nutrient levels related to Niagara River inputs. With continued declines in nutrients entering Lake Ontario via the Niagara River, recent studies now find little difference between eastern and western Lake Ontario nutrient levels.

4.4.6 Degradation of Fish Populations

Prior to 2005, this BUI was considered not impaired. The reasons are described in the Lake Ontario LaMP 1998 Stage 1 report and in the background for Lake Ontario in this status report (see Chapter 2). At the time of the last assessment, Lake Ontario's native species were showing signs of recovery with high abundances of walleye, lake whitefish, wild reproduced lake trout, and deep water sculpin. The Pacific salmonids were all being managed based on prey supply and the ecosystem appeared balanced. But, since that time the colonization of Lake Ontario by non-native species, continued pressures from fishing, rapid changes in abundance of prey fishes and subsequent declines in the survival of lake trout, lake whitefish and walleye, and reduced growth of virtually all Pacific salmonids clearly showed that the fish populations in Lake Ontario are stressed. Because of the obvious changes occurring in Lake Ontario, the Lake Ontario LaMP Management Committee followed the Working Group recommendation to re-assess the fish populations BUI.

The re-assessment of this BUI took into account the LaMP's primary ecosystem objective,

"Aquatic communities: The waters of Lake Ontario shall support diverse and healthy reproducing and self-sustaining communities in dynamic equilibrium, with an emphasis on native species" (see Section 3.2.2).

Thus, the rating of degraded relates to achieving the objective as stated. Currently, there are two ecological indicators for this BUI and they are prey fish and lake trout (see Sections 3.3.2 and 3.3.3). Lake trout are used as an indicator of the health of the offshore fish community and prey fish are used as an indicator of both offshore and nearshore fish community health.

Lake trout restoration efforts have not been successful in achieving the objective of self sustaining populations of lake trout. USGS trawls for lake trout clearly show that natural reproduction occurs at very low levels (USGS/NYSDEC, 2005). In addition, there are signs of poor survival of recently stocked lake trout, low but stable harvest and catches in agency assessment programs, and changes in adult lake trout distribution favoring the southwest portion of the lake (NYSDEC, 2005; OMNR, 2005). Currently, none of the wild produced lake trout indicator targets have been met in spite of meeting adult biomass and fish and sea lamprey mortality targets (See Chapter 3 lake trout indicator).

A health issue resulting from the reliance on a diet of alewife and smelt is early mortality syndrome. Alewife and rainbow smelt are known sources of thiaminase, an enzyme that causes thiamin deficiency in adult fish, particularly salmon and trout (Honeyfield et al, 2005 and references therein). Thiamin deficiency results in increased mortality of embryonic and larval fish as well as secondary disease states that lead to increased mortality at older life stages (Brown et al., 2005). The Lake Ontario Committee of the Great Lakes Fishery Commission recognizes thiamin deficiency as an important issue and research on sources of thiaminase, effects of low thiamin and remedies for low thiamin are underway now. Native prey fishes such as the deepwater ciscoes and deepwater sculpin, though extirpated or very rare, contain low levels of thiaminase (Honeyfield et al. 2005), therefore, fishery managers are examining the possibility of restoring some of these native prey fish.

The focus of restoration should be on understanding the factors causing increased mortality during the lake trout's early life history. Potential bottlenecks hampering lake trout restoration are: increased mortality on shallow reefs from shock and turbulence; predation on eggs by benthic predators; increased predation on young lake trout by alewife when their abundance is high and increased predation on young lake trout by other salmonids when alewife abundance is low; diet caused thiamin deficiencies, and predation of young fish particularly by gobies (Fitzsimons et al, 2003). As well, exploitation of adult fish, even at a very low level, can hamper any restoration effort (Christie et al, 1987). Addressing these

bottlenecks and reducing or stopping lake trout exploitation may allow the Lake Ontario LaMP to meet its objective for the lake trout indicator and take one step towards reclassifying the fish populations BUI.

The prey fish community is dominated by a non-native species. The prey diversity in order of highest biomass includes alewife, 3-spine stickleback, with rainbow smelt and slimy sculpin a distant 3rd and 4th (OMNR, 2005). Deepwater sculpin are very rare but have been captured in larger numbers in 2005 than seen in many years (O'Gorman, personal communication). There are no deep water ciscoes in the offshore of the main basin and lake herring are restricted to the eastern or Kingston basin. All prey species are self sustaining at present. The diversity of prey species although seemingly adequate with respect to the measures for the indicator, is heavily biased towards alewife (Chapter 3, Section 3.3.2) and does not support healthy predator populations as shown by lake trout indicator and the condition of other top predators. The purpose of the objective is to have a prey base with enough diversity and biomass to achieve stable predator prey relationships. At the time of the last assessment, fisheries agencies had not set a target measure for prey biomass that would support the predator fishes and this target is a research priority with the Lake Ontario Committee. A review of the changes in prey and predator fish species, zooplankton and the entire food chain is needed to assess the stability of predator prey relationships and health of the predator populations supported.

Assessing the status of the prey fish with respect to the indicator objective suggested in Chapter 3 requires using measures of abundance, age and size distribution of the prey fish. The offshore prey fish are dominated by alewife (Mills et al, 2004). Alewife biomass is lower in recent years than in the 1980s and early 1990s (NYSDEC, 2005; OMNR, 2005). Body condition, a function of weight at a given length, of older alewife is improving, suggesting that the abundance of this prey fish has declined. It is important to note that the abundance of rainbow smelt, slimy sculpin and deepwater sculpin are low to near zero, respectively.

In the offshore, the top predators are Chinook salmon, rainbow trout, lake trout, Coho salmon and Atlantic salmon. Assessment of Atlantic salmon is very poor in Lake Ontario and focuses more on tributaries. However, Atlantic salmon is a native species, once extirpated, that is surviving in Lake Ontario due primarily to restoration efforts. The Lake Ontario Committee's fish community objective for the offshore pelagic fish community is to have a diversity salmon and trout with Chinook as the primary species and due to stocking rates and wild reproduction Chinook salmon dominate all other salmonines (GLFC, 1999; Mills et al, 2004; NYSDEC, 2005; OMNR; 2005). They are well represented in assessment of the offshore food web and as such, are an excellent indicator of changes in their prey base. Their diet is almost solely alewife. Chinook condition (weight at length) is closely related to body condition of alewife. The weight of 900 mm Chinook salmon has steadily declined and reached an all time low in 2004 suggesting these fish are not finding enough food (NYSDEC 2005; OMNR 2005). Since 2000, an average of 2.2 million Chinook salmon has been stocked into Lake Ontario. Angler catch rates show that the abundance of Chinook may have increased in the last 3 years. It is a fair assumption that when coupled with wild reproduction estimates (at least 25%, Ian Craine, University of Toronto, unpublished data), the abundance of Chinook has increased. The increase in the number of Chinook in Lake Ontario combined with the decrease in prey fish biomass is likely the reason why Chinook weight at age has declined.

Other salmonids have shown signs of decreased growth too. Coho salmon continue to show signs of reduced condition factor, and variable wild reproductive success (OMNR 2005). The number of rainbow trout returning to the Ganaraska River in Ontario, has been steadily declining since about 1989 (OMNR 2005). It has been suggested that the declining return rate is due to reduced survival of wild and stocked rainbow trout soon after they enter Lake Ontario and as mortality estimates of age 3+ fish have not changed over the same period of time; it is unlikely that fishing mortality has increased (Bowlby, J. personal communication). One plausible alternative is increased predation of young rainbow trout soon

after entering the lake. This phenomenon is also suggested for lake trout soon after stocking directly into the lake.

Both NYSDEC and OMNR stock significant numbers of Coho salmon and rainbow trout into Lake Ontario and its tributaries every year and no reductions in numbers stocked have occurred for several years (NYSDEC, 2005; OMNR, 2005). Both species also show varying levels of wild reproduction which adds to the number of top predators in the lake and have established wild runs in several tributaries (Christie, 1973). The cumulative effects of increased predators and decreased prey fishes could be an imbalance in the ratio of predators to prey.

In nearshore areas walleye and cormorants also eat alewife. Walleye and cormorants both seek other prey items when alewife are not abundant. Nevertheless, they both increase the demand on alewife. Lake trout, Chinook salmon and rainbow trout are resident in the Kingston basin too. Recent surveys of the Kingston basin suggest alewife abundance is lower there than in the rest of the lake (Casselman and Scott, 2003; Mills et al, 2004; OMNR, 2005).

There is one other good indicator of predator prey imbalance and this occurs in the lower food web. Although under review, zooplankton are also in a state of flux due to two recently introduced non-native species, the fish hook and spiny water fleas (*Cercopagis pengoi* and *Bythotrephes longiminus*, respectively). The fish hook did very well and for several years was the more abundant of the two species. The fish hook water flea is less susceptible to alewife predation and shows less response to alewife abundance. Johannsson (2003) suggested that the reason the spiny water flea never became abundant while the fish hook water flea did was due to alewife predation. Spiny water flea is a prey item for alewife so when alewife abundance declines one would predict spiny water flea abundance to increase. In 2003 and 2004, the abundance of spiny water flea has increased (Johannsson pers. comm.).

Considering trends in alewife indices and that of the other prey species, the changes in growth of Chinook salmon, the continuous stocking rate of predator species, the abundance of other predators, the contribution of 'wild' produced fish and the trends observed in the lower food web, it is not difficult to surmise that the balance between predators and prey has changed since the last assessment of this BUI. From an ecological perspective, the downward trends in size at age, reduced returns of wild fish, poor survival of recently stocked fish, reduced biomass and abundance of alewife and rainbow smelt both in main basin and in Kingston basin all suggest an impairment of 'fish' populations.

Perhaps the epitome of impaired Lake Ontario fish populations is shown by lake whitefish, an important native prey fish. This species had appeared to recover through the 1980s. Lake whitefish declined precipitously soon after the colonization of the Bay of Quinte and eastern Lake Ontario by dreissenid mussels (Hoyle et al, 1999; Hoyle et al, 2003; Chapter 2 this report). During the mid-1990s, lake whitefish were appearing emaciated and Hoyle et al (2003) suggests that dead whitefish caught in bottom trawls during 1998 died from starvation, perhaps indicating a drastic and rapid change in the food web for the entire eastern basin as this species is resident in the Kingston basin and throughout the Bay of Quinte, in Lake Ontario and Chaumont Bay, NY. The populations of whitefish are still fished, and still reproducing but the survival of their young appears to be very low as of 2004 (OMNR 2005). Research is currently underway to address potential causes but there are no remedies in sight.

Finally, the BUI "degradation of fish populations" is impaired simply as a result of the status of other BUIs such as contaminants in fish, fish habitats, and phytoplankton within their habitats which are all impaired. As these BUIs are all interconnected, a discussion of remediation needs to be inclusive.

The primary objective for the LaMP is to have self sustaining fish populations with a preference towards native species. Today, there is no evidence that native species such as lake whitefish, lake trout, sculpins,

and their food, *Diporeia* will recover in the foreseeable future. Species like Atlantic salmon remain due to a small stocking effort. There are pathological issues directly related to non-native prey fishes and thiamin in their predators, especially lake trout and Atlantic salmon. Also, it is impossible to ignore that the GLQWA has reduced phosphorus and this, combined with the filter feeding effects of dreissenid mussels, has resulted in reduced primary production, less secondary production, and less production of prey species such as alewife, smelt, sculpins and lake whitefish.

As mentioned earlier, the status of fish populations is a key concern of the Lake Ontario LaMP and also of the GLFCs Lake Ontario Committee (LOC). The LOC is in the process of updating its Fish Community Objectives (FCOs) which state clear fish community objectives based on a holistic ecological approach. The Lake Ontario LaMP will work with the LOC to develop its revised FCOs over 2006-2007.

4.5 Unimpaired Lakewide Beneficial Uses in Lake Ontario

The LaMP's Stage 1 beneficial use assessment determined that the following beneficial uses were unimpaired on a lakewide basis:

- Tainting of fish and wildlife
- Fish tumors
- Restrictions on dredging activities
- Eutrophication or undesirable algae
- Drinking water restrictions or taste and odor problems
- Beach closings
- Degradation of aesthetics
- Degradation of zooplankton populations*
- Added costs to agriculture and industry

* Under review.

The following sections provide the basis for these determinations.

4.5.1 Tainting of Fish and Wildlife Flavor

The contamination of surface waters by certain types of organic contaminants, such as the class of chemicals known as phenols, can taint fish and wildlife flavor. During the 1950s, 1960s, and 1970s, levels of phenols near the mouth of the Niagara River often exceeded standards designed to prevent tainting of fish and wildlife flavor. Since that time, improvements in wastewater treatment systems and remediation of uncontrolled hazardous waste sites have dramatically reduced the amounts of these substances being discharged to surface waters. Today, levels of phenols are well below levels of concern.

At the time of the Stage 1 beneficial use assessment, there were no existing reports that indicated tainting of fish and wildlife flavor was a concern for the open waters of Lake Ontario. Neither was this potential

impairment identified as a problem in any nearshore areas of the lake. Evaluating this type of impairment is difficult given the very subjective nature of taste. Studies have shown that fish consumers cannot consistently detect the difference between tainted and non-tainted fish. The length of time and preservation methods used before cooking fish can also contribute to taste problems.

4.5.2 Fish Tumors

Fish tumors are more common in some species of nearshore fish, such as brown bullheads and white suckers, than others; however, it is very difficult to determine what the natural tumor incidence rate is for a particular location (Hayes et al., 1990). Relatively high levels of tumors can be found in fish from both clean and polluted water bodies. For example, skin and liver tumors have been documented in fish taken from relatively pristine drinking water reservoirs in New York and Pennsylvania, where no elevated levels of carcinogens [such as polycyclic aromatic hydrocarbons (PAHs)] have been detected in sediments or water (Bowser et al., 1991). This fact complicates the process of selecting a control or background site to which the incidence of fish tumors in a contaminated area can be compared. Viruses, genetic differences, and naturally occurring carcinogens, in addition to chemical contaminants, are thought to have a role in fish tumor development.

The presence of tumors in Lake Ontario fish was first noted in the early 1900s before persistent toxic contaminants became a problem in the lake. Liver tumors were first identified in wild fish in the 1960s. However, a temporal correlation between any change in the incidence of fish tumors and the onset of the severe environmental contamination problems of the 1960s cannot be firmly established because the first detailed studies of fish tumors in Lake Ontario were not conducted until the 1970s.

A 1996 collection of spawning walleye in the Salmon River, a tributary of the Bay of Quinte, found that the frequency of liver tumors increased with the age of the fish and was more prevalent (87.5%) in female walleye greater than 14 years of age. The frequency-age relationship is comparable to previous walleye collections in the St. Lawrence River. The tumors are non-invasive and it is possible that the tumors are a naturally occurring phenomenon in old walleye. However, before any interpretation of probable cause can be made, it will be necessary to determine the rates of liver tumors in similarly aged walleye from other more pristine habitats.

Contaminant-related fish tumors would be expected to be most prominent in Lake Ontario AOCs where there are generally higher contaminant levels than in open water areas. To date, Hamilton Harbour is the only Lake Ontario AOC which lists this impairment. The Oswego Harbor AOC completed a fish tumor study shortly before the BUI assessment that found no impairment. The Toronto and Region, Bay of Quinte, and Eighteenmile Creek AOCs have each indicated that additional information is necessary to fully evaluate the status of this impairment. An assessment of the status of this beneficial use impairment is currently underway in all the Canadian AOCs (except for Port Hope), as part of Environment Canada's Fish and Wildlife Health Effects and Exposure Study.

As there were few reports of tumors in open water fish, fish tumors were not considered to be a lakewide impairment in the Stage 1 beneficial use assessment. The lakewide status of this impairment will need to be periodically evaluated as new information is developed on the incidence of tumors in open water fish as well as the role of contaminants and other factors involved in fish tumor development.

4.5.3 Restrictions on Dredging Activities

Localized areas of sediments with elevated levels of persistent toxic contaminants are found in some Lake Ontario harbors and river mouths. Periodic dredging of these sediments is necessary to maintain shipping and small craft channels. This beneficial use impairment is not considered to be a lakewide impairment

because dredging restrictions do not pertain directly to open water areas; however, this impairment is a concern in a number of localized nearshore areas and AOCs.

Criteria that are used to assess dredging activities are not based on whether or not dredging should take place, but rather the mode of dredged material disposal. There are five main ways to dispose of dredged sediments. Clean, uncontaminated sediments can either be placed on beaches or reused along shorelines as fill. The other three methods of disposal, offshore, upland, and confined, are based on the degree of contamination of the sediments. The most highly contaminated sediments require confined disposal in special contaminated sediment facilities. Less contaminated sediments can be stored in landfills or disposed in deep offshore waters.

The Canadian Department of Public Works and Government Services used to maintain a register for Canadian navigational dredging project data. The register recorded location of dredging, volume of sediments dredged, disposal methods, and chemical analysis data. Information on dredging activities was registered from 1975 until a few years prior to the Stage 1 assessment , when navigational dredging activities declined in the Canadian sections of the Great Lakes. The Hamilton Harbour, Toronto and Region, Port Hope, and Bay of Quinte AOCs all continue to identify dredging restrictions as an impairment. In addition to Lake Ontario LaMP critical pollutants (e.g., dioxins and furans, mercury, PCBs, DDT and its metabolites) sediment concentrations of other organic pollutants (e.g., PAHs, oils and grease), metals (e.g. copper, lead, and zinc) and nutrients (e.g. nitrogen and phosphate) have been identified as elevated above Canada's federal or provincial sediment quality criteria in some near-shore areas (see Screening Level Surveys of Lake Ontario Tributaries, section 6.5.3.1).

In the United States, the Army Corps of Engineers (USACE) oversees and approves dredging projects in coordination with USEPA, NYSDEC and NYSDOS. At the time of the Stage 1 beneficial use assessment, there were no restrictions on dredging or dredged material disposal activities in the U.S. waters of Lake Ontario due to contaminated sediments. Sediment dredged from major Lake Ontario harbors met USEPA and USACE guidelines for open water disposal. No dredging restrictions were identified by the RAPs for Rochester Embayment or Oswego Harbor. The only U.S. dredging restriction applied to the type of dredging methods that could be used on the Genesee River. In response to local concerns regarding excessive turbidity levels, dredging techniques that caused excessive turbidity in the river were not allowed. Contaminated sediments were not a cause of these limitations.

In February 1998, USEPA and USACE finalized the Inland Testing Manual, which laid out stringent testing protocols for dredged material disposal in inland waters. Then, over the next 12 to 18 months, USEPA and USACE worked with their partners to develop a regional manual to implement the national testing protocol in the New York State portions of Lakes Ontario and Erie. The status of this beneficial use could change if future dredging projects encounter sediments that exceed these new, more stringent testing requirements.

4.5.4 Eutrophication or Undesirable Algae

Eutrophication is a process in lakes that is characterized by an overload of nutrients. It is often accompanied by algal blooms, low oxygen concentrations, and changes in food web composition and dynamics. In Lake Ontario, persistent eutrophication and undesirable algae are no longer causes of lakewide problems. The elimination of eutrophication problems in Lake Ontario during the 1950s and 1960s is largely due to the success of the binational phosphorus reduction programs and improvements in wastewater treatment plants throughout the entire Great Lakes basin. In the summer of 1993, the average Lake Ontario total phosphorus level was 9.7 ug/L, near the GLWQA objective of 10 ug/L for open lake spring conditions (IJC, 1980 and Thomas et al., 1980).

In the 1950s and 1960s, algal blooms and fish die-offs occurred throughout Lake Erie and Lake Ontario, raising concerns about the environmental impacts of excessively high phosphorus levels. In an attempt to remedy this problem, the GLWQA set a target load of 7,000 metric tonnes of phosphorus per year. To measure the success of the reduction programs, additional targets were set: phosphorus concentration (10 ug/L), chlorophyll a (2.6 ug/L), and water clarity (5.3 m in open waters).

In response to the phosphorus control programs, open lake phosphorus concentrations declined from a peak of about 25 ug/L in 1971 to the 10 ug/L guideline in 1985. By 1991, Lake Ontario phosphorus levels were well below the guideline. In addition, at the time of the Stage 1 beneficial use assessment, water clarity had increased by 20 percent, compared to the early 1980s. Likewise, photosynthesis had declined approximately 18 percent, and late summer zooplankton production had declined by 50 percent. All of these were changes reflecting an overall shift of the lake back towards its original condition of low nutrient levels.

Although significant progress has been made in reducing eutrophication problems in nearshore areas, this is still a concern in local areas. Each of the Lake Ontario AOCs, with the exception of Port Hope and Oswego Harbor, has identified eutrophication as a local impairment. In New York State, Braddock Bay, Irondequoit Bay, Sodus Bay, East Bay, Port Bay, Little Sodus Bay, Chaumont Bay, and Mud Bay are showing signs of eutrophication. Nutrients from agricultural runoff and on-site waste disposal systems (septic systems) are the most frequently identified sources of the problem in these areas. County level environmental planning efforts are providing the lead on controlling these localized eutrophication problems in the U.S.

Growth of the attached green algae *Cladophora* appears to be widespread in the nearshore of western Lake Ontario and along the north shore of the lake. The fouling of shoreline by decaying mats of algae composed largely of *Cladophora*, a common occurrence in the 1960 and 1970s, has been reported in recent years in the St. Catharines, Burlington, Oakville and Mississauga areas. The cause of the apparent resurgence in the abundance of *Cladophora* is unclear, however, an abundance of *Cladophora* has historically been considered as an indicator of nutrient enrichment in the Great Lakes.

In conclusion, it appears that eutrophication is no longer a problem in offshore waters. This is largely due to the success of the binational phosphorus reduction programs and improvements in wastewater treatment plants throughout the entire Great Lakes basin. Although substantial improvements have been made in the nearshore areas, eutrophication may still be a significant issue in some areas.

4.5.5 Restrictions on Drinking Water Consumption, or Taste and Odor Problems

Regular monitoring of the quality of water supplies drawn from Lake Ontario shows that water quality meets or exceeds public health standards for drinking supplies. Open lake surveillance monitoring conducted as part of Canadian and United States research efforts also confirms the high quality of Lake Ontario water.

The largest category of consumer complaints about drinking water worldwide, is taste and odor problems (AWWA, 1987). Changes in the taste of drinking water may indicate possible contamination of the raw water supply, treatment inadequacies, or contamination of the distribution system. Alternatively, microorganisms naturally present in the source water may periodically produce compounds with off taste and flavour. Although there are standards for some parameters that may cause taste and odor problems, such as phenolic compounds, there is considerable variation among consumers as to what is acceptable. Aesthetically acceptable drinking water supplies should not have an offensive taste or smell.

Although there are no drinking water restrictions on the use of Lake Ontario water, many nearshore areas, such as Rochester, the Bay of Quinte, and much of Canadian shores of western Lake Ontario report occasional taste and odor problems. Lake Ontario water suppliers most commonly receive consumer complaints regarding an "earthy" or "musty" taste and odors. Studies conducted by Lake Ontario water suppliers have shown that these problems are related to naturally occurring chemicals, such as geosmin (trans, trans-1,10-dimethyl-9- decalol) and methylisoborneol (MIB), produced by blue-green algae and bacteria. Using chlorine to clear water supply intakes of zebra mussels may also exacerbate the release of these taste and odor-causing chemicals into the water mass. Geosmin and MIB can cause taste and odor problems for sensitive individuals at levels as low as one part per trillion (ppt), well below the detection limits of the analytical equipment currently available to water authorities (2 to 3 ppt). Once identified, taste and odor problems can be alleviated at water treatment plants by the use of powdered activated carbon or potassium permanganate.

Taste and odor problems are more common during algal blooms. Localized eutrophication problems in some nearshore areas may also contribute to taste and odor problems.

During the late summers of 1998 and 1999 a number of water treatment facilities drawing source water from the Canadian shores of western Lake Ontario experienced taste and odor in raw water due to elevated levels of the naturally occurring compound geosmin. The taste and odor episodes of 1998 and 1999 were the impetuous for an ongoing program of research and monitoring into the sources of taste and odor compounds in western Lake Ontario by a consortium of Ontario municipal and government partners known as the Ontario Water Works Research Consortium (see www.owwrc.com). There have not been any severe episodes of taste and odor on the Canadian shores of western Lake Ontario since 1999; however, a late summer pulse in geosmin production has been detected annually in western Lake Ontario since 2000. The wide-scale production of geosmin in the surface waters of the lake is thought to be due to the development of a population of the cyanobacteria *Anabaena lemmermanii* in the lake plankton during late summer.

In summary, taste and odor problems are considered to be a locally impaired beneficial use in some areas yet may be of a more wide-spread problem such as the episodes in western Lake Ontario of 1998 and 1999. There is a diversity of potential causes of off taste and odor in lake water. Naturally occurring algae, eutrophic conditions, and zebra mussel controls may all be important contributing factors.

4.5.6 Beach Closings

Beach closings are restricted largely to shorelines near major metropolitan centers or the mouths of streams and rivers. These closings follow storm events when bacteria-rich surface water runoff is flushed into nearshore areas via streams, rivers, and combined sewer overflows (CSOs). In some instances beaches may be closed based on the potential for high bacteria levels to develop following storm and rain events. Beaches are also closed for aesthetic reasons, such as the presence of algal blooms, dead fish, or garbage. Given the localized nature of beach closings and their absence along much of the Lake Ontario shoreline, they are not a considered lakewide problem.

In Ontario, Canada, beaches are closed when bacterial (E. coli) levels exceed 100 organisms/100mL. From 1995 to 2005 closings have continued in heavily urbanized areas in the western part of the basin due to storm events, but are less frequent in the central and eastern regions. Examples of ongoing problems include the beaches of the Bay of Quinte, Toronto, Burlington, Hamilton, Niagara, Pt. Dalhouse, and St. Catherines. Upgrading stormwater controls through the installation of collection tanks so stormwater from CSOs can be treated in Toronto and Hamilton should reduce number, duration and scale of beach closings in these areas.

On the U.S. side, Congress passed the Beaches and Environmental Assessment and Coastal Health (BEACH) Act in 2000 to improve the protection of public health at beaches with stronger beach monitoring programs. The Act establishes uniform criteria for testing, monitoring and notifying public users of coastal recreational waters, and provides funds to support state and local government monitoring and public notification. From 2001-2005, NYS received $1.4 million for monitoring and public notification. In addition, in 2004 USEPA announced a Clean Beaches strategy which includes a Clean Beaches Plan.

There are 19 beaches on Lake Ontario on the U.S. side. One hundred per cent of Lake Ontario beaches have beach monitoring and public notification in place. The beaches are monitored by county health departments, state health department or State Offices of Parks, Recreation and Historic Preservation (OPRHP). In 2005, 12 beaches were not closed at all and 7 beaches had beach closings totaling 68 days of closure. The closures were for reasons including algae, exceedences of the E. coli single sample limit (235/100 ml); poor water clarity and preemptive closure based on rainfall models.

The sampling frequency for E. Coli is determined by location of beach, closeness to stormwater outfalls, possibility of agricultural run-off and other factors. Sampling is done at 14 beaches once a week; at 1 beach 5 times/month; at 3 beaches every 2 weeks and daily at Ontario Beach. Ontario Beach is in a harbor used by both commercial and recreational boating.

NYS Department of Health is planning a workshop with county and state health departments and OPRHP to review conditions resulting in closures and discuss the status of efforts in identifying and eliminating where possible, the sources of contamination and conditions that contribute to the closures. Follow-up will include monitoring the implementation of mitigation efforts to determine effectiveness.

NYS Department of Health will also analyze beach samples using a rapid test methodology which will provide results in a few hours. The present standard method takes from 24-72 hrs. for a result. If this new method proves valid it will be a tremendous help in the beach closing and re-opening decision making process.

4.5.7 Degradation of Aesthetics

At the time of the Stage 1 beneficial use assessment, there were no aesthetic problems in the open waters of Lake Ontario. This can be attributed to the elimination of widespread eutrophication problems and the restoration of water clarity. However, some Lake Ontario AOCs have identified this impairment. Evaluating aesthetic problems is subjective, often based on individual value judgments. Localized aesthetic problems along Lake Ontario shorelines include algal blooms, dead fish, debris, odor, silty water, improper disposal of boat sewage wastes, and litter problems at parks and scenic highway stops.

On the U.S. side, the Rochester AOC has listed silt, odors related to alewife dieoffs, and decaying algae as aesthetic problems. A water quality survey conducted at the Oswego Harbor AOC around the time of the Stage 1 assessment indicated that this beneficial use was not impaired.

On the Canadian side, the Toronto and Region RAP listed debris and litter, turbidity in the vicinity of tributary mouths and landfilling operations, and weed growth along shorelines as aesthetic problems. In addition, the Royal Commission for Toronto's Waterfront noted the continued loss of Toronto area historical buildings and landscapes and the lack of adequate public access to the lake as aesthetic concerns. The Bay of Quinte RAP identified algal blooms as the primary cause of aesthetic concerns. Major causes of aesthetic impairment in Hamilton Harbour included oil sheens, objectionable turbidity, floating scum, debris, putrid matter, and reduced water clarity in shallow areas.

4.5.8 Degradation of Zooplankton

After the 1997 review, the LaMP Partners agreed that degradation of zooplankton populations was not a lakewide impairment but due to recent changes in the lake described below this BUI is currently being reviewed. The structure and population levels of zooplankton communities are strongly controlled by phytoplankton levels and by the size and distribution of prey fish that feed on them (such as alewife and smelt). Prey fish may have been the most important controlling factor in the 1980s and early 1990s when their populations were much higher than current levels. Declining nutrient levels also played a role. Although the total zooplankton biomass decreased significantly between 1981 and 1987 as nutrient levels fell, the composition of the zooplankton community changed very little in the main lake.

The transport of exotic zooplankton by oceangoing freighters to the Great Lakes remains an on-going threat to Lake Ontario. *Bythotrephes longimanus* (the spiny water flea) was discovered in Lake Ontario in 1982, followed by the zebra mussel in 1989. A decade later in 1998, *Cercopagis pengoi* (also known as the fishhook flea, a zooplankton native to the Ponto-Caspian region of Europe) was discovered in Lake Ontario. Both *Bythotrephes* and *Cercopagis* are predatory cladocerans that feed on smaller native zooplankton. *Bythotrephes* is generally very rare in the lake; however, *Cercopagis* populations develop each summer throughout the surface waters of the lake. The potential impact that these predatory zooplankton will have on Lake Ontario zooplankton communities is not well understood at this time. In addition, it is anticipated that reductions in phytoplankton densities due to zebra and quagga mussel filtering may result in smaller zooplankton populations, particularly in nearshore regions.

Research has provided a better understanding of seasonal changes in zooplankton populations in nearshore, offshore and embayments. Studies carried out around the time of the 2002 BUI assessment in U.S. waters of Lake Ontario indicated that embayments are very productive habitats compared to nearshore and offshore areas. Embayment phosphorus concentrations were nearly twice those in nearshore and three times those in offshore areas. Embayment chlorophyll-a and zooplankton density were higher than both nearshore and offshore habitats. This suggests that embayments may be an important source of food for developing fish.

4.5.9 Added Costs to Agriculture or Industry

This is not a lakewide impairment as Lake Ontario waters do not require any additional treatment costs prior to agricultural or industrial use. The Rochester Embayment AOC was the only Lake Ontario AOC to identify this impairment, based on the additional maintenance costs associated with the physical removal of zebra mussels from water intake pipes.

Many industries and municipalities adjacent to Lake Ontario are experiencing zebra mussel infestation in their water intakes. The main treatment for this problem is to use various chlorine compounds, together with other chemicals such as calcium permanganate, to kill the mussels -- an ongoing maintenance cost.

4.6 Actions and Progress

During the period between the Stage 1 report and this update (1998-2005), no BUIs were delisted and one, degradation of fish populations was added, even though contaminants in fish and wildlife continued to decline. In summary, contaminant levels declined in bald eagles, colonial waterbirds, mink, otter and snapping turtles, and healthy populations of these animals exist around much of Lake Ontario where habitat is suitable. The exception is in the Golden Triangle area where contaminant issues still exist for mink and snapping turtles. For most species, physical habitat quality and loss are greater concerns now, however, disease issues like botulism may also play an important negative role for fish and wildlife. In 2005, the fish population BUI was deemed impaired due mainly to the impacts of non-native species.

Research into the re-introduction of Atlantic salmon, deep water ciscos as well as food quality issues including thiamin deficiency are key action items currently underway that directly address the impaired fish population BUI. Habitat and phytoplankton (nearshore) are deemed impaired mainly due to the impacts of non-native species. Several projects on lower foodweb and benthos status have been completed or are continuing to assess the impacts of these non-native species on the near and offshore ecosystems. The LaMP directly participated in the Lake Ontario Lower Aquatic Foodweb Assessment project (LOLA) and results of this project should be made public in 2006. The zooplankton BUI is currently listed as not impaired and is under review by the LaMP member agencies.

The Lake Ontario LaMP also participated in the International Joint Commissions water level regulation planning exercise for St. Lawrence River and Lake Ontario. LaMP members sat on the Environmental Technical Working Group and the Fish Sub-Committee and also the STELLA simulations Model Evaluation group. In 2005, the LaMP management committee commented on the 3 plans presented to them (see Section 10.2.3).

In 2003, the Lake Ontario LaMP participated in the Lake Ontario Committee Annual Meeting and did so again in March 2006. The 2003 meeting was particularly important because the LOC presented its State of the Lake Report that year and relied heavily on the LaMP member agencies to contribute information about their agencies areas of monitoring and research. This information provided the basis for SOLEC later in 2004 and was key in re-assessing the fish populations BUI in this report. The State of the Lake Report was submitted for publication by the GLFC and will be used by the LOC to create the next Fish Community Objectives as well as Environmental Objectives for Lake Ontario. The Lake Ontario LaMP will also participate in the development of both of these objectives.

4.7 References

Fish & Wildlife Consumption Advisories

Armstrong, R.W. and R.J. Sloan. 1980. Trends in Levels of Several Known Chemical Contaminants in Fish from New York State Waters. June 30, 1980.

Cain, B.W. 1982. Nationwide residues of organochlorine compounds in wings of adult mallards and black ducks, 1979-1980. Pestic. Monit. J. 15:128-134.

Connelly, N.A. and B.A. Knuth. 1993. Great Lakes fish consumption advisories: Angler response to advisories and evaluation of communication techniques. Human Dimensions Research Unit, Department of Natural Resources, New York State College of Agriculture and Life Sciences, Fernow Hall, Cornell University, Ithaca, NY 14853.

DOH. 1993. 1993-1994 Health Advisories, Chemicals in Sportfish and Game, 1993-1994, Center for Environmental Health, 2 University Place, Albany, New York 12203-3399. April 1993.

Foley, R.E. and G.R. Batcheller. 1988. Organochlorine Contaminants in Common Goldeneye Wintering on the Niagara River. Journal of Wildlife Management, 52(3):441-445.

Foley, R.E. 1992. Organochlorine Residues in New York Waterfowl Harvested by Hunters in 1983-1984. Environmental Monitoring and Assessment, 21:37-48.

Heath, R.G. and S.A. Hill. 1974. Nationwide organochlorine and mercury residues in wings of adult mallards and black ducks during the 1969-70 hunting season. Pestic. Monit. J. 7:153-164.

Honeyfield, D.C., Hinterkopf, J.P., Fitzsimons, J.D., Tillitt, D.E., Zajicek, J.L. and S.B. Brown. 2005. Development of thiamin deficiciencies and early mortality syndrome in Lake Trout by feeding experimental and feral fish diets containing thiaminase. J. Aquatic Animal Health 17:4-12

Kim. H., K.S. Kim, J.S. Kim, and W. Stone. 1985. Levels of polychlorinated biphenyls, DDE, and mirex in waterfowl collected in New York State, 1981-1982. Arch. Environ. Contam. Toxicol. 14:13-18.

Kim, K., M. Pastel, J.S. Kim, and W. Stone. 1984. Levels of polychlorinated biphenyls, DDE, and mirex in waterfowl collected in New York State, 1979-1980. Arch. Environ. Contam. Toxicol. 13:373-381.

Knuth, B.A. and C.M. Velicer. 1990. Receiver-centered risk communication for sportfisheries: Lessons from New York Licensed Anglers. Paper presented at: American Fisheries Society Annual Meeting, Pittsburgh, PA. August 1990. Department of Natural Resources, Cornell University, Ithaca, NY 14853.

Olafsson, P.G., A.M. Bryan, B. Bush, and W. Stone. 1983. Snapping Turtles - A biological screen for PCB's. Chemosphere. 12(11,12):1525-1532.

Ontario Ministry of the Environment.(MOE) 2005. Guide to Eating Ontario Sport Fish: 2005-2006 Edition. 23rd Edition. Queens Printer for Ontario. 251p.

Prouty, R.M. and C.M. Bunck. 1986. Organochlorine residues in adult mallard and black duck wings. Environ. Monit. Assess. 6:49-57.

Ryan, J.J., B.P.-Y. Lau, J.A. Hardy, W. Stone, P. O'Keefe, and J.F. Gierty. 1986. 2,3,7,8-Tetrachlorodibenzop-dioxin and related dioxins and furans in snapping turtle (Chelydra serpentina) tissues from the upper St. Lawrence River. Chemosphere. 15(5):537-548.

Skinner, L.C. 1990a. "Lake Ontario Contaminant Trends." NYSDEC Bureau of Environmental Protection, interoffice memo. May 10, 1990.

Skinner, L.C. 1990b. "Dioxin in Lake Ontario Fish". NYSDEC Department of Environmental Protection, interoffice memo. September 7, 1990.

Skinner, L.C. 1991. "Lake Ontario Contaminants-1991 Spring Collections". NYSDEC Bureau of Environmental Protection, interoffice memo. October 4, 1991. 10 pp.

Skinner, L.C. 1992 "Lake Ontario-Contaminants in Fish." NYSDEC Bureau of Environmental Protection, interoffice memo. October 26, 1992.

Skinner, L.C. 1993. "FDA Analytical Results". NYSDEC Bureau of Environmental Protection, interoffice memo. June 10, 1993.

Skinner, L.C. and R.W. Bauer 1989. Lake Ontario Contaminant Trend Analysis. NYSDEC. 3/17/89.

Skinner, L.C. and R.W. Bauer. 1992. "Near shore Contaminants in Young Fish From New York's Great Lakes Basin". NYSDEC, Bureau of Environmental Protection, interoffice memo. July 22, 1992.

Skinner, L.C. and R.W. Bauer. 1993. NYSDEC Protocol: Special Fish Collections from the Great Lakes Basin for Chemical Analyses. 2/26/93.

Skinner, L.C. and E.G. Horn. 1985. Policy on Chemical Contaminants in Fish: New York State, NYSDEC.

Skinner, L.C. and S.J. Jackling. 1989. Chemical contaminants in young of the year fish from New York's Great Lakes Basin: 1984 through 1987. Tech. Rep. 89-1 (BEP), Division of Fish and Wildlife, NYSDEC, Albany, 43 pp.

Sloan, R. 1987. Toxic Substances in Fish and Wildlife: Analyses since May 1, 1982. NYSDEC Bureau of Environmental Protection, Albany, 182 pp., 5/1/87.

Stone, W., E. Kiviat, and S.A. Butkas. 1980. Toxicants in Snapping Turtles, New York Fish and Game Journal. Vol. 27, No. 1.

Swift, B.L., R.E. Foley, and G.R. Batcheller, 1993. Organochlorines in Common Goldeneyes Wintering in New York, Wild. Soc. Bull. 21:52-56.

Suns, K., G. Crawford, D. Russell, and R. Clement 1985. Temporal trends and spatial distribution of organochlorine and mercury residues in Great Lakes spottail shiners (1975-1983). Ontario Ministry of the Environment. Rexdale, 24 p.

Suns, K., G. Hitchin, and D. Toner. 1991a. Spatial and temporal trends of organochlorine contaminants in spottail shiners (Notropis husonius) from the Great Lakes and their connecting channels (1975-1988), Water Resources Branch, Ontario Ministry of the Environment, Rexdale, 97 p.

Trends of Organochlorine Contaminants in Young-of the-Year Spottail Shiners (Notropis husonius) from Lake Ontario. Can. J. Fish. Aq. Sc. 48:1568-1573.

Suns, K. and G. Hitchin. 1992. Species-specific Differences in Organochlorine Accumulation in Young of the-Year Spottail Shiner, Emerald Shiners, and Yellow Perch. J. Great Lakes Res. 18(2):280-285.

Suns, K., G. Hitchin, and D. Toner. 1993. Spatial and Temporal Trends of Organochlorine Contaminants in Spottail Shiners from Selected Sites in the Great Lakes (1975-1990). J. Great Lakes Res.19(4):703-714.

USEPA. 1992. National Study of Chemical Residues in Fish, Vol. 1 & 2. Office of Science and Technology, Standards and Applied Science Division, EPA 823-R-92-008a. September 1992.

Vena, J.E. 1992. Risk perception, reproductive health risk and consumption of contaminated fish in a cohort of New York State anglers. Year 1 progress report of the New York State Angler Cohort Study, February 14, 1992. Department of Social and Preventative Medicine, School of Medicine, 270 Farber Hill, University at Buffalo, State University of New York, Buffalo, New York, 14214.

White, D.H. 1979. Nationwide residues of organochlorine compounds in wings of adult mallards and black ducks, 1976-77. Pestic. Monit. J. 13:12-16.

White, D.H. and R.G. Heath. 1976. Nationwide residues of organochlorines in wings of adult mallards and black ducks, 1972-73. Pestic. Monit. J. 9:176-185.

Tainting of Fish & Wildlife Flavor

DEC. 1991. Water Quality Regulations: Surface Water and Groundwater Classifications and Standards, New York State Codes, Rules and Regulations, Title 6, Chapter X, Parts 700-705, New York State Department of Environmental Conservation.

DEC and MCDPD. 1993. Rochester Embayment, Remedial Action Plan, Stage 1, August 1993. New York State Department of Environmental Conservation and Monroe County Department of Planning and Development.

Heil, T.P. and R.C. Lindsay. 1990. Environmental and industrial factors relating to flavor tainting of fish in the upper Wisconsin River. Journal of Environmental Science and Health, B25(4):527-552.

Jardine, C.G. and A.B. Bowman. 1990. Spanish River Remedial Action Plan, Fish Tainting Evaluation, Spanish Harbour Remedial Action Plan. Ontario Ministry of the Environment, Northeastern Region, Technical Report SR-90-01, 15 pp.

Degradation of Fish and Wildlife Populations

Bouvier, E. 2002. Mink and otter as ecosystem indicators for the Lake Ontario LaMP. 55 pp.

Brown, S.B., Fitsimons, J.D., Honeyfield, D.C. and D.E.Tillitt. 2005. Implications of thiamine deficiency in Great Lakes Salmonines. J.Aquatic Animal Health 17:113-124

Christie, W.J. 1972. Lake Ontario: effects of exploitation, introductions and eutrophication on the salmonid community. Journal of the Fisheries Research Board of Canada. 29:913-929.

Christie, W.J. 1973. A review of the changes in fish species composition of Lake Ontario. Great Lakes Fishery Commission Technical Report No. 23, 65 pp.

DEC. 1993a. 1993 Annual Report, Report of the Lake Ontario Committee to the Great Lakes Fishery Commission, G. LeTendre [ed.]. Division of Fish and Wildlife, New York State Department of Environmental Conservation, Albany, New York 12233. 208 pp.

DEC. 1993b. New York State, Ontario Revises Lake Ontario fish stocking plans. News release, New York State Department of Environmental Conservation, April 7, 1993. NYSDEC, 50 Wolf Road, Albany, New York 12233-1020.

Edsall, T.A, C.L. Brown, G.W. Kennedy, J.R.P. French. 1992. Surficial substrates and bathymetry of five historical lake trout spawning reefs in near-shore waters of the Great Lakes. Technical report 58, Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 209, Ann Arbor, MI 48105-1563. October 1992.

Eshenroder, R.L., T.P. Poe, and C.H. Oliver. 1984. Strategies for rehabilitation of lake trout in the Great Lakes: Proceedings of a conference on lake trout research, August 1983. Technical report No. 40. Great Lakes Fishery Commission, Ann Arbor Michigan.

Fitzsimons, J., B. Lantry, and R. O'Gorman. 2003. A review of lake trout (*Salvelinus namaycush*) restoration in Lake Ontario from and early life history perspective. *in* M. Munawar (Ed.), The State of Lake Ontario (SOLO), Past, Present and Future. Ecovision World Monograph Series. Aquatic Ecosystem Health Management. pp. 492-516.

GLFC. 1993. 1993 Annual report, Bureau of Fisheries, Lake Ontario Unit to the Lake Ontario Committee and the Great Lakes Fishery Commission. April 1993. Prepared by Bureau of Fisheries, Lake Ontario Unit and NYSDEC Region 6-9 Fisheries Management Units and Ontario Ministry of Natural Resources – Lake Ontario Unit.

GLFC. 1994. 1994 Annual report, Bureau of Fisheries, Report of the Lake Ontario Committee to the Great Lakes Fishery Commission. June 1 1994. GLFC Annual Meeting. Agenda Item #9.

Guiney, P., E. Zabel, R. Peterson, P. Cook, J. Casselman, J. Fitzsimons, H. Simonin. 1993. Abstract: Assessment of Lake Ontario lake trout for 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents (TEQs)-induced sac fry mortality in 1991. In Proceedings: Society of Environmental Toxicology and Chemistry, 14th Annual Meeting, Houston, Texas. November 1993.

Honeyfield, D.C., Hinterkopf, J.P., Fitzsimons, J.D., Tillitt, D.E., Zajicek, J.L. and S.B. Brown. 2005. Development of thiamin deficiciencies and early mortality syndrome in Lake Trout by feeding experimental and feral fish diets containing thiaminase. J.Aquatic Animal Health 17:4-12

IJC. 1987. The 1987 Report on Great Lakes Water Quality, Appendix B, Great Lakes Surveillance, Vol. 1, [eds.] D.E. Ratke and G. McRae. Great Lakes Water Quality Board report to the International Joint Commission. IJC. 1990. Proceedings of the Roundtable on Contaminant-caused reproductive problems in salmonids, Executive Summary, [eds.] M. Gilbertson and M. Mac. Windsor, Ontario, September 24 and 25, 1990. ISBN 1-895085-41-1.

Johannsson, O.E. 2003. A history of changes in zooplankton community structure and function in Lake Ontario: Responses to whole-lake remediation and exotic invasions, *in* M. Munawar (Ed.), The State of Lake Ontario (SOLO), Past, Present and Future. Ecovision World Monograph Series. Aquatic Ecosystem Health Management. pp. 221-256.

Kerr, S.J and G. LeTendre. 1991. The state of the Lake Ontario fish community in 1989. Special Publication No. 91-3. Great Lakes Fishery Commission, 1451 Green Road, Ann Arbor MI 48105, November 1991. 38 pp.

Krueger, C.C. Personal communication. Department of Natural Resources, Fernow Hall, Cornell University, Ithaca, NY 14853.

Krueger, C.C., D.L. Perkins, E.L. Mills, and J.E. Marsden. 1994. Alewife predation of lake trout fry in Lake Ontario: role of exotic species in preventing native species restoration. Submitted to: Rehabilitation of Lake Trout in the Great Lakes: A critical assessment. J. Great Lakes Res., Internat. Assoc. Great Lakes Res. Version. 1/28/94.

Lange, R. and P. Smith. 1993. Signs of Change in the Lake Ontario Ecosystem. Fact sheet developed by Great Lakes Fishery Section, New York Department of Environmental Conservation and the Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources. Distributed by NYSDEC, 50 Wolf Road, Albany, New York 12233.

Lange, R. Personal communication. Great Lakes Fisheries Head, Bureau of Fisheries, Division of Fish and Wildlife, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233.

Mac, M. 1990. Lake trout egg quality in Lakes Michigan and Ontario. In Proceedings of the Roundtable on Contaminant-caused reproductive problems in salmonids, Executive Summary, [eds.] M. Gilbertson and M. Mac. Windsor, Ontario, September 24 and 25, 1990. ISBN 1-895085-41-1.

Mac, J.M. and C.C. Edsall. 1991. Environmental Contaminants and the reproductive success of lake trout in the Great Lakes: an epidemiological approach. J. of Toxicology and Environmental Health,33:375-394.

Marsden, J.E., C.C. Krueger, and C.P. Schneider. 1988. Evidence of natural reproduction by stocked lake trout in Lake Ontario. J. Great lakes Res. 14(1):3-8.

Marsden, J.E. and C.C. Krueger. 1991. Spawning of hatchery origin lake trout (Salvelinus namaycush) and diver observations. Can. J. Fish. Aquat. Sci., 48:2377-2384.

Ontario Ministry of Natural Resources. 1990. Lake Ontario Fisheries Unit, 1989 annual report. Lake Ontario Committee Annual Meeting (Minutes). March 28-29, 1990. Great Lakes Fishery Commission. p. 441-591.

Perkins, D.L. and C.C. Krueger. 1992. Dynamics of lake trout reproduction: distribution and density of eggs and fry on cobble substrate. Final report to the Great Lakes Fishery Commission, August 28, 1992. Department of Natural resources, Fernow Hall, Cornell University, Ithaca, NY 14853.

Schaner, T., C.P. Schneider, T.H. Eckert, J.H. Elrod, R. O'Gorman, and R.W. Owens. 1993. Lake trout rehabilitation in Lake Ontario, 1992. 1993 Lake Ontario Committee Report, Great Lakes Fishery Commission, Lake Ontario Committee Meeting, March 23-24, 1993. Niagara Falls, NY.

Schneider, C.P., D.P. Kolenosky, and D.B. Goldthwaite. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario. Great Lakes Fishery Commission, Lake Ontario Committee, Special Publication, 50 pp.

Schneider, C.P., T. Schaner, J.E. Marsden, and W.D. Busch. 1990. Draft Lake Ontario Lake Trout Rehabilitation Plan. Lake Trout Technical Committee. Lake Ontario Committee. Great Lakes Fisheries Commission.

Schneider, C.P., T.H. Eckert, J.H. Elrod, R. O'Gorman, and R.W. Owens. 1995. Lake Trout Rehabilitation in Ontario, 1995. In 1995 Annual Report to the Great Lakes Fisheries Commission. NYSDEC. Lake Ontario Unit.

Simonin H., J. Skea, H. Dean, and J. Symula. 1990. Summary of Reproductive studies of Lake Ontario salmonids. In Proceedings of the Roundtable on Contaminant-caused reproductive problems in salmonids, Executive Summary, [eds.] M. Gilbertson and M. Mac. Windsor, Ontario, September 24 and 25, 1990. ISBN 1-895085-41-1.

Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson. 1991. 2,3,7,8-Tetrachlorodibenzo-pdioxin (TCDD) toxicity during early life stage development of lake trout (Salvelinus namaycush). Can. J. Fish. Aquat. Sci. 48:875-883.

Fish Tumors

Baumann, P.C., W.D. Smith, and M. Ribick. 1982. Hepatic tumor rates and polynuclear aromatic hydrocarbon levels in two populations of brown bullheads (Ictalurus nebulosus). In Polynuclear Aromatic Hydrocarbons; Physical and Biological Chemistry, [eds.] M. Cooke, A.J. Dennis and G.L. Fisher, pp 93-102. Columbus Ohio: Battelle Press.

Bowser, P.R., M.J. Wolfe, J. Reimer, and B.S. Shane. 1991. Epizootic papillomas in brown bullheads (Ictalurus nebulosus) from Silver Stream Reservoir, New York. Dis. Aquat. Org. 11:117-127.

Black, J.J., P.P. Dymerski, and W.F. Zapisek. 1980. Fish tumor pathology and aromatic hydrocarbon pollution in a Great Lakes estuary. In: Afgan, B.K. and D. Mackay [eds.]. Hydrocarbons and halogenated

Black, J.J. 1983. Field and laboratory studies of environmental carcinogenesis in Niagara River Fish. J. Great Lakes Res. 9(2):326-334.

Black, J.J., H. Fox, P. Black, and F. Block. 1985. Carcinogenic effects of river sediment extracts in fish and mice. In: R.L. Joley et al. [eds.] Water Chlorination: Chemistry, environmental impacts and health effects. Lewis Publishers, Inc. Vol. 1:55-81.

Cairns, V.W. and J.D. Fitzsimons. 1988. The occurrence of epidermal papillomas and liver neoplasia in white suckers (Catostomus commersoni) from Lake Ontario. Abstract in: Niimi, A.J. and K.R. [eds.]Proceedings of the fourteenth annual aquatic toxicity workshop: Nov. 2-4, 1987. Government of Canada. 1991. Toxic chemicals in the Great Lakes and associated effects. Vol. II -Effects. Environment Canada, Department of Fisheries and Oceans, Health and Welfare Canada, March 1991.

Hayes, M.A., I.R. Smith, T.H. Rushmore, T.L. Crane, C. Thorn, T.E. Kocal, and H.W. Ferguson. 1990. Pathogenesis of skin and liver neoplasms in white suckers from industrially polluted areas in Lake Ontario. The Science of the Total Environment, 94:105-123.

Harshbarger, J.C. and J.B. Clark. 1990. Epizootiology of neoplasms in bony fish of North America. Science of the Total Environment 94:1-32.

Hickey, J.T., R.O. Bennett, and C. Merckel. 1990. Biological indicators of environmental contaminants in the Niagara River: Histological evaluation of tissues from brown bullheads at the Love Canal-102nd Street Dump Site compared to Black Creek, reference site. U.S. Fish and Wildlife Service, New York Field Office, 100 Grange Place, Room 202, Cortland, New York 13045.

LeTendre, G. 1993. 1993 Lake Ontario Committee Report to the Great Lakes Fishery Commission. 1992. Lake Ontario Program Summary, Lake Ontario Fisheries Unit, New York State Department of Environmental Conservation, Cape Vincent, New York, 13618.

Mix, M.C. 1985. Cancerous diseases in aquatic animals and their association with environmental pollutants: a critical review of the literature. Final report for the American Petroleum Institute. 239 p.

Rice, C. 1990. Preliminary Investigations of “tumors” in brown bullheads from Lake Ontelaunee, Ontelaunee and Maiden Creek Townships, Berks County, Pennsylvania. U.S. Fish and Wildlife Service Special Report 90-1. State College, PA.

Smith, I.R., K.W. Baker, M.A. Hayes, and H.W. Ferguson. 1989. Ultrastructure of malpighian and inflammatory cells in epidermal papillomas of white suckers (Catostomus commersoni). Dis. of Aquatic Organisms 6:17-26.

Smith, I.R. and B.A. Zajdlik. 1987. Regression and development of epidermal papillomas affecting white suckers (Catostomus commersoni), from Lake Ontario, Canada. Journal of Fish Diseases 10:487-494.

Sonstegard, R.A. 1977. Environmental carcinogenesis studies in fishes of the Great Lakes of North America. Annals of the New York Academy of Science, 298:261-232.

Spitsbergen, J. M. Personal communication. Dept. of Avian and Aquatic Animal Medicine, College of Veterinary Medicine, Cornell University, Ithaca, New York, 14853.

Wolfe, M. 1986. Pathology Report, Salvelinus namaycush, Charity Shoal, Lake Ontario, September 9-10, 1986. Cornell University, Dept. of Avian and Aquatic Animal Medicine.

Bird and Animal Reproduction Problems and Deformities

Addison, E.M., G.A. Fox, and M. Gilbertson. 1991. Summary, In: Proceedings of the Expert Consultation Meeting on Mink and Otter, Windsor, Ontario, March 5 and 6, 1991. International Joint Commission, ISBN 1-895085-32-2.

Anderson, D.W. and J.J. Hickey. 1972. Eggshell changes in certain North American birds, Proc. Int. Ornithol. Congr. (15):514-540.

Aulerich, R.J. and R. Ringer. 1977. Current Status of PCB Toxicity in Mink and Effect on Their Reproduction. Archives of Environmental Contamination and Toxicology. (6):279-292. Best, D. 1992. Reproductive impairment of bald eagles along the Great Lakes shorelines of Michigan and Ohio, and association with contaminant residues in addled eggs. In: Proceedings of the third expert consultation meeting on bald eagles in the Great Lakes Basin, International Joint Commission, Windsor Ontario, February 25 to 26, 1992.

Bishop, C.A., D. Weseloh, N.M. Burgess, J. Struger, R.J. Norstrom, R. Turle, and K.A. Logan. 1992. An Atlas of Contaminants in Eggs of Fish-eating Colonial Birds of the Great Lakes (1970-1988) Vols 1 and 2. Canadian Wildlife Service Technical Report Series Nos. 152 and 153. Ontario Region.

Blokpoel, H. and D.V. Weseloh. 1982. Status of colonial waterbird nesting on Little Galloo Island, Lake Ontario. Kingbird. Summer 1982. pp. 149-157.

Blokpoel, H. and G.D. Tessier. 1988. The ring-billed gull in Ontario: a review of a new problem species. Can. Wild. Serv. Prog. Notes No. 87.

Blokpoel, H. and G.D. Tessier. 1996. Distribution and abundance of colonial waterbirds nesting on Lake Ontario, 1976 to 1987. Can J. Fish. Aquatic Sci.

Bowerman, W., D. Best, T. Kubiak, S. Postupalsky, J. Giesy, and D. Tillit. 1991. Bald eagle reproductive impairment around the Great Lakes: association with organochlorine contamination, In: Cause and Effect Linkages II Symposium Abstracts, Michigan Audubon Society, September 27-28, 1991. Traverse City, Michigan.

Broley, C.L. 1952. Eagle Man, Pelligrine and Cudahy, New York, NY. 210 pp.

Courtney, P.A. and H. Blokpel. 1983. Distribution and numbers of common terns on the lower Great Lakes during 1900-1980: A review. Colonial Waterbirds 6:107-120.

Custer, T.W., R.M. Erwin, and C. Stafford. 1983. Organochlorine residues in common tern eggs from nine Atlantic coast colonies. 1980. Colonial Waterbirds 6:197-204.

DEC. 1993. Draft Niagara River Remedial Action Plan, Volume I, March 1993, Albany, New York.

Edwards, M. 1970. (43). Uninhabited island in Lake Ontario. Audubon Field Notes 24:767-768.

Eisler, R. 1985. Selenium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wild. Serv. Biol. Rep. 85(1.5). 57 pp.

Eisler, R. 1986. Chromium hazards to fish wildlife and invertebrates: a synoptic review. U.S. Fish Wild. Serv. Biol. Rep. 85(1.6). 60 pp.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wild. Serv. Biol. Rep. 85(1.10). 90 pp.

Ewins, P.J. and D.V. Weseloh. 1994. Effects on Productivity of Shooting of Double-crested Cormorants on Pigeon Island, Lake Ontario, in 1993. J. Great Lakes Res. 20(4):761-767.

Fimreite, N. 1971. Effects of dietary methylmercury on ring-necked pheasants. Canadian Wildlife Service, Occasional Papers No. 9.

Foley, R.E., S.J. Jackling, R.J. Sloan, and M.K. Brown. 1988. Organochlorine and mercury residues in wild mink and otter: comparison with fish. Environ. Toxicol. Chem. 7:376-374.

Foley, R.E., T. Martin, and G. Caputo. 1991. Mink and Otter in New York State: Contaminants and preliminary population studies, In: Proceedings of the Expert Consultation Meeting on Mink and Otter, Windsor, Ontario, March 5 and 6, 1991. 12 pp. International Joint Commission, ISBN 1-895085-32-2.

Fox, G.A. 1976. Eggshell quality: its ecological and physiological significance in a DDE-contaminated common tern population. Wilson Bull. 88:459-477.

Fox, G.A., D.V. Weseloh, T.J. Kubiak, T.C. Erdman. 1991. Reproductive outcomes in colonial fisheating birds: A biomarker for developmental toxicants in Great Lakes food chains, J. Great lakes Res. 17(2):153-157, Internat. Assoc. Great Lakes Res., 1991.

Gilbertson, M. 1974. Pollutants in breeding herring gulls in the lower Great Lakes. Can. Field Naturalist (88):273-280.

Gilbertson, M. 1975. A Great Lakes tragedy. Nature Canada 4:22-25.

Gilbertson, M. 1983. Etiology of chick-edema disease in herring gulls in the lower Great Lakes. Chemosphere 12:357-370.

Gilbertson, M and R. Hale. 1974. Early embryonic mortality in a colony of herring gulls in Lake Ontario. Can. Field Naturalist 88:354-356.

Gilbertson, M., R.D. Morris, and R.A. Hunter. 1976. Abnormal chicks and PCB residue levels in eggs of colonial waterbirds on the lower Great Lakes (1971-1975). Auk 93:434-442.

