A Binational Biodiversity Conservation Strategy for

Lake Ontario

Appendix B: Biodiversity Targets, Viability & Threats
Appendix C: Summary of Lake Ontario Plans & Studies
Appendix D: Ontario Watershed Plans

Prepared by the Lake Ontario Biodiversity Conservation Strategy Working Group
In cooperation with the U.S. – Canada Lake Ontario Lakewide Management Plan

April 2009
Updated July 2009

Appendix B: Biodiversity Targets, Viability and Threats

In developing a biodiversity strategy for Lake Ontario, this project followed a time- and place-tested approach, commonly referred to as "Conservation Action Planning". The first step in this approach is to recognize that it is impossible to consider all of the species and natural communities of any ecosystem in the development of a conservation plan. Instead, we have deliberately focused on a smaller subset of key natural resources to encompass the biodiversity of the entire lake ecosystem. In this report, we refer to these key natural resources as "biodiversity targets".

Expert participants in the first workshop selected seven biodiversity targets based on the likelihood that their conservation will preserve the full array of biodiversity in the Lake Ontario ecosystem. In effect, these biodiversity targets are carefully chosen to serve as surrogates for all the ecosystem's species and natural communities. For example, a systematic focus on coastal wetlands – identifying the threats to their continued viability, and designing actions to abate these threats – will also benefit the species that depend on coastal wetlands.

Section 3 of this report identifies the seven biodiversity targets that have been the focus for analysis, discussion, and planning during this project. This appendix provides a fuller description of the targets and evaluates the current state (health) of each target. Evaluations of the current state of each target are based on the key indicators of target health developed during the workshops and in subsequent small-group discussions.

Both the evaluations of target status (presented here as letter grades that average the ratings for the key indicators) and the proposed key indicators have attracted comments and questions from several reviewers. This appendix will present both the key indicators, as products of the workshops, and the questions raised by reviewers to provide a full picture of an on-going discussion. Future iterations of this report will refine these indicators, with the goal of achieving a set of indicators that directly measure the impact of the strategies recommended in this report.

In this appendix, the benthic and pelagic zones of the lake are discussed separately, since participants distinguished between them in proposing ecosystem objectives and indicators. During the second workshop, the decision was reached to combine these two zones into one target.

Maps showing in this report (and additional project resources) are available at the project website: http://conserveonline.org/workspaces/lakeontario.conservation

Lake Ontario Biodiversity Target 1: Benthic Offshore System

What is it? The Benthic Offshore System is associated with the bottom of the lake in permanently cold water greater than 20 m in depth. *Why is it important?* Lake Ontario is a deepwater ecosystem that once supported a diverse and plentiful coldwater fish community. The benthic zone provides habitat for *Diporeia (*shrimp-like amphipod*), Mysis* (a small freshwater shrimp)*,* deepwater sculpin, slimy sculpin, lake trout, burbot, deepwater ciscos (no longer present), lake herring and lake whitefish. This fishery once provided between 2,000 to 5,000 tons of whitefish, herring, lake trout and walleye annually. This habitat is where drinking water intakes are located.	***Current State***: C-

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Benthic Offshore System

Indicator	***Measure of a Healthy System***	***Our Current State***
Zooplankton: mean length [4]	>800 µm	**B:** 400-700 µm
Diporeia: density of individuals in grab samples at 30-90 m [1,3,4,6]	>2000/m²	**D:** <500/m²
Diporeia: density of individuals in grab samples at >90 m [1,3,4,6]	>2000/m²	**C:** 500-1000/m²
Diporeia: proportion of grab samples from lakewide survey with >700/m² [2,3]	>80%	**C:** 40-60%
Lake whitefish: numbers per 350 bottom trawls [5]	>400	**C:** 50-100
Slimy sculpin: numbers per 350 bottom trawls [5]	>10,000	**D:** <4,000
Burbot: total numbers per 60 gill net lifts [5]	>40	**C:** 10-30
Lake trout: CPUE for all age/sex categories [5]	>50	**D:** <20
Lake trout: proportion of recruits from wild origin [5]	>50%	**D:** <10%

1: (Dermott 2001)*; 2:* (Lake Ontario Biodiversity Conservation Strategy, Workshop 1 2006)*; 3:* (Lozaro 2001)*; 4:* (Mills et al. 2003 a/b)*; 5:* (Owens et al. 2003)*; 6:* (Watkins et al. 2007)

What Does the Information Tell Us?

Significant changes in benthic zone have been occurring, including introductions of round goby and invasive Dreissenids, and the significant decline of *Diporeia* (Morrison and LaPan 2007). Once an extremely productive and diverse coldwater system, the benthic ecosystem of Lake Ontario has been highly altered at all levels and will not spontaneously recover. Restoration will need to include stocking of top predators (e.g. lake trout), re-introduction of the mid-level planktivorous deepwater ciscoes (a level now dominated by non-native alewife), and recovery of lake whitefish.

The Good News

- There is some evidence of natural reproduction (at low levels) among lake trout (however, populations are now at their lowest levels in over 20 years, and stocking requirements cannot be met).

Reviewer's Comments/ Research Questions

- Zooplankton mean length – is the length of zooplankton collected in the epilimnion truly reflective of benthic conditions? Maybe an indicator for *Mysis* would be more appropriate. Zooplankton mean length is better as an indicator of offshore pelagic condition.
- These indicators should include indices of thiamine deficiency in lake trout and sea lamprey abundance.
- The indicator for slimy sculpin should be based on information for the entire south shore, not just trawls off Oswego. The USGS can provide the proper scale.
- The "measure for a healthy system" for burbot may be too high. Perhaps ">17" should be used instead. At the present time, sampling is finding fewer than 1 per 60 gill net lifts.
- An additional indicator for lake trout is necessary: Gill net CPUE for mature females GT 4,000 g. The ecosystem objective should be GT 2.0. This reviewer questions whether a CPUE for all age/sex categories is useful.
- The ecosystem objective for lake whitefish should be >600 /350 bottom trawls. The proposed value of 400 is too low.

Lake Ontario Biodiversity Target 1 (continued): Offshore Pelagic System

What is it? The Offshore Pelagic System is the open water of Lake Ontario beyond the 20-m depth contour. *Why is it important?* This is the largest ecosystem in Lake Ontario. The native food web includes: non-toxic algae, zooplankton, *Mysis* (a small shrimp), emerald shiner, threespine stickleback, lake herring, lake trout, and Atlantic salmon. Atlantic salmon were once the dominant top predator, and lake herring were very abundant. Herring once supported a commercial fishery.	***Current State***: C

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Offshore Pelagic System

Indicator	***Measure of a Healthy System***	***Our Current State***
Mysis: density of individuals [1,3,5]	>350/m²	**B:** 350/m²
Lake herring: total catch per 350 bottom trawls [4]	>45	**D:** <10
Three-spine stickleback: total catch per 100 bottom trawls [4]	>5000	**B:** 2500-5000
Emerald shiner: total catch per 100 bottom trawls [4]	>1000	**B:** 500-1000
Atlantic salmon: proportions of recruits from wild origin [2]	TBD*	**D:** very low

1: (Johannsson et al. 2003)*; 2:* (Lake Ontario Lakewide Management Plan 2007)*; 3:* (Mills, et al. 2003 a/b)*; 4:* (Owens et al. 2003)*; 5:* (Watkins et al. 2007)
** to be determined.*

What Does the Information Tell Us?

While the native top predator of the pelagic system, Atlantic salmon, is still in the very early stages of experimental re-introduction, and lake herring are uncommon, portions of the native food web (*Mysis*) are still intact. Since *Diporeia* has functionally disappeared from the shallower portions of their distribution, any further decline of *Mysis* will have grave consequences for the fishery. Alewife are much reduced from 1980s levels, but are still the dominant planktivore in the lake.

Lake Ontario's offshore waters have changed from a mesotrophic system towards an oligotrophic system. Aquatic invasive species such as Dreissenid mussels, and currently the invasive predatory zooplankton, such as *Bythotrephes cederstromi* and *Cercopagis pengoi*, have become established and may be impacting food web dynamics.

The Good News

- *Mysis* appears to be stable as a key constituent of the lower food web, but *Diporeia* declines are serious.
- Early efforts to restore Atlantic salmon have had some success. High quality spawning steams have been restored through local conservation efforts. However, habitat restoration will not address the problems of a prey base dominated by alewife.

Lake Ontario Biodiversity Target 2: Native Migratory Fish

What is it? "Migratory" fish depend on multiple habitats to satisfy their life cycles (in particular, spawning, nursery, and rearing) and may spend part of their life cycles in the open lake, nearshore, embayments, wetlands, tributaries, as well as the Atlantic Ocean. (Figure B1 illustrates the condition of this target. Significance was based on expert opinion and this assessment was incorporated into the selection of key areas (Section 6 of report)). *Why is it important?* These fish link Lake Ontario to its many different habitats, and extend inland into small tributaries and the Atlantic Ocean. Key migratory species are: lake sturgeon, Atlantic salmon, American eel, lake trout, redhorse sucker, walleye, northern pike, muskellunge, yellow perch and white sucker. Some of these species once formed part of a valuable commercial fishery, and many of them today support recreational fishing.	***Current State***: C-
Key to the Current State **A:** Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services. **B:** Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services. **C:** Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services. **D:** Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.	

Key Indicators of Health: Migratory Fish

Indicator	***Measure of a Healthy System***	***Our Current State***
Lake sturgeon: number of spawning fish (catch-per-standard gillnet) [1,2]	TBD*	**D:** very low
Yellow perch: number of spawning fish (catch-per-standard gillnet) [1]	>25	**C:** 5-10
White sucker: number of spawning fish (catch-per-standard gillnet) [1]	>4	**B:** 2-4
Walleye: number of spawning fish (catch-per-standard gillnet) [1]	>35	**C:** 10-20
Northern pike: number of spawning fish (catch-per-standard gillnet) [1]	>10	**C:** 2-5
American eel- Number of returning adults ascending ladder per day during 31-day peak period [1] (Final targets will be provided in the Great Lakes Research Consortium Eel Restoration Plan, still in draft)	>20,000	**D:** <1,000

1: (Lake Ontario Lakewide Management Plan 2007)*; 2:* (Klindt 2006)
** to be determined.*

What Does the Information Tell Us?

There is great variation in the status of migratory fish. Of concern is the recent decline of many nearshore species that were once formerly abundant, such as (walleye see below). American eel, the only ocean spawning fish in Lake Ontario, was once very abundant and played a key ecosystem role as a top predator in the nearshore and tributaries. Numbers of this species have greatly declined and it will likely become extirpated from the lake without concerted restoration and mitigation.

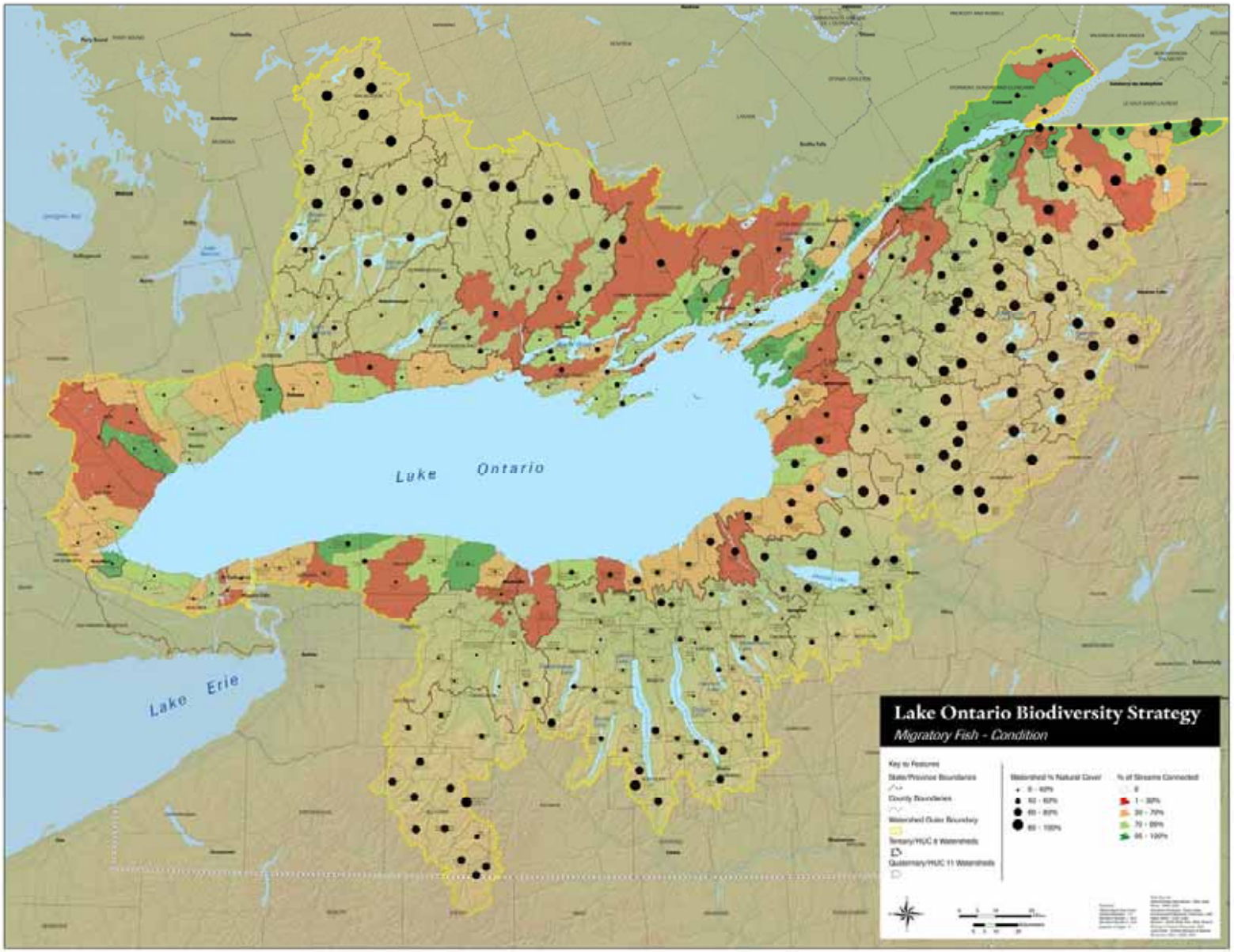
The Good News

- There are active restoration projects underway for Lake Sturgeon and ongoing natural reproduction is assumed in the Niagara River, Lower Black River and possibly the Trent River.
- NY waters of the Eastern Basin: walleye abundance has increased and provides an important recreational fishery.

Reviewer's Comments/ Research Questions

- The indicator for American eel will need to be updated to reflect the objectives of the Eel Restoration Plan. One review recommends that the indicator focus on the number of juvenile eels ascending the ladder at Moses-Saunders Dam annually. Our current state is <20,000, and the Measure of a Healthy System is not yet established.
- One reviewer questions the inclusion of yellow perch as an indicator for this target. These indicators and data sets need to be updated with MNR and DEC staff.

Figure B1: Native Migratory Fish - Condition



Lake Ontario Biodiversity Target 3: Coastal Wetlands

What is it? Coastal Wetlands that have or historically had a hydrologic link to Lake Ontario and the Upper St. Lawrence River. In Lake Ontario, most coastal wetlands are characterized by marshes and swamps, with a few rare coastal meadow marsh and fen communities. There are approximately 32,375 ha/80,000 ac of coastal wetlands. Figures B2 and B3 illustrate the significance and condition of coastal wetlands. *Why is it important?* Coastal wetlands support rare species and habitats and provide important ecosystem functions. Wetland ecosystems include wet meadows, sedge marshes, fens, and provide habitat for marsh-nesting birds, muskrats and fishes. Wetlands also trap sediment and nutrients from tributaries and support migrating waterfowl. Approximately 50% of Lake Ontario's original wetlands have been lost **(Environmental Protection Agency and Environment Canada 2006).**	***Current State***: C-

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Coastal Wetlands

Indicator	***Measure of a Healthy System***	***Our Current State***
Shoreline Hardening [5,12]	<20%	**B:** 20-30%
Water Quality Index (WQI) [4,12]	1 to 3	**C:** -1 to 0
Annual range and timing of lake level (seasonal fluctuations) [1,6,8]	Mimics natural, unregulated water level cycles (short and long-term). Restores high correlation with Lake Erie levels	**C:** Limited variation (magnitude of seasonal fluctuations of 0.6m)
Long-term lake level cycle [19]	30-40 yr cycle	**C:** No long term cycle
Area of meadow marsh [6,12]	Extensive in response to low lake levels in growing season	**D:** Highly restricted in extent / frequency
Muskrat house density [9,18]	>1.5/ha	**C:** 0.5 - 1.5/ha
Marsh Bird Index of Bio. Integrity [7,10,16]	67-100	**C+:** 33-67
Amphibian Index of Bio. Integrity [7,10,16]	75-100	**C:** 25-50
Biomass of algae [3,15,17]	Low (PC1 -2.5 or lower)	**C:** High-moderate (PC1 0 to 2.5)
Wetland Zooplankton Index [13,14]	1 to 3	**C:** -1 to 0
Wetland Fish Index [2,11,16]	1 to 3	**C:** -1 to 0
Area of all wetlands [6]	Most wetlands >1500 ha	**C:** Most wetlands are 20-200 ha

1: (Barko 1999); 2: (Brazner and Beals 1997); 3: (Brinson 1981); 4: (Chow-Fraser 2006); 5: (CJS Consulting 2002); 6: (Committee to Review the Lake Ontario-St. Lawrence River Studies 2006); 7: (Crewe and Timmerman 2005); 8 (Environment Canada and Central Lake Ontario Conservation Authority 2004); 9: (Farrell et al. 2005); 10: (GLEI Collaboration 2006); 11: (Jude and Pappas 1992); 12 (Lake Ontario Biodiversity Conservation Strategy, Workshop 1 2006); 13: (Lougheed & Chow-Fraser 1998); 14: (Lougheed & Chow-Fraser 2002, Chow-Fraser 2006); 15: (McNair & Chow-Fraser 2003); 16: (Meixler et al. 2005); 17: (Mills et al. 2003); 18: (Toner 2006); 19: (U.S. Army Corps of Engineers 2005)

What Does the Information Tell Us?

