Assessment of

Fish Consumption Beneficial Use Impairment (BUI)

at the Toronto and Region Area of Concern

by

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October 2016

Executive Summary

Restoring Areas of Concern (AOCs) across the Great Lakes through the implementation of Remedial Action Plans (RAPs) has been a priority for both the U.S. and Canadian governments for about 30 years. RAPs have guided the restoration of beneficial use impairments (BUIs), such as "restrictions on fish consumption" toward the goal of delisting the AOCs. Fish consumption was designated impaired in many AOCs including the Toronto and Region waterfront. This report is an assessment of the status of this BUI in the Toronto and Region AOC. The Fish Consumption re-designation criteria for the Toronto and Region AOC is: *"That there are no restrictions on fish consumption that are attributable to local sources"*

This document presents a brief background on the AOCs, BUIs, and the re-designation criteria adopted by various AOC RAPs for the Fish Consumption BUI. Details on various factors that should be considered in a re-designation assessment of the Fish Consumption BUI are provided. These details ensure that the assessment is conducted in a transparent, consistent and scientifically defensible manner. Potential challenges that may be encountered while conducting the assessment have also been highlighted. A 3-tier BUI Assessment Framework developed by the Toronto RAP is first discussed, and then applied to investigate whether the fish consumption beneficial use has been restored at the Toronto and Region AOC. Tier 1 of the framework is a "*Guideline Criteria"* which examines whether contaminant concentrations and the fish consumption advisories for the AOC have improved with respect to contaminant benchmarks developed by the Ontario Ministry of Environment Climate Change (OMOECC). In cases where the advisories for the AOC are still "restricting" the consumption of fish, *"Comparison Criteria",* or Tier 2 of the framework, can be applied to compare fish consumption advisories for the AOC with those of other appropriate reference locations. Finally, Tier 3 or *"Weight-of-evidence (WOE) Criteria"*, if required, considers the findings of Tiers 1 and 2 and other metrics or lines of evidence and uses expert judgement to make an assessment.

Restrictions on fish consumption are based on contaminant levels exceeding their respective advisory benchmarks. The advisory benchmarks for many contaminants have generally become more stringent since the AOCs and BUIs were identified in the mid to late 1980s. This implies that not only are these contaminants considered more toxic than previously thought, but also that the contaminant benchmarks for "unrestricted" advisories became more stringent with time. For example, the PCB advisory benchmark which permits the consumption of 8 meals per month has become nearly 20 times more stringent, decreasing from 2000 ppb during the 1980s to 105 ppb at present. As such, advisories could still be in place even if the contaminant levels have declined substantially over time. Nevertheless, advisories restricting

fish consumption due to elevated contaminant levels within the AOC indicate that there is an impairment of this beneficial use.

Tier 1 of the Framework identified that advisories for many resident fish found along the Toronto Waterfront are "unrestricted" which means that you can eat 8 to 32 meals per month; in contrast, advisories for most migratory fish species, as well as Carp and White Sucker are still restrictive in some cases. In keeping with Tier 2 of the Framework, a comparison with reference sites was conducted. The comparison suggests that the advisories for most local fish are either "unrestricted" or similar to other locations in Lake Ontario, but in some cases are still more restrictive for the Toronto and Region AOC.

A variety of factors were considered in the Tier 3 WOE assessment. Temporal trend analyses showed substantial declines in contaminant levels in fish from the Toronto Waterfront area, especially for PCB, the major contaminant of concern for the AOC. Brown Bullhead, a sentinel species for PCB, demonstrated substantial (80-90%) declines in PCB concentrations, and the recent levels are well within the "unrestricted" advisory category. PCB levels in White Sucker, although still above the benchmarks, are estimated to achieve the "unrestricted" advisory classification in about a decade, based on the half-life of the contaminant in the fish. Substantial declines in PCB levels in forage fish at many locations in the GTA tributaries have also been observed over time. Some tributary locations do exhibit elevated concentrations of PCBs in forage fish, such as the reaches downstream of the G. Ross Lord Dam and Clairville Dam. A direct link between the contributions of tributaries to contaminant burden of fish along the Toronto Waterfront is unclear and may be outside the scope of the Toronto and Region RAP. The Great Lakes Water Quality Agreement (GLWQA) is applicable to the Waters of the Great Lakes, which may include the tributaries to the extent that they have a direct link with an identified impairment in the Great Lakes. Another line of evidence used in this assessment is the concentrations of PCBs in lake sediments which can contribute to elevated concentrations in fish. PCB concentrations in the Toronto Waterfront sediments have declined since the 1970s, but the levels have remained unchanged in the last 25 years. Comparisons of PCB levels in the sediments at the Toronto Waterfront are generally similar to the Lake Ontario wide average. Recent sediment assessments in the deeper basins of Lake Ontario (Marvin et al. 2002, 2004) show that contaminants in sediments exceed the sediment guidelines in large areas of the lake and that exceedances are not restricted to the AOCs.

An angler survey conducted in the mid-1990s suggested that most anglers in the area at that time did not consume locally caught fish on a very frequent basis (only 1% of the surveyed anglers consumed 8+ meals a month) mainly due to their concerns about contamination of the water and fish. With recent improvements in water quality and fish contaminant levels, the frequency of fish consumption may increase, although high frequency consumers eating 8+

meals per month will still likely represent a small percentage of the anglers. An updated survey of the Toronto and Region waterfront may provide important insight into current consumption patterns and perceptions in the AOC.

Positive for the Toronto and Region AOC, is that many of the resident fish present on the Toronto Waterfront can be consumed without any restriction or limited restrictions. Unfortunately, some of the larger and popular sport fish among anglers, such as Rainbow Trout and Brown Trout, continue to have more restrictive consumption advisories. These migratory species which spend part of their life history on the Toronto Waterfront are exposed to contaminants over much larger home ranges, consequently their contaminant burdens may not be an appropriate reflection of the conditions of the AOC. Of greater concern and relevance to the Toronto and Region RAP are the consumption restrictions for White Sucker and Carp, the latter of which is a popular fish for consumption among immigrants based on a mid-1990s study conducted by Health Canada (Kraft 1998). Although these fish can be migratory they likely have more limited home ranges and are accumulating higher PCB levels in the Toronto AOC as well as a number of nearby Lake Ontario locations.

Using the BUI Evaluation Framework, the balance of evidence shows that the restrictions on fish consumption for most resident fish species have improved along with environmental conditions such that they can be considered "Not Impaired". This conclusion, unfortunately, is confounded by the continued high PCB burdens in Carp and larger sizes of White Sucker, consumption of which clearly remain impaired in the AOC. Overall, evaluation results ranged from "impaired" to neutral (not conclusive) to "Not impaired". However, no compelling reasons can be identified to consider it as "Impaired", especially if we presume that there is no additional practical local action that can be undertaken to further improve the AOC conditions leading to "unrestrictive" advisories for all types of fish found along the Toronto Waterfront. It may be advisable to take a precautionary approach and consider the BUI "requires further assessment", gather new data in a few years to ensure continued declines in fish contaminant levels and improvements in the fish consumption advisories. Meanwhile, it should be examined if there is any additional action that can be undertaken to improve the BUI and sampling of young of the year (YOY) fish near the mouths of the major tributaries shall be considered to gather the most up-to-date information on potential contaminant loading to the AOC.

Acknowledgements

The following researchers assisted in preparing this document and/or generating the knowledge presented in the document.

- Rex Tang, U of Windsor
- Prof. Ken Drouillard, U of Windsor
- Dr. Margaret Neff, U of Toronto, OMOECC
- Prof. Donald Jackson, U of Toronto
- Jennifer Robinson, U of Toronto

Feedback on the initial draft from the following reviewers helped in improving quality of the document.

- Laud Matos
- Conrad deBarros
- Nadine Benoit
- Tanya Long

The financial assistance was provided by Environment Canada and TRCA. Such support does not indicate endorsement of the content.

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1. Background

Long-term environmental degradation and pollution in the Great Lakes resulted in the establishment of the Great Lakes Water Quality Agreement (GLWQA) between Canada and the United States. The agreement was first signed in 1972, later revised in 1978, 1987, and updated in 2012. The purpose of the Agreement is to restore and maintain the chemical, physical, and biological integrity of the Waters of the Great Lakes, which, as per the 2012 agreement, does not include tributaries, unless they have a direct link with an identified impairment in the Great Lakes. It outlines the identification of shared priorities and coordinating actions between the two nations in restoring and protecting the physical, chemical and biological integrity of waters of the Great Lakes (Environment Canada 2013a). Under Annex 2 of the agreement, both Canada and the United States are to take an "ecosystem approach" for Great Lakes' protection and restoration (Environment Canada 2013b). The GLWQA also underlines the holistic approach in environmental management by including humans, plants and animals as a part of the Great Lakes environment, and balancing human development and ecosystem health as a long-term sustainable goal (International Joint Commission 2014).

The International Joint Commission (IJC) with members from both Canada and the United States was established in 1909 to oversee disputes regarding boundary waters under the Boundary Waters Treaty agreement. As part of the IJC mandate, under the GLWQA Article 7, its goal is to facilitate the identification, remediation and monitoring of the environmentally degraded areas of the Great Lakes (Great Lakes Water Quality Agreement, 2012). Through collaboration with multiple levels of government, first nations, stakeholders and stewardship groups, actions are taken to resolve current environmental issues and to move towards long-term sustainability in the Great Lakes.

1.1. Area of Concern (AOC)

An Area of Concern (AOC) is an area in the Great Lakes that has been identified with environmental degradation under the GLWQA. The objective of an AOC is to restore impaired beneficial uses of the ecosystem by cleaning up areas where water quality and ecosystem health have been severely degraded by human activities (Environment Canada, 2013c). To qualify as an AOC, an area must contain at least one beneficial use impairments (BUI) listed by the IJC (see section 1.2).

Initially, 42 AOCs were identified by the IJC and one was added at a later time after revision, with a total of 12 AOCs within Canada, 25 AOCs within the United States, and 5 AOCs shared by both countries (Figure 1; International Joint Commission 2003). The 12 designated Canadian AOCs were: Thunder Bay, Nipigon Bay, Jackfish Bay and Peninsula Harbour in Lake Superior; Spanish Harbour, Collingwood Harbour, Severn Sound in Lake Huron; Wheatley Harbour in Lake Erie; Hamilton Harbour, Toronto and Region, Port Hope Harbour and Bay of Quinte in Lake Ontario (Figure 1). The AOCs that are shared with the United States are: St. Marys River, St. Clair River, Detroit River, Niagara River and St. Lawrence River at Cornwall.

Location	Status
Thunder Bay	?
Nipigon Bay	N/A
Jackfish Bay ^	?
Peninsula Harbour	x
St. Mary's River	x
Spanish Harbour ^	x
Severn Sound *	√
Collingwood Harbour *	√
St. Clair River	x
Detroit River	x
Wheatley Harbour *	√
Niagara River	x
Hamilton Harbour	x
Toronto and Region	x
Port Hope Harbour	N/A
Bay of Quinte	x
St. Lawrence River	x

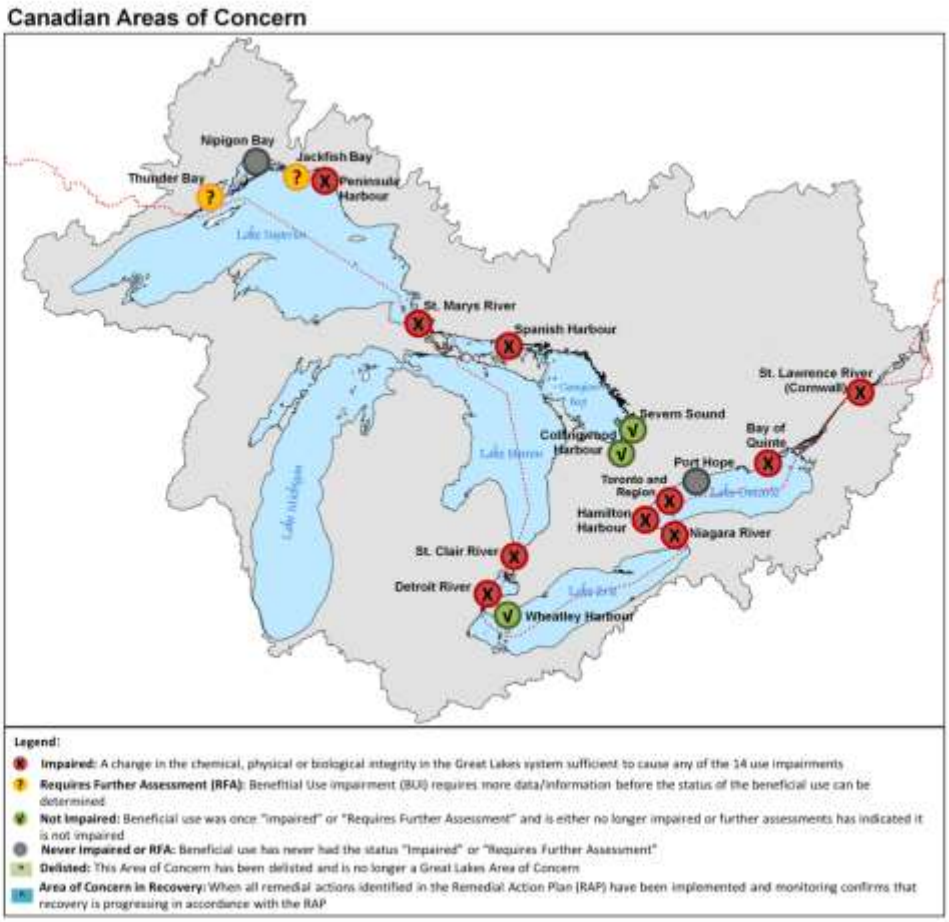


Figure 1. Canadian and shared Areas of Concern (AOCs) and their Fish Consumption BUI status

The following AOCs have been de-listed so far: Collingwood Harbour (Georgian Bay), Severn Sound (Georgian Bay) and Wheatley Harbour (Lake Erie) in Canada (Figure 1), and Oswego River (Lake Ontario), Presque Isle Bay (Lake Erie), Deer Lake (Lake Superior) and White Lake (Lake Michigan) in the United States. In addition, Spanish Harbour (Lake Huron) and Jackfish Bay (Lake Superior) AOCs have been re-designated as Area of Concern in Recovery (AiR) (Environment Canada 2013c).