Government of Canada. 1991. Toxic chemicals in the Great Lakes and associated effects, Vols. 1 and 2,

Environment Canada, Dept. of Fisheries and Oceans, Health and Welfare Canada Cat. No. En 37-95/1990-1E, ISBN 0-662-18317-7, March 1991.

Hall, E. and K. Kelson. 1959. The Mammals of North America. Ronald Press Co., New York. 1083 pp.

Harper, L.H. and J.E. Fontaine. 1991. Conservation and Management of St. Lawrence River/Lake Ontario common terns (Sterna hirundo), 1991 Final report, St. Lawrence University, Dept. of Biology, Canton, New York 13617.

Hartsough, G. 1965. Great Lakes Fish Now Suspect as Mink Food. American Fur Breeder. 38:25.

Heaton, S.N., R.J. Auerlich and S.J. Bursian, J.P. Giesy, D.E. Tillit, J.A. Render, and T.J. Kubiak. 1989.Reproductive effects in mink fed carp from Saginaw Bay, Michigan. Presented at Society of Environmental Toxicology and Chemistry, Tenth Annual Meeting, Toronto 1989.

IJC. 1992. Preamble. In: Proceedings of the third expert consultation on bald eagles in the Great Lakes basin. [ed.] M. Gilbertson., February 25 to 26, 1992. ISBN 1-895085-42-X.

Karwowski, K. Personal communication. Fish and Wildlife Biologist, Ecological Services, New York Field Office, U.S. Fish and Wildlife Service, Cortland, New York, 13045.

Lake Ontario Lakewide Management Plan 4-27 February 27, 2004

Karwowski, K. 1992. Draft biomonitoring report and assessment of environmental contaminants in breeding common terns (Sterna hirundo) of the St. Lawrence River. U.S. Fish and Wildlife Service, New York Field Office, 3817 Luker Road, Cortland, New York 13045.

Kirk, R.J. 1971. Fish meal, higher cereal levels perform well. U.S. Fur Rancher 50:4-6.

Kurita, H., J.P. Ludwig, and M.E. Ludwig. 1987. Results of the 1987 Michigan Colonial Waterbird Project on Caspian Terns and Double-crested Cormorants: Egg Incubation and Field Studies of Colony Productivity, Embyrologic Mortality and Deformities. Ecological Research Associates, Inc., Bay City, MI, report to the Michigan Department of Natural Resources.

Linscombe, G., N. Kinler, and R. Aulerich. 1982. Mink. In: J. Chapman and G. Feldhamer [eds.], Wild Mammals of North America: Biology, management and economics. John Hopkins Univ. Press, Baltimore. pp. 629-643.

Mayack, D. Personal communication. Conservation Biologist, Division of Fish and Wildlife, Hale Creek Field Station, New York State Department of Environmental Protection. Miller, R.L. Personal communication. Wildlife Resources Center, New York State Department of Environmental Conservation, Delmar, New York 12054-9767.

Miller, R.L. 1992. Little Galloo Island - Field Visit, 1992, New York State Department of Environmental Conservation, September 10, 1992. Wildlife Resources Center, Delmar, New York 12054-9767.

Miller, R.L. 1993. Field Visit to Little Galloo Island, Lake Ontario, New York, September 17, 1993. Field report, Wildlife Resources Center, Delmar, New York 12054-9767.

Mineau P., G.A. Fox, R.J. Norstrom, D.V. Weseloh, D.J. Hallett, and J.A. Ellenton. 1984. Using the herring gull to monitor levels and effects of organochlorine contamination in the Canadian Great Lakes. In: Toxic Contaminants in the Great Lakes. [eds.] J.O. Nriagu and M.S. Simmons, pp. 425-452. New York: Wiley.

Moore, F.R. 1976. The dynamics of seasonal distribution of Great Lakes herring gulls. Bird Banding 47:141-159.

Morris, R.D., I.R Kirkham, and J.W. Chardine. 1980. Management of a declining common tern colony. Journal of Wildlife Management 44:241-245.

New York Department of State. 1991. Designated Habitat: Braddock Bay and Salmon Creek, Significant Coastal Fish and Wildlife Program. Albany.

Nye, P. 1979. Present and historic activity of bald eagles in New York, Study No. II., Project No. E-1-3, New York State Department of Environmental Conservation, Endangered Species Unit, Delmar, NY 12504.

Nye, P. 1992. Status, problems, and prognosis for New York State bald eagles, In: Proceedings of the third expert consultation meeting on bald eagles in the Great Lakes Basin. [eds.] M. Gilbertson and M. Mac. International Joint Commission, Windsor, Ontario February 25 to 26, 1992. ISBN 1-895085-42-X.

Pekarik, C., Robinson, J., Weseloh, D.V., Welch, K., Shutt, L. and Barrett, G. Type-E Botulism-Related Mortality of Waterbirds in Lake Ontario During Autumn 2004. Abstracts: One Hundred and Twenty-Third Stated Meeting of American Ornithologists' Union. 23-27 August 2005.

Pettitt, K., C.A. Bishop, D.V. Weseloh, and R.J. Norstrom. 1994. An Atlas of Contamination in Eggs of Fish-eating Colonial Birds of the Great Lakes (1989-1992). Volume 1. Technical Report Series No. 193. Canadian Wildlife Service, Ontario.

Platonow, N.S. and L.H. Karstad. 1973. Dietary effects of polychlorinated biphenyls on mink. Can. J. Comp. Med. 37:391-400.

Price, I.M. and D.V. Weseloh. 1986. Increased numbers and productivity of double-crested cormorants, Phalacrocorax auritus, on Lake Ontario. Can Field Nat. 100:474-482.

Postupalsky, S. 1978. Toxic Chemicals and cormorant populations in the Great Lakes. Canadian Wildlife Service Wildlife Toxicology Division Manuscript Report. No. 40.

Quilliam, H.R. 1973. The History of the Birds of Kingston, Ontario. 2nd Ed., Kingston Field Naturalists. Kingston, Ontario.

Sealander, J. 1943. Notes on some parasites of the mink in southern Michigan. J. Parisitol. 29:361-362.

Schiavone, A. and D. Faulknham. 1993. Double-crested cormorant task force report, New York State Department of Environmental Conservation, Region 6, April 1993.

Shugart, G.W. and W.C. Scharf. 1983. Common terns in the northern Great Lakes: Current status and populations trends. J Field Ornithol. 54:160-169.

Sileo, L., L. Karstad, R. Frank, M.V.H. Holdrinet, E. Addison, and H.E. Braun. 1977. Organochlorine poisoning of Ring Billed Gulls in southern Ontario. J. Wildl. Dis. 13:313-321.

Stein, R., K. Bogenrieder and R. Cull. 1991. Status of Common Terns on the Buffalo and Upper Niagara River. 1990, Final Report, FY 1990-1991. Buffalo State College, January 31, 1991.

Stein, R.C., M.S. Rajczak, and R. Cull. 1992. Status of Common Terns on the Buffalo and Upper Niagara River, April 1991 to August 1991. Final Report, FY 1991-1992. State University College, Buffalo, NY.

Switzer, B., V. Lewin, and E.H. Wolfe. 1973. DDE and reproductive success in some Alberta Common Terns. Can. J. Zool. 51:1081-1086.

Toweill, D. 1974. Winter food habits of river otters in western Oregon. J. Wildl. Manage. 38(1):107-111.

Toweill, D.E. and J.E. Tabor. 1982. River otter. In J. Champman and G. Feldhammer [eds.], Wild Mammals of North America. John Hopkins Univ. Press, Baltimore. pp. 688-703.

Weseloh, D.V., A. Bath, J. Robinson, and E. Addison. 1992. Lakes Erie and Ontario habitat surveys, In: Proceedings of the third expert consultation meeting on bald eagles in the Great Lakes Basin, International Joint Commission, Windsor Ontario, February 25 to 26, 1992.

Weseloh, D.V., C.A. Bishop, R.J. Norstrom, and G.A. Fox. 1991. Monitoring levels and effects of contaminants in herring gull eggs on the Great Lakes, 1974-1990, In: Cause-Effect Linkages II Symposium Abstracts, September 27-28, 1991. Grand Traverse Resort, Traverse City, Michigan, Michigan Audubon Society.

Weseloh, D., T.W. Custer, and B.M. Braune. 1989. Organochlorine Contaminants in Eggs of Common Terns from the Canadian Great Lakes, 1981. Environmental Pollution. 59:141-160.

Weseloh, C., Gee, K., Robinson, J. Campbell, D. 2003. Mortality in Great Black-Backed Gulls near Presqu'ile. Canadian Cooperative Wildlife Health Centre Newsletter 9(2), 8-9. Available on the internet at: http://wildlife1.usask.ca/ccwhc2003/newsletters/newsletter9-2.htm#gulls

Weseloh, D., P. Mineau, and D.J. Hallett. 1979. Organochlorine Contaminants and Trends in Reproduction in Great Lakes Herring Gulls, 1974-1978. Trans. 44th N.A. Wildlife Natural Resources Conference. 543-557 pp.

Weseloh, D.V. Personal communication. Canadian Wildlife Service, Environment Canada, Burlington, Ontario.

Weseloh, D.V. and J. Casselman. 1992. Calculated fish consumption by double-crested cormorants in Eastern Lake Ontario. Unpublished manuscript. 15 p.

Benthic Organisms

Adamstone, F. B. 1924. The distribution and economic importance of the bottom fauna of Lake Nipigon with an appendix on the bottom of Lake Ontario. Univ. of Toronto Stud. Biol. Ser. 25: 34-100.

Cook, D.G. and M.G. Johnson. 1974. Benthic macroinvertebrates of the St. Lawrence and Great Lakes. J. of Fish. Res. Board Can. 31:763-782.

Dermott, R. 2001. Sudden Disappearance of the Amphipod *Diporeia* from Eastern Lake Ontario, 1993-1995. J. Great Lakes Res., 27:423-433.

Flint, R.W. and R.J.J. Stevens. 1989. Lake Ontario a Great Lake in Transition. Great Lakes Monograph No. 2, Great Lakes Program, State University of New York, Buffalo, New York and Water Quality Branch, Inland Waters Directorate, Environment Canada, Ottawa, Ontario, March 1989.

Fox, M.E., J.H. Carey, and B.G. Oliver. 1983. Compartmental distribution of organochlorine contaminants in the Niagara River and the western basin of Lake Ontario. J. Great Lakes Res. 9:287-294 .

J.M. Haynes, T. W. Stewart and G.E. Cook. 1999. "Benthic Macroinvertebrate Communities of Southwestern Lake Ontario Following Invasion of Dreissena: Continuing change." Journal of Great Lakes Research 25(4): 828-838.

Keilty, T.J., D.S. White, and P.F. Landrum. 1988. Sublethal responses to endrin in sediment by *Stylodrilus heringianus* (Lumbriculidae). Aquat. Toxicol. 12:227-250.

Kinney, W.L. 1972. The macrobenthos of Lake Ontario. Proc. 15th Conf. Great Lakes Res. (Inter. Assoc.Great Lakes Res.):53-79.

Landrum, P.F. 1988. Toxikinetics of organic xenobiotics in the amphipod, *Pontoporeia hoyi*: role of physiological and environmental variables. Aquat. Toxicol. 12:245-271.

Lozano, S.J., Scharold, J.V., Nalepa, T.F., 2001. Recent Declines in Benthic Macroinvertebrate Densities in Lake Ontario. Can. J. Fish. Aquatic Sci. 58:518-529.

Magnuson, J.J., A.M. Forbes, and R.J. Hall. 1976. An assessment of the environmental effects of dredged material disposal in Lake Superior, Final Report, Vol. 3. Duluth-Keweenaw study areas. Mar. Stud. Cent., University of Wisconsin, Madison, WI. 172 p.

Mills, E.L., R.M. Dermott, E.F. Roseman, D. Dustin, E. Mellina, D.B. Conn, and A. Spidle. 1993. Colonization, ecology and population structure of the "quagga" mussel (Bivalvia: Dreissenidae) in the lower Great Lakes. Can. J. Fish. Aquat. Sci. 50: 2305-2314.

Mozley, S.C. 1990. Review of Lake Ontario benthic studies. In N.A. Thomas and W.J. Christie [ed.] Status of the biota of Lake Ontario. Great Lakes Fishery Commission and International Joint Commission. Spec. Publ. No. 88-2.Nalepa, T.F. 1991. Status and Trends of the Lake Ontario macrobenthos, Canadian Journal of Fisheries and Aquatic Sciences, Volume 48, No. 8, pp. 1558-1567.

Nalepa, T. F. 1991. Status and trends of Lake Ontario macrobenthos. Can. J. Fish. And Aquat. Sc. 48:1558-1567.

Nalepa, T.F. and P.F. Landrum. 1988. Benthic Invertebrates and contaminant levels in the Great Lakes: effects, fates, and role in cycling, p. 77-102. In M.S. Evans [ed] Toxic contaminants and ecosystem health: a Great Lakes focus. John Wiley and Sons, New York, NY.

Nalepa, T.F. and N.A. Thomas. 1976. Distribution of macrobenthic species in Lake Ontario in relation to sources of pollution and sediment parameters. J. Great Lakes Res. 2:150-163.

Plumb, R.M. and C.N. Merckel. 1980. Characterization of Dredged Material Disposal Areas in the Great Lakes. Great Lakes Laboratory, State University College of Buffalo, New York 14222, Grant No. R805005010, Project Officer, M. Mullin, Environmental Research Laboratory - Duluth, Large Lakes Research Station, Grosse Ile, Michigan 48138.

Whittle, D.M. and J.D. Fitzsimmons. 1983. The influence of the Niagara River on contaminant body burdens of Lake Ontario biota. J. Great Lakes Res. 9:295-302.

Phytoplankton & Zooplankton

Christie, W.J., and N.A. Thomas. 1981. Biology, pg. 327-340. In: E.J. Aubert and T.L. Richards (adds.)IFYGL - The International Field Year for the Great Lakes. NOAA, Great Lake Environ. Res. Lab., Ann Arbor.DEC. 1993. Draft Niagara River Remedial Action Plan, Vol. 1, March 1993, NYSDEC, Div. of Water, 50 Wolf Road, Albany, NY 12233.

EPA. 1985. Limnology and Phytoplankton Structure in Nearshore Areas of lake Ontario: 1981, [ed.] Paul Bertram. EPA-905/3-85-003, August 1985. GLNPO, 536 South Clark Street, Chicago, Illinois 60605.

Flint, R.W. and R.J.J. Stevens. 1989. Lake Ontario: A Great Lake in Transition, Great Lakes Monograph No. 2, Great Lakes Program, State University of New York at Buffalo.

Gannon, J.E. 1980. Changes in Zooplankton Populations in Lakes Erie and Ontario, Proceedings of the Conference on Changes in the Biota of Lakes Erie and Ontario, Buffalo Society of Natural Sciences, March 10 & 11th, 1980.

GLFC. 1992. Status of the Lake Ontario Offshore Pelagic Fish Community and Related Ecosystem in 1992. Great Lakes Fishery Commission, internal report, Kingston, Ontario.

Gotham, I.J. and G-Yull Rhee. 1982. Effect of a hexachlorobiphenyl and pentachlorophenol on growth and photosynthesis of phytoplankton. J. Great Lakes Res. 8(2) 326-327.

Haile, C.L., G.D. Veith, G.F. Lee, and W.C. Boyle. 1975. Chlorinated hydrocarbons in the Lake Ontario ecosystem (IFYGL), U.S. Environmental Protection Agency, EPA-660/3-75-022. 28 p.

Johannsson, O., R. Dermott, R. Feldcamp, and J. Moore. 1985. Lake Ontario Long Term Biological Monitoring Program, 1981, 1982 data base. Can. Data Rept. Aquat. Sci., No. 552.

Johannsson, O. E., E.L. Mills, and R. O'Gorman. 1991. Changes in the nearshore and offshore zooplanktoncommunities in Lake Ontario: 1981-1988. Can. J. Fish. Aquat. Sci.

Makarewicz, J.C. 1993. Phytoplankton as indicators of environmental health. Verh. Internat. Verein. Limnol. 25:363-366.

Mayfield, C.I. and M. Munawar. 1983. Preliminary study of the effects on contaminants from sediments on algal membranes. J. Great Lakes Res. 9(2):314-316.

Mazumder, A., D.R. Lean, and W.D. Taylor. 1992. Dominance of small filter feeding zooplankton in the Lake Ontario foodweb. J. Great Lakes Res.18(3):456-466.

Mills. E.L., Wafer, C.C., Pueschel, E.M., Rudstam, L.G., Lantry, B., McCullough, R., Bishop, D., Pearsall, W., Norris, J., Trometer, B., Knauf, C., and Brown, G. 2000. 2000 Status of the Lake Ontario Ecosystem: A Biomonitoring Approach. NYSDEC Lake Ontario Annual Report 2000. Section 23. Bureau of Fisheries Lake Ontario and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. March 2001.

Munawar M., A. Mudroch, I.F. Munawar, and R.I. Thomas. 1983. The impact of sediment associated contaminants from the Niagara River on various size assemblages of phytoplankton. J. Great Lakes Res. 9(2):303-313.

Munawar M., P.T.S. Wong, and G.Y. Rhee. 1988. The Effects of Contaminants on Algae: An Overview, pp 113-123 In: Schmidtke, N.W. [ed.] Toxic Contaminants in Large Lakes, Vol. I: Chronic Effects of toxic Contaminants in Large Lakes, Lewis Publishers, Chelsea, MI.

Nicholls, K.H. 2000. Preliminary (Class Level) Assessment of Lake Ontario Phytoplankton and Zooplankton-Lake Ontario LaMP: Impairment of Beneficial Uses. Environment Canada, Technical Report (unpublished).

Nicholls, K.H. CUSUM Phytoplankton and Chlorophyll Functions Illustrate the Apparent Onset of the Dreissenid Mussel Impacts in Lake Ontario. J. Great Lakes Res., 27:393-401.

Nicholls, K.H., G. Hopkins, S. Standke, and L. Nakamoto. Trends in Total Phosphorus in Canadian Near-Shore Waters of the Laurentian Great Lakes: 1976-1999. J. Great Lakes Res., 27:402-422.

NYSDEC. 1996. Lake Ontario Sediment Survey, 1995 Sediment Coring Results. Division of Water, Bureau of Watershed Assessment and Research, 50 Wolf Road, Rm 305, Albany, NY 122233-3502.

Ontario Ministry of Natural Resources, New York State Department of Environmental Conservation1994. Ecosystem Watch; Status of the Lake Ontario Ecosystem.

Rawson, M., J. Bowlby, and T. Schnaner. 1994. Pelagic Piscivores. Ontario Ministry of Natural Resources 1994 Annual Report.

Sicko-Goad, S. and E.F. Stroemer. 1988. Effects of Toxicants on Phytoplankton with Special Reference to the Laurentian Great Lakes, pp. 19-51. In: Evans, M.S. [ed.] Toxic Contaminants and Ecosystem Health: A Great Lakes Focus. Wiley Series in Advances in Environmental Science and Technology, John Wiley and Sons, Inc., New York, NY.

Stoermer, E.F., M.M. Bowman, J.C. Kingston, and A.L. Schoedel. 1975. Phytoplankton composition and abundance in Lake Ontario during IFGYL. Ecol. Res. Series, EPA-660/-75-004, Corvallis Oregon, 373 p.

Tressler, W.L. and T.S. Austin. 1940. A Limnological Study of Some Bays and Lakes of the Lake Ontario Watershed, in: A Biological Survey of the Lake Ontario Watershed, State of New York Conservation Department, Biological Survey (1939), No. XVI, Chapter VIII, pp. 187-210.

Whittle, D. M., and J.D. Fitzsimmons. 1983. The influence of the Niagara River on contaminant burdens in Lake Ontario. J. Great Lakes Res.9:295-302.

Wolin, J., E. Stoermer, and C. Schelske. 1991. Recent Changes in Lake Ontario 1981-87: Microfossil evidence of phosphorus reduction, J. of Great Lakes Research, 17:229-241.

Eutrophication Problems

Bertram, P. Personal communication, Unpublished USEPA 1993 Lake Ontario open lake water quality monitoring results. USEPA, GLNPO.

Bertram, P. [ed.]. D.C. Rockwell, M.F. Palmer, and, J.C. Makarewicz. 1985. Limnology and Phytoplankton Structure in Nearshore Areas of Lake Ontario, 1981. United States Environmental Protection Agency, Great Lakes National Programs Office, Chicago, Illinois, EPA-905/3-85-003, 172 pp.

DEC. 1992. New York State Water Quality 1992, submitted pursuant to Section 305(b) of the Federal Clean Water Act. Prepared by Quality Evaluation Section, Bureau of Monitoring and Assessment, Division of Water, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, NY 12233, August 1992.

Glumac, V. Personal communication. Environment Canada data for Lake Ontario yearly average spring total phosphorus levels, 1971-1992, Great Lakes Studies Division, EQB, Inland Waters Directorate -Ontario, Canada.

GLFC. 1992. Status of the Lake Ontario offshore pelagic fish community and related ecosystem in 1992, prepared by the Lake Ontario Committee of the Great Lakes Fishery Commission, July 1992.

GLWQB. 1989. 1987 Report on Great Lakes Water Quality, Report to the International Joint Commission. Prepared by the Great Lakes Water Quality Board.

Gray, I.M. 1987. Difference between nearshore and offshore phytoplankton communities in Lake Ontario. Can. J. Fish Aquat. Sci. 44:2155-2163.

IJC. 1980. Phosphorus Management for the Great Lakes. Final Report of the Phosphorus Management Strategies Task Force to the IJC's Great Lakes Water Quality Board and Great Lakes Science Advisory Board. July 1980. 129p.

Longabucco, P. 1989. Phosphorus reductions in the Great Lakes. NYSDEC Water Bulletin. August 1989, New York State Department of Environmental Conservation, Division of Water, 50 Wolf Road, Albany, NY 12233.

Makarewicz, J.C., T.W. Lewis, and R.K. Williams. 1991. Nutrient loadings of streams entering Sodus Bay and Port Bay, N.Y., 1 April, 1990 to 30 June, 1991. Prepared for the Wayne County Soil and Water Conservation District, 8340 Ridge Road, Sodus, NY., September 1991.

NYS. 1991. New York State phosphorus reduction plan for the Great Lakes, final report, 1989-1990. Prepared by the New York State Great Lakes Phosphorus Reduction Task Force. February 1991.

Painter, D.S. and G. Kamaitis. 1985. Reduction in Cladophora biomass and tissue phosphorus concentration in Lake Ontario, 1972-1983. Canadian Journal of Fisheries and Aquatic Sciences, 44:2212-2215.

Schelske, C.L. 1991. Historical nutrient enrichment of Lake Ontario: paleolimnological evidence, Canadian Journal of Fisheries and Aquatic Sciences, v 48, no. 8, pp. 1529-1538.

Sly, P.G. 1990. The Effects of Land Use and Cultural Development on the Lake Ontario Ecosystem since 1750. Rawson Academy of Aquatic Science, Suite 404, One Nicholas St., Ottawa, Ontario, K1N7b7

Stevens, R.J.J. and M.A. Neilson. 1987. Response of Lake Ontario to reductions in phosphorus load, 1967-82, Can. J. Fish Aquat. Sci. 44:2059-2068.

Wolin, J., E. Stoermer and C. Schelske. 1991. Recent Changes in Lake Ontario 1981-87: Microfossil evidence of phosphorus reduction, J. of Great Lakes Research, 17:229-241.

Beach Closings

DEC. 1992. New York State Water Quality 1992. Submitted pursuant to Section 305(b) of the Clean Water Act, Quality Evaluation Section, Bureau of Monitoring and Assessment, Division of Water, NYSDEC, 50 Wolf Road, Albany, NY, 12233.

DEC and MCDPD. 1993. Rochester Embayment Remedial Action Plan, August 1993. Monroe County Department of Planning and Development, 47 South Fitzhugh Street, Rochester, NY 14614.

Gwozdek, R.G. 1993. Personal Correspondence, 1993 Coliform Sampling Reports for Porter Beach, Olcott Beach, Somerset Beach and Wilson Beach. Niagara County Health Department, Environmental Health Division, Main P.O. Box 428, 10th & East Falls St., Niagara Falls, NY 14302.

Makarewicz, J.C. and T.W. Lewis. 1989. Limnological studies of Sodus Bay and its tributaries. Prepared for the Wayne County Soil and Water Conservation District, 8340 Ridge Road, Sodus, NY. January 1989.

Makarewicz, J.C. and T.W. Lewis. 1990. Chemical Analysis and nutrient loading of streams entering Sodus Bay, NY. Prepared for the Wayne County Soil and Water Conservation District, 8340 Ridge Road, Sodus, NY. May 1990.

Monroe County Health Department. 1977 - 1991. Annual Monroe County beach coliform sampling reports.

Mullarney, M. H. 1993. Personal Correspondence, Coliform Sampling Results for Southwick Beach and Westcott Beach State Park, 1991, 1992, and 1993. New York State Office of Parks, Recreation and Historic Preservation, Thousand Islands Region, P.O. Box 247, Keewaydin State Park, Alexandria Bay, New York 13607.

Stoner, S. 1992. Coliform standards - Bathing beaches, internal memorandum, NYSDEC, 50 Wolf Road, Albany NY 12233-3508

Dredging Restrictions

Aqua Tech Environmental Consultants, Inc. 1990. Sediment analyses: Rochester Harbor, Irondequoit Bay, New York. Prepared for U.S. Army Engineer District, Buffalo.

Busch, W.D.N., M. Lazeration, M. Smith, and M. Scharf. 1993. 1992 Inventory of Lake Ontario Aquatic Habitat Information. U.S. Fish and Wildlife Service, Lower Great Lakes Fishery Resources Office, Amherst, New York. January 1993.

COE. 1987. The Analyses of Sediments from Oswego Harbor, Contract #DACW49-87-D-0002, Technical Report #I0175-02, June 1987. Prepared for: T.P. Associates International Inc.,Harpster, Ohio and COE Buffalo District Office, Water Quality Section.

COE. 1993. Seminar Notebook for Dredged Material Assessment and Management Seminar, Ann Arbor Michigan, Section A, Presentation by Joe Wilson, HQ, USACE, Legal and Institutional Considerations for Federal (CE) Dredging Projects, 10 pp.

COE/EPA. 1992. Evaluating environmental effects of dredged material management alternatives - A technical framework. EPA 842-B-92-008. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Washington, D.C.

DEC/MCDPD. 1993. Rochester Embayment Remedial Action Plan, Stage I, Executive Summary, August 1993. New York State Department of Environmental Conservation and Monroe County Department of Planning and Development. 47 South Fitzhugh Street, Rochester, NY 14614.

EPA/COE. 1993. Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters - Testing Manual (Inland Testing Manual) (Draft), May 1993.

EPA. 1984. Great Lakes National Program Office Harbor Sediment Program, Lake Ontario 1981. EPA-905/4-84-002, prepared by: A.G. Kizlauskas, D.C. Rockwell, and R.E. Claff, 536 South Clark Street, Rm 958, Chicago Illinois 60643.

IJC. 1982. Guidelines and Register for Evaluation of Great Lakes Dredging Projects, Report to the Water Quality Programs Committee of the Great Lakes Water Quality Board, January 1982. 363 pp.

Plumb, R.M. and C.N. Merckel. 1980. Characterization of Dredged Material Disposal Areas in the Great Lakes. Great Lakes Laboratory, State University College of Buffalo, New York 14222. Grant No. R805005010, Project Officer, M. Mullin, Environmental Research Laboratory - Duluth, Large Lakes Research Station, Grosse Ile, Michigan 48138.

Drinking Water Restrictions & Taste and Odor Problems

AWWA. 1987. Identification and treatment of taste and odors in drinking water. American Water Works Association Research Foundation. American Water Works Foundation, 6666 W. Quincy Ave.,Denver, CO. 80235 ISBN 0-89867-392-5.

Boxberger, T. 1993. Personal Correspondence. 1990, 1991, and 1992 drinking water quality monitoring results for the villages of Chaumont and Sacketts Harbor. District Director, District Office, New York State Department of Health, 317 Washington St., Watertown, N.Y. 13601.

Brownlee, B.G, D.S. Painter, and R.J. Boone, 1984, Identification of taste and odor compounds from Western Lake Ontario, Water Pollution Research Journal of Canada, 19:111-118.

Clancy, J. Personal communication. Director of Water Quality, Erie County Water Authority, Buffalo, NY.

DEC. 1993. Draft Niagara River Remedial Action Plan, New York State Department of Environmental Conservation, Division of Water, March 1993. 50 Wolf Road, Albany, NY 12233-3501.

Dickinson, W. 1993. Personal Correspondence. 1993 Quarterly drinking water monitoring reports for the villages of Albion and Lyndonville, Orleans County Health Department, 14012 Route 31, Albion, NY 14411.

Doran, J. 1993. Treatment Manager, Metropolitan Water Board, Personal communication.

Gerber, N.N. and H.A. Lechevalier. 1965. Geosmin, an earthy-smelling substance isolated fromactinomycetes. Applied Microbiology. 13:935.

Izaguirre, G., C.J. Hwang, and S.W. Krasner. 1983. Investigations into the source of 2-methylisoborneol in Lake Perris, California. Proc. AWWA WQTC, Norfolk, Va.

Metropolitan Water Board. 1992. 1992 Lake Ontario Monitoring Program. Onondaga County, Metropolitan Water Board, December 1992, prepared by Obrien & Gere Engineers, Inc., 5000 Brittonfield Parkway, Syracuse, NY 13221.

Nugent, J. Personal Communication, Chemist, Monroe County Water Board.

Safferman, R.S. et al. 1967. Earthy-smelling substance from a blue-green algae. Envir. Sci. & Technol. 1:429.

Tabachek, J.L. and M. Yurkowski. 1976. Isolation and identification of blue-green algae producing muddy odor metabolites, geosmin, and 2-methylisoborneol, in saline lakes in Manitoba. J..Fish. Res. Bd. Can. 33:25.

Habitat & Wetlands Losses

Busch, D.N., M. Lazaration, M. Smith, and M. Scharf. 1993. Inventory of Lake Ontario Aquatic Habitat Information. USF&WS, Lower Great Lakes Fishery Resources Office, Amherst New York, January 1993.

Great Lakes Wetlands Conservation Action Plan. 1995a. Great Lakes Wetlands Land Securement Workshop. Final Report.

Great Lakes Wetlands Conservation Action Plan. 1995b. Priority Rehabilitation and Creation Sites for the Lower Great Lakes Including a Selected Site Registry for Coastal Wetlands of the Lower Great Lakes. Environment Canada, Ontario Region and the Federation of Ontario Naturalists. 182 pp.

Hough Woodland Naylor Dance. 1995. Restoring Natural Habitats. Waterfront Regeneration Trust, Ontario.

Luste, T. And M. Paley. 1996. A Guide to Great Lakes Shoreline Approvals in Ontario. Waterfront Regeneration Trust, Ontario.

Waterfront Regeneration Trust. 1995. Lake Ontario Greenway Strategy. Waterfront Regeneration Trust, Ontario.

Waterfront Regeneration Trust. Natural Heritage Workgroup. 1995. A Natural Heritage Strategy for the Lake Ontario Greenway. Waterfront Regeneration Trust, Ontario.

Waterfront Regeneration Trust. Shoreline Management Workgroup. 1996. Shore Management Opportunities for the Lake Ontario Greenway. Waterfront Regeneration Trust, Ontario.

Whillans, T.H., R.C. Smardon, and D. Busch. 1992. Status of Lake Ontario Wetlands, a working paper published by the Great Lakes Research Consortium, 24 Bray Hall, SUNY College of Environmental Science and Forestry, Syracuse, NY 13210.

CHAPTER 5 HABITAT ASSESSMENT AND RESTORATION

5.1 Summary

This chapter provides an overview of the types of habitat in the Lake Ontario basin, status of the habitat, and the restoration and protection activities that have been completed or are still ongoing in the U.S. and Canada. The material presented is based on information that existed as of January 2003.

5.2 Habitat Types of the Lake Ontario Basin

Clean water alone cannot restore the Lake Ontario ecosystem. Habitat of sufficient quality and quantity is essential to achieve the restoration and protection of a fully functioning ecosystem. The Lake Ontario LaMP will work with its partners to identify priority lakewide habitat issues and will work to coordinate government and voluntary efforts so that degraded habitat will not limit the restoration of the Lake Ontario ecosystem.

5.2.1 Habitat Zones and Foodwebs

Habitats that are critical to the health and functioning of Lake Ontario's aquatic foodweb are: (1) nearshore fish spawning grounds; (2) nearshore wetland and coastal bird and fish nesting and spawning grounds; and (3) tributaries. In turn, the lake can be partitioned into two major overlapping and interacting habitat zones: the nearshore and the offshore. The boundary between these two zones is loosely defined as the 15-metre depth contour.

The feeding relationship among the fish and other organisms within each zone is called a foodweb. All aquatic foodwebs depend on the production of microscopic algae (Phytoplankton) that require adequate light and nutrients to thrive. Algae are fed upon by microscopic zooplankton or by bottom-dwelling benthic organisms (that depend on living and dead material that settles to the bottom). Zooplankton and the benthos provide the link from algae to fish and ensure that material is cycled through the foodweb.

5.2.2 Nearshore Habitat

The nearshore zone includes the shallow coastal waters adjacent to shore and all embayments. Within this zone, the degree of wind and wave exposure varies from very shallow protected embayments with little water exchange with the open lake, to exposed coastal areas. Similarly, nutrient levels and the impact of shoreline development varies widely along the coast. The type of aquatic plants, bottom characteristics, water flow, light and temperature found in nearshore zones determines where fish can find food, avoid predation, or spawn.

The importance of the nearshore zone to Lake Ontario fish communities cannot be over-emphasized. With very few exceptions, most Lake Ontario fish species spend part of their life cycle in the nearshore zone. For many species, the earliest and most critical life stages of egg, larvae and juveniles depend on nearshore habitat. The nearshore resident fish community varies with season, the degree of nutrient enrichment, temperature and available habitat. Dominant fish species spending most of their life cycle in the nearshore include walleye, smallmouth and largemouth bass, freshwater drum, yellow perch, white perch, gizzard shad, various minnows, and several sunfish species.

5.2.3 Offshore Habitat

Temperature is a dominant influence on fish distribution in the offshore zone. The development and expansion of the thermal bar in spring (a band of warm nearshore water), the establishment of the thermocline in mid-summer, and the wind driven mixing and movement of water results in large variations in temperature over depths and regions. Mixing of offshore waters results in more uniform water quality, compared to the nearshore. Many fish species associated with the offshore rely on the nearshore zone or tributaries for spawning and nursery habitat for young.

5.2.4 Nearshore Wetlands

Sixty-eight species of fish use coastal wetlands of Lake Ontario, either as permanent residents or for spawning, nursery or feeding during their lifecycle. The ecosystem and fish and wildlife values associated with wetlands are difficult to quantify systematically. However, protection and rehabilitation of wetlands offers improved habitat for fish and wildlife species. Throughout Lake Ontario, water level regulation is a major stress on remaining wetlands. Low levels of variation in water levels are thought to have lead to cattail dominance and reduced species diversity in coastal wetlands. More variable water levels can lead to greater diversity of wetland plant communities and improve fish and wildlife habitat. Other wetland rehabilitation techniques include planting of aquatic vegetation, creating channels in cattail marshes, excluding carp, and local control of water levels through diking.

Since 1960, Lake Ontario's water level has been regulated by a series of dams on the St. Lawrence River. Water levels are determined by the International Joint Commission (IJC) under a formula that seeks to balance a number of interests. Many biologists believe that water level regulation has had serious and lasting impacts on Lake Ontario's natural resources, including fish and wildlife (particularly shorebirds and spawning fish), shoreline habitat and dune barrier systems, and the numerous wetland complexes that line the shoreline. The full range of these impacts, however, has never been documented. The IJC is now in the second year of a five-year binational study to estimate the impacts that water level regulation has had on shipping, riparian property owners, boating and natural resources.

5.2.5 Tributaries

Recent observations of large numbers of wild chinook salmon and rainbow trout in tributaries have increased the recognition of the potential for greater contribution from wild fish. The main spawning and nursery habitats for approximately one-third of the fish species in the Great Lakes are located within tributaries. The value of most tributaries to Lake Ontario, for migratory trout and salmon spawning and nursery use, has been limited by barriers blocking access, poor water and habitat quality, and unsuitable flow regimes. Stream rehabilitation programs, management of fish passage, and storm water management can improve the spawning and nursery habitat for cold water fish species and increase wild production. Land use practices that better control erosion can reduce run-off of sediments and associated nutrients and contaminants into streams, and act in concert with other water quality control programs.

5.3 Current Status of Basin Habitat

It has been estimated that since colonial times about 50 percent of Lake Ontario's original wetlands have been lost. Along intensively urbanized coastlines, 60 to 90 percent of wetlands have been lost. These losses are a result of the multiple effects associated with urban development and human alterations, such as draining wetlands to establish agricultural land, marina construction, diking, dredging, and

disturbances by public utilities. Currently, approximately 80,000 acres of Lake Ontario's wetlands remain. The largest expanses are located in the eastern portion, along the coastline of Presqu'ile Bay and Bay of Quinte in Ontario and Mexico Bay in New York. More than 20 percent of Lake Ontario's wetlands are fully protected in parks, while additional areas are subject to a variety of municipal, state/provincial or federal rules, regulations, acts or programs. Opportunities to protect, restore or replace these valuable habitats need to be explored.

Several Lake Ontario basin habitat assessments and inventories have been conducted by U.S. and Canadian governments over the last few decades.

On the U.S. side, the 24,720-square mile U.S. portion of the Lake Ontario basin, from the St. Lawrence River and including the Niagara River corridor, is diverse in fish and wildlife habitat. The St. Lawrence River supports habitat for the lake sturgeon. Along the shoreline are sand beaches, sand dunes, and wetlands including fens and coastal marshes, significant habitats for shorebirds, raptors, passerines, and waterfowl. Black terns and common terns nest and forage in the marshes. Sprinkled at the western end of the lake, alvars, which are areas of flat limestone bedrock where soils have been scraped away by ice, wind, and water, are habitats for grasses, wildflowers, mosses, lichens, stunted trees, and specialized birds and invertebrates. Upland are forests of oak, ash, white cedar, and hickory.

Threats to fish and wildlife habitats are physical, biological and chemical. Controlled lake levels are having a profound impact on shoreline habitats. For example, sand transport mechanisms needed to nourish sand beaches, dunes, and coastal wetlands have been disrupted. Shoreline development has impacted terrestrial and aquatic habitats. Non-indigenous invasive species are replacing native species in both terrestrial and aquatic habitats. Swallowort, for example, an invasive weed, is threatening the native plants of limestone communities. Urban and agricultural runoff may impact tributary and harbor habitats.

The current status of fish and wildlife habitats that takes into account natural resource values and threats is incomplete. Efforts are now underway to assess particular habitats by a number of agencies and organizations. The U.S. Fish and Wildlife Service is continuing to update endangered species, wetland inventory, and aquatic habitat information and inventories. Regional bird conservation mapping being undertaken by Vermont University will help to characterize habitat used by songbird migrants. The Nature Conservancy is completing its second iteration of ecoregional planning that defines habitat protection and restoration needs for a number of Lake Ontario sites. Local watersheds and partnerships, such as the Ontario Dunes Coalition, are conducting assessments of local natural resources and threats.

On the Canadian side, a recently completed assessment of the status of Canadian habitat in the Lake Ontario basin developed the following findings:

- Nearshore terrestrial habitats in a natural state (such as forests, dunes, beaches and shorecliffs) are in very limited supply and are continuing to decline further. There are many examples of specialized lakeshore natural communities lacking long-term protection. Coastal wetlands have been heavily impacted by historic development activities and remaining wetlands are threatened by habitat alteration, water level controls and sedimentation. The regulation of lake levels since 1960, together with hardening of shoreline areas, have degraded natural shoreline processes (such as erosion and sand transport) affecting the health of nearshore habitats.
- One area of improvement relates to tributary habitats: suspended sediment loadings have declined in most tributaries over the past 26 years. On the other hand, an increasing variability of streamflow is being measured in watersheds associated with intensive agricultural and urban land uses.

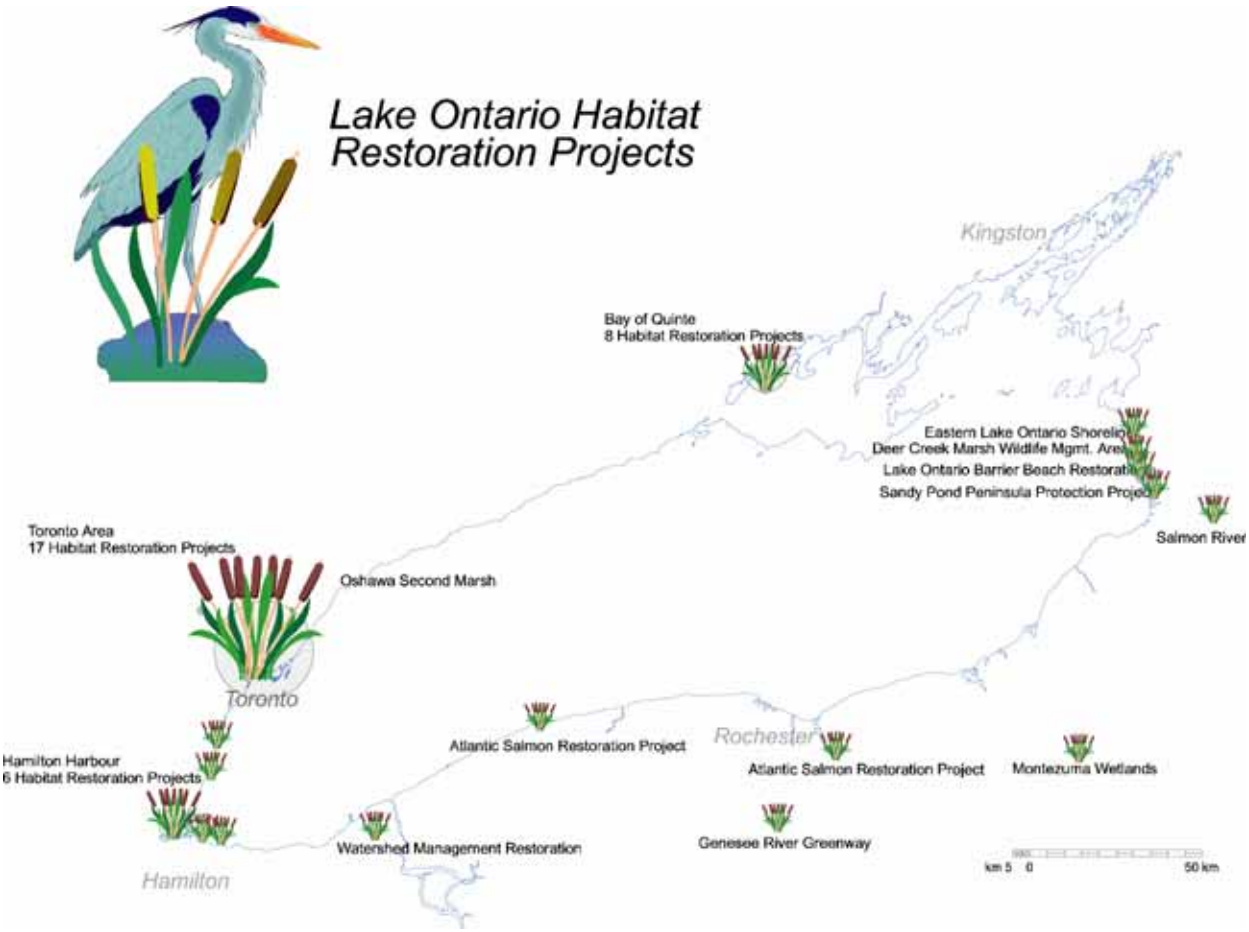
- Historic wetland losses have been significant, and the remaining concentrations of wetlands are associated with the Peterborough drumlin field, the edge of the Canadian Shield, and the Niagara Escarpment. Rare vegetation communities also tend to be clustered, but rare species are broadly distributed with a particular concentration in the Niagara area.
- Human population growth is a major stressor, especially in the urban fringe areas of the Greater Toronto Area and the Hamilton to Niagara corridor. Land uses are changing rapidly as a result of urban sprawl. Rural areas are also changing relatively quickly, with the most intensive agricultural practices and the greatest rates of farmland loss in the western parts of the watershed. The number of active farmers is rapidly decreasing, as are the number of farms and total area farmed.
- Protective policies through municipal official plans and habitat areas of provincial interest (such as the Niagara Escarpment and Oak Ridges Moraine) are in place for about half of the regions and counties within the watershed. Private land stewardship programs and property tax incentives have been important factors in encouraging habitat conservation in some areas. Overall, however, the Canadian Lake Ontario watershed is deficient in protected areas that represent the full range of its habitat types.
- A broad mix of government and non-government activity has also taken place to address the rehabilitation of various habitats. Many rehabilitation projects are associated with the four Remedial Action Plans along the Canadian Lake Ontario shore. Wetland, shoreline and stream rehabilitation projects are the most common types, with agricultural programs receiving particular attention. Many rehabilitation projects feature community and volunteer involvement, often with the support of federal or other funding.

5.4 Ongoing Work

Many habitat restoration and protection projects are underway in the Lake Ontario basin (Figure 5.1). The following information provides some highlights of the projects supported, in part, by federal, provincial, and state agencies as well as various county, conservation authority, municipal, and private organizations.

Over the last two decades, governmental regulations protecting lake-connected wetlands, shorelines, and littoral zones have significantly reduced the rate of loss of these valuable habitats. Since the loss of significant wetland and shoreline habitats has been curtailed, more attention is now being given to identifying the opportunities to restore and replace degraded or lost habitats.

Figure 5.1 Lake Ontario Habitat Restoration Projects [Many local restoration projects are in progress or proposed in the Lake Ontario basin which are not highlighted in this figure.]



5.4.1 Binational Activities

Fish population restoration activities are managed jointly by the natural resource agencies with jurisdiction for Lake Ontario. These include the Ontario Ministry of Natural Resources (MNR), the Department of Fisheries and Oceans (DFO), the U.S. Fish and Wildlife Service (USF&WS), and the NYSDEC. A binational process to develop Fish Community Objectives was completed in 1999, led by MNR and NYSDEC, and including public consultation (Stewart et al., 1999). This process produced long term directions for management actions such as fish stocking and habitat protection. The development of Fish Community Objectives by the Lake Ontario Committee took into consideration a variety of interests including commercial and recreational fisheries, stocking policies, and food web dynamics. The Fish Community Objectives are reviewed and updated every five years. The rehabilitation of lake trout is guided by the Joint Plan for Rehabilitation of Lake Ontario Lake Trout (Schneider et al., 1983). Some progress has been achieved. By 1994, natural production of lake trout in the Kingston Basin had been documented for several years (Rawson et al., 1994). NYSDEC and USGS have also documented natural reproduction in several areas in New York waters since 1994 (Lantry et al. 2001). The survival rate of adult lake trout in 1994 and 1995 exceeded the rehabilitation target of 60 percent per year. In addition, mortality induced by sea lamprey wounding has been reduced.

Efforts to restore partial self-sustainability of Atlantic salmon populations have been limited due to the damming, deforestation, and stream modification of tributaries used for spawning, as well as competition with rainbow trout.

There has been a dramatic recovery of lake whitefish and walleye populations in the east end of the lake. More active management could contribute to the further recovery of these native species.

The multi-partner International Alvar Initiative inventoried alvar sites and proposed direct actions to preserve habitats. The binational Marsh Monitoring Program utilizes citizen volunteers to monitor coastal wetlands and their amphibian and marsh bird populations. Another binational committee, the Great Lakes Fishery Commission's Lake Ontario Committee (LOC) is also making progress in Lake Ontario ecosystem restoration. See Sections 3.4 and 8.2.1 of this report for information regarding the LOC.

5.4.2 U.S. Activities

Several New York State habitat restoration and protection projects are being conducted through the cooperative efforts of county, city, local, and private organizations as well as state and federal agencies. The New York State Open Space Conservation Plan provides a statewide process to identify and acquire undeveloped habitats. The state works in partnership with local governments, non-profit conservation organizations, and private landowners to establish and achieve land conservation goals. Funding for the program is provided by the state's Environmental Protection Fund and, where possible, leveraged by federal and other sources of funding. Ongoing habitat acquisition programs include: Salmon River Corridor, Northern Montezuma Wetlands, Genessee Greenway, and Eastern Lake Ontario shoreline.

The USEPA's Great Lakes National Program Office provides funding for a variety of Great Lakes habitat restoration projects. Projects include: wetland creation in the Lower Genessee River/Irondequoit Bay; barrier beach and wetlands habitat restoration on the Lake's shoreline; barrier beach restoration and stabilization; public education; creation of wildlife nesting habitat and exotic vegetation control at Deer Creek Marsh Wildlife Management Area; and protection and restoration of Sandy Pond Peninsula.

There are many habitat restoration and protection projects currently underway in the U.S. Lake Ontario basin, by both government and private partners.

- A community-based conservation program to protect the wetlands, rivers, streams, and working forests of the Tug Hill Plateau in New York is being carried out by The Nature Conservancy (TNC).
- An evaluation of lake sturgeon habitat by USGS and USFWS is underway in the Genessee River, a major tributary to Lake Ontario. The early history of the Genesee River records the existence of giant sturgeon in the lower portions of the river, but sturgeon population has declined over the years. Now there is great interest in restoring the sturgeon to the river.
- On the Oswego River, a shoreline restoration incentive program is being implemented.
- An education program on shoreline stewardship practices for private landowners has recently begun.
- Protection efforts in the Finger Lakes area are focused especially on the watersheds of the three western Finger Lakes (Hemlock, Canadice, and Honeoye), which remain largely intact and unfragmented. Hemlock Lake and Canadice Lakes are both part of the City of Rochester's water supply system; the city owns 7,200 acres of land within the watershed of the lakes, including their entire shorelines. South of Honeoye Lake lies the Bristol Hills, a relatively intact forest system that stretches east to Naples. This area is the largest documented Appalachian oak-hickory forest in New York. The site also includes a large swamp and wetland complex at the south end of Honeoye Lake. TNC and the Finger Lakes Land Trust are both working to expand protection of

the western Finger Lakes by identifying and acquiring important lands and conservation easements in the Bristol Hills, and in the Hemlock, Canadice, and Honeoye watersheds. TNC has protected nearly 1,400 acres in the western Finger Lakes within the last several years. Future strategies will include land acquisition to protect key tracts; land management to restore native forests; and outreach programs to build awareness of the importance of safeguarding watersheds and preventing forest fragmentation.

- The Montezuma wetlands complex, located between Syracuse and Rochester, once comprised more than 40,000 acres of contiguous marshland. Although agricultural activities have drained nearly half of these wetlands, Montezuma is still considered one of the state's premier wetland conservation areas and is one of the most important sites in the state for migratory birds. Every spring and fall, hundreds of thousands of ducks, geese, and shorebirds utilize the complex as a staging area. Both the U.S. Fish & Wildlife Service (USFWS) and the NYSDEC are protecting and restoring wetlands at Montezuma, with a goal of returning the complex to its original size. TNC is working in partnership with both agencies and with Ducks Unlimited to protect key parcels for transfer or donation to NYSDEC or USFWS. Montezuma is a laboratory for invasive species control, where USFWS officials are releasing beetles to control purple loosestrife and experimenting with fire and herbicides to control phragmites.
- At Eighteenmile Creek, an ongoing wetlands protection project of the Western New York Land Conservancy, partially funded by the USEPA, is coordinating the towns in the watershed to help design best management practices and zoning ordinances; conduct decision making exercises in each town; produce outreach materials; and prepare criteria for prioritizing acquisition areas and produce a land use/wetland map of the area. Portions of the streambank have been physically re-established and re-vegetated to reduce erosion and instream sedimentation from man-made disturbances.
- Efforts are currently underway to assist the recovery of river otter populations in the Lake Ontario basin. In 1995, the non-profit New York River Otter Project began the process of introducing nearly 300 river otters to the Lake Ontario basin.
- The Nearshore Habitat Priorities for Migratory Songbirds (Vermont University and State Agricultural College) project is identifying concentrations of songbirds in nearshore Lake Ontario and eastern Lake Erie habitats using a new remote sensing technique.
- The Landscape-Level Conservation on Tug Hill project (The Nature Conservancy) is launching a community-based conservation program to protect the wetlands, rivers, streams, and working forests of the Tug Hill Plateau in New York.
- The Collaborative Restoration and Education at Eastern Lake Ontario project (The Nature Conservancy, New York Sea Grant, Oswego County, Lake Ontario Dunes Coalition) is implementing a coordinated Dune Steward Program for the beaches and dunes of eastern Lake Ontario, restoring and re-vegetating damaged dunes using locally-grown native beachgrass, protecting dunes with sensitive public access, and engaging the local community through a dune/wetland education program.
- The Contributing Factors in Habitat Selection by Lake Sturgeon project (Research Foundation of State University of New York) is determining the preferred prey types of St. Lawrence River juvenile and adult lake sturgeon, and examining the relationship between feeding characteristics of juvenile and adult lake sturgeon and the benthic invertebrate community.
- The Identification of Lake Sturgeon Habitat in the St. Lawrence River (State University of New York College of Environmental Sciences and Forestry) project is obtaining new information about specific habitat preferences by the critical juvenile stage lake sturgeon in the St. Lawrence River near Massena, New York.
- The Controlling the Spread of Swallowort project (The Nature Conservancy) is developing new techniques for controlling the non-indigenous invasive plant swallowort, which is threatening limestone communities from New York to Wisconsin.

- The Restoration of Rush Oak Openings project (The Nature Conservancy) is working with state, local, and regional partners to develop and effect a joint restoration plan to unite ownerships, and to use volunteer and paid staff to implement restoration of the relict oak savannah community.
- The Sand Transport in the Barrier Beach Ecosystem of Eastern Lake Ontario project (The Nature Conservancy and U.S. Army Corps of Engineers) is addressing the issue of changes in the coastal processes affecting distribution and transport of beach sands along the barrier beaches of eastern Lake Ontario.
- The Conversion of Dry Basins to Created Wetlands for Mitigation of Runoff Water Quality project (Monroe County Environmental Health Laboratory) is demonstrating conversion of suburban dry retention basins into wetland detention ponds to provide treatment and thermal moderation of storm runoff, reducing hydraulic, thermal, and nutrient loading of receiving bodies while providing wetland habitat functions.
- The Eastern Lake Ontario Conservation Initiative (The Nature Conservancy) identified key resources and ecosystem stresses, initiated land protection activities, developed partnerships with state, local, and citizen's groups active in the area, conducted outreach, and developed an initial conservation plan with specific protection, stewardship, and outreach programs for the Eastern Lake Ontario 29,000-acre dune/wetland/alvar system.

In the Sandy Pond Beach Natural Area along 17 miles of eastern Lake Ontario shoreline, a broad range of public and private partners have worked together to conserve highly significant dune and wetland habitats. The ecological function of the dunes is to shelter the wetlands and protect them from being encroached upon by blowing sand and by high energy wave action from Lake Ontario. The fragile dune barrier is threatened by sand loss caused by a variety of harmful activities.

Numerous private holdings lie amidst 6,500 acres of land protected as a state park, three NYSDEC wildlife management areas, a state unique area, and three Nature Conservancy preserves. Collaborating through The Ontario Dune Coalition, agencies, conservation organizations, local and county governments, and private landowners convened a Coordinated Dune Management Conference in October 1998. As one important outcome, the group will expand a pilot Dune Steward program to station seasonal stewards on all public access beaches. The Nature Conservancy will manage the program, which aims to encourage willing compliance with use guidelines and address problems in a comprehensive, cross-agency fashion.

Stewards have also worked with The Friends of Sandy Pond Beach, NY State Parks, DEC, private landowners, and The Nature Conservancy to restore about five acres of degraded dunes on four protected sites and two private sites with the rare native Champlain beachgrass. With advice and support from the United States Department of Agriculture, NY Natural Heritage Program, and the University of Vermont, The Friends expanded that effort in 1999, with native material cultured by local farmers to supply local needs.

Other efforts include development of an interactive dune education website, developed by NY Sea Grant, the Nature Conservancy and local school districts. In addition, four NY universities and a Canadian agency have undertaken research to define the sources, transport, and fate of sandy sediments that supply the beaches, to explain apparent sand loss and make informed management decisions. Researchers are working with Coalition members, the US Army Corps of Engineers, and the shoreline towns of Sandy Creek, Richland, and Ellisburg.

5.4.3 Canadian Activities

Environment Canada through its Great Lakes Sustainability Fund (formerly known as the Cleanup Fund) and in conjunction with its many partners, has supported a large number of habitat rehabilitation projects in the Lake Ontario watershed. These projects, primarily in Toronto, Hamilton, and the Bay of Quinte, focused on creating various nesting and loafing areas for birds such as eagles, ospreys, and terns; enhancing fish spawning habitats; improving littoral and deep water habitats; improving fish access; rehabilitating and creating riparian habitat; and placing structural fish habitat in the form of shoals, reefs, brush bundles, and log cribs. Other projects focused on coastal wetland rehabilitation and reforestation activities on flood plains and stream banks.

As reported in the Stage 1 Report, by March of 1996, 45 km of riparian and 40 hectares (ha) of wetland habitats had been rehabilitated in the Lake Ontario basin as a result of project activities supported by the Sustainability Fund and its partners. Since that time these figures have expanded considerably as a result of continued commitment to these and other rehabilitation projects. Throughout Lake Ontario, initiatives are underway that will benefit other rehabilitation projects such as techniques for the control of exotic species, creating nesting platforms, reestablishing native plant species, erosion control using bioengineering techniques, and techniques to prevent wildlife from consuming newly planted vegetation.

Canada's Great Lakes Wetlands Conservation Action Plan (GLWCAP), a plan that focuses on the conservation of coastal wetlands, developed a priority acquisition list for coastal wetland sites along the lower Great Lakes (Great Lakes Wetlands Conservation Action Plan, 1995a). Specific actions and priority areas for protection and rehabilitation were also identified along the western Lake Ontario shoreline between the Niagara River and Hamilton, along the northern shore, and in eastern Lake Ontario (Great Lakes Wetlands Conservation Action Plan, 1995b). The GLWCAP is being implemented through a cooperative partnership between governments and non-governmental organizations in Canada. As of 1998, nearly 900 hectares of wetlands had been protected at priority Lake Ontario sites.

Working with a steering committee consisting of representatives of waterfront municipalities, conservation authorities, provincial and federal ministries, and community groups, the Waterfront Regeneration Trust prepared and published the Lake Ontario Greenway Strategy in 1995. This strategy described the actions needed to regenerate the waterfront from Burlington Bay to Trenton by protecting and restoring ecological health, and developing community and economic vitality. Between 1993 and 1995, the Waterfront Regeneration Trust conducted a natural heritage study, identifying significant natural areas and corridors along the north shore of Lake Ontario. This natural heritage system has been mapped on GIS, and a database of associated sources of information has been tagged to each area ("A Natural Heritage Strategy for the Lake Ontario Greenway"). The Trust has also conducted an analysis of coastal processes along the north shore ("Shore Management Opportunities for the Lake Ontario Greenway").

Oshawa Second Marsh

Nestled between the urban setting of the City of Oshawa and the shores of Lake Ontario, Second Marsh is one of the few remaining coastal wetlands in the area that provides habitat for fish and wildlife. This 123 hectare wetland is home to a variety of wetland plant species and provides recreational and educational opportunities for the local community. The health of Second Marsh has been in decline since the early 1930's due to a combination of human activities including alterations upstream of the marsh which have increased sedimentation and turbidity.

In response to the stresses on the wetland, Friends of Second Marsh, a community-based action group, and partners from all sectors, implemented the Second Marsh Management Plan, and rehabilitation

initiatives were undertaken. These partners included the Great Lakes Sustainability Fund, Environment Canada, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, City of Oshawa, Central Lake Ontario Conservation Authority, Ducks Unlimited Canada, Ontario Federation of Anglers and Hunters, Durham Board of Education, Trent University, Waterfront Regeneration Trust, General Motors of Canada Limited and many others.

Habitat restoration activities have concentrated on improving habitat for fish and birds. Log barriers were installed to facilitate plant growth by limiting wind and wave action. Techniques were implemented to prevent wildlife from consuming newly planted vegetation. Fish migration was improved by the removal of a log jam and root-wads and cribs were designed and constructed to improve fish habitat. An original outlet to Lake Ontario was restored and islands were created to redirect flow and provide habitat. Artificial nesting platforms for osprey were erected and actions were taken to control purple loosestrife.