There is a strong gradient in wetland health and diversity from east to west. Wetlands in the western basin are much more impacted due to greater urban and agricultural land uses. Changes to annual and long-term lake level cycles have impacted all wetlands in Lake Ontario by reducing the diversity of vegetation communities as well as the fish and wildlife species these communities support.

The Good News

- Lake Ontario still includes large, diverse wetlands in the eastern basin and there are several examples of successful wetland restoration projects in the western basin.

Reviewer's Comments/ Research Questions

- The indicators do not include a vegetative diversity indicator, or an indicator of the prevalence of invasive plants. These indicators should be added.

Figure B2: Coastal Wetlands – Biological Significance

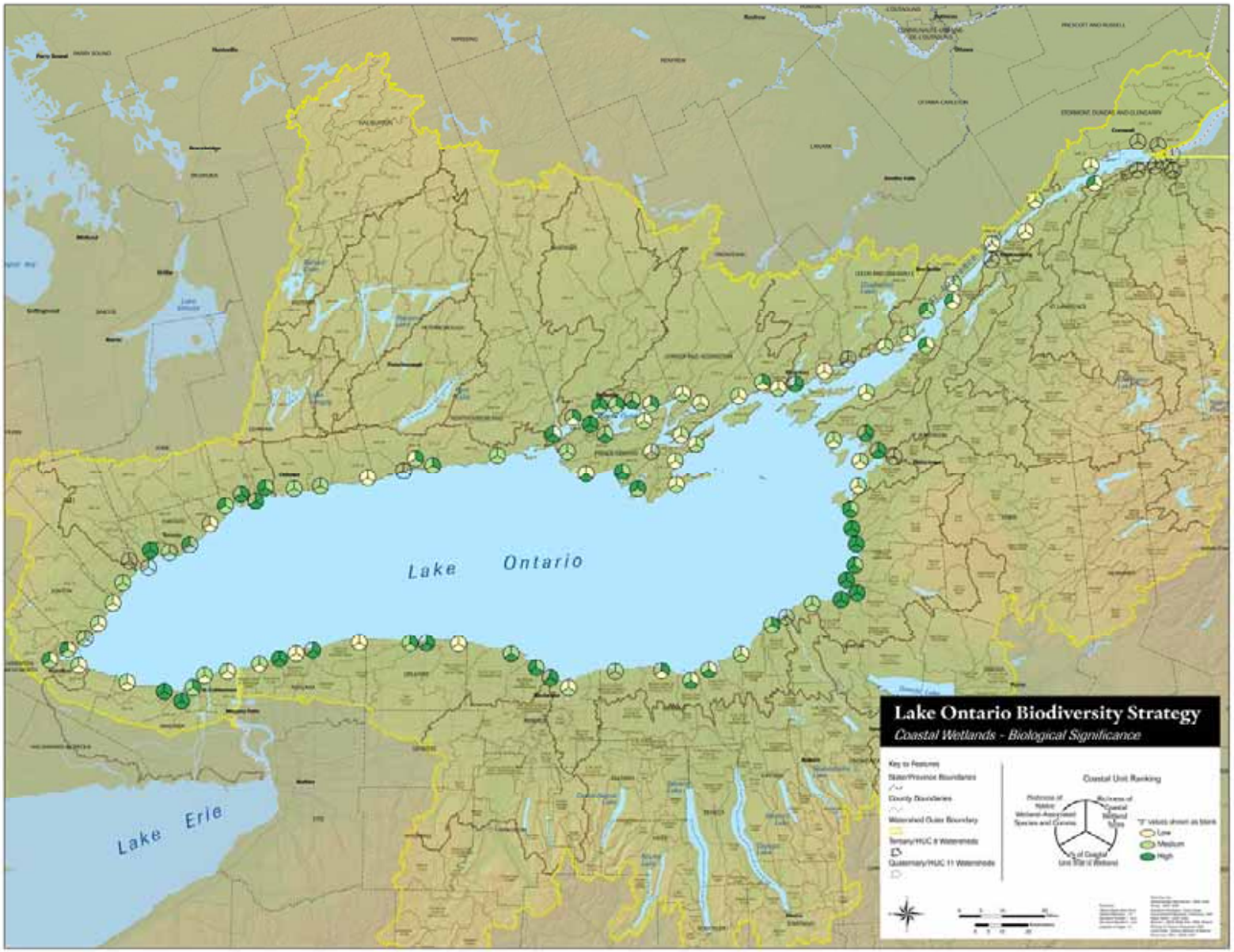
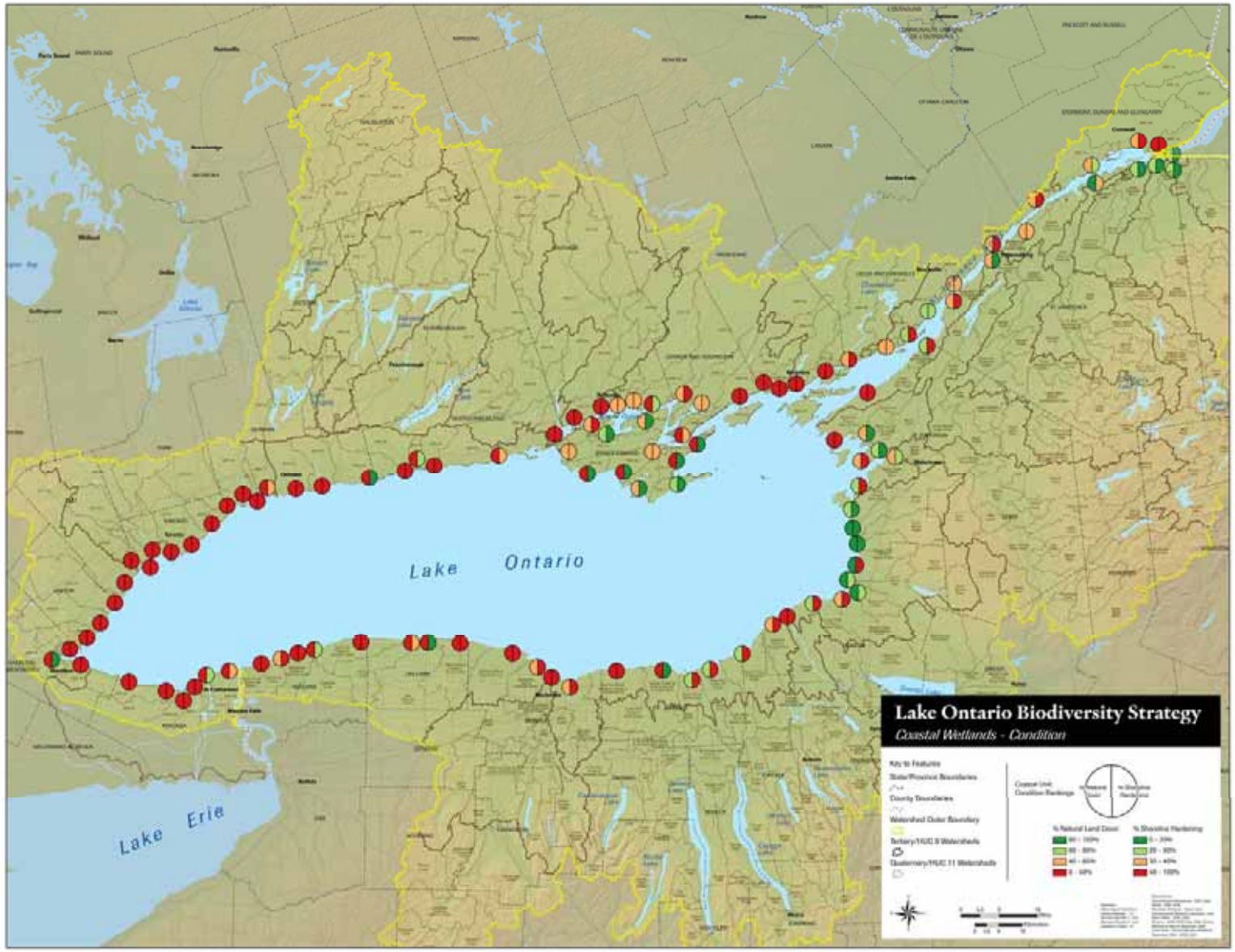


Figure B3 – Coastal Wetlands – Condition



Lake Ontario Biodiversity Target 4: Nearshore Zone

What is it? The nearshore zone occurs from the 20-m depth contour to the mean high water mark along the coast. This zone also includes active beaches. Figures B4 and B5 illustrate the significance and condition of coastal wetlands. *Why is it important?* **The nearshore zone is a key link between land and lake, and is the main interface between people and the ecosystem.** The shallow productive waters support submerged plant communities that are critical for waterfowl and many fish species including smallmouth bass and yellow perch. Nearshore embayments have the greatest fish production and diversity in Lake Ontario. The active beach areas provide habitat for shorebirds. Many recreational activities are concentrated in the nearshore zone.	***Current State***: C

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Nearshore Zone

Indicator	***Measure of a Healthy System***	***Our Current State***
Amount of Shoreline Hardening [2,7]	<20%	**C:** 30-40%
Substrate Type [2,3]	Wide diversity of substrates, predominance of gravel, sand and silt	**C:** Some substrate diversity; increase level of sediments from harbours/embayments
Nutrient concentration and cycles [3,5,9]	Sufficient nutrients to support biodiversity without causing persistent water quality issues	**C:** Some localized water quality issues and loss of biodiversity
Erosion and deposition rates [1,10]	Very low soil erosion by water risk (<6 t/ha/yr)	**C:** Moderate soil erosion by water risk (11-22 t/ha/yr)
Long-term lake level cycle [6,11]	30-40 yr cycle	**C:** No long term cycle
Abundance and distribution of exotics [3,4,8]	Preventing establishment of new exotics, no net gain in existing exotic distribution	**C:** New introductions continue, and it is unclear if the rate of introduction or discovery is changing. Abundance and distribution of existing exotics like quagga mussel and round goby increasing.

1 (Baird & Associates 2005)*; 2:* (CJS Consulting 2002)*; 3:* (Edsall and Charlton 1997)*; 4:* (Edsall et al. 1995)*; 5:* (LaMP 2004)*; 6:* (Farrell 2001)*; 7* (Lake Ontario Biodiversity Conservation Strategy, Workshop 1 2006)*; 8:* (Mills, et al. 2003 a/b)*; 9:* (Environment 1999)*; 10:* (Ouyang et al. 2001)*; 11:* (U.S. Army Corps of Engineers 2005)

What Does the Information Tell Us?

There have been significant improvements in nearshore water quality in the last few years due to improvements in stormwater management, best practices for agriculture and wetland restoration. The quality of the nearshore waters is closely linked to the quality and land uses of the adjacent coast and watersheds. Water clarity has increased due to dreissenid mussel invasion, causing increases in the aquatic macrophyte community which favours additional fish species (Morrison and LaPan 2007). Unfortunately there has been recent re-occurrence of nearshore algal blooms, resulting in beach closures, drinking water quality concerns, added costs to industry and reduced recreational experiences along the lake shore. The invasion of the dreissenids has caused significant long-term ecosystem disruptions to the nearshore zone of Lake Ontario and the other Great Lakes. These mussels have re-engineered the flow of nutrients in the lake causing a "nearshore shunt" where nutrients are concentrated in the nearshore. The result has been increases in growth of the nuisance algae, *Cladophora*, and other water quality effects.

The Good News

- Bacteria counts in many beaches have been declining.
- Yellow perch populations are providing high quality fisheries.

Reviewer's Comments/ Research Questions

- There are no key indicators for fish, plants, and birds, even though fish and macrophytes are mentioned in "Why is it important" and "What does the information tell us" sections.

- Why are erosion and deposition rates key indicators for biodiversity? The complex sediment flow of Lake Ontario, and the difficulty of modeling deposition rates, make these indicators problematic, and their connection to biodiversity is unclear.
- There are no indicators for bacteria counts on beaches. Improving bacteria counts are listed in “good news”, although the connection to biodiversity is unclear.

Figure B4: Nearshore Zone – Biological Significance

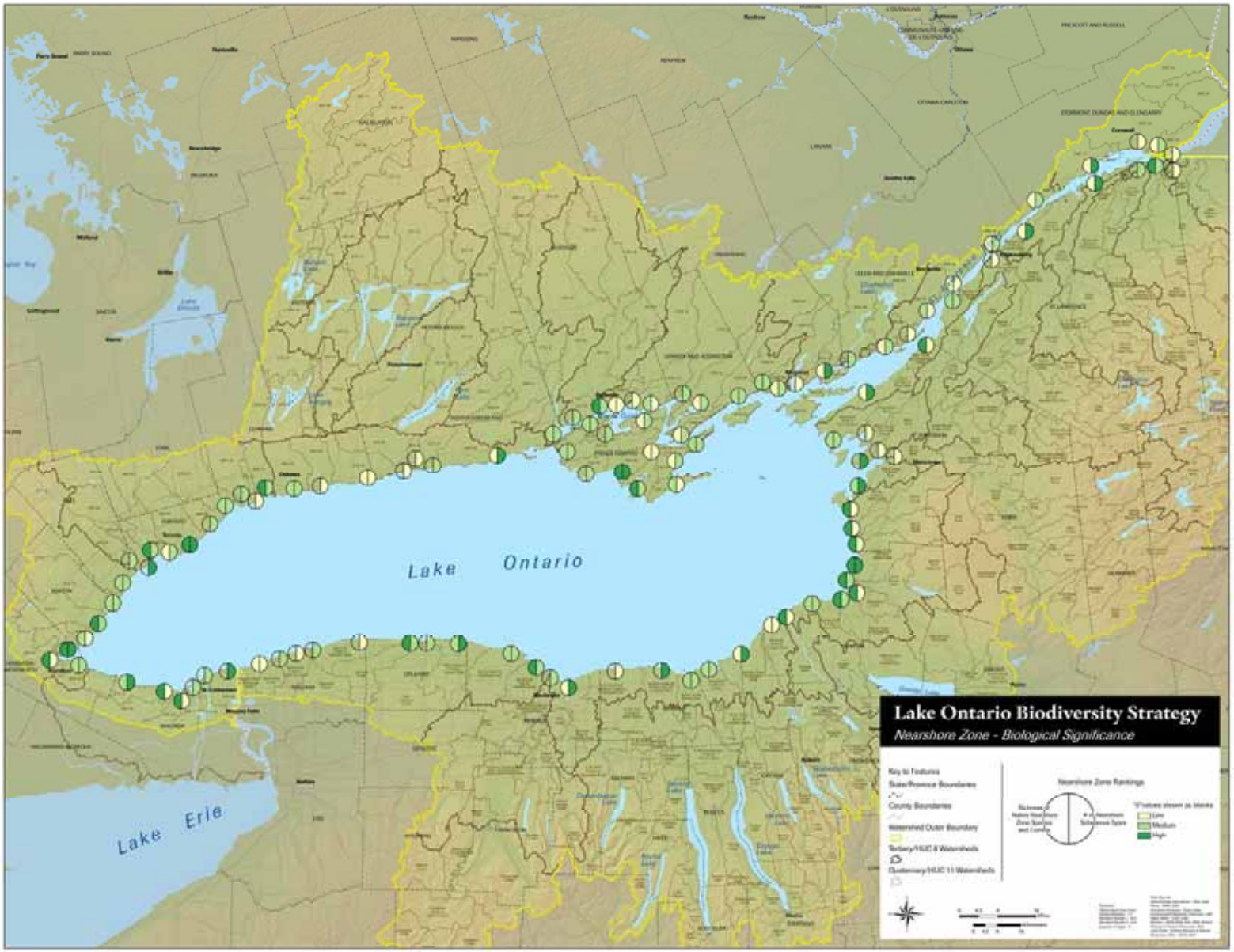
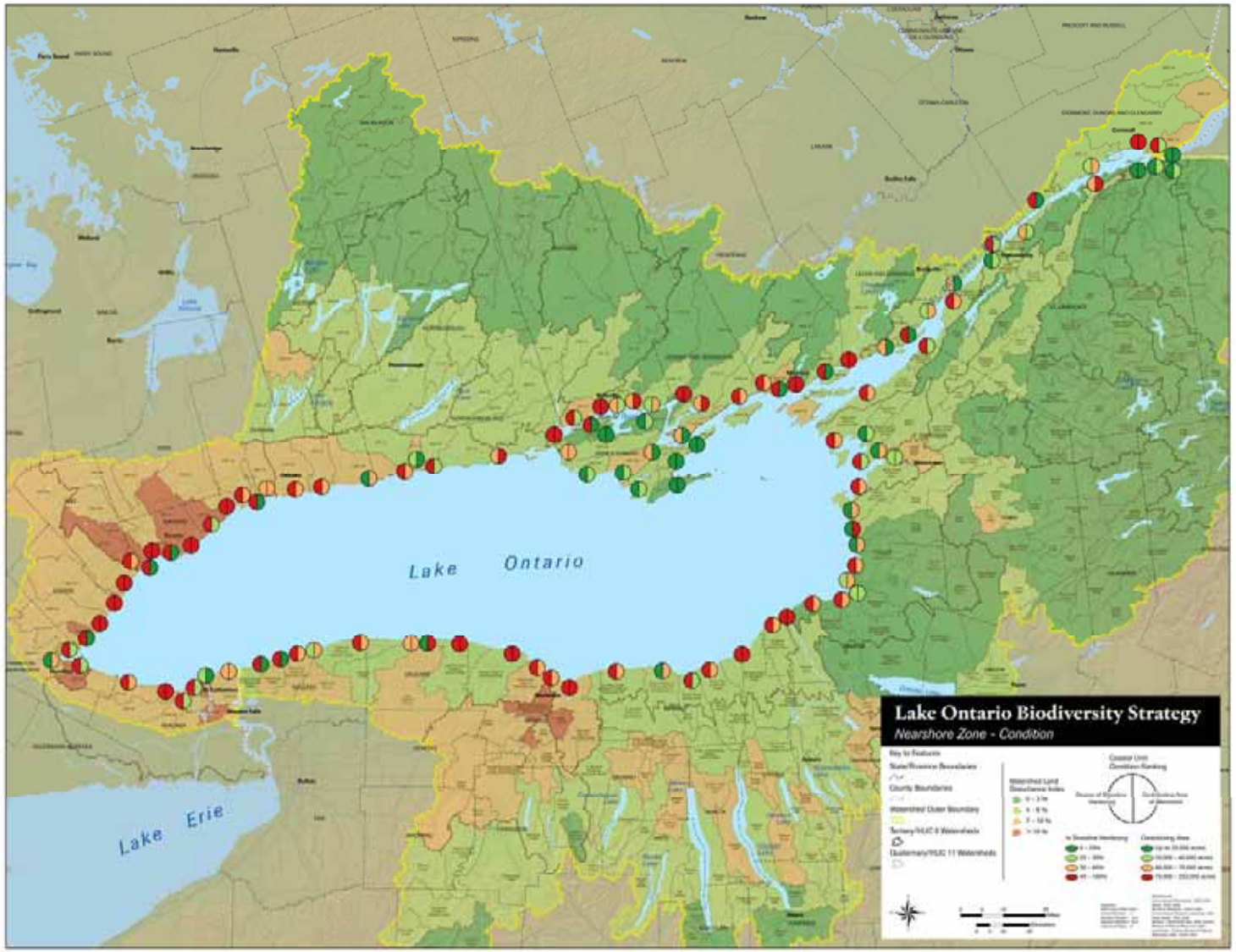