1.2. Beneficial Use Impairments (BUIs)

A Beneficial Use Impairment (BUI) under the GLWQA [Annex 2, section 1(c)] is defined as a change in chemical, physical or biological integrity that is sufficient to cause impairment of any of the 14 uses (listed below) in an area of the Great Lakes (Great Lakes Water Quality Agreement 2012, Environment Canada and the Ontario Ministry of the Environment 2011). The BUIs were developed by a collaborative effort between the Great Lakes Water Quality Board, and many stakeholders including the general public. After months of development, the BUIs were approved by IJC in 1991. The intent of the BUIs is to provide a structural guideline and a reference point for the development of Remedial Action Plans (RAPs) (See section 1.3) which serves as a focus and direction for restoration efforts (Great Lakes Water Quality Agreement 2012). A total of 14 beneficial use categories were defined, and the status of AOC was designated when an area had one or more BUI (Figure 2, Great Lakes Water Quality Agreement 2012).

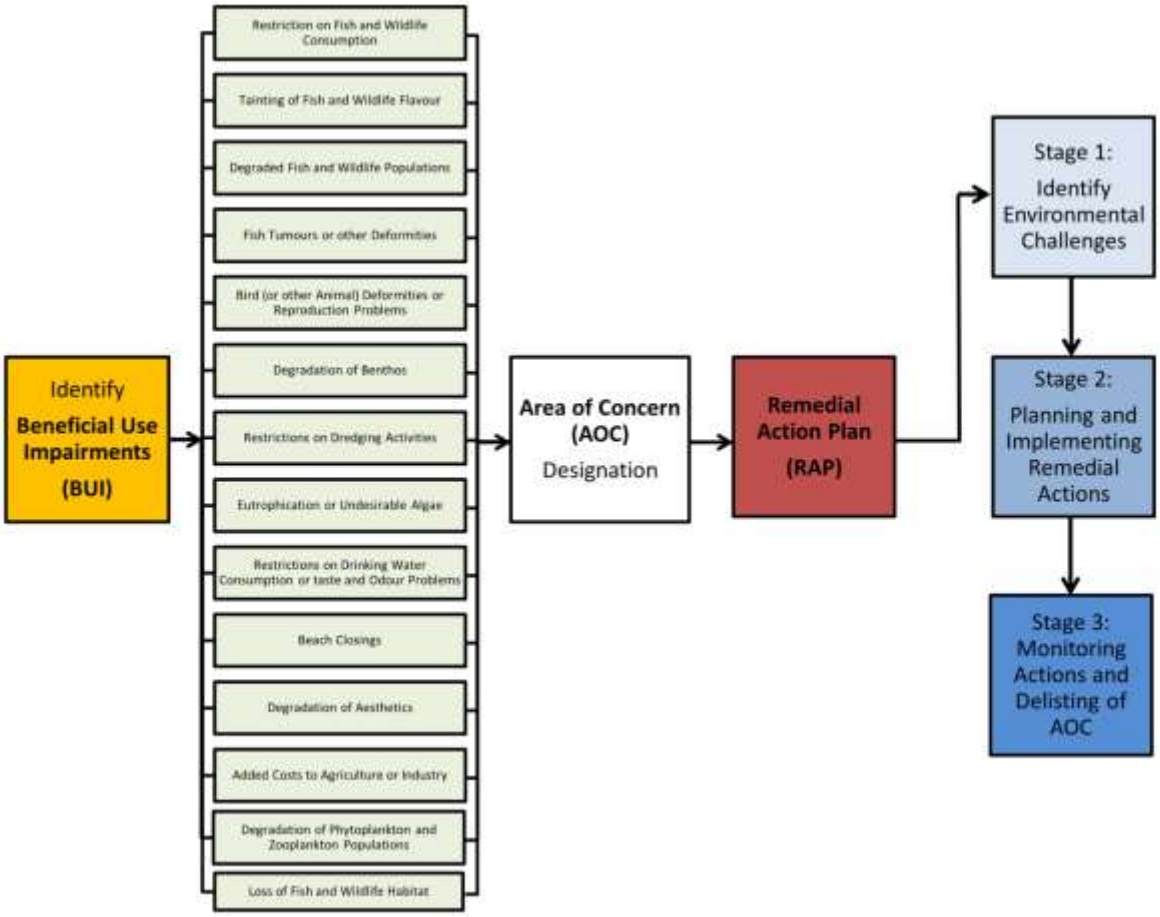


Figure 2. Stages in Area of Concern (AOC) designation and Remedial Action Plan (RAP)

The BUI categories are as follows:

1. Restrictions on Fish and Wildlife Consumption
2. Tainting of Fish and Wildlife Flavor
3. Degraded Fish and Wildlife Populations
4. Fish Tumors or Other Deformities
5. Bird or Animal Deformities or Reproductive Problems
6. Degradation of Benthos
7. Restrictions on Dredging Activities
8. Eutrophication or Undesirable Algae
9. Restrictions on Drinking Water Consumption or Taste and Odor Problems
10. Beach Closings
11. Degradation of Aesthetics
12. Added Costs to Agriculture or Industry
13. Degradation of Phytoplankton and Zooplankton Populations
14. Loss of Fish and Wildlife Habitat

Since 1987, remediation actions have been undertaken in AOCs to restore these beneficial uses and the physical, chemical or biological integrity of the Great Lakes. Changes in status of BUIs (i.e. Delisting) are also used to highlight improvements in the environmental conditions in the AOC.

1.3. Remedial Action Plan

Each AOC developed a Remedial Action Plan (RAP) to address their specific environmental impairments or BUIs under the GLWQA. The RAPs outline actions and targets for protecting and restoring AOCs using a systematic approach. Each RAP identifies re-designation criteria (i.e., delisting criteria) associated with individual BUIs (Environmental Canada and Ontario Ministry of the Environment 2011).

The RAP follows a 3 stage process (Figure 2):

- Stage 1 – Identifying the Environmental Challenges
- Stage 2 – Planning and Implementing Remedial Actions
- Stage 3 – Monitoring Actions and Delisting of the AOC

In Stage 1, origins and causes of environmental degradation in an AOC are identified using monitoring data and scientific research. In Stage 2, potential remedial actions are

planned, implemented and reviewed with the goal of restoring beneficial uses and delisting the AOC. In Stage 3, the status of the AOC is reviewed based on post-remedial action monitoring activities to confirm BUIs have been restored. When Stage 3 is complete with all RAP goals achieved, the AOC can be delisted based on a joint decision between multiple levels of government, local stakeholders and the IJC (Environment Canada and the Ontario Ministry of the Environment 2011). However, despite delisting continued monitoring is required to ensure environmental quality and sustainability in the future. RAPs provide an opportunity for engaging in collaborative environmental stewardship and measuring the progress towards meeting the delisting criteria defined for each AOC.

1.4. Fish Consumption BUI

The beneficial use of fish consumption remains impaired at many Canadian AOCs (Table 1). Major contaminants of concern include mercury, PCBs, dioxins, furans, and other pesticides. This results in a number of fish consumption advisories issued by the Ontario Ministry of the Environment and Climate Change (OMOECC) based on the most restrictive contaminant of concern (Ontario Ministry of the Environment and Climate Change 2015). Historically, fish consumption advisories ranged from complete restrictions (i.e., do not eat) to minor restrictions (2 or 4 meals/month) in the Canadian AOCs. Since the designation of Canadian AOCs in 1987 and the subsequent implementation of RAPs, levels of contaminants in fish have gradually improved and the consumption advisories are now typically less restrictive, even with implementation of more stringent health guidelines over time. Many Canadian AOCs considering delisting will require a status assessment to determine whether the consumption of fish remains an impaired beneficial use.

Re-designation criteria for the fish consumption BUI are generally broad in context and analogous among the Canadian AOCs (Table 1). In most cases, the fish consumption beneficial use is no longer considered to be impaired at a Canadian AOC when fish consumption advisories for the AOC are no more restrictive than advisories for a suitable reference site(s) due to the same contaminants (Table 1).

Table 1. Re-designation criteria for the BUI Fish Consumption for the Canadian AOCs

Source: Great Lakes AOC 2014 RAP Implementation Workshop. Summary of BUI Status, Delisting Criteria and Remaining Actions for Canadian Great Lakes AOCs.

AOC	BUI Status	Re-designation Criteria for Fish Consumption BUI
Thunder Bay	Requires further assessment	This beneficial use will no longer be impaired when the fish consumption advisories in the AOC (inner and outer Harbour) are no more restrictive than the advisories for the same contaminants in an open water reference site (Schreiber Point to Sewell Point – Block 7), based on samples collected in the same time frame (< 5 years) for a minimum of two consecutive studies.
Nipigon Bay	Never impaired	
Jackfish Bay	Requires further assessment	This BUI will no longer be impaired when the fish consumption advisories in the AOC are no more restrictive than at an appropriate reference site in Lake Superior
Peninsula Harbour	Impaired	This beneficial use will no longer be impaired when a comparison study of fish tissue contaminant levels demonstrates that there is no statistically significant difference in fish tissue concentrations of contaminants causing fish consumption advisories in the AOC compared to suitable Lake Superior reference sites.
St. Marys River	Impaired	This beneficial use will no longer be impaired when the fish consumption advisories in the Area of Concern are no more restrictive than the advisories for the same contaminants in a suitable reference site. Comparisons shall be based on samples collected in the same timeframe for a minimum of two consecutive sampling events.
Spanish Harbour	Impaired	This BUI will no longer be impaired when the fish consumption advisories in the Area of Concern in Recovery are no more restrictive than the advisories for the same contaminants in a suitable reference site, based on samples collected in the same time frame (≤ 5 years).
Severn Sound	Not impaired	
Collingwood Harbour	Not impaired	
St. Clair River	Impaired	This BUI will be considered restored when fish consumption advisories in indicator fishes (e.g., walleye, brown bullhead, and smallmouth bass) in the AOC are the same or less restrictive than the associated Great Lake or appropriate control site and when the general guidance for the consumption of indicator

		wildlife (e.g., snapping turtles, geese) are no different than the non-AOC sites in the Great Lakes.
Detroit River	Impaired	When contaminant burdens that have been accumulated within the AOC and are contributing to fish consumption advisories in indicator fish species (walleye, brown bullhead, and smallmouth bass) decline below established safe consumption levels for a minimum of three years.
Wheatley Harbour	Not impaired	When consumption advisories for sport fish in the AOC are consistent with those in the central basin of Lake Erie.
Niagara River	Impaired	1. No restrictions on the consumption of sport fish in the Ontario portion of the AOC due to locally-controllable contaminant (PCBs and dioxin-like PCBs) sources. 2. OR if a contaminated site (as designated by the Niagara River Contaminated Sediment Technical Advisory Group*) fails to meet the criteria described above in regard to fish and wildlife consumption, then a risk based Contaminated Sediment Management Strategy must be in place with appropriate monitoring and mitigation measures and/or administrative controls.
Hamilton Harbour	Impaired	When there is no significant difference in the fish consumption advisories for Hamilton Harbour compared to reference location(s) and the contaminants of concern are declining in Hamilton Harbour fish.
Toronto and Region	Impaired	1. There are no restrictions on fish consumption that are attributable to local sources.
Port Hope Harbour	Never impaired	
Bay of Quinte	Impaired	Target: When it can be demonstrated that fish consumption restrictions are not significantly influenced by contaminant sources in the Bay. Contaminants of concern are PCBs, dioxin-like PCBs, dioxins/furans. 1. Fish consumption restrictions in the upper, middle bay are stable or declining and comparable to the least restrictive of Lake Ontario reference zones 6 and 8 as defined in the provincial government's Guide to Eating Ontario Sport Fish; 2. When contaminant levels in brown bullhead and yellow perch (or a similar sentinel species) collected in the Trent River mouth and at the Belleville waterfront near established sources of contamination result in the same consumption limits as the general population for these fish in the upper bay.
St. Lawrence River	Impaired (pending re-designation to not impaired)	1. Contaminant levels in fish in the AOC are the same or less than those in upstream non-AOC areas in the St. Lawrence River. 2. Restrictions same or fewer/less restrictive than upstream non-AOC areas in the St. Lawrence River.