The promotion of the project in the community fostered a sense of stewardship and school groups, residents and tourists have been visiting the Marsh for its aesthetic and educational values. Volunteers, a key component of the Second Marsh Project, devoted their time to planting aquatic vegetation and building a secondary trail. Others assisted with the monitoring program by listening for calling birds and amphibians, calculating vegetation cover, and sampling water quality. Teachers and students from Durham Region also helped by growing wetland seedlings for planting.

An important component of the project was information sharing and technology transfer. Many of the lessons learned as well as the monitoring protocols that were developed, have been used in other projects on Lake Ontario.

The Second Marsh Project took a proactive step in managing the Marsh by implementing a watershed stewardship program. The purpose of this program was to improve the quality of water entering the Marsh by encouraging landowners upstream to adopt environmentally sound land management practices.

5.5 Actions and Progress

The information contained in this chapter has been compiled based on documents produced up to January 2003. This chapter has not been updated for the LaMP 2004 Report. The LaMP process is a dynamic one and therefore the status will change as progress is made. This chapter will be updated in future LaMP reports as appropriate.

5.6 References

Busch, D.N., M. Lazaration, M. Smith, and M. Scharf. 1993. Inventory of Lake Ontario Aquatic Habitat Information. USF&WS, Lower Great Lakes Fishery Resources Office, Amherst New York, January 1993.

Environment Canada, Ontario Region and the Federation of Ontario Naturalists. 182 pp. Hough Woodland Naylor Dance. 1995. Restoring Natural Habitats. Waterfront Regeneration Trust, Ontario.

Great Lakes Wetlands Conservation Action Plan. 1995a. Great Lakes Wetlands Land Securement Workshop. Final Report.

Great Lakes Wetlands Conservation Action Plan. 1995b. Priority Rehabilitation and Creation Sites for the Lower Great Lakes Including a Selected Site Registry for Coastal Wetlands of the Lower Great Lakes.

Lantry, B.F., T.H. Eckert, R. O'Gorman, and R.W. Owens, 2001. Lake trout rehabilitation in Lake Ontario, 2000. In NYSDEC 2000 Annual Report of the Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Luste, T. And M. Paley. 1996. A Guide to Great Lakes Shoreline Approvals in Ontario. Waterfront Regeneration Trust, Ontario.

Reid, R. 2001. Fish and Wildlife Habitat Status and Trends in the Canadian Watershed of Lake Ontario. Technical Report Series No. 364, Environment Canada, Canadian Wildlife Service- Ontario Region.

Schneider, C.P., D. P. Kolenosky, and D.B. Goldthwaite. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario. The Lake Trout Subcommittee of the Lake Ontario Committee, Great Lakes Fishery Commission. 50 p.

Stewart, T. J., R.E. Lange, S.D. Orsatti, C.P. Schneider, A. Mathers, and M.E. Daniels. 1999. Fish-community Objectives for Lake Ontario. Great Lakes Fishery Commission Spec. Pub. 99-1. 56 p.

Waterfront Regeneration Trust. 1995. Lake Ontario Greenway Strategy. Waterfront Regeneration Trust, Ontario.

Waterfront Regeneration Trust. Natural Heritage Workgroup. 1995. A Natural Heritage Strategy for the Lake Ontario Greenway. Waterfront Regeneration Trust, Ontario.

Waterfront Regeneration Trust. Shoreline Management Workgroup. 1996. Shore Management Opportunities for the Lake Ontario Greenway. Waterfront Regeneration Trust, Ontario.

Whillans, T.H., R.C. Smardon, and D. Busch. 1992. Status of Lake Ontario Wetlands, a working paper published by the Great Lakes Research Consortium, 24 Bray Hall, SUNY College of Environmental Science and Forestry, Syracuse, NY 13210.

CHAPTER 6 SOURCES AND LOADS OF CRITICAL POLLUTANTS

6.1 Summary

This chapter provides information on the sources and loadings of critical pollutants (i.e. DDT and its metabolites, dieldrin, dioxins/furans, mercury, mirex and PCBs) to Lake Ontario, based on information that existed as of December 2005. This chapter also describes the status of selected actions by LaMP Parties as of December 2005 to address known and potential sources of critical pollutants throughout the Lake Ontario basin, in keeping with the LaMP's sources and loadings strategy.

Critical Pollutants are bioaccumulative and persistent toxic substances that are known or suspected to be responsible for lakewide impairments of beneficial uses: PCBs, DDT & its metabolites, mirex, dioxins/furans, mercury, and dieldrin. These substances are the focus of the Lake Ontario LaMP source reduction activities.

6.2 Identifying Lakewide Problems and Critical Pollutants

The beneficial use impairment assessment from the LaMP Stage 1 Report (1999) identified the lakewide use impairments in Lake Ontario and the toxic substances contributing to these impairments (i.e., those substances for which there was direct evidence of impairment of beneficial uses). It was also considered important for the Lake Ontario LaMP to consider toxic substances which were likely to impair beneficial uses (i.e., there was indirect evidence that these chemicals are impairing beneficial uses if they exceed the most stringent US or Canadian standard, criteria, or guideline). The results from the Stage 1 review in 1999 are summarized below.

Mercury – identified as a LaMP critical pollutant because, although not responsible for consumption advisories on a lakewide basis, mercury concentrations in larger smallmouth bass and walleye frequently exceeded Ontario's fish consumption criteria[1].

Dieldrin – identified as a LaMP critical pollutant because it was found to exceed the most stringent water quality and fish tissue criteria lakewide. Although dieldrin was not causing lakewide impairments of beneficial uses, it was included as a LaMP critical pollutant given the lakewide nature of these criteria exceedences.

PCBs – identified as LaMP critical pollutants because levels of PCBs in Lake Ontario fish and wildlife exceeded human health standards, and because PCB levels in the Lake Ontario food chain may have posed health and reproduction problems for bald eagles, mink, and otter.

Mirex – identified as a LaMP critical pollutant because levels in some Lake Ontario fish exceeded human health standards.

Dioxins and Furans – identified as LaMP critical pollutants because levels of these contaminants exceeded human health standards in some Lake Ontario fish and because these chemicals may

[1] At the time of the Stage 1 Review, the Ontario fish consumption advisory limit for mercury was 0.5 ppm. Health Canada has since *reduced* the tolerable daily intake for mercury for women of child-bearing age and children, but not for the general population. The new tolerable daily intake is temporary, pending the completion of additional long-term study. For women of child-bearing age and children under 15, consumption restrictions for sport fish containing mercury begin at levels of 0.26 ppm with total restriction advised for levels above 0.52 ppm.

limit the full recovery of the Lake Ontario bald eagle, mink, and otter populations by reducing the overall fitness and reproductive health of these species.

DDT and its metabolites – identified as LaMP critical pollutants because they were responsible for wildlife consumption advisories and were identified as a potential problem contaminant for bald eagles as they re-establish their shoreline nesting territories.

Previous Lake Ontario Toxics Management Plan reports had also identified three other contaminants as potentially exceeding water quality standards and criteria: octachlorostyrene (OCS), chlordane, and hexachlorobenzene (HCB). A review of information showed that none of these contaminants persist as a lakewide issue, and that OCS, chlordane, and HCB are well below applicable water quality criteria.

6.3 Lake Ontario Sources and Loadings Strategy

A goal of the Lake Ontario LaMP is to reduce inputs of designated critical pollutants to meet LaMP ecosystem objectives and restore associated beneficial use impairments. Due to the scale and complexity of pollutant sources within the basin, the LaMP agencies agree that a load reduction schedule based on a per cent reduction target is not practical. Instead, the LaMP Parties take a focused and strategic approach to identify, assess and mitigate sources of critical pollutants.

Recognizing that the LaMP Parties have regulatory mandates, the LaMP uses a cooperative approach, working closely with regulatory programs, local governments, industry and individuals to develop and coordinate an effective critical pollutant reduction strategy to address known and potential sources of critical pollutants throughout the Lake Ontario basin. The LaMP critical pollutant reduction strategy has three main elements: (1) data/information synthesis; (2) coordination with regulatory actions; and (3) promoting voluntary actions.

Data/Information Synthesis:

- Information on the concentrations, sources, loadings and pathways of critical pollutants are evaluated, with the aim of identifying source reduction actions.
- Available regulatory monitoring information often does not include critical pollutants in routine monitoring, or may use methods that cannot detect low levels of contaminants of concern. Qualitative information is acknowledged as an important component of the LaMP critical pollutant source identification process and decision making.

Coordination with Regulatory Actions:

- The LaMP identifies and highlights remedial and other regulatory program efforts underway that contribute to LaMP pollutant reduction goals on which LaMP strategies can build.
- Regulatory programs are being kept apprised of any information relevant to their enforcement interests or monitoring requirements, so that regulatory tools can be applied as appropriate to address specific LaMP priority sources.
- Critical pollutants from the upstream Great Lakes and connecting channels enter Lake Ontario via the Niagara River and from out of basin atmospheric sources. Restoring beneficial uses in Lake Ontario depends in part on the successful implementation of LaMPs and RAPs upstream, and out of basin programs that reduce emissions of critical pollutants.

Voluntary Actions:

- The LaMP promotes voluntary efforts to reduce inputs of critical pollutants by: encouraging community and local government pollution prevention programs (such as pesticide “clean

sweeps" and mercury equipment/thermometer collections); communicating and highlighting the LaMP goals and objectives and the importance of voluntary efforts (through success stories); and encouraging accelerated product phase-outs, pollutant minimization plans or other actions by industry or local governments.

The LaMP's critical pollutant reduction strategy may go beyond existing programs to address significant sources identified by the LaMP as a binational priority. The US and Canada are using compatible approaches to source reduction strategies in order to best utilize current initiatives, historic actions and individual human and information sources. The US has evaluated critical pollutant information and related actions in all watersheds within its portion of the basin. Canada has focused on actions within priority watersheds, based on available ambient monitoring information and emissions data from industrial, municipal and other non-point source discharges (such as combined sewer overflows, stormwater, waste sites). Local strategies are developed to address identified sources of critical pollutants in these watersheds.

6.4 Identifying Sources and Loadings of Critical Pollutants

Critical pollutants enter Lake Ontario *via* a number of pathways, including its tributaries, precipitation, point sources (e.g., sewage treatment plants, industrial facilities, waste sites) and non-point sources (e.g., urban stormwater, agricultural runoff). Being the last in the chain of Great Lakes, Lake Ontario receives some of its known contaminant loadings from upstream lakes. The sources of critical pollutants to Lake Ontario are defined in the following categories for this report: Upstream (*via* Niagara River); Canadian Tributaries (including Hamilton Harbour); US Tributaries; Canadian Direct Discharges; US Direct Discharges; and Atmospheric Sources (wet and dry deposition plus gas-phase absorption).

6.4.1 Data Sources and Limitations

The approach taken by the Lake Ontario LaMP has been to report all available data regarding loadings to Lake Ontario. The LaMP does not have a formal screening procedure or selection criteria to independently evaluate whether available data are suitable for estimating loadings. The LaMP relies on the advice and conclusion provided by individual agency on whether their data can be reasonably used for quantifying loadings to Lake Ontario.

The LaMP provides estimated loading data in Table 6.1 with the caution that management decisions should not be based solely on these comparative loadings. Confidence in many of these data is low, and the potential for errors is high. Comparing the magnitude of loadings from one source to another is confounded by differences in sampling methods used by the various agencies that collect these data. Analytical methods have changed over time, and agencies have adopted new methods at varying times. The reporting of analytical results is not consistent between programs either; concentrations of contaminants from some sources may be "below the detection limit," and the methods used to handle these censored data differ between monitoring programs. Data presented in Table 6.1 were collected at different times over a 15-year time frame. Confidence and recognized limitations specific to each source are described below.

Where acceptable quantitative loadings information is not available, qualitative indicators provided by water quality monitoring, or by other monitoring such as sediment and aquatic organisms, have been used to identify contaminant sources.

6.4.1.1 Sources Within the Lake Ontario Basin

Point Sources

New York State requires wastewater dischargers to monitor and report on known or suspected contaminants. Discharge permits include specific parameter limits and are designed to address toxicity testing, pollution prevention, pretreatment, and compliance schedule requirements. A Pollutant Minimization Program (PMP) guidance manual for wastewater treatment was completed in 2004 to focus on mercury and other toxic discharge reductions (see Section 6.5.2.2)

The Toxics Release Inventory (TRI) is useful in summarizing the annual release of toxic chemicals reported by certain industrial facility groups. Reports for 1997 through 2000 are posted on NYSDEC's website. Release to receiving waters accounts for about 15 per cent of the total inventory. TRI data are not used for calculating US point source loadings to Lake Ontario in Table 6.1, but rely instead on a NYSDEC study from 1997 (Litten, 1997).

On a national basis in Canada, information on point source releases of mercury, dioxins and furans to water are included in the National Pollutant Release Inventory (NPRI). Facilities are able to report loadings that are based on monitoring or direct measurement, mass balance calculations, emission factors or other engineering calculations. However, the criteria for reporting to this program are such that an unknown number of smaller direct point sources are not captured. NPRI data are used for calculating Canadian point source loadings of mercury to Lake Ontario in Table 6.1, with one exception noted below.

Ontario's Municipal/Industrial Strategy for Abatement (MISA) regulations require nine industry sectors to report concentrations and loading of toxic contaminants, including dioxins (2,3,7,8 - T4CDD) and furans (2,3,7,8 - T4CDF). In 2004, no facilities reported concentrations of dioxins and furans above the detection limit. Through facility-specific approvals, OMOE requires some facilities to report loadings of mercury. In 2004, one facility did report loadings of mercury, and these data are used in lieu of NPRI's data for that facility in calculating the summary shown in Table 6.1.

In the fall of 2004, OMOE launched a sampling program at selected landfill sites and municipal sewage treatment plants to characterize harmful pollutants in landfill leachate and municipal influent, effluent and sludge. The results from this sampling program will help to characterize harmful pollutant loadings to Lake Ontario, as well as inform policy development for the control of these pollutants in municipal effluent. The study consists of a one-year sampling program which was continued until November 2005. Lab analysis of these samples is currently being conducted.

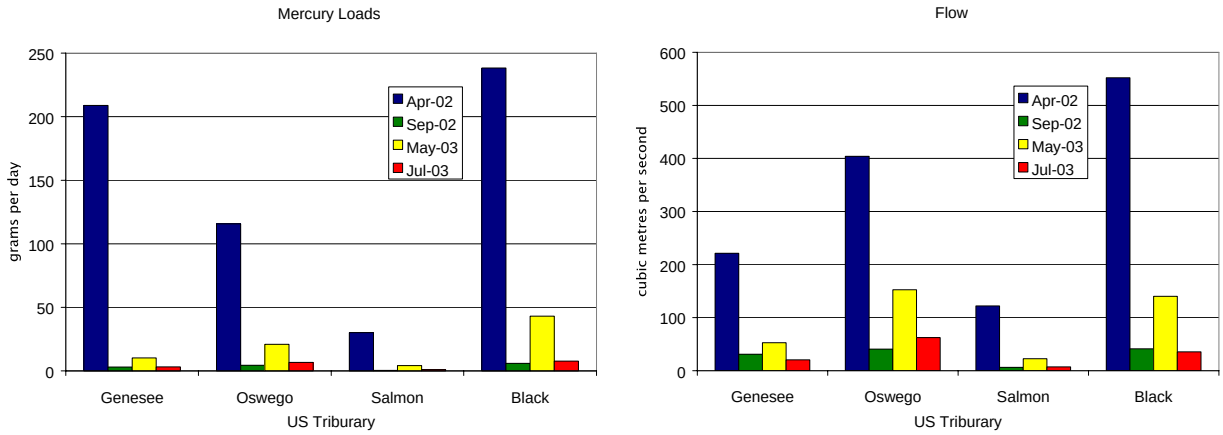
Tributaries

In order to calculate the total loading of any pollutant being carried by a tributary, it is necessary to know both flow (i.e., the total volume of water flowing out of the tributary) and the concentration of the pollutant in the river. In the spring, or after several days of heavy rain, flow can increase dramatically, with a corresponding increase in loading, due to increases in sediment carried in the river, or because of the increased runoff entering the river. These changes can cause large variations in loadings, as seen in Figure 6.1.

Critical pollutants entering tributaries may originate from a number of sources or activities (such as point sources, atmospheric deposition onto the watershed, contaminated industrial sites, landfills, historic use of pesticides, storm drainage, combined sewer overflows, etc). Therefore, pollutant concentrations can be highly variable. Ideally, in order to accurately estimate loadings of critical pollutants, there should be frequent data covering the range of seasons and flow conditions. However, due to logistical constraints, this is often not possible. As a result, available quantitative and qualitative monitoring data, as well as

biological monitoring results, were used to estimate loadings, or the relative presence or absence of critical pollutants within each tributary watershed.

Figure 6.1 Variations in flows and loads of mercury in US Tributaries



US tributary loadings presented in Table 6.1 are calculated differently than Canadian tributary loadings. The USEPA's data are, at this time, based on approximately eight sampling events per tributary. These are the best available estimates and are subject to changes as additional data become available and as monitoring techniques improve. These loading estimates for tributaries should be considered qualitative and approximate, as sampling in most cases was not event-based. The data that are provided are only estimates, and are subject to significant changes in the future.

Canadian tributary loading estimate protocols from OMOE requires a larger number of samples to estimate contaminant loadings. This protocol was the basis for work in Toronto-area tributaries in 1991 through 1992, and only these Toronto-area tributaries are used to estimate contaminant loads from Canadian tributaries in Table 6.1. The magnitude of the remaining loadings cannot be quantified.

In-place Sediments

The LaMP is not currently reporting estimates from loadings to Lake Ontario water from in-place sediments. The LOTOX2 model, discussed subsequently in this chapter, uses modeling techniques to estimate the loadings of PCBs from in-place sediment that have occurred historically (see Section 6.6.1.4)

Other In-Basin Sources

This assessment does not include information on combined sewer overflows (CSOs), stormwater and other non-point sources that discharge directly to the lake. The magnitude of these missing loads cannot be estimated based on current data.

Loadings from air emissions sources within the basin, versus those from air emissions sources *outside* the basin, cannot currently be differentiated, although modelling and other research is ongoing in this area. See Atmospheric Deposition (section 6.4.1.3) below.

6.4.1.2 Sources and Releases Outside the Lake Ontario Basin

Long-term water quality monitoring programs are conducted by Environment Canada at Fort Erie and Niagara-on-the-Lake (at both ends of the Niagara River). These programs use similar sampling and analytical methods and the loading calculation methodologies have been agreed to by the LaMP Parties.

These data provide a good estimate of the critical pollutant loadings that originate from upstream Great Lakes basins, and those that originate in the Niagara River basin, and are summarized in Table 6.1.

The amounts of critical pollutants that leave Lake Ontario via the St. Lawrence River are monitored at Wolfe Island at the head of the St. Lawrence River. While data collection at this station is ongoing, Lake Ontario's loadings to the St Lawrence River have not been compiled into updated estimates, and 1997 data are reported in Table 6.1.

6.4.1.3 Atmospheric Deposition

Estimates of atmospheric loadings of critical pollutants to Lake Ontario were developed by the Integrated Atmospheric Deposition Network (IADN) for PCBs, DDT and dieldrin. IADN is an international network of seven master air sampling stations located throughout the Great Lakes basin and has measured levels of persistent chemicals in the air since 1991. The IADN network for Lake Ontario consists of a master station at Point Petre (near the eastern end of Lake Ontario), and a satellite station located in Burlington, Ontario (at the west end of the lake). As in previous LaMP reports, IADN data are used in Table 6.1 to report atmospheric deposition of PCB and pesticide critical pollutants; new for this report are mercury loading information.

In past IADN reports, flows and fluxes were calculated seasonally and then summed to give annual loads and averaged to give annual fluxes. Loadings estimates of dry and wet deposition and absorption are now calculated monthly. Volatilization estimates are calculated annually by IADN, although IADN does not measure water concentrations and must rely on other researchers' measurements.

In IADN's report, errors are presented for each term as a coefficient of variation (COV). Because monthly loadings estimates are now calculated and only two or three values were available, the standard deviation over mean as a measure of uncertainties for ambient air concentrations was not used. Instead, limit of detection over mean was adopted. This has resulted in slightly smaller overall COVs since temporal variability was one of the major sources of error in previous reports. Readers are referred to *Atmospheric Deposition of Toxic Substances to the Great Lakes: IADN Results Through 2000* for parameter-specific COVs (Blanchard *et al*., 2004).

IADN results are included with results from the Lake Ontario Atmospheric Deposition Project (LOADS) project, which provides estimates of atmospheric loadings of mercury (elemental and reactive gaseous), PCBs, DDE, mirex, and dioxins/furans. LOADS sampling occurred every six days for a period of twelve months at a site on the shoreline of Lake Ontario in Sterling, New York, along with three one-week cruises aboard the Lake Guardian. Land based sampling at Sterling, New York is still underway.

6.4.2 Loadings – General

Table 6.1 presents four major categories of critical pollutant loadings estimates based on the best data available in 2005. Again, as a result of the many limitations described previously, the loading numbers in Table 6.1 are only estimates.

Table 6.1 Estimates of Critical Pollutant Loadings to Lake Ontario

Note: Loadings in this table are only ESTIMATES. The data are drawn from a number of different sources and monitoring programs which use different criteria, methods, and loading calculation methodologies. As a result, these estimates contain a significant degree of uncertainty and should only be considered as general indications of the current state of the LaMP's Parties knowledge of the significance of loadings from various sources. Data sources are provided on the next page.

Data Year	Loadings from Sources Upstream of the Lake Ontario Basin MEAN (Lower 90 percent CI to Upper 90 percent CI) kg/yr						Loadings from Water Discharges within the Lake Ontario Basin kg/yr					Loadings from the atmosphere kg/yr		Amounts Leaving Lake Ontario kg/yr		
	Other Great Lakes		Niagara River Basin		Total		Tributaries MEAN (+/-RMSE)		Direct Point Sources Discharges		Total	LOADS	IADN	Via St. Lawrence River	Loss to Atmosphere	
							Can.	US	Can.	US					LOADS	IADN
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1991-1998	2002-2004	2003	1997		2005	2000	1995	2005	2000
PCBs	16 (13 to 21)	30 (19 to 47)	61 (37 to 90)	11 (-16 to 35)	77 (58 to 103)	41 (31 to 54)	3.6 (2.7 to 4.5)	11	NA	1.6	19.7	NQ	45	NQ	NQ	320
Total DDT	19 (15 to 25)	22 (13 to 40)	-9.7 (-19 to 2)	-13 (-34 to 0)	9.3 (5.8 to 17)	9.2 (6.7 to 13)	1.1 (0.8 to 1.4)	ND	NA	1.7	2.6	NQ	22	1.1	NQ	NA
Mirex	ND	ND	1.5 (0.9 to 2.5)	0.9 (0.7 to 1.2)	1.5 (0.9 to 2.5)	0.9 (0.7 to 1.2)	NQ	ND	NA	ND	0.004	NQ	ND	NA	NQ	NA
Dieldrin	17 (16 to 19)	20 (18 to 23)	-1 (-4 to 1)	-4 (-11 to 3)	16 (14 to 17)	16 (12 to 21)	0.3 (0.27 to 0.33)	ND	NA	0.15	0.35	NA	24	40	NA	190
Dioxins/Furans	ND	ND	ND	ND	ND	ND	NQ	ND	ND	ND	NQ	NQ	NA	ND	NQ	NA
Mercury	93 (86 to 99)	119 (95 to 150)	-22 (-39 to -2)	-71 (-110 to -36)	71 (60 to 84)	49 (40 to 59)	NQ	53	68	3.5	124.5	558	185	ND	410	157

NA = Not Analysed – no data are available
ND = Not Detected – concentration data are available, but are below analytical detection limits
NQ = Not Quantified – parameter is detected, but only qualitative data are available
RMSE = Root Mean Square Error
CI = Confidence Interval

Data Sources for Table 6.1

Loadings from Sources Upstream of the Lake Ontario Basin

- Klawunn, P. *et al.*, 2005 (unpublished). The Niagara River Upstream/Downstream Program. Ecosystem Health Division, Environment Canada – Ontario Region. Values are for 1999/2000 and 2000/2001.
- **N.B.** Values for Niagara River Basin estimated based on measured results at Niagara-On-The-Lake (total) minus Fort Erie (other Great Lakes). Upper and Lower Confidence Intervals Physical and chemical processes within the Niagara River (e.g., volatilization to air , deposition to sediment) may be in part responsible for reported 'negative' loadings), as may inaccuracies inherent in calculating loadings.
- **N.B.** Mercury measurements did not include particle-bound mercury.

Loadings from Water Discharges within the Lake Ontario Basin
Direct Point Source Discharges – Canada

- 2003 NPRI National Databases

Direct Point Source Discharges – US

- Litten, 1997. NYSDEC; New York State SPDES program.

Atmospheric Loadings

- Blanchard et al., 2004. Atmospheric Deposition of Toxic Substances to the Great Lakes: IADN Results to 2000, US/Canada IADN Scientific Steering Committee. Values for PCBs, DDTs and Dieldrin are for 2000 and represent wet deposition (via precipitation and gas absorption).
- Holsen, T. Estimation of Mercury Loadings to Lake Ontario in the Lake Ontario Atmospheric Deposition Study (LOADS) (in press) Hg loading is comprised of : atmospheric loadings into the lake = 300 (Hg_0) + 170 (wet deposition) + 68 (RGM) + 20 Hg (p) = 558 kg/yr. Hg load leaving the lake thru loss to atmosphere = 410 kg/yr (DGM)

Point and Non-Point via Tributaries - Canada

- Boyd, D. and H. Biberhofer, 1999. Large Volume Sampling at Six Lake Ontario Tributaries During 1997 and 1998
- Boyd, D. 1999. Assessment of Six tributary Discharges to the Toronto Area Waterfront. Volume 1
- Boyd, D. D'Andrea, M. Anderton, R. 1999. Assessment of Six Tributary Discharges to the Toronto Area Waterfront. Volume 2.
- Fox, M.E. R.M. Khan and P.A. Thiessen. 1996. Loadings of PCBs and PAHs from Hamilton Harbour to Lake Ontario. Water Quality Research Journal of Canada, 31(3): 593-608. **N.B.** This study involved a 10-day sampling period in July 1990 and a 14-day sampling period in March 1991. Annual loadings of 2.8 kg/ year of PCBs were calculated. However, those data are not included in the totals above.

Point and Non-Point via Tributaries – US

- Coleates, R., *et al*. 2005. Means of Total Loadings from Five Tributaries , calculated from concentration and flow data from sampling events between April 2002 and September 2004 for Eighteen Mile Creek, Genesee River, Oswego River, Salmon River and Black River (unpublished, United States Environmental Protection Agency).

St. Lawrence River

- Merriman, J., 1998. Trace Organic Contaminants in the St. Lawrence River at Wolfe Island. (1994-1995).
- **N.B.** Previously, PCBs discharged from Lake Ontario at Wolfe Island were calculated at 360 kg/yr. Subsequently, it was determined that PCB measurements made at Wolfe Island were influenced by lab contamination, resulting in reported PCB concentrations that over-estimated actual values by as much as a factor of two for current levels. Data for Wolfe Island will be updated by the LaMP as soon as the final data are available.

6.4.3 Loadings of Critical Pollutants

The LaMP previously reported that, based on the very limited loadings data available, the most significant source of critical pollutants to Lake Ontario comes from outside the Lake Ontario basin, specifically the Niagara River Basin and upstream lakes. Based on the current, although still very limited loadings data available, it appears that the upstream Great Lakes are still a significant source of critical pollutants to Lake Ontario. However, for some critical pollutants, the loadings from atmospheric deposition, whose source is from activities both within and outside the Lake Ontario basin, is equal in magnitude to loadings from upstream Great Lakes.

6.4.3.1 PCBs

Polychlorinated biphenyls (PCBs) were manufactured between 1929 and 1977. PCBs were considered an important industrial safety product for conditions where high heat or powerful electric currents posed explosive and fire hazards. PCB oils were used in electrical transformers as a nonflammable electrical insulating fluid. PCBs were also used as industrial lubricating oils to replace earlier types of hydraulic oils that could more easily catch fire under conditions of high pressure and temperature. Since the 1970s, the production of PCBs in North America has been banned, and the uses of PCBs are being eliminated.

Levels of PCBs in the environment have decreased in response to the banning and phasing out of the various uses of PCBs. The Great Lakes Binational Toxics Strategy (GLBTS, 2004) indicates that 88 per cent of high-level PCB wastes in storage in Ontario had been destroyed compared to a reduction target of 90 per cent. The USEPA has committed to reassess the PCB equipment inventory in 2005 in order to report progress towards its GLBTS challenge goal of a 90 per cent national reduction of high-level by 2006.

Upstream loadings of PCBs from the NRTMP have changed significantly since 2002; however, this change is in part due to protocol changes in the laboratory analysis. Beginning in April 1998, PCBs in water and solids were analyzed as individual congeners, and reported as total congener PCBs (TCPCB) using capillary columns chromatography. Prior to this date, total PCBs were analyzed and reported based on a 1:1:1 mixture of Aroclors 1242, 1254 and 1260 using packed column chromatography. A comparison of the two methods shows that the new capillary column method results in higher PCB concentrations reported in both water and suspended sediments. Therefore, it is not possible to compare the results of the methods used prior to April 1998 to results after this date.

6.4.3.2 DDT and its Metabolites

DDT was the most widely used pesticide in North America and other countries from 1946 to 1972. Agricultural use of DDT has since been banned in North America following a determination that DDT and its breakdown products were causing widespread reproductive failures in eagles and other wildlife species.

The IADN data indicate that atmospheric deposition of DDT has fluctuated in Lake Ontario from 1993 through 2000, with deposition lower in 1998 to 2000 than in the proceeding years. IADN does not track loss from the lake through volatilization.

6.4.3.3 Mirex

Mirex was used in the Lake Ontario basin primarily as a flame retardant in manufacturing and electrical applications. Use and production of mirex is now banned in North America. During the 1970s, a

manufacturer discharged large quantities of mirex-contaminated wastewater to the Niagara River, resulting in widespread contamination of Lake Ontario sediment and fish.

The only measurable mirex that enters Lake Ontario originates in the Niagara River basin. However, the Niagara River Upstream/Downstream water sampling program operated by EC shows substantial decreases in the concentrations of mirex.

Two facilities located on the Oswego and Credit Rivers, which used mirex in the 1970s, have been extensively investigated as there were concerns regarding known or potential mirex releases to these rivers. A review of 1999 information, including mirex levels in resident fish, indicated that the Oswego and Credit Rivers are not significant sources of mirex to the lake.

No reliable estimates of atmospheric deposition or volatilization of mirex are yet available.

6.4.3.4 Dioxins and Furans

Dioxins and furans are a group of chemical by-products that are created by a variety of chemical and combustion processes. Steps have been taken to control and limit those processes that produce high levels of dioxins and furans, resulting in a significant decrease in environmental levels of these chemicals over the last two decades. Some of the processes that continue to produce dioxins and furans include wood burning stoves, internal combustion engines, incinerators, and a variety of other chemical processes. Natural sources, such as forest fires, also produce dioxins and furans.

Dioxins and furans exist at very low levels in the environment and, as a result, are difficult and costly to detect and accurately quantify. Historically chemical manufacturing sources in the Niagara River Basin were significant sources of these contaminants to Lake Ontario. These sources have been effectively controlled, although low-level releases to water from one Ontario site to the Niagara River Basin are reported to Canada's National Pollutant Release Inventory.

Although the Niagara River upstream-downstream program did not detect dioxins and furans in Niagara River water, information from other media (mussels, spottail shiners) do confirm low-level releases of dioxins and furans along the Niagara River. Using the same types of qualitative water and biological sampling methods, dioxins and furans have also been detected in some Lake Ontario tributaries and harbours.

Air emissions are recognized as an important source of these contaminants to the environment. High volume air samples have been collected and analyzed through the Lake Ontario Atmospheric Deposition Study (LOADS). A summary of results of the concentrations of dioxins/furans in the air over the lake and at a land-based site is shown in Table 6.5. The estimated load to the lake will be done by LOADS, but is not available at this time.

The US and Canada are well advanced toward meeting their Great Lakes Binational Toxics Strategy dioxin/furan emission reduction goals. The BTS reported that the US projected that it has met its challenge goal of 75 per cent reduction of the aggregate of air releases of dioxins and furans nationwide, and water releases within the Great Lakes basin. Canada, which estimates an 87 per cent reduction of releases to air and water within the Great Lakes basin, expected to meet its 90 per cent target by the end of 2005.

6.4.3.5 Mercury

Mercury is a naturally-occurring metal, which is found in small amounts in most soils and rocks. Mercury is used in medical and dental products, electrical switches, batteries and in the production of various synthetic materials, such as urethane foam.

The upstream loading data presented for 2005 are changed from the LaMP's 2002 reporting year. Previously, mercury loadings from the Niagara River were estimated based on values for particle and dissolved-phase concentrations for mercury at the analytical detection limit. In Table 6.1, Niagara River data are presented based on analysis of mercury in suspended solids only; future years will include dissolved-phase mercury in the water column as well.

With respect to mercury point source water discharges from the Canadian-side, data in Table 6.1 are based on reports to the NPRI The NPRI reporting criteria for mercury is such that only facilities that manufactured, processed or otherwise used five kilograms or more of mercury (at any concentration) are required to submit a report. Therefore, Table 6.1 under-reports the point source mercury emissions to Lake Ontario. Mercury loadings from point sources in the US have not been re-quantified since 1997, and methodological improvements as well as improvements in sewage treatment plant operation and efficiency suggest that these data should be considered cautiously.

Atmospheric deposition of mercury to Lake Ontario results from sources from both within and outside of the lake's drainage basin, including loadings from U.S., Canadian and international sources. The question of whether reductions within the Lake Ontario basin and other North American emissions reductions are offset by global emissions increases is an area of research.

The USEPA has renewed tributary sampling of the Genesee River, 18 Mile Creek, Oswego River, Salmon River and the Black River during the period 2002 through 2005. These data are reported here as the loadings from U.S. tributaries from 2002 through 2004. Monitoring is expected to continue for the near future, and should improve the reporting of loadings from these tributaries. Smaller creeks that were not previously sampled will also be added to the monitoring regime. Estimated loadings will be updated as new data are available.

6.4.3.6 Dieldrin

Dieldrin is a formerly used pesticide that is now banned from use in the Lake Ontario basin and throughout North America. Aldrin, another formerly used pesticide, transforms into dieldrin through natural breakdown processes.

Most of the dieldrin that enters the lake comes from upstream sources and atmospheric deposition. Gas exchange of dieldrin at Lake Ontario is consistently the largest flux observed, indicating net volatilization (loss) of this pesticide.

6.5 Actions and Progress

The information contained in this chapter has been compiled based on documents produced up to December 2005. The LaMP process is a dynamic one and therefore the status will change as progress is made.

It should be recognized that programs in place today that have or will reduce critical pollutant loadings may not have an impact on environmental levels for decades, particularly in fish and wildlife. Organisms accumulate chemicals or metals that have been in the ecosystem for long periods of time, either in

sediment or in organisms which are lower on the food chain. This time lag must be considered when evaluating data which were often collected several years before being reported and which reflect loadings which occurred many more years before data collection.

6.5.1 Binational Activities

6.5.1.1 Niagara River Toxics Management Plan

Because of the critical link between Lake Ontario and the Niagara River, the Four Parties agreed in 1987 to implement the Niagara River Toxics Management Plan (NRTMP). The NRTMP works to "reduce toxic chemical concentrations in the Niagara River by reducing inputs from sources along the river with a goal of achieving water quality that will protect human health, aquatic life, and wildlife, and while doing so, improve and protect water quality in Lake Ontario as well." Eighteen priority toxics were identified and 10 (including Lake Ontario LaMP critical pollutants dioxin, mercury, mirex, and PCBs) were selected for 50 per cent reduction. To do this, the Four Parties committed to: 1) reduce point and non-point sources of pollution to the river; 2) monitor the water quality and health of the river; and, 3) report progress to the public.

Since 1987, significant improvements in the river have been made by completing site specific clean-up activities, controlling point source discharges, encouraging pollution prevention techniques and restoring critical habitat areas along the river. A Letter of Support was signed by the Four Parties on December 3, 1996, to continue the commitment to the Declaration of Intent and to further actions to reduce loadings of toxic chemicals to the Niagara River.

Improvements, as shown by the ongoing results of monitoring contaminants in river water, tissues of fish or mussels and river sediments are reported in Niagara River Toxics Management Plan Progress Report and Work Plans (e.g. Williams and O'Shea, 2004; Williams and O'Shea, 2003). Included in these reports are summaries of the Niagara River Upstream/Downstream program, including the Williams et al. (2000) summary describing trends in contaminant reductions over the period of 1986-1997, and the ongoing monitoring program reports (e.g., Merriman and Kuntz, 2002).

6.5.1.2 Lake Ontario Air Deposition Study (LOADS)

The LOADS project is a multi-year collaboration to study the levels of mercury, polychlorinated biphenyls (PCBs), dioxins/furans, mirex and dichloro-diphenyl-dichloroethylene (DDE) that deposit from the air into the lake. Scientists and agency personnel from Clarkson University, SUNY Oswego, SUNY Fredonia, University of Michigan, Environment Canada, New York State Department of Environmental Conservation and the US Environmental Protection Agency are taking part in the study.

The objectives of the study are to: 1) estimate contaminant loadings being deposited from the air into the lake. (This information will be integrated into the Lake Ontario Mass Balance Model, a mathematical model that predicts what effect reducing pollution will have on the lake and its fish (see Section 6.5.1.4)) ; 2) assess any differences in concentrations and deposition over land and over water; and, 3) examine the effect of urban areas on deposition to the lake.

During 3 intensive sampling events, samples of air and water were taken from the Environmental Protection Agency (USEPA) research vessel Lake Guardian during April and September 2002 and July 2003 cruises. At the same time, samples were collected at the land-based site at Sterling, NY. Sampling was coordinated with the IADN Pt. Petre, Ontario sampling schedule.

The land-based site operated by SUNY Oswego is located at Sterling Nature Center, Sterling, NY and is situated on a bluff overlooking Lake Ontario. The site samples for air deposition for PCBs, dioxins/furans, DDE, mirex, reactive gaseous mercury (RGM) and total gaseous mercury (TGM).

At Sterling, samples were collected every six days from April 2002 to March 2003, matching the sampling protocols of the Integrated Atmospheric Deposition Network (IADN). The closest IADN site to Sterling is located at Pt. Petre approximately 50 miles (30 km) across Lake Ontario on the northeastern shore. Prior to the LOADS project no dedicated measurement of airborne contaminants was occurring on the southeastern shore of Lake Ontario.

PCB Results

Table 6.2 PCB air concentrations, pg/m3 and air temperature. Sampled from Ship and from nearby Land based station. Average of three intensive sampling events (April and September 2002 and July 2003)

Sampling Location	R/V Lake Guardian (pg/m^3)	Temperature (°C)	Land based Sterling, N.Y. (pg/m^3)	Temperature (°C)
L1	226	16.8	450	17.7
L2	156	15.8	601	19.5
L3	148	17.6	583	20.8
L5	203	14.2	443	20.2
L6	216	16.5	321	16.5
L6-D	366	17.0	588	22.3
L6-N	350	18.3	323	19.3

L1 = eastern basin between Pt. Petre and Oswego
L2 = eastern basin mid lake north of Rochester
L3 = middle of lake
L4 = middle of lake
L5 = off shore of Toronto
L6 = off Hamilton Harbor
L6 –D = off Hamilton Harbor sampled in daytime
L6 –N = off Hamilton Harbor sampled at night

For the period April 2002 – March 2003 over 200 samples were extracted and analyzed for PCBs. The following general statements can be made:

- Levels of atmospheric total PCBs measured on the southeastern shore of Lake Ontario at Sterling for the period 2002-2003 are higher than similar rural sites on the Great Lakes as reported by IADN between the years 1998-2000 (Figure 6.2).
- The pattern of PCBs measured at Sterling is markedly different than any of the other IADN sites, consisting of more higher-chlorinated PCBs.
- Air sampling conducted on Lake Ontario during three cruises aboard the RV Lake Guardian indicate that Lake Ontario is not the source of the higher-chlorinated PCB fingerprint measured at Sterling.
- Land-based sampling conducted at Sterling for the period 2002-2003 indicates that the amounts of PCBs found in the air are directly linked to air temperature, that is, as the air temperature increases the amount of PCBs in the air also increases (Figure 6.3)

Figure 6.2 Total PCB comparison of IADN (1998-2000) and Sterling (2002-2003)

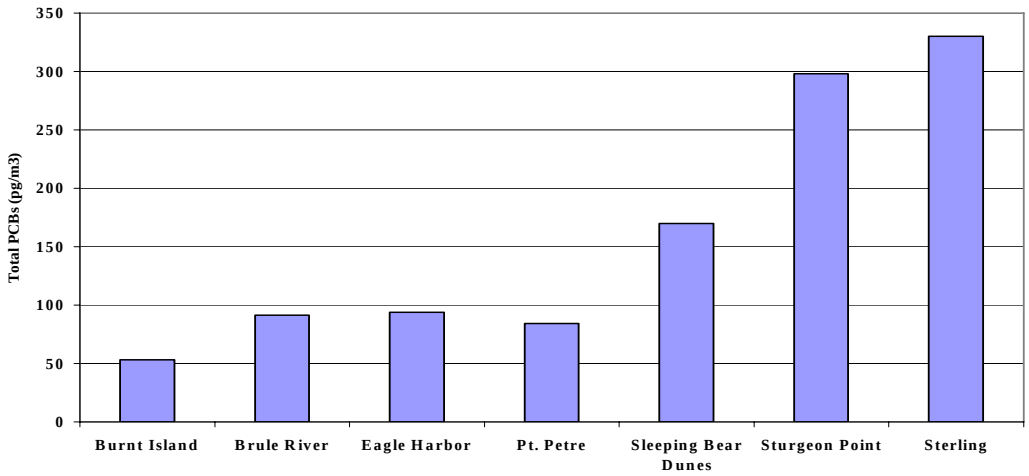
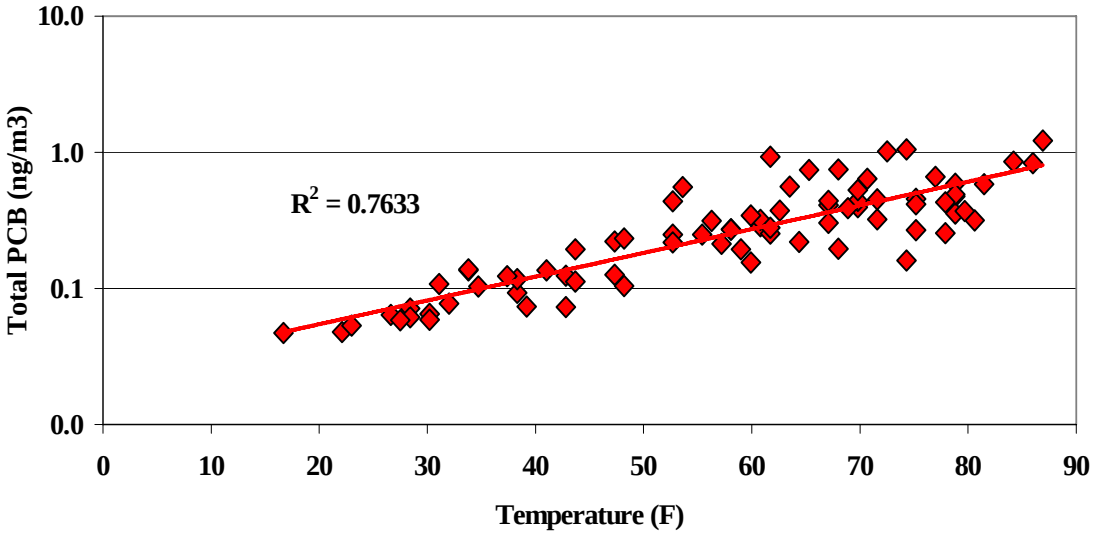


Figure 6.3 PCB air sampling at Sterling for the period April 2002 – March 2003 showing direct relationship between air temperature and amount of PCBs measured



Water Column Results

The criteria for including results shown in Table 6.3 were that the result had to be equal or greater than five-times the concentration observed in "blank" samples. PCB congener 11 was the most commonly found PCB and on the average was more than 20 per cent of the total PCBs. This congener is produced by dye manufacturers. Congeners 5, 8 and 18 were the next most commonly found.

Table 6.3 Total PCBs, DDE and Mirex in Lake Ontario Surface Water dissolved phase, ng/L (Average of 3 intensive sampling events: April and Sept. 2002 and July 2003)

PCBs *(ng/L)*	p-p' DDE *(ng/L)*	Mirex *(ng/L)*
0.093	**0.004**	**0.000**

Mercury Results

When inorganic forms of mercury (Hg) enter water, the mercury may be altered by bacterial or chemical action into an organic form, primarily methylmercury. Methylmercury is more toxic than the inorganic mercury, and has the ability to migrate through cell membranes and bioaccumulate in living tissue. Bioaccumulation of methylmercury in natural ecosystems is an environmental concern because it inflicts increasing levels of harm on species higher up the food chain. Through the biomagnification process, methylmercury increases in concentration from microorganisms, to fish, to fish eating predators, then to humans.

Atmospheric deposition is a major input route of mercury to the water. Atmospheric Hg is primarily emitted from natural and anthropogenic sources and exists mainly in three inorganic forms: elemental mercury (Hg°), reactive gaseous mercury (RGM) and particulate mercury. Hg^0 makes up more than 90 per cent of total gaseous mercury (TGM). It is inert, water insoluble and volatile. It is not readily removed from the atmosphere by wet and dry deposition, and has a long residence time in the atmosphere (approximately 1 year). It has an approximate homogeneous atmospheric concentration of between 1-5 ng/m^3.

Gaseous divalent mercury (Hg^{++}) is absorbed by cloud droplets, deposits more than 100 times as readily as Hg°, and has a short residence time in the atmosphere (a couple of days). In atmospheric water it tends to be present either dissolved or absorbed onto particles in droplets. Hg^{++} reacts to form water soluble compounds (e.g. $HgCl_2$ or Hg $(OH)_2$) and is then referred to as reactive gaseous mercury (RGM). RGM concentrations can vary from 1-600 pg/m3, depending on location, and make up about 3 per cent of total gaseous mercury in the atmosphere. Particulate mercury consists of mercury associated with atmospheric particulate matter and makes up less than 1 per cent of total mercury in the atmosphere. It can contribute significantly to atmospheric deposition due to its short lifetime (a few days). In the water column, Hg^{++} can be methylated, buried in sediments or re-suspended from the sediments.

As part of the LOADS project, four types of mercury were measured: TGM , which consists of both Hg^0 and RGM in the atmosphere; RGM in the atmosphere; TGM in the water column (filtered and unfiltered); and dissolved gaseous mercury (DGM) in the water column. TGM and RGM concentrations were measured onboard the R/V Lake Guardian, at Sterling, New York in April and September 2002, and July 2003 and at the IADN station , Pt. Petre, Ontario in Sept. 2002 and July 2003. Results are reported in Table 6.4.

RGM is produced by sources that directly emit it to the atmosphere. Variations in RGM concentrations were large, consistent with RGM being a more local pollutant than Hg^0. RGM concentrations measured at some of the sites when the ship was located near Toronto were significantly higher than samples collected at other locations in September 2002 and July 2003, but this trend did not occur in April 2002, possibly due to varying wind directions.

Overall, there was no consistent trend in TGM or RGM between the western part of the lake and the eastern part of Lake Ontario.

Both unfiltered and filtered TGM samples were collected from the Lake Guardian. The unfiltered and filtered TGM concentrations were consistently higher in western Lake Ontario than in eastern Lake Ontario, with the exception that similar filtered TGM concentrations were measured in both areas in July 2003. Results are reported in Table 6.4. Dissolved gaseous mercury (DGM) which consists mainly of Hg^0 in surface water were found to be higher in western Lake Ontario than those measured in eastern Lake Ontario.

Table 6.4 Concentrations of Total Gaseous Mercury (TGM) and Reactive Gaseous Mercury (RGM) in Air and filtered Total Gaseous Mercury (TGM) and Dissolved Gaseous Mercury (DGM) in the Water Column of Lake Ontario

Analyte	Units	Sample Date	Western Basin	Eastern Basin	Land-based Site Sterling, N.Y.	IADN Site Pt. Petre, Ont.
TGM	ng / m^3	April 02 Sept. 02 July 03	1.86 1.75 1.55	1.79 1.52 1.71	1.99 7.43 3.01	1.67 1.61 1.97
RGM	ng / m^3	April 02 Sept. 02 July 03	3.80 8.50 5.32	19.82 5.83 5.62	7.59 3.72 7.39	NA 6.31 3.98
TGM (unfiltered water)	ng/liter	April 02 Sept. 02 July 03	0.45 0.23 0.36	0.33 0.16 0.26		
TGM (filtered water)	ng/liter	April 02 Sept. 02 July 03	0.30 0.22 0.23	0.19 0.16 0.24		
DGM	pg/liter	July 03	17.46	13.64		

Dioxin/Furan Results

One of the objectives of the LOADS project was to compare the air concentrations over land vs. over water. The summary results of air concentrations (Table 6.5) below shows the total concentration of dioxins/furans at the land based site was greater than that measured over water. Another objective of the LOADS project was to compare the western basin of Lake Ontario to the eastern basin. The observation that the western basin has higher dioxins/furans that the eastern basin for all three periods suggests that the urban areas ringing the western portion of the lake (e.g. Toronto, Hamilton Harbor, Niagara Falls, and perhaps Buffalo), may be a significant contributor to the dioxins/furans measured here. Accordingly, these urban areas may be important sources for the atmospheric deposition of dioxins/furans to Lake Ontario. The land based site which has higher dioxin/furan concentrations may be influenced by nearby urban areas.

Ten water column samples, representing 4000 L of filtered lake water, were combined and analyzed for dioxins/furans. The total was not significantly greater than the ship field blank of 0.4 pg/L. This is not surprising, since it is widely hypothesized that the majority of dioxins/furans in the water column are to be found absorbed to suspended particulates. During the LOADS project, the glass fiber filters used to filter the water were frozen and archived. Future plans include developing a procedure to analyze these filters and measure the concentration of dioxins/furans in the Lake Ontario water column particulate phase.

Table 6.5 Total Dioxins / Furans air concentrations (pg/m^3) LOADS three intensive sampling periods

Sampling Location	Aboard R/V Lake Guardian in Lake Ontario Western Basin	Aboard R/V Lake Guardian in Lake Ontario Eastern Basin	Land-Based Sterling, NY
April 2002	0.45	0.23	0.97
Sept. 2002	0.62	0.25	0.75
July 2003	0.64	0.46	0.74

6.5.1.3 Great Lakes Binational Toxics Strategy

The Great Lakes Binational Toxics Strategy: A Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances (hereafter the GLBTS) was conceived in response to the International Joint Commission's (IJC) Seventh Biennial Report on Great Lakes Water Quality, 1994. The IJC, the independent body of government-appointed commissioners with the responsibility to assist and evaluate US and Canadian efforts under the Great Lakes Water Quality Agreement (GLWQA), called upon the two governments to "…adopt a specific, coordinated strategy within two years with a common set of objectives and procedures for action to stop the input of persistent toxic substances into the Great Lakes environment."

Signed in 1997, the GLBTS is a binational partnership agreement between Canada and the United States to virtually eliminate persistent toxic substances from the Great Lakes environment through pollution prevention and toxic reduction activities. GLBTS "Level 1" substances include all the Lake Ontario critical pollutants (mercury, PCBs, dioxins/furans, DDT, mirex and dieldrin) as well as hexachlorobenzene, benzo(a)pyrene, octachlorostyrene, alkyl-lead, chlordane and toxaphene.

EC, the USEPA, and stakeholders from industry, academia, state/provincial and local governments, Tribes, First Nations, and environmental and community groups have worked together toward the achievement of the Strategy's challenge goals. Of 17 GLBTS reduction goals set forth for the 12 level I persistent toxic substances in April 1997, 9 have been met, 4 will be met by the target timeline date of 2006, and the remaining 4 will be well advanced toward meeting their targets by 2006.

For more information, please visit www.binational.net.

6.5.1.4 Lake Ontario Mass Balance Models

Mass balance models are developed to relate loadings of toxic contaminants to the lake to levels in water, sediment, and fish. These models provide an initial technical basis for determining load reduction targets, estimating how long it will take to meet these targets, and planning for additional measures necessary to achieve load reduction goals. One of the benefits of a Lake Ontario mass balance modeling effort is an improved ability to quantify the relationship between the mass loading of contaminants of concern to the lake and their concentration in water, sediments and biota. This information could then be used by the LaMP to help determine the most effective source reduction strategies. Some of the management questions that can be addressed include:

- What is the relative significance of each major type of source discharging toxic contaminants into Lake Ontario?
- How will contaminant levels in the lake and its biota respond to changes in contaminant loads and how long will it take?
- What is the effect of toxic contaminants already present in the sediments?
- Can observed trends in toxic contaminants over time be explained and can future trends be predicted?

With USEPA support and in coordination with the LaMP, a group of researchers led by Dr. Joseph V. DePinto of LimnoTech, Inc. have developed a mass balance and bioaccumulation computer model called LOTOX2 that can be used to assess the effectiveness of various load reduction scenarios aimed at reducing toxic contamination in the lake water, sediments, and sportfish.

Because contaminant loads are required inputs to the model, early efforts in the development of this model focused on obtaining contaminant load estimates for Lake Ontario and its tributaries. The first year results of the LOTOX project provided preliminary estimates of contaminant loads from all major source categories. When possible, these were calculated from primary data (e.g., monitoring data such as the Niagara River Upstream-Downstream Program); but frequently it was necessary to use published literature sources. Recognizing the uncertainty of many of the estimates, several sampling efforts have been undertaken to improve the loading estimates of Lake Ontario's critical pollutants and thus improve LOTOX2's predictive ability in forecasting the response of water, sediment and fish concentrations to load reductions

Efforts to reduce uncertainty in load estimates have proceeded along three tracks. Initial work focused on developing a history of tributary contaminant loading based on sediment cores collected by New York State Department of Environmental Conservation near the mouths of Lake Ontario tributary streams. Dated sediment cores provide a time history of contaminant accumulation at the location of the core. Using such cores, a method was developed to interpret the sediment accumulation data in a way that yields an estimate of the history of contaminant loading from the associated tributary. Additional information on current loadings from Canadian tributaries from the OMOE and EC tributary monitoring program was used to update tributary loading estimates.

Recognizing the importance of atmospheric deposition as a source of critical pollutants to Lake Ontario, air monitoring program over the lake supplemented ongoing monitoring supported by EC at the Point Petre, Ontario IADN site. In September 1998, Dr. Keri Hornbuckle, with support from USEPA as part of the LOTOX project, used the USEPA research vessel Lake Guardian to sample air and water at seven locations around the lake. The initial survey detected generally higher air and water PCB concentrations in the western end of the lake than in the east. This suggests the presence of PCB sources in the urbanized areas on the western end of the lake. In 2002, Dr. Thomas Holsen of Clarkson University and collaborators at SUNY Fredonia, SUNY Oswego and the University of Michigan with support from USEPA, embarked on the Lake Ontario Atmospheric Deposition Study to provide an estimate of atmospheric loadings of critical pollutants to Lake Ontario (see section 6.5.1.2). Currently, the data are being analyzed, and being transmitted to the modelers. Loading estimates will be made in the near future.

The third track of load estimation work focused on data from New York point sources that report their discharges pursuant to New York State Pollutant Discharge Elimination System (SPDES) requirements. This analysis assessed the contribution of 1) point sources; 2) non-point sources; and, 3) Lake Ontario watersheds. In other words, it provides an estimate of the fraction of a given tributary's loading that originates from point sources within its watershed.

USEPA began tributary sampling of the Genesee River, 18 Mile Creek, Oswego River, Salmon River and the Black River in 2002. Samples were taken in spring and fall 2002; spring, summer and fall 2003; and spring and fall 2004. The monitoring plan is planned to continue for the near future. The water samples are tested for total mercury, mirex, dieldrin, DDT, DDD, DDE, dioxins/furans and PCBs.

Using these historical reconstructed and present-day load estimates, the LOTOX2 model was calibrated for total PCB concentrations in Lake Trout (Figure 6.4), water column concentrations, and sediment concentrations. The calibrated model was confirmed by running the model through 2010 and comparing the output with new data for water column PCB concentrations, PCB lake trout concentrations, and sediment PCB concentrations collected in the period subsequent to the model calibration. All calibration and confirmation results, as well as the results of sensitivity analyses, loadings reconstruction, and a detailed discussion of model development and history are contained in the LOTOX2 model documentation report, *LOTOX2 Model Documentation in Support of Development of Load Reduction Strategies and a TMDL for PCBs in Lake Ontario* (Limno Tech, Inc. 2003).

In July 2003, an eleven-member peer review panel of modeling experts from academia, Great Lakes research institutes, USEPA, EC, NYSDEC, and OMOE met at a two-day workshop to critically review the LOTOX2 model, its documentation, and its intended use in forecasting Lake Trout PCB levels under a variety of load reduction scenarios. All reviewer comments and the modeler responses to these comments are detailed in the *LOTOX Peer Review Report* (USEPA, 2003). After the successful peer reviewer, LOTOX2 was used to run a number of sample management scenarios selected by the LaMP Parties. Figure 6.5 illustrates the model output from a few of these scenarios including the model's base forecast (that assumes a constant PCB load from all sources after 2000) and a cumulative source elimination scenario where point source, tributaries, Niagara River and atmospheric deposition are sequentially zeroed.

The results of these management scenarios provide important insights into the possible effects of PCB load reductions beyond what has already been achieved. The key insights gained from comparing these loading scenarios are that continued PCB load reductions are expected to produce in-lake benefits, in this case exemplified by lower PCB concentrations in lake trout; however, it will also take some time for those benefits to be realized. As can be observed in Figure 6.5, which illustrates the 2000 PCB mass balance for Lake Ontario, there is a significant reservoir of PCBs in Lake Ontario's sediment and a net flux of PCBs from the sediment into the water column. It is estimated that it will take 10-15 years for these internal process to achieve a steady state. Until that time, in-lake processes, in particular sediment feedback, acting on historical inputs of PCBs will govern the rate of decline and buffer the rate at which PCBs decline in the water column in response to decreasing external loads. Because of this response time, it will not only be difficult to distinguish between loading scenarios in the near term, but the benefits of PCB load reductions will not be realized for several decades. However, once equilibrium is reached, the steady state water column concentrations will become proportional to the external loading and the benefits of the load reductions will become apparent (Figure 6.5).

Sample Management Scenarios Run on LOTOX2

1. **Baseline "No Action" scenario:** constant load from all sources after 2000
2. **Onoing recovery scenario**: loads from all sources continue to decline at first-order rate based on previous 15 years
3. **Point source elimination** : zero all point sources (PS) with other loads held constant
4. **Tributary source elimination:** zero all tributary loads (including PS) while holding Niagara River and atmospheric sources constant
5. **Niagara River elimination:** zero load from Niagara River with all other sources held constant
6. **Atmospheric load elimination:** eliminate wet/dry deposition and zero atmospheric gas phase concentration with all other sources held constant
7. **Cumulative source category elimination scenario:** sequentially zero PS, tributaries, Niagara River, and atmospheric deposition
8. **Eliminate all external loads and atmosphere boundary condition**

Despite the fact that PCB concentrations in fish are still responding to the historical inputs of PCBs, the substantial decline in PCB concentrations depicted in Figure 6.5 for the "no action" scenario suggest the importance of banning PCB production and use in the 1970s. On average, lake trout in Lake Ontario today have PCB levels below 2 ppm. Furthermore, the scenarios indicate that continued load reductions will produce additional benefits to the lake, as reflected in the differences in the ultimate lake trout PCB concentrations among the scenarios.