Figure B5: Nearshore Zone – Condition



Lake Ontario Biodiversity Target 5: Coastal Terrestrial Systems

What is it? Coastal Terrestrial Systems are natural cover from the line of wave action to two kilometers inland and include the following components: active and mature dunes, associated wetlands, beaches; barrier spits and associated embayments; bluffs/cliffs; bedrock shores; coastal forests; coastal alvars. The total length of this zone is 3,573 km. Figure B6 illustrates biological significance. Condition is based on the same attributes as the Nearshore Zone (Figure B3). *Why is it important?* Coastal terrestrial systems are a key habitat for biodiversity in the Great Lakes basin and include many rare species and vegetation communities. They are also important as migratory stopover habitat.	***Current State***: C

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Coastal Terrestrial Systems

Indicator	***Measure of a Healthy System***	***Our Current State***
Mean patch size of coastal forests [3,10,13]	>200 ha	**C:** 20-100
Forest cover [5]	>60%	**C:** 20-35%*
% natural cover [2,4,6,11]	>80%	**C**: 40-60%
Distance of land areas from roads [9]	<20% of land area within 375 m of roads	**C**: 60-80% of land area within 375 m of roads
Road density (km road / km^2) [3]	<0.5 km/ km^2	**C:** 1.25-2 km/ km^2
Building density along coast (number of buildings/ ha) [12]	<0.5 buildings/ ha	**C:** 1-2 buildings/ ha
Piers & other constructions (m piers/ km of coast) [12]	<40	**C:** 120-200
% hardened shoreline/ unit of analysis [7]	<20%	**B:** 20-30%
Annual range and timing of lake level (seasonal fluctuations) [1,14]	Mimics natural, unregulated water level cycles (short and long-term)	**C:** Limited variation in annual water levels (magnitude of seasonal fluctuations of 0.6m)
Annual range of lake level (long-term fluctuations) [14]	30-40 yr cycle	**C:** No long-term cycling

1: (Committee to Review the Lake Ontario-St. Lawrence River Studies 2006) *2:* (Dodd and Smith 2003)*; 3:* (Eastern Ontario Model Forest 2003)*; 4:* (Environment Canada and Central Lake Ontario Conservation Authority 2004)*; 5:* (Environment Canada 2004)*; 6:* (Findlay et al. 2001)*; 7:* (Lake Ontario Biodiversity Conservation Strategy, Workshop 1 2006)*; 8:* (Reschke at al. 1999)*; 9:* (Ritters and Wickham 2003)*; 10:* (Robbins et al. 1989)*; 11:* (Rubbo and Kiesecker 2005)*; 12:* (Dave 2001)*; 13:* (Tate 1998)*; 14:* (U.S. Army Corps of Engineers 2005)

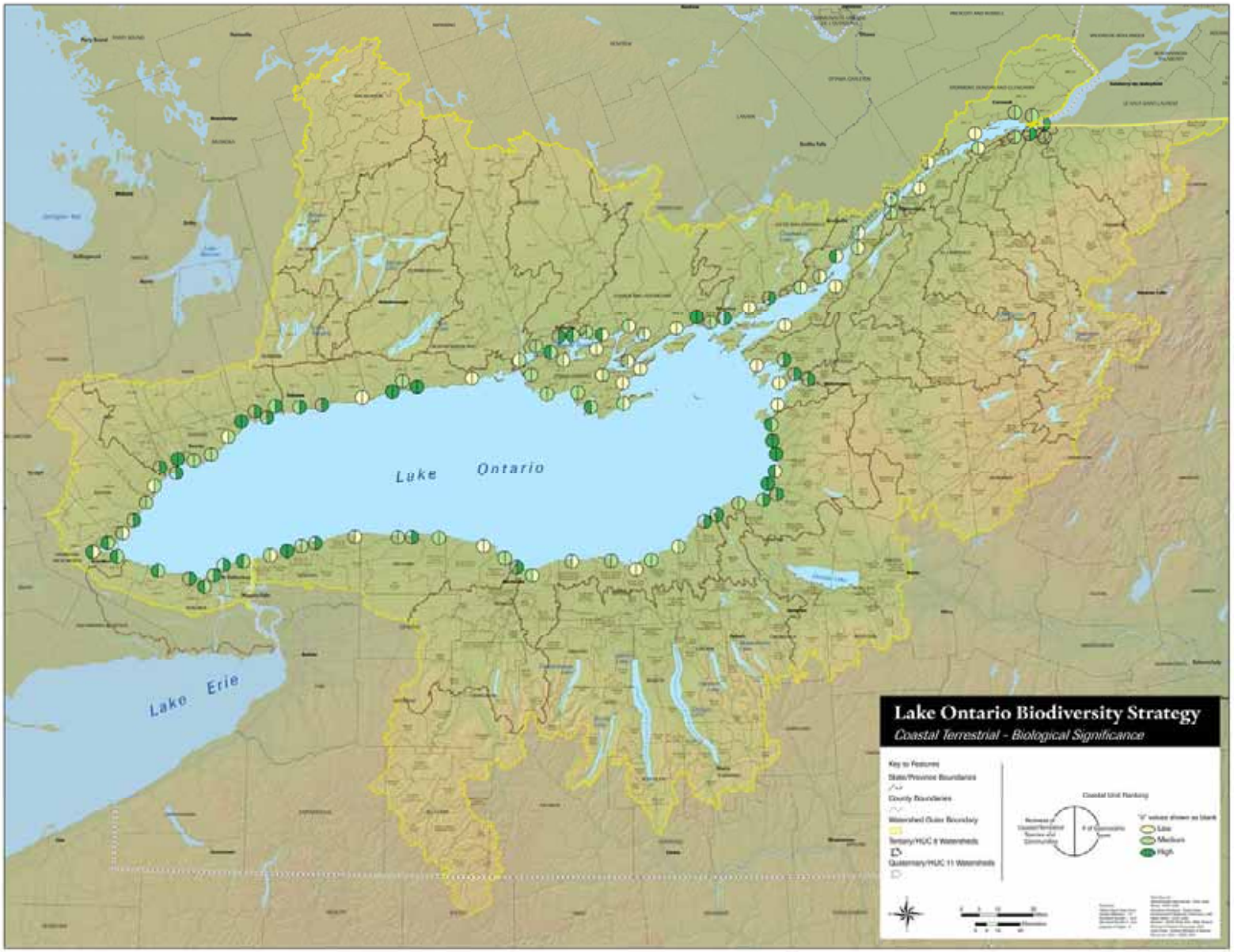
What Does the Information Tell Us?

The coastal terrestrial systems of Lake Ontario are very rich and harbour species and vegetation communities that do not occur further inland. There is much greater natural cover along the coast in the eastern basin compared to the west.

The Good News

- Large areas of significant sand beaches, dunes and coastal forests are in public ownership.
- Approximately 25% (over 85,000 ha/209,950 ac) of the 2 km coastal band around Lake Ontario is still forested.
- Bald eagles are showing early signs of recovery along the Lake Ontario coast.
- Many municipalities and Conservation Authorities in Ontario have developed natural heritage systems that identify cores and linkages along part of the coast.

Figure B6: Coastal Terrestrial Systems – Biological Significance



Lake Ontario Biodiversity Target 6: Rivers, Estuaries & Connecting Channels

What is it? Tributaries to the lake and their associated riparian zones and estuaries. Includes major inlet and outlet rivers (connecting channels). The figure for migratory fish B1 and Figure 5.2 in the main report illustrate some of the condition attributes of this target. *Why is it important?* Tributaries support native fish, mussel and macro-invertebrate communities and native fish communities and have a significant influence on the quality of the nearshore habitats in Lake Ontario.	***Current State***: C

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Rivers, Estuaries & Connecting Channels

Indicator*	***Measure of a Healthy System***	***Our Current State***
% Natural cover in watershed [1]	> 80%	C-: highly variable from east and west
%Impervious cover in watershed (Land Disturbance Index) [1,2]	<3%	C-: highly variable from east and west
Extent of stream length connected to Lake Ontario [1]	Lake-tributary connectivity is sufficient to support viable populations of all native species that require connections between Lake and tributary habitats	C: highly variable from east and west

* Seventeen indicators were identified at the workshop, but many of these have not been applied all tributaries in Lake Ontario.
1: (Center for Watershed Protection 1998)*; 2:* (Lake Ontario Biodiversity Conservation Strategy, Workshop 1 2006)*; 3:* (Stanfield and Kilgour 2006)

What Does the Information Tell Us?

There are large variations in the quality of Lake Ontario's tributaries and watersheds.

The Good News

- There is still the opportunity to protect and restore the headwaters of watersheds in the western basin that are highly impacted near the coast.
- The suspended sediment load in most tributaries has been declining (Lake Ontario LaMP 2008).
- Many watersheds in Ontario have watershed plans that guide land use planning.

Reviewer's Comments/ Research Questions

- Key indicators should include water quality, fish communities, mussels, and macroinvertebrates.

Lake Ontario Biodiversity Target 7: Islands

What is it? Islands include both naturally formed islands and artificially formed islands that have become naturalized and/or support nested targets. *Why is it important?* Lake Ontario and the upper St. Lawrence River have almost 2,000 islands, primarily in the eastern basin. The islands of Lake Ontario are important for colonial nesting waterbirds, migratory birds and support many rare species. Islands in the eastern basin and the upper St. Lawrence River provide "stepping stones" in the linkage between Ontario and New York.	***Current State***: B

Key to the Current State

A: Very Good – Ecologically desirable status; requires little intervention for maintenance and provision of biodiversity and ecological services.
B: Good – Generally within acceptable range of variation; some intervention required for maintenance of biodiversity and ecological services.
C: Fair – Generally outside acceptable range of variation; requires human intervention to restore biodiversity and ecological services.
D: Poor – Restoration increasingly difficult and expensive; may result in fundamental loss of biodiversity and ecological services.

Key Indicators of Health: Islands

Indicator	***Goal***	***Current State***
Consistency of colonial waterbird use[1]	Consistent use (2-3 times since the 1970s or consistently during the 1990s	**B:** Most islands that are suitable for colonial nesting waterbirds remain in use, although there have been major changes in species composition.
Productivity of colonial waterbird nests[1]	>25% of nest produce 1+ fledglings	**B:** Most colonies are productive.
Docking sites[1]	<0.5 docks/ ha	**B:** While many larger islands are heavily developed, most are still natural.

1: (Lake Ontario Biodiversity Conservation Strategy, Workshop 1 2006)

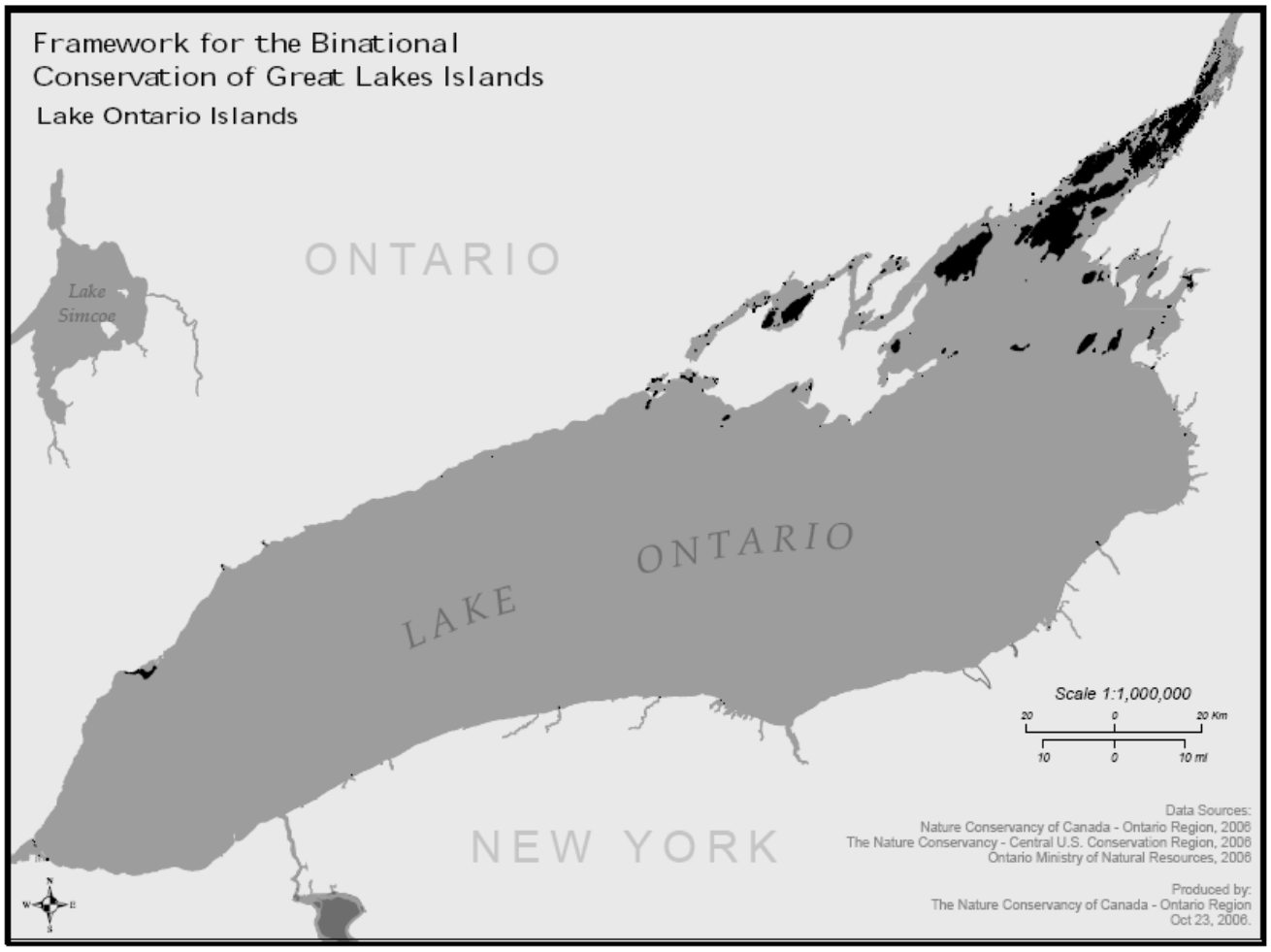
What Does the Information Tell Us?

Lake Ontario's islands are very diverse and are particularly important for colonial nesting waterbirds, with nearly one million birds. Double-crested cormorant populations are expanding. Herring gull populations are stable but may be in flux possibly due to nesting competition with double-crested cormorants. Great black-backed gulls are in decline having suffered severely from a botulism outbreak in 2005. While many larger islands have been developed, most small islands have not been developed. Over 50% of the islands do not have houses, cottages or other direct human impacts.

The Good News

- Many smaller islands are in public ownership.
- A bin-national assessment on biodiversity values and conservation needs for all islands of the Great Lakes will be published in 2009.

Figure B7: Lake Ontario Islands



Threats to Biodiversity

Threats to the health of Lake Ontario have clear and measureable impacts on the biodiversity of the lake. The workshop process required the project team to link threats to the key ecological attributes of targets and to rank individual threats based on their scope, severity and irreversibility. This expert input was supplemented with threats information from the literature and GIS analysis (e.g. mapping of dams and barriers). The overall conclusion from this analysis is that the threats to each ecological system are very high and the Lake Ontario ecosystem as a whole is under a very high level of threat. The biodiversity of Lake Ontario is imperiled by five critical threats:

Critical Threat #1: Incompatible Development
Impact Summary: Incompatible development fragments watersheds and natural habitats, and disrupts natural processes such as the flow of water and movement of sediment.