1.5. Scope of the Report

This report presents an application of the BUI re-designation framework developed by the Toronto and Region RAP team to investigate the status of the Fish Consumption BUI at the Toronto and Region AOC. This assessment builds on the effort invested by TRCA and OMOECC in gathering a comprehensive fish contaminant dataset for the Toronto AOC during the last few years.

The assessment of status of the Fish Consumption BUI is an independent process from the issuance of fish consumption advisories by OMOECC through the Guide to Eating Ontario Fish. Some contaminants can be naturally present in fish (e.g. mercury), and as such, restrictions on fish consumption cannot always be viewed as a negative impact of human activities. There have been restrictive fish consumption advisories for remote locations in Ontario where no human activities have directly impacted fish contaminant levels, and influence through atmospheric deposition can be considered minimal. This has been now recognized in the updated re-designation criteria for the BUI at many AOCs, where the requirement of "no restriction on fish consumption" has been reworded and a comparison with reference site(s) have been considered more appropriate. Further, this assessment relies on contaminants of concern identified during the Stage 1 of the RAP process, and so called *contaminants of emerging concern* were not within the scope of this evaluation.

An examination of the restoration activities conducted to date and any additional reasonable actions that can be undertaken to further improve the conditions at the AOC can help in assessing the status of the Fish Consumption BUI. However, the Toronto and Region AOC RAP team is better suited to conduct such an examination of the actions, and as such, an evaluation of actions has not been considered in this assessment. Finally, the assessment focuses more on the Toronto waterfront area because of its direct link to the Great Lakes. The tributaries of the GTA were assessed to understand their potential influence on the waterfront part of the AOC.

2. BUI Re-designation Framework

2.1. Toronto AOC "Tiered" Framework

A generic science-based "Tiered" framework for re-designation of all BUIs at the Toronto and Region AOC was recently developed by the Toronto and Region RAP team (Figure 3) (Toronto and Region Conservation Authority 2011). The framework sets out the order in which three potential data evaluation methods or "tiers" are to be applied, and based on the outcomes of these evaluations a recommendation is made on potential re-designation of a BUI for the AOC.

Guideline (Tier 1) Criteria of the Toronto BUI Evaluation Framework examines whether conditions in the AOC meet the targets set for a BUI (Figure 3). The guideline criteria or targets are based on appropriate environmental benchmarks or standards against which decisions about environmental quality can be made. If environmental conditions within the AOC meet ALL the guideline criteria or targets for a given BUI, the status of the beneficial use at the AOC is re-designated as "Not Impaired". If the conditions at the AOC still exceed the guideline criteria, then the assessment moves to Tier 2 of the BUI Evaluation Framework (Figure 3).

Comparison (Tier 2) Criteria of the Toronto BUI Evaluation Framework examines whether environmental conditions pertaining to the BUI in the AOC are comparable to those at appropriate other non-AOC reference site(s) in the Great Lakes (Figure 3). If the AOC conditions are better or not significantly different than the non-AOC reference sites, the status of the BUI at the AOC is considered as "Not Impaired"; otherwise, the assessment moves to Tier 3 of the BUI Evaluation Framework (Figure 3).

Weight of Evidence (Tier 3) Criteria of the Toronto BUI Evaluation framework examines the status of the BUI using the Weight of Evidence (WOE) approach involving multiple qualitative and quantitative lines-of-evidence. For example, a general trend of the condition as well as occurrence/frequency of exceedances compared to the criteria/target could be considered together in the WOE approach. Based on the WOE approach and careful evaluation, the status of the BUI at the AOC can be re-designated as "Not Impaired", or further examination is conducted to determine whether additional remedial actions for the AOC are possible. At this stage, an identification of further remedial action(s) would result in the continued "Impaired" status of the BUI. However, if all practical remedial actions have been implemented, then the BUI Evaluation Framework results in continued "Impaired" or re-designated "Not Impaired" status of the BUI.

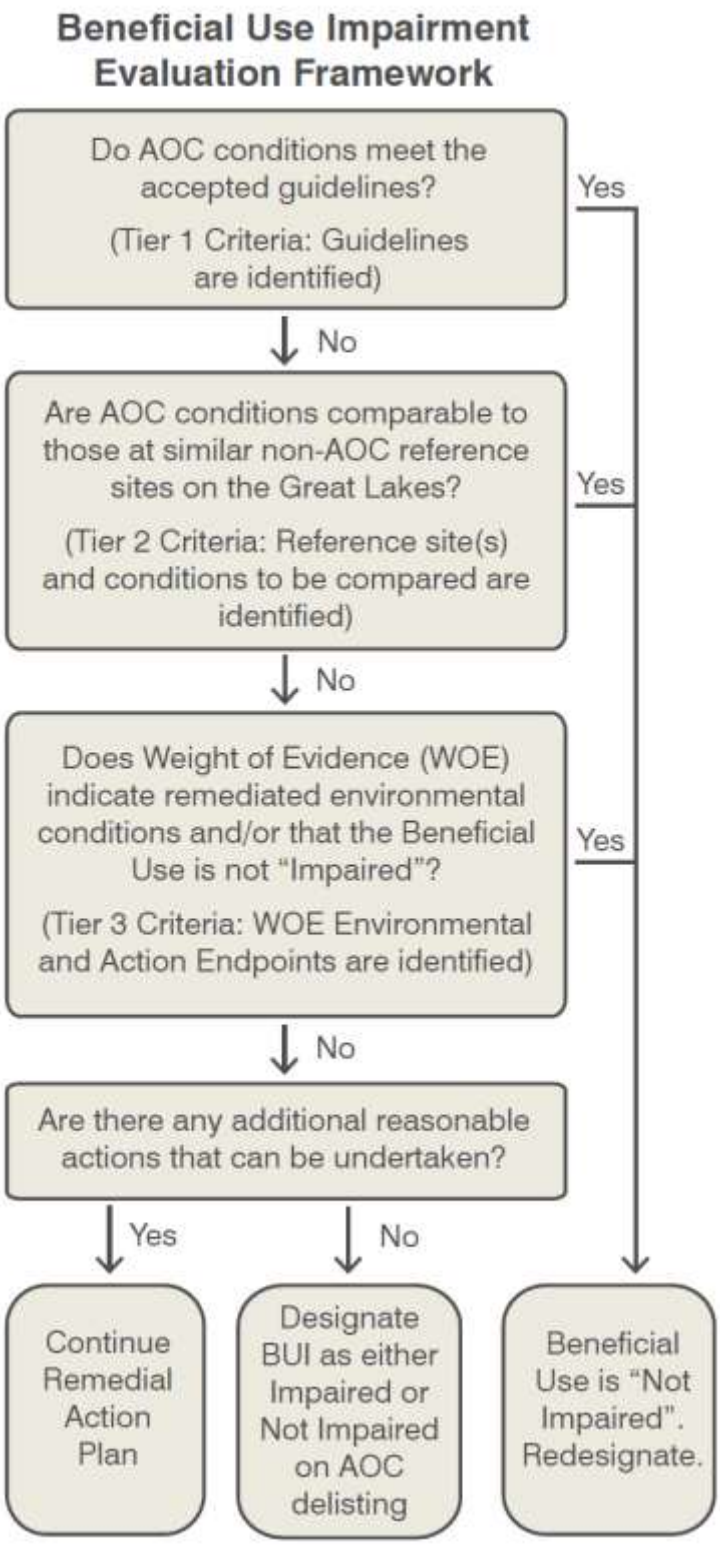


Figure 3. Toronto RAP's "Tiered" Beneficial Use Impairment Evaluation Framework

Source: Toronto and Region Conservation Authority 2011

2.2. Application of Framework to Fish Consumption BUI

This section discusses technical points to consider while conducting an assessment of the Fish Consumption BUI using the Framework. These details ensure that the assessment is conducted in a transparent, consistent and scientifically defensible manner.

2.2.1. Source of contaminant data

The OMOECC, in partnership with the Ontario Ministry of Natural Resources and Forestry (OMNRF), has been monitoring fish contaminant levels in the Great Lakes since the 1970s. These data are collected for a variety of reasons including for issuing fish consumption advisories. Fish samples from the Great Lakes are collected by diverse methods including gill netting, electrofishing and angling. For most sport fish samples, a skinless, boneless dorsal fillet, which is generally considered the most edible portion, is sampled for contaminant analysis. A number of contaminants including mercury, PCBs (includes dioxin like PCBs), dioxins/furans, DDT, toxaphene, mirex, photomirex, other pesticides and emerging contaminants are measured. These data are then used to issue fish consumption advisories for the Canadian waters of the Great Lakes, which have been divided into about 60 smaller regions or blocks to account for differences in the contaminant levels. All of the Canadian and shared AOCs have been generally designated as separate blocks. Therefore, a fish consumption BUI assessment for a Canadian AOC shall use data collected by the Fish Contaminant Monitoring Program of OMOECC to examine severity of restrictions on fish consumption for the Canadian AOCs. As required and appropriate, other available data can also be supplemented to strengthen the analysis.

2.2.2. Extent of data

Fish contaminant data for the AOC and reference sites should be extensive enough to ensure sufficient coverage for analysis. In many cases, judgement should be applied to best utilize the available data without substantially compromising integrity of the assessment.

2.2.3. Contaminant(s) of interest for the AOC

Contaminants are selected based on persistence, bioaccumulation and toxicity of contaminants from local sources. The selection could be guided by the contaminants responsible for causing restrictions on fish consumption. Other contaminants can be considered

in the assessment (if data are available) to ensure that they are not of concern, and if there is any, then to examine if there is any local AOC specific issue related to the contaminant.

2.2.4. Appropriate fish species

Fish species should be relevant to what people eat and the contaminant(s) of concern within the AOC. Accumulation of different contaminants depends on their chemical properties and type of fish. For example, lipophilic (fat loving) chemicals like PCBs and mirex accumulate at higher levels in fatty fish like Lake Trout, Salmon and Brown Bullhead, while chemicals like mercury accumulate at higher levels in lean top predatory fish like Walleye and Northern Pike. Therefore, fish species relevant to the contaminant of concern for the AOC should be selected for the assessment. Other species can also be considered based on availability of data.

The effects of fish traits such as size and foraging area should also be considered. Bioaccumulation of contaminants in fish is affected by fish size (e.g., length, weight) (Somers and Jackson 1993, Gewurtz et al. 2011a), where larger and older fish reflect higher levels of accumulated contaminants over time. Many higher trophic level fish could also be migratory. Levels of contaminants in such migratory species can be impacted by time spent in an AOC; however, it may be challenging to directly link contaminant levels in these fish with the AOC conditions given their use of larger home ranges. As such, resident higher trophic level fish or appropriate lower trophic level local fish may be selected for the assessment even though they may not be popular among the consumers.