Figure 6.4 Model Confirmation 1998 - 2001

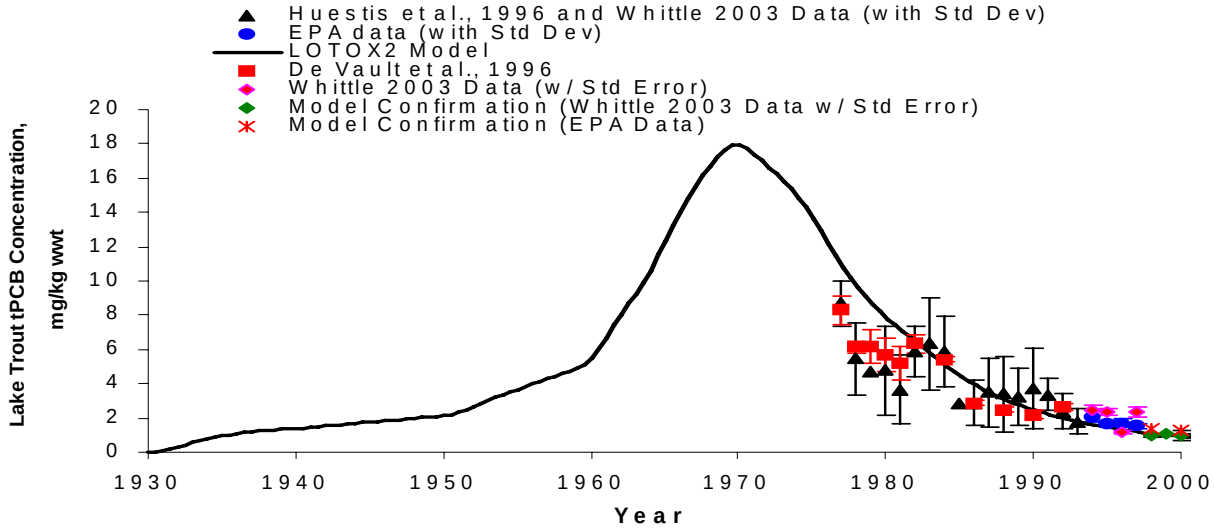


Figure 6.5 Output for Lake Trout PCB Concentrations under Baseline and Other Loading Scenarios

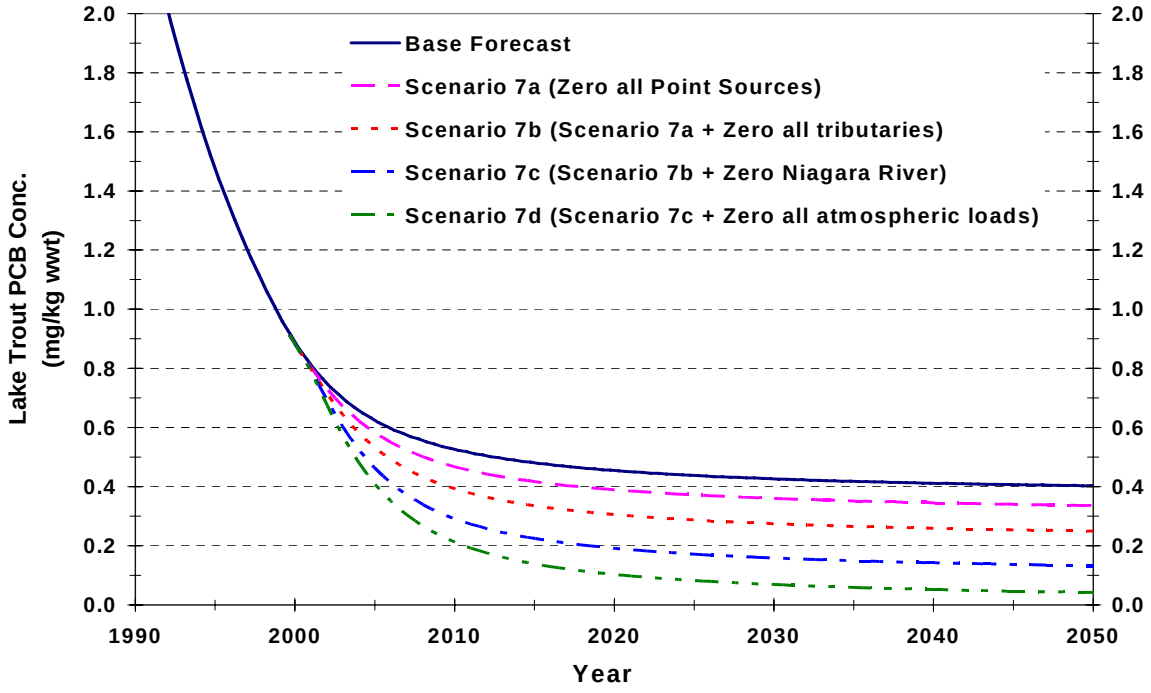
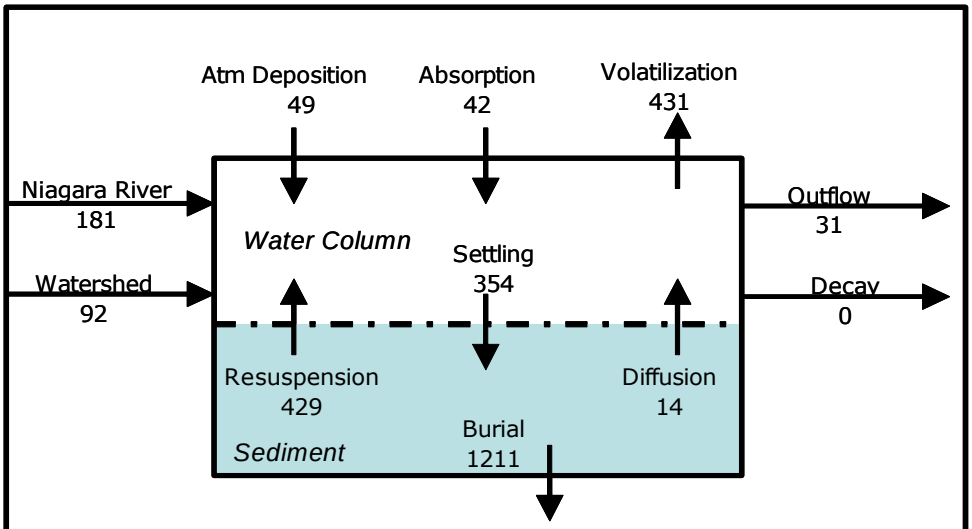


Figure 6.6 Lake Ontario PCB Mass Balance for the Year 2000.

Arrows represents the uptake and loss processes included in the LOTOX model. Numeric data provided are in units of kilograms per year (kg · yr^{-1}). The figure indicates that on an annual basis, the system loses approximately ~1300 kg of PCBs, with the main loss mechanisms being sediment burial (1200 kg yr^{-1}) and volatilization (430 kg yr^{-1}).



	Initial Mass (kg)	Final Mass (kg)	Change in Mass (Δ kg)
Water Column	271	262	(9)
Sediment	30 590	29 290	(1300)

6.5.1.5 Binational Sediment Workshop

In March 2004, the LaMP organized a binational sediment workshop that was held in East Aurora, New York. The workshop brought together sediment experts from Environment Canada, the US Environmental Protection Agency, the Ontario Ministry of the Environment and New York State Department of Environmental Conservation, as well as LaMP workgroup and management committee members. Experts shared results from a number of significant sediment surveys undertaken in Lake Ontario including:

- A comprehensive survey of sediment quality in Lake Ontario undertaken in 1997 by scientists from the USEPA, National Oceanic Atmospheric Administration (NOAA) and NYSDEC, intended to evaluate surficial sediment quality in the lake as a whole, establishing a baseline of environmental information by which future trends could be measured;
- A 1998 survey of Lake Ontario bottom sediments undertaken by EC's National Water Research Institute (NWRI) which repeated a 1968 EC survey, intended to determine any changes in the spatial, or geographic, distribution of contaminants over that time span;

- A nearshore sediment survey of harbours and embayments in Lake Ontario on the Canadian side including the Canadian Areas of Concern, which was undertaken in 2000 by OMOE scientists,; and,
- Sediment surveys undertaken by NYSDEC where sediment from the nearshore of Lake Ontario on the US side, including tributary sediment cores were collected and analyzed.

The objectives of the workshop were: to share the results of the open water sediment surveys as well as nearshore sediment investigations carried out by the Four Parties; to improve our understanding of the nature and significance of sediment sources of critical pollutants to Lake Ontario; and, to reach consensus on next steps with respect to a binational sediment monitoring program. Presentations and discussions focused on: A) Open Water; B) the Nearshore; C) Integration of Results; and D) Next Steps. The following is a summary of the presentations and results of the workshop:

A) *Open Water* – What is the nature and significance of open water sediment sources of critical pollutants? What is known, what is not known and what are the management implications?

<u>Presentations</u>

- Spatial and Temporal Trends in Contaminants in Lake Ontario -- Chris Marvin (EC), Alice Dove (EC), Scott Painter (EC)
- Surficial Sediment Quality in Lake Ontario -- Dick Coleates (USEPA)

<u>What is known</u>

- There is no acute toxicity anywhere in open water.
- Sediment quality has improved from the 1960s to the 1990s. Generally, levels have gone down 60-70 per cent (mercury 25-75 per cent; PCBs 40 per cent; dioxins 70 per cent; total DDT 60 per cent). Lindane and dieldrin are ubiquitous, and are found in similar concentrations; USEPA did not detect either parameter. HCB, OCS and mirex patterns suggest localized sources.
- LaMP critical pollutants concentrations are frequently greater that the Ontario Provincial Sediment Quality Guidelines' lowest effect level (LEL), but less than its severe effect level (SEL); values approach the probable effect level (PEL- the concentration at which effects are likely to occur) from the Canadian Sediment Quality Guidelines. EC results were similar to USEPA results.
- The Lake basins are very homogeneous – differences are due primarily to bathymetry, with contaminant levels generally higher in deeper basins.
- Fish consumption advisories are being driven by PCBs and dioxins/furans.
- Lake Ontario open water sediment chemistry levels are still the highest among the Great Lakes.

<u>What is not known</u>

- Emerging chemicals (e.g., PBDEs). There are some limited data on sediment concentrations of other emerging chemicals of concern (e.g., brominated flame retardants, polychlorinated naphthalenes) in Lake Ontario (see section 10.5). The extent and range of emerging chemical concentrations in Lake Ontario's sediments is still largely unknown.
- Sediment chemistry is only part of the picture. Sediment quality guidelines are not linked to food web effects.

B) *Nearshore* – What is the nature and significance of nearshore sediment sources of critical pollutants? What is known, what is not known and what are the management implications?

Presentations

- New York Lake Ontario Basin Contaminated Sediment Issues – Fred Luckey (USEPA), Frank Estabrooks (NYSDEC)
- Sediment Quality in Lake Ontario Harbours and Embayments – Lisa Richman (OMOE), Camelia Rusmir (OMOE), Duncan Boyd (OMOE)

What is known

- The most contaminated sediments in Lake Ontario remain largely confined to the already identified Areas of Concerns. Some smaller areas of highly-contaminated sediments and some ongoing sources do remain, but both are addressed as they are encountered (see Contaminant Trackdown, Sections 6.5.2.1 and 6.5.3.1).
- The nearshore zone is very dynamic and variable, which is important for design of sediment sampling programs.
- On the US side- focus is on Areas of Concern (18 Mile Creek , Genesee River (silver), Oswego) and major tributary watersheds (e.g., Black River (DDT)) where sources are being addressed.
- On the Canadian side, lots of data on harbours and embayments. Surprises included Whitby Harbour (dioxins/furans) and Niagara (DDT- active source suspected), but overall problems are being addressed.

C) *Integration of Results* - How can we integrate the results of the surveys? What's missing/what additional data is available? Is the data compatible?

Presentations

- Integrated Mapping of Results by Environment Canada -- Scott Painter (EC), Alice Dove (EC)
- Tributary Screening- Alice Dove (EC)

Summary

- Agreement-in-principle amongst the workshop participants on the need to share/pool data and develop a screening level map, integrating the results of the various sediment surveys.
- Workshop participants agreed that a project be scoped out by the LaMP Workgroup for Management Committee approval (including the resources required).
- Based on the Lake Erie LaMP experience, where it took one person four years to assemble all the data, the preferred approach would be for one of the Four Parties to take the lead and have each agency assign technical staff to the project work with their own data so that they can be provided in a specified format and address technical issues as they arise.

D) *Next Steps* – What is the timing and need for next sediment survey? Are there other approaches to consider?

Presentations

- A Proposal to Develop a Binational Approach to Monitoring Contaminant Trends Using Radiodated Sediment Cores- Lake Ontario LaMP – Fred Luckey (USEPA)

Summary

- Agreement-in-principle amongst workshop participants on a draft proposal by USEPA for adopting a binational approach to monitoring contaminant trends using radio-dated sediment cores. The proposed approach is to use dated sediment cores and surficial sediments to infer potential harm to ecosystems, track progress in reducing inputs of critical pollutants and to identify new contaminants of concern.

- This approach would replace the need to undertake another intensive spatial survey, as was done by EC (1998) and USEPA (1997). EC's NWRI is willing to provide in-kind support to collect and radio-date the cores, but will require approximately $50K for chemical analyses.
- The LaMP is implementing the proposed approach of monitoring contaminant trends using radio-dated sediment cores. Details and status are provided in the LaMP workplan.

6.5.2 U.S. Activities

6.5.2.1 Contaminant Trackdown

Information on critical pollutant sources and related problems has been synthesized and used to plan environmental monitoring /sampling which in turn is used to identify and confirm suspected pollutant sources for following up investigation and possible remedial action.

NYSDEC and USEPA conduct a wide variety of environmental investigations across the Lake Ontario basin, evaluating critical pollutant concentrations in water, sediment, fish, and biological samples. Much of this sampling has been guided by reviews of existing information and recommendations provided by core environmental program monitoring and/or other special purpose environmental monitoring activities.

For example, inactive hazardous waste sites in the basin were ranked based on their potential risk to nearby surface waters. Surface waters adjacent to sites with the highest potential were sampled to identify any sites requiring additional attention. Similar approaches have been used to evaluate potential areas of sediment contamination, contaminants in surface water discharges, fish tissue contamination and the effectiveness of remedial actions.

Other types of contaminant trackdown activities include sampling receiving waters and wastewaters at Publicly Owned Treatment Works (POTW) using state-of-the-art technology capable of achieving extremely low (parts per quadrillion) detection limits for PCBs, pesticides and dioxins. These projects include participation by the treatment plant operators, local governments, NYSDEC and USEPA. Wastewater samples are also collected at strategic points within the sewer collection system in an effort to identify where the majority of critical pollutants originate within these systems. This information assists sewage treatment plant operators in applying for various grant funding to upgrade their treatment systems to improve the quality of their wastewater.

The work to date has developed a good understand of the location and extent of critical pollutant sources and problems in the U.S. portion of the basin. Key highlights of investigation results and critical pollutant control actions completed or underway in the various New York state Lake Ontario watersheds are summarized below.

Lake Ontario Western Watershed

The Lake Ontario western watershed consists of the minor tributaries and nearshore area that extends from the Niagara River watershed to the Genesee River watershed. This nearshore area is not heavily populated and therefore not considered a significant source of contamination to Lake Ontario. The tributaries and historically identified sources of pollution in this nearshore are:

Eighteenmile Creek – Twelve miles upstream from where the RAP Area of Concern enters Lake Ontario, contaminated sediments are located near the City of Lockport downtown area and in the Barge Canal and its tributaries. These sediments have moved downstream and are trapped behind the Newfane and Burt Dams. The Williams Street Island (Flintkote Site) has PCB sediments in the creek bed.

The Lockport wastewater treatment facilities have been upgraded with New York State Environmental Bond Act and Great Lakes Protection Funds to address the sewage collection system, combined overflows and related stormwater. With RAP coordination activities now led by the Niagara County Soil & Water Conservation District starting in 2005, data synthesis, trackdown, and remedial measures in the AOC and watershed are to be further assessed, reported on, and implemented.

Slater Creek – Follow-up sediment and water sampling conducted in 1998 and 1999 at several points along the creek attempted to identify PCB sources. Results showed that PCB concentrations in sediment and water to be low with no evidence of significant inputs of PCBs to the creek. Dieldrin was found to be slightly elevated in Young of the Year , water and sediment samples. The source of dieldrin may be historical use of this pesticide in orchards located in the headwaters of Slater Creek. Follow up sampling of resident creek fish targeted by anglers for consumption should be considered.

Genesee River Watershed

The Genesee River watershed has its headwaters in Pennsylvania and flows north across the width of New York State to Lake Ontario (about 157 miles or 253 km). It collects water from 52 tributaries and 6 lakes on the way to Lake Ontario. The watershed includes the 4 most westernmost Finger Lakes: Conesus, Hemlock, Canadice, and Honeoye. - The mouth of the Genesee River is approximately 75 miles (121 km) east of the mouth of the Niagara River and six miles (9.7 km) north of the City of Rochester. This area is also known as the Rochester Embayment Area of Concern. The Genesee River watershed consists of 2,400 square miles (6,216 square km) in New York and is inhabited by approximately 400,000 persons. The historic sources of pollution are:

Monroe County's Sewer Collection System – at Rochester, reevaluation of wastewater treatment and point source discharge limits according to Great Lakes Initiative and SPDES permit requirements including added pretreatment and pollution minimization provisions has occurred. Monitoring and remedial measures are ongoing and have included the interceptor system and Combined Sewer Overflow abatement. A cooperative federal, state and county contaminant trackdown project was conducted. One section in the western metropolitan area of Rochester was identified as having wastewaters high in PCB concentrations. Follow-up action for the Delphi automobile parts manufacturing facility was identified and groundwater remediation was implemented resulting in treated wastewater being discharged to the sewer system. Actions to address mercury discharged from the Taylor Instruments facility have been taken.

In addition, Monroe County Department of Health has implemented several pollution prevention projects to address mercury discharges form Hospital and dental clinic wastewaters. A guidance manual was developed and voluntary actions have resulted in mercury phase out, collection, and prevention efforts at many dental and hospital facilities.

Lake Ontario Central Watershed

The Lake Ontario central watershed consists of the minor tributaries and nearshore area that extends from the Genesee River watershed to the Oswego River watershed. This nearshore area is not heavily populated and therefore not considered a significant source of contamination to Lake Ontario. The minor tributaries and historically identified sources of pollution are:

Sodus Bay and Creek – Historic bay area and watershed activities consisting of poor management of pesticides resulted in contaminated runoff. Analysis of Sodus Bay sediment has not determined problems in the concentrations of pesticides or dioxins. YOY fish samples from Sodus Creek have shown total DDT levels exceeded criteria designed to protect fish-consuming wildlife. The bay and ponds along this

nearshore area present a challenge for shoreline nuisance management conditions due to nutrients and other invasive species.

Seneca-Oneida-Oswego River Watershed

The average water flow into the Oswego Harbor from the Oswego River is 4.2 billion gallons 53.8 billion liters) (per day and includes runoff from its 5,100 square mile (13,209 square km) watershed. The waters of the Oswego River include the drainage from the Finger Lakes and agricultural lands as well as wastewater from many towns, villages, and small cities in the watershed.

The Oswego River watershed includes the Oswego-Oneida-Seneca three rivers system. Within this very large watershed, significant environmental cleanup and protection activities have been accomplished over the years. The result of widespread remedial measures and protection activities in the watershed has been to mitigate and/or eliminate sources of pollution entering or leaving the Oswego River AOC boundaries that can contribute to or cause local impairments.

Oswego River – A detailed assessment for potential sediment contamination in the Oswego Harbor, Oswego River and the Seneca River was carried out in 1994 in response to data needs identified in the Oswego RAP Stage II report. One particular area of interest was the status of historical releases of mirex to the Oswego River from an inactive hazardous waste site well upstream from the RAP Area of Concern. Information on benthic community structure richness, biological impairment and sediment toxicity, as well as sediment contaminant levels, was collected at key points along the river and depositional areas behind dams. With the exception of Oswego River's Battle Island area, sediment contaminant levels were found to be low, with little to no evidence of toxicity to benthos. Based on these findings, a more detailed sediment evaluation was conducted in the Battle Island area. Smaller "pockets" of buried, historical contamination have been located; however, none approach the threshold level for remedial measure action.

Lake Ontario Eastern Watershed

The Lake Ontario eastern watershed is a relatively small nearshore area with minor tributaries that extends from the Oswego River watershed to the Black River watershed. This nearshore area is not heavily populated and therefore not considered a significant source of contamination to Lake Ontario. The minor tributaries and historically identified sources of pollution are:

Wine and White Creeks – Wine Creek enters Lake Ontario approximately two miles east of the mouth of the Oswego River. White Creek flows into Wine Creek approximately one mile upstream of the lake. PCBs have been remediated at the Pollution Abatement Services inactive hazardous waste disposal site, located at the junction of Wine and White Creeks. The Fire Training Area facility is located on White Creek and is required to monitor PCBs in its storm water. An abandoned landfill is located upstream of this facility. The detection of some PCB release at the PAS and Fire Training Area has not been linked to an environmental impact and the significance of the level of detection requires continued assessment.

Black River Watershed

The Black River and smaller tributaries to the northeastern Lake Ontario shoreline drain about 2,500 square miles in north-central New York State. This area includes portions of the western Adirondack Mountains, the Tug Hill Plateau and lowlands along the Lake Ontario shore. The Black River itself drains 1,920 square miles (4,973 km). Land use is diverse but not intense. The eastern portion of the basin features the densely forested woodland of the western Adirondack Mountains. The primary land uses in this sparsely populated region are silviculture and tourism/recreation.

Black River PCB Trackdown – at Carthage and Watertown, the waterbody inventory and assessment was completed in 2005. Updating is to include revised status of Priority Waterbody strategies. Implementation of watershed and non-point source abatement activities continues while the evaluation of sources and further remedial measures is ongoing. A local PCB sediment source is known to exist below the Village of Carthage. Since the impact is not significant the remedial action here and in other isolated areas of the Black River remains under review. Shutdown of paper manufacturing facilities as well as upgrades at the Carthage/ West Carthage Municipal Sewage Treatment Plant have resulted in significant sampling result improvements in discharge waters as well as in the receiving waters of the Black River.

6.5.2.2 Government Activities

U.S. Great Lakes Regional Collaboration

In December 2004, President Bush signed an executive order directing USEPA to lead a regional collaboration of national significance for the Great Lakes. The collaboration is a unique partnership of key members from federal, state, and local governments, tribes and stakeholders for the purpose of developing a strategic plan to restore and protect the lakes. Over 1,500 people from government and nongovernmental organizations participated in drafting the strategy, which includes recommendations for action. The final strategy was released in December 2005.

The strategy for toxic pollutants is based on the goal to establish and maintain the chemical integrity of the Great Lakes Basin Ecosystem, as called for in the Great Lakes Water Quality Agreement.

The strategy seeks to: 1) reduce and virtually eliminate sources of current priority pollutants; 2) prevent new chemical threats from entering the basin; 3) develop a sufficient knowledge base to address toxic chemicals in the Great Lakes environment; 4) protect public health and engage the public to do its part in reducing Priority Toxic Substances, and 5) address international sources.

The strategy seeks to build upon the efforts of the Binational Toxics Strategy (BTS), the Lakewide Management Plans (LaMPs), and the Remedial Action Plans (RAPs) in Areas of Concern, and offers the following recommendations:

1) Reduce and virtually eliminate the principal sources of mercury, PCBs, dioxins and furans, pesticides and other toxic substances that threaten the Great Lakes basin ecosystem

2) Prevent new toxic chemicals from entering the Great Lakes basin.

3) Institute a comprehensive Great Lakes research, surveillance and forecasting capability to help identify, manage, and regulate chemical threats to the Great Lakes basin ecosystem.

4) Protect human health through consistent and easily accessible basin-wide messages on fish consumption and toxic reduction methods.

5) Support efforts to reduce continental and global sources of persistent toxic substances to the Great Lakes basin.

Great Lakes Water Quality Guidance

In February 1998, NYSDEC completed the adoption process and began to implement the regulations, policies, and procedures contained within the Great Lakes Water Quality Guidance (GLWQG). The

implementation of the GLWQG will result in consistent state water pollution control programs throughout the US Great Lake States and will lead to substantial reductions in the loading of LaMP critical pollutants and other pollutants.

The GLWQG will play a major role in addressing all of the lakewide impairments identified in this document. The following illustrates how the implementation of the GLWQG by the eight Great Lakes States will significantly address these concerns.

- Restrictions on fish and wildlife consumption: The GLWQG requires that the eight Great Lakes States adopt human health criteria based on the consumption of aquatic life, which will result in the eventual elimination of restrictions on fish and wildlife consumption by humans. The GLWQG includes numeric human health criteria for 16 pollutants, and methodologies to derive cancer and non-cancer human health criteria for additional pollutants.
- Degradation of wildlife populations and bird or animal deformities or reproductive problems: The GLWQG requires that the eight Great Lakes States adopt wildlife criteria, which, once achieved, will result in the eventual elimination of degraded wildlife populations and bird or animal deformities or reproductive problems. The GLWQG includes numeric criteria to protect wildlife from four pollutants (PCBs, DDT and its metabolites, dioxin, and mercury) and a methodology to derive criteria for additional bioaccumulative chemicals of concern (BCCs) discharged to the Great Lakes system.
- Targeting the pollutants of concern, which are bioaccumulative and persistent: The GLWQG focuses on the reduction of 22 known chemicals of concern, including PCBs, dieldrin, DDT and its metabolites, and dioxin. In addition to requiring the adoption of numeric water quality criteria for BCCs and other pollutants, as well as the detailed methodologies to develop criteria for additional pollutants, the GLWQG also includes implementation procedures that will result in loading reductions of BCCs to the Great Lakes basin. These include requirements for the development of more consistent, enforceable water quality-based effluent limits in discharge permits (including requirements for pollution minimization plans to track down and eliminate sources of BCCs); the development and implementation of total maximum daily loads for pollutants that can be allowed to reach the Great Lakes and their tributaries from all sources; and antidegradation policies and procedures which further restrict new or increased discharges of BCCs.
- The Majority of the Loadings of these Pollutants are from other Great Lakes: Since the GLWQG will be implemented in all eight Great Lakes States, the loadings of the identified pollutants of concern will be significantly reduced throughout the entire Great Lakes basin. Therefore, the major source of the loadings of the pollutants of concern to Lake Ontario will be substantially reduced.

New York's Water Comprehensive Assessment Strategy

New York State Department of Environmental Conservation's Comprehensive Assessment Strategy applies a watershed approach as the basic organizing unit in developing water pollution control strategies. Statewide, a Waterbody Inventory is maintained for the numerous individual stream segments and lakes. A Priority Waterbodies List is further developed where designated beneficial uses of these waterbodies are categorized as threatened, stressed, impaired, or precluded. Annual monitoring, assessment, and strategy implementation activities are based on a five-year cycle of the "Rotating Intensive Basin Survey (RIBS)" program which tracks and facilitates watershed actions in each of New York's 17 major watersheds. Each year 2 to 3 watershed cycles are re-started in the RIBS process while 2 to 3 watershed cycles are completed.

Lake Ontario watersheds include the following: 1) Niagara River-Lake Erie; 2) Genesee River; 3) Oswego-Seneca-Oneida Rivers; 4) Black River; 5) St. Lawrence River, and 6) Lake Ontario Minor Tributaries-Nearshore. In any given year, one or more Great Lakes watersheds are in each of the phases of the RIBS process. In conducting a watershed approach, local governments and stakeholders are involved in the monitoring, assessment, and implementation phases of the process. The goal is restoration and protection of a designated waterbody and the watershed. Grant funding, technical assistance, other federal, state or local agencies, and related watershed resources form a partnership to address the priority water and natural resource needs in a targeted watershed.

Under the RIBS program watershed assessments are used to update the Water Inventory and Priority Waterbodies List which summarize the water quality information and identify priority problems in rivers and lakes across the state. These assessments also provide a starting point for the development and implementation of watershed restoration and protection action strategies. These strategies involve coordinating agencies and stakeholders to focus grant monies, technical assistance, regulatory efforts and other resources to address water quality priorities and natural resource needs of a watershed. Information developed involving the LaMP, such as lake and tributary monitoring, directly supports the development of comprehensive assessment and action strategies for Lake Ontario watersheds

Developing watershed strategies is rooted in the 1998 federal Clean Water Action Plan that accelerated watershed restoration across the country. The Action Plan strives to fulfill the original goals of the 1972 Clean Water Act to accomplish fishable, swimmable, and safe waters for all Americans. The Action Plan lays out a broad vision of watershed protection, involving coastal and estuarine waters, fresh waterbodies, wetlands, groundwater, natural resources, and drinking water sources. Under the plan assessments and implementation schedules have been built on existing water program and natural resource initiatives (especially RIBS).

Many resources come to bear on each watershed to provide a comprehensive restoration and protection program addressing: point and nonpoint sources of pollution, storm water and sewer flows, land use, construction activities, stream corridor improvements, habitat protection and modification, fishery enhancement, agricultural management, nutrient and pesticide use, and pollution prevention.

Based on a number of water quality and natural resource factors and assessment, waterbody segments have been placed in one of four categories: 1) need of restoration; 2) meeting goals to sustain water quality, 3) pristine or sensitive aquatic area administered by government jurisdictions; and 4) insufficient information to assess water quality.

Total Daily Maximum Load (TMDL) for Lake Ontario

USEPA and NYSDEC are currently working together on the development of a watershed-based, pollutant management tool known as a “total maximum daily load” (TMDL). The *Clean Water Act* requires that TMDLs, which identify point and non-point sources of a pollutant, be developed for impaired waters such as Lake Ontario. The TMDL also identifies reductions in point and non-point loadings necessary to restore impairments. Presently, USEPA and NYSDEC are collecting and analyzing data, and refining a water quality modeling tool that will support the development of a TMDL (see paragraph 6.5.1.5, LOTOX2 mass balance model). The schedule for TMDL development will be made available to the public through future LaMP documents.

Pollution Minimization Plans (PMP) Guidance Manual

NYSDEC with the assistance of USEPA funding has developed a Pollution Minimization Plan Guidance Manual.

The goal of Pollution Minimization Programs (PMP) for New York State point source dischargers and industrial users discharging to publicly owned treatment facilities is to achieve effluent quality at or below the water quality based effluent standard. Achieving the stringent pollutant-specific water quality standards demanded by state, national and international water quality goals now requires extra effort and performance measures. The purpose of a PMP guidance manual for regulatory agencies is to assure that treatment facility managers are informed about what is required and understand the steps needed to demonstrate that a strategy is being implemented. Carrying out a PMP requires certain activities to be conducted and performance measures to be defined and assessed towards achievement of a pollutant-specific goal in an industrial sector process.

Monitoring and reporting are critical to a PMP and its steps are subject to regulatory oversight; however PMP goals are results-based. It is therefore the responsibility of the permittee to demonstrate continued progress towards achieving compliance with the goals.

This manual is intended to be a reference for use by those responsible for development of Pollutant Minimization Programs at wastewater treatment plants. It was developed cooperatively by the New York State Department of Environmental Conservation's Division of Water and the Center for Integrated Waste Management of the University at Buffalo (the Center). Funding for the development and distribution of the manual was provided by the United States Environmental Protection Agency through a grant to the New England Interstate Water Pollution Control Commission, which contracted with the Center.

Background: Great Lakes Initiative, Bioaccumulative Chemicals of Concern, and New York State's Water Quality Standards)

Recognizing the significance of the Great Lakes as a resource and also the challenges that the resource faced, USEPA and the Great Lakes states agreed in 1995 to a comprehensive plan to restore and sustain the health of the Great Lakes. The resulting Water Quality Guidance for the Great Lakes System is known as the Great Lakes Initiative (GLI). The GLI establishes minimum water quality standards, anti-degradation policies, and implementation procedures for protecting and improving the waters of the Great Lakes System. Particular emphasis in the GLI was placed on reducing the levels of toxics being introduced to the Great Lakes System, especially persistent and bioaccumulative toxics. Bioaccumulative is the term used to describe chemicals that do not easily break down, enabling concentrations in an organism to increase up the food chain. Thus, people and the animals, birds and fish that are at the top of the food chain are exposed to the highest levels of these toxics.

The GLI lists 22 bioaccumulative chemicals of concern (BCCs), including mercury, polychlorinated biphenyls (PCBs), dioxin, chlordane, DDT, mirex and 16 other highly bioaccumulative chemicals. Because BCC's are harmful at extremely low concentrations, permitted discharge levels frequently need to be set at a calculated water quality based effluent limit (WQBEL) that is below the Practical Quantification Limit. In such cases, analytical uncertainties make it impossible to be certain of providing the necessary protection of water quality by simple establishment of an effluent limit. One rational approach to permitting – and more significantly – protecting the environment in such circumstances is for the permit to require the discharger to submit a Pollutant Minimization Program (PMP).

A PMP can be defined as an organized set of activities focused on achieving the maximum reduction of the target pollutant in the facility's discharge through means other than treatment at the facility.

6.5.2.3 Pollution Prevention Partnerships

Medical and Dental Projects

In the Rochester Embayment watershed, the Monroe County, New York, Department of Health implemented a mercury pollution prevention program for hospitals and dental offices. The project, made possible by a grant from the US Environmental Protection Agency, was undertaken in cooperation with the University of Rochester's Strong Memorial Hospital, Department of Dentistry and Eastman Dental Center. The project was a response to concerns about the health impacts of mercury and new federal regulations that greatly reduce the amount of mercury that can be discharged from a municipal wastewater system or an incinerator.

The US Environmental Protection Agency Region 2 presented one of its 1999 Environmental Quality Awards to the Monroe County Health Department and the University of Rochester for their mercury pollution prevention project.

Health Care

In New York State, Strong Memorial Hospital replaced mercury thermometers with electronic thermometers, mercury-filled sphygmomanometers with aneroid devices, and mercury-filled GI tubes with tungsten filled tubes. Strong Memorial Hospital also discontinued using mercury containing laboratory reagents unless there is no adequate substitute. Non-medical products that contain mercury are being phased out. A specialized training program for hospital staff was developed. The experiences at Strong and extensive research led to the preparation of a how-to manual that was distributed to other hospitals in the Rochester Embayment watershed and, by request, to other parts of the US and Canada. The manual is entitled Reducing Mercury Use in Health Care: Promoting a Healthier Environment (1998). It is available on the web at www.epa.gov/glnpo/bnsdocs/merchealth/.

Dentistry

In New York State, techniques for handling and recycling dental amalgam were developed by the Health Department and University of Rochester dental facilities. A booklet and poster, "Prevent Mercury Pollution: Use Best Management Practices for Amalgam Handling and Recycling", were distributed to dental offices in the Rochester Embayment watershed. The booklet contents are also included in the hospital manual.

Agricultural Pesticide Clean Sweeps

USEPA is continuing its commitment to reduce inputs of agricultural pesticides into Lake Ontario, by funding the County of Erie to expand its Clean Sweep project throughout the Lake Ontario basin. Erie County will use the strategies that were successful in previous Clean Sweep projects to solicit new participating counties and will provide local project management teams with the guidance and technical expertise necessary for successful implementation of this program.

Over the years Ontario and New York have significantly reduced and eliminated stores of unwanted and unusable agricultural pesticides held by farmers and others by holding voluntary pesticide collection events commonly referred to as "Clean Sweeps." Combined Ontario and New York efforts have collected and safely disposed of more than 750,000 kg/1,650,000 lbs of pesticides, including LaMP critical pollutants such as DDT, dieldrin, and mercury-based pesticides - all potential non-point source pollution threats to Lake Ontario water quality.

The New York State Department of Environmental Conservation, in partnership with the New York State Department of Agriculture and Markets (NYSDAM), Soil and Water Conservation Districts, and the Cornell Cooperative Extension, is conducting a new round of agricultural pesticide collection efforts in the Lake Ontario basin as part of their "Clean Sweep NY" Program. The program provides an entirely legal and economical opportunity to dispose of all canceled, obsolete or otherwise unusable pesticides and any elemental mercury used by a dairy or food storage facility. Triple-rinsed plastic or metal pesticide containers will also be collected and recycled. This latest round of pesticide collection efforts has included two Lake Ontario basin counties that have never held Clean Sweeps before, Lewis and Jefferson.

The "Clean Sweep NY" Program hires a professional waste hauler to dispose of unwanted pesticides and elemental mercury; provides on-farm or on-site assistance, when needed; provides analytical services to identify unknown/unlabeled pesticide products; collects triple-rinsed metal and plastic pesticide containers for recycling; and provides on-farm pickup for predetermined structurally unstable containers. Collection efforts were held in the eastern Lake Ontario basin in Herkimer, Jefferson, Lewis, Madison, Oneida, Otsego and Hamilton Counties in the fall of 2004. Spring 2005 collections were held in east-central basin including Onondaga, Oswego, Cayuga, and Cortland Counties. Collections targeting the west-central part of the basin occurred the week of November 6-11, 2005 in Wayne, Monroe, Livingston, Ontario, Seneca, and Yates Counties.

This program is free of charge for New York growers and commercial applicators applying products to agricultural commodities. Other potential holders of pesticides such as applicators, local municipalities, and retail/distribution establishments can approach NYSDEC and request to participate in this program.

6.5.3 Canadian Activities

6.5.3.1 Contaminant Trackdown

Concentrations of total PCB in some Lake Ontario tributaries were found to exceed the Provincial Water Quality Objective of 1.0 ng/L in an OMOE 1997-98 study, which confirmed results from other investigations. In response, a commitment was made by OMOE to confirm these findings using an integrated high-frequency sampling approach to characterize typical concentrations of PCBs along with other priority pollutants including polynuclear aromatic hydrocarbons (PAHs), and organochlorine compounds (including DDT and mirex). This approach involved the collection of four-week composite samples made up of subsamples collected every six hours throughout the entire year, rather than relying on 10 to 15 grab samples to characterize annual conditions. In this way, a more complete range of seasonal hydrological conditions within the watershed would be taken into account. This approach was first applied to several Lake Ontario tributaries from July 2000 through June 2001.

As PCBs represent the primary contaminant responsible for many fish consumption advisories, they were chosen as the main target critical pollutant for a pilot study: "Project Trackdown." For selected tributaries, this study was to address: (a) quantifying upstream-downstream differences in total concentrations (and congener patterns where possible) of PCB in water, sediment, and juvenile fish tissue; (b) quantifying differences in biomonitored (caged mussel) tissue PCB concentrations and congener patterns at selected points throughout the watershed; and, (c) quantifying differences in PCB concentrations and congeners in semi-permeable membrane devices (SPMDs), which are passive samplers used to determine the relative "bioavailability" of PCBs at various sites. These devices act as an artificial substitute for fish tissue.

The objective of this pilot project was to develop and evaluate approaches for identifying ongoing PCB sources and to provide guidance for conducting future source trackdown projects. Three pilot watersheds, Twelve Mile Creek, Etobicoke Creek and Cataraqui River were selected from Lake Ontario tributaries

where elevated PCB levels were known to exist and good screening level data for biota, water, and sediment were available from both provincial and federal studies (Figure 6.7). These included water quality and juvenile fish data from the 2000-01 and 1997-98 studies described above, along with previous data from the 1991-92 Toronto area six tributary study.

Figure 6.7 Ontario Tributary Source Trackdown locations.

Each source trackdown project has been conducted in a staged approach. The stages act to narrow down each system in either a spatial manner, or to confirm or rule-out suspected PCB sources. Each project has included the collection of multiple lines of evidence, including sediment, event-based water sampling, biota samples and semi-permeable membrane devices (SPMDs). A weight-of-evidence approach is then used to guide the interpretation of the collected information and the next phase of field sampling.

Environment Canada and the Ministry of the Environment provided an initial assessment of the trackdown initiative in an interim guidance framework for PCB Source Trackdown Projects (Environment Canada, 2003). The interim guidance framework includes four separate phases in the Trackdown processes. These phases are:

A. Planning: Information is gathered to assess a site as a potential PCB Trackdown site.

B. Source identification: A project plan is created to find out whether local anomalies exist within the watershed.

C. Compliance/remediation follow-up: When a potential or ongoing source is located, compliance and abatement actions would ensue.

D. Project evaluation and recommendation: Upon completion of the abatement program, or of contamination removal, the abatement area is revisited to assess whether efforts have been successful.

Activities are ongoing at each of the three projects in 2005. As data from the 2003-2005 field seasons are compiled, the information will be used to update the guidance framework with the acquired knowledge. The results to date of these trackdown activities are summarized in Table 6.5, and details of each project are provided below.

The project involves extensive sampling for PCBs in water, sediment, fish and caged mussels at various locations along the tributaries to determine the sources of critical pollutants. The project will also try to determine whether sources of PCBs are historical or ongoing and locally controllable. Results will help determine the need for future measures and/or remediation actions that will ultimately reduce the amount of critical pollutants entering Lake Ontario.

Table 6.5 Phases of Lake Ontario Trackdown Studies

Project	Project start	Planning phase	Source identification	Compliance and remediation	Project evaluation and recommendations
Twelve-Mile Creek, St. Catharines and Thorold, ON	2000	Complete	Several ongoing sources identified. Further upstream work occurred in 2005 Endosulfan study initiated in Richardson's Creek as a result of Trackdown findings in small Tributary to Beaverdams Creek/ Lake Gibson area.	Working with the City of St. Catharines to locate on land sources of contamination into Old Welland Canal. Two former landfills currently under investigation. One company under preventative measures order to determine source of contaminated sediment in Beaverdams Creek. Endosulfan study initiated in Richardson's Creek as a result of Trackdown findings	Project success to be evaluated in 2007 Abatement stages in various phases
Cataraqui River, Kingston ON	Summer 2001	Complete	Two main areas of contamination identified. Contamination determined to likely be historic With the City of Kingston, groundwater determined not to be an ongoing major source	Sediment dredging project completed near the Emma Martin Park area completed in December 2004. Cooperative work with the City of Kingston determined that groundwater is not a likely ongoing source of PCB contamination. Determined that contamination likely from historical sources.	Success of dredging project to be evaluated during 2006-2007

Table 6.5 Phases of Lake Ontario Trackdown Studies

Project	Project start	Planning phase	Source identification	Compliance and remediation	Project evaluation and recommendations
Etobicoke Creek, Toronto, ON	2001	Complete	Two potential tributary outfalls identified as potential sources. Further work ongoing in 2005	Findings of the study likely to lead to abatement actions in sewer systems with Cities of Toronto and Mississauga.	Project success will be evaluated in 2008 pending initiation of compliance activities

Twelve Mile Creek

Twelve Mile Creek has a relatively small watershed and more than 95 per cent of the water entering the creek is Lake Erie water diverted through the Welland Canal.

Sampling by OMOE and EC conducted in 1997/1998 revealed total PCB concentrations (2.4 -12.3 ng/L) in water at the mouth of Twelve Mile Creek that were significantly higher than those observed in the Niagara River (Boyd and Biberhofer, 1999). These results suggested the possible existence of local PCB sources to Twelve-Mile Creek. Additionally, total PCB concentrations in juvenile fish (spottail shiners) collected at the mouth of Twelve-Mile Creek in 1997 were significantly higher than those collected at a nearby Lake Ontario beach.

Fieldwork specific to the PCB trackdown study started during the summer of 2000, with sediment and water samples collected at upstream and downstream sites of Twelve Mile Creek, including Lake Gibson. Mussels were deployed upstream of the confluence with Lake Gibson, downstream of Lake Gibson (in the vicinity of two outfalls discharging into the creek), at the power dam (Martindale Pond), and at a combined sewer outflow drainage ditch downstream of the power dam. Young-of-the-year shiners were collected from the upstream location, Lake Gibson and the downstream location (Martindale Pond). Caged mussels were also deployed at three sites along the Old Welland Canal: above and below a pulp and paper mill, and downstream close to the confluence with Twelve Mile Creek.

PCBs were shown to be bioavailable to the mussels at all of the sample locations. The concentrations of bioavailable PCBs increased in freshwater mussels with increasing distance downstream of Lake Gibson and the confluence with the Old Welland Canal. Follow-up investigations conducted with large volume water samples and caged mussels in 2002 identified several areas of the watershed that needed further study. PCB concentration in the mussel tissue was highest at an outfall used jointly by GM and the municipality of St Catharines. PCB tissue concentrations were similar between the upstream and downstream stations in the Old Welland Canal; however, congener pattern analysis suggests that there may be additional sources of PCBs entering the Old Welland Canal. The congener patterns observed in the Old Welland Canal were different from those observed in the mussels deployed at the municipal outfall by the GM plant, which had the highest PCB tissue concentrations. Downstream congener patterns from Martindale pond suggest a mixture of the Old Welland Canal and GM/municipal congener patterns. Although these preliminary biomonitoring results have succeeded in identifying potential sources of PCBs to Twelve Mile Creek, they are not sufficient to quantify their significance.

Young-of-the-year fish from Martindale Pond indicated an increase in PCB tissue concentrations compared to the upstream locations in Twelve Mile Creek and Lake Gibson. Interestingly, when the fish were normalized on a lipid weight basis, the PCB concentrations were similar to those in the mussels. PCB concentrations in Martindale Pond were elevated compared to concentrations observed at the upstream station on the southern side of Lake Gibson.

Based on these results, sampling in Twelve-Mile Creek in 2003 focused on three areas of the watershed: 1) Richardson's Creek; 2) Twelve-Mile/Old Welland Canal (OWC); and, 3) Beaverdams Creek and the Lake Gibson area. The purpose of the follow-up work in 2003 was to either discount each area as a likely source, identify outfalls that may contribute to further contamination or narrow down and identify stream stretches that would require further study. The 2003 sampling used up to four matrices (water, sediment, mussels, and SPMDs) to provide a weight-of-evidence approach for tracking down sources of PCBs.

Richardson's Creek data from 2003 showed no evidence of a PCB source. However, elevated levels of endosulfan (an insecticide) and its metabolites (an insecticide used to control the Colorado potato beetle, flea beetle, cabbageworm, peach tree borer, and the tarnished plant bug) were found in water samples. No further PCB trackdown was conducted in 2004 in the Richardson's Creek area; however, the identification of endosulfan initiated an additional trackdown-type study to determine the source of this contaminant.

The Twelve-Mile Creek – OWC stations tested in 2003 identified two feeder creeks as having potential upstream PCB sources linked to landfills. Follow-up work on these potential sources was started in 2004. Municipal and provincial governments are involved in abatement activities related to these landfills.

Beaverdams Creek findings suggest a source of waterborne contamination that may influence biota in the area. However, further work is required to determine whether there is an active source, or if the concentrations detected could be considered as typical background concentrations to the urban St. Catharines and Thorold areas. In the 2004 and 2005 field seasons, the Twelve-Mile Creek Trackdown study has shifted increasingly towards identifying sources of contamination entering the Lake Gibson system from smaller tributaries of Beaverdams Creek. Results from these studies are still pending.

Etobicoke Creek

Etobicoke Creek was selected for a PCB trackdown study as result of large-volume water sampling that showed elevated concentrations of PCBs in water compared to other tributaries in the Greater Toronto area (Boyd, 1999). The Etobicoke Creek watershed drains a total area of 211 km^2 (81.5 mi^2).The creek's headwaters are located within the City of Brampton and drain southward into Lake Ontario. The watershed is comprised of three main branches that flow through Brampton, Mississauga and Etobicoke.

Field work for the PCB trackdown started during the summer of 2001. Eleven locations along Etobicoke Creek were initially sampled, the majority of which were located at the mouths of the major tributaries into the main branch of the creek. The trackdown project included biomonitoring (fish and mussels), sediment collection, and large volume water samples integrated over a ten-week period. Environment Canada collected surficial sediment samples from the 11 sites for the study. Juvenile fish were collected from 9 of the 11 sites and caged mussels deployed at the locations where no fish were observed, as well as, upstream and downstream locations. As a result of the initial sediment screening, additional caged mussels were deployed at the mouths of two minor tributaries entering the main creek in areas of elevated PCB levels.

Activities in 2001 discounted various branches of the creek as sources of contamination. Two areas of focus were identified for study based on sediment and large volume water sampling. In 2002, SPMDs and caged mussels were placed upstream and downstream of discharges or outfalls within the area of interest. The results showed high concentrations near a tributary outfall draining an industrial area, with overall PCB congener patterns in mussels similar to conger patterns in SPMDs. Follow-up investigations were initiated in 2005 to investigate all inputs leading into the creek from this small tributary. Currently, a large storm sewer output is also being investigated as a potential source of PCB contamination to Etobicoke Creek, and several other areas of investigation have been identified for future work.

Cataraqui River

A 1994 OMOE study located PCB contaminated sediments in Kingston's inner harbour and the Cataraqui River. The closed Belle Island landfill was identified as a former source of PCBs, with scrap yards, contaminated sites (brownfields), and industry discharges as potential additional sources. Contamination in the sediments of the Cataraqui River was greatest on the west side of the river, where urban and industrial activities historically occurred.

As a result of these findings, the trackdown study was initiated in 2001 to determine if sources are historic or if they are ongoing. Work focused on the west side of the river, and included biomonitoring using caged mussels, large volume water samples integrated over a ten-week period and collected directly from the municipal sewer pipes, and sediment core sampling. Caged mussels were deployed at the mouth of six municipal sewers discharging into the west-side of the river, and four caged mussel experiments were deployed in other areas of concern and at an upstream reference location. Sediment core samples were collected from six storm sewers on the west side of the river, and 26 core samples were collected from the south west side of the landfill in an attempt to spatially quantify PCB levels in this area. More intensive sediment sampling was undertaken in an area immediately south of the landfill and adjacent to an old tannery property, based on PCB levels observed in earlier sediment core studies. Results from the 2001 work confirmed a number of potential sources of PCB (either past or ongoing) to Cataraqui River, which included historically-contaminated sediments. Storm sewers were shown to not be a likely significant source of recent PCB contamination to the Cataraqui River and Kingston Harbour.

Based on results from 2001, the following objectives were developed to guide the 2002-2003 sampling program: 1) to determine where there was ongoing contamination into the Cataraqui River; 2) to assess if re-suspension of historically contaminated sediments contribute to bioaccumulation and mortality; and 3) to assess bioaccumulation in young of the year fish and sportfish near Belle Island Landfill, the tannery and Emma Martin Park in key locations using caged mussels and young of the year fish.

Results from 2002 for PCBs in Cataraqui River sediments showed that concentrations were highest near the southeast arm of the closed Belle Island Landfill, however elevated concentrations in sediment were also found near the former tannery and near Emma Martin Park. PCBs in SPMDs and fish in 2002 showed that the landfill and Emma Martin Park areas had elevated concentrations, which in turn agreed with 2001 data for caged mussels and juvenile fish collected from the same area. PCBs in benthic invertebrates for 2002 exceeded CCME guidelines for PCBs for the protection of mammals and birds that consume aquatic biota. Follow-up sampling in the fall of 2003 identified elevated PCB concentrations in the biologically active sediment layer (0-10 cm) between the docks located near at Emma Martin Park.

As a result of these findings, the removal of this contaminated sediment 'hotspot"' near Emma Martin Park was planned, with the goal of reducing biological exposure from this active source. Emma Martin Park was a good candidate for rapid remediation because there was potential for sediment disturbance from the activities of a local rowing club, and it was a relatively small and confined area of higher contamination and with potential for biological uptake. Prior to remediation, a near-shore groundwater assessment was funded by OMOE to establish that there was no ongoing off-site contamination. A sediment delineation study established the depth and volume of sediment that would need to be remediated. A screening-level Human Health Risk Assessment also established that past exposure to the sediment presented no undue risk to Kingston Rowing Club members or area users.

Funding for the planning and implementation of the remediation project was provided by OMOE, EC, Transport Canada, and an in-kind contribution from the City of Kingston, totaling just under $350,000. This project removed 780 cubic meters (1,020 cubic yards) of sediment containing not only PCBs, but

also containing mercury, arsenic, chromium and lead. This reduced the PCBs in sediment of this area to local background concentrations. Future monitoring will assess the effectiveness of the dredging at reducing local-scale biological uptake of PCBs in the Cataraqui River and reducing PCB loadings to Lake Ontario

Whitby Harbour

An OMOE source track down study in 2000 for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, identified high concentrations of these compounds in sediment within Pringle Creek, at the mouth of the Creek and at stations downstream of the creek in Whitby harbour. Data from additional studies in 2001 and 2004 suggested that the flood plain in a portion of the creek was also contaminated. Caged mussel data and indigenous juvenile fish data showed that the dioxin and furan contamination in the creek and harbour sediment was bioavailable. These studies are continuing in 2005 to identify all possible sources of dioxins and furans to the harbour as well as a review of options for site remediation and possible next steps.

Trent River Trackdown

As part of the ongoing monitoring work to assess sediment quality and to determine the need for sediment management actions within the Bay of Quinte Area of Concern, comprehensive sampling of the sediment was undertaken in 2000 and 2001. Analysis of the sediment samples taken by EC at the mouth of the Trent River found dioxin/furan levels higher than other sediment samples collected within the Bay of Quinte. As a follow up, in November 2004, six additional samples were taken by EC in the vicinity of the original samples at the mouth of the Trent River. Significantly elevated levels of dioxins/furans were found in the 2004 samples. A cooperative multi-agency initiative with representation from the Ontario Ministry of the Environment, Environment Canada, Lower Trent Conservation, Quinte Remedial Action Plan, Ontario Ministry of Natural Resources, City of Quinte West and the Hastings, Prince Edward Counties Health Unit, is underway to determine the source and the potential environmental and human health effects of these elevated levels. Specific actions to date include:

- The OMOE's Environmental Monitoring and Reporting Branch is currently conducting a source identification and bio-monitoring study of the lower Trent River.
- EC and OMOE conducted further sediment core and surface sampling the week of November 28th, 2005.
- The OMOE's Safe Drinking Water Branch, conducted dioxin/furan sampling at the Quinte West and all downstream Bay of Quinte water treatment plants on September 28, 2005. Results were received October 12, 2005. As expected, dioxins and furans were not detected.
- Dillon Consulting Limited has been retained to undertake a screening level human health risk assessment.
- Environment Canada and the Ontario Ministry of the Environment are undertaking an ecological risk assessment.

Also in response to these findings, the Trent River Mouth Investigation Steering Committee has been formed. It includes representation from OMOE (Chair), EC, City of Quinte West, Hastings, and Prince Edward Counties Health Unit, Lower Trent Conservation Authority, the Bay of Quinte RAP Restoration Council and the Ministry of Natural Resources. The purpose of the committee is to determine the sources and significance of the dioxin/furan contamination and any remedial action that may be required. It is proposed that a Screening Level Human Health Risk Assessment and an Ecological Risk Assessment be undertaken to evaluate any potential human health or ecological impacts.

Screening Level Surveys of Lake Ontario Tributaries

Screening-level surveys of the quality of recently-deposited sediments was undertaken in the summers of 2002 and 2003 near the mouths of tributaries draining from the province of Ontario to the Niagara River, Lake Ontario and the St. Lawrence River up to the Quebec border (Dove et al., 2003; Dove et al., 2004). A total of 244 samples was obtained, representing 211 tributaries and 26 field blanks. This screening-level survey was based on the *Guidelines for Collecting and Processing Samples of Stream Bed Sediment for Analysis of Trace Elements and Organic Contaminants*, developed by the United States Geological Survey for the US National Water-Quality Assessment Program (Shelton and Capel, 1994). A number of sub-samples are obtained to represent overall tributary conditions.

The samples were analysed for organochlorine compounds, Total PCBs, four PCB Arochlor mixtures, 27 metals and 16 polycyclic aromatic hydrocarbons (PAHs), as well as organic carbon content and grain size distribution of each sample. For many of the tributaries, this study represents the first information related to organic compounds in the sediments. Results were compared with the available Canadian Environmental Quality Guidelines for Sediment, and to Ontario's Provincial Sediment Quality Guidelines.

Results for Lake Ontario LaMP critical pollutants are summarized below:

- One or more PCB Aroclors were detected in about 50 per cent of the sites sampled; of those sites, approximately half of those had concentrations of PCBs above the Canadian "Threshold Effect Level."
- DDT or its metabolites were detected in about 50 per cent of the sites sampled, although DDT and its metabolites were much more prevalent in the western end of Lake Ontario than the eastern; more targeted studies are recommended to determine if ongoing sources of DDT exist in these watersheds;
- Dieldrin was detected in 8 tributaries (4 per cent) of Lake Ontario, all located in the western end of the Lake, in small tributaries located in urban areas;
- Mirex was only detected in the sediments of Stony Creek, and at levels below the Provincial Sediment Quality Guideline's "Lowest Effect Level"; and,
- Mercury, a naturally-occurring element, was detected in all tributaries to Lake Ontario, but typically at very low concentrations; only 15 of the 218 sediment samples had concentrations that were above naturally-occurring background concentrations.

These results are being used to determine relative contamination in tributaries of Lake Ontario and St. Lawrence River, and will be used in prioritizing any future contaminant trackdown activities.

6.5.3.2 Government Activities

Mercury

Regulatory efforts to reduce releases of harmful pollutants such as mercury have included the following:

- Ontario Regulation 196/03 required Ontario dental clinics (that place, repair, or remove amalgam) to install separators by November 15, 2003. Preliminary results from the Royal College of Dental Surgeons of Ontario indicate that approximately 99 per cent of the 7,800 dentists in Ontario appear to be in compliance with the regulation. The installation of amalgam traps/filters reduces loadings to the municipal sewer systems substantially and immediately.

- Ontario Regulation 323/02 required existing hospital incinerators to close by December 6, 2003; these closures have been verified by OMOE staff. Hospital incinerators were the fourth largest emission source of mercury in the province.

Ontario has implemented the Canada Wide Standards (COWS) for mercury emissions from hazardous waste incinerators. Notices amending the Certificates of Approval for these facilities to include the mercury CWS limit (50 $\mu g/m^3$) were issued prior to the end of December 2003.

The Ontario government is moving forward with a 2003 commitment to phase out coal fired generating stations (GS) in the province and replace this energy loss with cleaner more diversified power. The government has set in motion 7,605 megawatts of capacity additions to help support the replacement of coal including wind, hydraulic, natural gas cogeneration, nuclear refurbishment and demand side management. Under the coal replacement plan, five generating stations are to be replaced. Of significance to Lake Ontario are the closing of the Lakeview (closed April 2005) and Nanticoke (planned closure 2009) stations. The closing of these two coal fired generating stations will help reduce both smog causing pollutants and an estimated 259 kilograms/year (571 pounds/year) of mercury loading to the environment within the lake basin area, based on data provided by Ontario Power Generation.

PCBs

Environment Canada's PCB regulations are being amended and targeted for Canada Gazette publication in 2005. These regulations are:

1) *The Chlorobiphenyl Regulations* (1977)
2) *The Storage of PCB Material Regulations* (1992)
3) *Export of PCB Regulations* (1996)
4) *Federal PCB Destruction Regulations* (1989).

The most significant revisions to the regulations will be the imposition of strict phase-out dates for certain categories of PCBs. Revisions to the Federal PCB destruction regulations will see the strengthening of emissions release provisions mainly to bring the federal regulations in line with existing provincial requirements.

6.5.3.3 Pollution Prevention Partnerships

Dioxins and Furans – Uncontrolled Household Garbage Burning

Household garbage burning is estimated to emerge as the largest source of dioxin emissions after air emissions standards for industrial sources are in place. The practice of household garbage burning typically is carried out in old barrels, open pits, woodstoves, or outdoor boilers, and represents a significant source of dioxins and furans. To reduce loadings of dioxins and furans from household garbage burning, the Household Garbage Burning Strategy was developed in May 2001 under the Great Lakes Binational Toxics Strategy. The GLBTS maintains a website for information sharing at www.openburning.org.

In Ontario GLBTS partners have been implementing the Household Garbage Burning Strategy through public education workshops and public displays. In 2004 and 2005, 22 Burn It Smart! workshops were held in the Lake Ontario basin, promoting energy efficient USEPA certified wood stoves, the use of clean wood or alternatives, and not burning garbage. The workgroup is also working with municipalities and other non-government groups to distribute the Don't Burn Garbage fact sheet, as well as other fact sheets and videos on wood burning.

Mercury – "Switch Out" Program Continues to Expand

The "Switch Out" program was initiated in June 2001 to recover mercury switches from end-of-life vehicles. The program started with eleven auto recyclers in Ontario who collected approximately 2,500 switches in 2001. In 2004, four hundred auto recyclers in three provinces (Ontario, Alberta, and British Columbia) participated in a "Switch-Out Program" and over 58,000 switches have been collected.

Mercury – Appliance Switch Collection Program

In 2002, the Regional Municipality of Niagara conducted a pilot program to collect mercury switches from white goods (e.g. fridges, washers, dryers, etc.). Following a successful pilot program, an instruction manual and video were developed and the Association of Municipal Recycling Coordinators (AMRC) actively promoted the program with other municipalities. By 2003, several municipalities had adopted the program and AMRC estimated that 45 kg of mercury were collected in 2003. In February 2005, the AMRC hosted a mercury workshop for Ontario municipalities with a focus on programs that the municipalities could initiate.

Mercury – Dental Clean Sweep Launched

Based on a survey conducted by the Ontario Dental Association in 2001, it is estimated that nine per cent of Ontario dental practices have elemental mercury in their offices. A working group involving the Ontario Dental Association, the OMOE, EC and waste carriers developed an Ontario Wide Dental Elemental Clean Sweep Project to remove stores of elemental mercury from Ontario dental practices. The program ran until March 2005.