Quick Facts:

- armoring causes lack of shoreline flushing and disruption of natural longshore transport processes; in western lakeshore 35-38% of shore has been hardened
- shoreline development and modification is a major threat to Lake Ontario coastal wetlands by limiting the ability of wetland communities to migrate upland or downslope in response to periods of higher or lower lake levels
- average size of woodlands becoming smaller as large blocks are broken up for roads, housing, etc.; fragmentation dramatically reduces habitat quality by creating harmful edges
- 50% of Lake Ontario's original wetlands have been lost, and 60-90% have been lost in urbanized areas such as Toronto and the GTA
- over three quarters of original wetlands around western Lake Ontario have been lost, and about half in the remaining part of the watershed
- loss of ecosystem to rapid development – especially on the Canadian side of Western Lake Ontario
- the status of land cover – land conversion in the Lake Ontario basin is mixed, with a trend yet undetermined; there is a very high rate of conversion of undeveloped land to developed land, and a low rate of wetland development; Lake Ontario watershed shows highest conversion rate of forest into developed land
- According to the International Joint Commission, development of shoreline tracts in the lake and upper river increased at a decadal rate of 6% from 1990 to 2000, and this rate of growth in developed land along the shore is projected to continue

Key References:
Reid 2001; Environment Canada and Ontario Ministry of Natural Resources 2003; Environment Canada and United States Environmental Protection Agency 2008; Wolter 2007

Critical Threat #2: Invasive Species

Impact Summary: Invasive species, which have altered the food web and nutrient cycling of the lake and river.

Quick Facts:

Invasive Species

- there is no apparent reduction in introduction rate of new invasive species and the distributions and abundance of existing AIS appear to be increasing
- the entire volume of Lake Ontario is filtered through Dreissenid mussels about once a year
- status of native aquatic species is poor and deteriorating in Lake Ontario; native *Diporeia* populations decline as zebra and quagga mussel populations thrive a possible link exists between botulism deaths and water conditions created by invasives such as the Dreissenid mussel
- Sea lamprey first observed in Lake Ontario in the 1830s (Great Lakes Fishery Commission) – probably native, but has increased due to changes in the structure of the fish community and a decrease in predation
- round goby, thought to be a ballast water introduction; was first documented in Lake Ontario in 1998 and since then the biomass and abundance of the fish has grown exponentially, and its distribution is lakewide; is used as a prey species by double-crested cormorant and many native fish species; first found in St. Clair River, and likely made its way to Lake Ontario through Welland Canal; first noted in Lake Ontario in 1998 near Welland Canal a possible link exists between avian botulism deaths and water conditions created by invasives such as round goby
- possible positive effect of round goby invasion is its role as a predator on non-native mussels (which is largely outweighed by negative effect) likely future invaders include Asian carp spp., grass carp, bighead carp Viral Hemorrhagic Septicemia (VHS) is an emerging threat to fish species such as muskellunge, smallmouth bass, freshwater drum and burbot which have exhibited mortality, and the virus is also present in healthy fish such as rock bass, bluegill, brown bullhead and emerald

Key References:

Reid 2001; Mills, Holeck, and MacIsaac 2007; New York State Department of Environmental Conservation 2007; Walsh et al. 2007; Environment Canada and United States Environmental Protection Agency 2008

Critical Threat #3: Dams & Barriers

Impact Summary: Dams and barriers alter hydrologic rhythms that sustain riparian and coastal habitats, restrict access by fish to spawning and nursery habitats, alter the thermal regime of streams, and interrupt movement of sediments. There are several thousand dams in the tributaries and connecting channels of Lake Ontario.

Quick Facts:

- over 110 instream barriers such as dams and weirs have been identified in the Humber River watershed alone
- hydroelectric dams along the St. Lawrence have contributed to the decline of the American eel
- major stressor to coastal wetlands in Lake Ontario is water level regulation – has occurred since construction of St. Lawrence Seaway in 1959; natural decadal cycles of high and low levels have been eliminated by regulation with clear impacts to the distribution and diversity of wetland communities and species, also causing invasive species to dominate

Key References:

Reid 2001; Environment Canada and Ontario Ministry of Natural Resources 2003; Environment Canada and United States Environmental Protection Agency 2008

Critical Threat #4: Non-point Source Pollution

Impact Summary: Nutrient and sediment runoff leads to algal blooms in nearshore waters that alter water chemistry, decrease oxygen levels, and may combine with actions of invasive mussels to alter chemical and species composition in the nearshore. This is an issue of particular importance in the urban settings of the western basin, but research in New York has revealed high nutrient levels in nearshore waters adjacent to rural settings as well. The proposed bi-national target for phosphorus concentration in nearshore waters is 15ug/liter.

Quick Facts:

- eutrophication and toxic contamination have been major pollution problems in Lake Ontario; although filtration and sterilization provide safe drinking water from the lake, concern over water quality and human health persist
- current levels of contaminants do not appear to be having an impact on the fish community and reproduction
- critical pollutant levels in Lake Ontario have declined significantly over last 20-25 years in response to regulatory and voluntary actions, but many pollutants still occur in the waters in excess of critical levels
- water entering Lake Ontario from the Niagara River is the single largest source of contaminants for Lake Ontario, and atmospheric discharges, tributary and wastewater contributions comprise the remainder
- harmful algal blooms are an emerging problem which alters habitats and habitat functionality; caused by excess of nutrients from human input frequent exceedences of nitrogen and phosphorus limits can lead to overgrowth of algae
- phosphorus in drinking water is still a concern at times
- in parts of Lake Ontario, lawns of *Cladophora* and growth of toxic cyanophytes such as *Microcystis* are common and suggest high phosphorus levels in some areas; much fluctuation over time in nearshore areas; general status of phosphorus loads in Lake Ontario is good in the open lake, poor in the nearshore, while the trend is improvement in the open lake and undetermined in the nearshore , phosphorus levels have been declining since the 1970s
- nutrients, especially phosphorus, have a major impact on Lake Ontario's fish communities; mainly come in from Lake Erie via the Niagara River, sewage treatment plants and runoff from urban or agricultural land; loading was a significant problem in the 1960s and while mostly abated, some results from these historical loading events are still present in the Lake today
- in recent years, improvements to wastewater treatment have reduced excessive nutrients to historic, more natural levels, lowering the overall productive capacity of Lake Ontario's ecosystem
- urban sources also contribute oil, grease, road salt, metals from sewer outfalls, snow dump sites, landfill leachate and atmospheric fallout

Key References:

Morrison and LaPan 2007; Environment Canada and United States Environmental Protection Agency 2008; Toronto and Region Conservation Authority and Ontario Ministry of Natural Resources 2005; Dove and Warren 2007; New York State Department of Environmental Conservation 2007; Reid 2001

Critical Threat #5: Climate Change

Impact Summary: Climate change is predicted to lead to decreased winter ice-cover, resulting in increased evaporation and lower lake levels. Expected impacts include altered hydrologic regimes, shifts in ecological systems such as coastal wetlands, increased water temperatures in tributaries with changes in fish spawning habitats, and increased severity of coastal storms.

Quick Facts:

- expected to have a major impact on tributary streams in the coming years due to decreasing streamflows, groundwater recharge and higher summer temperatures; could worsen effects of current stresses and make restoration very difficult (Reid 2001)
- nearshore habitats will likely be negatively impacted by climate change and resulting effects such as lower water levels, higher summer temperatures and reduced winter ice cover
- 11.7% reduction in ice cover since 1970s
- climate change predicted to increase evapotranspiration over Lake Ontario basin by 120 mm/year (model spans 1998-2068), with a seasonal spike in evapotranspiration over summer months
- temperature and annual precipitation are also predicted to increase
- warmwater fish recruitment will likely increase exponentially with temperature increases
- for coldwater species that find the southern limit of their range in Lake Ontario, such as Lake Trout, problems with continued existence might occur in the face of increasing temperatures

Key References:

Reid 2001; Farris 2007; Lofgren 2008; Quinte Conservation 2004

Appendix C:
Summary of Lake Ontario Plans and Studies

Many conservation plans, at the local, watershed, state and province, and Great Lakes basin-wide scales, preceded this Lake Ontario Biodiversity Conservation Strategy. The intent of this project has been to build on these previous efforts and avoid "re-inventing the wheel". Accordingly, in preparation for the first expert workshop in Kingston, Ontario on June 21-22, 2006, the following summary of previous planning efforts, at various geographic scales, was distributed to workshop participants.

While these plans may not have explicitly identified conservation targets, or defined the threats to these targets in the approach taken in this report, there is great commonality between the Great Lakes Regional Collaboration and NY State's Comprehensive Wildlife Conservation Strategy, to name two recent large-scale planning efforts, and the biodiversity conservation strategy presented in this report.

This appendix highlights these common features by presenting the summary of each previous plan in the format we have followed in this project: selecting biodiversity targets; identifying the stresses, or threats, to the viability of these targets, and the sources that contribute to these stresses; developing strategies to abate these threats; and defining measures to assess the progress of these strategies. This appendix provided a starting point for discussions during the first workshop, when participants selected the ecosystem components and species we used as biodiversity targets for discussion and analysis.

This collection of summaries was intended to be representative of previous planning efforts, rather than an exhaustive presentation of all relevant plans.

Lake Ontario Lakewide Management Plan Ecosystem Objectives/Indicators (2004)	
Author/ Lead organization	US Environmental Protection Agency & Environment Canada
Website	www.epa.gov/glnpo/lakeont/2004update/LO2004.pdf
Targets	• self-sustaining benthic and pelagic communities in dynamic equilibrium, with emphasis on native species • coastal wetlands • nearshore zones • uplands • tributaries • lake trout • American eel • bald eagle
Stresses	•
Sources	•
Strategies	•
Measures	•

Developing Lakewide Habitat Priorities for New York's Lake Ontario Basin (2004) ***Working draft as part of Lake Ontario Lakewide Management Plan***	
Author/ **Lead organization**	Peter Taylor, Frederick Luckey, Brandt Brown, Jack Brunner US Environmental Protection Agency
Targets	• tributary buffer zones • tributary upstream reaches • coastal wetlands and embayments • migratory bird habitats • unique and rare habitats: alvars, sand plains, coastal sand dunes
Stresses	• high tributary water temperatures • degraded water quality • impaired fish passage in tributaries – habitat fragmentation • invasive species • altered hydrology • reduced wetland species diversity • habitat destruction/degradation
Sources	• unvegetated tributary buffers • sediment and nutrient runoff from agricultural fields and residential/commercial areas • barriers to passage – dams • lake level regulation • residential development • limestone quarrying • uncontrolled ATV use • international shipping – poor ballast water controls
Strategies	• restore tributary buffer zones, with priority to Salmon River and tributaries, Trout and Orwell Creeks, Oswego River, tributaries to North Pond, Grindstone Creek • improve tributary upstream fish passage, through dam removal and fish ladders in priority tributaries • restore and conserve coastal wetlands and embayments • protect migratory bird habitats • protect unique and rare habitats • prevent introduction of new invasive species • increased monitoring and enforcement of regulations to exchange ballast water outside the GL • retrofitting ships with protected ballast water exchange mechanisms
Measures	• number of river miles with natural or managed buffer zones • additional upstream miles of fish passage generated by dam removal or fish ladders • use of birds as indicators of habitat quality/structure? • changing distribution of wetland natural communities – focus on cattail-dominated wetlands • percentage of rare habitats under conservation management • monitor extent and location of habitat alteration due to shell deposition from zebra and quagga mussels

Lake Ontario Fish Community Objectives (1999, 2003 update)	
Author/ Lead organization	Great Lakes Fishery Commission
Website	http://www.glfc.org/lakecom/loc/lochome.php
Targets	• Nearshore fish community composed of self-sustaining native fishes, including walleye ▪ yellow perch ▪ lake sturgeon ▪ smallmouth bass ▪ largemouth bass ▪ sunfish ▪ American eel • Offshore benthic fish community composed of self-sustaining native fishes, including lake trout ▪ lake whitefish ▪ native prey fishes • Offshore pelagic fish community characterized by diversity of salmon and trout; with Chinook as top predator, abundant populations of rainbow trout, fishable populations of Coho and brown trout; stocked Atlantic salmon; diverse prey fish with alewife as important species. Pelagic community includes Atlantic salmon ▪ burbot ▪ lake herring ▪ deepwater ciscoes ▪ deepwater sculpin ▪ slimy sculpin ▪ emerald shiner ▪ spottail shiner
Stresses	• early mortality syndrome of predatory fishes • changes in how nutrients are cycled through food webs • decreased availability of prey fish • water quality degradation • virtual elimination of large piscivores • reduced abundance of native fishes • overabundance of exotic species • excessive bacteria • excessive nutrients • excessive sediments • contaminants • wetland loss • cancerous tumors on benthic-feeding fishes • loss of *Mysis* and *Diporeia* • change in diet and growth rate of fishes • decreased abundance of diatoms • avian botulism
Sources	• thiamine deficiency in parental diets (alewife) • invasion of zebra and quagga mussels • industrial inputs • runoff from urban development • runoff from agriculture • landfills • water level management • invasion of alewife, rainbow smelt, and sea lamprey via Erie Canal • commercial fishing pressure • inputs from sewage treatment plants • loss of zooplankton productivity • wetland drainage for agriculture and urban encroachment • predation by cormorants
Strategies	• reestablishment of native forage fishes (ciscoes, deepwater sculpin) that can provide prey alternatives to alewife, rainbow smelt, and slimy sculpin • maintain quality fishing opportunities (trout and salmon) without putting excess predation pressure on alewives • reduce salmon and trout stocking to balance demand on prey-fish populations • phosphorous reduction through Great Lakes Water Quality objectives

Lake Ontario Fish Community Objectives (1999, 2003 update)	
	• improved fish diversity through fish stocking • sea lamprey control • wetland rehabilitation • replant aquatic vegetation • create channels in cattail marshes • restore natural water level fluctuation in dyked areas • stormwater management • eel ladder • improve fish passage • improve water level regulation • protect genetic diversity of native fishes • protect and rehabilitate native fishes • protect and enhance rare and endangered fishes • control new introductions of aquatic species • maintain sea lamprey marking rates < 0.02 rates per lake trout • achieve nearshore water quality targets • protect and rehabilitate critical fish habitat, including tributary and nearshore spawning and nursery areas • reduce contaminant concentrations in fish to levels that result in no sport-fish consumption advisories and that cause no impairment of fish and wildlife reproduction • stocking • fish harvest controls
Measures	• lake trout wound rates • angler catch rates

Draft Fish Community Objectives for the St. Lawrence River (2001) **(includes information from two discussion papers: *Fish Habitat Changes - Thousand Islands, Middle Corridor, and Lake St. Lawrence* and *Fish communities and fisheries - Thousand Islands, Middle Corridor, and Lake St. Lawrence*)**	
Author/ **Lead organization**	Great Lakes Fishery Commission; *RE Grant & Associates*
Website	http://www.glfc.org/lakecom/loc/lochome.php
Targets	• Game and sport fish species, including smallmouth bass ▪ largemouth bass ▪ northern pike ▪ walleye ▪ muskellunge ▪ yellow perch ▪ pumpkinseed sunfish ▪ rock bass ▪ brown bullhead • Commercial fish species, including: lake sturgeon ▪ American eel • Rare/sensitive fish species (non-game), including: mooneye ▪ pugnose shiner ▪ greater redhorse ▪ stonecat ▪ channel darter ▪ blacknose dace ▪ lake sturgeon ▪ cutlips minnow ▪ blackchin shiner ▪ bridle shiner • Atlantic salmon • Forage fish species • Egg, fry, young-of-year, and juvenile life stages of all species
Stresses	• frequent and rapid fluctuation of water level and velocities • loss of rapids habitat • loss of wetlands and submerged aquatic vegetation (loss of spawning, nursery and forage habitats) • loss of underwater shoals and structures that created habitat diversity • poor fish reproduction and recruitment • flooding of wetland and tributary mouths • water quality degradation due to excessive nutrients (e.g. phosphorous or nitrogen) • reduction in primary production • disrupted flow of nutrients and energy through the food web

Draft Fish Community Objectives for the St. Lawrence River (2001) **(includes information from two discussion papers: *Fish Habitat Changes - Thousand Islands, Middle Corridor, and Lake St. Lawrence* and *Fish communities and fisheries - Thousand Islands, Middle Corridor, and Lake St. Lawrence*)**	
	• limited vegetative growth (due to low nutrients) • loss of top predators (lake trout, Atlantic salmon, burbot, whitefish) • suppressed yellow perch populations • loss of diversity of wetland habitat • chemical and heavy metal contamination • altered water temperature regime • blocked fish passage • resuspension of contaminants and toxins in water column • loss of invertebrates (due in part to loss of submerged aquatic vegetation) • increased turbidity due to erosion and suspended materials • replacement of soft, vegetated shoreline with hard materials (rock) • hard shorelines limit landward migration of wetlands and decrease plant diversity • increase in mean water levels and limited annual water level fluctuation • creation of unstable and unproductive habitats • fragmentation of underwater plants • erosion of sand, clay, and silt materials causing uprooting of submerged and emergent plants • decreased water clarity in localized areas (e.g. tributary mouths) • alteration of native fish community structure and composition • unsuitable environmental and habitat changes (due to invasive species) • reduced size of smallmouth bass and northern pike
Sources	• water level regulation for hydroelectric power and shipping/navigation interests • channelization • low water temperatures • overharvest • predation by cormorants • disruption of spawning by anglers • Seaway construction • dredging for navigation • dredging, filling, and shoreline modification (concrete, rock retaining walls, rip rap) • poorly operated sewage treatment and sewer overflows • improper disposal of phosphate-based detergents • poor agricultural practices • invasion of zebra and quagga mussels • anticipated lower lake levels due to global warming • invasion of sea lamprey • alewife predation on native fish species early life stages • use and improper disposal of phosphate-based detergents • major St. Lawrence dams • tributary dams • dredging and filling • shoreline modification • water level regulation - fluctuating water levels and velocities • water extraction for industrial and residential use • pollution due to discharge and spills • pollution due to stormwater drainage • pollution due to industrial plants • unintentional exotic species introductions • intentional exotic species introductions • habitat change/loss