2.2.5. Advisory benchmarks

The OMOECC is the only agency that issues fish consumption advisories for the Canadian waters of the Great Lakes. Fish consumption advisory benchmarks used by OMOECC are generally based on tolerable daily intake levels established by the Food Directorate of Health Canada. The OMOECC fish consumption advisories recommend monthly meals based on a 227 g (half a pound or 8 oz) meal of fish for a 70 kg (154 lb) adult. It is assumed that the meal size of a smaller or larger person would be proportionate. Two separate advisory benchmarks are used: 1) for the general population and 2) for the sensitive population of children and women of child-bearing age. The OMOECC calculates advisories for each contaminant, location, fish species and 5 cm size interval between the smallest and largest fish sample collected. The categories for advised meals per month are 32, 16, 12, 8, 4, 2, 1 and 0 (do not eat) for the general population. To be conservative in protecting the sensitive population, they are advised to avoid eating fish containing contaminants at elevated levels by converting 2 and 1 meal per month advisories into 0 meal per month (do not eat). The final location/species/size-specific

advisories are based on the most restrictive contaminant (Bhavsar et al. 2011, Ontario Ministry of the Environment and Climate Change 2015).

Table 2. Current OMOECC fish consumption advisory benchmarks

Source: Ontario Ministry of the Environment and Climate Change 2015
Note: Only major contaminants of concern for the Great Lakes are included in the table; they all are not necessarily of concern for the Toronto AOC

	Hg (ug/g)		PCB	Dioxin/Furan/ dlPCB TEQ (pg/g)	Mirex	Photomirex	Toxaphene
Meals/ month	**Sensitive**	**General**	**ng/g**		**(ng/g)**	**(ng/g)**	**(ng/g)**
0	>0.5	>1.8	>844	>21.6	>657	>122	>1877
1			422-844	10.8-21.6	329-657	61-122	939-1877
2		1.2-1.8	211-422	5.4-10.8	164-329	31-61	469-939
4	0.25-0.5	0.6-1.2	105-211	2.7-5.4	82-164	15-31	235-469
8	0.16-0.25	0.4-0.6	70-105	1.8-2.7	55-82	10-15	156-235
12	0.12-0.16	0.3-0.4	53-70	1.3-1.8	41-55	8-10	117-156
16	0.06-0.12	0.15-0.3	26-53	0.7-1.3	21-41	4-8	59-117
32	<0.06	<0.15	<26	<0.7	<21	<4	<59

2.2.6. Calculation of consumption advisories

Consumption advisories shall be calculated using the method employed by the OMOECC and briefly described below (Bhavsar et al. 2011, Ontario Ministry of the Environment and Climate Change 2015). Utilizing the available OMOECC data for a location of interest, a set of power series regressions for contaminant level versus fish length for each location/species/contaminant/period combination shall be conducted (e.g., Figure 4). These regressions are then used to calculate contaminant levels at 5 cm intervals (rounded to the closest 5 or 10) between the largest and smallest sizes of the fish samples for that combination. These values are then compared with the advisory benchmarks specific to the contaminant, and meals per month advisory is formulated for each 5 cm size interval for every location/species/contaminant/period combination.

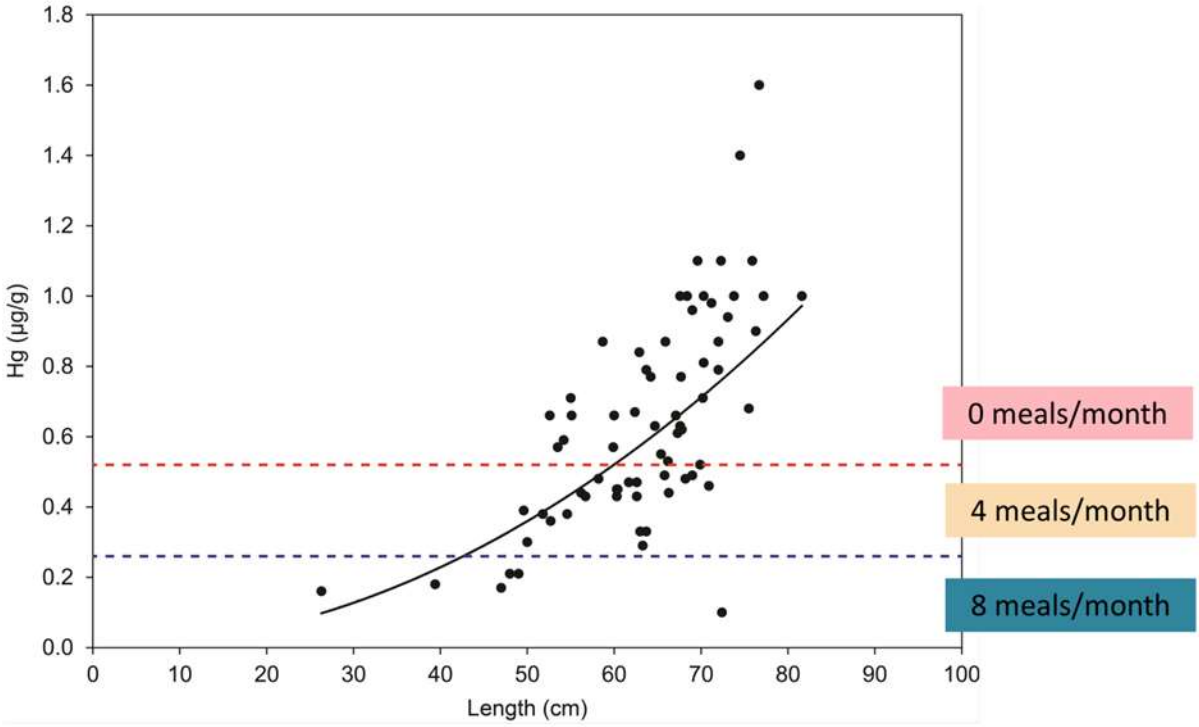


Figure 4. Example of a power regression for calculating fish consumption advisories.

2.2.7. Classification of advisories

It should be noted that the OMOECC advisories were only up to 8 meals per month until very recently (2015) when additional categories of 12, 16 and 32 meals per month were added so that 8 meals per month advisories can be further broken down to less restrictive advisories for cleaner fish. The maximum of 8 meals per month was based on the OMOECC angler surveys showing that most (>90%) anglers do not eat wild fish more often (Awad 2006), while the recent addition of higher meals per month categories was to address the needs of more frequent consumers (e.g., subsistence fishers) (Ontario Ministry of the Environment and Climate Change 2015). For this Tier 1 of the BUI Fish Consumption assessment, it may be appropriate to classify 8+ meals per month advisories as "not considered restrictive (unrestricted)" because lake wide contamination in the Great Lakes can result in fish consumption advisories of 8-16 (or even more restrictive - less than 8) meals per month (Ontario Ministry of the Environment and Climate Change 2015). The advisory categories of 4, 2 and 1 can be considered "partially restricted", while 0 meal per month or "do not eat" can be considered "completely restricted".

Table 3. Advisory categories and their classifications for the BUI assessment.

General Population		Sensitive Population	
Meals per month	**Classification**	**Meals per month**	**Classification**
0	Do not eat	0	Do not eat
1	Partially restricted	4	Partially restricted
2			
4			
8	Not considered restrictive (Unrestricted)	8	Not considered restrictive (Unrestricted)
12		12	
16		16	
32		32	

2.2.8. Weight of Evidence

A weight of evidence (WOE) approach is used in Tier 3 of the BUI Evaluation Framework when assessments in Tiers 1 and 2 suggest that the BUI is still impaired. In Tier 3, a number of environmental indicators are examined in detail along with best professional judgement.

A variety of measures can be considered in the WOE approach. For example, an investigation of the temporal trends in the fish contaminant levels can provide insight into how much improvement has happened over time. An estimate of how much time it will require for the fish contaminant levels to fall below the fish consumption advisory benchmarks would indicate the outlook for the BUI. Other measures include a comparison of the current AOC levels with other non-AOC Great Lakes locations and appropriate Ontario inland waterbodies. Also, examining the trends in Young-of-the-Year (YOY) or forage fish in AOC and reference sites may provide further contextual information on more local conditions. Furthermore, an examination of the level and trends of the contaminants of concern in other appropriate matrices such as sediments can provide additional support to the findings for fish. Certain measures may not be quantifiable; however, a qualitative assessment of them can provide supporting information to make an informed decision about the status of the BUI. For example, a review of information related to food web structure, which may affect fish health and/or accumulation of contaminants in fish, would help in strengthening the assessment.

Tier 3 considers the quantifiable and qualitative measures along with the findings of Tiers 1 and 2 with best professional judgement to conclude if the BUI is still impaired or it can

be re-designated to “Not Impaired”. Where a substantial response delay to previous action can be expected, no additional relevant actions have been identified, and fish consumption advisories are predicted to be not restrictive or same/less restrictive than reference sites within a reasonable time period (e.g., in 10 years), the BUI can be re-designated as not impaired.

2.2.9. Other considerations and potential challenges

In addition to the framework for a re-designation of the BUI, a number of other factors and potential challenges shall be considered in the assessment.

It has been identified that the fish contaminant monitoring data of OMOECC is the best available data for the assessment of Fish Consumption BUI. However, it is also advised to include other available and appropriate datasets to strengthen the assessment. If other datasets are utilized, precautions should be taken to ensure compatibility of the datasets. For example, sampling locations and laboratory analytical methods should be comparable among the datasets. The measurements should also be relevant for assessing risk to human health from fish consumption (e.g., fish fillet vs whole body measurements).

Limited availability of data can pose a challenge in conducting a thorough assessment of the BUI status. As appropriate, additional sampling should be considered before conducting a re-designation assessment. Similarly, lack of common species and fish size range between the AOC and reference sites can also be a potential challenge for comparing temporal trends. Furthermore, if temporal trends differ among species within the same location/block, an interpretation of the results would be challenging without looking into other ecological or environmental factors such as fish trophic position and traits.

3. Fish Consumption BUI Assessment for the Toronto AOC

The fish consumption beneficial use has been designated as "Impaired" at the Toronto and Region AOC (Figure 1; Environment Canada and Ontario Ministry of the Environment 2010). As per the re-designation criterion, the fish consumption beneficial use will no longer be impaired when there are no restrictions on fish consumption that are attributable to contaminants from local AOC sources (Table 1). The BUI Assessment Framework discussed in Section 2 was applied to investigate whether this beneficial use has been restored and if the status of the Fish consumption BUI at the Toronto and Region AOC can be re-designated as "Not Impaired".

3.1. Toronto AOC: Background

The Toronto and Region AOC is a part of the northern shoreline of Lake Ontario. It extends from the Rouge River in the east to the Etobicoke Creek in the west side of the region. The area covers approximately 200 000 ha (2000 km^2) in the region with 45 km of waterfront along Lake Ontario (Figure 5). There are six city-wide watersheds within this area that drain into Lake Ontario, including: Etobicoke, Mimico, Humber, Don, Highland and Rouge watersheds. Land use in the region is dominated by urban (47%), urbanizing (13%), rural (21%), moraine/escarpment (18%) and natural cover (17%) (Toronto and Region Conservation Authority 2014).

Due to several decades of urbanization and development in the area, the Toronto waterfront has been affected by many sources of contaminants in its aquatic environment including urban runoff, and industrial and municipal discharges. Since the area was designated as an AOC, progress has been made to reduce pollution, including reduction in the flow of contaminants into the watershed via storm water and spill management (Toronto and Region Conservation Authority 2011a). However with a growing population and increasing urbanization, restoration and remediation of the Toronto and Region AOC remains a challenge (Toronto and Region Conservation Authority 2011a).

At Stage 2 of the RAP, many key actions were completed to improve the BUIs at the AOC including fish consumption. These actions include: (1) implementation of provincial and federal regulations to control the release of toxic chemicals in industrial discharges; (2) implementation

of stringent municipal sewer-use-bylaws to control the release to toxic chemicals into the city's sanitary and stormwater sewers; (3) reduction of contaminant loadings by implementing the wet weather flow management master plan; (4) reduction of contaminants discharge into Lake Ontario through the use of new municipal jurisdictions; (5) identification and reduction of an ongoing source of PCBs into Etobicoke Creek via a PCB Trackdown (Environment Canada and Ontario Ministry of the Environment 2010); and (6) compliance with the Canadian Wide Standards (CWS) to remove PCB storage sites by 2010. Remaining actions include continual implementation of the wet weather flow management master plan (Environment Canada and Ontario Ministry of the Environment 2010).