Mercury – Mercury Clean Sweep Program for Schools

Environment Canada and the Ontario Ministry of Environment are working together to implement a Mercury Clean Sweep Program for Schools. This program aims to safely remove stores of mercury-containing equipment and products from classrooms and science labs, and to reduce the potential for the accidental release of mercury into schools and the environment.

A pilot Clean Sweep Program was launched November 10 through 12, 2005 at the Science Teachers' Association of Ontario 2005 Conference. The program will run from January to March 2006. This pilot project is intended to gage the number of schools willing to participate in the program and to further determine the feasibility of hosting a province-wide Mercury Clean Sweep Project for Schools. Participating schools will be asked to perform an inventory of mercury-containing equipment or products in their classrooms and science labs. Collected mercury-items will be removed by waste management companies for proper disposal and recycling.

Ontario Waste Agricultural Pesticides Collection Program.

From November 22 to 23, 2005, Ontario farmers were able to take unwanted or old pesticides free of charge to 13 select farm supply dealers across Ontario. The Ontario Waste Agricultural Pesticide Collection Program provided free, safe disposal of de-registered, outdated or unwanted agricultural and commercial pesticides. The collected pesticides were sorted, recorded and packaged before being transported to an approved facility for safe disposal. Participants were also provided with helpful tips on reducing pesticide waste and other waste pesticide issues.

The program was funded by CropLife Canada, the Ontario Ministry of the Environment, Environment Canada and Agriculture and Agri-Food Canada through the Agricultural Adaptation Council's CanAdvance Program. The program was also supported by AGCare, the Ontario Agri Business Association and its network of participating agricultural dealers, and the Ontario Ministry of Agriculture, Food and Rural Affairs.

6.6 References

Blanchard, P. Audette, C. Hulting, M.L., Basu, I, Brice, K.A., Chan, C.H., Dryfout-Clark, H, Froude, F., Hites, R.A. Neilson, M. 2004. Atmospheric Deposition of Toxic Substances to the Great Lakes: IADN Results through 2000 Published by Environment Canada and the United States Environmental Protection Agency ISBN: 0-662-37467-3 Public Works and Government Services Canada Catalogue Number: En56-156/2000-1E USEPA Report Number: 905-R-04-900. http://www.epa.gov/glnpo/monitoring/air/iadn/reports/IADN_1999_2000.pdf

Boyd, D. 1999. Assessment of Six tributary Discharges to the Toronto Area Waterfront. Volume 1. Environment Canada and Ontario Ministry of the Environment. Queen's Printer for Ontario, 1999.

Boyd, D. 1999. D'Andrea, M. and R. Anderton Assessment of Six tributary Discharges to the Toronto Area Waterfront. Volume 2. Environment Canada and Ontario Ministry of the Environment. Queen's Printer for Ontario, 1999.

Boyd, D. Biberhofer, J. 1999. Large Volume Sampling at Six Lake Ontario Tributaries During 1997 and 1998: Project Synopsis and Summary of Selected Results. Environment Canada and Ontario Ministry of the Environment. Queen's Printer for Ontario, 1999. ISBN 0-7778-9257-X

D'Andrea, M. and R. Anderton. 1996. "Assessment of Tributary Discharges along the Metropolitan Toronto Waterfront," unpublished report to the Metropolitan Toronto and Region Remedial Action Plan. Environmental Monitoring and Reporting Branch, Ontario Ministry of Environment and Energy.

Data Interpretation Group, River Monitoring Committee. January 1995. Joint Evaluation of Upstream-Downstream Niagara River Monitoring Data, 1992-93. (Loadings measured at the head of the Niagara River at Fort Erie).

Dove, A. S. Painter and J. Kraft. 2003. Sediment Quality in Canadian Lake Ontario Tributaries Part I - West of the Bay of Quinte". Ecosystem Health Division, Ontario Region. Environmental Conservation Branch. Environment Canada. ECB/EHD-OR/03-01/I

Dove, A. S. Painter and J. Kraft. 2004. Sediment Quality in Canadian Lake Ontario Tributaries Part II - Bay of Quinte and St. Lawrence River". Ecosystem Health Division, Ontario Region. Environmental Conservation Branch. Environment Canada. ECB/EHD-OR/04-01/I

Environment Canada 2003. Interim Guidance Framework for PCB Source Track-Down Projects. Report No. ECB/EHD-OR/03-04/I.

Fox, M.E., R.M. Kahn, and P.A. Thiessen. 1996. Loadings of PCBs and PAHs from Hamilton Harbour to Lake Ontario. Water Quality Res. J. of Canada, V. 31, No. 3, pp. 593-608.

Great Lakes Binational Toxics Strategy. 2004. Annual Progress Report. http://binational.net/bns/2004/index.html

Klawunn, P. *et al.*, 2005 (unpublished). The Niagara River Upstream/Downstream Program. Ecosystem Health Division, Environment Canada – Ontario Region. Values are for 1999/2000 and 2000/2001. *pers comm.*.

Limno Tech, Inc. (2003). LOTOX2 Model Documentation in Support of Development of Load Reduction Strategies and a TMDL for PCBs in Lake Ontario. Report by Limno Tech, Inc., Ann Arbor, MI for USEPA Region 2.

Litten, S. 1996. Trackdown of chemical contaminants to Lake Ontario from New York State Tributaries. Bureau of Watershed Assessment and Research, Division of Water, NYSDEC, 50 Wolf Road, Albany, N.Y. 12233-3502, April 11, 1996.

Merriman, J. 1997. Water Quality in the St. Lawrence River at Wolfe Island. Report. No. EHD 97-01/I. Environment Canada – Ontario Region, Ecosystem Health Division. 17 pp.
Merriman, J. 1998. Trace Organic Contaminants in the St. Lawrence River at Wolfe Island. Report No. EHD 98-02/I. Environment Canada – Ontario Region, Ecosystem Health Division. 32 pp.
Merriman, J. and K.W. Kuntz. 2002. Upstream / Downstream Niagara River Monitoring Program Final Report. 1997-98 & 1998-1999. For the Data Interpretation Group.
Municipal and Industrial Strategy for Abatement (MISA) Clean Water Regulation 760-93; Sample Results Data Store, 1994. Ministry of Environment and Energy, Ontario.
Shelton, L.R. and P. D. Capel. 1994. Guidelines for Collecting and Processing Samples of Stream Bed Sediment for Analysis of Trace Elements and Organic Contaminants for the US National Water-Quality Assessment Program. United States Geological Survey Open-File Report 94-458, Sacramento, USA.
USEPA (2003) LOTOX Peer Review Report. Available from USEPA Region 2
Williams, D.J and O'Shea, M.L. 2003. Niagara River Toxics Management Plan Progress Report And Work Plan. Prepared for The Niagara River Secretariat. (http://www.epa..gov/grtlakes/lakeont/nrtmp/pr_wp_2003.pdf).
Williams, D.J and O'Shea, M.L. 2004. Niagara River Toxics Management Plan (NRTMP) Interim Progress Report And Work Plan. (http://www.epa.gov/grtlakes/lakeont/nrtmp/pr_wp_2004.pdf)
Williams, D.J., M.A.T. Neilson, J. Merriman, S. L'Italien, S. Painter, K. Kuntz and A.H. El-Shaarawi. 2000. The Niagara River Upstream/Downstream Program 1986/87 -1996/97: Concentrations, Loads, Trends. Environment Canada, Environmental Conservation Branch - Ontario Region, Ecosystem Health Division, Report No. EHD/ECB-OR/00-01/I.

APPENDIX 1 SOURCES OF ADDITIONAL INFORMATION

New York State Contaminant Trackdown

Contaminants in Young-of-the-Year Fish from Selected Lake Ontario Tributaries, 1996. December 1998. T.L. Preddice; Jackling, S.L.; Skinner, L.C. Bureau of Habitat, Division of Fish, Wildlife and Marine Resources, NYSDEC, Albany, NY.
Dioxin/Furan in Lake Ontario Tributaries 1995-1997. October 1999. K. Woodeld & F. Estabrooks. Sediment and Management Section, Bureau of Watershed Assessment & Research, Division of Water
Eastern Lake Ontario Drainage Basin Sediment Study. Summary 1997 results. February 2000. NYSDEC.
Enhanced Toxics Monitoring from Final chlorinated Wastewater Effluents and Surface Waters Using the Trace Organics Platform Sampler (TOPS). August 1997. S. Litten. Bureau of Watershed Assessment & Research, NYSDEC, Albany, New York.
Potential Sources of Priority Contaminants in the Lake Ontario Drainage Basin of New York State. September 1997. F. Luckey . Great Lakes Section, Division of Water, NYSDEC, Albany, NY
Inactive Hazardous Waste Disposal Sites in the Lake Ontario Basin. July 1995. F. Luckey. Great Lakes Section, Division of Water, NYSDEC, Albany, NY.
The State of the New York Lake Ontario Basin: A report on water resources and local watershed management programs. 2000. Finger Lakes-Lake Ontario Watershed Protection Alliance. 309 Lake Street, Penn Yan, New York.
Trackdown of Chemical Contaminants to Lake Ontario from New York State Tributaries. April 1996. S. Litten. Bureau of Watershed Assessment & Research, NYSDEC.

Binational Sediment Workshop

OPEN WATER

Coleates, Richard 2003. Surficial Sediment Quality in Lake Ontario- A Summary of Sampling Results from September 1997. US Environmental Protection Agency.

Marvin, C.H., Painter, S., Williams, D.J., Richardson, V., Rossmann, R. and Van Hoof, P. 2004. Spatial and temporal trends in surface water and sediment contamination in the Laurentian Great Lakes. Environmental Pollution. In Press.

Marvin, C.H., Painter, S. and Rossmann, R. Spatial and temporal trends in mercury contamination in sediments of the Laurentian Great Lakes. Environmental Research. In Press.

Marvin, C.H., Sverko, E., Charlton, M.N., Thiessen, P.A. and Painter, S. 2004. Contaminants associated with suspended sediments in Lakes Erie and Ontario. Journal of Great Lakes Research. In Press.

Marvin, C.H., Grapentine, L. and Painter, S. 2004. Application of a sediment quality index to the lower Great Lakes. Environmental Monitoring and Assessment. 91: 1-16..

Marvin, C.H., Charlton, M.N., Stern, G.A., Braekevelt, E., Reiner, E.J. and Painter, S. 2003. Spatial and temporal trends in sediment contamination in Lake Ontario. Journal of Great Lakes Research. 29(2): 317-331.

Marvin, C.H., Charlton, M.N., Reiner, E.J., Stern, G.A., Braekevelt, E., Estenik, J.F., Thiessen, P.A. and Painter, S. 2002. Surficial sediment contamination in Lakes Erie and Ontario: A comparative analysis. Journal of Great Lakes Research, 28(3):437-450.

NEARSHORE

Great Lakes Reports (1992-2004) NYS Department of Environmental Conservation - Division of Water Sediment Assessment and Management Section Contact: Frank Estabrooks, (518) 402-8207 website address: \VWW .dec.state.n):: .us/website/dow /bwam

Richman, L., C. Rusmir, D. Boyd. 2004. “Sediment Quality in Lake Ontario Harbours and Embayments”. Ontario Ministry of the Environment, Environmental Monitoring and Reporting Branch. (draft report)

INTEGRATION OF RESULTS

Dove, A., S. Painter and J. Kraft, 2003: Sediment Quality in Canadian Lake Ontario Tributaries: Part One (West of the Bay of Quinte), A Screening-Level Survey, Ecosystem Health Division, Ontario Region, Environmental Conservation Branch, Environment Canada, Report No. ECB/EHD-OR/03-01/I

Dove, A., S. Painter and J. Kraft, 2004 (in review): Sediment Quality in Canadian Lake Ontario Tributaries: Part Two (Bay of Quinte and St. Lawrence River), A Screening-Level Survey, Ecosystem Health Division, Ontario Region, Environmental Conservation Branch, Environment Canada, Report No. ECB/EHD-OR/04-01/I

CHAPTER 7 HUMAN HEALTH

7.1 Summary

This Chapter introduces human health issues on a global scale, and then focuses on the binational concerns relating to the human health beneficial uses for Lake Ontario and how the Lake Ontario LaMP addresses the related use impairment indicators. The three key human beneficial uses for the waters of Lake Ontario are for fish consumption, drinking water, and bathing beaches (including recreational use). Only fish consumption has been identified as impaired on a lakewide basis. The chapter describes the pathways through which pollutants can affect human health. Through binational cooperation, a binational Great Lakes Human Health Network has been established to more comprehensively address human health impacts in the Great Lakes as a whole and for the Lake Ontario Lakewide Management Plan. The material presented is based on information that existed as of January 2003.

7.2 Background

There is concern about the effects that Great Lakes' contaminants, and in particular persistent, bioaccumulative toxic chemicals, may have on human health. The 1987 Protocol to the Great Lakes Water Quality Agreement of 1978 (GLWQA) states that Lakewide Management Plans (LaMPs) for open lake waters shall include: "A definition of the threat to human health or aquatic life posed by Critical Pollutants, singly or in synergistic or additive combination with another substance, including their contribution to the impairment of beneficial uses." Critical pollutants are those persistent bioaccumulative toxic chemicals that have caused, or are likely to cause, impairments of the beneficial uses of each Great Lake. Three of these beneficial uses (fish consumption, drinking water consumption and recreational water use) are directly related to human health. The goal of this Lake Ontario LaMP 2004 section is to fulfill the human health requirements of the GLWQA, including:

- to define the threat to human health and describe the potential adverse human health effects arising from exposure to critical pollutants and other contaminants (including microbial contaminants) found in the Lake Ontario basin;
- to address current and emerging human health issues of relevance to the LaMP but not currently addressed in the other components of the LaMP; and
- to identify implementation strategies currently being undertaken to protect human health.

The World Health Organization defines human health as "state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (World Health Organization, 1984). Therefore, when assessing human health, all aspects of well-being need to be considered, including physical, social, emotional, spiritual and environmental impacts on health. Human health is influenced by a range of factors, such as the physical environment (including environmental contaminants), heredity, lifestyle (smoking, drinking, diet and exercise), occupation, the social and economic environment the person lives in, or combinations of these factors. Exposure to environmental contaminants is one among many factors that contribute to the state of our health (Health Canada, 1997).

In defining the threat to human health from exposure to the Lake Ontario LaMP critical pollutants, this assessment applies a weight of evidence approach, which uses the overall evidence from wildlife studies, experimental animal studies, and human studies in combination.

7.3 Human Health and the Lake Ontario LaMP

The Lake Ontario LaMP is concerned with human health issues related to water quality. Other human health issues, such as air pollutants, infectious diseases, and pesticide residues on food are not addressed as part of the LaMP and are under the jurisdiction of other programs. Three of the Great Lakes Water Quality Agreement (GLWQA) impairments of beneficial uses are directly related to human health issues: Restrictions on Drinking Water Consumption, Fish and Wildlife Consumption, and Beach Closings. Of these three, only fish and wildlife consumption advisories have been identified as a lakewide problem.

Localized beach closings due to occasional high bacteria levels are a problem in some areas and are being addressed by several Remedial Action Plans. While some taste and odor problems have been observed, there are no restrictions on drinking water consumption. The LaMP will work with U.S. and Canadian health agencies to assure that health issues are being adequately addressed.

7.4 Human Health Pathways

Potential environmental pathways of human exposure to Great Lakes pollutants include inhalation of air, ingestion of water, foodstuffs, or contaminated soil, and dermal contact with water or airborne particulates. Multimedia analyses indicate that the majority (80 to 90%) of human exposures to chlorinated organic compounds and mercury comes from the food pathway, a lesser amount (5 to 10%) from air, and minute amounts (less than 1%) from water (Birmingham et al., 1989; Newhook, 1988; Fitzgerald et al., 1995).

Most of the available data on human exposure to toxic substances in the Great Lakes comes from the analyses of contaminant levels in water and sport fish. The consumption of contaminated sport fish and wildlife can significantly increase human exposure to Lake Ontario critical pollutants. The risks associated with fish consumption are greatly reduced if people follow consumption advisories. Those who are unaware of or do not follow these advisories are at greatest risk. Investigators have demonstrated that blood serum levels of these contaminants are significantly increased in consumers of contaminated Great Lakes sport fish as compared to non-fisheaters (Humphrey, 1983a,b; Kearney et al., 1995; Health Canada, 1997; Fitzgerald et al., 1995).

Even though residents of the Great Lakes basin are exposed to toxic substances from many sources originating within and outside the region, the main routes of human exposure to contaminants from the waters of the Great Lakes are ingestion of fish and, to a lesser extent, ingestion of drinking water (Department of Fisheries and Oceans and Health and Welfare Canada, 1991). Also, several investigators have shown that exposure from fish far outweighs atmospheric, terrestrial, or water column sources (Swain, 1991; Humphrey, 1983b; Fitzgerald et al., 1995). These patterns may vary for populations living in the vicinity of industrialized areas.

Several epidemiologic investigations have been conducted on the association between water pollutants in the Great Lakes and the health of people in the Great Lakes basin. These studies have demonstrated increased tissue levels of toxic substances in these populations that may be associated with or potentially result in reproductive, developmental, behavioral, neurologic, endocrinologic, and immunologic effects (Fitzgerald et al., 1995).

Some studies have reported subtle effects in children of mothers who consumed large amounts of Great Lakes fish. At birth, some of the children most highly exposed to the mixture of contaminants present in the fish were slightly smaller, showed slightly delayed neuromuscular development during infancy, and had a reduced ability to deal with stressful situations. A small percentage of such children showed slightly delayed or reduced intellectual development during their school years. Recent epidemiologic and laboratory studies complement and continue to build upon the scientific data gathered over the last two decades that document health consequences associated with exposures to persistent toxic substances. The findings of elevated polychlorinated biphenyl (PCB) levels in human populations, together with findings of developmental deficits and neurologic problems in children whose mothers ate PCB-contaminated fish, have significant health implications. Additional research is necessary to better understand the human health impacts that persistent toxic substances may have on sensitive populations (Johnson et al., draft 1997).

Endocrine disruption has emerged as a major issue in regulatory toxicology with significant human health implications. While human health effects due to endocrine disruption remain controversial, some pesticides and certain industrial chemicals, as well as some naturally occurring substances have been shown to mimic the action of estrogen in tissue cultures and laboratory animal studies. Laboratory and animal studies reveal that fetuses and infants are especially susceptible to bioaccumulating and endocrine disrupting chemicals because exposure occurs during critical periods of early tissue and organ development and growth.

7.5 Beneficial Use Impacts

The critical pollutants and chemical pollutants of concern in Lake Ontario include organochlorines and metals that are known to cause adverse health effects in animals and humans. These chemicals do not break down easily, persist in the environment and bioaccumulate in aquatic biota, animal and human tissue - thus they are called persistent bioaccumulative toxic chemicals (PBTs). Organochlorines tend to accumulate in fat (such as adipose tissue and breast milk), and metals tend to accumulate in organs, muscle and flesh. Food is the primary route of human exposure to these PBT chemicals, and consumption of Great Lakes' fish is the most important source of exposure originating directly from the lakes.

Fish and Wildlife as a Sentinel for Human Health

The health of fish and wildlife provides a good indication of the overall condition of an ecosystem. The dramatic reproductive failure of cormorants on Lake Ontario due to DDT in the 1960s provided a clear indication that something was wrong. Since that time, contaminant reduction programs have succeeded in banning and controlling many toxic substances and, as a result, environmental levels have declined and the cormorants and other sensitive species are reproducing normally. This would suggest that the potential risks to human populations posed by these persistent environmental contaminants have also declined.

Ongoing fish and wildlife populations can provide an important tool to identify any currently unrecognized contaminant risks that may develop in the future. Given that the metabolisms and diets of fish and wildlife are very different from humans and that these species are exposed to much higher contaminant levels than the general human population, caution must be used when interpreting the significance of fish and wildlife problems for human populations. For example, tumors in fish may reflect high levels of contaminants in sediment or may be the result of natural causes such as viruses or genetic factors. Nonetheless, Canadian and U.S. health agencies [Health Canada and the Agency for Toxic Substances and Disease Registry (ATSDR)] have concluded that the weight of evidence based on the findings of wildlife biologists, toxicologists, and epidemiologists clearly indicates that populations

continue to be exposed to PCBs and other chemical contaminants and that significant health consequences are associated with these exposures (Johnson et al., draft 1997; Health Canada, 1997).

In additions to the presence of tumors, other use impairment indicator can be useful as a warning to scientists that beneficial uses are being affected. These Lake Ontario LaMP indicators include degradation of fish and wildlife populations, degradation of benthic communities, degradation of plankton populations and other bird or animal deformities or reproductive problems.

Indicators of Human Health Trends

Ideally, indicators of human health would gauge trends in any adverse human health effects related to environmental contaminants. Contaminant concentrations in fish tissue, human tissue, and other environmental media can be used as an indication of changes in contaminants levels and that certain human populations are being exposed. However, except in cases where individuals are exposed to relatively high levels of contaminants that can cause clearly recognizable health effects, it may not be possible to separate out any adverse effects due to environmental contaminants from other human health factors, such as diet, lifestyle, work environment, and genetic factors.

There are a number of U.S. and Canadian stakeholders collaborating to define indicators for the basin and the individual Great Lakes. The development of these human health indicators may provide the basis for future monitoring and data gathering efforts.

Sources of persistent toxic substances from Lake Ontario are known to contribute very little to the exposure of the general population. For the general population, a general market diet contributes to over 95% of their contaminant intake and drinking water, recreational water contact and air pollution constitute very minor exposure. Consequently, the approach taken by the responsible agencies has been to examine groups at higher risk of exposure to persistent toxic substances from Great Lakes sources, such as high consumers of sportfish: recreational anglers, certain ethnic groups, subsistence anglers and others.

7.5.1 Fish Consumption Advisories

Fish are low in fat, high in protein, and may have substantial health benefits when eaten in place of high-fat foods. However, chemicals such as mercury and PCBs enter the aquatic environment and build up in the food chain. People need to be aware of the presence of contaminants in sport fish, and in some cases, take action to reduce exposure to chemicals while still enjoying the benefits of catching and eating fish. Contaminants usually persist in surface waters at very low concentrations. They can bioaccumulate in aquatic organisms and become concentrated at levels that are much higher than in the water column. This is especially true for substances that do not break down readily in the environment, like the Lake Ontario LaMP critical pollutants PCBs and mercury. As contaminants bioaccumulate in aquatic organisms, this effect biomagnifies with each level of the food chain. As a result of this effect, the concentration of contaminants in the tissues of top predators, such as lake trout and large salmon, can be millions of times higher than the concentration in the water.

Both the Province of Ontario and New York State issue fish consumption advisories for fish caught in Lake Ontario waters. In general, the consumption advisories are based on contaminant levels in different species and ages of fish, taking into account that contaminant levels are generally higher in older, larger fish. While there are some differences in the fish tissue monitoring methodologies used by the two governments, both jurisdictions agree that PCBs, dioxin, and mirex are responsible for lakewide fish consumption advisories. The LaMP is coordinating binational efforts to control and reduce inputs of these contaminants to the lake.

Ontario anglers should refer to the Guide to Eating Ontario Sport Fish, published every two years by the Ministry of Natural Resources and the Ontario Ministry of the Environment, for size and species-specific consumption advice. *www.ene.gov.on.ca.*

U.S. anglers should refer to New York State Department of Health's Chemicals in Sportfish and Game, which includes specific and general advisories for Lake Ontario. *www.health.state.ny.us/nysdoh/environ/fish.htm.*

Various jurisdictions around the Great Lakes carry out sport fish monitoring programs that provide consumption advice. The LaMP recognizes there are differences in reporting and consumption advisories between jurisdictions in Canada and the U.S. As part of Ontario's Sport Fish Contaminant Monitoring Program, sport fish from the Canadian waters of Lake Ontario are monitored on an annual basis. The results are published every other year - along with consumption advice for sport fish from Ontario's inland lakes, rivers and Great Lakes - in the Guide to Eating Ontario Sport Fish. The guide offers size-specific consumption advice based on health protection guidelines developed by Health Canada for approximately 1,700 species.

Between 4,000 and 6,000 fish per year are tested through the Sport Fish Contaminant Monitoring Program. Staff involved in the program, a partnership between the Ontario Ministries of Natural Resources and the Environment, have been testing Ontario sport fish for more than 25 years. Staff from both ministries collect fish and send them to the Ministry of the Environment laboratory in Toronto. The skinless, boneless dorsal fillets of the fish are analyzed for a variety of substances, including mercury, PCBs, mirex/photomirex, and dioxins/furans – contaminants identified by the LaMP as critical pollutants.

In Ontario, consumption restrictions on Lake Ontario sport fish are the result of PCBs (47 percent of advisories), mercury (26 percent), mirex/photomirex (24 percent), toxaphene (2 percent) and dioxins/furans (1 percent). Other chlorinated organic contaminants such as DDT, hexachlorobenzene, octachlorostyrene, chlordane and lindane are regularly detected in Lake Ontario sport fish but do not result in consumption restrictions.

It is well known that sport fishing has nutritional, social and cultural benefits. However, because of the detection of PCBs and other contaminants found in Lake Ontario sportfish, both the New York State Department of Health as well as the Ontario Ministry of the Environment issue fish advisories recommending restrictions for several fish species depending on their degree of contamination. The advisories also explain how to minimize exposure to contaminants in sportfish and reduce the health risks associated with those contaminants. It is critical that women of childbearing age, young children and the elderly pay close attention to these advisories, as there are concerns that they are more sensitive to potential developmental, reproductive, immunological and neurological health risks posed by these contaminants.

Further information on persistent toxic substances and human health, and other Great Lakes health and environment issues can be found on the following internet Web sites:

- http://www.hc-sc.gc.ca/ehp.index.htm
- http://www.atsdr.cdc.gov/grlakes.html
- http://www.ene.gov.on.ca/water.htm
- http://www.epa.gov/OGWDW/
- http://www.health.state.ny.us/nysdoh/environ/fish.htm

7.5.2 Drinking Water

Access to clean drinking water is essential to good health. The average adult drinks about 1.5 liters of water a day. Lake Ontario is the primary source of drinking water for people who live in the Lake Ontario basin. Fortunately Lake Ontario is a very high quality source of drinking water with most contaminants, such as bioaccumulative contaminants, at levels well below drinking water criteria. Raw and treated surface water are monitored for a variety of contaminants, including micro-organisms (e.g. bacteria, viruses and protozoa), chemical contaminants (both naturally occurring, synthetic and anthropogenic), and radiological contaminants, including naturally-occurring inorganic and radioactive materials, to ensure that water treatment systems are effective and functioning properly.

Before the mid 1900s microbial contamination of drinking water posed a serious public health risk in terms of acute outbreaks of disease such as typhoid and cholera. Today bacterial contamination of municipal water supplies has been largely eliminated by adding chlorine or other disinfectants to drinking water to prevent waterborne disease. When used with multiple barrier systems (i.e. coagulation, flocculation, sedimentation and/or filtration), chlorine is effective against most infective agents. Diseases such as typhoid and cholera have been virtually eliminated.

Research is on-going on how to improve our ability to detect and prevent potential outbreaks of microbes resistant to drinking water disinfection, especially encysted forms of protozoan parasites such as Cryptosporidium. Potential human health impacts of chlorination by-products of drinking water disinfection such as trihalomethanes are also being studied. Although important areas of research, neither of these issues have been identified as a significant concern for residents of the Lake Ontario basin.

7.5.3 Bathing Beach (Closings) and Recreation

Local beach closings along some of the more populated shorelines due to elevated levels of E. coli (or fecal coliform bacteria) are indicative of fecal contamination and the possible presence of enteric (intestinal) pathogens which can pose a potential health risk. Microbiological water quality indicators are used as surrogates for the presence of pathogenic organisms that may cause illness. In Lake Ontario, a number of local beach closings occur due to microbial contaminants, primarily along the more populated shorelines. Exceedence of microbial standards and criteria typically occurs following a storm event when the treatment capacity of some sewage treatment plants can be exceeded. Given the localized nature of beach closings and their absence along much of the Lake Ontario shoreline, they are not considered a lakewide problem. The frequency of beach closings is expected to decrease as sewage treatment plants continue to improve and upgrade their systems. It should be noted that beaches may also be closed due to other factors such as storm events, excessive turbidity, or lack of funding.

Beach closings are restricted largely to shorelines near major metropolitan centers or the mouths of streams and rivers. These closings follow storm events when bacteria-rich surface water runoff is flushed into nearshore areas via streams, rivers, and combined sewer overflows (CSOs). In some instances beaches may be closed based on the potential for high bacteria levels to develop following storm and rain events. Beaches are also closed for aesthetic reasons, such as the presence of algal blooms, dead fish, or

garbage. Given the localized nature of beach closings and their absence along much of the Lake Ontario shoreline, they are not a considered lakewide problem.

In Ontario, beaches are closed when bacterial (E. coli) levels exceed 100 organisms/100mL. During recent years (1995 to 1997) beach closings have continued in heavily urbanized areas in the western part of the basin due to storm events, but are less frequent in the central and eastern regions. Examples of ongoing problems include the beaches of the Bay of Quinte, Toronto, Burlington, Hamilton, Niagara, Pt. Dalhouse, and St. Catherines. Upgrading stormwater controls through the installation of collection tanks so stormwater from CSOs can be treated in Toronto and Hamilton should reduce beach closings in these areas.

The only U.S. beach with recent closings is Ontario Beach within the Rochester AOC. These closings have been posted due to rain events, storm runoff, excessive algae, waves greater than four feet, or water clarity less than one-half meter. Ontario Beach is routinely closed as a precaution during storm and rain events because these conditions have the potential to cause high bacteria levels along the beach shore. Ontario Beach summer fecal coliform levels have been well below the state's action level of 200 fecal coliforms/100mL. The implementation of a combined sewer overflow abatement program resulted in significant decreases in fecal coliform levels in the Genesee River and adjacent shoreline areas. Actions are also underway to address stormwater problems that impact other areas of the Rochester Embayment.

The Great Lakes are an important resource for recreation, including activities such as swimming, water-skiing, sail-boarding and wading that involve body contact with the water. Apart from the risks of accidental injuries, the major human health concern for recreational waters is microbial contamination by bacteria, viruses, and protozoa. Many sources or conditions can contribute to microbiological contamination, including sewer overflows after heavy rains. On-shore winds can stir up sediment or sweep bacteria in from contaminated areas. Animal/pet waste may be deposited on the beach or washed into storm sewers. Agricultural runoff, such as manure, is another source. Stormwater runoff in rural and wilderness area watersheds can increase densities of fecal streptococci and fecal coliforms as well. Other contaminant sources include infected bathers/swimmers; direct discharges of sewage from recreational vessels; and malfunctioning private on-site sewage disposal systems (e.g. cottages, resorts).

Human exposure to micro-organisms occurs primarily through ingestion of water, and can also occur via the entry of water through the ears, eyes, nose, broken skin, and through contact with the skin. Gastro-intestinal disorders, respiratory illness and minor skin, eye, ear, nose and throat infections have been associated with microbial contamination of recreational waters. Studies have shown that swimmers and people engaging in other recreational water sports have a higher incidence of symptomatic illnesses such as gastroenteritis, otitis, skin infection, and conjunctivitis, and acute febrile respiratory illness (AFRI) following activities in recreational waters. Although current studies are not sufficiently validated to allow calculation of risk levels, there is some evidence that swimmers/bathers tend to be at a significantly elevated risk of contracting certain illnesses (most frequently upper respiratory or gastro-intestinal illness) compared with people who do not enter the water. In addition, children, the elderly, and people with weakened immune systems are those most likely to develop illnesses or infections after swimming in polluted water. Chemical contaminants such as PAHs have been identified as a possible concern for dermal (skin) exposure in recreational waters. Dermal exposure may occur when people come into contact with contaminated sediment or contaminated suspended sediment particulates in the water.

7.6 Great Lakes Human Health Network

Information sharing is the focus of the newly created Great Lakes Human Health Network. Annex 2 of the Canada-U.S. Great Lakes Water Quality Agreement requires that Lakewide Management Plans (LaMPs) "include a definition of the threat to human health posed by critical contaminants". In order to

facilitate better communication and information sharing between governments on human health issues directly related to Great Lakes water quality, a Great Lakes Human Health Network has been formed.

Working through the existing LaMP and RAP processes, the Network is intended to focus on ongoing and emerging human health issues in the Great Lakes basin. The Network is a voluntary partnership of federal, provincial, state and local health agencies, being supported by the U.S. Environmental Protection Agency and Health Canada.

Great Lakes Human Health Network (Network) was established to improve the exchange of environmental- related health information across the Great Lakes basin. The Network was formed in December 2002 under the guidance of the Binational Executive Committee (BEC), a body comprised of senior Canadian and U.S. officials, to create a forum or mechanism to discuss human health issues directly related to Great Lakes water quality. The Network addresses health issues related to the ecosystem of the Great Lakes basin, including drinking water and recreational water quality, and fish consumption. The Network is a voluntary partnership of representatives of both US and Canadian governments and their agencies whose purpose is to exchange information, facilitate communication and support the coordination of public health and environmental agencies. Network members will be able to return to their organizations and relay shared information to the communities they serve. The network is also designed to support the LaMP and Remedial Action Plan (RAP) process. Currently, the Network has representatives from six federal government agencies, five tribal government agencies, and eleven state and provincial government agencies, and one county government agency. Network membership continues to build. To learn more about the Great Lakes Human Health Network, visit the USEPA website http://www.epa.gov/glnpo/health.html. Contact information and links to related human health topics are provided.

7.7 Actions and Progress

The Great Lakes Water Quality Agreement (GLWQA) states that Lakewide Management Plans shall include "a definition of the threat to human health or aquatic life posed by critical pollutants". Lake Ontario LaMP Stage 1 Report provided an overview of the human health issues for Lake Ontario, especially with respect to the health-related beneficial uses of the Lake (recreational/drinking water quality and restrictions on fish and wildlife consumption). At present the LaMP is in the process of gaining a better understanding of human health impacts by working through the Human Health Network in close partnership with health agencies.

The information contained in this chapter has been compiled based on documents produced up to January 2003. This chapter has not been updated for the LaMP 2004 Report. The LaMP process is a dynamic one and therefore the status will change as progress is made. This chapter will be updated in future LaMP reports as appropriate.

7.8 References

ATSDR (Agency for Toxic Substances and Disease Registry). 1998. Polychlorinated Biphenyls Toxicological Profile (updated draft). Atlanta, Georgia: U.S. Department of Health and Human Services.

Birmingham, B., A. Gilman, D. Grant, J. Salminen, M. Boddington, B. Thorpe, I. Wile, P. Tote, and V. Armstrong. 1989. PCDD/PCDF multimedia exposure analysis for the Canadian population: detailed exposure estimation. Chemosphere 19(1-6):637-642.

Buck, G.M., Mendola, P., Vena, J.E., Sever, L.E., Kostyniak, P., Greizerstein, H., Olson, J., Stephen, F.D. 1999. Paternal Lake Ontario fish consumption and risk of conception delay, New York state angler cohort. Environmental Research 80(2): S13-S18.

Buck, G.M., Sever, L.E., Mendola, P., Zielezny, M., Vena, J.E. 1997. Consumption of contaminated sport fish from Lake Ontario and time-to-pregnancy. American Journal of Epidemiology 146(11): 949-954.

Courval, J.M., De Hoog, J.V., Stein, A.D., Tay, E.M., He, J.P., Paneth, N. 1997. Spot caught fish consumption and conception failure in Michigan anglers. Health Conference '97 Great Lakes and St. Lawrence. Montreal, Quebec, Canada.

Courval, J.M., DeHoog, J.V., Holzman, C.B., Tay, E.M., Fischer, L.J., Humphrey, H.E.B., Paneth, N.S., and Sweeney, A.M. 1996. Fish consumption and other characteristics of reproductive-aged Michigan anglers - a potential population for studying the effects of consumption of Great Lakes fish on reproductive health. Toxicology and Industrial Health 12: 347-359.

Craan, A., Haines, D. 1998. Twenty-Five Years of Surveillance for Contaminants in Human Breast Milk. Archives of Environmental Contamination and Toxicology. 35: 702-710.

Daly, H., Darvill, T., Lonky, E., Reihman, J., Sargent, D. 1996. Behavioral effects of prenatal and adult exposure to toxic chemicals found in Lake Ontario fish. Toxicology and Industrial Health 12: 419-426.

De Rosa, C.T. and Johnson, B.J. 1996. Strategic elements of ATSDR=s Great Lakes human health effects research program. Toxicology and Industrial Health 12: 315-325.

Department of Fisheries and Oceans and Health and Welfare Canada. 1991. Toxic Chemicals in the Great Lakes and Associated Effects. Department of Fisheries and Oceans and Health and Welfare Canada. March 1991.

Environment Canada and U.S. EPA. 1999. State of the Great Lakes 1999. Chicago, Illinois: U.S.EPA.

Environmental Research. 1999. Proceedings of Health Conference >97 - Great Lakes/St. Lawrence.

Fein, G.G., Jacobson, J.L., Jacobson, S.W., Schwartz, P.M., Dowler, J.K. 1984. Prenatal exposure to polychlorinated biphenyls: effects on birth size and gestation age. Journal of Pediatrics 105: 315-320.

Fitzgerald, E.F., S. Hwang, K.A. Brix, B. Bush, J. Quinn, and K. Cook. 1995. Exposure to PCBs from hazardous waste among Mohawk women and infants at Akwesasne. Report for the Agency for Toxic Substances and Disease Registry.

Hanrahan, L.P., C. Falk, H.A. Anderson, L. Draheim, M. S. Kanarek, J. Olson, and the Great Lakes Consortuium. 1999. Serum PCB and DDE levels of frequent Great Lakes sport fish consumers - a first look. Environ. Research 80:S26-S37.

Health Canada, Great Lakes Health Effects Program. 1995. Great Lakes Water and Your Health – A Summary of the Great Lakes Basin Cancer Risk Assessment: A Case-Control Study of Cancers of the Bladder, Colon and Rectum. December, 1995.

Health Canada. 1997. State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes Basin. Minister of Public Works and Government Services Canada. Ottawa.

Health Canada. 1997. State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes basin. Great Lakes Health Effects Program, Ottawa, Canada.

Health Canada, 1998a. Health Canada Drinking Water Guidelines. It=s Your Health. Fact Sheet Series, May 27, 1997.

Health Canada. 1998b. Health-Related Indicators for the Great Lakes Basin Population: Numbers 1-20. Great Lakes Health Effects Program, Ottawa, Canada.

Health Canada. 1998c. Persistent Environmental Contaminants and the Great Lakes Basin Populations: An Exposure Assessment. Great Lakes Health Effects Program, Ottawa, Canada No.: H46-2198-218E.

Health Canada. 1998d. Summary: State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes Basin. Great Lakes Health Effects Program, Ottawa, Canada.

Health Canada. 1998e. The Health and Environment Handbook for Health Professionals. Great Lakes Health Effects Program, Ottawa, Canada No.: H46-2198-211-2E.

Health Canada. 1998f. Waterborne Disease Incidence Study. Technical Report. Great Lakes Health Effects Program, Ottawa, Canada.

Humphrey, H.E.B. 1983a. Population studies of PCBs in Michigan residents. In: PCBs: Human and Environmental Hazards. D'Itri, F.M. and Kamrin, M.A., eds. Ann Arbor, Michigan: Ann Arbor Science Populations; 299-310. (Cited in Kreiss, K. 1985. Studies on populations exposed to polychlorinated biphenyls. Environ Health Perspect 60:193-199).

Humphrey, H.E.B. 1983b. Evaluation of Humans Exposed to Water-borne Chemicals in the Great Lakes. Final Report to the Environmental Protection Agency (Cooperative Agreement CR-807192). Lansing, Michigan: Michigan Department of Public Health, Center for Environmental Health Sciences.

Jacobson, J.L., H.E. Hicks, D.E. Jones, W. Cibulas, and C.T. DeRosa. 1997 (Draft). Public Health Implications of Persistent Toxic Substances in the Great Lakes and St. Lawrence Basin, Atlanta, Georgia. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.

Jacobson, J.L., H.E.B. Humphrey, S.W. Jacobson, S.L. Schantz, M.D. Mullin, and R. Welch. 1989. Determinants of polychlorinated biphenyls (PCBs), polybrominated biphenyls (PBBs), and dichlorodiphenyl trichloroethane (DDT) levels in the sera of young children. Amer J. Publ Health 79:1401-1404.

Kearney, J., DC Cole, and D. Haines. 1995. Report on the Great Lakes Angler Pilot Exposure Assessment Study. Great Lakes Health Effects Program. Env. Health Directorate, Health Canada (Draft).

Lake Erie Lakewide Management Plan 2000, Chapter 6

Newhook, R.C. 1988. Polybrominated biphenyls: multimedia exposure analysis. Contract report to the Department of National Health and Welfare, Ottawa, Canada.

Steward, P., Darvill, T., Lonky, E., Reihman, J., Pagano, J., Bush, B. 1999. Assessment of prenatal exposure of PCBs from maternal consumption of Great Lakes fish. Environmental Research 80(2): 587-596.

Swain, W.R. 1991. Effects of organochlorine chemicals on the reproductive outcome of humans who consumed contaminated Great Lakes fish: an epidemiological consideration. J Toxicol Environ Health 33(4):587-639.

U.S. EPA, 1997a. Mercury Study Report to Congress. Volume IV: An Assessment of Exposure to Mercury in the United States. Office of Air Quality Planning & Standards and Office of Research and Development. EPA-452/R-97-006.

U.S. EPA, 1997b. Mercury Study Report to Congress. Volume V: Health Effects of Mercury and Mercury Compounds, Office of Air Quality Planning and Standards and Office of Research and Development.

U.S. EPA, 1997c. Special Report on Environmental Endocrine Disruption: An Effects Assessment and Analysis Washington, D.C.: USEPA Office of Research and Development. EPA/630/R-96/012.

U.S. EPA, 1997d. Supplement to Endocrine Disruptors Strategy Report. Washington, D.C.: USEPA.

U.S. EPA, 1998a. BEACH Action Plan. EPA/600/R-98/079.

U.S. EPA, 1998b. Clean Water Action Plan. Washington, D.C.: USEPA. EPA-840-R-98-001.

U.S. EPA, 1999a. Office of Drinking Water and Ground Water Home Page, Website at http://www.epa.gov/safewater/about.html , Revised December 2, 1999.

World Health Organization. 1998. Guidelines for safe recreational water environments: Coastal and fresh-water.

CHAPTER 8 PARTNERSHIPS

8.1 Summary

Working together through partnerships has become a priority of the LaMP in its effort to restore and protect Lake Ontario and its biological resources. Whether it is providing input into the International Joint Commission's water level study, developing and coordinating a lakewide cooperative monitoring project, or working with the Great Lakes Fishery Commission, partnership is the key to restoring and protecting Lake Ontario. In addition, the ongoing partnerships within the Areas of Concern, that focus on Remedial Action Plans, are just a few of the many links and working relationships that have been formed between all levels of governments, non-government organizations, citizens, and industry in both the United States and Canada.

8.2 Binational Partnerships

This section summarizes cooperative efforts of governments, organizations, citizens, and industry in the United States and Canada.

8.2.1 Lake Ontario Committee

Partnership is the key to restoring, protecting and conserving the Great Lakes. With the cooperation and collaboration of governments, organizations, citizens and industry on both sides of the border, we are making progress towards understanding and protecting Lake Ontario.

The partnership between the Lake Ontario LaMP and the Great Lakes Fishery Commission's Lake Ontario Committee (LOC) has led to increased information sharing and the development of common aquatic ecosystem goals and objectives to help track progress in restoring the Lake Ontario ecosystem. Where possible, the LaMP and LOC are working together to manage changes occurring in the ecosystem.

The LaMP and LOC conducted a 2003 cooperative monitoring project that included intensive sampling of water, zooplankton and other aquatic organisms to better understand the impact that exotic species are having on the Lake Ontario ecosystem.

The 2003 State of Lake Ontario conference is another example of the value of the LaMP and LOC partnership. Working with other government partners, such as the Department of Fisheries and Oceans (DFO) and the United States Environmental Protection Agency, the LOC and LaMP organized a conference of experts who shared information on existing conditions and emerging trends in Lake Ontario. Cooperative efforts such as this illustrate that partnership is indeed the key to protecting and conserving the Great Lakes!

The Great Lakes Fishery Commission was established in 1955 by the Canadian/U.S. Convention on Great Lakes Fisheries. The Commission coordinates fisheries research, controls the invasive sea lamprey and facilitates cooperative fishery management among the state, provincial, tribal, and federal management agencies.

The LOC has representatives from the New York State Department of Environmental Conservation (NYSDEC) and the Ontario Ministry of Natural Resources (OMNR), organizations with the authority over fish management issues in Lake Ontario. Their responsibilities include setting allowable catch limits, stocking fish and managing the recovery of native fish populations.

Each year the LOC and its partners conduct surveys using net trawls and other techniques to estimate populations of alewives, smelt, lamprey, lake trout and other fish. This information is carefully considered in making management decisions aimed at maintaining and where necessary, restoring a healthy fishery. The results of these studies are reported out each spring at the LOC's annual meeting. For more information, see http://www.glfc.org/.

8.2.2 Lake Ontario-St. Lawrence Water Level Study

The International Lake Ontario-St. Lawrence River Study Board was established by the International Joint Commission (IJC) in December 2000 and is coordinating a five-year study to assess and evaluate the current rules for the water level regulation of Lake Ontario, and the outflow from Lake Ontario through to the St. Lawrence River.

The IJC formed the Study Board to evaluate the impacts of changing water levels on all affected interests including environmental factors, shore erosion, flood damages, recreational boating and tourism. A binational team of experts from government, Native communities, academia, and interest groups, has been assembled to examine the geographic, scientific, economic and community concerns within the Lake Ontario - St. Lawrence River system.

Extensive public consultation is a major component of the water level study, and is provided through a Public Interest Advisory Group (PIAG). After completion of the five-year study, the Board will, based upon the results of the Study and consultations with the public, deliver recommendations to the IJC for possible amendments or additions to the present criteria and the recommended regulation plan, that gives effect to those criteria.

The Lake Ontario LaMP has been participating in the IJC study by attending round table discussions and sessions of both the Public Interest Advisory Group and the Environmental Technical Work Group to offer comments on how to include LaMP goals and objectives when considering the effects of changing water levels on the ecosystem of Lake Ontario.

For additional information on the IJC water level study, go to www.ijc.org

The Boundary Waters Treaty, between Canada and the United States, established the **International Joint Commission** in 1909. This six person Commission has three members appointed by the President of the United States, with the advice and approval of the Senate, and three who are appointed by the Governor in Council of Canada, on the advice of the Prime Minister. The Commissioners must follow the Treaty and act impartially as they review problems, resolve disputes and decide on issues related to mutual boundary waters throughout Canada.

8.2.3 Cooperative Monitoring

In 2003, the Lake Ontario LaMP and the Lake Ontario Committee coordinated a number of monitoring efforts to help understand how changes to the ecosystem have altered the flow of nutrients and contaminants through the aquatic foodweb. Building on routine long term programs and adding new components where needed, water sediment, and lower foodweb organisms were collected across the lake. This binational effort (partnership) will promote improved communication and data sharing amongst monitoring programs and staff will pull together key researchers to interpret the data and to effectively communicate the "big picture" to stakeholders. The 2003 year of intensive lake sampling was the first step in developing a long term binational monitoring strategy that meets the needs of both water quality and fishery managers. (See Sections 3.4 and 3.5 for more details.)

8.2.4 Remedial Action Plans

The International Joint Commission has identified seven "Areas of Concern" in the Lake Ontario basin based on their potential to be significant sources of critical pollutants to the lake. These are: Eighteen Mile Creek, Rochester Embayment, and Oswego River in New York State; and Hamilton Harbour, Toronto and Region, Port Hope and Bay of Quinte in Ontario. In addition, both of the Lake's connecting channels, the St. Lawrence River and the Niagara River (for which separate RAPs have been developed on the Canadian and U.S. sides) have also been designated as "Areas of Concern." RAPs concentrate on identifying and addressing local environmental problems. The successful implementation of RAPs in these AOCs is a key component of the overall LaMP strategy.

The RAP process is a continuing and iterative process that: identifies environmental problems (Impaired Beneficial Uses), as well as the pollutants causing the problems and their sources; recommends remedial activities to restore beneficial uses; conducts and influences remedial activities to achieve an ecosystem approach; and documents progress towards the restoration and protection of beneficial uses in the AOCs.

All New York RAPs have completed and certified to USEPA, as part of the State's 1997 Water Quality Plan, their problem definition and action plan reports. RAP Remedial Advisory committees continue to meet on a regular basis to focus efforts on the implementation of priority remedial measures and provide periodic status reports. Funding opportunities in New York State provide stakeholders a means to implement selected projects. Such support may include financing from the New York State 1996 Clean Water/Clean Air Environmental Bond Act, the NYS Environmental Protection Fund, the Great Lakes Protection Fund, and USEPA/other federal grant agencies.

Similarly, the Ontario RAPs have all completed their problem definition and action plan reports, and implementation is on-going through various funding sources. A summary of progress on the Lake Ontario RAPs is presented in Chapter 11.

8.3 Public Partnerships

This section will be completed as information becomes available.

8.4 Actions and Progress

The information contained in this chapter has been compiled based on past documents and was updated as of December 2003. The LaMP process is a dynamic one and therefore the status will change as progress is made. This chapter will be updated in future LaMP reports as appropriate.

8.5 References

Great Lakes Fishery Commission, Fish Community Objectives for Lake Ontario, Special Publication 99-1, August 1999

International Joint Commission, United States and Canada, Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987.

CHAPTER 9 PUBLIC INVOLVEMENT AND COMMUNICATION

9.1 Summary

This chapter discusses the Public Involvement and Communication component of the Lake Ontario LaMP. It highlights the goals for public involvement and describes ways in which the LaMP implements these goals. The chapter focuses on the activities that have been conducted over the past ten years and lists contacts for further information.

9.2 Public Involvement Goals

The goals of the public involvement program, as set out in the Lake Ontario LaMP Stage 1 Report, are to: (1) increase public understanding and awareness of LaMP planning and activities; (2) provide opportunities for meaningful public consultation; (3) promote environmental stewardship actions; and (4) build partnerships with others who are working to preserve and protect Lake Ontario.

9.3 Meeting Public Involvement Goals

The Lake Ontario LaMP provides a variety of opportunities for people to keep informed about the LaMP projects and progress, and to provide their input and ideas. Public information and participation are encouraged. The LaMP provides information to the general public through the media, publications, the LaMP websites, and public meetings. Individuals can add their names to the LaMP mailing list for more regular contact.

The LaMP continues to reach out to many organizations each year, using displays and brochures to showcase its basin-wide activities. Public Involvement and Outreach activities constantly evolve based on the LaMP implementation activities going on around the lake. We hope that the outreach improvements presented here, enhance our efforts to reach out and we look forward to future changes and improvements.

The LaMP uses a variety of methods for communicating with and engaging the public. Some actions and initiatives are joint efforts; others are conducted by individual members.

9.3.1 Public Meetings

Beginning in 1996, the Lake Ontario LaMP held annual public meetings in conjunction with the Niagara River Toxics Management Plan to provide an update on activities throughout the year. These meetings alternated from Niagara Falls, Ontario to Niagara Falls, New York.

In 2004 the LaMP adopted a new two-phase approach for conducting public meetings. This new approach calls for a LaMP Overview meeting every three years, held in conjunction with the Niagara River Toxics Management Plan, to present a comprehensive overview of LaMP activities and status of the lake ecosystem's health. These meetings will continue to be held alternately in Niagara Falls, Ontario and Niagara Falls, New York.

The second phase includes theme-specific public meetings held in locations around the Lake Ontario basin. These meetings are held in an effort to reach a broader audience and involve more people in the protection and restoration of Lake Ontario. Each meeting not only provides an opportunity to report on specific activities focused on a particular theme, but allows the LaMP to engage the public in a dialogue about specific topics of interest (e.g., watershed stewardship, non-point source pollution control, and coastal wetland protection).

9.3.2 Publications

The Lake Ontario LaMP keeps partner agencies and the public informed through two key publications: (1) the biennial *Status*, and (2) the annual *Update*. A number of historical publications are also available for reference.

Stage 1 Report: The Stage 1 Report was released in May 1998 to meet the requirement under Annex 3 of the binational Great Lakes Water Quality Agreement (GLWQA) to report to the International Joint Commission (IJC) in stages. The first stage was described as the "Problem Definition" phase. A draft report was released in 1997 for public comment. The consultation period included Open Houses in both Canada and the United States, where agency staff made presentations and were available to answer questions. After adjustments were made to the report, based on input from the public, the report was transmitted to the IJC.

Biennial Report: The biennial report, also required under Annex 3 of the GLWQA, provides detailed information on the LaMP including: background, beneficial use impairments, sources, and loadings of critical pollutants, and ecosystem goals, objectives and indicators. In addition, it reviews habitat restoration, human health considerations, and emerging issues. The full five-year LaMP workplan is included in this document.

The LaMP reporting schedule is mandated by the Great Lakes Binational Executive Committee (BEC), which is the group of senior government representatives to the GLWQA. In June 1999, the BEC implemented a new biennial reporting process and cycle for the LaMPs. The intent was to accelerate time frames, to emphasize action over planning and to streamline the review and approval process for the LaMPs. The date for the biennial release of the LaMP reports was set by the BEC and linked to Earth Week. The first progress report for the Lake Ontario LaMP was released April 2002.

Beginning in 2004, the BEC requested that all LaMPs use a "virtual binder" format for reporting all technical and workplan information. The Lake Ontario LaMP adopted the new format and changed the title of the report to *LaMP Status {year}*.

The *LaMP Status 2004* amalgamated existing information from previous LaMP reports, and provides some updates to longer-term, on-going activities. The new format used the Stage 1 report of 1998 as its base, along with other reports which were prepared up to 2003.

The new binder is considered a living document for partner-agency use, and will be updated regularly and submitted to the International Joint Commission every two years. Copies of the *LaMP Status 2004* were distributed to agency partners and the IJC on Earth Day, April 22, 2004.

Highlights Brochure: In 2002, the LaMP produced a brochure as a companion to the biennial report. The format was discontinued when the format of the biennial report changed.

Brochure: The LaMP brochure is a full colour tri-fold publication, produced in 1999 as a way of providing a general description of the Plan and to encourage public participation.

Updates: The Lake Ontario LaMP *Update* is a newsletter-style publication that provides highlights on each year's activities to the public. The first *Update* was released in 1999, providing information on projects and progress. *Update* was mailed to contacts on the mailing list, distributed at the annual Lake Ontario LaMP/NRTMP public meeting, and posted on the website. Editions were also distributed in 2000, 2001, and 2003. *Updates* were to be produced semi-annually in years when the biennial report was

not produced. When the format of the biennial report changed, and the *Highlights* brochure was discontinued, the LaMP decided to issue *Updates* annually.

9.3.3 Websites

In 1998, the Four Parties created a binational Lake Ontario LaMP website, accessible from either the US Environmental Protection Agency's website or from Environment Canada's site. Since then, the site has been moved to a binational site - a collaborative website which includes information on programs that are binational in nature. The LaMP site includes information on Lake Ontario and the LaMP, and provides access to LaMP publications. An on-line "postcard" has been added for those who want to join the mailing list. The site can be accessed at www.binational.net.

LaMP reports continue to be available through the US Environmental Protection Agency's Great Lakes Information Network at www.epa.gov/glnpo/lakeont. Both of these websites can also be accessed from the LaMP page on the Ontario Ministry of the Environment's website: www.ene.gov.on.ca .

9.3.4 Media events

There were no media events in 2004/ 2005.

9.3.5 Special projects

a. Stewardship Poster

From time to time individual LaMP partners identify their own particular communications needs and work alone or with other partner agencies to develop communications products and initiatives.

In 2003, the LaMP enhanced its focus on stewardship, encouraging people to be responsible for actions that might have an effect on the health of the lake. To support that goal, on the Canadian side of the basin, the governments of Canada and Ontario produced a Lake Ontario poster targeted toward Grade 7 and 8 students and teachers.

The front of the poster boasts an attractive graphic of the Canadian side of the Lake Ontario basin. The back of the poster features nine panels with tips on how students (and their families) can take action to help protect the lake: in the home, in the yard, at the cottage, on the farm, on the street, and in the community. The poster provides a list of websites for more information on environmental protection.

The posters were distributed to all 1,500 schools and 400 libraries on the Canadian side of the basin with the intention that teachers could use these resources in their lesson plans. The poster can be found on Environment Canada's website www.on.ec.gc.ca/pollution/fpd/fsheets/intro-e.html (English); www.on.ec.gc.ca/pollution/fpd/fsheets/intro-f.html (French).

b. Ecogallery

Building on the theme of stewardship, the Ontario Ministry of the Environment led an initiative to develop a temporary exhibit on the Lake Ontario ecosystem at the Marine Museum of the Great Lakes in Kingston, Ontario. The exhibit was created through an innovative partnership between the Ministry of the Environment, the Marine Museum, and the Community Foundation of Greater Kingston, and with the cooperation of Environment Canada. The two-year exhibit, opened Earth Day, April 22, 2004.
The displays review the environmental history of Lake Ontario, outline the Lake Ontario LaMP, and promote individual actions in protecting the environment. While the exhibit appeals to a broad audience,

the primary focus is on young people, and includes a strong interactive component. This exhibit represents a unique, creative partnership between the LaMP and local community groups that are committed to environmental education and stewardship.

c. Enlightening Educators on LaMPs

In 2002-2003, the New York Sea Grant developed a series of training kits for educators in coastal communities bordering both Lake Erie and Lake Ontario. Referred to as "Enlightening Educators on LaMPs," the project provides information about the problems facing the Great Lakes. The goal is to help increase educator awareness of what students can do to help restore the ecological health of the ecosystem, and support the priorities of the LaMP. The project involved multiple educational outreach activities including the development of a Lake Erie and Lake Ontario LaMP educational compendium; a CD-ROM presentation on LaMPs for teachers; and a series of training workshops for teachers, non-formal educators, and stakeholders.
The package incorporated Lake Ontario LaMP public information materials.

9.3.6 Speaking Engagements

The LaMP reaches out to individuals and groups that are already involved and working to conserve and restore Lake Ontario, either by attending their meetings, or inviting them to speak at LaMP meetings, or by mailing information to these groups or their members.

9.3.7 LaMP Display

The LaMP has two displays, a 10-foot "pop-up" and a smaller table-top display unit. The display is used at symposiums, fairs, forums and other events throughout the Lake Ontario basin as a means of informing the public about the LaMP.

9.3.8 Information Distribution

The LaMP maintains a mailing network of some 1,500 Canadian and US contacts and responds to requests for input and comments on Lake Ontario LaMP documents.

Since the release of the LaMP Stage 1 Report, the LaMP has been updating the mailing list and looking at additional ways to reach the public.

9.4 Information Connections

If you would like to receive information regarding the Lake Ontario LaMP, please contact one of the names below.

In Canada:

Ms. Marlene O'Brien
Environment Canada
867 Lakeshore Road
Burlington, Ontario
L7R 4A6
Phone: (905) 336-4552
Fax: (905) 336-6272

In the United States:

Mr. Mike Basile
US Environmental Protection Agency
Western New York Public Information Office
186 Exchange St.
Buffalo, N.Y.
Phone: (716) 551-4410
Fax: (716) 551-4416
E-mail: Basile.Michael@epa.gov

9.5 Actions and Progress

In June 2005 the LaMP hosted a public information session at the Marine Museum of the Great Lakes in Kingston, Ontario. The meeting was timed to coincide with the International Joint Commission's (IJC) Biennial Meeting. The theme topic of the meeting was stewardship. A presentation on the LaMP was followed by presentations from the {Canadian} Centre for Sustainable Watersheds and the {New York} Finger Lakes - Lake Ontario Watershed Protection Alliance to share their approaches to stewardship. An opportunity for public discussion followed the presentations. The LaMP will plan future public meetings for other areas around the basin.

In 2006 the LaMP will host a joint public meeting with the Niagara River Toxics Management Plan. The meeting will be held October 26, 2006 in Niagara Falls, New York.

The LaMP continues to pursue the goal of participating at other agencies' meetings and conferences. In 2004, the LaMP had material available at the SOLEC Conference in Toronto and the plan is to participate in a like fashion at SOLEC 2006 to be held in Milwaukee, Wisconsin in November.

The LaMP also regularly participates at the International Joint Commission Biennial Meeting. In June 2005, materials were made available in the display area at Queen's University in Kingston, Ontario. The LaMP intends to be at the 2007 meeting which will be held in the United States.