Draft Fish Community Objectives for the St. Lawrence River (2001) **(includes information from two discussion papers: *Fish Habitat Changes - Thousand Islands, Middle Corridor, and Lake St. Lawrence* and *Fish communities and fisheries - Thousand Islands, Middle Corridor, and Lake St. Lawrence*)**	
	• changes to weather patterns • reduced food availability • increased predation • blocked migration routes
Strategies	• commercial licenses to restrict fishing to specific areas, locations, seasons, and gears • management quotas (commercial) for black crappie, yellow perch, and American eel • fishing regulations - size restrictions, catch, possession and season limits • sea lamprey control • fish stocking to restore spawning stock • improved fishery assessment / surveillance (angler survey, fish community survey) • harmonize New York and Ontario fishing regulations, as appropriate • manage commercial fisheries consistent with fish community objectives • protect genetic diversity of native fishes • protect and rehabilitate native fishes • protect and enhance populations of rare and endangered fishes • control new introductions of exotic species • maintain phosphorous at current levels (within guidelines set by GLWQA) • protect and rehabilitate critical fish habitat, including tributaries and nearshore areas • enhance or recreate spawning and nursery habitats for affected fish species • develop water level management practices that will promote maintenance and recovery of habitat diversity and successful reproduction of northern pike and other fish and wildlife species • reduce contaminant levels/ reduce concentrations to levels safe for consumption • reduce contaminants to levels that cause no impairment of fish and wildlife reproduction • encourage IJC and St. Lawrence River Board of Control to consider fish habitat management concerns when revising or setting new water level management objectives • mechanically cutting into cattail beds to keep pike spawning habitat flooded in spring • installing or maintaining dykes in wetlands to keep pike spawning habitat flooded in spring • nutrient and pollutant reduction through implementation of levels set in Great Lakes Water Quality Agreement • fish culture and stocking • improved sewage management • improved agricultural practices • eel ladder at Moses-Saunders dam • fish habitat protection laws in Ontario and New York • existing state and provincial shoreland and in-water permit applications consider fish habitat • improved mitigation • existing shoreline protection laws • retain existing shore-to-water interfaces • return annual water level fluctuations to more natural state • restriction of winter shipping • reduced speed limits in areas with high shoreline erosion potential • continued ban or restricted use of man-made chemicals (PCBs, mirex, DDT, toxophene, chlordane) and naturally occurring chemicals (mercury, cadmium) to reduce fish consumption advisories • eliminate ballast water exchange

Draft Fish Community Objectives for the St. Lawrence River (2001) **(includes information from two discussion papers: *Fish Habitat Changes - Thousand Islands, Middle Corridor, and Lake St. Lawrence* and *Fish communities and fisheries - Thousand Islands, Middle Corridor, and Lake St. Lawrence*)**	
	• improve communications and education about consequences of invasive species and prevention strategies
Measures	• netting surveys • surveillance for sea lamprey

Comprehensive Wildlife Conservation Strategy (2006)	
Author/ Lead organization	New York State Department of Environmental Conservation
Website	www.dec.state.ny.us/website/dfwmr/swg/cwcs2005.html
Targets	***Note:*** This is a partial list of the statewide Species of Greatest Conservation Need (SGCN) that relate directly to Lake Ontario/St. Lawrence. • Freshwater fish: ▪ brook trout, heritage strains ▪ eastern sand darter ▪ lake sturgeon ▪ pugnose shiner ▪ redfin shiner ▪ river redhorse ▪ sauger ▪ round whitefish ▪ mooneye ▪ longear sunfish ▪ • Extirpated fishes: ▪ Atlantic salmon ▪ kiyi ▪ shortjaw cisco ▪ shortnose cisco ▪ silver chub ▪ spoonhead sculpin ▪ black redhorse ▪ deepwater sculpin • Marine fish: ▪ American eel • freshwater marsh-nesting birds: ▪ American bittern ▪ black tern ▪ east bittern ▪ pied-bill grebe ▪ king rail ▪ yellow rail • Beach and ground-nesting birds • Colonial nesting herons • Transient shorebirds • Lake/river reptiles • Uncommon turtles of wetlands: ▪ Blanding's turtle ▪ spotted turtle • Eastern pondmussel • Riparian tiger beetles
Stresses	• habitat loss/fragmentation • degraded water quality • altered hydrology • invasive species • siltation/nutrient runoff • climate change
Sources	• atmospheric deposition • development • dredging • lake level regulation • changes in farming practices • wetland draining • incompatible agriculture/silviculture • water temperature increases • lowered dissolved oxygen • dams/weirs/culverts • groundwater withdrawal • PCBs, bioaccumulative toxins • erosion – road banks, fields • shore hardening
Strategies	• develop watershed management plans for each watershed basin within five years • expand restoration of extirpated fish and freshwater fish to suitable historic waters • continue hatchery programs for lake sturgeon, Atlantic salmon

Comprehensive Wildlife Conservation Strategy (2006)	
	• develop statewide eel management and recovery plan • survey waters for remnant populations of SGCN • improve mapping and understanding of habitat distribution for SGCN • fill gaps in information on SGCN – American eel, secretive marsh-nesting birds, surveys for freshwater fish
Measures	• develop statewide strategy for monitoring and assessment of all SGCN • define objectives and identify monitoring questions • inventory the ongoing and existing monitoring data relevant to SGCN and their habitats across the state; identify gaps where such assessments do not exist. Collaboration with existing monitoring efforts – conduct outreach and diligent investigation into ongoing monitoring efforts across the state. These assessments will provide a starting point and help track progress toward improving the health of these populations and their habitats statewide. • hold several meetings with key partners in order to build on past and present monitoring efforts • form a stakeholder committee • create geo-referenced central database – identify an accessible data management system • design ideal sampling strategy for individual SGCN and their habitats • cost-benefit analysis to refine data collection techniques and prioritize resources • analyze pilot monitoring data and evaluate management actions; evaluate ranking of target resources • propose changes in data collection and management as part of iterative, adaptive process

Fish and Wildlife Habitat Status and Trends in the Canadian Watershed of Lake Ontario (2001)	
Author/ Lead organization	R. Reid Environment Canada, Canadian Wildlife Service, Ontario Region: Technical Report Series Number 364
Targets	• open lake – pelagic and benthic zones • coastal shore system – dunes and beaches, bedrock shores, alvars • coastal marsh system • lakeplain system • tributaries and connecting channels • inland terrestrial system • inland wetland system
Stresses	Lake Ontario watershed • forest fragmentation and loss • loss and degradation of wetlands Lake Ontario tributaries • altered hydrology – increased variability in streamflow • impaired water quality • habitat fragmentation • impaired fish passage Nearshore lands and waters • altered hydrology – reduced natural periodicity in lake levels • impaired natural erosion and sediment transport processes • impaired nutrient cycling through food webs – altered energy flow • altered species composition • bioaccumulation of persistent toxins • declines in native bivalve populations • rapid habitat alteration Offshore waters of Lake Ontario

Fish and Wildlife Habitat Status and Trends in the Canadian Watershed of Lake Ontario (2001)	
	• declines in *Diporeia* • altered species composition of pelagic phytoplankton and zooplankton communities • altered species composition of benthic organisms, and declines in benthic biomass • degradation of benthos by contaminants • instability and altered species composition of pelagic fish community
Sources	• invasive species • continued introduction of invasive species • development and urban sprawl • population growth, particularly western basin • lake level regulation • dams/weirs • shoreline hardening • airborne pollutants – atmospheric deposition • elevated levels of sediments in tributaries • groundwater withdrawals • intensive agriculture • loadings of sediments and other pollutants in tributary waters • climate change
Strategies	• interconnected nature of lake ecosystem with tributaries and watershed should be recognized and stressed • cooperative programs and a coordinated approach to establish priority sites and to direct resources from multiple sources to those sites • development of a consistent and workable classification system for aquatic habitat types is an important early step in the above process • development of Lake Ontario LaMP as a broad framework to address ongoing habitat issues with offshore, nearshore, tributary, and watershed areas • focus planning efforts at the watershed and sub-watershed scale, as the most appropriate planning units, and direct more resources to this level of planning • improve forest cover in the watershed • develop a much-improved information base on groundwater resources within the watershed • promote stronger steps to protect significant groundwater resources such as Oak Ridges Moraine • actions to develop new techniques to prevent and remediate aquatic habitat impacts from urban development, and promote buffers and BMPs, should be encouraged • cooperative development of strategies for prevention of further introductions and remediation of impacts of invasive species • stronger incentive programs for private land stewardship • improved digital information on land-use change, forest and wetland cover, nearshore sediments and bathymetry, tributary physical characteristics, and fish communities • process of adaptive management for the lake, to enable responses to super-stressors such as zebra mussels and climate change
Measures	• improved coordination of existing site-specific monitoring programs to allow comparability

Great Lakes Coastal Wetlands Consortium Inventory and Classification (2003)	
Author/ Lead organization	Albert, D.A., J. Ingram, T. Thompson, and D. Wilcox, on behalf of the Great Lakes Coastal Wetland Consortium
Website	http://www.glc.org/wetlands/inventory.html
Targets	Lacustrine system • open shoreline (LOS-) • open embayment (LOE-)

Great Lakes Coastal Wetlands Consortium Inventory and Classification (2003)	
	• protected lacustrine (LP-) • protected embayment (LPP) • sand-spit embayment (LPS) Riverine System • drowned river mouth (RR-) • open, drowned river mouth (RRO-) • barred, drowned river mouth (RRB-) • connecting channel (RC-) • delta (RD-) Barrier-Protected • barrier beach lagoon (BL-) successional barrier beach lagoons • swale complexes (BS-) sand-spit swales (BSS-) ridge and swale complexes (BSR-)
Stresses	• whole lake regulation • watershed alteration • dyking, dredging, in-filling • modification of the hydrological connection with the lake

Conservation Blueprint for the Great Lakes (2006)	
Author/ Lead organization	The Nature Conservancy & Nature Conservancy of Canada
Website	http://www.nature.org/wherewework/northamerica/greatlakes/
Targets (US)	• Plant Communities: Maple-Ash-Elm Swamp Forest ▪ Speckled Alder Swamp ▪ Bog Birch - Willow Rich Boreal Fen ▪ Leatherleaf-Sweetgale Shore Fen ▪ Willow - Mixed Rich Shrub Fen ▪ Tufted Hairgrass Wet Alvar Grassland ▪ Northeastern Cinquefoil - Sedge Fen ▪ Great Lakes Pondweed Submerged Aquatic Wetland ▪ Great Lakes Shallow Marsh ▪ Bulrush - Cattail - Burreed Shallow Marsh ▪ Midwest Mixed Emergent Deep Marsh ▪ Great Lakes Shoreline Cattail Marsh • Migratory Stopover Sites: Landbird stopover sites ▪ Raptor stopover sites ▪ Shorebird stopover sites ▪ Waterfowl stopover sites • Species: Henslow's Sparrow ▪ Grasshopper Sparrow ▪ American Bittern ▪ Piping Plover ▪ Black Tern ▪ Northern Harrier ▪ Sedge Wren ▪ Trumpeter Swan ▪ Cerulean Warbler ▪ Prairie Warbler ▪ Bobolink ▪ Osprey ▪ Prothonotary Warbler ▪ Clay-colored Sparrow ▪ Common Tern ▪ Golden-winged Warbler ▪ Blue-winged Warbler ▪ American ternate grapefern ▪ False hop sedge ▪ Bog Turtle ▪ Ram's head lady's slipper ▪ Bald Eagle ▪ Bog buckmoth ▪ Eastern small-footed bat ▪ Indiana bat ▪ Ogden's pondweed • Stream system types: tributaries to southern Lake Ontario bays ▪ Lake Ontario lake plain coastal streams ▪ western Tug Hill streams ▪ small marine plain coastal streams ▪ St. Lawrence lake plain mainstems ▪ St. Lawrence lake plain tributaries • Lake types: Great Lakes coastal ponds ▪lake plain lakes • Nearshore habitat types: baymouth/barrier beaches and shoreline bluffs with sand nearshore ▪ baymouth/barrier beaches with bedrock nearshore ▪ bedrock (resistant) with bedrock (resistant) nearshore ▪ clay banks with clay nearshore ▪ open shoreline wetlands with bedrock nearshore ▪ open shoreline wetlands with clay nearshore ▪ sandy beach/dunes with bedrock (resistant) nearshore ▪ sandy beach/dunes with sand nearshore ▪ sandy/silty banks with bedrock nearshore ▪ semi-protected wetlands with bedrock (resistant) nearshore ▪ shoreline bluffs and beach with bedrock nearshore

Great Lakes Regional Collaboration Strategy (2005)	
Author/ Lead organization	Great Lakes Regional Collaboration strategy teams

Great Lakes Regional Collaboration Strategy (2005)	
Website	http://www.glrc.us/strategy.html
Targets	• native fish communities in open waters and nearshore habitats • wetlands • stream and riparian habitats in Great Lakes tributaries • coastal and upland habitats • nearshore waters and coastal areas
Stresses	• degradation and loss of fish and wildlife habitat, including fish spawning and nursery habitat • loss of native species • food web disruption • disruption of sediment transport • impairment of human uses • loss of diversity of aquatic life • impairment of wildlife health
Sources	• aquatic invasive species entering via maritime commerce (e.g. ship ballast), aquaculture, canals and waterways, recreational activities, and trade and use of live organisms • non-point source pollution • altered lake levels • loss of floodplains and buffers • hydrologic alteration • landscape fragmentation and alteration • combined sewer overflows • untreated or inadequately treated human and industrial waste • contaminated sediments • runoff from hazardous waste sites • habitat degradation and destruction • nutrients • contaminants • pathogens • sedimentation • persistent toxic substances • industrial processes • groundwater contamination
Strategies	• prevent AIS introductions by ships through ballast water and other means • stop invasions of species through canals and waterways • restrict trade in live organisms • pass comprehensive federal AIS legislation • establish program for AIS rapid response and management • continue education and outreach on AIS introduction and prevention • develop and evaluate lake trout restoration efforts through strategies such as a 40 percent increase in the number of lake trout stocked, using guidance from existing fishery management plans • develop an initiative to reestablish native lake sturgeon and coregonines in five areas of the Great Lakes from which they have been extirpated • refine or develop techniques or models to improve assessment and exploitation strategies and management protocols for important fish species such as yellow perch, lake whitefish, lake trout, and walleye stocks • develop and understanding of factors involved in recruitment of lake trout and other important native species, and remove or mitigate major impediments to recruitment • restore or protect 550,000 acres of wetlands and associated uplands • achieve at least 1.54 million breeding pairs of waterfowl (annual breeding population under average environmental conditions)

Great Lakes Regional Collaboration Strategy (2005)	
	• update inventory and mapping of wetland habitat types in the Great Lakes basin • acknowledge, develop, and enhance federal and state regulations and enforcement for coastal and inland wetland protection that also facilitate and accelerate wetland restoration • restore ten Great Lakes tributaries (five tributary barrier projects and five riparian habitat projects) • restore coaster brook trout and lake sturgeon in Great Lakes tributaries • adopt a method to characterize or classify watersheds based on degree of altered hydrology • inventory and assess all Great Lakes coastal habitats and prioritize them for protection and restoration • protect or restore 10,000 acres of high priority coastal and upland habitats per year across the basin • conduct detailed monitoring of Areas of Concern in coastal shore areas • protect and restore 1,000,000 acres of upland associated with wetlands • major improvements in wet weather discharge controls from combined and sanitary sewers • identify and control releases from indirect sources of contamination • implement a risk-based approach to manage recreational water • protect sources of drinking water • improve drinking water infrastructure and support source water protection • amend Great Lakes Legacy Act to increase funding and streamline the process • improve federal, state, and local capacity to manage the AOC cleanups • create a federal-state AOC coordinating committee to work with local and tribal interests to speed cleanups • promote clean treatment and disposal technologies as well as better beneficial use and disposal options • wetland restoration • restoration of buffers strips • improvement of cropland soil management • implementation of comprehensive nutrient and manure management plans for livestock operations • improvements to watershed hydrology • reduce and virtually eliminate the discharge of mercury, PCBs, dioxins, pesticides, and other toxic substances to the Great Lakes • prevent new toxic substances from entering the Great Lakes • institute a comprehensive research, surveillance, and forecasting capability • create consistent, accessible basin-wide messages on fish consumption and toxics reduction methods and choices • support efforts to reduce continental and global sources of toxics to the Great Lakes • adapt and maintain programs that promote sustainability across all sectors • align governance to enhance sustainable planning and management of resources • build outreach that brands the Great Lakes as an exceptional and competitive place to life, work, invest, and play • provide leadership for sustainable development through implementation of the Strategy recommendations
Measures	• better coordinate the collection of critical information regarding the Great Lakes ecosystem and support the US Integrated Earth Observation System (IEOS) and the Integrated Ocean Observing System (IOOS) as key components of the Global Earth Observation System of System s (GEOSS) • promote the continued development of science-based indicators, including those developed through the SOLEC process • double funding for Great Lakes research over the next five years

Great Lakes Regional Collaboration Strategy (2005)	
	• establish a regional information management infrastructure • create a Great Lakes communications workgroup to manage scientific and technical information

State of The Great Lakes (SOLEC; Lake Ontario and St. Lawrence) (2003)	
Author/ Lead organization	U.S. Environmental Protection Agency and Environment Canada
Website	http://binational.net/sogl2003/sogl03eng.pdf
Stresses	• loss of wetland plant species diversity • loss of wetland area • habitat loss • declining whitefish stocks • pollutants in fish tissues • loss of *Diporeia* • nutrient enrichment
Sources	• non-native species • toxic contaminants • municipal effluent • water level manipulation • dredging • estrogenic chemicals • land use • population growth • concentrated feedlot operations • development • dyking • pathogens
Measures	• Salmon and Trout • Lake Trout • Benthic Diversity and Abundance • Phytoplankton Populations • Zooplankton Populations • Amphibian Diversity and Abundance • Wetland-Dependent Bird Diversity and Abundance • Area, Quality and Protection of Alvar Communities • *Hexagenia* (mayfly) • Walleye • Preyfish Populations • Abundance of Benthic Amphipod *Diporeia* • Native Freshwater Mussels • Urban Density • Economic Prosperity • Area, Quality and Protection of Great Lakes Islands • Spawning-Phase Sea Lamprey • Phosphorus Concentrations and Loadings • Contaminants in Colonial Nesting Waterbirds • Atmospheric Deposition of Toxic Chemicals • Contaminants in Edible Fish Tissue • Air Quality • Ice Duration on the Great Lakes • Extent of Hardened Shoreline • Contaminants Affecting Productivity of Bald Eagles • Acid Rain