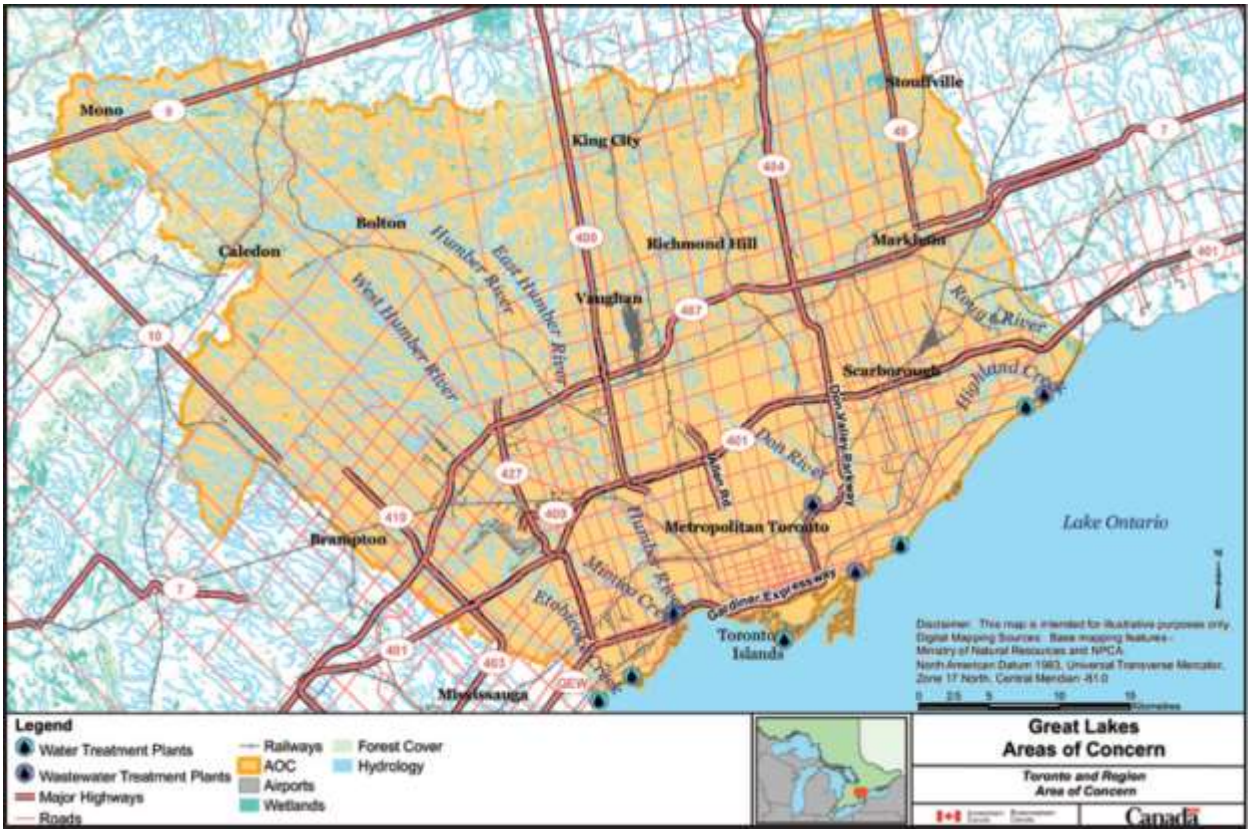


Figure 5. A Map of Toronto and Region AOC.

Source: Environment Canada and Ontario Ministry of the Environment 2010

3.2. Tier 1: Guideline Criteria

An advice of restricting consumption of fish results when levels of contaminants exceed their respective advisory benchmarks. Recent studies in the Great Lakes have demonstrated a general decline in the fish contaminant levels over the last 30-40 years (Bhavsar et al. 2007, 2008, 2010a, 2011, Gewurtz et al. 2011a). However, advisory benchmarks for many contaminants have generally moved downward implying that these contaminants are more toxic than previously thought. For example, the mercury benchmark for an 8 meals per month advisory for the sensitive population was 0.5 ppm during the 1980s, but is 0.25 ppm at present (Table 4). For PCB, the changes in the advisory benchmarks have been even more dramatic (Table 4). For example, PCB concentrations up to 2000 ppb would result in an 8 meals per month advisory during the 1980s, while this benchmark now stands at 105 ppb (Table 4).

Table 4. Changes in advisory benchmarks of mercury and PCB between the 1980s and 2015-16. *Source: Ontario Ministry of the Environment and Climate Change*

# meals/ month	Sensitive Population		General Population	
Years →	1977-1994	2015-2016	1977-1994	2015-2016
Mercury (ppm)				
0	>0.5	>0.5	>1.5	>1.8
2			1.0-1.5	1.2-1.8
4		0.25-0.5	0.5-1.0	0.6-1.2
8	0-0.5	0.16-0.25	0-0.5	0.4-0.6
12		0.12-0.16		0.3-0.4
16		0.06-0.12		0.15-0.3
32		<0.06		<0.15
PCB (ppb)				
0	>2000	>844		>844
1		422-844	>2000	422-844
2		211-422		211-422
4		105-211		105-211
8	0-2000	70-105	0-2000	70-105
12		53-70		53-70
16		26-53		26-53
32		<26		<26

As such, advisories could still be in place even if the levels have declined over time. Nevertheless, advisories restricting fish consumption due to elevated levels of contaminants from controllable sources within the AOC mean an impairment of the beneficial use. The goal of a Tier 1 assessment is to examine if the advisories aimed at protecting the health of humans

consuming AOC fish are still limiting the beneficial use of fish consumption due to elevated levels of contaminants from controllable sources within the AOC.

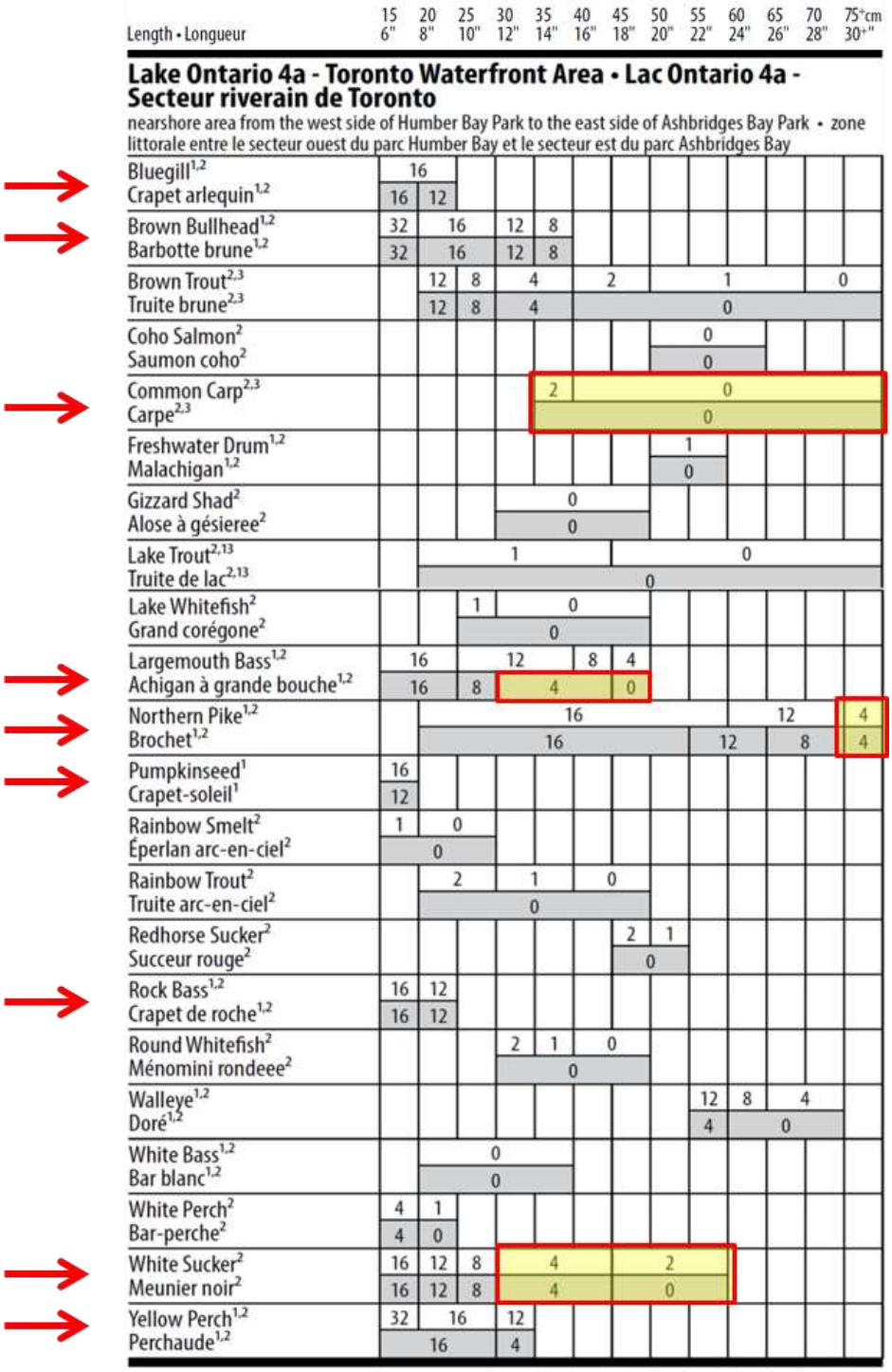
The recent (2015-2016) advisories published by OMOECC through the Guide to Eating Ontario Fish recommend "unrestricted" (8+ meals per month) consumption of many fish found along the Toronto Waterfront (Table 5). All monitored sizes of many panfish, namely Bluegill, Pumpkinseed, Rock Bass and Yellow Perch (except 30-35cm for the sensitive population) can be consumed at 8+ meals per month. In addition, Brown Bullhead advisories are also "unrestricted". Similarly, most or small sizes of many other fish such as Largemouth Bass, Northern Pike and White Sucker can be consumed at 8+ meals per month. However, the Guide also recommends restricting consumption of many fish found along the Toronto Waterfront (Table 5). For example, it is advised not to eat or restrict consumption of almost all sizes of Coho Salmon, Common Carp, Freshwater Drum, Gizzard Shad, Lake Trout, Lake Whitefish, Rainbow Smelt, and White Bass. Restriction on consuming large sizes of Brown Trout, Rainbow Trout, Round Whitefish, Walleye, White Perch and White Sucker has also been recommended.

It should be noted that not all the fish found along the Toronto Waterfront are local residents. Bluegill, Brown Bullhead, Common Carp, Largemouth Bass, Northern Pike, Pumpkinseed, Rock Bass, White Sucker and Yellow Perch are typically local resident, while other types of fish that are generally large in size are migratory. Some individuals of local resident fish such as Common Carp can also be migratory (Susan Doka, DFO, presentation at the Toronto AOC RAP Science Seminar 2015). In general, migratory species may not appropriately reflect impact of local contamination levels; however, in certain circumstances they may exhibit more influence of conditions from the area they were sampled compared to the same type of fish found at another location and may not have spent any time at the area of interest. Also, when appropriate, the advisories published in the Guide utilize relatively older measurements to maximize advice given to the public on safe consumption of fish. As such, the advisories in the Guide may not present the true current scenario.

The advisories in the Guide show that almost all restrictions on fish consumption are a result of elevated levels of either PCB or mercury. Mirex and dioxin like PCBs cause some minor restrictions. It should be noted that PCB and mercury can be considered contaminants of local concern (Robinson et al., 2015), while mirex in Lake Ontario fish was from historical sources in the Niagara and Oswego Rivers (Gandhi et al., 2015). Dioxin like PCBs are a subset of the PCB group and are linearly related to the total PCB measurements (Bhavsar et al., 2007a; Bhavsar et al., 2007b).

Table 5. Published (2015-16) fish consumption advisories for the Toronto Waterfront Area.