The LaMP will continue to seek opportunities to partner with other organizations around the Lake Ontario basin in order to share information and expand its outreach activities.

9.6 References

No references were identified for inclusion in this section.

CHAPTER 10 SIGNIFICANT ONGOING AND EMERGING ISSUES

10.1 Summary

This section provides insight into some of the significant ongoing and emerging issues facing Lake Ontario including: invasive species; fish and wildlife disease issues; Type E botulism; emerging chemicals of concern; lake levels; rapid urbanization and toxin-producing planktonic blooms. Some of the issues are ongoing, and have been the subject of much research and reporting, while others are newer issues that may present challenges for the Lake Ontario LaMP and lake managers in future. The material presented is based on information that existed as of October 2005.

10.2 Significant Ongoing Issues

This section provides a brief description of significant ongoing lakewide issues and provides an update on their status and progress.

10.2.1 Protection and Restoration of Native Species

Lake Trout

One of the key restoration components of the lake trout indicator (see Chapter 3) is reducing mortality so that the adult population can reach a level promoting self-sustenance. Lake trout are preyed upon by sea lamprey and presumably their eggs are consumed by round goby. The abundance of sea lamprey is controlled by the US Fish and Wildlife Service and Canada's Department of Fisheries and Oceans and the entire control program is managed by the Great Lakes Fishery Commission (GLFC). Currently this program is meeting its control targets and sea lamprey are not presently considered a major limiting factor in lake trout restoration. But, sea lamprey control is a perpetual source of mortality and is a significant annual cost to both federal governments directly and to provincial, state and federal governments indirectly due to loss of recreationally important fish.

American Eel

American eel are an important component of the biodiversity of Lake Ontario and the St. Lawrence River and were once a very abundant top predator throughout much of these waters. The numbers of eels migrating upstream of the power dam at Cornwall and into Lake Ontario have declined so precipitously that American eels may be extirpated from this part of their range. This near shore top predator remains in Lake Ontario for up to 14 years and then returns to spawn in the Sargasso Sea. The Lake Ontario portion of the population is composed entirely of female fish and they are among the largest and most fecund. The American eel is doing so poorly in its entire range that efforts are underway in both Canada and the US to provide additional protection for this species and aid in their rehabilitation.

The Lake Ontario LaMP agencies will continue to work with stakeholders such as the hydro-electric power companies that operate dams on the St. Lawrence River to restore abundance of this important species in the upper St. Lawrence River and Lake Ontario. Some examples of recent actions include, closure of the commercial fishery for eels in Ontario, reductions to fishing in Quebec, eel stocking in Lake Champlain, decision analysis on alternative approaches to encourage safe eel migration in the St. Lawrence River, and research projects in both Canada and the U.S. into improving our ability to manage eel.

10.2.2 Invasive Species

An invasive species is defined as a species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species in the Great Lakes may occur in riparian areas, tributaries, and in nearshore and open waters. Impacts of invasive species include environmental (predation, parasitism, competition, introduction of new pathogens, genetic, and habitat alterations), economic (industrial water users, municipal water supplies, nuclear power plants, commercial and recreational fishing, and other water sports), and public health concerns (pathogens).

Since the early 1800s at least 162 new organisms have been introduced into the Great Lakes (Ricciardi 2001, Mills et al. 1993). Approximately 10 per cent of these species have had demonstrably substantial impacts on the Great Lakes (Mills et al. 1993). Methods of introduction include deliberate release, unintentional release (i.e. aquarium, escape from cultivation or aquaculture, bait bucket, and with stocked fish), from shipping activities, canals, and railroads and highways. Shipping activities followed by unintentional release have been the major vectors of introduction into the Great Lakes (Mills et al. 1993).

It is difficult to predict some of the more subtle interactions that might develop between newly introduced non-native species, naturalized non-native species, and native species. This evaluation is further complicated by other chemical and physical changes that are taking place in the basin concurrently. It is clear, however, that non-native species have had a significant impact on the Lake Ontario ecosystem and continue to do so. The Lake Ontario ecosystem has experienced several significant impacts by non-native species, some of which are discussed in Chapter 2 and Chapter 4, section 4.4.6, (degradation of fish populations). Some of the key invasive species impacting the Lake Ontario ecosystem are highlighted below (also see section 4.4.3). Other non-native species that are causing or are likely to cause economic or environmental harm in Lake Ontario are listed in Table 10.1.

Table 10.1 Other non native species threatening Lake Ontario ecosystem, their origin, date and location of first sighting, mechanism of introduction into the Great Lakes, and their current or potential impacts. (Dermot and Legner 2002, Mills et al. 1993, Owens et al. 1998, Ricciardi 2001, Witt et al. 1997, and Zaranko et al. 1997)

Common Name & Species	Type	Origin	Date and Location of First Sighting	Mechanism	Impacts
Rudd Scardinius erythrophthalmus	fish	Eurasia	1989 - Lake Ontario	Bait bucket release	Compete w/native species
Blueback herring Alosa aestivalis	fish	Atlantic N. Amer.	1995 - Lake Ontario	Canals	Impede recovery of native fishes
Eurasian ruffe Gymnocephalus cernuus	fish	Eurasia	1986 - St. Louis River, Lake Superior[1]	Shipping (ballast water)	Compete w/native species
New Zealand mud snail Potamopyrgus antipodarum	benthic inverte-brate	New Zealand	1991 - SW Lake Ontario	Shipping (ballast water)	Clog water intakes, compete w/native species
Amphipod Echinogammarus ischnus	benthic inverte-brate	Black Sea	1995 - Detroit River[2]	Shipping (ballast water)	Displacing native species
Eurasian watermilfoil Myriophyllum spicatum	plant	Eurasia	1952 - Lake Erie 1960 - S. Lake Ontario	Release (aquarium, accidental)	Clogs waterways, compete w/native species
European frogbit Hydrocharis morsus-ranae	plant	Eurasia	1972 - Lake Ontario	Release (Aquarium, Deliberate), Shipping (Fouling)	Clogs waterways, compete w/native species

Table 10.1 Other non native species threatening Lake Ontario ecosystem, their origin, date and location of first sighting, mechanism of introduction into the Great Lakes, and their current or potential impacts. (Dermot and Legner 2002, Mills et al. 1993, Owens et al. 1998, Ricciardi 2001, Witt et al. 1997, and Zaranko et al. 1997)

Common Name & Species	Type	Origin	Date and Location of First Sighting	Mechanism	Impacts
Water chestnut Trapa natans	plant	Eurasia	<1959 - Lake Ontario tributaries	Release (aquarium, accidental)	Clogs waterways, compete w/native species
Filamentous bacteria *Thioploca ingrica*	bacteria	Europe Japan S. Amer.	1999 - Eastern Lake Ontario	Unknown	May reduce energy flow from benthic to pelagic communities

1. Not presently in Lake Ontario.
2. Has spread downstream into SW Lake Ontario.

Zebra and Quagga Mussels

Zebra mussels (*Driessena polymorpha*) were first discovered in Lakes St. Clair and Erie in 1988. Their introduction into the Great Lakes likely occurred in 1985 or 1986 when one or more transoceanic ships from Europe discharged ballast water into Lake St. Clair. Quagga mussels (*D. bugensis*) were first discovered in the early 1990s in Lakes Ontario and Erie. Both species have since proliferated throughout the Great Lakes and beyond by natural spread of their planktonic veliger larvae, transported as microscopic veligers in water pockets on boats or in aquatic weeds attached to boat trailers, and as adults attached to boat hulls. Maximum out-of-water survival is about 10 days for adults and three days for newly settled juveniles.

The zebra and quagga mussels have impacted the Great Lakes both economically and ecologically. It is estimated that they cause $500 million per year in economic impacts to tourism, electric power plants, public water supplies, commercial fishing, sport fishing, boating, and transport industries (Pimentel 2005). Zebra and quagga mussel infestations cause pronounced ecological changes in the Great Lakes and major rivers of the central United States. Their rapid reproduction in combination with their high consumption of microscopic plants and animals affects the aquatic food web and places valuable commercial and sport fisheries at risk. These two species of mussels filter water to feed on microscopic phytoplankton and other organic material, thereby reducing the amount of food available to other filter feeding organisms. The filtering action of the mussels has contributed to the dramatic improvements in water clarity. It is anticipated that reductions in phytoplankton densities due to zebra and quagga mussel filtering may result in smaller zooplankton populations. Zebra and quagga mussels cover large areas of the bottom of Lake Ontario. Their presence on the bottom surface of the lake has dramatically altered the habitat making it less suitable for some native invertebrates. Populations of many native benthic organisms have generally declined, most notably the burrowing amphipod *Diporeia*. The reduction of *Diporeia* is expected to have a significant impact on fish species that depend on it for their growth and survival.

Fishhook and Spiny Waterfleas

The spiny waterflea (*Bythotrephes longimanus*) was first introduced in Lake Huron in 1984 and found in Lake Ontario by 1985. The fishhook waterflea (*Cercopagis pengoi*) was first found in Lake Ontario in 1998. These two related zooplankton species also arrived in transoceanic ships' ballast from Eurasia. The first noticeable impact of these species was on recreational fishing. The tail spines of both fishhook and spiny waterfleas hook on fishing lines, fouling fishing gear. The spiny waterflea has never been very common in Lake Ontario, whereas the fishhook waterflea is found throughout the lake. Both the fishhook

flea and the spiny water flea are large zooplankton that feed on smaller native zooplankton. There is evidence that the fishhook waterflea predation on small zooplankton has caused decreased juvenile copepod production and changed their vertical distribution. There is evidence that small young-of-the-year fish are not able to feed on these waterfleas due to their long tail spines, but larger planktivorous fish do eat them. The long-term impacts to the fish community are unknown.

Round Goby

The round goby (*Neogobius melanostomus*), first discovered in the St. Clair River in 1990, has spread rapidly throughout the Great Lakes. It was first sighted in Lake Ontario in 1998 and is now found in many areas of the lake. This bottom dwelling fish is native to Eurasia, and was introduced through the release of ballast water of transoceanic ships from Europe. The round goby has established itself in the nearshore and is colonizing offshore waters to depths greater than 120 m (394 ft.) and in association with quagga mussels. This benthic fish feeds primarily on *Dreissena spp.* but early life stages compete with other young fish for zooplankton, veligers, and other small food items. The round goby can displace native bottom dwelling fish such as sculpin. They will feed on fish eggs and young fish, take over optimal habitat, spawn multiple times in a season, and survive in poor quality water, thus giving them a competitive edge over our native fish. Research on Lake Erie suggests that round gobies are important fish to the upper food web as they redirect energy tied up in *Dreissena* to fish that eat goby. There is the potential for redistribution of contaminants to the pelagic fishes via round gobies. Their spread into some areas of Lakes Erie and Ontario has been followed by outbreaks of botulism in fish and birds, leading to speculation that round goby may be playing a role in these outbreaks.

Asian Carps

There are four species of Asian carp introduced into North America which pose a potential threat to the ecology of the Great Lakes. These are commonly referred to as grass carp, bighead carp, silver carp and black carp. Grass carp have been widely introduced to control aquatic vegetation and are reproducing naturally in many areas of the United States (Cudmore and Mandrak 2004). Bighead and silver carps were brought into aquaculture facilities as a food fish and for controlling plankton blooms. These two species have escaped into nearby natural waters, and are currently reproducing throughout most of the Mississippi River basin (Mandrak and Cudmore 2004). Black carp are used in aquaculture facilities for controlling snails and a few individuals have escaped into natural waters. Natural reproduction of this species has not yet been confirmed (Mandrak and Cudmore 2004).

In the Great Lakes basin, only a few individuals of grass and bighead carps have been reported. Grass carp has been collected from the Lake Ontario watershed and bighead carp have been collected from Lake Erie (Mandrak and Cudmore 2004, Morrison et al. 2004). A bighead carp was also found in a fountain on University Avenue in Toronto in 1991 (Mandrak and Cudmore 2004). To date, there is no evidence of reproduction in the lower Great Lakes and it is suspected that these individuals originated from live food fish markets in the Greater Toronto Area. Only grass and bighead carps are recorded from the live food fish markets. However, a silver carp (not listed on imported records from the Canadian Food Inspection Agency) was identified in a tank in one of these markets in 2004 (Mandrak and Cudmore 2004). Silver and bighead carp have been collected in the Illinois River which is connected with Lake Michigan via the Chicago Sanitary and Ship Canal. An electrical barrier system is being installed in the canal in an attempt to block this path into the Great Lakes; although concern regarding potential egg drift has been raised.

Known ecological risks of Asian carps from their potential rapid range expansion and population increase include habitat alteration and disruption of the Great Lakes food web at most trophic levels (Mandrak and Cudmore 2004). Grass carp can eliminate vast areas of aquatic plants that are important as fish food and spawning and nursery habitats, which could potentially reduce recruitment and abundance of native

fishes. Bighead and silver carps already make up more than 80 per cent of the biomass in many areas in the Mississippi River basin, out competing native fishes for food and space (Mandrak and Cudmore 2004). Silver carp have the ability to jump up to 10 feet (3 m) out of the water, a behavior which has resulted in injuries to boaters. Black carp could reduce abundance and diversity of already rare mollusks.

Current Activities/Legislation to prevent further introductions

The Lake Ontario LaMP partner agencies are working with many groups on international, national and local-level invasive species management activities and share information and new techniques for fighting invasive species. Prevention, detection and monitoring, and control and management are key components of many programs. Preventing introductions and further spread of invasive species is occurring through legislative and regulatory actions, and public outreach and education.

Ballast Water Control

The international community recognized that uncontrolled discharge of ballast water and sediment has been the leading method of transfer of harmful aquatic organisms and pathogens into the Great Lakes. The United Nations International Maritime Organization (IMO) has been addressing the issue since 1988, and adopted voluntary guidelines in 1991 to help prevent further introductions. In response to national concern regarding aquatic invasive species, the National Invasive Species Act of 1996 (NISA) was enacted within the United States which reauthorized and amended the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). NISA required the Coast Guard to establish national voluntary ballast water management guidelines. If the guidelines were deemed inadequate, NISA directed the Coast Guard to convert them into a mandatory national program. Voluntary ballast water management was initiated in 1998. However, the rate of compliance was found to be inadequate, and the voluntary program became mandatory on July 28, 2004. In Canada, voluntary ballast water control measures were established in Transport Canada Publication TP 13617, Guidelines for the Control of Ballast Water Discharge from Ships in Waters under Canadian Jurisdiction (TP 13617), in 2001 as part of the Canada Shipping Act.

It is expected that Canadian Regulations to control ballast water will be promulgated in 2006. In June 2005, the *Ballast Water Control Management Regulations* were posted in the Canada Gazette (Vol. 139, No. 24 — June 11, 20) for a 75 day public comment period. The proposed Regulations are made pursuant to the Canada Shipping Act (S. 657.1). The purpose of the proposed Regulations is to require ships to manage ballast water in such a manner as to reduce the potential for the release of invasive (exotic) species in Canadian waters. The regulations will make several of the existing voluntary measures outlined in TP 13617 mandatory for all ships designed to carry ballast water that enter waters under Canadian jurisdiction. The proposed Regulations are harmonized as much as possible with the United States' rule for ballast water management and with the International Convention for the Control and Management of Ships' Ballast Water and Sediments.

Neither the international convention, proposed Canadian Regulations or U.S. legislation provide specific requirements or procedures that address ships that have no ballast on board (NOBOB). Both Transport Canada and the US Coast Guard are both jointly working on a solution to the NOBOB issue. Both countries' regulations require open ocean ballast water exchange for all vessels entering the US or Canada from outside the Exclusive Economic Zone (EEZ), but not for vessels operating inside the EEZ. The regulations also allow for alternative treatment methods, and require ballast water management plans and record books for each vessel. The Lake Ontario LaMP will continue to follow the development of ballast water control.

Prohibition of the Sale of Live Fish

The province of Ontario has recently passed legislation prohibiting the possession and sale of live individuals of the four Asian carp species, snakeheads and the round and tubenose goby. Therefore, it is illegal for these species to be sold in the live food fish, aquarium or bait trades. New York has a statewide ban on the possession of three live species of Asian carp (Bighead, Silver and Black) and all species of live snakeheads, and their eggs, with an exemption for allowing live bighead carp for retail sale purposes in limited sections of New York City. Although bighead carp may be maintained live for retail purposes, they must be killed at the time of sale to prevent further transport and distribution within the state. The live food fish markets do pose a potential source for release of live invasive species, despite prohibitions for certain listed species. Species not included in the prohibitions include swamp eel and marbled goby.

Education and Outreach

The LaMP agencies, other governmental agencies and NGOs are all involved with various education and outreach activities. Posters and brochures, watch cards and stickers have been developed to help identify and prevent the unintentional introduction or spread of invasive species. "Habitattitude" is a national initiative in the US developed by the Aquatic Nuisance Species Task Force and its partner organizations educating aquarium hobbyists, backyard pond owners and water gardeners about protecting the environment from unintentional introductions (http://www.habitattitude.net). Aquatic Invasive Species Hazard Analysis and Critical Control Point (AIS-HACCP) is a system to reduce or prevent the spread of unwanted species into new water bodies. This training is targeted for baitfish and aquaculture operators, fish managers and researchers, and enforcement officers. AIS-HACCP training is available through various agencies including the US Fish and Wildlife Service and Sea Grant.

In 1992 the Ontario Federation of Anglers and Hunters, in partnership with the Ontario Ministry of Natural Resources, established The Invading Species Awareness Program (http://www.invadingspecies.com/). The objectives of this program are to raise public awareness of invasive species and encourage their participation in preventing their spread; monitor and track the spread of invading species in Ontario waters through citizen reports to the Invading Species Hotline and the Invading Species Watch program; and conduct research on the impacts and control of invasive species.

The Ontario Ministry of Natural Resources also provides publicly accessible information on their website (http://www.mnr.gov.on.ca/MNR/fishing/threat.html) to inform and assist the public in identifying and taking proper action to help prevent spread of invasive species.

Other Initiatives

Within Canada the federal government has initiated the development of a national aquatic invasive species program consistent with the *Canadian Action Plan to Address the Threat of Aquatic Invasive Species* approved by the Canadian Council of Fisheries and Aquaculture Ministers in September 2004. Activities will support the highest priority areas: prevention, early detection, and rapid response. This initiative will include the Lake Ontario and Great Lakes basins.

10.2.3 Lake Ontario Water Levels

Artificial control of the Lake Ontario water levels threatens the natural ecosystem through the alteration of wetland plant communities and habitat quality.

The LaMP has determined that fish and wildlife habitat are impaired on a lakewide scale due to the artificial management of lake levels. Since 1960, Lake Ontario's water level has been regulated based on criteria set by the IJC in 1956 (available at www.losl.org). Water levels are determined by the IJC under a formula that seeks to balance a number of interests and are controlled by a series of dams on the St. Lawrence River (IJC Lake Ontario Regulation 1958D (see Section 4.4.3)). Many biologists believe that water level regulation has had serious and lasting impacts on Lake Ontario's natural resources including fish and wildlife (particularly shorebirds and spawning fish), shoreline habitat and dune barrier systems, and the numerous wetland complexes that line the shoreline. The full range of these impacts, however, has never been documented.

The artificial control of lake level affects water level changes in coastal wetlands and dune areas. This change can be a threat to natural ecosystems through the alteration of wetland plant communities and habitat quality. In addition, throughout Lake Ontario, water level regulation is a major stress on remaining wetlands. More variable water levels can lead to greater diversity of wetland plant communities and improve fish and wildlife habitat.

In 2000, the International Joint Commission initiated the International Lake Ontario - St. Lawrence River Study to examine the effects of water level and flow variations on all users and interest groups and determine if better regulation were possible at the existing structures controlling Lake Ontario outflows. A five-year study was undertaken by the International Lake Ontario - St. Lawrence River Study Board (Study Board) to identify and evaluate how changes to current Lake Ontario regulation will affect the interests of various users, while ensuring that any suggested changes are consistent with relevant treaties and agreements between Canada and the United States. The Study Board is in the final year of this comprehensive study. The Study Team engaged by the IJC is a binational group of diverse experts from government, academia, native communities, and interest groups representing the geographical, scientific and community concerns of the Lake Ontario - St. Lawrence River system (see Section 8.2.2 Lake Ontario - St. Lawrence River Study).

The Study Board evaluated the impacts of changing water levels on shore-line communities, domestic and industrial water users, commercial navigation, hydropower production, the environment, and recreational boating and tourism. The evaluation also took into account the forecasted effects of climate change. From this work the Study Board developed three candidate Water Level Plans which best met the Study's Guiding Principles and which will be presented through public consultation for consideration. These plans are: Plan A - a balanced economic plan; Plan B - a balanced environmental plan; and Plan C - a plan with blended economic and environmental benefits.

In response to the three proposed Plans, the Lake Ontario LaMP has communicated to the Study Board US and Canadian Co-Directors that "the restoration of more natural ranges and long term patterns of lake level fluctuations is one of the LaMP's priorities and is perhaps the single greatest opportunity to truly restore more natural functioning to Lake Ontario's ecosystem. For this reason the "Environmentally Balanced" Plan B (as summarized in the LOSL Study's June 2005 Ripple Effects public fact sheet) is the most reflective of a management approach that would support the LaMP's goal of restoring more natural hydrologic conditions to coastal wetlands.

The Lake Ontario LaMP also stated to the Study Board Co-Directors that the selection of a final plan should be viewed as the first step in the process of improving water level management for Lake Ontario. The Study Board should recommend that the IJC consider using an adaptive management approach, coupled with a strong monitoring program and wetland conservation actions, to ensure that the selected plan is achieving its desired environmental goals.

The LaMP will continue to work with the IJC to restore, to the maximum extent possible, the natural functioning of the Lake Ontario ecosystem.

10.3 Emerging Issues

Emerging Issues are those issues that are relatively new to Lake Ontario and may warrant the LaMP's attention. For many of the emerging issues discussed below it is unclear if they pose a threat to the lakewide ecosystem. For this reason the LaMP will track each of these issues and as more information is accumulated the LaMP will assess and determine whether there is a need to develop and coordinate binational actions to address them.

10.3.1 Rapid Urbanization of the Canadian Side of Western Lake Ontario

Land use and population growth in the Greater Toronto Area are impacting Lake Ontario and the stress is growing.

The western end of Lake Ontario (a region commonly known as the Golden Horseshoe) is rapidly urbanizing. It is projected that the region's population will grow from 7.4 million in 2000 to 10.5 million in 2031- an increase of 43 per cent. In fact, this is the third fastest growing area in North America and one of the top 10 most sprawling regions in the world. It is projected that more than 1000 square kilometers of land in this area will be urbanized- most of it prime agricultural land. This is almost double the area of the City of Toronto and represents a 45 per cent increase in the amount of urbanized land in the region.

At issue is not only the absolute growth in population, but the nature of that growth. The fringe development is sprawling- consuming 2 to 3 times more land per person than neighborhoods in the old City of Toronto, which were built prior to World War 2. The large quantities of land consumed per person through urbanization has resulted in increases in the amount of impervious land area, increases in vehicular travel and transportation related emissions and increases in stormwater runoff.

Urbanization radically alters an area's hydrologic regime. There is a strong negative relationship between urban stream quality and impervious cover- the more impervious the land area, the greater the level of stream impairment. A review of the literature has shown that less than 10 per cent imperviousness in an urbanizing watershed is required to maintain stream water quality and quantity, and preserve aquatic species density and biodiversity. An upper limit of 30 per cent has been found to be a threshold for degraded streams

Urbanization also creates a "hidden supply issue." While increasing the relative contribution to surface water bodies from wastewater discharges- groundwater recharge rates decline due to more imperviousness, storm drains and other urban infrastructure.

Two-thirds of coastal wetlands have been lost and those that remain are disturbed. The average size of woodlands is getting smaller and woodlands are being fragmented by roads, utility corridors and housing. This fragmentation is a serious concern when it comes to securing ecosystem function and maintaining at least 30 per cent of our watersheds in natural cover. Overall, ecological conditions in the watersheds of the Golden Horseshoe are degraded and slowly getting worse.

The Province of Ontario has introduced the Greenbelt Act, 2005 which enables the creation of a Greenbelt Plan to protect about 1.8 million acres of environmentally sensitive and agricultural land in the Golden Horseshoe (western Lake Ontario) from urban development and sprawl (see Figure 10.1). It includes and builds on about 800,000 acres of land within the Niagara Escarpment Plan and the Oak Ridges Moraine Conservation Plan.

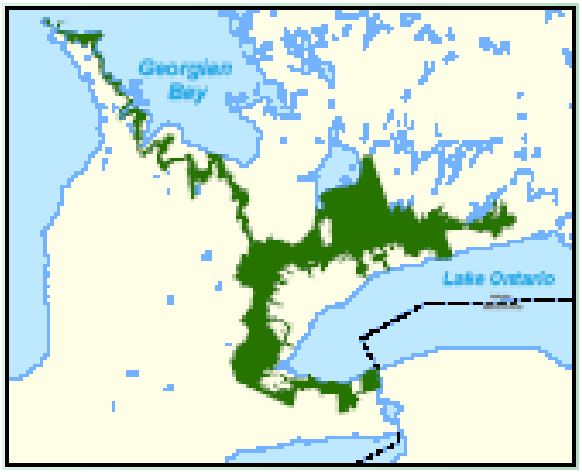


Figure 10.1 Greenbelt Plan Area

10.3.2 Emerging Chemicals of Concern

In addition to pursuing the elimination of critical pollutant inputs, the LaMP tracks information on other bioaccumulative contaminants and encourages member institutions to contribute the collection of information for possible assessment. The LaMP continues to monitor, support, and evaluate scientific investigations into other bioaccumulative or toxic contaminants that may cause lakewide impairments. There are several classes of compounds that have attracted the attention of academic and government research and monitoring programs in the Great Lakes region. In Lake Ontario, a number of recent studies have been presented or are underway, either through the participation or funding by LaMP agencies, on the occurrence and temporal trends of emerging and other chemicals of concern. These include studies on brominated flame retardants, particularly polybrominated diphenyl ethers (PBDEs), perfluorinated compounds, and polychlorinated naphthalenes (PCNs).

Flame Retardants

Studies of brominated flame retardants have focused on PBDEs, however others are in wide use, including hexabromocyclododecane (HBCD) and tetrabromobisphenol A (TBBPA), while others are coming on the market as potential PBDE replacements.

Polybrominated diphenyl ethers (PBDEs)

Polybrominated diphenyl ethers are a class of bioaccumulative chemicals that have been widely used over the last two decades as flame retardant in textiles, polyurethane foam, acrylonitrile butadiene styrene plastic (ABS), building materials, and electrical components such as computers and televisions. These materials can contain between 5 to 30 per cent PBDE by weight, greatly reducing risks due to fires. PBDEs have been manufactured primarily as three mixtures, the penta-mix (PBDEs with 4-6 bromines per molecule), the octa-mix (6-10 bromines) and the deca-mix (10 bromines). Unfortunately, PBDEs are also highly mobile in the environment and are now recognized as a globally persistent organic pollutant found even in the marine foodweb of remote Arctic regions.

Concentrations of PBDEs have increased dramatically in the Great Lakes system. Monitoring studies conducted in Lake Ontario have shown exponential increases in PBDE concentrations with time in

archived eggs of herring gulls (Norstrom et al., 2002), in lake trout tissues (Zhu & Hites, 2004), and in dated sediment cores (Song et al., 2005). Results of other studies (e.g. Luross et al., 2002) suggest that local emissions from large urban/industrial areas are the major sources.

A number of uncertainties remain for PBDEs in the Great Lakes region with respect to the magnitude of the various sources to the environment, their fate, and their potential for effects on humans and wildlife. As a result, there are currently no water quality or fish tissue criteria for PBDEs.

A number of recent actions by governments and industry in Canada and the US to address PBDEs include:

- November 2003: The Great Lakes Chemical Corporation, the only manufacturer of PBDEs in the US, agreed to voluntarily phase-out PBDE (penta- and octa-BDE products) production by December 31, 2004

- May 2004: Environment Canada and Health Canada published a screening assessment that concluded that PBDEs are "toxic" under the Canadian Environmental Protection Act, 1999. This assessment relied, in part, on data generated through the LaMP for Lake Ontario surface water concentrations.

- December 2004: USEPA issued a draft "Significant New Use Rule" under the Toxic Substances Control Act for two of the three major commercial PBDE products. The draft rule would require manufacturers and importers to notify EPA at least 90 days before commencing the manufacture or import of these PBDEs.

- August 2004: The manufacture, process or distribution of brominated flame retardants was prohibited within the New York State under Section 37-0111 of the New York State Laws.

- The USEPA Great Lakes National Program Office (GLNPO) has recently added flame retardants (e.g. PBDEs) and two other classes of chemicals, PCNs and PFOS (perfluorooctane sulfonate), to its list of organic contaminants that are routinely monitored for under the Great Lakes Fish Monitoring Program.

Hexabromocyclododecane (HBCD)

Hexabromocyclododecane (HBCD) is another brominated flame retardant consisting of three cycloaliphatic isomers (α-, β- and γ- isomers). Like PBDEs, these are additive flame retardants widely used in extruded and expanded polystyrene foam insulation but also used in textiles. The manufacture and use of HBCD is thought to be increasing in recent years as these are likely replacements of PBDEs in some applications as the latter are phased out. However, HBCD has an estimated logarithm of the octanol-water partition coefficient (log K_{OW}) of 5.6 indicating that HBCD may bioaccumulate.

A recent study of the Lake Ontario food web (plankton-invertebrates-forage fish-lake trout) has shown that HBCD biomagnifies to a similar extent as p,p'-DDE and total PCBs (Tomy et al., 2004). Very little is known about the long term persistence and potential toxicity of these compounds.

Perfluorinated Compounds

Perfluorinated compounds such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) and their precursors are used in a broad range of applications including fire-fighting foams, surface

coatings in textiles and carpeting, and in fluoropolymer formulations. These compounds are found throughout the global environment, including remote arctic regions. They are very stable in the environment and PFOS has been found to bioaccumulate.

Studies on these compounds have been conducted in Lake Ontario. PFOS has been found to biomagnify in the Lake Ontario food web (plankton-invertebrates-forage fish-lake trout) while PFOA does not seem to biomagnify (Martin et al., 2004). Perfluorinated carboxylic acids with carbon chains longer than PFOA do biomagnify. An increasing trend in PFOS concentrations in lake trout was found for the period between 1980 and 2001 (Martin et al., 2004). PFOS and PFOA were reported in Lake Ontario surface waters (Boulanger et al., 2004) and a preliminary mass balance model suggests that, besides inputs from upstream (Niagara River and Lake Erie), sewage treatment plant effluents are major sources to Lake Ontario (Boulanger et al., 2005).

The fate and distribution of these chemicals in the environment, and the identification of primary sources (i.e. degradation products, residuals from products, or direct releases) remain topics of study.

Recent actions:

- May 2000: 3M voluntarily stops production and use of PFOS (e.g. in Scotchgard™)

- October 2004: Environment Canada and Health Canada publish, for public comment, the draft Screening Assessment on Perfluorooctane Sulfonate, Its Salts and Its Precursors, proposing that PFOS, its salts and its precursors be considered "toxic" under the *Canadian Environmental Protection Act, 1999*.

- January 2005: USEPA released for public comment, the draft Risk Assessment of the Potential Human Health Effects Associated with Exposure to Perfluorooctanoic acid and its salts (PFOA).

Polychlorinated Naphthalenes (PCNs)

Polychlorinated naphthalenes (PCNs) are persistent, bioaccumulative compounds which exhibit dioxin-like toxicity. PCNs were used as dielectrics for flame resistance and insulation in capacitors and cables, are trace contaminants in PCB mixtures, and are produced in combustion emissions. The sources of these compounds to the Great Lakes was the past use of products containing Halowax mixtures and their subsequent disposal, industrial discharges from production and use, chlor-alkali production, PCB usage, and combustion from sources such as waste incinerators and metals refining.

PCNs have been detected in several environmental matrices from Lake Ontario. PCNs were measured in air in Toronto, Canada and over Lake Ontario with the highest concentrations found in Toronto (Harner & Bidleman, 1997; Helm & Bidleman, 2003; Helm et al., 2003). The urban and industrial areas at the west end of Lake Ontario influence air concentrations with higher concentrations found in air collected over this part of the lake (Helm et al., 2003). The atmosphere may continue to be a source of PCNs to Lake Ontario but this needs further investigation. PCNs also biomagnify in the Lake Ontario foodweb with trophic magnification factors and predator-prey bioaccumulation factors similar to PCBs and p,p'-DDE (Helm et al., 2005). PCNs in Lake Ontario surface sediments were found to have concentrations considerably higher than found in background sites in Lake Michigan, but much lower than concentrations in highly contaminated portions of the Detroit River. Isomer patterns indicate that the source of PCNs in Lake Ontario sediments may differ from those in the Detroit River.

Recent actions:

- Environment Canada is currently conducting a screening level assessment under the *Canadian Environmental Protection Act, 1999.*

10.3.3 Other Emerging Chemicals

Other classes of emerging chemicals include endocrine disrupting compounds (EDCs), pharmaceuticals, and personal care products. EDCs refer to chemicals that may mimic hormones or interfere with hormone receptors in some manner, and include many pharmaceutical and personal care products. EDCs include birth control hormones, detergents such as nonylphenol ethoxylates, and plastics components such as bisphenol A. Pharmaceuticals which may be present in the aquatic environment include antibiotics, anti-depressants, lipid regulators, and analgesics/ anti-inflammatory drugs. Personal care products include fragrance compounds such as synthetic musks, anti-microbial agents like triclosan, detergents/ surfactants, and cosmetic agents. There have been recent reports detecting some of these compounds in surface waters, particularly in Areas of Concern such as Hamilton Harbour. It is unclear at this time whether these compounds are of significant concern in Lake Ontario.

Activities Regarding Emerging and Other Chemicals of Concern

LaMP agencies are supportive of projects assessing sources and occurrence of other chemicals of concern in Lake Ontario, including:

- collection and dating of Lake Ontario sediment cores from the Mississauga Basin and the Niagara Bar and subsequent analysis for a range of brominated flame retardants, perfluorinated compounds, polychlorinated naphthalenes, polychlorinated dioxins and furans, and dioxin-like PCBs. This project, funded in part through the Canada-Ontario Agreement (COA) involves Environment Canada, Ontario Ministry of the Environment, NYSDEC, and USEPA; and

- a joint project between the Ontario Ministry of the Environment, the Department of Fisheries and Oceans and Environment Canada assessing the occurrence and bioaccumulation of polychlorinated naphthalenes in Lake Ontario sediment and biota.

The LaMP will continue to encourage partner agencies to remain proactive in this area, reporting new findings to the LaMP as they become available.

10.3.4 Fish and Wildlife Disease

Fish and wildlife die-offs are common on Lake Ontario and are usually attributable to rapid changes in environmental conditions such as water temperature fluctuations and more rarely to events like spills, water draw downs, etc. However, occasional die-offs do occur that can either be attributed to new or emerging diseases affecting fish and wildlife, or to ongoing concerns. The first category of emerging issues for this section is ‘new’ diseases and the second category is ongoing issues about prevention of the spread of diseases.

New Diseases

In early spring 2005, a major die off of freshwater drum occurred in the Bay of Quinte in which thousands of drum died. Lab reports have since confirmed that Viral Haemorrhagic Septicemia (VHS) virus was associated with the drum mortalities. This virus has not previously been detected in the Great Lakes. The Ontario Ministry of Natural Resources notified the Department of Fisheries and Oceans (as required) and

other stakeholders. As well, the Fish Health Committee of the Great Lakes Fishery Commission was notified. The Department of Fisheries and Oceans is doing further testing on drum to see if the strain can be better identified.

As an aside, muskellunge were found dead and floating in the St. Lawrence River primarily in the Thousand Islands area shortly after the drum die off. Pathologists in the state of New York suggest a bacterial infection brought on due to stress from water temperature and/or spawning were likely causes of the muskellunge die-off. As well, round goby were being found dead throughout eastern Lake Ontario during the spring die-off of both drum and muskie. No cause can be attributed to the die-off of goby. It is clear that botulism was not the cause. Samples of musky and goby are undergoing further testing.

The second recent or 'new' disease is a response to infection by a parasite called *Heterosporis* sp. This is a microsporidian found in crappie and yellow perch in Lake Ontario that forms spores inside muscle cells causing the flesh to appear opaque or freezer burnt, resulting in a decline in flesh quality and appearance, and a loss of marketability. How this parasite got into Lake Ontario is not known, as the only other sites where it is found are a number of inland waterbodies in Wisconsin, Minnesota and Michigan.

Like non-native fish species, there is a large list of diseases that could be introduced to Lake Ontario or may already be here. Fish diseases that are a potential concern for Lake Ontario are piscirickettsia, Koi herpes virus, largemouth bass virus, and spring viremia of carp; the latter of which has been detected in farmed koi in North Carolina and Virginia, and was diagnosed as the cause of a mass mortality of wild carp in Wisconsin.

Transmission Prevention

The Great Lakes Fish Health Committee, a body of the Great Lakes Fishery Commission, is focusing a lot of effort at identifying and reducing the modes of transmission of fish diseases and movement of organisms causing disease states in fish within the Great Lakes and connected inland waterbodies. Modes of transmission being reviewed are purposeful introductions, baitfish use, contiguous waterways, and by birds.

The LaMP supports the initiatives of the Great Lakes Fishery Commission to monitor and address the outbreaks and transfer of fish diseases in the Great Lakes basin.

10.3.5 Type E Botulism

Recent outbreaks of Type E Botulism in Lake Ontario waterbirds has raised the concern of US and Canadian conservation and natural resource agencies who are keeping a close watch for potentially affected fish and waterbirds along the shorelines of the lake.

Type E Botulism is a specific, ubiquitous strain of the botulinum bacterium most commonly affecting fish-eating birds. It causes rapid paralysis in the affected birds and often is fatal. The bacterium, *Clostridium botulinum*, produces the Type E Botulinum toxin. Spores of the bacteria occur naturally within the water and sediment of the Great Lakes. The spores are harmless, but under specific conditions of appropriate temperatures, anoxia (no oxygen) and rich organic medium, these spores vegetate and grow to produce the toxin.

Type E Botulism is of particular concern to the Lake Ontario LaMP, because it affects healthy populations of gulls, bald eagles and lake trout -- key ecosystem indicators. During the summer and autumn of 2002, at least five dead gulls and four ducks found along New York's eastern Lake Ontario shoreline were confirmed to have died from the Type E Botulinum toxin. It was unknown whether the

birds had consumed the toxin in Lake Ontario or elsewhere. In the Niagara region of Lake Ontario, botulism has been linked to the death of small numbers of fish and birds since 2002. In 2004, Type E Botulism was allegedly responsible for several long-lasting and large die-offs of birds (and possibly fish) in the north east part of the lake. This outbreak was first reported on August 9, 2004, and reports continued into November of the same year. During late July and early August 2005, moderate numbers of dead and dying waterfowl and fish showing the signs of Type E Botulinum poisoning were observed in Lake Ontario. Testing by the Canadian Cooperative Wildlife Health Centre (University of Guelph) confirmed Type E Botulism in a double-crested cormorant collected on the south shore of Prince Edward County, Ontario. The New York State Department of Environmental Conservation confirmed that several birds of different species collected from the eastern Lake Ontario, Cape Vincent and Galloo Island area, in August of 2005, also died from Type E Botulinum toxin.

There is a loose association between birds affected by botulism, and a diet which includes a high proportion of zebra or quagga mussels and round gobies (both recent invaders of the Great Lakes). Although the linkage from lower food web to top predators is not well understood, it has been suggested that the digestive waste of zebra and quagga mussels, as well as the redox conditions in these mussels, may provide suitable habitat for the bacteria to proliferate and produce toxin. Fish that eat these mussels, or other food items found among the mussels, may consume the pre-formed toxin and pass it on to fish-eating birds. Research to determine if this is indeed the case is currently underway in the Aquaculture Centre, University of Guelph, Ontario.

Type E botulinum toxin can be harmful or even fatal to humans and other animals if they consume birds or fish that contain the pre-formed toxin. There have been no reports of any human illnesses associated with the outbreaks in Lake Ontario or Lake Erie. Type E Botulism is destroyed by heat through the proper cooking of fish and game birds. People are advised not to handle dead or dying animals they suspect to have botulism or that are situated in areas having a history of botulism outbreaks.

In response to the Type E botulism outbreaks, which have also been occurring in Lakes Erie and Huron since 1999, the US Environmental Protection Agency and Environment Canada have supported research projects to help understand the sources, conditions of production, exposure pathways, and possible predictive indicators of the toxin.

Any discovery of dead or dying waterbirds, or fish, showing clinical signs of botulism such as an inability to walk, fly or swim, should be reported to the New York State Department of Environmental Conservation, or the Ontario Ministry of Natural Resources immediately. For information on local offices see your phone book or check the website – in the United States at www.dec.state.ny.us/ or in Canada at www.mnr.gov.on.ca/MNR/.

10.3.6 Climate Change

Appropriate text for this section will be inserted in a future Lake Ontario LaMP Status Report.

10.3.7 Harmful Algal Blooms

Microcystis, Anabaena, Planktothrix, Oscillatoria are naturally occurring algae which produce cyanotoxins including microcystins (MCs), the most common form (Falconer 1995; Codd et al. 2005). Conditions of high temperature, high nutrients and low circulation can produce conditions that allow these algae to rapidly grow producing noxious algal blooms on the water's surface which can result in elevated MC levels. In addition to serious aesthetic problems, elevated MC levels raise potential health concerns for organisms that may come in contact with the blooms and may impact the structure of the food web where the blooms occur (Carmichael 1997). Generally these problems are restricted to bays

and marshes. The blooms persist until wind, wave or precipitation events break up the surface layer of algal blooms. Currents, waves and lower nutrient levels of Lake Ontario's nearshore and open waters do not favor the development of MC-related algal blooms.

Health Canada has developed a drinking water guideline of 1.5 ug/L for microcystin-LR, one of the most toxic and also one of the most common microcystin congeners forms found in the Great Lakes (e.g. Brittain 2001). As most major drinking water intakes are located away from shore in fairly deep, well mixed waters, microcystin is not expected to present a problem for public drinking water supplies although it may be a potential concern for private water sources with intakes in shallow waters with poor water circulation. Researchers sampling blooms in restricted bays, which could be considered representative of a worst case scenario, have found MC levels well below the Health Canada guideline.

Ontario has adopted the Health Canada guideline as the maximum acceptable concentration (MAC). Ontario advocates visual monitoring of drinking and recreational water bodies with a history of algal blooms during the summer when the risk for bloom formation and MC production is greatest according to a protocol similar to that developed in Europe and Australia (OME 2003).

Some research suggests that the incidence of microcystin related planktonic blooms in Lake Ontario embayments and the St. Lawrence River is increasing in some north shore areas (Watson et al. 2003; Watson and Millard 2002, 2003; Boyer et al.; Watson and Ridal unpublished). Dreissenid mussels and increasing urban development and associated diffuse shoreline nutrient influx have been implicated as potential factors promoting these blooms (e.g. Abiley et al. 1999; Nicholls 2001; Vanderploeg et al. 2001, Baker et al.).

10.4 Actions and Progress

The information contained in this chapter has been compiled based on documents produced up to October 2005. The table below contains a summary of the actions and progress on significant ongoing and emerging issues within Lake Ontario. The LaMP process is a dynamic one and therefore the status will change as progress is made. For many of the emerging issues, the LaMP partners are sharing information so the LaMP as a whole can maintain its awareness of the status of the various issues. As new information becomes available the LaMP will assess whether there is a need for a coordinated binational action plan.

This chapter will be updated in future LaMP reports as appropriate.

Table 10.2 Summary of Actions and Progress

ISSUE	ACTIONS AND PROGRESS
Protection and Restoration of Native Species	• **Lake Trout** o US Fish and Wildlife Service and Canadian Department of Fisheries and Oceans have controlled Sea Lamprey at or near levels targeted by the Lake Ontario Committee of the Great Lakes Fishery Commission. • **American Eel** o US and Canada are taking steps to provide additional protection and aid in the rehabilitation of this species. o The commercial fishery for American Eel has been closed in Ontario (no commercial fishery existed within the US portion of Lake Ontario and the St. Lawrence River). o Both US and Canada are supporting research directed at improving the ability to manage American Eel.
Invasive Species	• **Regulatory Initiatives** o US Coast Guard voluntary actions to manage ballast water under the National Invasive Species Act (1996) became mandatory on July 28, 2004. o Transport Canada's proposed *Ballast Water Control Management Regulations* under the Canada Shipping Act have undergone public comment. The Regulations are expected to come into force in 2006. o US Coast Guard and Transport Canada are jointly working on measures to manage ships with no ballast on board. o Ontario recently passed legislation prohibiting the possession and sale of live individuals of the four Asian carp species, snakeheads and the round and tubenose goby. o New York State has banned the possession of three live species of Asian carp (Bighead, Silver and Black) and all species of live snakeheads, and their eggs, with an exemption for allowing live bighead carp for retail sale purposes in limited sections of New York City. Bighead carp must be killed at the time of sale to prevent further transport and distribution within the state. • **Education and Outreach** o The LaMP agencies, other governmental agencies and NGOs are all involved in coordination and promotion of various education and outreach activities. • **Other Initiatives** o National initiatives are underway in US and Canada aimed at prevention, early detection, and rapid response. o US Fish and Wildlife Service surveys the Lower Genesee River twice a year as part of an early detection program for the potential introduction of ruffe to Lake Ontario.

Table 10.2 Summary of Actions and Progress

ISSUE	ACTIONS AND PROGRESS
Type E Botulism	• **Research** o US Environmental Protection Agency, Environment Canada have supported research projects to help understand the sources, conditions of production, exposure pathways, and possible predictive indicators of the Type E Botulinum toxin. • **Monitoring and Tracking** o New York State Department of Environmental Conservation, Ontario Ministry of Natural Resources, Environment Canada and other partners continue to monitor and track the occurrence of Type E Botulism within Lake Ontario.
Lake Ontario Water Levels	• Lake Ontario LaMP has been participating in the IJC Water Level study and communicated the LaMP support for "Environmentally Balanced" Plan B to the IJC Water Levels Study Team.
Emerging Chemicals of Concern	• **Voluntary Actions** o The Great Lakes Chemical Corporation agreed to voluntarily phase-out PBDE (penta- and octa-BDE products) production by December 31, 2004 o May 2000 3M voluntarily stopped the production and use of PFOS (e.g. in Scotchgard™) • **Regulatory Initiatives** o May 2004, PBDEs were defined as "toxic" under the *Canadian Environmental Protection Act*. This assessment relied, in part, on data generated through the LaMP for Lake Ontario surface water concentrations. o October 2004 draft Screening Assessment on Perfluorooctane Sulfonate, Its Salts and Its Precursors, proposes that PFOS, its salts and its precursors be considered "toxic" under the *Canadian Environmental Protection Act*. o Environment Canada is currently conducting a screening level assessment for Polychlorinated naphthalenes (PCNs) under the *Canadian Environmental Protection Act*. o August 2004: The manufacture, process or distribution of brominated flame retardants were prohibited within the New York State under Section 37-0111 of the New York State Laws. • **Monitoring and Trend Analysis** o Joint U.S., Canadian project to collect, date and analyze Lake Ontario sediment cores from the Mississauga Basin and the Niagara Bar. o Joint Canadian Agency project to assess the occurrence and bioaccumulation of polychlorinated naphthalenes in Lake Ontario sediment and biota. o US EPA – routine monitoring of flame retardants (PBDEs, PCNs and PFOS) under the Great Lakes Fish Monitoring Program (GLNPO). • **Other Actions** o January 2005 the US EPA draft Risk Assessment of the Potential Human Health Effects Associated with Exposure to Perfluorooctanoic acid and its salts (PFOA). o December 2004, US EPA issued a draft "Significant New Use Rule" under the Toxic Substances Control Act for two of the three major commercial PBDE products.

Table 10.2 Summary of Actions and Progress

ISSUE	ACTIONS AND PROGRESS
Fish and Wildlife Diseases	• **Prevention** o LaMP partner agencies are working with the Great Lakes Fishery Commission to identify and reduce the modes of transmission of fish diseases and movement of organisms causing disease states in fish within the Great Lakes and connected inland waterbodies.
Rapid Urbanization of Western Lake Ontario	• **Regulatory Initiatives** • The Province of Ontario has introduced the Greenbelt Act, 2005 which enables the creation of a Greenbelt Plan to protect approximately 1.8 million acres of environmentally sensitive and agricultural land in the Golden Horseshoe (western Lake Ontario)
Harmful Algal Blooms	• Health Canada has developed a drinking water guideline of 1.5ug/L for microcystin-LR. • Ontario has in place a monitoring procedure for high risk areas and a protocol that is implemented in the event of a potential threat (i.e. algal bloom) to protect drinking water. **Research** • Environment Canada is conducting and supporting research on occurrence and causes of these recent blooms.

10.5 References

Alaee, M., Luross, J.M., Sergeant, D.B., Muir, D.C.G. Whittle, D.M., and Solomon, K.R. 1999. Distribution of polybrominated diphenyl ethers in the Canadian Environment. Organohalogen Compounds 40:347-350.

Aquatic Nuisance Species Task Force website, http://www.anstaskforce.gov/ansimpact.htm

Bennett, E.R.; Metcalfe, C.D. Distribution of degradation products of alkylphenol ethoxylates near sewage treatment plants in the lower Great Lakes, North America. Environ.Toxicol.Chem. 2000, 19: 784-792.

Berg, D.J. 1995. The spiny water flea, *Bythotrephes cederstroemi*: another unwelcome newcomer to the Great Lakes. Fact Sheet FS-049. Ohio Sea Grant College Program.

Boulanger, B., Vargo, J., Schnoor, J.L. and Hornbuckle, K.C. (2004) Detection of perfluorooctane surfactants in Great Lakes water. Environ. Sci. Technol. 38: 4064-4070.

Boulanger, B., Peck, A.M., Schnoor, J.L. and Hornbuckle, K.C. (2005) Mass budget of perfluorooctane surfactants in Lake Ontario. Environ. Sci. Technol. 39: 74-79

Cudmore, B. and N.E. Mandrak. 2004. Biological synopsis of grass carp (Ctenopharyngodon idella). Can. MS Rpt. Fish. Aquat. Sci. 2705. 44 pp.

Dermott, R. Sudden Disappearance of the Amphipod *Diporeia* from Eastern Lake Ontario, 1993-1995. J. Great Lakes Res., 27:423-433

Dermott, R. and M. Legner. 2002. Dense mat-forming bacterium *Thioploca ingrica* (Beggiatoaceae) in eastern Lake Ontario: implications to the benthic food web. Journal of Great Lakes Research 28(4):688-697

Dermott R., J. Witt, Y.M. Um, M. González. 1998. Distribution of the Ponto-Caspian amphipod *Echinogammarus ischnus* in the Great Lakes and replacement of native *Gammarus fasciatus*. Journal of Great Lakes Research 24(2):442-452

Glassner-Shwayder, K., K. Cogsdill. 1998. Biological Invasions. Brochure published by the Great Lakes Panel on Aquatic Nuisance Species, Great Lakes Commission.

Kavanagh, R.J.; Balch, G.C.; Kiparissis, Y.; Niimi, A.J.; Sherry, J.; Tinson, C.; Metcalfe, C.D. Endocrine disruption and altered gonadal development in White Perch (Morone americana) from the Lower Great Lakes region. Environ. Health Persp. 2004, 112: 898-902.

Harner, T. and Bidleman, T.F. (1997) Polychlorinated naphthalenes in urban air. Atmos. Environ. 31: 4009-4016.

Helm, P.A. and Bidleman, T.F. (2003) Current combustion-related sources contribute to polychlorinated naphthalene and dioxin-like polychlorinated biphenyl levels and profiles in air in Toronto, Canada. Environ. Sci. Technol. 37:1075-1082.

Helm, P.A., Whittle, D.M., Tomy, G.T., Fisk, A.T. and Marvin, C.H. (2005) Biomagnification of Polychlorinated Naphthalenes and Dioxin-like PCBs in Lake Ontario Biota. Organohalogen Compounds 67:1990-1994.

Kavanagh, R.J.; Balch, G.C.; Kiparissis, Y.; Niimi, A.J.; Sherry, J.; Tinson, C.; Metcalfe, C.D. Endocrine disruption and altered gonadal development in White Perch (Morone americana) from the Lower Great Lakes region. Environ. Health Persp. 2004, 112: 898-902.

Lozano, S.J., Scharold, J.V., Nalepa, T.F., 2001. Recent Declines in Benthic Macroinvertebrate Densities in Lake Ontario. Can J.Fish.Aquatic Sci. 58:518-529.

Luross, J.M., Alaee, M., Sergeant, D.B., Cannon, C.M., Whittle, D.M., Solomon, K.R. and Muir, D.C.G. (2002) Spatial distribution of polybrominated diphenyl ethers and polybrominated biphenyls in lake trout from the Laurentian Great Lakes. Chemosphere 46: 665-672.

Mandrak, N.E. and B. Cudmore. 2004. Risk assessment for Asian carps in Canada. Can. Sci. Adv. Sec. Research Document 2004/103. 48 pp

Metcalfe, C.D.; Miao, X.-S.; Koenig, B.G.; Struger, J. Distribution of acidic and neutral drugs in surface waters near sewage treatment plants in the lower Great Lakes, Canada. Environ. Toxicol. Chem. 2003, 22: 2881-2889.

Mills, E.L., J.H. Leach, J. T. Carlton, C.L. Secor. 1993. Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19(1):1-54.

Mills, E.L., J. M. Casselman, R. Dermott, J.D. Fitzsimons, G. Gal, K.T. Holeck, J.A. Hoyle, O.E. Johannsson, B.F. Lantry, J.C. Makarewicz, E.S. Millard, I.F. Munawar, M. Munawar, R. O'Gorman, R.W. Owens, L.G. Rudstam, T. Schaner, and T.J. Stewart. 2005. A synthesis of ecological and fish-community changes in Lake Ontario, 1970-2000. Great Lakes Fishery Commission Technical Report 67.

Martin, J.W., Whittle, D.M., Muir, D.C.G. and Mabury, S.A. (2004) Perfluoroalkyl contaminants in a food web from Lake Ontario. Environ. Sci. Technol. 38: 5379-5385.

Metcalfe, C.D.; Miao, X.-S.; Koenig, B.G.; Struger, J. Distribution of acidic and neutral drugs in surface waters near sewage treatment plants in the lower Great Lakes, Canada. Environ. Toxicol. Chem. 2003, 22: 2881-2889.

Moisey, J., Simon, M., Wakeford, B., Weseloh, D.V., and Nostrum, R.J. 2001. Spatial and temporal trends of polybrominated diphenyl ethers in Great Lakes herring gulls, 1981 to 2000. In Proc. 2nd International Workshop on Brominated Flame Retardants. Pp. 153-157, Stolkholm University, Sweden.

Morrison, B.J., Casselman, J.C., Johnson, T.B. and D.L. Noakes. 2004. New Asian carp species (*Hypopthalmichthys*) in Lake Erie. Fisheries 29: 6-7, 44-45.

Nicholls, K.H. 2000. Preliminary (Class Level) Assessment of Lake Ontario Phytoplankton and Zooplankton-Lake Ontario lamp: Impairment of Beneficial Uses. Environment Canada, Technical report (Unpublished).

Nicholls, K.H. CUSUM Phytoplankton and Chlorophyll Functions Illustrate the Apparent Onset of the Dreissenid Mussel Impacts in Lake Ontario. J. Great Lakes Re., 27:393-401.

Norstrom, R.J., Simon, M., Moisey, J., Wakeford, B. and Weseloh, D.V.C. (2002) Geographical distribution (2000) and temporal trends (1981-2000) of brominated diphenyl ethers in Great Lakes Herring Gull Eggs. Environ. Sci. Technol. 36: 4783-4789.

Owens, R. W., R. O'gorman, E. L. Mills, L. G. Rudstam, J. J. Hasse, B. H. Kulik, and D. R. MacNeill. 1998. Blueback herring (Alosa aestivalis) in Lake Ontario: First record, entry route, and colonization potential. Journal of Great Lakes Research, 24(3):723-730.

Peck, A.M.; Hornbuckle, K.C. Synthetic musk fragrances in Lake Michigan. Environ. Sci. Technol. 2004, 38: 367-372.

Pimentel, D. 2005. Aquatic Nuisance Species in the New York State Canal and Hudson River Systems and the Great Lakes Basin: an economic and environmental assessment. Environmental Management, 35(1):1-11.

Ricciardi, A. 2001. Facilitative interactions among aquatic invaders: is an “invasion meltdown” occurring in the Great Lakes? Canadian Journal of Fisheries and Aquatic Sciences, 58:2513-2525.

Song, W., Ford, J.C., Li, A., Sturchio, N.C., Rockne, K.J., Buckley, D.R. and Mills, W.J. (2005) Polybrominated diphenyl ethers in the sediments of the Great Lakes. 3. Lakes Ontario and Erie. Environ. Sci. Technol. 39: 5600-5606.

Tomy, G.T.; Budakowski, W.; Halldorson, T.; Whittle, D.M.; Keir, M.J.; Marvin, C.; Macinnis, G.; Alaee, M. (2004) Biomagnification of alpha- and gamma-hexabromocyclododecane isomers in a Lake Ontario food web. Environ. Sci. Technol. 38: 2298-2303.

Valters, K.; Hongxia, L.; Alaee, M.; D’Sa, I.; Marsh, G.; Bergman, Å.; Letcher, R.J. Polybrominated diphenyl ethers and hydroxylated and methoxylated brominated and chlorinated analogues in the plasma of fish from the Detroit River. Environ. Sci. Technol. 2005, 39: 5612-5619.

Witt, J.D.S., P.D.N. Herbert, and W.B. Morton. 1997. Echinogammarus ischnus: another crustacean in the Laurentian Great Lakes basin. Canadian Journal of Fisheries and Aquatic Science 54:264-268.

Zaranko, D.T., D.G. Farara, and F.G. Thompson. 1997. Another exotic mollusk in the Laurentian Great Lakes: the New Zealand native *Potamopyrgus antipodarum* (Gray 1843) (Gastropoda, Hydrobiidae). Canadian Journal of Fisheries and Aquatic Science 54:809-814.

Zhu, L.Y., and Hites, R.A. (2004) Temporal trends and spatial distributions of brominated flame retardants in archived fishes from the Great Lakes. Environ. Sci. Technol. 38: 2779-2784.

CHAPTER 11 SUMMARY OF AREA OF CONCERN STATUS

11.1 Summary

There are nine Areas of Concern (AOCs) identified around Lake Ontario. Two of these AOCs are binational and are located at the inlet (Niagara River) and outlet (St. Lawrence River.) For each AOC, a Remedial Action Plan (RAP) has been developed and is being implemented. The table lists the status of the fourteen use impairment indicators developed by the International Joint Commission (IJC) to assess beneficial uses in the Areas of Concern. This chapter provides a summary of progress as of December 2003.

11.2 Background and Current Status

These same fourteen use impairment indicators have been applied in the Lake Ontario Lakewide Management Plan to assess lakewide beneficial uses. In addition to lakewide impairments, the AOCs served to identify problems found in localized nearshore areas, embayments, and tributary watersheds. This is not surprising as industrial and municipal contamination can become concentrated at the mouths of rivers or harbors. Remedial Action Plans (RAPs) serve as the primary mechanism for addressing these localized contaminant problems and other issues unrelated to lakewide impairments. Additional nearshore problems (e.g. temporary beach closings, and eutrophication / algae) beyond the scope of specific AOCs are being addressed through a variety of other environmental management programs. Table 11-1 summarizes the status of these use impairment indicators for the Lake Ontario LaMP and AOCs. Lakewide and nearshore areas, two binational AOCs (the Niagara and St. Lawrence Rivers), and the seven other Areas of Concern for which RAPs have been developed in Lake Ontario are included. Contact information is listed at the end of RAP summary reports for each AOC located on websites by USEPA and Environment Canada.

Each AOC is required to develop and implement a Remedial Action Plans (RAP) as called for in the 1987 amendments to the Great Lakes Water Quality Agreement, signed by the federal governments of the United States and Canada. The federal governments, in cooperation with state and provincial governments, committed to developing and implementing RAPs in 43 Areas of Concern (AOCs). The RAP process strives to identify environmental problems (beneficial use impairments); identify pollutants and other causes of the problems; identify the sources of the pollutants; recommend and implement remedial activities to restore the beneficial uses and document progress towards restoration. The ultimate goal, therefore, is to restore the area's beneficial uses and be able to delist the AOC. Read on to find out about what's happening with all the AOCs associated with the Lake Ontario LaMP. The following Table 11.1 provides useful comparison information from which common beneficial use impairments can be identified.