State of The Great Lakes (SOLEC; Lake Ontario and St. Lawrence) (2003)	
	• Non-Native Species Introduced into the Great Lakes • Contaminants in Young-of-the-Year Spottail Shiners • Toxic Chemicals Concentrations in Offshore Waters • Concentrations of Contaminants in Sediment Cores. • *E.coli* and Fecal Coliform Levels in Nearshore Recreational Waters • Drinking Water Quality • Contaminants in Snapping Turtle Eggs • Effect of Water Level Fluctuations • Mass Transportation • Water Use • Energy Consumption • Solid Waste Generation • Population Monitoring and Contaminants Affecting the American Otter • Citizen/Community Place-based Stewardship Activities • Brownfield Redevelopment • Sustainable Agriculture Practices • Green Planning Process

Twelfth Biennial Report on Great Lakes Water Quality (2004)	
Author/ Lead organization	International Joint Commission
Website	http://www.ijc.org/php/publications/html/12br/english/report/
Stresses	• disappearance of fish food organisms • nuisance algae • loss of natural habitat • pathogens and disease-bearing microorganisms • groundwater / drinking water contamination • fish consumption advisories • loss of diverse fish communities • thermal impacts • streamflow (low flow) depletion • waterborne disease outbreaks • emergence of new pollutants • increased phosphorous concentrations • oxygen depletion • low phytoplankton production • lake whitefish decline (Lake Erie) • blue-green algae blooms • *Cladophora* accumulation on shoreline • *Diporeia* decline • fish and wildlife die-offs from botulism
Sources	• climate change • toxic chemical release • aquatic invasive species entering via ocean-going vessels, bait fish releases, aquarium fish, aquaculture, connecting tributaries and canals • expansion of major urban areas • agriculture • development • industry • chemical spills • treated effluents discharged from sewage treatment plants • untreated effluents that bypass sewage treatment plants • treated and untreated storm water runoff

Twelfth Biennial Report on Great Lakes Water Quality (2004)	
	• combined sewer overflows that carry a mix of untreated sewage and storm water • increased impervious surfaces • population growth • "first flush" of standing water heated by hardened surfaces • excessive pesticide and fertilizer use • leaking underground storage tanks • malfunctioning septic systems • spills or leachate from industrial sites, uncapped wells, and road salts • groundwater withdrawals • decreased groundwater recharge • increased demand for water • pet waste from urban parks • animal and human waste from land-based sludge applications • manure storage piles • aging infrastructure • unregulated use of antibiotics in agriculture and aquaculture • disturbance of previous mercury deposition • atmospheric deposition of mercury from coal-fired utilities • point and non-point sources of pollution
Strategies	• evaluation of best management practices for urban runoff • dissemination of information on urban best management practices to local authorities and implementers • pass National Aquatic Invasive Species Act (NAISA) reauthorizing the National Invasive Species Act (NISA) • implement National Action Plan to address aquatic invasive species in Canada • ratify and implement the International Maritime Organization's Convention for the Control and Management of Ships' Ballast Water and Sediments, and pursue more stringent measures and rapid timelines • issue a reference to IJC to identify the most effective ways to coordinate binational prevention efforts and harmonize national plans • evaluate effectiveness of current institutional arrangements on AIS • establish a regional standard stronger than the minimum required by the IMO convention • ensure that economic analysis for projects with potential environmental effects include environmental and social costs of AIS control, damage, and mitigation and cost and benefits of prevention • protect drinking water from industry, urban expansion, aging infrastructure, and agriculture, including large-scale animal operations • conduct epidemiological studies in AOCs and other locations to better understand potential neuro-development effects associated with methyl mercury and PCBs • clarify fish advisories • implement programs in US and CA that would reduce mercury deposition • pursue multi-lateral strategies for mercury control on a global basis • toxic remediation • wastewater and storm water treatment • habitat rehabilitation and protection • flood protection • increase groundwater recharge • runoff reduction • natural area protection • water gardens • coordinated watershed planning • smart growth

Twelfth Biennial Report on Great Lakes Water Quality (2004)	
	• ban sale and transport of live Asian carp and snakehead • electrical barrier in Chicago Sanitary and Ship Canal • Canadian National Action Plan on aquatic invasive species • ballast water testing to verify performance of ballast water treatment technologies • revision of state ballast water law • develop a biologically protective standard for ballast management • strengthen requirements for NOBOB vessels • full-scale tests of ballast water treatment technologies • develop and adopt alternative technologies to surpass IMO Conventions proposed standards for ballast water discharge • validate effectiveness of ballast water discharge and its treatment in the Great Lakes • develop analytical tools to detect new high-risk invasive species, including DNA finger printing that could be used to trace the point of origin of these species • shipboard treatment technologies • shore-based technologies • cargo transfer facilities • entry restrictions for foreign ships from ports containing biota that could threaten the Great Lakes ecosystem • implement best management practices for manure storage • upgrade infrastructure for sewage treatment, stormwater management, drinking water, and water distribution • reduce mercury emissions
Measures	• assessment of cumulative impacts of urbanization • monitor private wells for microbial contamination • improved phosphorous monitoring

Niagara River Remedial Action Plan	
Author/ Lead organization	Niagara Peninsula Conservation Authority
Website	www.on.ec.gc.ca/water/raps/niagara/intro_e.html
Targets	• Fish and fish communities • Colonial nesting waterbirds • Shoreline and riparian habitats
Stresses	• Restrictions on fish consumption • Degradation of fish populations • Bird or animal deformities • Degradation of benthos • Restrictions on dredging activities • Eutrophication • Beach closings • Loss of fish and wildlife habitat
Sources	• industrial pollution • sewage discharge • agricultural land uses • development
Strategies	• 37 recommendations in the Stage 2 report • Examples of remedial projects aimed at improving water quality and habitat include: manure storage containment, manure nutrient management plans, livestock fencing, milkhouse washwater containment, stream buffer revegetation, wetland restoration, and upland reforestation

Hamilton Harbour Remedial Action Plan	
Author/	Bay Area Implementation Team (BAIT) and the Bay Area Restoration Council (BARC).

Hamilton Harbour Remedial Action Plan	
Lead organization	
Website	http://www.on.ec.gc.ca/water/raps/hamilton/intro_e.html
Targets	• Fish and fish communities • Colonial nesting waterbirds • Shoreline habitats/ coastal wetlands
Stresses	• Water Quality and Bacterial Contamination • Urbanization and Land Management • Toxic Substances and Sediment Remediation
Sources	• industrial pollution • sewage discharge • agricultural land uses • development
Strategies	• shoreline rehabilitation and a trail at Chedoke Creek • pike spawning habitat and a boardwalk at Grindstone Creek • underwater reefs and shoreline naturalization at Bayfront Park, Pier 4, Hamilton Pier and Hamilton Harbour Waterfront Trail • shoreline naturalization, beach restoration, reefs and a trail at LaSalle Park • colonial waterbird nesting islands, trail and lookout at Northeastern Shoreline • aquatic nursery and herptile ponds at Cootes Paradise marsh; as a result of a successful program of Carp exclusion, species of plants and animals are beginning to reappear in areas where they had not been found for some time in Cootes Paradise • reduction of bacterial contamination in the west end of the harbour

Toronto and Region Area Remedial Action Plan	
Author/ Lead organization	Environment Canada, the Ontario Ministry of the Environment and the Toronto and Region Conservation Authority with support from the Ontario Ministry of Natural Resources
Website	http://www.on.ec.gc.ca/water/raps/toronto/intro_e.html
Targets	Watersheds of the: Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek and Rouge River
Stresses	• restrictions on fish and wildlife consumption; • beach closings; • eutrophication or undesirable algae; • restrictions on dredging activities; • degradation of benthos; • loss of fish and wildlife habitat; • degradation of fish and wildlife populations; and • degradation of aesthetics
Strategies	During the past 5 years, some of the key activities have included: • development of a watershed-based framework for RAP coordination and public involvement; • integration of RAP objectives into related initiatives such as the City of Toronto Environmental Plan, Waterfront Part II Plan, Wet Weather Flow Management Master Plan, York Region Environment Report Card and many others; • development of an integrated monitoring framework; • four clean waters summits on priority issues; • annual RAP awards of excellence program; • publication of annual RAP bulletins and progress reports; • contributions to the RAP on Wheels and Aquatic Plants education programs; • development of a comprehensive natural heritage strategy; • a pilot study on sediment contributions from development sites; and • contributions to stormwater retrofit studies in Vaughan, Richmond Hill, Markham, Peel, Stouffville and King

Toronto and Region Area Remedial Action Plan	
	• development of Toronto Waterfront Aquatic Habitat Restoration Strategy

Port Hope Harbour Remedial Action Plan	
Author/ Lead organization	Natural Resources Canada
Website	http://www.on.ec.gc.ca/water/raps/porthope/intro_e.html
Targets	The Port Hope Harbour Area of Concern (AOC) is located adjacent to the mouth of the Ganaraska River on the north shore of Lake Ontario approximately 100 km east of Toronto. The AOC includes the harbour area and extends 300 m from the lower Ganaraska River to the confluence area bounded by breakwalls
Stresses	Port Hope Harbour was designated as an AOC due to contaminated sediments in the harbour. Approximately 90 000 cubic metres of sediments in the turning basin and west slip areas of Port Hope Harbour are contaminated with uranium and thorium series radionuclides, heavy metals, and PCBs. The contamination of the harbour sediments is the result of past waste management practices in the refining and processing of uranium and radium during the 1930s and 1940s.
Strategies	An agreement between the federal government and the Town of Port Hope and adjacent municipalities was reached in March 2001 on the cleanup of the wastes and development of facilities for their long-term management. The initial preconstruction and regulatory phases, including a full environmental assessment, are expected to take approximately five years with the implementation of the cleanup taking another projected five years. Implementation of the estimated $260 million project is managed by Natural Resources Canada through the Low-Level Radioactive Waste Management Office.

Bay of Quinte Remedial Action Plan	
Author/ Lead organization	The Bay of Quinte RAP is a partnership between the Canadian federal and Ontario provincial governments, with support from the Quinte Conservation Authority, Lower Trent Conservation Authority and Quinte Watershed Cleanup Inc. (formerly the Bay of Quinte Public Advisory Committee).
Website	http://www.on.ec.gc.ca/water/raps/quinte/intro_e.html
Targets	The Area of Concern (AOC) encompasses the Bay and its 18 000 square km drainage basin. The Trent River is responsible for most of the flow through the Bay
Stresses	• excessive nutrients, from sewage treatment plants, particularly those that discharge directly to the Bay; faulty septic tanks and surface run-off from urban, agricultural and rural lands • habitat loss, in particular wetlands, due to shoreline development • contaminated sediment from historical activities along the shore of the Bay and in the watershed • beach closings resulting from bacterial contamination from sewage treatment plants, stormwater discharges and run-off from agricultural and rural lands
Strategies	Substantial progress toward delisting the Bay of Quinte Area of Concern has been made. Direct discharges of industrial wastes have been substantially lowered. Beach closings occur less frequently. Over 27,000 ha of farmland have been converted from conventional to conservation tillage, and phosphorus inputs from rural sources have been lowered at source by more that 16,000 kg annually. At sewage treatment plants bordering directly on the Bay of Quinte, phosphorus loads have been reduced from 50 kg/day in 1986 to less than 25 kg/day with cost savings of $1.75 million resulting from sewage treatment plant optimization for four facilities within the watershed. Within the Bay of Quinte waters, phosphorus concentrations are approaching the Bay of Quinte RAP target of 40 µg/L. Water clarity is improving and the algal blooms are less severe. Over 40 km of shoreline have been planted with native trees, shrubs and grasses to reduce erosion and improve habitats. Important wetlands and shoreline resources have been mapped. Over 800 hectares of wetland have been either rehabilitated or protected.
Measures	• Fewer restrictions on fish and wildlife consumption

Bay of Quinte Remedial Action Plan	
	• Stable, healthy and diverse fish and wildlife populations • A community of bottom dwelling creatures (benthic invertebrates) consistent with a healthy ecosystem • Sediment quality such that it does not cause restrictions • Nutrient inputs managed so as to result in fewer nuisance algae blooms and a related improvement in water quality • Fewer beach closures • Healthy communities of creatures that form the base of the aquatic food chain (phytoplankton and zooplankton) • Fish and wildlife habitat protected and/or restored to acceptable levels

St. Lawrence (Cornwall) Remedial Action Plan	
Author/ Lead organization	The Cornwall RAP is a partnership between federal and provincial governments, with support from the Mohawks of Akwesasne, and the Cornwall and District Environment Committee (formerly the Cornwall Public Advisory Committee).
Website	http://www.on.ec.gc.ca/water/raps/cornwall/intro_e.html
Targets	The Cornwall Area of Concern (AOC) includes a stretch of the St. Lawrence River approximately 80 km long, from the Moses-Saunders power dam (just upstream of Cornwall) to the eastern outlet of Lake St. Francis in Quebec.
Stresses	• Mercury, PCBs and other contaminants of concern in water, sediments and fish • Bacterial contamination leading to beach closings • Habitat destruction and degradation • Excessive growth of nuisance aquatic plants • Exotic species • Fish and wildlife health impacts
Sources	Historically, contaminants have entered the St. Lawrence River environment from the upper river and Lake Ontario, through local industrial and municipal discharges, urban stormwater, agricultural runoff and other diffuse sources such as air deposition.
Strategies	There have been several notable successes in the St. Lawrence AOC. For example, the implementation of the littoral zone habitat strategy is well underway with several projects ongoing and completed; over 85 000 trees have been planted and more than 49 km of fencing has been installed to protect riparian habitat near watercourses. Also, the retrofit of the City of Cornwall's stormwater pond is part of the implementation strategy from a 1997 pollution control plan for the City of Cornwall. There are no longer any significant sources of mercury or other heavy metals in the Cornwall area. Of the three historical sources: Domtar has installed a $60M treatment facility; Courtaulds Fibres has closed and ICI Forest Products has ceased operating its chlor-alkali plant. Decommissioning has been completed at Courtaulds, ICI and an associated chemical packaging plant. Recent moves by the Restoration Council to take stock of progress and refocus the RAP towards delisting have resulted in a more detailed and scientifically defensible set of delisting criteria, a monitoring plan, and a strategic plan for implementation. Stage 2 of the RAP Reported that development along the waterfront area of Cornwall had drastically reduced the structure and diversity of fish and wildlife habitat in the littoral (nearshore, shallow water) zone. Furthermore, the invasion of non-native zebra mussels and elevation of nutrient levels has altered conditions in the water which the existing fish community had adapted to and relied on for survival. Recommendations were made in the Stage 2 report to rehabilitate the littoral zone along the Cornwall waterfront with the focus on creating habitat conditions that would benefit fish. The littoral zone fish community is dominated by cool and warm-water species such as smallmouth bass, northern pike, yellow perch, rock bass, brown bullhead, pumpkinseed, walleye and muskellunge. Eighteen possible projects from a 1993 consultant's report were identified to this end, and links were made between the biological value of the projects, and other

St. Lawrence (Cornwall) Remedial Action Plan	
	benefits to the community and local economy such as increasing the recreational and educational potential of the waterfront. Most of these projects focused on creating a combination of spawning and rearing (or nursery) habitat, designed based on templates of naturally occurring habitat structures found in healthy ecosystems. Putting these two types of habitat together maximized their value by providing stable, high quality conditions for both spawning adult fish, as well as for young fish which emerge weeks later from eggs laid at spawning sites. Fifteen rock shoals and four coves have been built along the Cornwall waterfront. The structures not only provided excellent conditions for survival of incubating fish eggs, but providing the necessary calm conditions for the growth of macrophytes (aquatic plants) and invertebrates (insects) which are essential shelter and food for fish. Furthermore, 7.1 km of shoreline habitat has been restored, as well as the removal of hard structures, such as concrete walls, in favour of softer structures, such as plants, to control erosion of the shoreline along 0.5 km of the waterfront. In a central area of the waterfront, several habitat restoration projects were tied into the existing waterfront bike path and park to form the Rotary EcoGarden. The projects included creation of a meandering cool-water stream whose banks have been planted with native shrubs and trees, and an artificial wetland. Both provide important habitat for fish and wildlife, and recreational and educational habitat for people. Ongoing monitoring to determine the benefits of habitat restoration in the littoral zone of the Cornwall waterfront indicate that the fish community is flourishing in the vicinity of project sites. Preliminary results indicate that there have been significant increases in the number of fish species and the total number of fish present at some sites when comparing the same site prior to restoration. A report on the efforts to monitor the effectiveness of littoral zone restoration projects in currently being completed.