Values are in meals per month, separate for the general and sensitive populations. Species with red arrow can be considered mostly non-migratory. Red boxes highlight restrictive advisories for the non-migratory species. Superscripts 1, 2, 3 and 13 are for advisories caused by mercury, PCB, dioxin-like PCB and mirex, respectively. Source: Ontario Ministry of the Environment and Climate Change 2015



Length • Longueur	15 6"	20 8"	25 10"	30 12"	35 14"	40 16"	45 18"	50 20"	55 22"	60 24"	65 26"	70 28"	75+cm 30+"
Lake Ontario 4a - Toronto Waterfront Area • Lac Ontario 4a - Secteur riverain de Toronto													
nearshore area from the west side of Humber Bay Park to the east side of Ashbridges Bay Park • zone littorale entre le secteur ouest du parc Humber Bay et le secteur est du parc Ashbridges Bay													
Bluegill[1,2] / Crapet arlequin[1,2]	16 / 16	12											
Brown Bullhead[1,2] / Barbotte brune[1,2]	32 / 32	16		12 / 12	8 / 8								
Brown Trout[2,3] / Truite brune[2,3]		12 / 12	8 / 8	4 / 4		2		1 / 0				0	
Coho Salmon[2] / Saumon coho[2]								0 / 0					
Common Carp[2,3] / Carpe[2,3]					2 / 0			0 / 0					
Freshwater Drum[1,2] / Malachigan[1,2]								1 / 0					
Gizzard Shad[2] / Alose à gésieree[2]				0 / 0									
Lake Trout[2,13] / Truite de lac[2,13]		1 / 0					0 / 0						
Lake Whitefish[2] / Grand corégone[2]			1 / 0		0 / 0								
Largemouth Bass[1,2] / Achigan à grande bouche[1,2]	16 / 16		12 / 8		8 / 4	4 / 0							
Northern Pike[1,2] / Brochet[1,2]		16 / 16							12 / 12		12 / 8		4 / 4
Pumpkinseed[1] / Crapet-soleil[1]	16 / 12												
Rainbow Smelt[2] / Éperlan arc-en-ciel[2]	1 / 0	0 / 0											
Rainbow Trout[2] / Truite arc-en-ciel[2]		2 / 0		1 / 0		0 / 0							
Redhorse Sucker[2] / Succeur rouge[2]							2 / 0	1 / 0					
Rock Bass[1,2] / Crapet de roche[1,2]	16 / 16	12 / 12											
Round Whitefish[2] / Ménomini rondeee[2]				2 / 0	1 / 0	0 / 0							
Walleye[1,2] / Doré[1,2]									12 / 4	8 / 0	4 / 0		
White Bass[1,2] / Bar blanc[1,2]		0 / 0											
White Perch[2] / Bar-perche[2]	4 / 4	1 / 0											
White Sucker[2] / Meunier noir[2]	16 / 16	12 / 12	8 / 8	4 / 4			2 / 0						
Yellow Perch[1,2] / Perchaude[1,2]	32 / 16	16 / 16		12 / 4									

Next, fish consumption advisories were simulated for the Toronto Waterfront area using only recent (2009 onwards) PCB and mercury measurements and the standard OMOECC advisory method. A comparison of these simulated advisories (Table 6) with the published advisories in the Guide (Table 5) suggests that for the recently monitored fish species, the advice in the Guide is mostly up-to-date. Certain migratory species such as Salmon have not been monitored in the recent years and represent historical contaminant body burden which might have improved over time in light of reductions observed in PCB and mercury concentrations in other fish species.

Table 6. Simulated fish consumption advisories for the Toronto Waterfront Area.
Values are in meals per month, separate for the general and sensitive populations. Only 2009 onwards collected PCB and mercury measurements were considered. Non-migratory species have been highlighted in bold.

		Fish length (cm)												
Fish type	**Population**	**15-20**	**20-25**	**25-30**	**30-35**	**35-40**	**40-45**	**45-50**	**50-55**	**55-60**	**60-65**	**65-70**	**70-75**	**75+**
Bluegill	General	16	12											
	Sensitive	12	4											
Brown Bullhead	General	32	32	16	12	8								
	Sensitive	32	32	16	12	8								
Brown Trout	General		12	8	4	4	2	2	1	1	1	1		
	Sensitive		12	8	4	4	0	0	0	0	0	0		
Common Carp	General						0	0	0	0	0	0	0	0
	Sensitive						0	0	0	0	0	0	0	0
Freshwater Drum	General								1	1				
	Sensitive								0	0				
Largemouth Bass	General	16	16	12	12	12	8	8						
	Sensitive	16	16	12	8	4	4	0						
Northern Pike	General		16	16	16	16	12	12	8	8	8	8	8	4
	Sensitive		16	16	16	16	12	12	8	8	8	8	8	4
Redhorse Sucker	General							2	1					
	Sensitive							0	0					
Rock Bass	General	16	12											
	Sensitive	16	12											
White Sucker	General	16	12	8	4	4	4	2	2	2				
	Sensitive	16	12	8	4	4	4	0	0	0				
Yellow Perch	General	32	16	16										
	Sensitive	16	16	16										

As shown in Table 6, most advisories based on only the recent data for most resident fish such as Bluegill, Brown Bullhead, Largemouth Bass, Northern Pike, Rock Bass and Yellow Perch would be “unrestricted” (8+ meals a month). Most or all advisories for the migratory

Brown Trout, Freshwater Drum and Redhorse Sucker would be restrictive either partially or completely. Many/all advisories for Carp and White Sucker, which are typically local resident, would be partially to completely restrictive. Among the local resident fish species with at least some advisories being restrictive, Carp and White Sucker can be considered good PCB indicators for PCB contamination, while Pike and Largemouth Bass can be considered good indicators for mercury. Based on the nature of the simulated advisories for these species, PCB seems to be more of a concern than mercury.

Overall, the published and simulated advisories show that the consumption is restricted for not only many migratory fish but also some local fish found along the Toronto Waterfront. As such, the first step of Tier 1 results in a conclusion that the recent advisories for the AOC are still restrictive in some cases, and a comparison with reference sites shall be conducted (Figure 6).

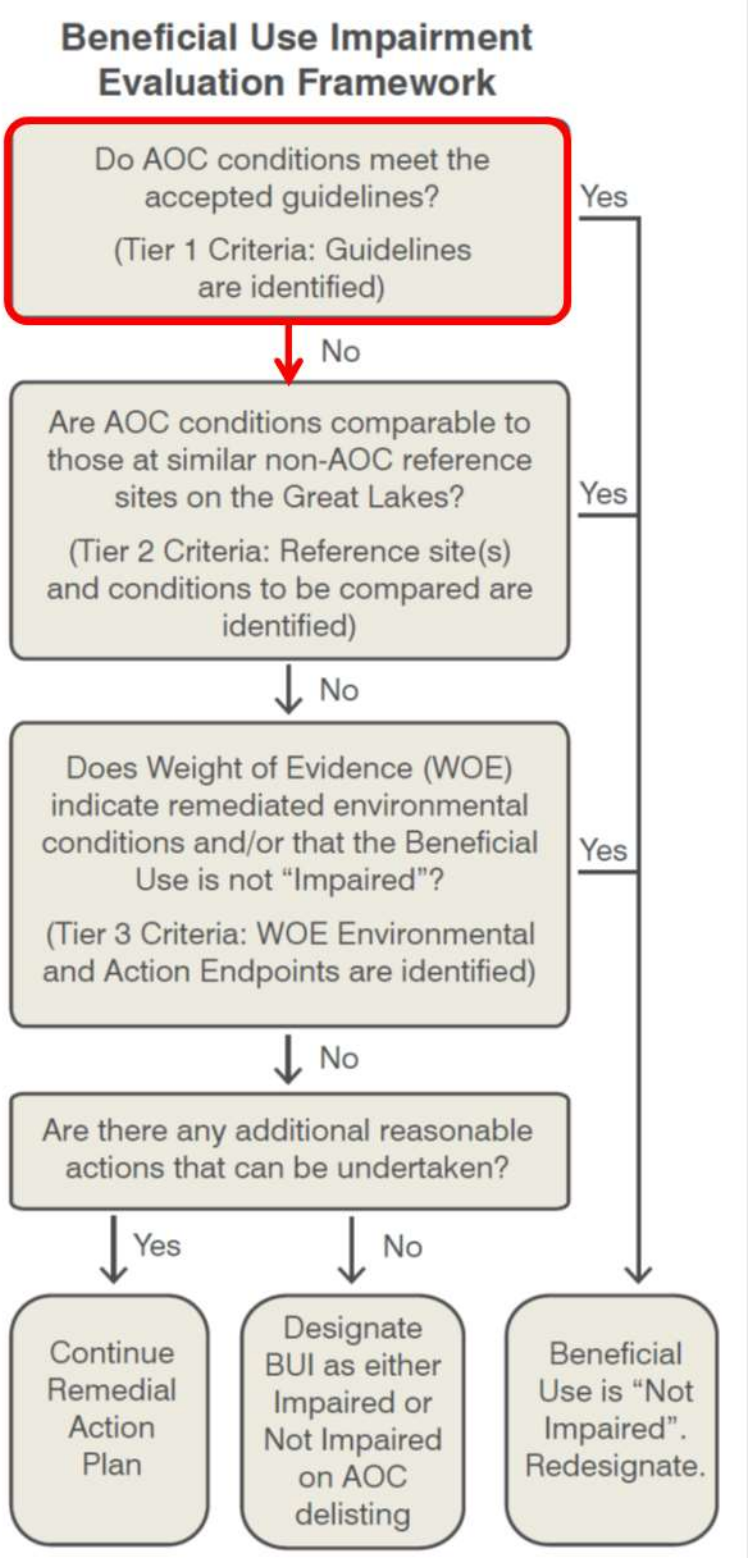


Figure 6. Outcome of Tier 1 application to the Fish Consumption BUI at the Toronto AOC.

3.3. Tier 2: Comparison with Reference

As per the Tier 2 of the Toronto RAP BUI Assessment Framework, a comparison is conducted of environmental endpoint(s) of interest in the AOC to the conditions of a comparable Great Lakes site(s) that are not on the list of AOCs. When there is no significant difference between the two sites for these indicator(s), the BUI in the AOC can be re-designated as "Not Impaired". Accordingly, fish consumption advisories for the AOC were compared with other Lake Ontario locations that are not AOCs. Whitby Harbour, although it is not an AOC, was omitted from the analysis due to a known contamination issue. A consideration of all other non-AOC Lake Ontario locations in the comparison would allow us to not only understand the lake wide advisory scenario but also readily utilize certain appropriate locations to conduct an in-depth comparison, if warranted. The Toronto Waterfront area of the AOC corresponds to Lake Ontario block 4a of the OMOECC fish consumption advisories, which covers nearshore area from the west side of Humber Bay Park to the east side of Ashbridges Bay Park (Figure 7).

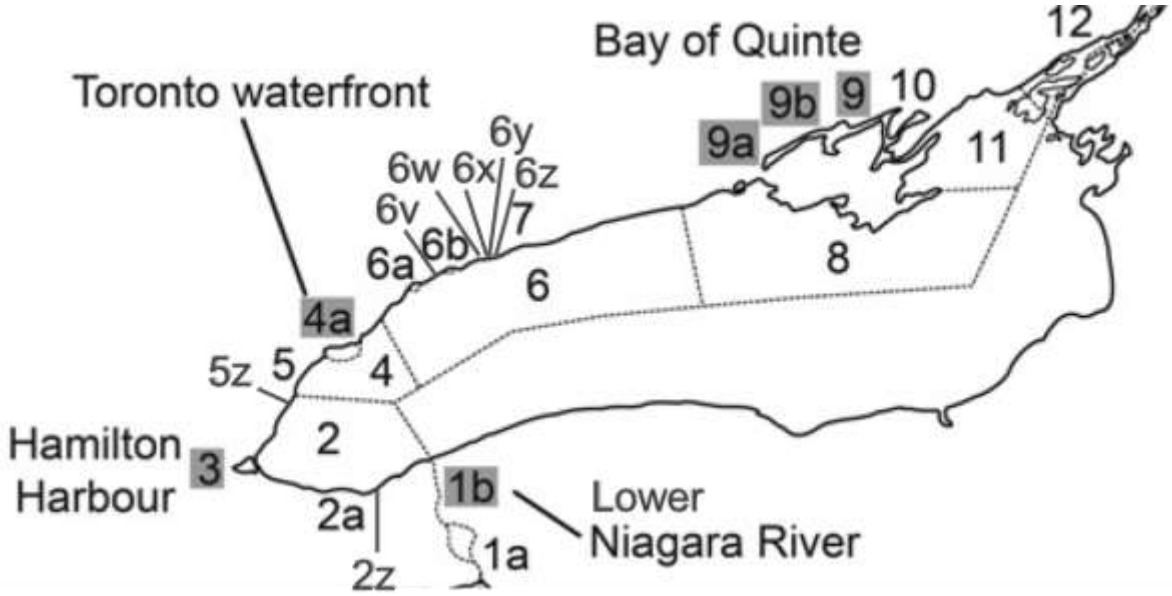


Figure 7. Map of the Lake Ontario showing OMOECC advisory blocks/locations.
AOCs have been highlighted in grey.