Table 11.1 Summary of Beneficial Use Impairments for Lake Ontario Lakewide, Nearshore, and Areas of Con
(Based on the 14 IJC Use Impairment Indicators)

Use Impairment Indicator	Lake-wide Lake Ontario	Niagara River (U.S.)	Niagara River (Canada)	Saint Lawrence at Massena + (U.S.)	Saint Lawrence at Cornwall (Canada)	Eighteen-mile Creek	Rochester Embay-ment	Oswego River	Hamilton Harbour		
1. Restrictions on Fish and Wildlife Consumption	I	I	I (fish) (wild life?)	I	I	I	I	O	I		
2. Tainting of Fish and Wildlife Flavor							?				
3. Degradation of Fish and Wildlife Populations	I(wild life)	?	I (fish) (wild life?)	?	I	?	I	O	I		
4. Fish tumors or Other Deformities		I	?	?	?	?	?		I		
5. Bird/Animal Deformities or Reproductive Problems	I	?	I	?	?	?	I		I		
6. Degradation of Benthos	I	I	I	?	I	I	I-		I		
7. Restrictions on Dredging Activities		I			I	I	I**		I		
8. Eutrophication or Undesirable Algae			I		I		I	R	I		
9. Drinking Water Restrictions or Taste and Odor Problems				?			I*				
10. Beach Closings			I		I		I		I		
11. Degradation of Aesthetics							I		I		
12. Added Costs to Agriculture or Industry							I		I		
13. Degradation of Phytoplankton and Zooplankton Populations	I		?	?	?		I-		I		
14. Loss of Fish and Wildlife Habitat	I	I	I	I	I		I	O	I		

See key next page

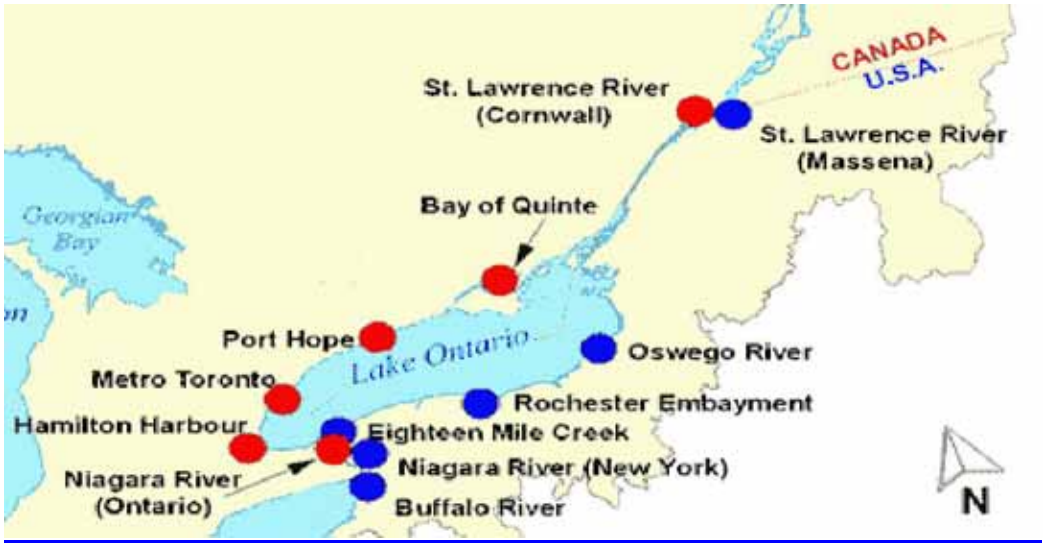
Key: Use Impairment Status for Table 11.1

I	=	Impaired
R	=	Beneficial Use Restored
O	=	Resolution by Other Responsibility
?	=	Further Assessment Needed
(Blank)	=	Not Impaired

Key: Other Notations for Table 11.1

I*	=	Taste and Odor Problems unless otherwise not marked for indicator #9 only
I-	=	Lower Genesee River Impaired; Rochester Embayment Needs further study
+	=	"Transboundary Impacts" is an added indicator in this RAP
I**	=	Stage 1 impairment identified as an issue of navigational dredging method and to be resolved by agreement to eliminate overflow dredging in the Rochester Harbor

Figure 11.1 Lake Ontario Areas of Concern (AOCs)



11.3 Binational Areas of Concern

Canada and the United States have agreed to develop Remedial Action Plans for the Binational AOCs independently within a broader context of intergovernmental cooperation. Separate RAP documents have been developed and are being implemented for the two binational AOCs. Joint participation on technical and public participation activities is part of this RAP Process for these shared waterbodies.

11.3.1 Niagara River Area of Concern

The Niagara River flows 60 kilometres from Lake Erie to Lake Ontario. Downstream from Niagara Falls the river flows for a 15 kilometre stretch through a 100 metres deep and 1 kilometre wide gorge. The binational AOC extends the entire length of the Niagara River and includes the Welland River and other tributary watersheds on the Canadian side. The Niagara River passes through heavily industrialized areas, residential and parkland interspersed with remnant natural areas, and drains extensive farmland on the Canadian side. It borders Erie and Niagara counties in western New York. Here, the AOC extends from Smokes Creek near the southern end of the Buffalo Harbor, north to the mouth of the Niagara River at Lake Ontario.

Past municipal and industrial discharges and waste disposal sites have been a source of contaminants to the Niagara River. A long history of development has also changed the original shoreline along much of the river, affecting fish and wildlife habitat. More than half of the flow of the river is diverted for electric power generation on both sides of the river. The gorge and cliff face are habitat for some of the highest concentrations of rare plant species in Ontario. The Niagara River annually supports one of the largest and most diverse concentrations of gulls in the world.

Joint participation includes the Niagara River Toxics Management Plan (NRTMP), the Important Bird Area Program and the International Board of Control. Environment Canada and MOE, working in partnership with the Niagara Peninsula Conservation Authority (NPCA), are responsible for the delivery of the Canadian RAP. USEPA Region 2 and NYSDEC deliver the US portion of the RAP. Both RAPs were established in 1989. Summaries of the Remedial Actions plans follow.

11.3.1.1 Niagara River (U.S. Side)

Background: A representative group of Niagara River stakeholders was appointed by NYSDEC as an advisory committee to help develop the RAP. The committee persons and NYSDEC direct RAP development. Goals were established, a workplan was developed, responsibilities were defined to complete the RAP document. This RAP document, that effectively combines the Stage 1 and Stage 2 RAP elements, was completed September 1994. A Status Report for the Niagara River RAP that updates remedial actions was published in June 2000. The RAP addresses use impairments, sources, and existing remediation programs, and recommends future remedial strategies. A multiple committee approach was utilized to address the complexities of implementation. A technical subcommittee was formed to develop ways to quantify concerns and to communicate progress to address the impaired uses. A public outreach subcommittee was created to develop a binational strategy to address the many issues involved with achieving sustainable development, and an International Advisory Committee was established to foster binational cooperation.

Impairments: The Remedial Action Plan (RAP) identifies five use impairments based on the fourteen possible International Joint Commission (IJC) impairments. Two other use impairments are listed that will require further investigation to determine the extent of their existence. The major impairment is restrictions on fish and wildlife consumption, primarily due to PCB and dioxin contamination. Mirex and chlordane also are chemicals of concern contributing to the consumption restriction use impairment. These restrictions are part of a lakewide advisory for Lake Ontario. Based on the presence of contaminated sediment pockets at certain tributary mouths and nearshore areas, the sediments were evaluated as contributing to a degradation of benthos use impairment at these areas. Existing restriction on open lake disposal of contaminated sediments from the Niagara River cause the AOC to have a dredging restrictions use. In the upper Niagara River, fish tumors have been reported and the loss of fish and wildlife habitat due to human activities has been dramatic. Degradation of fish and wildlife populations and the presence of bird or animal deformities or reproductive problems will require further investigations.

RAP Structure: Most recently the combined committee of the Friends of the Buffalo/Niagara Rivers (FBNR) advises and assists NYSDEC on the Niagara River RAP implementation. Committee members include local government, academia, public and economic interest groups, and private citizens. The RAP process involves various components: periodic progress status reports with remedial strategy identification; regular Remedial Advisory Committee meetings; project and plan reviews as part of ongoing activities; monitoring and tracking progress; and, public participation coordinated through the RAC. In the Niagara River RAP, priority activities and strategies address: stream water. quality; inactive hazardous waste site remediation; contaminated river sediments; point source control programs; fish and wildlife habitat improvements; and, enhanced environmental monitoring activities.

RAP Status and Progress: A Niagara River RAP public information video was completed by the RAC members. This accomplishment of a video by the RAC was based on earlier international cooperation in the development of a slide show. A major recent activity benefiting the RAP is: the Bond Act funding of a $1 million habitat restoration project for Strawberry Island. The International Joint Commission has completed the RAP Status Assessment for the Niagara River Area of Concern. The findings and

recommendations report notes significant progress in documentation for the Niagara River under the Niagara River Toxics Management Plan identifies challenges and opportunities for the binational community to accomplish RAP goals under the Great Lakes Water Quality Agreement.

***RAP Outlook For The U.S. Side*:** Implementation of the Niagara River RAP is a continuous improvement process that include periodic updates and improvements as knowledge of the use impairments, sources and the effectiveness of remedial actions increases. Remedial actions will be evaluated and coordinated as to the impacts on restoration of beneficial uses. Within the AOC and watershed, a number of studies and assessments will continue to be priorities. These include fish and wildlife consumption restrictions, habitat evaluation, sediment investigation and contaminant trackdown. Restoring and maintaining an improved quality of life in the ecosystem of the Niagara River and its watershed is the goal.

11.3.1.2 Niagara River (Canada Side)

***Environmental Issues*:** Much of the impact to the river is from the U.S. side, specifically from past industrial management practices. Efforts on the US side are addressing these issues. Most of the environmental issues on the Canadian side of the river are associated with non-point sources within the rural watersheds of the Niagara-Welland basin. Former industrial activities have resulted in contaminated sediment in the Welland River (remediated) and Lyons Creek (strategy under development). Pesticide use, nutrient runoff, wetland and habitat loss, riparian zone impacts and the health of fisheries all remain concerns

***Impairments*:** There are seven impaired beneficial uses in the Canadian portion of the AOC. These include restrictions on fish consumption, degradation of fish populations, bird or animal deformities and reproductive problems, degradation of benthos, eutrophication, beach closings, and loss of fish and wildlife habitat. The status of the following four impairments requires further assessment: restrictions on wildlife consumption, degradation of wildlife populations, fish tumours and deformities, degradation of phyto/zooplankton populations. Taste and odor problems persist in drinking water, however, this impairment is not due to local sources.

***RAP Structure*:** Through an agreement signed in 1999, the Niagara Peninsula Conservation Authority (NPCA) has assumed responsibility for coordinating the implementation of the RAP and has developed an Implementation Annex that provides a practical strategy for doing this.

***RAP Status and Progress*:** A rural watershed heritage strategy is being implemented for the Welland River. Actions have included the planting of more than 96,000 trees, rehabilitation of 10.5 hectares of wetland habitat, the installation of over 18 kilometres of fencing to protect riparian habitat adjacent to watercourses and the reduction of phosphorus entering local watercourses by more than 1,500 kilograms per year. By 2002, 135 projects were completed. These activities to date have increased forest cover on 90 hectares of land, restored 21 kilometres of riparian habitat and seven hectares of wetlands. The NPCA has also been actively involved with local landowners since 1994 to improve water quality in streams. Nutrient and bacterial loadings have been reduced through livestock fencing and manure storage projects. Through a grant program, the NPCA will provide incentives to local landowners within the Niagara-Welland basin in order to foster best management practices for agriculture, create habitat and protect ecologically sensitive land.

Urban stormwater and combined sewer overflows (CSOs) are also being addressed. In the City of Niagara Falls, 4300 urban homeowners were asked to disconnect their roof downspouts. The City also continues to actively promote water conservation through a newly developed corporate water conservation strategy and is now proceeding with full scale implementation of innovative technology for

High Rate Treatment of combined sewer overflows. Another large scale initiative is an ongoing program to separate domestic and storm sewers to reduce combined sewer overflow events. Fort Erie and Welland have also initiated projects intended to reduce combined sewer overflows.

The extensive loss of fish and wildlife habitat in the AOC is being addressed by the NPCA and the Niagara Restoration Council. Habitat restoration is ongoing and significant progress has been made towards meeting delisting criteria. The Niagara River corridor was named as a binationally Important Bird Area (IBA) in 1996. A conservation plan for this IBA is being developed through a coalition of interested groups. The Niagara Restoration Council is undertaking a project to remove all barriers to fish passage in the watersheds within the Niagara AOC. In 2001, all barriers to fish passage were identified, mapped and classified by type and size. It is anticipated that the majority of barriers will be removed or mitigated by 2005, thus making hundreds of kilometres of upstream fish habitat available to spawning fish.

Progress has also been made in addressing contaminated sediments. Based on the contaminated sediments sites identified in the Stage 2 Niagara River RAP report, the NPCA has submitted a management proposal for all known sites. In 1995, approximately 10,000 cubic metres of contaminated sediments were remediated in a section of the Welland River adjacent to Atlas Specialty Steels. Biological sampling since the sediments were remediated indicates that this section of the river is recovering as anticipated. A sediment management strategy is being developed for Lyons Creek.

Very substantial progress has also been made jointly with the U.S., especially in reducing toxic chemicals. Monitoring results in the Niagara River show that the concentrations for most of the 18 priority toxics targeted by the NRTMP have been significantly reduced, in many cases by more than 50 percent. On the Canadian side, monitoring results for point sources between 1986 and 1995 show loading reductions of 99 percent for the 18 chemicals of concern.

***Delisting Outlook For The Canadian Side*:** Full implementation of remedial actions in the Niagara River AOC will require many years and is contingent on federal, provincial and/or municipal funding availability and in some cases private sector involvement. MOE has lead responsibility for the RAP and Environment Canada and the Niagara Peninsula Conservation Authority will continue to work in partnership as they move towards delisting. Remediation of CSO discharges is essential to complete RAP implementation and several large infrastructure needs have been identified. Infrastructure costs are estimated at $26M for high rate treatment of combined sewer overflows for the cities of Niagara Falls and Welland. Developing and implementing a contaminated sediment strategy for Lyons Creek will also require significant funding.

11.3.2 St. Lawrence River Area of Concern

The St. Lawrence River drains the Great Lakes and is among the largest rivers in the world. The AOC is an 80 kilometre stretch of the river that extends upstream from the Moses-Saunders power dam in Cornwall, Ontario, downstream to the eastern outlet of Lake St. Francis in Quebec. This AOC is a complex jurisdictional area involving Canada, the United States, Ontario, Quebec, New York State and Mohawks of Akwesasne interests. Separate RAPs were developed for the Canadian (Cornwall) and U.S. (Massena) sides of the St. Lawrence River, however a binational joint Problem Statement document was prepared in 1994.

11.3.2.1 St. Lawrence River at Massena, New York

***Background*:** NYSDEC began development of the St. Lawrence River at Massena RAP in 1988. This process is assisted by the Massena Remedial Advisory Committee (RAC) which consists of members

from industry, local government, environmental groups, sporting interests, academia, and business. The Stage 1 report was completed in 1990 and identifies use impairments, their causes, and sources. The Stage 2 RAP, completed in 1991, includes the development of remedial strategies to restore water quality and beneficial uses of the tributary rivers and the St. Lawrence River and to eliminate adverse impacts to the AOC from sources of pollutants at major local hazardous waste sites as well as from other sources within the Area of Concern watershed. A comprehensive RAP Update document was published in April 1995 which established a format to identify remedial strategies and track progress.

***Impairments*:** The waters and river bottoms of the AOC have been impacted by industrial discharges sources including Lake Ontario, municipal treatment facilities, atmospheric deposition, non-point source discharges and physical disturbances as a result of the power dam and seaway construction. The Stage 1 RAP identified industry as a major source of contaminants to the AOC. Stage 1 also confirmed two use impairments (fish consumption advisories, and fish habitat) and identified five other use impairments that will require further evaluation. A "transboundary impacts" use impairment indicator was added to the standard fourteen indicators developed by the International Joint Commission's (IJC) listing/delisting guidelines . A transboundary impact assessment is needed for a complete evaluation of this AOC.

***RAP Structure*:** Because of the international aspect of this RAP, an evaluation of the possible transboundary effects associated with the downstream interests and jurisdictions (Canadian, Provincial, and Mohawk Nation at Akwesasne) is an important consideration for this binational connecting channel Area of Concern. The St. Regis Mohawk Tribe has received New York State Environmental Bond Act funding to implement an erosion and nonpoint source pollution protection project. As New York State has taken the lead to address the Massena area impairments, Canadian jurisdictions have taken responsibility for RAP implementation concerning the Ontario and Quebec side of the river.

***RAP Status and Progress*:** Priority strategies involve completing the land-based and contaminated river sediment remediation, conducting further investigations, and reassessing use impairment status in light of remedial progress and additional study results. The latest RAP Status Report published in May 2000, identifies remedial progress and includes delisting criteria for the AOC. Efforts are underway to produce a Status Report update in 2004. Significant progress has been made with land-based remediation at the ALCOA (west), Reynolds Metals (now ALCOA east), and General Motors industrial sites, as well as with the contaminated sediment removal in the St. Lawrence River at General Motors and Reynolds Metals. Major dredging of the St. Lawrence River at the Reynold Metals site was conducted in 2001. Cleanup requirements now provide for contaminated dredged materials to be removed from the property instead of receiving on-site treatment and disposal.

***RAP Outlook For The U.S. Side*:** In addition to the Stage 1 Binational Summary document, International cooperation has been fostered by producing a joint monitoring statement and the current development of delisting criteria by each RAP's advisory committees. An annual ecosystem conference is conducted each spring to maintain information sharing for this important St. Lawrence River area. Significant funding opportunities are under development for the construction of the St. Lawrence Aquarium and Ecological Center (SLAEC) as well as an accompanying Great Rivers Institute (GRI). Further, the International Joint Commission has completed a RAP Status Assessment of the Area of Concern. The document notes the accomplishments in the AOC and makes recommendations to further address the use impairments including contaminated sediments. The Massena RAC is currently focusing on the identification of endpoints for establishing delisting criteria and goals. Following the completion of remedial activities, a reassessment of the use impairment indicators and the causes and sources is needed.

11.3.2.2 St. Lawrence River at Cornwall, Ontario

***Environmental Issues*:** The Cornwall waterfront has been the site of industrial activities for more than 100 years. Although many of the contaminant sources have been eliminated, historical inputs have continued to impact the aquatic environment as contaminated sediment and organisms transfer and cycle mercury and other metals. Local contaminant sources include industrial and municipal discharges, and diffuse sources such as urban stormwater and agricultural runoff. Contaminants also enter the AOC from upstream and from the Great Lakes via Lake Ontario and from air deposition. Land use practices, shipping and the extensive shoreline and water flow alteration that resulted from the construction of the St. Lawrence Seaway, continue to alter the natural ecosystem. Major environmental issues of concern in the area include:

- mercury, PCBs and other contaminants in water, sediments and fish;
- fish and wildlife health effects related to contaminants;
- bacterial contamination leading to beach closings;
- habitat destruction and degradation;
- excessive growth of nuisance aquatic plants;
- exotic species.

Impairments: The RAP has identified seven impaired beneficial uses in the Canadian portion of the AOC. Three more, fish tumours and other deformities, bird and animal deformities, and degradation of plankton populations require further assessment.

RAP Structure: There were 64 RAP recommendations for improving the aquatic environmental conditions in the AOC most of which have been implemented or are in progress. The St. Lawrence River Restoration Council provides the local lead for RAP implementation. The group has representatives from Environment Canada, the Ontario Ministry of the Environment, the Ontario Ministry of Natural Resources, the Mohawk Council of Akwesasne, local municipalities, environmental groups, the Raisin Region Conservation Authority (RRCA) and other groups.

RAP Status and Progress: Since 1990, the GLSF has provided over $2.3 million towards 25 restoration projects in the AOC. Partnerships have achieved over $5.6 million in direct partner funding including $3.8 million for urban infrastructure improvements, $1.8 million in-kind contributions and citizen participation valued at $900,000.

There have been several notable implementation actions in the St. Lawrence AOC:

- The City of Cornwall's Fly Creek Stormwater pond has been retrofitted to reduce contaminant loads to the river.
- There are no longer any significant sources of mercury or other heavy metals to the river in the Cornwall area.
- The littoral zone habitat strategy has been implemented along an eight kilometre stretch on the Cornwall waterfront. Sixteen projects were completed between 1994 and 2002. Preliminary monitoring indicates a dramatic increase in fish abundance and diversity.
- The first phase of the Cooper Marsh Enhancement Project has been completed. The result is an increase the amount of spawning and nursery habitat for fish and breeding habitat for migratory birds.

Outstanding issues in the St. Lawrence AOC include: the development of a sediment management strategy; assessing the status of zooplankton and phytoplankton populations; the restoration and protection of fish and wildlife habitat; a review of sources and levels of bacterial pollution in waters used for body contact recreation.

Cornwall Sediment Strategy - Environment Canada and the Ontario Ministry of the Environment are currently working in partnership with local municipalities, the Mohawks of Akwesasne, industry and environmental groups to develop a strategy for managing contaminated sediment in the AOC.

Fish Habitat Management Plan - Activities under this project will include research and compilation of existing information on fish and wildlife species, habitat types, shoreline alteration, nearshore currents, erosion and water quality into a GIS-based database to identify and prioritize data needs.

Municipal Wastewater Issues - Candidate projects include: 1) facilitating upgrades of smaller, downstream sewage treatment plants by providing technical assistance or assistance in obtaining infrastructure financing; 2) the completion of pollution prevention and control plans to manage stormwater and combined sewer overflows for communities within the AOC; 3) assisting small and rural communities in the AOC address issues of potential water contamination caused by inadequate septic systems.

Delisting Outlook: When a sediment management plan is developed and implemented, the RAP will be well on its way towards meeting its goals. A targeted approach over the next few years to complete all non-point source and habitat projects, and a dedicated effort to put mechanisms in place to maintain environmental quality is critical. Municipal infrastructure upgrades will also be required to address the management of sewage and wastewater in some communities within the AOC. When RAP implementation actions have been successfully completed, it will be imperative to monitor the recovery. This may be one AOC which becomes an Area in Recovery while the environment needs time to respond to the actions that have taken place.

11.4 U.S. Areas of Concern

11.4.1 Eighteenmile Creek

The Eighteenmile Creek Area of Concern (AOC) is located in the town of Newfane, Niagara County, in western New York state. The creek flows from the south and discharges into Lake Ontario, approximately 18 miles east of the mouth of the Niagara River, through Olcott Harbor. The AOC includes Olcott Harbor at the mouth of the creek and extends upstream to the farthest point at which backwater conditions exist during Lake Ontario's highest monthly average lake level. This point is just downstream of the Burt Dam located about two miles from the harbor.

***Background and RAP Structure*:** Development of the Eighteenmile Creek RAP was initiated in March 1994. The Area of Concern includes Olcott Harbor on Lake Ontario and Eighteenmile Creek upstream to a point just below the Burt Dam in the Hamlet of Burt. A combined final Stage 1 and Stage 2 RAP document was completed and published in August 1997 by NYSDEC in cooperation with the Eighteenmile Creek Remedial Advisory Committee. Efforts to complete this publication included conducting two RAP review workshops, public information and comment meetings, field trips, as well as numerous committee meetings

***Impairments*:** Past industrial and municipal waste disposal practices have contributed to the causes of use impairments in Eighteenmile Creek. Fish consumption restrictions exist because of PCBs and dioxins found in fish flesh. This is linked to Lake Ontario. The health of the benthos has been impaired by PCBs and metals in sediments. Bird and animal health is likely impaired by the PCBs, dioxins, DDT and its metabolites, and dieldrin found in fish flesh. PCB and metal contamination prevents open lake disposal of dredged sediment material. Additional investigations need to be conducted concerning fish and wildlife populations and the presence of fish tumors or other deformities.

RAP Status and Progress: A RAP Status Report document was completed in June 2001. An investigative study of the plankton community was conducted by SUNY College at Brockport under an EPA grant. The report was published and distributed. The results of the Plankton Study establish that the plankton use impairment indicator is not impaired. A presentation by the author was provided to the Remedial Advisory Committee in June 2002. The upgrading and addition of wastewater treatment facilities at Lockport is to be funded by the New York State Environmental Bond Act.

RAP Outlook: At an October 2003 RAP Workshop, Remedial Advisory Committee members decided to explore opportunities on how the committee can better address RAP implementation in conjunction with DEC and EPA. Currently, RAP activities are focused on continuing the investigation and assessment of creek sediments; evaluating possible sources of PCBs and other contaminants in the watershed; remediating inactive hazardous waste sites; correcting combined sewer overflows (CSOs); and, continuing surveillance activities. A recent USACE grant award to Niagara County Dept. of Panning, Development, and Tourism focuses various project components on habitat restoration and watershed management to benefit the AOC. The projects provide for streambank stability, sediment assessment, best management practices, and community outreach. A separate New York State Department of State grant will develop and implement a monitoring plan to document restoration activities. Other RAP implementation addresses: continued trackdown sampling for PCBs; assessment and remedial considerations for sediment sites such as the Barge Canal at Lockport and the William Street Island; an evaluation of potential pollutant sources within the sewer system in the City of Lockport; and, continued fish flesh analyses for contamination.

11.4.2 Rochester Embayment

The Rochester Embayment is an area of Lake Ontario formed by the indentation of the Monroe County (New York) shoreline between Bogus Point in the town of Parma and Nine Mile Point in the town of Webster, both in Monroe County. The northern boundary of the embayment is delineated by the straight line between these two points. The southern boundary includes approximately 9.6 km (6 miles) of the Genesee River that is influenced by lake levels, from the river's mouth to the Lower Falls. The drainage area of the embayment is more than 7,770 km^2 (3,000 square miles) in area. This area consists of the entire Genesee River Basin and parts of two other drainage basins; the easternmost area of the Lake Ontario West Basin and the westernmost area of the Lake Ontario Central Basin.

***Background and RAP Structure*:** Starting October 2003, the Monroe County Department of Health received EPA funding to provide RAP management. The focus is on research, priority project implementation, and delisting considerations. A number of initiatives need RAP reporting and coordination including Monroe County's source trackdown and CSO abatement, and the funded studies of local aquatic conditions. Monroe County is to develop RAP related programs and seek funding for RAP gaps and needs to address watershed improvements including nonpoint sources, habitat restoration and watershed openspace. The Monroe County Water Quality Management Advisory Committee (WQMAC) and its subcommittees provide advice and oversight on general water quality, public participation, and RAP implementation activities. Further, the Monroe County Water Quality Coordinating Committee (WQCC), continues to provide guidance contributing to RAP progress. The Stage 1 document was completed in August 1993.

***Impairments*:** Twelve of the fourteen IJC use impairments were identified as existing in the Area of Concern. The development of the Stage 2 RAP was completed and published in September 1997. The Area of Concern includes a 35 sq.mi. portion of Lake Ontario and a six mile reach of the lower Genesee River. RAP remedial measures address lawn care practices, wetland education, pollution prevention for auto recyclers and dentists, volunteer stream and wetland monitoring programs, advancement of

phosphorus removal at small wastewater treatment facilities, and a streambank erosion assessment program.

RAP Status and Progress: Watershed planning projects are in various phases of implementation. A Stormwater Coalition was formed to plan for compliance with new stormwater regulations. Completed projects include several point and nonpoint source pollution abatement projects, extensive combined sewer overflow abatement, and a mercury pollution prevention project. Publications include manuals for hospital mercury pollution prevention, auto recyclers, volunteer stream monitoring, and volunteer wetland monitoring; biannual newsletter; two watershed plans; a watershed developers packet; and a report on a water quality opinion survey.

RAP Outlook: Delisting criteria and monitoring methods for use impairments have been developed. Grants have been received for hyperspectral imaging of algae beds along the Lake Ontario shoreline, a study of the benthic health of the Rochester Embayment, and further development of monitoring methods for toxic-related use impairments. The RAP reporting was updated by a Status Report update in March 2001 and a RAP Addendum at the end of 2002. To address algae and nutrients, Monroe County sponsored a "Lake Ontario Algae Cause and Solution Workshop" in 2002 and later participated in a conference entitled "New York's North Coast: A Troubled Coastline". Reorganization of RAP oversight and sub-committees by Monroe County is likely now that the EPA grant has been received for RAP coordination in 2003. A Water Education Collaborative exists to coordinate all public participation activities regarding water quality in the County. The US Army Corps of Engineers has been proposed to assist funding a sediment transport study led by SUNY at Geneseo.

11.4.3 Oswego River

The Oswego River/Harbor Area of Concern (AOC) is located on the southeastern shore of Lake Ontario and is centered in the City of Oswego, New York. The AOC includes the harbor area and the lower segment of the Oswego River up to the Varick power dam. The harbor itself is characterized as a multiple-use resource and over 1.2 million people live in the drainage basin. The Oswego River watershed includes the Finger Lakes, industries, municipalities, and extensive areas of farmland and forest that expand an area of over 5,000 square miles. The Oswego River is second only to the Niagara River in size as a tributary to Lake Ontario. Upstream pollutants are known to have traveled through the river and harbor, and impacted the Lake Ontario ecosystem, thereby forming the basis for the Area of Concern designation.

***Background and RAP Structure*:** The Oswego River RAP process began in 1987 and the Stage 1 RAP was completed in 1990. Use impairments that were observed involved fish habitat and population loss, fish consumption restrictions, and undesirable algae. The impairments were linked to Lake Ontario and upstream sources. The Stage 2 RAP, completed in 1991, identified remedial strategy activities necessary to restore water quality in the lower river and harbor and to eliminate adverse impacts to Lake Ontario from sources of pollutants carried by the Oswego River. The advisory committee consisted of a multi-stakeholder group included persons from industry, environmental organizations, government agencies, academia, and private interests.

RAP Status and Progress: A comprehensive RAP Update document was published in December 1996 that established a format to identify remedial strategies and track progress. Because of the RAP, additional water quality and sediment investigations, as well as a fish pathology study, were performed in the Oswego River AOC. Significant upstream hazardous waste site remediation and point source pollution control measures have been accomplished. New York State Environmental Bond Act funding has assisted the City of Oswego in addressing sewer infiltration and overflows. A two-day technical

workshop was conducted in June 1998 to evaluate study results and assess use impairment impacts and needs. A Workshop Summary and RAP Update report was published in May 1999 that documents workshop proceedings, study results, and RAP implementation strategies. AOC delisting criteria were developed based on IJC and EPA guidance. In May 2002, a draft Stage 3- Delisting Proposal was completed by NYSDEC and the Remedial Advisory Committee (RAC). A "power point" presentation (also developed by NYSDEC and the RAC) on the delisting of the AOC was delivered four times in the local area. Group meetings (some open to the public) addressed by the presentations included: the RAP Remedial Advisory Committee, the Great Lakes Basin Advisory Council, the Oswego County Water Quality Coordinating Committee, the Oswego County Environmental Management Council, and the Oswego County Soil and Water Conservation District.

Beneficial Use Status and RAP Outlook: Resolution of the Oswego RAP use impairments is based on no contamination source specific to the AOC and a 40 year Federal Energy Regulatory Commission (FERC) power dam license. The delisting strategy relies on handing off the responsibility for resolving the larger (non-AOC) concerns to the appropriate oversight agency programs. Because the fish consumption advisory is lakewide and not specific to the AOC, it is to be addressed by the Lake Ontario Lakewide Management Plan. The fish habitat and population concerns are to be addressed by the FERC license. This is consistent with federal delisting criteria and supported by NYSDEC's Priority Waterbody Listing (PWL) in conjunction with the 303(d) listing, the new Watershed Restoration and Protection Strategies (WRAPS) initiative, and the Fish Health Advisory. Together, these responsible and appropriate agency programs will address the non-AOC sources and larger watershed concerns that are beyond the RAP scope. The Stage 3- Delisting Proposal has completed internal NYSDEC and other state agency review is now under further review by IJC, USEPA Region 2, and the Great Lakes National Program Office (GLNPO). A formal public comment period is planned. Delisting comments are to be incorporated with a responsiveness summary in a final delisting document. NYSDEC will then seek formal delisting action with EPA Region 2 through the United States Department of State. With the delisting proposal and limited resources for further activity, members of the Oswego RAC decided to discontinue regular meetings and the committee effective September 6, 2002. Certificates of Appreciation have been awarded to the RAC members, two of which are original members participating in the process since 1987. Committee members remain available for future consultation and necessary action to complete formal delisting.

11.5 Canada Areas of Concern

11.5.1 Hamilton Harbour

Hamilton Harbour is a 2,150 hectare embayment located at the western tip of Lake Ontario. The Area of Concern includes the harbour, Cootes Paradise wetland and open water, and the surrounding watershed drained by three main tributaries: Grindstone Creek; Red Hill Creek; and Spencer Creek, covering a total of 50,000 hectares. The urban population, which includes Hamilton, Burlington, Stoney Creek, Dundas and Ancaster, is growing rapidly and now is approaching 700,000.

Environmental Issues: The ecosystem of the harbour reflects its natural conditions (a small water body with a long retention time), a high volume of sewage treatment plant discharges, large scale industrial activities and extensive land use changes. The water and sediments are contaminated by metals, pesticides, PCBs, and PAHs. The sediments of Randle Reef and industrial boat slips are highly contaminated with PAHs and have an adverse effect on the local ecosystem. In addition, the shoreline has been radically transformed with 75 percent of wetlands eliminated and 25 percent of the harbour filled in. Habitat for fish and wildlife is greatly reduced and resident species are exposed to toxic contaminants. The water quality of the harbour continues to be characterized by poor water clarity, low oxygen levels, high nutrient levels and high bacterial levels.

Impairments: Hamilton Harbour AOC has twelve beneficial use impairments: restrictions on fish consumption; degradation of fish and wildlife populations; fish tumours; animal (snapping turtle) deformities; degradation of benthos; restrictions on dredging activities; eutrophication and undesirable algae; beach closures; degradation of aesthetics; added costs to agriculture and industry; degradation of phyto/zooplankton populations; and the loss of fish and wildlife habitat.

RAP Structure: In 1991, stakeholders organized into two distinct groups: the Bay Area Restoration Council (BARC) and the Bay Area Implementation Team (BAIT). BARC maintains a balanced voice for all stakeholders of the harbour, performs a watchdog role by monitoring RAP progress, and keeps the public informed. The BAIT is composed of the major implementors of the RAP. The RAP Office has recently completed a RAP Stage 2 Update that provides the current status of the RAP and identifies recommendations from the public. The Update was reviewed by the public, approved by the governments and sent to the IJC in 2003.

RAP Status and Progress: Very positive, visible progress has been made in restoring fish and wildlife habitat. Work at six sites has resulted in: restoration of 340 hectares of habitat; secured habitat for 670 nesting pairs of Caspian and common terns; considerable shoreline rehabilitation; the return of amphibians and reptiles at Cootes Paradise, and increased diversity of native plants and waterfowl partially due to a successful program of carp exclusion. Furthermore, as a result of the Hamilton Harbour Watershed Stewardship Project, over 6500 hectares of land have been protected since 1994 through verbal stewardship agreements in the Spencer and Grindstone Creek watersheds including 120 kilometres of riparian habitat and 2900 hectares of significant wetland and upland habitat.

Sediment remediation remains one of the priorities for Environment Canada in this AOC. Efforts will continue on Randle Reef and the Dofasco boat slip to clean up known sediment hotspots. Environment Canada is working with its government and industrial partners on the Randle Reef Sediment Remediation Project to dredge and contain approximately 500,000 cubic metres of contaminated sediment from Hamilton Harbour.

Progress has also been made on improving water quality by reducing the phosphorus, chlorophyll and bacteria levels in the harbour. Reduction of bacterial contamination was achieved by the installation of CSO tanks which store and channel excess storm and sanitary sewage to the Woodward Wastewater Treatment Plant. Further reductions have resulted from low-cost optimization techniques introduced at Halton's Skyway Wastewater Treatment Plant. As a result of these improvements, two beaches were opened in 1993 after a 50-year long swimming prohibition in Hamilton Harbour.

Another notable achievement of the RAP has been the substantial increase in public access to the shoreline and watershed. The Hamilton Harbour Waterfront Trail was opened in 2000 and has increased access to the shoreline to 21 percent. This is a considerable achievement considering that there was essentially no public access to the harbour when the RAP began.

Delisting Outlook: The Hamilton Harbour AOC cannot be delisted in the short-term since many of the issues affecting the harbour require significant capital costs and 10-15 years or longer to complete. The total funding required between now and 2015 to achieve delisting of the AOC has been estimated at $650M. This includes $543M for upgrades to Hamilton and Halton's Waste Water Treatment Plants and the Hamilton CSOs to meet RAP water quality targets. The other major capital cost is to remediate PAH contaminated sediments in the area of Randle Reef estimated at $31M. Smaller capital costs are: $9M for City of Hamilton water metering; $9M for further creation and maintenance of fish and wildlife habitat: and an additional $10M for recreational trail development of and enhancement of lands recently transferred from the Port Authority to the City of Hamilton.

11.5.2 Toronto and Region

The Toronto and Region AOC extends from the Rouge River in the east to the Etobicoke Creek in the west and includes six tributary watersheds which drain into Lake Ontario: Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek and Rouge River. The drainage basin of these watersheds covers 2 000 square kilometres, and over 40 percent of the AOC is still classified as rural. The AOC includes the City of Toronto and encompasses 11 other municipal jurisdictions within the neighbouring Regions of Peel and York. More than four million people reside in the Greater Toronto Area.

***Environmental Issues*:** Over the years, urban growth in the AOC has resulted in extensive physical restructuring of the shorelines, watersheds and landscapes. In the process, wetlands, forests, fish and wildlife habitat in the urbanized portion of the AOC were lost. Most of the stormwater in the city is discharged into rivers, creeks and Lake Ontario. The discharge contains high levels of bacteria and nutrients, heavy metal and organic chemical contamination, and this remains the single biggest cause of a degraded aquatic environment. In addition, the many industries of the region discharge into municipal sewage systems which are not designed to removed chemical contaminants. Agricultural non-point sources of sediments, nutrients and pesticides contribute to the loads measured at the river mouths.

***Impairments*:** The RAP has designated the following eight beneficial uses of the waters of the AOC as impaired: fish consumption restrictions, degraded fish and wildlife populations, degradation of benthos, restrictions on dredging, elevated nutrient levels, beach closures, degradation of aesthetics, and habitat loss. It has also designated the following three as requiring further assessment: fish tumours or other deformities, bird or animal deformities or reproductive problems, degradation of phyto/zooplankton populations.

***RAP Structure*:** A five year Memorandum of Understanding (MOU) between Environment Canada, the Ontario Ministry of the Environment, and the Toronto and Region Conservation Authority (TRCA) was signed in 2002. The TRCA is now taking the lead in the implementation of the RAP and will develop a

five year plan. Through the MOU, the RAP is continuing to support the various watershed alliances and councils that are working to improve key watersheds.

***RAP Status and Progress*:** There have been notable successes in the Toronto and Region AOC. Bacterial conditions have improved in the Eastern Beaches with the installation of two stormwater detention tanks that hold the water until it can be treated at the Ashbridge's Bay STP. Construction of a detention tunnel and treatment facility for combined sewer/stormwater has partly relieved the bacterial problems at the Western Beaches. In addition, various innovative and cost effective stormwater treatment systems such as exfiltration and flow balancing systems, were installed in the City of Toronto.

Other promising signs of progress include: removal of stream barriers returning historical access for salmon to the upper reaches of the Don River; the creation of 20 hectares of new waterfront fish and wildlife habitats during the 1990s; the presence of rainbow trout in the East Humber; and the first Ontario nesting of Canvasback Ducks.

Most of the causes of environmental degradation, however, remain in place--the Toronto Region loses 24 hectares of land to development every day. Urbanization and the large population base of the AOC are the largest challenge to restore the beneficial uses which are impaired.

Implementation of the RAP requires a long-term commitment, and one important component of this commitment will be the City of Toronto's Wet Weather Flow Management Master Plan (WWFMMP). This plan is based on the hierarchy of source control, pollution prevention and infrastructure improvement, and its implementation will require a paradigm shift in wastewater management. The Master Plan will identify the most effective means to introduce controls into the stormwater regime (both remedial and preventative) and will take advantage of new technologies for sewage/stormwater treatment. It focuses on swimable waterfront beaches; eliminating discharges of CSOs; protection against basement flooding and meeting the province's CSO policy; protection of the City's infrastructure from stream erosion; restoration of degraded local streams and improvement of stream water quality; reducing the extent of algal growth along the waterfront and in streams; and the restoration of aquatic habitat.

Another important component is the revitalization of the Toronto Waterfront. This will significantly rehabilitate fish and wildlife habitats and populations if it is undertaken in the context of ecological sustainability. The Toronto Waterfront Revitalization Corporation has made a commitment to sustainability. The RAP hopes to work with the Corporation and other partners to further incorporate the benefits of aquatic and terrestrial ecosystem restoration in the overall revitalization plan.

***Delisting Outlook*:** Implementation of the Toronto and Region RAP will be a decades-long undertaking. The City of Toronto is now considering a 100 year plan for the control of water pollution sources. The preliminary projection of capital costs for implementation of the wet weather flow recommendations of the Toronto RAP (excluding industry) is $1 billion over a 25 year period.

The RAP program is only one participant in a complex of agencies, large scale plans and external forces affecting Canada's largest city. The challenge facing the RAP and its management is to coordinate participation from others in achieving RAP goals while not being subsumed by larger scale economic activities and social trends.

11.5.3 Port Hope Harbour

Port Hope Harbour is located at the mouth of the Ganaraska River on the north shore of Lake Ontario, and 100 kilometres east of Toronto. The Town of Port Hope is located north of the Harbour. The AOC

includes the harbour area and extends 300 metres from the lower Ganaraska River to the confluence area bounded by breakwalls.

***Environmental Issues*:** Radioactive wastes were generated at a refinery (Eldorado Nuclear Limited) in Port Hope beginning in 1933. Low level radioactive wastes were initially stockpiled or disposed of in ravines and vacant lots in Port Hope during the 1930s. During the 1940s and 50s low level radioactive wastes were also placed in waste management facilities in two municipalities just outside of Port Hope. There is an estimated total of 1 to 1.5 million cubic metres of low-level radioactive waste and contaminated soils in the Port Hope area. The immediate health and safety risks have been assessed as minimal.

Within the harbour, most of the contaminant input occurred between 1933 and 1953 resulting from operations and waste management practices of the Eldorado refinery Process wastes were stored at the site and it is likely that surface runoff was the route of contamination for the harbour. An estimated 85,000-90,000 cubic metres of sediment containing low-level radioactive material is located within the turning basin and west slip of the harbour. Contaminants include uranium and thorium series radionuclides, heavy metals and PCBs.

In recent years, leaching of radioactive wastes and overflows at drainage ponds has occurred during heaving rains and has resulted in contamination entering the groundwater and Lake Ontario.

Impairments: Port Hope was initially designated as an AOC due to restrictions placed on dredging activities. There have been no other impaired beneficial uses identified.

Implementation Structure: Previously, Environment Canada was responsible for coordination of the Port Hope RAP. However, remediation of Port Hope Harbour is now following a different process, with progress dependant upon the selection and approval of an appropriate waste facility. Natural Resources Canada is working in cooperation with Environment Canada to develop the remediation of the Port Hope AOC within the larger low-level radioactive waste clean up in the Port Hope area.

In 1982 the federal government created the Low-Level Radioactive Waste Management Office (LLRWMO) to assume the responsibility of managing historic wastes in Port Hope and elsewhere in Canada. The office in Port Hope has assisted the RAP in developing costs estimates for cleanup, handles public information requests and offers assistance to residents to assess and remediate their properties. The LLRWMO has been designated by Natural Resources Canada as the proponent of the Port Hope Area Initiative.

Implementation Status and Progress: In March 2001, the Government of Canada (represented by Natural Resources Canada) and the three communities of the Town of Port Hope, the Township of Port Hope and the Municipality of Clarington, entered into a legal agreement for the clean up and long term management of local historic low-level radioactive wastes, including wastes found within Port Hope Harbour. The legal agreement is based on community-developed concepts for the local, long-term management of the wastes.

With the signing of the legal agreement, the Government of Canada began a 10 year, $260 million dollar plan called The Port Hope Area Initiative, to develop and implement a long term solution. Since that time, the Town of Port Hope and the Township of Port Hope have been amalgamated into one community, the Municipality of Port Hope.

Implementation of the legal agreement for the Port Hope clean up is now underway. The Low-Level Radioactive Waste Management Office (LLRWMO) is seeking the necessary approvals for development

of management facilities for the long-term management of the wastes from the Port Hope area, including those found within Port Hope Harbour..

Delisting Outlook: Natural Resources Canada is the lead for the clean up of all historic radioactive wastes found within the local municipalities, including those within Port Hope Harbour, and will work with Environment Canada to ensure that the requirements of the RAP are met. The development of low-level radioactive waste facilities will require licenses from the Canadian Nuclear Safety Commission and are subject to the Canadian Environmental Assessment Act. It is expected that the regulatory review process will be completed by 2006. An additional five years will be required for the physical clean up and emplacement of wastes in the newly constructed long-term management facilities.

11.5.4 Bay of Quinte

The Bay of Quinte is a narrow z-shaped inlet, 100 kilometres in length, located on the north shore of Lake Ontario's eastern basin. The Area of Concern contains the Bay and its tributaries and the drainage basin is the largest in Southern Ontario (17,520 square kilometers). The Trent River is the largest tributary entering the Bay of Quinte, influencing its water quality and water flow regimes. Parks Canada manages the Trent-Severn Waterway, of which the Trent River is a part.

Environmental Issues: The Bay of Quinte is a unique ecosystem within the Lake Ontario basin. Shallow, and flushed up to 10 times per year, in some respects the Bay behaves like a riverine estuary. The Bay has historically supported a large sportsfishery based primarily on walleye and valued at over $3 million dollars annually. In recent years the ecosystem of the Bay has been greatly influenced by invasive species, such as the zebra mussel, which, by ingesting plankton, have diverted this food source from fish species. Further, the aquatic environment has been altered decreased nutrient loadings, all of which has impacted the sustainability of the walleye.

The shoreline of the Bay contains 22 provincially significant wetlands, some of which are under pressure from urban development in the cities of Belleville, Trenton and the Towns of Napanee, Picton and Deseronto. Four First Nations are also located within the drainage basin.

Impairments: Nutrient loadings from sewage treatment plants and surface water runoff from agricultural and rural lands lead to cultural eutrophication, which was one of the main reasons why the Bay was listed as an Area of Concern. The Remedial Action Plan for the Bay identifies 10 Impaired Beneficial Uses that result from 4 main issues: i) excessive nutrients, ii) habitat loss (particularly coastal wetlands), iii) contaminated sediment from historical mining and industrial activities, and, iv) bacterial contamination from sewage treatment plants, stormwater discharge and agricultural runoff (which lead to beach closures). In addition, the incidence of fish tumours and other deformities is an issue which requires further assessment

RAP Structure: In 1997, a Restoration Council, with membership from Federal and Provincial Government agencies (EC, MOE, DFO, MNR, OMAF), local conservation authorities and Quinte Watershed Cleanup was formed to oversee the implementation of the 80 recommendations from the Remedial Action Plan (RAP). The Department of National Defense and the Mohawks of the Bay of Quinte have joined the Restoration Council since that time. In addition, Quinte Watershed Cleanup originated from a public advisory group set up to advise the Provincial and Federal Government during the development of the RAP. The Quinte Watershed Cleanup is a local community based group that works to promote the restoration and protection of the Bay of Quinte.

In 2000, a major public consultation was undertaken to establish restoration targets for the Bay of Quinte. The public was supportive of the proposed delisting targets which formed the basis for a Five Year Action Plan and 24 recommended environmental actions which when completed, should lead to delisting.

RAP Status and Progress: Substantial progress toward delisting the Bay of Quinte Area of Concern has been made. Over 27,000 hectares of farmland have been converted from conventional to conservation tillage, and phosphorous inputs from rural sources have been lowered at source by more than 16,000 kilograms annually. At sewage treatment plants bordering directly on the Bay of Quinte, phosphorous loads have been reduced from 50 kg/day in 1986 to less than 25 kg/day in 1997 with cost savings of $1.75 million resulting from sewage treatment plant optimization for four facilities within the watershed. Within the Bay of Quinte, phosphorous concentrations are approaching the Bay of Quinte RAP target of 30-40 g/L. Water clarity is improving and the algal blooms are less severe. Direct discharges of industrial wastes have been substantially lowered. Beach closings occur less frequently. Over 50 kilometres of shoreline have been planted with native trees, shrubs and grasses to reduce erosion and improve habitats. Three hundred and fifty-four hectares of wetlands has been rehabilitated and protection of an additional 482 hectares of wetland.

Delisting Outlook: A Phosphorus loading model is under development that will assist the Restoration Council in determining and implementing a phosphorus management strategy for the Bay which could include changes to municipal phosphorus loading "caps". Detailed delisting criteria for fish and wildlife communities and habitats are still to be developed. Also, based on existing natural heritage strategies and a fish habitat management plan (under development), additional habitat conservation and protection measures may be required.

11.6 Actions and Progress

The information contained in this chapter has been compiled based on past documents and was updated as of December 2003. The RAP process is a dynamic one and therefore the status will change as progress is made. This chapter will be updated in future LaMP reports as appropriate.

11.7 References

Environment Canada, Remedial Action Plan Web site: *http://www.on.ec.gc.ca/water/raps/*

Government of Canada, *Canada's RAP Progress Report 2003, Restoration Programs Division*, Environmental Conservation Branch, Environment Canada-Ontario Region, 2003.

Great Lakes National Program Office (GLNPO) Web site: *http://www.epa.gov/glnpo/aoc/*

Field Code Changed

CHAPTER 12 LAMP WORKPLAN ACTIONS AND PROGRESS

12.1 Summary

The LaMP parties developed a new 5-year binational workplan for the Lake Ontario LaMP which became effective in January 2005. The workplan outlines binational efforts to restore and protect Lake Ontario and its biological resources. The LaMP workplan is a fundamental component which directs and determines the progress towards achieving this goal.

The workplan contains many activities relating to the chemical, biological, and physical integrity of the lake, and also the LaMP's public outreach efforts; however, in the upcoming years, special attention will be concentrated on the following activities:

- Coordination of binational monitoring efforts and programs to better assess the health of Lake Ontario and its ecosystem.
- Reducing critical pollutant loadings to the lake.
- Reporting on the status of the LaMP's ecosystem indicators, and adopting new indicators.
- Assessing the current status of the lower food web and the fisheries.
- Re-evaluating the status of the Lake's beneficial use impairments.
- Developing a binational habitat conservation strategy.
- Conducting public outreach and promoting LaMP partnerships and stewardship of the Lake and its watershed.

Table 12.1 is a summary of the actions and progress made in all the workplan activities as of December 31, 2005. The full 5-year workplan can be found in Appendix D of this report.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
A. Chemical. Reduce inputs of LaMP's six critical pollutants		
1. Goals, objectives and targets		
a. Update adopted ecosystem indicators and make progress on additional indicators and target levels for critical pollutants.	LaMP to report on adopted indicators in LaMP Status 2006.	Indicators are being updated for LaMP Status 2006.
2. Problem identification		
a. Update current total lake contaminant problem.		
Update estimates of Lake Ontario critical pollutant loadings	LaMP to refine loadings estimates with new data in LaMP Status 2006	Draft chapter under review. Final version expected in LaMP Status 2006.
Evaluation of sediment core data to use as an indicator of contaminants in sediment, consistent with SOLEC sediment core indicator and establish a long term monitoring strategy.	Collect Sediment Core samples from the Lake Ontario central basin & Niagara River bar in 2005/06.	A sediment core from Lake Ontario central basin was collected in 2005 & is being analyzed. Planning for the collection & analysis of a Niagara River bar sediment core is underway.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
b. Cooperative monitoring	See specific deliverables below	Cooperative monitoring projects are all on track. (see specifics below).
Coordinate side-by-side analytical comparisons among 4 participating LaMP parties.	2005 – Party participants to evaluate data from Phase IV. 2006 – participants to prepare summary of data & submit a report to the LaMP on the comparability of results.	Parties are beginning to tabulate phase IV data.
Coordinate atmospheric deposition study	2005 – completed calculation of Hg load to Lake. 2006 – incorporate findings to date in LaMP Status 2006. Continue calculations of loads of dioxins and PCBs to Lake, based on sampling.	Sampling is continuing at land based site at Sterling, NY. Load calculation to Lake Ontario for Hg is completed and incorporated into the mass balance model for TMDL purposes. New data was added to LaMP Status 2006. Investigators are now calculating loads of PCBs and dioxins. These results will also be incorporated into the mass balance model.
Lake Ontario toxic chemicals monitoring surveys	2006 – EC-three open lake surveys 2006 – OMOE - nearshore survey	OMOE-regular nearshore monitoring work on Lake Ontario in 2006 will include assessment of toxics in sediment and suspended solids. EC- Spring, Summer & Fall open lake surveys in 2006 for toxic chemicals in dissolved phase water, sediment cores, and air.
3. Source identification		
a. Inventories		
Binational Sources & Loadings Strategy, to include updating of tables, maps, identification of air & water sources & prioritized listings of sources.	LaMP to update inventory and report in LaMP Status 2006.	Inventory data for tables partially updated as follows: 1) Niagara River updated for 2006; 2) atmospheric loadings and volatilization updated based on IADN and LOADS; 3) loading from Canadian point sources updated for 2006, based on NPRI; 4) Canadian and US tributary loadings updated; 5) US Point Sources and St. Lawrence River update pending assessment of significant change; otherwise to remain the same.
US: Tributary Monitoring	2005-2006 EPA to sample tributaries for critical pollutants, analyze samples & prepare report. Incorporate data into LaMP Status 2006. A summary report covering 2002 through 2004 monitoring will be prepared in 2006. 2006 – NYSDEC planning an intensive 5-yr tributary load project with EPA funding.	Eighteenmile Creek, Genessee River, Oswego River, Salmon River & Black River were monitored in May and August 2005. Four additional smaller tributaries were also sampled. Analytical data are added to a cumulative spreadsheet as they become available. The spreadsheet is circulated after each update. NYSDEC will begin an intensive 5-year project to determine tributary loads of critical LaMP pollutants in Eighteenmile Creek, Genessee River, Oswego River, Salmon River & Black River in 2006.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
Canada: Report on priority watersheds to include status information; remedial measures; monitoring; recommendations for further action.	2005 – EC to do further confirmation & follow-up sampling. EC to report on follow-up work (areas with PEL exceedances) with recommendations for further action. EC/OMOE to prioritize areas and develop workplan for follow-up work/trackdown strategies. 2006 – EC/OMOE to prepare final report with recommendations for PEL exceedances.	Follow-up confirmation sampling completed. Report for 2005 work complete; workplan is being prepared.
b. Source Trackdown		
United States: trackdown at Genessee River, Eighteenmile Creek and Black River.	2006 – RAP Coordinator leads planning trackdown activities: Monroe County, NY to conduct study of PCBs in the Rochester's westside Interceptor System based on EPA funding. Niagara County Soil & Water Conservation District to investigate PCB sources in Eighteenmile Creek based on EPA funding.	To date, source trackdown has resulted in various actions: Genesee River – at Rochester, reevaluation of wastewater treatment and point source discharge limits according to GLI and SPDES permit requirements including added pretreatment and pollution minimization provisions has occurred. Monitoring and remedial measures are ongoing and include Monroe County PCB trackdown in Rochester sewer system & monitoring treated effluent at waste treatment facility. Eighteenmile Creek – the Lockport wastewater treatment facilities have been upgraded with NYS Environmental Bond Act funds. With RAP Coordination activities now led by the Niagara County Soil & Water Conservation District starting in 2005, data synthesis, trackdown, and remedial measures in the AOC and watershed are to be further assessed, reported on, and implemented. PCB source trackdown is underway. Black River – at Carthage and Watertown completed its waterbody inventory assessment in 2005. Updating is to include revised status of Priority Waterbody strategies. Evaluation of PCB sources and further remedial measures is ongoing.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
Canadian PCB trackdown at 12 Mile Creek, Cataraqui River & Etobicoke Creek. The continuation of studies and analysis for contaminant source identification and sediment issues, and monitoring as required. Confirm point/non-point sources of chemical contaminants.	12 Mile Creek – 2006 On-going follow-up being conducted. Voluntary sampling being conducted by the City of St. Catharines. Etobicoke Creek – 2005 Further sampling undertaken. 2006 – Evaluate and assess data. Cataraqui River – 2006 Re-assessment phase: conduct monitoring to assess remedial measures (dredging) undertaken in December 2004.	12 Mile Creek – Initial analysis suggests an upstream source of PCBs. Etobicoke Creek – Actively looking at potential sources that have been identified (i.e. former landfills). Working in partnership with municipalities and others to achieve voluntary compliance. Cataraqui River – A $300,000 multi-government project that removed 90 truck loads (1134 cubic meters wet volume or 497 cubic meters dry volume) of PCB contaminated sediment was completed in 2005. The partners on the project were: OMOE; OMNR; EC; Transport Canada; the City of Kingston; the Kingston Rowing Club; and the Frontenac Lennox & Addington Health Unit. The partners worked together to provide the funding, expertise and approvals to remove, and to safely dispose of, the contaminated sediment along the Kingston waterfront near Cataraqui River.
Canadian Project Trackdown Part II	Mouth of the Trent River (Bay of Quinte watershed) – High levels of Dioxins/Furans have been located in the sediment at the mouth of the Trent River. Further investigation is to be carried out in 2005/06. Pringle Creek/Whitby Harbour – OMOE identified elevated levels of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in sediment and biota collected from Pringle Creek and Whitby Harbour.	Mouth of the Trent River (Bay of Quinte watershed) – Ongoing Pringle Creek/Whitby Harbour – OMOE is currently carrying out further studies to assess remedial options.
4. Reduction Strategies		
a. Regulatory and voluntary actions		
Regulatory actions	LaMP to facilitate & coordinate transfer of information from LaMP parties to appropriate enforcement, regulatory & remedial action branches of the LaMP parties. LaMP to report new regulatory actions & progress of LaMP agencies in LaMP Status 2006.	United States, New York – Updated PCB requirements are added to SPDES point source discharge permits addressing effluent, pretreatment, and pollution abatement/ minimization. Grant funding for upgrades at Carthage and Lockport have improved treatment results. Industrial pretreatment controls and the shutdown of certain manufacturing facilities address some key sources of contamination. NYSDEC has developed a "Pollution Minimization Program (PMP) Plan" guidance