Presqu'ile Important Bird Area	
Author/ Lead organization	Bird Studies Canada
Website	http://www.ibacanada.com/cpm_presq.html
Targets	• Colonial nesting waterbirds • Waterfowl • Shorebirds • Marsh birds • Land birds
Stresses	• Competition • Disturbance • Deer browse • Exotic species • Food supply • Forest fragmentation • Inundation of wetlands • Land-bridge • Loss of habitat • Micro-contaminants • Newcastle disease
Sources	• Cormorants, Ring-billed Gulls • park policy • Disturbance • lack of awareness • competition for resource use (beach)

Presqu'ile Important Bird Area	
	• attitudes • frogbit, purple loosestrife, mute swan, zebra mussels • algae management and beach use (park) • road and housing development • plantations • personal watercraft and motorboats in marsh channels • deposition, lake currents • recreation, building, storms • non-point (agriculture), wintering range • colony density • attitudes, lack of information, • competition with fishermen
Strategies	An IBA plan has been prepared: http://www.ibacanada.com/cpm_presq.html

Amherst Island Important Bird Area	
Author/ Lead organization	Bird Studies Canada
Website	http://www.bsc-eoc.org/iba/site.jsp?siteID=ON062
Targets	• Globally Significant: Congregatory Species • Continentally Significant: Congregatory Species
Stresses	Disturbance, Intensified management, Tourism, Urban/industrial development
Sources	Located close to the mainland and the city of Kingston, Amherst Island is within 5 km of thousands of tourists and summer vacationers. Housing and recreational development could threaten some of the remaining natural areas. Increased usage also increases the potential for inadvertent disturbance of the staging waterfowl and shorebirds.
Strategies	no IBA plan has been prepared

Prince Edward Point Important Bird Area	
Author/ Lead organization	Bird Studies Canada
Website	http://www.bsc-eoc.org/iba/site.jsp?siteID=ON003
Targets	• Globally Significant: Congregatory Species • Waterfowl Concentrations • Migratory Landbird Concentrations • Nationally Significant: Colonial Waterbird/Seabird Concentrations
Stresses	Disturbance, Other environmental events
Sources	Much of this area consists of long-abandoned fields that are succeeding into shrub thicket habitats. As a result, various species that formerly bred or foraged in the grasslands are no longer present. This includes the globally near-threatened, nationally endangered Henslow's Sparrow. A proposal to manage portions of the habitat for Henslow's Sparrow and other grassland species is under consideration.
Strategies	An IBA plan has been prepared: http://www.ibacanada.com/cpm_princeed.html

Leslie Street Spit Important Bird Area	
Author/ Lead organization	Bird Studies Canada
Website	http://www.bsc-eoc.org/iba/site.jsp?siteID=ON038
Targets	Globally Significant: Congregatory Species, Colonial Waterbirds/Seabird Concentrations, Continentally Significant: Congregatory Species, Nationally Significant: Congregatory Species, Wading Bird Concentrations
Stresses	Disturbance, interactions with native species/disease, industrial pollution, introduced species, other decline in habitat quality, other environmental events, recreation/tourism
Sources	The Leslie Street Spit is accessible to mammalian predators, and the colonies are subject

Leslie Street Spit Important Bird Area	
	to chronic disturbances by people and their dogs. Vegetation succession and predation by Ring-billed Gulls on eggs and young of other colonial species are also continuing problems. Numerous conservation measures have been taken, and others are in progress or have been proposed, including: vegetation control, control of Ring-billed Gull populations, reduction of human interference, creation of new nesting habitat, and control of mammalian predation on eggs and chicks.
Strategies	An IBA plan has been prepared: http://www.ibacanada.com/cpm_leslie.html

Hamilton Harbour Waterbird Colonies	
Author/ Lead organization	Bird Studies Canada
Website	http://www.bsc-eoc.org/iba/site.jsp?siteID=ON020
Targets	Globally Significant: Colonial Waterbirds/Seabird Concentrations, Nationally Significant: Congregatory Species
Stresses	Disturbance, interactions with native species/disease, industrial pollution
Strategies	No IBA plan has been prepared. Management efforts have focused primarily on enhancing nesting conditions for target species such as Black-crowned Night-Herons, Common Terns and Caspian Terns. The islands recently constructed in the northeast corner of the harbour were designed specifically to attract these species. On North Island, a 200 m? elevated mound was constructed of sand and pea gravel to attract Caspian Terns. Areas of sand and gravel, each 250 m?, were placed on both North and Centre island to attract Common Terns. Two additional areas, one on Centre Island and all of South Island, were covered with topsoil and leaf mulch in preparation for planting of native shrubs to attract Black-crowned Night-Herons.

Lake Ontario Greenway Strategy (2005)	
Author/ Lead organization	Waterfront Regeneration Trust
Website	http://www.waterfronttrail.org/library-publications.html#greenway Also see: Decade of Regeneration: Realizing a Vision for Lake Ontario, November 2000 - http://www.waterfronttrail.org/library-publications.html#decade
Targets	focused on creating a trail along Lake Ontario, recognized need to improve quality of the coast
Strategies	The goal of the Lake Ontario Greenway Strategy is to foster commitment to actions that will regenerate a healthy and sustainable waterfront that is clean, green, accessible, connected, open, useable, diverse. • protect the physical, natural and cultural attributes associated with the Lake Ontario Greenway; • identify restoration needs and methods and encourage landowners, communities and agencies to undertake regeneration activities; • promote greater awareness, understanding, access and recreational use of the waterfront and encourage community pride and participation in its regeneration; • promote economic activities and employment on the waterfront that are compatible with the other Greenway objectives;

Appendix D:

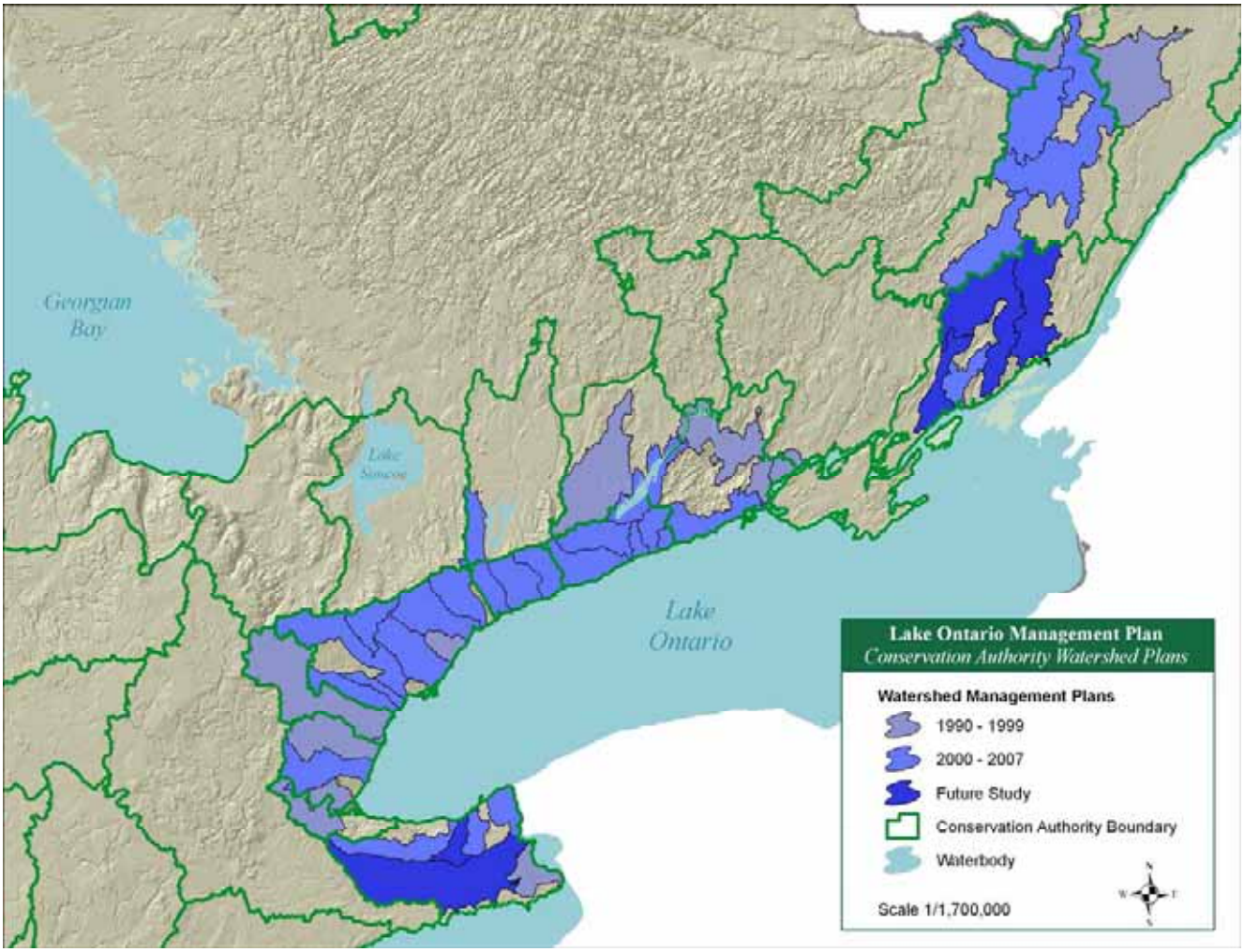
Ontario Watershed Plans (information collected in 2008)

Conservation Authority	Watershed/Subwatershed	Date	Notes
Cataraqui	Collins Creek Watershed Plan	2004	Watershed study focused on all groundwater and surface water considerations, as well as natural heritage information such as wetlands, aquatic life and ANSIs.
Cataraqui	Gananoque Creek	future	Plan will be completed when funds and resources permit
Cataraqui	Millhaven Creek	future	Plan will be completed when funds and resources permit
Cataraqui	Cataraqui River	future	Plan will be completed when funds and resources permit
Central Lake Ontario	Oshawa Creek Watershed Plan	2002	Subwatershed plan completed, gives consideration to ground and surface water issues, wildlife habitat, hazards and physical condition of land; provides recommendations for watershed and subwatershed management. Fish management plan completed and endorsed by CLOCA.
Central Lake Ontario	Lynde Creek Watershed	2007	Existing conditions draft report is complete and being circulated for comments. Fish management plan completed and endorsed by CLOCA.
Central Lake Ontario	Bowmanville/Soper Creek Watershed	2007	Aquatic Resource Management Plan has been prepared and is being implemented. Fish management plan completed and endorsed by CLOCA.
Central Lake Ontario	Black/Harmony/Farewell Watershed	2007	Aquatic Resource Management Plan is undergoing final edits. Fish management plan completed and endorsed by CLOCA.
Credit Valley	Fletcher's Creek Subwatershed Plan	1996	Surface water (flooding, stormwater, water quality), municipal water, aquatic life, transportation
Credit Valley	Sawmill Creek Subwatershed Plan	1995	Surface water (flooding, stormwater), aquatic life, stream channel/buffer
Credit Valley	Gateway West Subwatershed Plan	1999	Filling in gaps to update and improve plan.
Credit Valley	Shaw's Creek	2006	Subwatershed study well underway, will lead to subwatershed plan.
Credit Valley	Subwatershed 15	2006	Subwatershed study being completed.
Credit Valley	Mullet/Levi/Main Credit Subwatersheds	2000	Subwatershed study completed in 2000, including surface and municipal water issues as well as aquatic life/fisheries information.
Credit Valley	Caledon Creek/Credit River Subwatershed	2000	Subwatershed study completed in 2000, including surface and municipal water issues, aggregate extraction consideration, and aquatic life/fisheries information.
Credit Valley	East Credit Subwatershed	2002	Subwatershed study completed in 2002, including most water quality and quantity considerations, proximate land use (aggregates and agriculture) and natural heritage information (wetlands, ANSIs, aquatic life)
Credit Valley	Credit River Subwatershed 12&14 Study	2002	Subwatershed study completed in 2002, including most water quality and quantity considerations, proximate land use (aggregates and agriculture) and natural heritage information (wetlands, ANSIs, aquatic life)
Credit Valley	Credit River Subwatershed 7&8A	2001	Subwatershed study completed in 2001, includes most ground/surface water issues, natural heritage considerations (ANSIs, wetlands, aquatic life), municipal sewage, stream channel/buffers and proximate issues (aggregates).
Credit Valley	Silver Creek Subwatershed	2002	Subwatershed study completed in 2002, including most water quality and quantity considerations, proximate land use (aggregates and agriculture) and natural heritage information (wetlands, ANSIs, aquatic life)
Credit Valley	6 additional Subwatersheds	various, updated 2006	Subwatershed studies underway/completed in 16/20 CVCA subwatersheds; outcome of studies will be subwatershed plan.
Crowe Valley			no information available
Ganaraska Region	Wilmot Creek	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Fisheries Management Plan is complete and waiting approval. Watershed Report Card being written.
Ganaraska Region	Graham Creek	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.
Ganaraska Region	West Lake Ontario Tributaries	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.
Ganaraska Region	Ganaraska River	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.
Ganaraska Region	Gage Creek	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.

Ganaraska Region	Cobourg Creek	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Background document is being written. Watershed Report Card being written.
Ganaraska Region	East Lake Ontario Tributaries	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.
Ganaraska Region	Rice Lake Tributaries	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.
Ganaraska Region	East of Gage Tributaries	2007	Phase 1 underway: Characterizing the watershed, and completing water budgets. Some data gap collection is occurring. Watershed Report Card being written.
Halton	East Morrison Creek	1995	Subwatershed study completed which includes all ground and surface water considerations as well as aquatic life and transportation/agricultural issues.
Halton	Bronte Creek	2005	Watershed study completed.
Halton	North Shore Watershed	2005	Watershed study near completion in 2005.
Halton	Grindstone Creek Watershed	1998	Watershed study completed in 1998; includes surface/groundwater quantity and quality information as well as aquatic life, wetland and ANSI natural heritage information, and aggregate and agriculture considerations. It is currently being improved upon with regards to fish habitat.
Halton	Fourteen Mile/Taplow/McCraney Creeks Subwatershed	1995	Watershed study completed with consideration to all ground water and storm water issues, as well as aquatic life, transportation and agriculture as well as stream channel/buffers.
Halton	Glen Oak Creek Subwatershed Plan	1993	Subwatershed management plan completed with consideration for surface water issues, transportation, aquatic life habitat and stream channel/buffers.
Halton	Joshua's Creek Watershed Plan	1992	Watershed plan completed in 1992, includes all surface water issues as well as aquatic life, stream channel/buffers, and transportation.
Halton	Lower Morisson/Wedgewood Creeks Subwatershed Plan	1994	Watershed plan completed in 1994, includes all surface water issues as well as aquatic life, and stream channel/buffers.
Halton	Osenego Creek Subwatershed	1996	Subwatershed plan completed in 1996, including issues such as ground/surface water, aquatic life and stream channel/buffers.
Halton	Sheldon Creek Watershed		Watershed master plan completed in 1993, including surface water, aquatic life and stream channel/buffer considerations.
Halton	Sixteen Mile Creek Watershed	1996	Watershed plan completed in 1996, issues included surface and ground water concerns as well as aquatic life and stream/channel buffer considerations.
Hamilton	Spencer Creek Watershed	1990	Watershed management study initiated in 1990, includes study of all ground and surface water, as well as municipal and private water, land uses such as aggregate mining and agriculture, and natural heritage considerations such as aquatic life, wetlands and ANSIs.
Kawartha	Nonquon River Subwatershed	2005	Subwatershed management plan completed in 2005 with goals to direct sustainable development, protect natural heritage and protect from problems such as flooding and erosion.
Lower Trent	South Sidney Watershed	1995	Watershed plan completed in 1995, includes issues surrounding surface and ground water as well as stream channels/buffers and natural heritage considerations such as wetlands and ANSIs.
Lower Trent	Dead and York Creek Subwatershed	1998	Subwatershed management plan completed in 1998, includes some surface water and natural heritage (wetlands/ANSIs) considerations.
Mississippi Valley	Carp River Watershed/Subwatershed	unknown	Watershed/subwatershed management study completed; watershed management plan recommended.
Mississippi Valley	Upper Poole Creek Subwatershed	2000	Subwatershed study completed in 2000, including issues such as surface water, aquatic life and stream channel/buffers.
Mississippi Valley	Shirley's Brook and Watts Creek Subwatershed	1999	Subwatershed study competed in 1999, including issues such as stormwater and surface water quality along with aquatic life and stream channel/buffers.
Niagara Peninsula	Frenchman's Creek Watershed	1992	Watershed management plan initiated in 1992 with consideration for many water considerations as well as natural heritage considerations including aquatic life habitat, wetlands, and ANSIs.
Niagara Peninsula	Warren Creek Watershed	1996	Watershed master plan completed in 1996, includes surface and groundwater quality information as well as aquatic life/fisheries considerations.
Niagara Peninsula	Central Welland River Watershed	2007	Watershed plan in progress, includes many considerations such as surface and ground water quality and quantity, natural heritage considerations, habitat and proximate development.
Niagara Peninsula	Fifteen, Sixteen and Eighteen Mile Creek Watershed	2010	Watershed plan in progress, includes many considerations such as surface and ground water quality and quantity, natural heritage considerations, habitat and proximate development.
Niagara Peninsula	Fore Erie Creeks Watershed	2008	Watershed plan in progress, includes many considerations such as surface and ground water quality and quantity, natural heritage considerations, habitat and proximate development.