The comparison was conducted using 2009 onwards measurements because a number of sampling events have been conducted at the Toronto Waterfront since then to improve the data availability for the Fish Consumption BUI assessment. Only PCB and mercury measurements were considered in the analysis as they are the contaminants of concern for the AOC. Fish consumption advisories based on these measurements were simulated separately for PCB and mercury to account for site specific differences in the relative importance of these contaminants. Consumption advisories were simulated using the OMOECC method described

in Section 2.2.6 and classified into “unrestricted” (8+ meals per month), “partially restricted” (1, 2 and 4 meals month) and “completely restricted” (0 meal per month) as described in Section 2.2.7. Partially and completely restricted advisories were compared with the reference locations and categorised as “similar to the reference sites” or “more restrictive than the reference sites”.

Similar to the findings of the Tier 1 assessment, the simulated PCB related advisories for most non-migratory fish found along the Toronto Waterfront were “unrestrictive” (8+ meals per month) and mostly comparable to the reference locations (Table 7 and Table 8). These species include Bluegill, Brown Bullhead, Largemouth Bass, Northern Pike, Rock Bass and Yellow Perch (Table 7, Table 8). It should be noted though that reference locations for such a comparison were limited because the Fish Contaminant Monitoring Program of OMOECC does not analyse samples of fish such as pan fish for PCB levels if previous monitoring indicated very low levels. This is evident from a number of reference locations available for mercury compared to PCB even though the same time period has been considered (e.g., 7 vs 4 for Rock Bass; 4 vs 2 for Bluegill) (Table 7 to Table 10). Nevertheless, the advisories for these species along the Toronto Waterfront are “unrestricted” and not of a concern.

Some PCB related advisories for White Sucker and most advisories for Common Carp were more restrictive than the reference locations (Table 7, Table 8). Both these species are good indicator for a PCB contamination. It should be noted though that PCB levels in Carp from non-AOC Frenchman Bay, Lynde Creek Marsh and Whitby Harbour, and Hamilton Harbour AOC are also high. Since Carp could be migratory as discussed earlier, it is possible that Carp captured from the Toronto Waterfront area were influenced by these other locations. However, more restrictive advisories for Carp at the Toronto Waterfront compared to other non-AOC Lake Ontario locations, suggests continued monitoring is required, as these fish likely foraged and accumulated contaminants in the Toronto and Region AOC. In contrast to PCB, almost all mercury related advisories for the non-migratory fish found along the Toronto Waterfront are “unrestricted” (Table 9, Table 10). A few partially restricted advisories for the sensitive population are more or less similar to other reference locations (Table 10). These results confirm that mercury is not a major contaminant of concern for the AOC fish. The findings are in agreement with the general observations for Lake Ontario (Bhavsar et al., 2011).

Overall, some PCB related advisories for White Sucker and Carp are still a little more restrictive than other non-AOC locations in Lake Ontario, which prevents us from recommending re-designation of the BUI to “Not Impaired” without further assessment. As per the BUI Evaluation Framework, a detailed look at various lines of evidence along with best professional judgement (Tier 3) is necessary to define the status of the Fish Consumption BUI at the AOC (Figure 8).

Table 7. Comparison of simulated PCB related advisories for the general population.

AOC advisories: Green, "unrestricted"; yellow, similar to ref sites; red, more restrictive than ref sites.

Sp	Location ↓ Length (cm) →	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75+
Bluegill	02a - Jordan Harbour	16												
	04a - Toronto Waterfront Area	**16**	**12**											
Brown Bullhead	01a - Upper Niagara River			16										
	02a - Jordan Harbour	16	12	8	8									
	02z - Martindale Pond			8	8									
	04 - Toronto Offshore Area		12	12	12									
	04a - Toronto Waterfront Area			**16**	**12**	**8**								
	06 - Northwestern Lake Ontario		1											
	06a - Frenchman Bay		12	12	8	8								
	06v - Lynde Creek Marsh	8	4											
	06w - Oshawa Harbour		8	8	8									
	06y - Westside Marsh		12	12	12									
	10 - Middle B of Q	16	16	12	8									
Common Carp	01a - Upper Niagara River							4	4	4	4	4	4	4
	02a - Jordan Harbour				16	12	12	8	8	4	4	4		
	02z - Martindale Pond							4	4	2	2	2	1	0
	04 - Toronto Offshore Area					12	8	4	4	2	2	1	1	0
	04a - Toronto Waterfront Area						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	05z - Rattray Marsh						16	8	4	4	4	2		
	06a - Frenchman Bay							2	2	1	1	1	0	0
	06v - Lynde Creek Marsh									1	1	1	1	0
	06w - Oshawa Harbour			16	12	8	4	4	4	2	2	2	2	
	06x - McLaughlin Bay							4	4	4	4	4	4	4
Largemouth	01a - Upper Niagara River				16	16	8	4						
	02a - Jordan Harbour		16	16	16	16	16							
	04a - Toronto Waterfront Area	**16**	**16**	**12**	**12**	**12**	**12**	**8**						
	06a - Frenchman Bay	16	16	16	16	16								
Northern Pike	02z - Martindale Pond								8	4	4	4		
	04 - Toronto Offshore Area			8	8	8	8	8	8	8	8	8	8	8
	04a - Toronto Waterfront Area		**16**	**16**	**16**	**16**	**12**	**12**	**8**	**8**	**8**	**8**	**8**	**4**
	06x - McLaughlin Bay								8	8	8	8	8	8
	06z - Bowmanville Creek Marsh							16	12	8	8	4	4	
	11 - L B of Q/ELO								16	16	16	16	16	16
Rock Bass	01a - Upper Niagara River	16	16											
	04 - Toronto Offshore Area	16												
	04a - Toronto Waterfront Area	**16**	**12**											
	08 - Northeastern Lake Ontario	16	16											
White Sucker	01a - Upper Niagara River		16	16	12	8	8	4						
	02z - Martindale Pond					12								
	04 - Toronto Offshore Area	16	12	12	8	8	4	4	4	4				
	04a - Toronto Waterfront Area	**16**	**12**	**8**	**4**	**4**	**4**	**2**	**2**	**2**				
	06 - Northwestern Lake Ontario		16	16	16	12	12	12						
	06a - Frenchman Bay		16	16	12	8	4	4						
	06z - Bowmanville Creek Marsh						4							
Yellow Perch	01a - Upper Niagara River		16	16	16									
	04a - Toronto Waterfront Area	**32**	**16**	**16**										
	06a - Frenchman Bay	16	16	16										
	06v - Lynde Creek Marsh	16												
	06z - Bowmanville Creek Marsh	16	16											
	08 - Northeastern Lake Ontario	16	16											
	10 - Middle B of Q	16	16	16										

Table 8. Comparison of simulated PCB related advisories for the sensitive population.

AOC advisories: Green, "unrestricted"; yellow, similar to ref sites; red, more restrictive than ref sites

Sp	Location ↓ Length (cm) →	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75+
Bluegill	02a - Jordan Harbour	16												
	04a - Toronto Waterfront Area	**16**	**12**											
Brown Bullhead	01a - Upper Niagara River			16										
	02a - Jordan Harbour	16	12	8	8									
	02z - Martindale Pond			8	8									
	04 - Toronto Offshore Area		12	12	12									
	04a - Toronto Waterfront Area			**16**	**12**	**8**								
	06 - Northwestern Lake Ontario		0											
	06a - Frenchman Bay		12	12	8	8								
	06v - Lynde Creek Marsh	8	4											
	06w - Oshawa Harbour		8	8	8									
	06y - Westside Marsh		12	12	12									
	10 - Middle B of Q	16	16	12	8									
Common Carp	01a - Upper Niagara River							4	4	4	4	4	4	4
	02a - Jordan Harbour				16	12	12	8	8	4	4	4		
	02z - Martindale Pond							4	4	0	0	0	0	0
	04 - Toronto Offshore Area					12	8	4	4	0	0	0	0	0
	04a - Toronto Waterfront Area						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	05z - Rattray Marsh						16	8	4	4	4	0		
	06a - Frenchman Bay							0	0	0	0	0	0	0
	06v - Lynde Creek Marsh									0	0	0	0	0
	06w - Oshawa Harbour			16	12	8	4	4	4	0	0	0	0	
	06x - McLaughlin Bay							4	4	4	4	4	4	4
Largemouth	01a - Upper Niagara River				16	16	8	4						
	02a - Jordan Harbour		16	16	16	16	16							
	04a - Toronto Waterfront Area	**16**	**16**	**12**	**12**	**12**	**12**	**8**						
	06a - Frenchman Bay	16	16	16	16	16								
Northern Pike	02z - Martindale Pond								8	4	4	4		
	04 - Toronto Offshore Area			8	8	8	8	8	8	8	8	8	8	8
	04a - Toronto Waterfront Area		**16**	**16**	**16**	**16**	**12**	**12**	**8**	**8**	**8**	**8**	**8**	**4**
	06x - McLaughlin Bay								8	8	8	8	8	8
	06z - Bowmanville Creek Marsh							16	12	8	8	4	4	
	11 - L B of Q/ELO								16	16	16	16	16	16
Rock Bass	01a - Upper Niagara River	16	16											
	04 - Toronto Offshore Area	16												
	04a - Toronto Waterfront Area	**16**	**12**											
	08 - Northeastern Lake Ontario	16	16											
White Sucker	01a - Upper Niagara River		16	16	12	8	8	4						
	02z - Martindale Pond					12								
	04 - Toronto Offshore Area	16	12	12	8	8	4	4	4	4				
	04a - Toronto Waterfront Area	**16**	**12**	**8**	**4**	**4**	**4**	**0**	**0**	**0**				
	06 - Northwestern Lake Ontario		16	16	16	12	12	12						
	06a - Frenchman Bay		16	16	12	8	4	4						
	06z - Bowmanville Creek Marsh						4							
Yellow Perch	01a - Upper Niagara River		16	16	16									
	04a - Toronto Waterfront Area	**32**	**16**	**16**										
	06a - Frenchman Bay	16	16	16										
	06v - Lynde Creek Marsh	16												
	06z - Bowmanville Creek Marsh	16	16											
	08 - Northeastern Lake Ontario	16	16											
	10 - Middle B of Q	16	16	16										

Table 9. Comparison of simulated mercury related advisories for the general population.

AOC advisories: Green, "unrestricted"; yellow, similar to ref sites; red, more restrictive than ref sites.

Sp	Location ↓ Length (cm) →	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75+
Bluegill	02a - Jordan Harbour	12												
	02z - Martindale Pond	32												
	04a - Toronto Waterfront Area	**32**	**12**											
	10 - Middle B of Q	32												
Brown Bullhead	01a - Upper Niagara River		32	32										
	02a - Jordan Harbour	32	32	32	16									
	02z - Martindale Pond			32	32									
	04 - Toronto Offshore Area		32	32	32									
	04a - Toronto Waterfront Area	**32**	**32**	**32**	**32**	**32**								
	06 - Northwestern Lake Ontario		16											
	06a - Frenchman Bay		32	32	16	16								
	06v - Lynde Creek Marsh	32	32											
	06w - Oshawa Harbour	32	32	32	16									
	06x - McLaughlin Bay		16											
	06y - Westside Marsh	32	32	32	32									
	10 - Middle B of Q	32	32	32	16									
Common Carp	01a - Upper Niagara River							32	32	32	32	32	16	16
	02a - Jordan Harbour				32	32	32	32	32	16	16	16		
	02z - Martindale Pond							32	32	16	16	16	12	4
	04 - Toronto Offshore Area					32	32	32	32	32	32	32	16	8
	04a - Toronto Waterfront Area						**32**	**32**	**32**	**32**	**32**	**32**	**32**	**16**
	05z - Rattray Marsh						32	32	32	32	32	16		
	06a - Frenchman Bay							32	32	32	32	32	32	16
	06v - Lynde Creek Marsh									16	16	16	16	16
	06w - Oshawa Harbour	32	32	32	32	32	32	32	32	16	16	16	16	
	06x - McLaughlin Bay							32	32	32	32	16	16	4
	06y - Westside Marsh	32	32	32	32	32	32	32	32	32				
Largemouth Bass	01a - Upper Niagara River				16	16	8	4						
	02a - Jordan Harbour		32	32	16	16	12							
	02z - Martindale Pond			32	16	12	4							
	04a - Toronto Waterfront Area	**32**	**32**	**32**	**16**	**12**	**8**	**8**						
	06a - Frenchman Bay	32	32	32	32	16								
	06x - McLaughlin Bay	32	32	32	32	32	16							
	06y - Westside Marsh	32	32	32	16	16								
	10 - Middle B of Q		32	16	16	8								
Northern Pike	02z - Martindale Pond					32	32	32	16	16	16	12		
	04 - Toronto Offshore Area			32	32	32	32	32	32	16	16	16	16	12
	04a - Toronto Waterfront Area		**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**16**	**16**	**12**
	06a - Frenchman Bay						32	32	32	32	32	16	16	12
	06w - Oshawa Harbour		32	32	32	32	16	16	16	16	16			
	06x - McLaughlin Bay								32	32	32	32	32	32
	06y - Westside Marsh									16	16			
	06z - Bowmanville Creek Marsh							16	16	16	16	16	12	
	10 - Middle B of Q							16	16	16	16	16	16	8
	11 - L B of Q/ELO								16	16	12	12	8	4
Rock Bass	01a - Upper Niagara River	32	16											
	02z - Martindale Pond	16	4											
	04 - Toronto Offshore Area	32												
	04a - Toronto Waterfront Area	**32**	**32**											
	08 - Northeastern Lake Ontario	32	16											
	10 - Middle B of Q	16	12											
	11 - L B of Q/ELO	32	16											
White Sucker	01a - Upper Niagara River		32	32	32	32	32	32						
	02z - Martindale Pond					16								
	04 - Toronto Offshore Area		32	32	32	32	32	32	16	16				
	04a - Toronto Waterfront Area	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**16**	**16**				
	06 - Northwestern Lake Ontario		32	32	32	32	32	16						
	06a - Frenchman Bay		32	32	32	32	32	32						
	06w - Oshawa Harbour			16										
	06z - Bowmanville Creek Marsh						8							
Yellow Perch	01a - Upper Niagara River	32	32	16	16									
	02z - Martindale Pond		16	16										
	04 - Toronto Offshore Area	32												
	04a - Toronto Waterfront Area	**32**	**32**	**32**										
	06 - Northwestern Lake Ontario	32	32											
	06a - Frenchman Bay	32	32	32										
	06v - Lynde Creek Marsh	32												
	06w - Oshawa Harbour	32	32											
	06x - McLaughlin Bay	32												
	06y - Westside Marsh	32	32											
	06z - Bowmanville Creek Marsh	16	16											
	08 - Northeastern Lake Ontario	32	32											
	10 - Middle B of Q	32	32	16										
	11 - L B of Q/ELO	32	32	32										