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
		manual, initially focusing on mercury discharges, to assist point source dischargers in meeting strict limit requirements. Ontario is moving forward with the government's commitment to phase out coal-fired electrical generating stations within the province. Of significance to Lake Ontario is the closing of the Lakeview (closed April 2005) and Nanticoke (planned closure 2009) stations. The closing of these two coal fired generating stations will help reduce both smog causing pollutants and an estimated 259 kilograms/year of mercury loading to the environment within the lake basin area.
Voluntary actions and pollution prevention programs	LaMP to coordinate with Binational Toxics Strategy and agencies hazardous waste minimization & pollution prevention programs to encourage action on sources polluting Lake Ontario. LaMP to identify existing grants & programs; develop a strategy for promotion of pollution prevention programs. LaMP to facilitate partnerships between stakeholder groups for promoting pollution prevention. 2005 – Article on NYS pesticide clean sweeps in LaMP *Update 2005*. 2005 – Clean Sweep- Ontario Waste Agricultural Pesticides Collection Program to offer Ontario farmers safe, free disposal of outdated, de-registered, unwanted pesticides. 2006 – Monroe County, NY to begin a Mercury educational & sampling effort, funded by EPA.	NYS pesticide clean sweeps reported in LaMP Update 2005. Additional clean sweeps are planned for Central and Western basins. 2005 – Clean Sweep- Ontario Waste Agricultural Pesticides Collection Program offered Ontario farmers safe, free disposal of outdated, de-registered, unwanted pesticides. NYSDEC point source discharge permit renewal process to address & encourage voluntary actions at industrial & municipal permitted facilities through implementation of the *Pollution Minimization Plan manual.*
b. Mass balance model		
Develop plan for binational management oversight	LaMP to evaluate results and determine how the model can be used as a predictive tool in various management scenarios	PCB model workshop held in January 2004 for LaMP representatives. PCB model software was provided to the LaMP at that time. Hg submodel is under development.
Application of the model for PCB load reduction activities.	Both US & Canada to consider applying the model for PCB load reduction activities, consistent with regulations/framework of each country. EPA to fund project for	EPA is funding a project for technical support necessary to assist in the development of a PCB TMDL for Lake Ontario.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
	technical support necessary for the development of a PCB TMDL for Lake Ontario	
Integrate new data into model	EPA to integrate new data from cooperative monitoring into the mass balance model. Extend LOTOX2 model to other critical pollutants.	EPA-funded grant to integrate new data and add other critical pollutants is ongoing.
B. Physical/biological		
1. Goals, objectives and targets		
a. Update adopted ecosystem indicators and consider additional indicators and targets for physical and biological objectives as information becomes available.	LaMP to update adopted indicators in LaMP Status 2006.	Indicators are being updated for LaMP Status.
Mink and otter indicator	LaMP to publish report on status of mink/otter populations in LaMP Status 2006. OMNR to update Ontario populations in 2006.	Mink project in Monroe County, NY is detecting populations with videomonitoring and analyzing tissues. Report is due in 2006. OMNR plans to update Ontario populations in 2006.
Bald eagle indicator	2005 – Final report to be distributed to agency staff & potential partners such as local planning boards. 2006 – LaMP to encourage partnerships to conserve & restore identified bald eagle habitat areas & to develop new nesting sites.	LaMP has initiated and obtained USEPA and OMNR/COA funding for a project on "Conserving Lake Ontario & Upper St. Lawrence River Bald Eagle Habitats." The primary objective of the study is to identify and prioritize remaining high quality bald eagle nesting and overwintering habitats. A binational draft report was presented at the December 2004 meeting and is now being finalized.
Fish indicators	2005/2006 – Update lake trout & preyfish indicators in LaMP Status 2006.	LaMP Status 2006 being updated.
Coastal Wetlands Indicator	2005/2006 – Work with the Great Lakes Coastal Wetlands Consortium to develop implementation plan for proposed wetland indicators.	LaMP partners liaising with the Great Lakes Coastal Wetlands Consortium to plan binational workshop/information session in 2006.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
b. Evaluate information to complete assessment of beneficial use impairments.		
Benthos, Phytoplankton, Zooplankton Impairments	2005 – Complete data analyses of the Lake Ontario Lower Aquatic Foodweb Assessment (LOLA). 2006- LaMP to prepare LOLA synthesis report with recommendations for future actions.	Cornell University working with Lamp partners in coordinating data analyses. LOLA data workshop held Nov. 2005. Preliminary report expected in Spring 2006.
Fish population impairment	2005 – LaMP Management Committee, working in conjunction with the Lake Ontario Committee, to change status of fish population impairment. 2005/2006 – NYSDEC Creel Survey to be carried out to obtain information on # of fish caught by species & other information in 28 Lake Ontario tributaries. Data will improve understanding & management of the fishery. 2005/2006 – NYSDEC & Ontario to continue their ongoing assessments of fish populations. Information to be incorporated into the LOC Annual Report.	LaMP Management Committee changed status of fish populations from unimpaired to impaired; decision documented in LaMP *Update 2005*. LaMP Status 2006, Ch. 4 Beneficial Use Impairments, is being revised to reflect impairment status change from unimpaired to impaired for fish populations only. Relevant chapters of LaMP Status 2006 are being revised to indicate the change and additional information. NYSDEC Creel Survey, and NYSDEC/Ontario fish population assessments are ongoing.
Fish population remediation	2005/2006-LaMP to comment & support remediation plans for offshore food web & support Lake Ontario Committee remediation work. 2006- LaMP to support OMNR grant application for continued restoration efforts of offshore food web.	LOC is conducting research into the culture side of deep water ciscoe restoration. COA project focuses on gamete collection, culture & disease testing, to address the impaired fish population status.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
Lake Ontario biomonitoring and water quality surveys	2005/2006 – NYSDEC, USFWS & Cornell University cooperative monitoring. Conduct annual monitoring of phosphorus, chlorophyll a & zooplankton in NY waters. Results to be reported annually in NYSDEC Lake Ontario Unit, the St. Lawrence Unit Annual Report to the Lake Ontario Committee, & the LaMP. 2005/2006 – EPA to monitor Lake Ontario Spring & Summer at 8 open lake stations each year. 2006 – EC to conduct open lake water quality surveys.	The cooperative monitoring program between NYSDEC, USFWS & Cornell is monitoring lower food web parameters phosphorus, chlorophyll a and zooplankton. Sampling at 7 nearshore locations & 3 embayments along south shore from Niagara River to Chaumont Bay 12x /yr from May to October. Offshore sampling occurs during other offshore sampling programs. EPA conducted April & September 05 surveys. Monitoring includes phosphorus, nitrogen, silica, chloride, conductivity, dissolved oxygen, pH, physical parameters, phytoplankton, zooplankton & benthic community analyses.
2. Problem identification		
a. Habitat assessment		
Canadian habitat assessment and Watershed Management.	Cdn LaMP partners to identify & promote watershed management strategies in conjunction with Conservation Authorities and other agencies.	MOE is implementing a watershed management approach to water protection - with a major focus on source protection. Cdn LaMP partners are working with Lake Ontario Committee on COA funded activities related to fish and wildlife habitat issues in the AOCs and throughout the Lake Ontario basin. Eastern Habitat Joint Venture contributing funds to secure wetland habitats within AOCs.
US habitat assessment, strategy and actions.	2005 – EPA funded New York Rivers United project to begin a review of opportunities to restore upstream passage along Lake Ontario Tributaries. 2006 – Finalize US habitat assessment report. 2006 – Great Lakes islands priorities for long term conservation to be determined as to biological high diversity; threat analysis; not well protected. Islands to be selected for conservation. 2005/06 – NYSDEC to develop a Comprehensive Wildlife Conservation Strategy to focus on species in greatest need of conservation & identify management needs & strategies. 2006 – Incorporate US habitat assessment, including the	New York Rivers United final report is being developed in 2006. Draft US habitat assessment report was discussed with government agencies, NGOs and academics at workshop in November 2004. Final draft expected 2006. Great Lakes islands project finished mapping of islands; next step is ranking islands by priorities and selecting top priority islands for conservation. Draft NYS Comprehensive Wildlife Conservation Strategy has been written, including data on population & habitat trends, species at risk, threats & recommendations. Report notes that the bald eagle population is increasing; river otter is stable. The Lake Ontario Coastal Initiative, a private-public partnership funded by EPA, is completing the coastal strategic action plan to restore, remediate, protect, and conserve the 300 mile Lake Ontario coastal region.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
	Comprehensive Wildlife Conservation Strategy, & Lake Ontario Coastal Initiative strategy into the development of a binational habitat conservation strategy.	
Binational habitat conservation strategy	2005/2006 – EPA funded TNC to complete binational GIS data base of species & ecological systems; LaMP agencies to begin working with TNC on developing binational habitat strategy.	TNC is beginning to coordinate with LaMP agencies, NGOs , state & local governments for binational strategy.
Establish value added linkages to International Joint Commission's water level study.	2005/2006 – LaMP to integrate new technical data & information into LaMP reports, where applicable. LaMP to review Lake Ontario/St. Lawrence River water level control study.	The LaMP has been involved in the review of the Lake Ontario-St. Lawrence River water level study options and provided comment in support of the "Environmentally Balanced" Plan B.
Work with Great Lakes Fishery Commission's Lake Ontario Committee to identify priority projects & investigations; develop common indicators.	2005 – LaMP to work with Lake Ontario Committee in updating the status of beneficial use impairments for fish populations. 2006 – Participate in development of Lake Ontario Committee revised Fish Community Objectives for Lake Ontario.	LOC & LaMP collaborated to prepare a report for LaMP *Update 2005*. LOC to seek editorial & scientific peer review from LaMP for Fish Community Objectives being developed in 2006.
b. Invasive species	2005 – Review results of the LOLA project (B.1.b). 2006 – LOLA draft report to circulate for comments. 2005/2006 – LaMP to update available information and research on invasive species and recommend appropriate management options and strategies where necessary.	Assessment of LOLA project & data is ongoing. LaMP participated in LOLA data workshop. USFWS conducting annual surveys 2x/year in Lower Genessee River for ruffe as surveillance to identify potential introduction of this non-native species into Lake Ontario. Update LaMP Status report to include information on round goby as well as potential new invasive species such as ruffe and Asian carp. Report on activities of the USFWS, OMNR, DFO.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
c. Human Health Issues	LaMP to maintain connection with the Binational Great Lakes Human Health Network. LaMP to work with Network to gather/exchange information pertaining to human health. LaMP agencies to provide the public with advice on the safe consumption of Lake Ontario fish. Cdn LaMP partners to liaise with the Binational Great Lakes Human Health and Canadian Great Lakes Public Health Networks, and/or Human Health agencies, to gather/exchange information on current & emerging human health issues of relevance to the LaMP. Cdn LaMP partners to identify actions & address current & emerging human health issues of relevance to the LaMP & make that information available to the public. 2005- Health Canada to establish Canadian Great Lakes Public Health Network.	HHN Charter was finalized by network members. There are 31 members, including federal agencies (EPA, Health Canada, ATSDR, FDA), states and tribes. The US domestic network is in place with 6 Great Lakes states including NYS. Communication: Conference calls, emails and web conferencing. EPA & EC participate in Network conference calls. Information exchange: EPA, ATSDR and IJC websites; meetings and conferences. HHN EPA & ATSDR members are preparing information on a number of health issues. NYS advised public on the safe consumption of Lake Ontario fish through the publishing of NYSDOH Chemicals in Sportfish & Game 2004-2005 Health Advisories. US LaMP partners, in conjunction with NYSDOH, developed & posted fish consumption advisory signs at 18 Mile Creek, after sampling revealed high levels of PCBs & no signage at popular fishing spots. Health Canada established the Canadian Great Lakes Public Health Network. Collecting relevant health information as it becomes available. OMOE, Ontario Ministry of Health and Long Term Care and the Medical Officers of Health have been added to the Canadian Great Lakes Public Health Network. OMOE to provide the public with advice on the safe consumption of Lake Ontario fish through the publishing of its Guide to Eating Ontario Sport Fish in 2005/06 and 2007/08.
d. Contaminants in fish	2005/06 – EPA annual monitoring lake trout at North Hamlin/Oswego for Lake Ontario chemicals of concern. 2005/06 – Collect & analyze salmonid eggs/fillet muscle tissue from Salmon River Altmar Fish Hatchery for PCBs, organochlorine pesticides (OCs) & polybrominated diethyl ethers (PBDEs). 2005/2006 –OMOE/OMNR to continue program to sample	EPA annual lake trout monitoring for Lake Ontario chemicals of concern PCBs, DDT, Hg, mirex, dieldrin, dioxin/furan, PBDEs & PFOS. PCNs are monitored every 5 years. (www.epa.gov/glnpo). Project funded by EPA to analyze salmonid eggs and fillet muscle tissue from NYS Altmar Fish Hatchery on the Salmon River begun. Project to analyze PCBs, Ocs and PBDEs. OMOE will undertake sport fish (in partnership with OMNR) and juvenile fish monitoring at

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
	sportsfish in Lake Ontario and sportsfish and Young-of-the-year at Areas of Concern, and analyze for contaminants.	selected locations in 2006.
e. Emerging Issues	2005 – LaMP to facilitate & promote collection of information on emerging issues. 2006 – LaMP to assess available information & research and recommend appropriate management options & strategies where necessary. 2006 – US LaMP partners to determine interaction with Great Lakes Regional Collaboration strategy.	Tracking emerging issues such as Botulism E , proposed water level regulation plans, introduction/spread of new invasive species, interbasin water transfer, proposed wind power developments, and others as they arise. Evaluation of PBDE, and other emerging compounds to be undertaken by EC, OMOE and EPA. NYSDEC & OMNR monitoring shoreline for sick & dead birds & fish; testing for Type E botulism, & other diseases.
C. Public Outreach, Consultation, Reporting and Communicating		
1. Promote Partnerships	LaMP to continue to seek out partnerships for public involvement opportunities; LaMP to approach the Centre for Sustainable Watersheds (CSW) and Finger Lakes-Lake Ontario Watershed Protection Alliance (FL-LOWPA) to participate in public meeting in June 2005; provide LaMP information, display, public outreach materials; continue partnership with the IJC water levels study.	CSW and FL-LOWPA participated in LaMP public meeting in Kingston, Ontario. LaMP representatives continue to work with IJC Study's Environmental Technical Work Group.
2. Promote stewardship	LaMP to develop a strategy for more proactive promotion of stewardship; identify community-based actions & partnerships. 2005 – Continued partnership with the Marine Museum in Kingston, to maintain EcoGallery featuring the LaMP. 2005 – OMOE/OMNR participation at Perch Derby-Kingston to promote stewardship through displays and information handouts.	PIC will produce info packages for WG members on available outreach materials to take to meetings with stakeholders and the public. Letter to go out to potential partners requesting information on upcoming meetings. PIC is developing distribution list. LaMP held public meeting in Kingston, Ontario June 2005 on stewardship theme. Canadian LaMP partners developed an exhibit at the Marine Museum of the Great Lakes in Kingston, Ontario, to educate people about the Lake Ontario ecosystem and to promote stewardship.
3. Reports	LaMP to publish *LaMP Update* in 2005 and 2006 and biennial *LaMP Status* in 2006.	LaMP *Update 2005* published & mailed out to public June 2005.

Table 12.1 Status of Actions and Progress (as of December 31, 2005) in all of the 5-Year Binational LaMP Workplan Activities (for the full 2005-2009 Lake Ontario workplan, see Appendix D)

LaMP Activities	Deliverables 2005/2006	Status of Activity
4. Binational Public Meetings	LaMP to hold public meeting in Kingston in June 2005; joint LO LaMP/NRTMP meeting to be held in Niagara Falls, NY in 2006.	LaMP held binational public meeting in June 2005.
5. Prepare outreach material as necessary	LaMP to review update of display; produce other materials as needed	Ongoing
6. SOLEC/IJC Meetings	LaMP to participate in IJC Great Lakes Conference & Biennial Meeting (June 2005) and SOLEC in 2006	LaMP participated in IJC 2005. LaMP display and materials were available.
7. Maintain information connection	LaMP to update & maintain Lake Ontario website. LaMP to maintain mailing list. LaMP to encourage other GL and non-governmental organizations to add links from their websites to Lake Ontario website.	Ongoing.
8. Information and data transfer	LaMP to submit data for inclusion into other databases, such as the IJC database. LaMP to promote information exchange and the availability of data for the public and stakeholders.	Letter to IJC 7/05 giving LaMP perspective on the proposed candidate plans for the IJC Water Level Study.

CHAPTER 13 LAMP NEXT STEPS

13.1 Summary

The LaMP parties will continue their cooperative efforts towards the restoration and protection of Lake Ontario and its ecosystem. The LaMP workplan outlines details of activities by the LaMP parties for the next 5 years. In the upcoming years, special attention will be concentrated on the following activities:

- Coordinating binational monitoring efforts and programs to better assess the health of Lake Ontario and its ecosystem.
- Reducing critical pollutant loadings to the Lake.
- Reporting on the status of the LaMP's ecosystem indicators, and adopting new indicators.
- Assessing the current status of the lower food web and the fisheries.
- Re-evaluating the status of the Lake's beneficial use impairments, as needed.
- Developing a binational habitat conservation strategy.
- Conducting public outreach and promoting LaMP partnerships and stewardship of the Lake and its watershed.

The updated workplan and relevant documents can be viewed on the website at www.binational.net.

13.2 Next Steps

The parties of the LaMP will continue efforts to restore and protect Lake Ontario and its biological resources. The LaMP workplan directs and determines progress towards achieving this goal. An updated LaMP workplan became effective in January 2005 and is based on a 5-year schedule. Some of the activities that the LaMP is pursuing are described below.

Contaminant trackdown efforts in the US and Canada will continue so that contaminant sources can be identified and addressed.

Coordination of binational monitoring efforts, particularly those related to the LaMP's ecosystem indicators, has proven to be valuable for the LaMP, and will continue to be a special area of emphasis for future years. Planning is underway to continue the data analysis from the major binational monitoring efforts, to disseminate this information and evaluate the management implications and follow-up that will evolve from these efforts.

Further assessment of the biological aspects of the Lake is planned including the possible development of new biological indicators to establish well-defined endpoints for the LaMP's restoration efforts.

The Lake Ontario LaMP has leaped ahead in binational cooperative projects and sharing in recent years. We plan to continue and expand our collaborative efforts in the areas of bald eagle conservation and restoration and monitoring sediment contaminants.

A binational effort is planned to enhance habitat management. This will result in a binational data base and strategy for conservation. The coordinated work will draw information from the Canadian habitat assessment, New York State's Comprehensive Wildlife Conservation Strategy, the US Lake Ontario Coastal Initiative, and other relevant habitat documents.

The LaMP is planning on following the effects of a possible change in water level control by the Lake Ontario-St. Lawrence River Water Control Board, and the adaptive management actions that will be needed to monitor and mitigate any potential adverse impacts.

Since the ecosystem is constantly evolving, the LaMP will continue to re-evaluate the Lake's beneficial use impairments as new information becomes available to update their current status.

Providing the public with a sound understanding of the complex problems facing the Lake is the first step in gaining public support and participation in achieving the LaMP's goals. Ongoing and planned activities include opportunities to meet with existing groups, forming partnerships locally to assist in LaMP projects and providing information when requested and regularly through the LaMP website and mailings. Stewardship of the Lake will be emphasized at future partnership meetings and member agency programs. We will continue to inform the public through reporting and public meetings, and will participate in other meetings such as SOLEC and the International Joint Commission (IJC) biennial sessions.

Outreach materials that are developed for the public by either U.S. or Canadian agencies will be used in the Lake Ontario basin on both sides of the border whenever possible, to increase awareness of the pollution prevention opportunities in the ecosystem that we have in common.

We are looking forward to this next phase of progress for Lake Ontario and its ecosystem. The updated workplan and relevant documents can be found on the web at www.binational.net, and in Chapter 12 and Appendix D of this document.

13.3 Research and Monitoring Needs

The LOLA lower food web project was the start of binational cooperative projects to assess the status of the changing lower food web. More monitoring may be done in this area.

The extent of new emerging chemicals in the water and the sediment also needs to be studied.

13.4 Recommendations

The further reduction of critical pollutants is of primary importance to the LaMP. We recommend that federal, state, local governments, and partner agencies and organizations be encouraged to participate in developing and funding future actions of either a voluntary or a regulatory nature, to track down sources and reduce pollutants.

The binational habitat strategy that is beginning in 2006 will set the stage for coordinating future actions. We recognize that many projects have already been initiated and completed to restore and protect the habitat of the Lake Ontario ecosystem. Once the strategy is finalized, targeted restoration or protection projects can be selected and the funding, resources and partners be established to complete these projects.

Finally, the synergy that develops from linkages with other Great Lakes strategies that have common goals and objectives, such as pollutant reduction and habitat conservation, should be encouraged.

13.5 References

Lake Ontario 5-Year Workplan, Lake Ontario Biennial 2006 Report, Appendix D

Lake Ontario 5-Year Workplan, Status of Activities, Lake Ontario Biennial 2006 Report, Chapter 12

Appendix A

Glossary

33/50 Program: A pollution prevention program sponsored by USEPA in voluntary partnerships with industry. The program's goals are to reduce targeted chemicals by 33 percent by 1992 and 50 percent by 1995.

Anthropogenic: Effects or processes that are derived from human activities, as opposed to natural effects or processes that occur in the environment without human influence.

Benthic: Pertaining to plants and animals that live on the bottom of aquatic environments.

Bioaccumulation: The accumulation by organisms of contaminants through ingestion or contact with skin or respiratory tissue.

Bioaccumulative Chemical of Concern (BCC) (Bioaccumulative Toxics): Any chemical that has the potential to cause adverse effects which upon entering the surface waters, by itself or as its toxic transformation products, accumulates in aquatic organisms by a human health bioaccumulation factor greater than 1000, after considering metabolism and other physiochemical properties that might enhance or inhibit bioaccumulation, in accordance with the methodology in Appendix B of Part 132 - Water Quality Guidance for the Great Lakes System. Source: Water Quality Guidance for the Great Lakes System.

Combined Sewer Overflow (CSO): A pipe that, during storms, discharges untreated wastewater from a sewer system that carries both sanitary wastewater and stormwater. The overflow occurs because the system does not have the capacity to transport and treat the increased flow caused by stormwater runoff.

Deforestation: The clearing of wooded areas.

Degradation: A term used in the indicators of beneficial use impairments defined by the Great Lakes Water Quality Agreement to indicate an environmental condition or state that is considered to be unacceptable or less than the condition that would exist in a healthy ecosystem.

Diatoms: A class of planktonic one-celled algae with skeletons of silica.

Ecosystem: An ecological community and its environment functioning as a unit in nature.

Eutrophic: Relatively high amounts of nutrients (phosphorus and nitrogen) in the water column. Although eutrophic conditions occur naturally in the late stages of many lakes, rapid increases in nutrients due to human activities can destabilize aquatic food webs because plants and aquatic organisms cannot adjust to rapid changes in nutrient levels.

Final Effluent Limits: The amount of a pollutant allowed to be discharged by a U.S. industry or municipality.

Food Web: A network of interconnected food chains and feeding interactions among organisms.

Isothermal: Marked by equality of temperature.

Littoral: Relating to or existing on a shore.

Macroinvertebrates: Small organisms that do not have spinal columns; may filter bottom sediments and water for food.

Mesotrophic: Refers to a lake with relatively moderate amounts of nutrients (phosphorus and nitrogen) in its surface water.

Metric Tonne: Unit of weight used in Canada equal to 1,000 kilograms or 2,246 pounds. Equivalent to 1.102 U.S. tons.

Non-point Source: An indirect discharge, not from a pipe or other specific source.

Oligotrophic: Relatively low amounts of nutrients (phosphorus and nitrogen) in the water column. Lake Ontario's original nutrient levels can best be described as oligotrophic.

Pelagic: Related to or living in the open lake, rather than waters adjacent to the land.

Persistent Toxic Substance (Persistent Toxic Chemical): Any toxic substance with a half-life, i.e., the time required for the concentration of a substance to diminish to one-half of its original value, in any medium -- water, air, sediment, soil, or biota -- of greater than eight weeks, as well as those toxic substances that bioaccumulation in the tissue of living organisms. Source: Great Lakes Water Quality Agreement of 1978, expanded by the IJC's Sixth Biennial Report of Great Lakes Water Quality.

Phytoplankton: Microscopic forms of aquatic plants.

Publicly-owned Treatment Works (POTW): A system that treats (which can include recycling and reclamation) municipal sewage or industrial wastes of a liquid nature. Large facilities are generally owned and operated by local governments.

Riparian: Habitat occurring along the bank of a waterway.

Salmonid species: Salmonid species are essentially trout species (e.g. Lake trout, Brown, Brook,Chinook, Coho, Rainbow etc).

Sewage Treatment Plant (STP): A system that treats (which can include recycling and reclamation) municipal sewage or industrial wastes of a liquid nature. Large facilities are generally owned and operated by local governments.

Thermal Stratification (Thermocline): Differential rates of seasonal heating and cooling of shallow and deep waters result in the development of two horizontal layers of water having very different water temperatures. The depth where this abrupt temperature change occurs is known as the thermocline.

Toxic Substance: Any substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances. Source: 1978 Great Lakes Water Quality Agreement.

Volatilization: Evaporation.

Watershed: The land area that drains into a stream, river, estuary, or other water body; same as drainage area.

Water Quality Standards: In the U.S., a designated use of a water body (i.e., swimming, fishing, etc.) and the numerical or other criteria to protect that use.

Water Pollution Control Facility (WPCF): A system that treats (which can include recycling and reclamation) municipal sewage or industrial wastes of a liquid nature. Large facilities are generally owned and operated by local governments.

Water Pollution Control Plant (WPCP): A system that treats (which can include recycling and reclamation) municipal sewage or industrial wastes of a liquid nature. Large facilities are generally owned and operated by local governments.

Zooplankton: Microscopic animals that move passively in aquatic ecosystems.

List of Acronyms

AIS-HACCP	Aquatic Invasive Species Hazard Analysis and Critical Control Point
ALCOA	Aluminum Corporation of America
AOC	Area of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
AWWA	American Water Works Association
BAIT	Bay Area Implementation Team
BARC	Bay Area Restoration Council
BEAST	Benthic Assessment of Sediment
BEC	(Great Lakes) Binational Executive Committee
BQ RAP	Bay of Quinte RAP
BTMP	Binational Toxics Management Plan
BTS	(Canada-U.S. Great Lakes) Binational Toxics Strategy
BUIs	Beneficial Use Impairments
CDEC	Cornwall and District Environment Council
CDN	Canadian (for example, as in $24,000 (CDN))
CFIA	Canadian Food Inspection Agency
CSOs	Combined Sewer Overflows
CWS	Canadian Wildlife Service
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEC	(New York State) Department of Environmental Conservation (also NYSDEC)
DFO	(Canadian) Department of Fisheries and Oceans
DPW	(Canadian) Department of Public Works
EC	Environment Canada
EDCs	Endocrine Disrupting Compounds
EEZ	Exclusive Economic Zone
EOWG	(Lake Ontario) Ecosystem Objectives Work Group
EPA	(U.S.) Environmental Protection Agency
ETWG	Environmental Technical Work Group
FBNR	Friends of the Buffalo/ Niagara Rivers

FCOs	Fish Community Objectives
FDA	(U.S.) Food and Drug Administration
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System
GL	Great Lakes
GLBTS	(Canada-U.S.) Great Lakes Binational Toxics Strategy
GLCUF	(EC's) Great Lakes Cleanup Fund (renamed Great Lakes Sustainability Fund)
GLFC	Great Lakes Fishery Commission
GLI	Great Lakes Initiative
GLNPO	Great Lakes National Program Office
GLRC	Great Lakes Research Consortium
GLSF	(Environment Canada's) Great Lakes Sustainability Fund
GLU	Great Lakes United
GLWCAP	(Canada's) Great Lakes Wetlands Conservation Action Plan
GLWQA	Great Lakes Water Quality Agreement
GLWQI	(U.S.) Great Lakes Water Quality Initiative
GRI	Great Rivers Institute
HCB	Hexachlorobenzene
HHN	Human Health Network
HSPF	(EPA) Hydrologic Simulation Program
IADN	Integrated Atmospheric Deposition Network
IAGLR	International Association of Great Lakes Research
IJC	International Joint Commission
LaMP	Lakewide Management Plan
LEL	Lowest Effects Level
LLRW	Low Level Radioactive Waste
LLRWMO	Low-Level Radioactive Waste Management Office
LO	Lake Ontario
LOADS	Lake Ontario Atmospheric Deposition Study
LOC	(Great Lakes Fishery Commission's) Lake Ontario Committee
LOLA	Lake Ontario Lower Aquatic Food Web Assessment
LOSL	Lake Ontario – St. Lawrence
LOTC	Lake Ontario Technical Committee
LOTMP	Lake Ontario Toxics Management Plan
LOTOX	Lake Ontario Toxics Modeling Project
LOTOX2	Second version of LOTOX model
M	Million (e.g., $3.2M)
MAC	Maximum Acceptable Concentration
MCs	Microsystins
MIB	Methylisoborneol
MNR	(Ontario) Ministry of Natural Resources
MOE	(Ontario) Ministry of the Environment
MOU	Memorandum of Understanding
NA	No data available
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
ND	Not detected
NGOs	Non Government Organizations
NISA	National Invasive Species Act
NOAA	(U.S.) National Oceanic and Atmospheric Administration
NOBOB	No ballast on board
NPCA	Niagara Peninsula Conservation Authority

NRTMP	Niagara River Toxics Management Plan
NS	Not Sampled
NWF	National Wildlife Federation
NWRI	(Canadian) National Water Research Institute
NY	New York
NYC	New York City
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation (also DEC)
NYSDOH	New York State Department of Health
OCS	Octachlorostyrene
OMNR	Ontario Ministry of Natural Resources
OMOE	Ontario Ministry of the Environment
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PCNs	Polychlorinated napthalenes
PI	Principal Investigator
PIC	Public Involvement Committee
PISCES	Passive In-Situ Chemical Extraction Sampler
ppb	parts per billion
PPCP	Pollution Prevention and Control Plan
ppm	parts per million
ppt	parts per trillion
PWL	Priority Waterbody Listing
R2	(EPA's) Region 2
RAP	Remedial Action Plan
RAC	Remedial Advisory Committee
RRCA	Raisin Region Conservation Authority
SEL	Severe Effects Level
SLAEC	St. Lawrence Aquarium and Ecological Center
SLRIES	St. Lawrence River Institute of Environmental Sciences
SOLEC	State of the Lakes Ecosystem Conference
SPDES	(New York) State Pollutant Discharge Elimination System
STP	Sewage treatment plant
SUNY	State University of New York
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRCA	Toronto and Region Conservation Authority
USACE	United States Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USF&WS	U.S. Fish and Wildlife Service (also USFWS)
VHS	Viral Haemorrhagic Septicemia
WG	(Lake Ontario LaMP) Work Group
WPCF	Water pollution control facility
WPCP	Water pollution control plant
WQCC	Water Quality Coordinating Committee
WQMAC	Water Quality Management Advisory Committee
WQS	Water Quality Standards
WRAPS	Watershed Restoration and Protection Strategies
WRT	Waterfront Regeneration Trust
WTP	Water Treatment Plant

WWFMMP	(Toronto's) Wet Weather Flow Management Master Plan
YoY	Young of the Year (fish)

Appendix B
Lake Ontario Letter of Intent

Lake Ontario MAY 22 1996

Progression of Toxics Management Plan to Lakewide Management Plan Letter of Intent

In 1987, the Niagara River Declaration of Intent (DOI) committed the Four Parties (Environment Canada, U.S. Environmental Protection Agency, Ontario Ministry of the Environment, and New York State Department of Environmental Conservation) to develop Toxics Management Plans for the Niagara River and Lake Ontario. The Lake Ontario Toxics Management Plan (LOTMP) was developed in 1989 and was updated in 1991 and 1993.

The goal of the LOTMP is a lake that provides drinking water and fish that are safe for unlimited consumption and allows natural reproduction of the most sensitive native species. The LOTMP reduces toxic inputs to the Lake through the implementation of new and existing programs and the development of basin-wide pollution prevention strategies. The LOTMP has been the primary toxic substances reduction planning effort for Lake Ontario.

The 1987 amendments to the Great Lakes Water Quality Agreement committed the federal governments of the United States and Canada to develop Lakewide Management Plans (LaMP) for each of the five Great Lakes. The LaMP will provide a comprehensive ecosystem approach to restore beneficial uses by reducing levels of critical pollutants that cause lakewide problems. Critical pollutants are substances that singly or in combination pose a threat to human health or aquatic life due to their toxicity, persistence in the environment and/or their ability to accumulate in organisms.

The Four Parties agree that one program (the LaMP) should be developed which provides an overall framework for our efforts. The LOTMP has been the primary toxic substances reduction planning effort for Lake Ontario. As such, it serves as a foundation for the development of the Lake Ontario LaMP. In order to assure that the LaMP documents reflect the intent of the LOTMP, the Four Parties have agreed to review and incorporate all relevant commitments from the LOTMP. Documentation of the progress that has been achieved towards these goals will be provided in the first LaMP document.

The LaMP process provides a mechanism to continue to deliver the LOTMP committed to in the 1987 DOI. The attached Lake Ontario LaMP Workplan establishes commitments and milestones for the development of the LaMP, within the constraints of available resources.

John Mills
Regional Director General
Ontario Region
Environment Canada

Jeanne Fox, Regional Administrator
US Environmental Protection Agency
Region II

Michael D. Zagata, Commissioner
New York State Department of
Environmental Conservation

Sheila Willis, Assistant Deputy Minister
Operations Division
Ontario Ministry of Environment & Energy

Appendix C

LaMP Management Team

Lake Ontario Coordination Committee

Alan J. Steinberg, Regional Administrator, USEPA, Region 2
Pradheep Kharé Regional Director General, Ontario Region, EC
Denise M. Sheehan, Commissioner, NYSDEC
Michael J. Williams, Assistant Deputy Minister, Operations Division, MOE

Lake Ontario Management Committee

Mario Del Vicario, Chief, Community and Ecosystems Protection Branch, USEPA Region 2
Susan Humphrey, Manager, Restoration Programs Division, EC
Richard Raeburn-Gibson, Assistant Director, Eastern Region Operations Division, MOE
Don Zelazny, Great Lakes Programs Coordinator, NYSDEC Region 9
Rob MacGregor, Manager for Lake Ontario, St. Lawrence River and Lake St. Francis, OMNR
E. Scott Millard, A/Division Manager, Great Lakes Laboratory for Fisheries & Aquatic Sciences, Fisheries & Oceans Canada
Kofi Fynn-Aikins, Chief, Lower Great Lakes Fishery Resources Office, USFWS

Technical Workgroup

Barbara Belasco
DEPP-CEPB
USEPA Region 2
290 Broadway
New York, New York, 10007
phone: (212) 637-3848
fax: (212) 637-3889
e-mail: belasco.barbara@epa.gov
website: http://www.epa.gov/glnpo/ontario.html

Rimi Kalinauskas
Environment Canada
4905 Dufferin Street
Toronto, Ontario M3H 5T4
phone: (416) 739-5836
fax: (416) 739-4404
e-mail: rimi.kalinauskas@ec.gc.ca

Robert Townsend, P.E.
NYSDEC, Division of Water
625 Broadway, Albany, NY 12233-3502
phone: (518) 402-8284
fax: (518) 402-9029
e-mail: retownse@gw.dec.state.ny.us
website: www.dec.state.ny.us/website/dow

Betsy Trometer
US Fish and Wildlife Service
Lower Great Lakes Fishery Resources Office
405 N. French Rd. Suite 120A
Amherst, NY 14228
phone: (716) 691-5456 ext. 22
fax: (716) 691-6154
e-mail: betsy_trometer@fws.gov

Technical Workgroup

Bruce Morrison
OMNR, Lake Ontario Management Unit
41 Hatchery Lane
RR#4, Picton, ON K0K 2T0
phone: (613) 476-3147
fax: (613) 476-7131
e-mail: bruce.morrison@mnr.gov.on.ca

Conrad de Barros
MOE Regional Office
Eastern Region
133 Dalton Avenue
Kingston, Ontario K7L 4X6
phone: (613) 540-6858
fax: (613) 548-6908
e-mail: conrad.debarros@ene.gov.on.ca

Public Information Workgroup

Marlene O'Brien
Environment Canada
867 Lakeshore Road
Burlington, Ontario L7R 4A6
phone: (905) 336-4552
email: marlene.obrien@ec.gc.ca

Michael Basile
U.S. Environmental Protection Agency
Public Information Office
186 Exchange Street
Buffalo, New York 14204
phone: (716) 551-4410
e-mail: basile.michael@epa.gov

Heather Hawthorne
MOE Regional Office
Eastern Region
133 Dalton Avenue
Kingston, Ontario K7L 4X6
phone: 613-548-6927
email: heather.hawthorne@ene.gov.on.ca

Don Zelazny
NYSEC - Region 9
270 Michigan Avenue
Buffalo, New York 14202
phone: (716) 851-7000
email: dezelazn@gw.dec.state.ny.us

United States Repository

U.S. Environmental Protection Agency
Public Information Office
186 Exchange Street
Buffalo, New York 14204
phone: (716) 551-4410

Canadian Repositories

Environment Canada
Library Services Section
Canada Centre for Inland Waters
867 Lakeshore Road
Burlington, Ontario L7R 4A6
phone: (905) 336-4982

Environment Canada
Library Services
4905 Dufferin Street
Downsview, Ontario M3H 5T4
phone: (416) 739-5702

Agency Offices

United States Environmental Protection Agency

US Environmental Protection Agency
Region 2
290 Broadway
New York, New York, 10007
phone: (212) 637-3660

Environment Canada

Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4
phone: (416) 739-4809 (General Inquiries)

Environment Canada
867 Lakeshore Road
Burlington, Ontario L7R 4A6
phone: (416) 739-4809 (General Inquiries)

New York State Department of Environmental Conservation Regional Offices

NYSDEC - Region 6
317 Washington Street
Watertown, New York 13601
phone: (315) 785-2239

NYSDEC - Region 7
615 Erie Blvd. West
Syracuse, New York 13204-2400
phone: (315) 428-4497

NYSDEC - Region 8
6274 East Avon-Lima Road
Avon, New York 14414
phone: (716) 226-2466

NYSEC - Region 9
270 Michigan Avenue
Buffalo, New York 14202
phone: (716) 851-7000

Ontario Ministry of the Environment Offices

MOE Regional Office
Central Region
8th Floor, 5775 Yonge St.
North York, Ontario M2M 4J1
phone: (800) 810-8248

MOE Regional Office
Eastern Region
133 Dalton Avenue
Kingston, Ontario K7L 4X6
phone: (613) 549-4000

MOE Regional Office
West Central Region
119 King Street West
Hamilton, Ontario L8N 3Z9
phone: (800) 668-4557

Ontario Ministry of Natural Resources Offices

Ontario Ministry of Natural Resources
Lake Ontario Management Unit
300 Water Street, 5th Flr. North Tower,
Peterborough, Ontario K9J 8M5
phone: (705) 755-2001 (General Inquiries)

Ontario Ministry of Natural Resources
Lake Ontario Management Unit
41 Hatchery Lane, RR#4
Picton, Ontario K0K 2T0
phone: (613) 476-3255

Department of Fisheries and Oceans

Department of Fisheries and Oceans
Great Lakes Laboratory for Fisheries & Aquatic Sciences
867 Lakeshore Road
Burlington, Ontario
Canada, L7R 4A6
phone: (905) 336-4702

US Fish and Wildlife Service Offices

US Fish and Wildlife Service
Lower Great Lakes Fishery Resources Office
405 N. French Rd. Suite 120A
Amherst, NY 14228
phone: (716) 691-5456

US Fish and Wildlife Service
Ecological Services
New York Field Office
3817 Luker Rd.
Cortland, NY 13045
phone: (607) 753-9334

Remedial Action Plan Contacts

Hamilton Harbour RAP
John Hall, RAP Coordinator
Canada Centre for Inland Waters
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario L7R 4A6
phone: (905) 336-6465
e-mail: john.hall@ec.gc.ca

Port Hope RAP
Environment Canada,
Environmental Conservation Branch
4905 Dufferin Ave.
Toronto, Ontario M4T 1M2
phone: (416) 739-5836

Bay of Quinte RAP
Barry Jones, RAP Coordinator
Bay of Quinte Restoration Council
c/o Lower Trent Conservation
441 Front Street
Trenton, Ontario K8V 6C1
phone: (613) 394-4829 Ext.213
e-mail: implementation@bqrap.ca

Niagara River RAP (Canada)
Jocelyn Baker
c/o Niagara Peninsula Conservation Authority
250 Thorold Road West, 3rd Floor
Welland, Ontario L3C 3W2
phone: (905) 788-3135
e-mail: jbaker@conservation-niagara.on.ca

Remedial Action Plan Contacts

Toronto and Region RAP
Kelly Montgomery, RAP Project Manager
c/o Toronto and Region Conservation Authority
5 Shoreham Drive,
Toronto, Ontario M3N 1S4
phone: (416) 661-6600 Ext. 5576
e-mail: kmontergomery@trca.on.ca

St. Lawrence River RAP (Canada)
Katherine Beehler, RAP Coordinator
c/o Raisin Region Conservation
18045 County Road 2
P.O. Box 429
Cornwall, Ontario K6H 5T2
phone: (613) 938-3611
e-mail: Katherine.beehler@rrca.on.ca

Eighteenmile Creek RAP
Victor F. DiGiacomo
R.A.P. Coordinator
Niagara County Soil & Water
Conservation District
4487 Lake Avenue
Lockport, NY 14094
phone (716) 434-4949
fax: (716) 434-4985
Victor.digiacomo@ny.nacdnet.net
And RAP Coordination, Division of Water
New York State DEC
270 Michigan Avenue
Buffalo, New York 14203-2999
phone: (716) 851-7000

Rochester Embayment RAP
Monroe County Department of Health
Charles Knauf, Environmental Health Project Analyst
Monroe County Health Department
111 Westfall Road Room 976
Rochester, NY 14692
cknauf@monroecounty.gov
phone: (585) 274-8440
fax: (585) 274-6098
also Todd Stevenson, MCDOH
phone: (585) 274-7638
e-mail: TStevenson@monroecounty.gov

Oswego River Harbor RAP
Robert Townsend, RAP Coordinator
NYSDEC, Division of Water
625 Broadway
Albany, New York 12233-3502
phone: (518) 402-8284
fax: (518) 402-9029
e-mail: retownse@gw.dec.state.ny.us
e-mail: www.dec.state.ny.us/website/dow

St. Lawrence River at Massena AOC
Ron McDougall, Chairperson
General Motors Powertrain
Route 37 East, PO Box 460
Massena, NY 13662
phone: (315) 764-0271 or (315) 764-2293
also Steve Litwhiler, Citizen Participation Specialist
NYSDEC, Region 6 Office
State Office Building
Watertown, NY 13601
phone: (315) 785-2252

Governmental Remedial Action Plan Contacts

Robert Townsend, NYSDEC, Division of Water
625 Broadway, Albany, NY 12233-3502
phone: (518) 402-8284
e-mail: retownse@gw.dec.state.ny.us

Barbara Belasco, USEPA Region 2
290 Broadway, NY, NY 10007
phone: (212) 637-3848
e-mail: Belasco.Barbara@epamail.epa.gov
(Rochester, Oswego, St. Lawrence River Massena RAPs)

Marie O'Shea, USEPA Region 2
290 Broadway, NY, NY 10007
phone: (212) 637-3802
e-mail: Oshea.Marie@epamail.epa.gov
also NYSDEC, Division of Water, Region 9
c/o Regional Water Manager, Gerald Palumbo
270 Michigan Ave, NYSDEC Region 9
Buffalo, NY 14203-2999
phone: (716) 851-7070
(Niagara River, Eighteenmile Creek RAPs)

Janette Anderson
Environment Canada
Restoration Programs Division
867 Lakeshore Road
Burlington, Ontario L7R 4A6
Phone: (905) 336-6277
Janette.Anderson@ec.gc.ca
(Niagara River, St. Lawrence River Cornwall RAPs)

Conrad de Barros
MOE Regional Office
Eastern Region
133 Dalton Avenue
Kingston, Ontario K7L 4X6
phone: 613-540-6858
fax: 613-548-6908
e-mail: conrad.debarros@ene.gov.on.ca
(St. Lawrence River Cornwall, Quinte, Pt. Hope RAPs)

Rimi Kalinauskas
Environment Canada
Restoration Programs Division
4905 Dufferin Street
Downsview, Ontario M3H 5T4
phone: (416) 739-5836
e-mail: Rimi.Kalinauskas@ec.gc.ca
(Hamilton Harbour, Toronto, Quinte, Pt. Hope RAPs)

Appendix D

5-Year Binational Workplan for the Lake Ontario Lakewide Management Plan (2005 Through 2009)

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
A. Chemical. Reduce inputs of LaMP's six critical pollutants		
1. Goals, objectives and targets		
a Update adopted ecosystem indicators and make progress on additional indicators and target levels for critical pollutants.	LaMP to report on adopted indicators in LaMP Status 2006.	LaMP to identify & assemble information on additional indicators as information becomes available.
2. Problem identification		
a. Update current total lake contaminant problem.		
Update estimates of Lake Ontario critical pollutant loadings	LaMP to refine loadings estimates with new data in LaMP Status 2006	LaMP to update loadings as information becomes available
Evaluation of sediment core data to use as an indicator of contaminants in sediment, consistent with SOLEC sediment core indicator and establish a long term monitoring strategy.	Collect sediment core samples from the Lake Ontario central basin & Niagara River bar in 2005/06.	Analyze cores & prepare report on historical & emerging chemical trends in sediment. Using cores as an indicator of contaminants in sediment, consistent with the SOLEC sediment core indicator, develop a long term binational monitoring plan.
b. Cooperative monitoring	See specific deliverables below	LaMP parties to continue data analyses; publish synthesis reports; facilitate long term approach to binational monitoring strategy. Continued cooperative monitoring for identification of emerging needs for Lake Ontario. Plan for next Lake Ontario intensive 2008.
Coordinate side-by-side analytical comparisons among participating LaMP parties.	2005 – Party participants to evaluate data from Phase IV. 2006 – Participants to prepare summary of data & submit a report to the LaMP on the comparability of results.	LaMP to facilitate coordination amongst the Parties concerning the practical application of the comparability evaluation.
Coordinate atmospheric deposition study	2005 – completed calculation of Hg load to Lake. 2006 – incorporate findings to date in LaMP Status 2006. Continue calculations of loads of dioxins and PCBs to Lake, based on sampling.	LaMP to prepare synthesis report.
Lake Ontario toxic chemicals monitoring surveys	2006 – EC-three open lake surveys 2006 – OMOE - nearshore survey	EC to plan open lake survey for 2008. OMOE & EC continue data analyses. LaMP to prepare synthesis report.

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
3. Source identification		
a. Inventories		
Binational Sources & Loadings Strategy, to include updating of tables, maps, identification of air & water sources & prioritized listings of sources.	LaMP to update inventory and report in LaMP Status 2006.	LaMP to update inventory and report in LaMP Status 2008.
US: Tributary Monitoring	2005-2006 EPA to sample tributaries for critical pollutants, analyze samples & prepare report. Incorporate data into LaMP Status 2006. A summary report covering 2002 through 2004 monitoring will be prepared in 2006. 2006- NYSDEC planning an intensive 5-yr tributary load project with EPA funding.	LaMP to integrate tributary loading results into LaMP Status 2008. EPA to sample tributaries for critical pollutants in 2007, 2008, 2009. NYSDEC to continue intensive tributary load project.
Canada: Report on priority watersheds to include status information; remedial measures; monitoring; recommendations for further action.	2005- EC to do further confirmation & follow-up sampling. EC to report on follow-up work (areas with PEL exceedances) with recommendations for further action. EC/OMOE to prioritize areas and develop workplan for follow-up work/trackdown strategies. 2006- EC/OMOE to prepare final report with recommendations for PEL exceedances.	Address issues arising from collated data.
b. Source Trackdown		
United States: trackdown at Genessee River, Eighteenmile Creek and Black River.	2006 – RAP Coordinator leads planning trackdown activities: Monroe County, NY to conduct study of PCBs in the Rochester's westside Interceptor System based on EPA funding. Niagara County Soil & Water Conservation District to investigate PCB sources in Eighteenmile Creek based on EPA funding.	LaMP to incorporate results of trackdown activities & progress in remediating/ controlling contaminant sources in future LaMP reports. NYSDEC to follow-up on additional monitoring & remedial actions where indicated. Conduct monitoring, assess data, and report on source trackdown activities and implementation projects, as needed.
Canadian PCB trackdown at 12 Mile Creek, Cataraqui River & Etobicoke Creek. The continuation of studies and analysis for contaminant source identification and sediment issues, and monitoring as required. Confirm point/non-point sources of chemical contaminants.	12 Mile Creek – 2006 On-going follow-up being conducted. Voluntary sampling being conducted by the City of St. Catharines. Etobicoke Creek – 2005 Further sampling undertaken. 2006 Evaluate and assess data. Cataraqui River – 2006 Re-assessment phase: conduct monitoring to assess remedial measures (dredging) undertaken in December 2004.	Continue work on 12 Mile Creek & Cataraqui River. OMOE to complete report on 12 Mile Creek; determine & implement remedial action plans for 12 Mile Creek, Etobicoke Creek and Cataraqui River if and where required.

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
Canadian Project Trackdown Part II	Mouth of the Trent River (Bay of Quinte watershed) - High levels of Dioxins/Furans have been located in the sediment at the mouth of the Trent River. Further investigation is to be carried out in 2005/06. Pringle Creek/Whitby Harbour – OMOE identified elevated levels of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in sediment and biota collected from Pringle Creek and Whitby Harbour.	Plan additional trackdown work within identified priority watershed areas if warranted. OMOE is currently carrying out further studies to assess remedial options.
4. Reduction Strategies		
a. Regulatory and voluntary actions		
Regulatory actions	LaMP to facilitate & coordinate transfer of information from LaMP Parties to appropriate enforcement, regulatory & remedial action branches of the LaMP parties. LaMP to report new regulatory actions & progress of LaMP agencies in LaMP Status 2006	LaMP to liaise with enforcement branch of LaMP agencies & track regulatory actions in the Lake Ontario basin.
Voluntary actions and pollution prevention programs	LaMP to coordinate with Binational Toxics Strategy and agencies' hazardous waste minimization & pollution prevention programs to encourage action on sources polluting Lake Ontario. LaMP to identify existing grants & programs; develop a strategy for promotion of pollution prevention programs. LaMP to facilitate partnerships between stakeholder groups for promoting pollution prevention. 2005 – Article on NYS pesticide clean sweeps in LaMP *Update 2005*. 2005 – Clean Sweep – Ontario Waste Agricultural Pesticides Collection Program to offer Ontario farmers safe, free disposal of outdated, de-registered, unwanted pesticides. 2006- Monroe County, NY to begin a Mercury educational & sampling effort, funded by EPA.	LaMP will work to bring together our partners with agency programs that deliver Binational Toxics Strategy's programs. LaMP to continue to promote pollution prevention strategies and programs through partnerships. LaMP to report on future pesticide clean sweeps in LaMP *Update*. Continue Mercury educational effort in Monroe County, NY; LaMP to report on results of activities.
b. Mass balance model		
Develop plan for binational management oversight	LaMP to evaluate results and determine how the model can be used as a predictive tool in various management scenarios	Completed
Application of the model for PCB load reduction activities.	Both US & Canada to consider applying the model for PCB load reduction activities, consistent with regulations/framework of each country. EPA to fund project for technical support necessary for the development of a PCB TMDL for Lake Ontario.	The LOTOX2 mass balance model, in conjunction with other regulatory tools, will be applied to improve the assessment and responses to Lake loadings.
Integrate new data into model	EPA to integrate new data from cooperative monitoring into the mass balance model. Extend LOTOX2 model to other critical pollutants.	Calibrate and peer review, as needed, extend model for other critical pollutants.

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
B. Physical/biological		
1. Goals, objectives and targets		
a. Update adopted ecosystem indicators and consider additional indicators and targets for physical and biological objectives as information becomes available.	LaMP to update adopted indicators in LaMP Status 2006.	LaMP to identify & assemble information on additional indicators as information becomes available.
Mink and otter indicator	LaMP to publish report on status of mink/otter populations in LaMP Status 2006. OMNR to update Ontario populations in 2006.	LaMP to continue the collection & analysis of harvest statistics on mink/otter as required.
Bald eagle indicator	2006 – Final report to be distributed to agency staff & potential partners such as local planning boards. 2006 – LaMP to encourage partnerships to conserve & restore identified bald eagle habitat areas & to develop new nesting sites.	LaMP to review status of bald eagle habitat efforts.
Fish indicators	2005/2006 – Update lake trout & preyfish indicators in LaMP Status 2006.	OMNR & USFWS, in collaboration with DEC, USGS & LOC, to develop a diversity index for prey fish. OMNR & NYSDEC, with USFWS & in conformance with LOC & SOLEC, to develop a new indicator for fish connected to nearshore.
Coastal Wetlands Indicator	2005/2006 – Work with Great Lakes Coastal Wetlands Consortium to develop implementation plan for proposed wetland indicators.	Begin monitoring.
b. Evaluate information to complete assessment of beneficial use impairments.		
Benthos, Phytoplankton, Zooplankton Impairments	2005 – Complete data analyses of Lake Ontario Lower Aquatic Foodweb Assessment (LOLA). 2006- LaMP to prepare LOLA synthesis report with recommendations for future actions.	LaMP to determine need for, and feasibility of, developing additional Lake Ontario lower food web indicators. LaMP to re-assess status of beneficial use impairments & take action on results of assessment.
Fish population impairment	2005 – LaMP Management Committee, working in conjunction with the Lake Ontario Committee, to change status of fish population impairment. 2005/2006 – NYSDEC Creel Survey to be carried out to obtain information on # of fish caught by species & other information in 28 Lake Ontario tributaries. Data will improve understanding & management of the fishery. 2005/2006- NYSDEC & Ontario to continue their ongoing assessments of fish populations. Information to be incorporated into the LOC Annual Report.	Continue evaluation of beneficial use impairments & consistency with Lake Ontario Committee fishery objectives.

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
Fish population remediation	2005/2006 – LaMP to comment & support remediation plans for offshore food web & support Lake Ontario Committee remediation work. 2006- LaMP to support OMNR grant application for continued restoration efforts of offshore food web.	OMNR to continue collection of gametes from deep water ciscoes, disease testing & potential stocking of Lake Ontario with follow-up assessment by USGS.
Lake Ontario biomonitoring and water quality surveys	2005/2006 – NYSDEC, USFWS & Cornell University cooperative monitoring. Conduct annual monitoring of phosphorus, chlorophyll a & zooplankton in NY waters. Results to be reported annually in NYSDEC Lake Ontario Unit, the St. Lawrence Unit Annual Report to the Lake Ontario Committee, & the LaMP. 2005/2006 – EPA to monitor Lake Ontario Spring & Summer at 8 open lake stations each year. 2006 – EC to conduct open lake water quality surveys.	Continue NYSDEC, USFWS & Cornell University annual cooperative monitoring of phosphorus, chlorophyll a & zooplankton in NY waters. Results to be reported annually in NYSDEC Lake Ontario Unit, the St. Lawrence Unit Annual Report to the Lake Ontario Committee, & the LaMP. EPA to continue annual open lake water quality monitoring. Agencies will determine future cooperative actions.
2. Problem identification		
a. Habitat assessment		
Canadian habitat assessment and Watershed Management.	Cdn LaMP partners to identify & promote watershed management strategies in conjunction with Conservation Authorities and other agencies.	Cdn LaMP partners to establish partnerships between stakeholders to assist municipalities with the implementation of watershed management strategies.
US habitat assessment, strategy and actions.	2005- EPA funded New York Rivers United project to begin a review of opportunities to restore upstream passage along Lake Ontario Tributaries. 2006- Finalize US habitat assessment report. 2006 – Great Lakes islands priorities for long term conservation to be determined as to biological high diversity; threat analysis; not well protected. Islands to be selected for conservation. 2005/06 – NYSDEC to develop a Comprehensive Wildlife Conservation Strategy to focus on species in greatest need of conservation & identify management needs & strategies. 2006- Incorporate US habitat assessment, including the Comprehensive Wildlife Conservation Strategy, & Lake Ontario Coastal Initiative strategy into the development of a binational habitat conservation strategy.	New York Rivers United project report to be reviewed by US LaMP partners to determine next steps. US LaMP partners will promote implementation of identified habitat priorities. Great Lakes Islands project to develop conservation manuals for public & private island owners. Incorporate US assessment, including the Comprehensive Wildlife Conservation Strategy, & Lake Ontario Coastal Initiative strategy into the development of a binational habitat conservation strategy.
Binational habitat conservation strategy	2005/2006 – EPA funded TNC to complete binational GIS data base of species & ecological systems; LaMP agencies to begin working with TNC on developing binational habitat strategy.	LaMP partners to review binational strategy and develop implementation plans.

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
Establish value added linkages to International Joint Commission's water level study.	2005/2006 – LaMP to integrate new technical data & information into LaMP reports, where applicable. LaMP to review Lake Ontario/St. Lawrence River water level control study.	LaMP partners to follow the effects of any water level control changes & develop adaptive management recommendations where feasible.
Work with Great Lakes Fishery Commission's Lake Ontario Committee to identify priority projects & investigations; develop common indicators.	2005 – LaMP to work with Lake Ontario Committee in updating the status of beneficial use impairments for fish populations. 2006 – Participate in development of Lake Ontario Committee revised Fish Community Objectives for Lake Ontario.	Continue to partner, share information with Great Lakes Fishery Commission and the Lake Ontario Committee.
b. Invasive species	2005 – Review results of the LOLA project (B.1.b). 2006 – LOLA draft report to circulate for comments. 2005/2006 – LaMP to update available information and research on invasive species and recommend appropriate management options and strategies where necessary.	Share LOLA findings with agencies charged with invasive species management. All LaMP parties to continue to liase with appropriate agencies in working on the management & prevention of new invasive species.
c. Human Health Issues	LaMP to maintain connection with the Binational Great Lakes Human Health Network. LaMP to work with Network to gather/exchange information pertaining to human health. LaMP agencies to provide the public with advice on the safe consumption of Lake Ontario fish.	LaMP to continue awareness of human health concerns in the basin and connection with Binational Human Health Network. US LaMP agencies to continue to provide updated information to the public on the safe consumption of Lake Ontario fish.
	Cdn LaMP partners to liaise with the Binational and Canadian Great Lakes Public Health Networks, and/or Human Health agencies, to gather/exchange information on current & emerging human health issues of relevance to the LaMP. Cdn LaMP partners to identify actions & address current & emerging human health issues of relevance to the LaMP & make that information available to the public. 2005 – Health Canada to establish the Canadian Great Lakes Public Health Network.	Cdn LaMP partners, in association with human health organizations, and Canadian Great Lakes Public Health Network will continue to promote human & ecosystem health within the Lake Ontario basin & will disseminate information on the human health impacts of environmental contaminants. OMOE to continue to provide updated information to the public on the safe consumption of Lake Ontario fish.
d. Contaminants in fish	2005/06 – EPA annual monitoring of lake trout at North Hamlin/Oswego for Lake Ontario chemicals of concern. 2005/06 – Collect & analyze salmonid eggs/fillet muscle tissue from Salmon River Altmar Fish Hatchery for PCBs, organochlorine pesticides (OCs) & polybrominated diethyl ethers (PBDEs). 2005/2006 – OMOE/OMNR to continue program to sample sportsfish in Lake Ontario and sportsfish and Young-of-the-year at Areas of Concern, and analyze for contaminants.	EPA to continue annual fish monitoring for priority critical pollutants and emerging chemicals in whole fish. OMOE to continue annual fish monitoring for priority critical pollutants. LaMP to recommend management & regulatory policy efforts, if needed.

LaMP Activities	Deliverables 2005/2006	Proposed Activities 2007-2009
e. Emerging Issues	2005 – LaMP to facilitate & promote collection of information on emerging issues. 2006 – LaMP to assess available information & research and recommend appropriate management options & strategies where necessary. 2006 – US LaMP partners to determine interaction with Great Lakes Regional Collaboration strategy.	LaMP to continue building awareness of emerging issues in the basin.
C. Public Outreach, Consultation, Reporting and Communicating		
1. Promote Partnerships	LaMP to continue to seek out partnerships for public involvement opportunities; LaMP to approach the Centre for Sustainable Watersheds (CSW) and Finger Lakes-Lake Ontario Watershed Protection Alliance (FL-LOWPA) to participate in public meeting in June 2005; provide LaMP information, display, public outreach materials; continue partnership with the IJC water levels study.	Promote & pursue the concept of establishing additional locations for LaMP displays at various existing museums, or other venues, on both the Canadian side and US side of the Lake Ontario basin. LaMP to work with other agencies as appropriate
2. Promote stewardship	LaMP to develop a strategy for more proactive promotion of stewardship; identify community-based actions & partnerships. 2005 – Continued partnership with the Marine Museum in Kingston, to maintain EcoGallery featuring the LaMP. 2005 – OMOE/OMNR participation at Perch Derby-Kingston to promote stewardship through displays and information handouts.	LaMP to continue implementation.
3. Reports	LaMP to publish *LaMP Update* in 2005 and 2006 and biennial *LaMP Status* in 2006.	LaMP to publish *LaMP Status* in 2008 and *Updates* annually
4. Binational Public Meetings	LaMP to hold public meeting in Kingston in June 2005; joint LO LaMP/NRTMP meeting to be held in Niagara Falls, NY in 2006.	LaMP to convene binational meetings as necessary.
5. Prepare outreach material as necessary	LaMP to review update of display; produce other materials as needed	LaMP to produce materials as required
6. SOLEC/IJC Meetings	LaMP to participate in IJC Great Lakes Conference & Biennial Meeting (June 2005) and SOLEC in 2006	LaMP to participate in IJC in odd years and SOLEC meetings in even years.
7. Maintain information connection	LaMP to update & maintain Lake Ontario website. LaMP to maintain mailing list. LaMP to encourage other GL and non-governmental organizations to add links from their websites to Lake Ontario website.	LaMP to continue to update websites and the network of interested groups/individuals.
8. Information and data transfer	LaMP to submit data for inclusion into other databases, such as the IJC database. LaMP to promote information exchange and the availability of data for the public and stakeholders.	LaMP to continue to promote information & data transfer.