Niagara Peninsula	Lake Erie North Shore Watershed	2007	Watershed plan in progress, includes many considerations such as surface and ground water quality and quantity, natural heritage considerations, habitat and proximate development.
Niagara Peninsula	Niagara-on-the-Lake Creeks Watershed	2007	Watershed plan in progress, includes many considerations such as surface and ground water quality and quantity, natural heritage considerations, habitat and proximate development.
Niagara Peninsula	One Mile Creek Watershed	2005	Watershed plan completed in 2005, includes information about physiography, soils, surface water, groundwater, aquatic and terrestrial resources.
Niagara Peninsula	Port Robinson West Subwatershed	1999	Subwatershed plan completed in 1999, includes information about physiography, surface and groundwater, vegetation, wetlands and other natural heritage features.
Niagara Peninsula	South Niagara Falls Watershed	2008	Watershed plan in progress, includes many considerations such as surface and ground water quality and quantity, natural heritage considerations, habitat and proximate development.
Niagara Peninsula	Twelve Mile Creek Watershed	2006	Watershed plan completed in 2006, includes information about water quality, fish habitat, natural heritage, wetlands, woodlands as well as socioeconomic considerations.
Niagara Peninsula	Grimsby	2013	Watershed plan to be completed in 2013, includes information about water quality, fish habitat, natural heritage, wetlands, woodlands as well as socioeconomic considerations.
Niagara Peninsula	Twenty Mile Creek	2006	Watershed plan to be completed in 2006, includes information about water quality, fish habitat, natural heritage, wetlands, woodlands as well as socioeconomic considerations.
Niagara Peninsula	Lincoln	2013	Watershed plan to be completed in 2013, includes information about water quality, fish habitat, natural heritage, wetlands, woodlands as well as socioeconomic considerations.
Niagara Peninsula	Big fork Creek & Feeder Canal	2012	Watershed plan to be completed in 2012, includes information about water quality, fish habitat, natural heritage, wetlands, woodlands as well as socioeconomic considerations.
Niagara Peninsula	Upper Welland River	2011	Watershed plan to be completed in 2011, includes information about water quality, fish habitat, natural heritage, wetlands, woodlands as well as socioeconomic considerations.
Otonabee	Cavan Creek/Otonabee River Subwatershed Plan	1995	All surface water considerations, natural heritage considerations including aquatic life, wetlands and ANSIs.
Otonabee	Harper Creek	1995	Watershed planning study completed, includes surface and groundwater considerations as well as natural heritage considerations such as wetlands, ANSIs and aquatic life habitat.
Otonabee	Thompson Creek Subwatershed		Watershed study completed in 1994, includes surface water considerations as well as aquatic life, wetland and ANSI information
Otonabee	Meade Creek Watershed	1993	Watershed plan initiated in 1993, includes surface water and natural heritage (aquatic life, wetlands, ANSI) considerations.
Quinte	Potter Creek Watershed	1994	Watershed study completed in 1994, includes surface water and aquatic life considerations.
Quinte	Upper No Name Creek Watershed	1995	Watershed study completed in 1995, includes surface water and wetland/ANSI natural heritage considerations.
Raisin Region			Strategies have been developed, focus on natural heritage features (woodlands, wetlands, rare species and more); Fish Habitat Management Plans for tributaries to be completed by 2008/2009.
Raisin Region	Lake St. Francis	2007	Fish Habitat Management Plan completed in 2007.
Rideau Valley	Jock River Watershed	2001	Watershed management plan completed in 2001, includes issues such as groundwater and surface water quality and quantity, fish/wildlife/plant information as well as proximate issues such as development
Rideau Valley	Kemptville Creek Watershed	2007	Watershed management plan completed in 1999, updated in 2007, includes issues such as ground and surface water quality and quantity as well as development in the area
Rideau Valley	Tay River Watershed	2002	Watershed management plan completed in 2002, includes issues such as ground and surface water quality and quantity as well as development in the area. Fish Habitat report completed in 2001: existing conditions and opportunities for enhancement.
Rideau Valley	Lower Rideau Watershed	2004	Watershed management plan completed in 2004, includes issues such as ground and surface water quality and quantity as well as development in the area
Rideau Valley	Middle Rideau Watershed	2009	Watershed management plan to be completed by 2009
Rideau Valley	Rideau Lakes Watershed	2008	Watershed management plan to completed in 2008
Rideau Valley	Sawmill Creek Watershed	1994	Watershed plan completed in 1994, including issues such as surface water flooding/quality and aquatic life
South Nation	North Castor River Subwatershed	1996	Subwatershed plan completed in 1996, including issues such as ground/surface water, aquatic life and stream channel/buffer
South Nation	Shield's Creek Subwatershed	2007	Subwatershed study is currently being conducted with focus on preservation of natural heritage and riparian restoration
Toronto and Region	Centennial Creek Subwatershed Plan	1993	Surface and ground water, transportation, aquatic life, stream channel/buffer

Toronto and Region	City of Vaughan Subwatershed	1994	Subwatershed study completed. Plan?
Toronto and Region	Humber River Subwatershed	2007	Draft subwatershed plan completed, includes social, economic and many environmental considerations (aquatic and terrestrial)
Toronto and Region	Etobicoke and Mimico Creeks	2006	Watershed report card completed
Toronto and Region	Don River	2003	Watershed report card completed
Toronto and Region	Duffins and Caruthers Creeks Watershed Plan	2003	Watershed plan completed, includes terrestrial and aquatic natural heritage considerations as well as water, public use, air quailty and other considerations
Toronto and Region	Highland Creek	1999	Watershed Report completed
Toronto and Region	Rouge River Watershed Plan	2006	Draft watershed plan released in 2006, covers social, biological and physical components of watershed management
Toronto and Region	Morningside Tributary Subwatershed	1993	Subwatershed study initiated in 1993, looking at ground and surface water issues as well as aquatic life and stream channel/buffers
Toronto and Region	Robinson Creek Subwatershed	1994	Subwatershed study completed in 1994, includes issues such as ground/surface water. Municipal water and natural heritage information including aquatic life, wetlands and ANSIs.


Georgian Bay
Lake Simcoe
Lake Ontario
Lake Ontario Management Plan
Conservation Authority Watershed Plans
Watershed Management Plans
1990 - 1999
2000 - 2007
Future Study
Conservation Authority Boundary
Waterbody
Scale 1/1,700,000

References

Baird & Associates. Flooding Performance Indicator: Methodology and Shared Vision Model Application. IJC Plan Formulation and Evaluation Group, Windsor, ON: International Joint Commission, 2005.

Barko, J.W. Ecological effects of water level decreases in the Great Lakes. Vicksburg, Michigan: US Army Engineer Research and Development Center, 1999.

Brazner, J.C. and E.W. Beals. "Patterns in fish assemblages from coastal wetland and beach habitats in Green Bay, Lake Michigan: a multivariate analysis of abiotic and biotic forcing factors." Canadian Journal of Fisheries and Aquatic Sciences, 1997: 54: 1743–176.

Brinson, M.M., A.E. Lugo, and S. Brown. "Primary productivity, decomposition and consumer activity in freshwater wetlands." Annual Review of Ecology and Systematics, 1981: 12:123–161.

Center for Watershed Protection. Better Site Design: A Handbook for Changing Development Rules in Your Community. Ellicott City, MD: Center for Watershed Protection, 1998.

Chow-Fraser, P. "Development of the Water Quality Index (WQI) to assess effects of basin-wide land-use alteration on coastal marshes of the Laurentian Great Lakes ." In Coastal wetlands of the Laurentian Great Lakes: health, habitat and indicators, by T.P., Stewart, P.M., Munawar, M. and Edsall, T.A. (Eds) Simon, in press. CRC Press, 2006.

CJS Consulting. A Revised Geomorphic, Shore Protection and Nearshore Classification of the Canadian and United States Shorelines of Lake Ontario and the St. Lawrence River. Consulting. International Joint Commission, 2002.

Committee to Review the Lake Ontario-St. Lawrence River Studies. Review of the Lake Ontario-St. Lawrence River Studies. Washington, D.C.: THE National Academies Press, 2006.

Crewe, T.L. and S.T.A. Timmermans. Assessing biological integrity of Great Lakes coastal wetlands using marsh birds and amphibian communities. Technical report, Project # WETLAND3-EPA-01, Downsview, ON: Environment Canada, 2005.

Dave, G. "Assessment and monitoring of ecosystem health in the sea: A description of the Swedish monitoring system for coastal marine areas." Aquatic Ecosystem Health & Management, 2001: 12:263-274.

Dermott, R. "Sudden disappearance of the amphipod Diporeia from eastern Lake Ontario, 1993-1995. ." Journal of Great Lakes Research, 2001: 27:423-433.

Dodd, C.K. and L.L. Smith. "Habitat destruction and alteration: historical trends and future prospects for amphibians." In Amphibian Conservation, by R.D. Semlitsch (ed), 94-112 . Washington, D.C.: Smithsonian Institution, 2003.

Dove A. and G. Warren. Phosphorus Concentrations and Loadings: Indicator #111 (in State of the Great Lakes 2007). Environment Canada and Environmental Protection Agency. 2007: 70-73

Eastern Ontario Model Forest. Methods & Rationale for Assigning Woodland Value. June 2003. http://woodlandvaluation.eomf.on.ca/ (accessed July 2006).

Edsall, T.A. and M.N. Charlton. Nearshore Waters of the Great Lakes. Background paper, State of the Lakes Ecosystem Conference 1996, 1997.

Edsall, T.A., E.L. Mills, and J.H. Leach. "Exotic species in the Great Lakes." In Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems, by G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (eds) E.T. LaRoe, 442-444. Washington, D.C.: National Biological Service, 1995.

Environment Canada and Central Lake Ontario Conservation Authority. Durham Region Coastal Wetland Monitoring Project: year 2 technical report. ECB-OR, Downsview, ON: Environment Canada, 2004.

Environment Canada and Ontario Ministry of Natural Resources. The Ontario Great Lakes Coastal Wetland Atlas: A Summary of Information (1983-1987). Downsview, ON: Environment Canada, 2003.

Environment Canada and United States Environmental Protection Agency. State of the Lakes 2007. April 28, 2008. http://www.epa.gov/solec/sogl2007/ (accessed November 7, 2008).

Environment Canada. How much habitat is enough: a framework for guiding habitat rehabilitation in Great Lakes Areas of Concern. Downsview, ON: Environment Canada, Canadian Wildlife Service, 2004.

Environment, Ministry of the. Surface Water Monitoring and Assessment: 1997 Lake Ontario Report. Toronto, ON: Ministry of the Environment, 1999.

Farrell, J.M. "Reproductive success of sympatric northern pike and muskellunge in an Upper St. Lawrence River bay." Transactions of the American Fisheries Society. American Fisheries Society, 2001. 130:796-808.

Farrell, J.M., R. Casselman, and J.M. Klindt. Update of the Strategic Plan for Management of the St. Lawrence River Muskellunge Population and Sportfishery Phase III: 2003-2010. Albany N.Y.: New York State Department of Environmental Conservation, 2003.

Farrell, J.M., J. Toner, and J. Mead. Muskrat house abundance within Upper St. Lawrence River tributary wetlands: evaluation of responses to water level regulation plans. Windsor, ON: International Joint Commission, 2005.

Farris G. Climate Change: Ice Duration on the Great Lakes: Indicator #4858 (in State of the Great Lakes 2007). EC and USEPA. 2007: 202-205

Findlay, C.S., J. Lenton, and L.G. Zheng. "Land-use correlates of anuran community richness and composition in southeastern Ontario wetlands." Ecoscience, 2001: 8:336–343.

Great Lakes Environmental Indicators (GLEI) Collaborative. 2006. http://glei.nrri.umn.edu/default/ (accessed August, 2006).

International Joint Commission (IJC). 2006. Options for Managing Lake Ontario and St. Lawrence River Water Levels and Flows: Final Report by the International Lake Ontario

Johannsson O.E., L.G. Rudstam, G. Gal, and E.L. Mills. "Mysis relicta in Lake Ontario: population dynamics, trophic linkages." In The state of Lake Ontario: past, present, and future, by Munawar M. (ed), 257–288. Burlington, ON: Ecovision World Monograph Series, Aquatic Ecosystem Health and Management Society, 2003.

Jude, D.J. and J. Pappas. "Fish utilization of Great Lakescoastal wetlands." Journal of Great Lakes Research, 1992: 18(4):651-672.

Klindt, R.M. and R. Adams. Lake sturgeon spawning activity in the lower Black River: Section 21 In 2005 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. Albany, NY: New York State Department of Environmental Conservation, 2006.

Lake Ontario Biodiversity Conservation Strategy, Workshop 1. Kingston, ON, June 21-22, 2006.

Lake Ontario Lakewide Management Plan. Lake Ontario Lakewide Management Plan. December 4, 2007. http://binational.net/lakeontario_pub_e.html (accessed November 7, 2008).

LaMP. Lake Ontario Lakewide Management Plan 2004. April 22, 2004. http://www.epa.gov/greatlakes/lakeont/2004update/index.html (accessed November 7, 2008).

Lofgren B.M. Atmospheric and Hydrologic Impacts of Increased Greenhouse Gases on the Great Lakes Simulated Using CHARM2. 2008, IAGLR 2008: 51st Annual Conference on Great Lakes Research.

Lougheed, V.L. and Chow-Fraser, P. 2002. Development and use of a zooplankton index to monitor wetland quality in Canadian marshes of the Great Lakes basin. Ecological Applications 12 (2): 474-486.

Lougheed, V.L. and P. Chow-Fraser. 1998. Factors that regulate the community structure of a turbid, hypereutrophic Great

Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences 55: 150-161.

Lozaro, S.J., J.V. Scharold and T.F. Nalepa. "Recent declines in benthic macroinvertebrate densities in Lake Ontario. " Canadian Journal of Fisheries and Aquatic Sciences, 2001: 58(3): 518–529.

McNair, S.A. and Chow-Fraser, P. 2003. Change in biomass of benthic and planktonic algae along a disturbance gradient for 24 Great Lakes coastal wetlands. Canadian Journal of Fisheries and Aquatic Sciences, 60: 676-689.

Meixler, M. S., K. A. Arend and M. B. Bain. 2005. Fish community support in wetlands within protected embayments of Lake Ontario. Journal of Great Lakes Research 31 (S1): 188-196.

Mills E.L., K.T. Holeck, and H. MacIsaac. (2007) Non-native Species - Aquatic: Indicator #9002 (in State of the Great Lakes 2007). EC and USEPA. pp. 353-357

Mills, E.L, R. Dermott, M. Munawar, S. Millard, O. Johannsson, and L. Rudstam. Status of the Lake Ontario Food Web in a Changing Ecosystem: the 2003 Lake Ontario Lower Aquatic Food Web Assessment (LOLA). Chicago, IL: U.S. Environmental Protection Agency, 2003a.

Mills, E.L., J.M. Casselman, R.M. 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. Stewart. "Lake Ontario: food web dynamics in a changing ecosystem (1970–2000)." Canadian Journal of Fisheries and Aquatic Sciences, 2003b: 60: 471-490.

Morrison, B.J., and S.R. LaPan (eds). The state of Lake Ontario in 2003. Special Publication 07-01, Ann Arbor, MI: Great Lakes Fishery Commission, 2007.

New York Department of Environmental Conservation: A 25-Year Plan for the Great Lakes, June 1992

New York Ocean and Great Lakes Ecosystem Conservation Council, Report to New York State Governor and Legislature, April 2009 www.nyoglecc.org

New York State Department of Environmental Conservation 2007 Annual Report of the New York State Department of Environmental Conservation's Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee: Executive Summary.

Ouyang, D, J. Bartholic, and J. Selegean. "Assessing Sediment Loading from Agricultural Croplands in the Great Lakes Basin." The Journal of American Science,, 2001: 1(2)14-21.

Owens, R.W., R. O'Gorman, T.H. Eckert, and B.F. Lantry. "The offshore fish community in southern Lake Ontario, 1972-1998." In The state of Lake Ontario: past, present, and future., by M. Munawar (ed), 407-442. Burlington, ON: Ecovision World Monograph Series, Aquatic Ecosystem Health and Management Society, 2003.

Quinte Conservation. Climate Change Adaptation Options for Coastal Zone Management in the Great Lakes Basin: Minutes of Workshop, 2004.

Reid, R. Status and Trends in Fish and Wildlife Habitat on the Canadian Side of Lake Ontario. Downsview, ON: Environment Canada, 2001.

Reschke, C., R. Reid, J. Jones, T. Feeney, and H. Potter. Conserving Great Lakes Alvar: Final Technical Report of the International Alvar Conservation Initiative. Chicago, IL: The Nature Conservancy, 1999.

Ritters, K.H., and J.D Wickham. "How far to the nearest road?" Frontiers in Ecology and Environment, 2003: 1(3): 125-129.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. "Habitat area requirements of breeding forest birds of the Middle Atlantic States." Wildlife Monographs , 1989: 103:1-34.

Rubbo, M.J. and J.M. Kiesecker. "Amphibian breeding distribution in an urbanized landscape." Conservation Biology, 2005: 19:504–511.

Stanfield, L. and B. Kilgour. "Effects of percent impervious cover on fish and benthos assemblages and instream habitats in Lake Ontario tributaries." American Fisheries Society Symposium . Bethesda, MD, 2006. 48: 577-599.

Tate, D.P. Assessment of the Biological Integrity of Forest Bird Communities: A Draft Methodology and Field Test in the Severn Sound Area of Concern. Severn Sound RAP Technical Report, Downsview, ON: Canadian Wildlife Service, 1998.

The Nature Conservancy. Conservation Action Planning. November 3, 2006. http://conserveonline.org/workspaces/cbdgateway/cap/index_html (accessed November 7, 2008).

Toner, J. 2006. Muskrat house abundance and cattail use in upper St. Lawrence River tributary wetlands: modeling the effects of water level regulation. M.S. thesis. SUNY College of Environmental Science and Forestry. Syracuse, NY.

Toronto and Region Conservation Authority and Ontario Ministry of Natural Resources. Humber River Fisheries Management Plan. 2005.

U.S. Army Corps of Engineers. Great Lakes Water Levels. July 2005. http://www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels/ (accessed September 2006).

Walsh, M.G., D.E. Dittman and R. O'Gorman. “Occurrence and food habits of the round goby in the profundal zone of Southwestern Lake Ontario.” Journal of Great Lakes Research, 2007: 33, 83-92

Watkins, J.M., R. Dermott, S.J. Lozano, E.L. Mills, L.G. Rudstam, and J.V. Scharold. "Evidence for remote effects of dreissenid mussels on the amphipod Diporeia: analysis of Lake Ontario benthic surveys, 1972-2003." Journal of Great Lakes Research, 2007: 642-657.

Wolter, P. Land Cover - Land Conversion: Indicator #7002. State of the Lake Ecosystem Conference 2006, 2007.