Table 10. Comparison of simulated mercury related advisories for the sensitive population.

AOC advisories: Green, "unrestricted"; yellow, similar to ref sites; red, more restrictive than ref sites

	Location ↓ Length (cm) →	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75+
Bluegill	02a - Jordan Harbour	4												
	02z - Martindale Pond	16												
	04a - Toronto Waterfront Area	**12**	**4**											
	10 - Middle B of Q	16												
Brown Bullhead	01a - Upper Niagara River		16	16										
	02a - Jordan Harbour	32	16	12	8									
	02z - Martindale Pond			16	16									
	04 - Toronto Offshore Area		32	32	16									
	04a - Toronto Waterfront Area	**32**	**32**	**16**	**16**	**12**								
	06 - Northwestern Lake Ontario		8											
	06a - Frenchman Bay		16	16	12	8								
	06v - Lynde Creek Marsh	16	16											
	06w - Oshawa Harbour	32	32	16	8									
	06x - McLaughlin Bay		8											
	06y - Westside Marsh	32	16	16	12									
	10 - Middle B of Q	32	16	12	8									
Common Carp	01a - Upper Niagara River							16	16	12	12	12	8	8
	02a - Jordan Harbour				32	32	16	16	12	8	8	4		
	02z - Martindale Pond							16	12	8	8	4	4	0
	04 - Toronto Offshore Area					32	32	32	16	16	16	12	8	4
	04a - Toronto Waterfront Area						**32**	**32**	**16**	**16**	**16**	**16**	**12**	**8**
	05z - Rattray Marsh						32	16	16	16	12	12		
	06a - Frenchman Bay							16	16	16	16	16	12	12
	06v - Lynde Creek Marsh									8	8	8	8	8
	06w - Oshawa Harbour	32	32	16	16	16	16	12	12	8	8	8	8	
	06x - McLaughlin Bay							32	16	16	12	8	8	0
	06y - Westside Marsh	32	32	32	32	32	16	16	16	16				
Largemouth Bass	01a - Upper Niagara River				8	4	4	0						
	02a - Jordan Harbour		16	12	8	4	4							
	02z - Martindale Pond			16	8	4	0							
	04a - Toronto Waterfront Area	**32**	**16**	**12**	**8**	**4**	**4**	**0**						
	06a - Frenchman Bay	32	16	16	12	8								
	06x - McLaughlin Bay	32	32	32	16	16	12							
	06y - Westside Marsh	32	16	12	8	4								
	10 - Middle B of Q		16	8	4	4								
Northern Pike	02z - Martindale Pond					16	16	12	8	8	4	4		
	04 - Toronto Offshore Area			32	16	16	16	16	12	12	8	8	8	4
	04a - Toronto Waterfront Area		**32**	**32**	**32**	**16**	**16**	**16**	**16**	**12**	**12**	**8**	**8**	**4**
	06a - Frenchman Bay						16	16	16	12	12	8	8	4
	06w - Oshawa Harbour		16	16	16	12	12	8	8	8	4			
	06x - McLaughlin Bay								32	32	32	32	32	32
	06y - Westside Marsh									8	4			
	06z - Bowmanville Creek Marsh							8	8	8	4	4	4	
	10 - Middle B of Q							8	8	8	8	4	4	4
	11 - L B of Q/ELO								8	4	4	4	4	0
Rock Bass	01a - Upper Niagara River	12	8											
	02z - Martindale Pond	4	0											
	04 - Toronto Offshore Area	16												
	04a - Toronto Waterfront Area	**16**	**16**											
	08 - Northeastern Lake Ontario	12	8											
	10 - Middle B of Q	8	4											
	11 - L B of Q/ELO	12	8											
White Sucker	01a - Upper Niagara River		32	16	16	16	16	16						
	02z - Martindale Pond					8								
	04 - Toronto Offshore Area		32	32	16	16	16	12	12	8				
	04a - Toronto Waterfront Area	**32**	**32**	**16**	**16**	**16**	**12**	**12**	**8**	**8**				
	06 - Northwestern Lake Ontario		32	32	16	16	12	12						
	06a - Frenchman Bay		32	32	32	16	16	12						
	06w - Oshawa Harbour			8										
	06z - Bowmanville Creek Marsh						4							
Yellow Perch	01a - Upper Niagara River	16	12	8	8									
	02z - Martindale Pond		12	4										
	04 - Toronto Offshore Area	32												
	04a - Toronto Waterfront Area	**16**	**16**	**16**										
	06 - Northwestern Lake Ontario	16	16											
	06a - Frenchman Bay	32	16	16										
	06v - Lynde Creek Marsh	16												
	06w - Oshawa Harbour	16	16											
	06x - McLaughlin Bay	16												
	06y - Westside Marsh	16	16											
	06z - Bowmanville Creek Marsh	8	8											
	08 - Northeastern Lake Ontario	16	16											
	10 - Middle B of Q	16	12	12										
	11 - L B of Q/ELO	16	16	12										

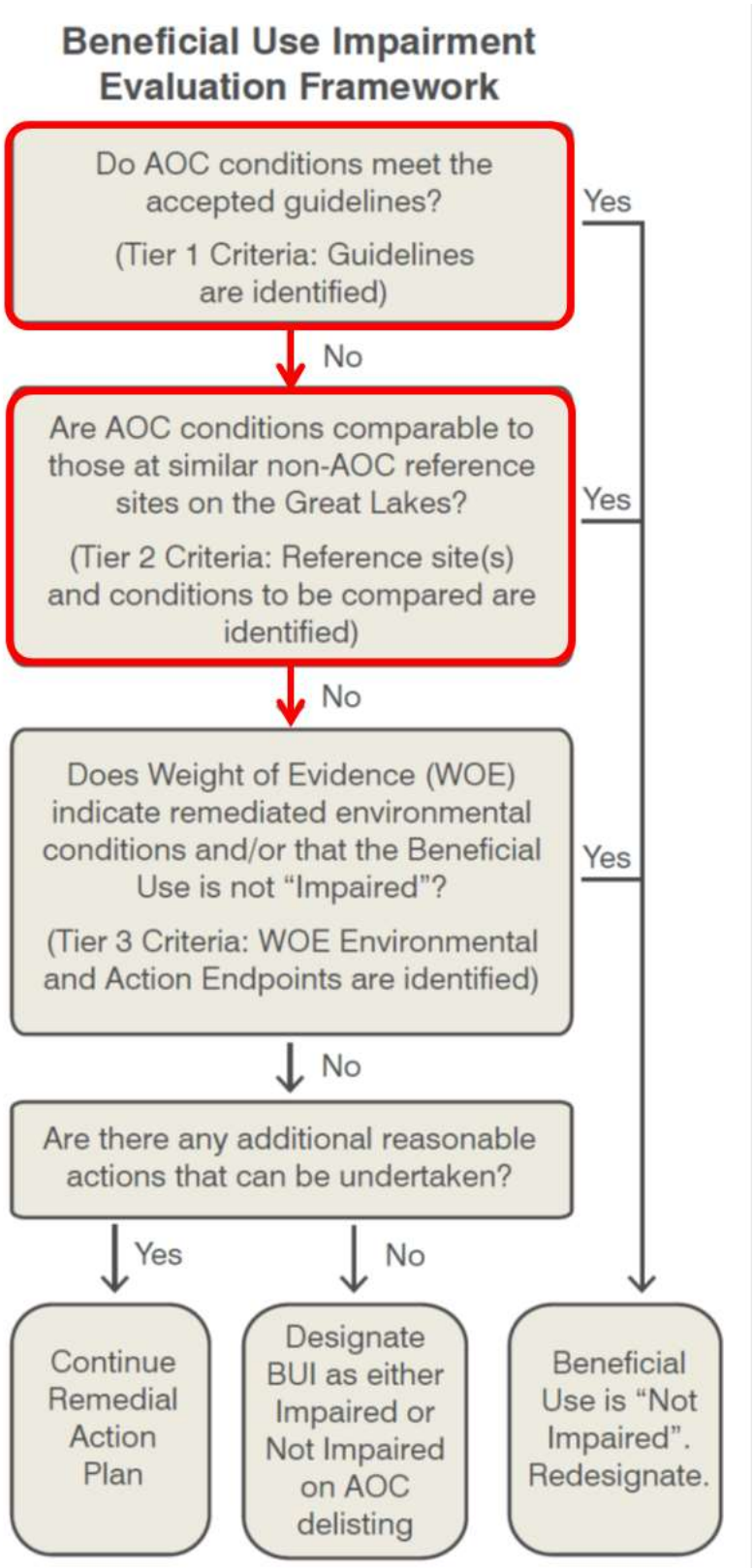


Figure 8. Outcome of Tier 2 application to the Fish Consumption BUI at the Toronto AOC.

3.4. Tier 3: Weight of Evidence (WOE)

In Tier 3 Weight of Evidence, a variety of environmental indicators along with the findings of Tiers 1 and 2 are taken into consideration when evaluating the status of a BUI. At present, the fish consumption advisories published in the 2015-2016 Guide to Eating Ontario Fish are primarily due to PCBs and secondarily due to mercury. The Tier 2 highlighted that PCB is the major contaminant of concern for the Fish Consumption BUI at the AOC. In the Tier 3 assessment, a variety of environmental indicators and factors are examined that can influence fish contaminant levels and human exposure, and provide insight into the environmental contamination. These lines of evidence along with best professional judgement are used to evaluate the status of the Fish Consumption BUI at the AOC.

3.4.1. Fish Contaminant trends for the AOC

Selection of Data

An analysis of the long term temporal trends (1975-2011) was conducted for PCB and mercury in fish from the Toronto harbour. The following species were considered in the analysis due to availability of data and their potential for contaminant accumulation: Brown Bullhead, Brown Trout, Common Carp, Northern Pike, Rainbow Smelt, White Sucker, and Yellow Perch. Note that Brown Trout and Rainbow Smelt are typically migratory species; as such, they may not provide a true representation of the contaminant trend for the AOC. Common Carp and White Sucker could also be migratory in some cases.

Accumulation of contaminants in fish are known to increase with fish length (Bhavsar et al. 2010c, Gewurtz et al. 2011a, Tang et al. 2013). Therefore, to account for the influence of size on trends, contaminant levels were standardized to three fish lengths representing small, medium and large size categories using power series regressions of contaminant level versus fish length for each species-year-contaminant combination. The standardized sizes for the selected species were as follows: 20, 30 and 35 cm for Brown Bullhead; 65, 75, 85 cm for Common Carp; 45, 60, 75 cm for Northern Pike; 15 and 20 cm for Rainbow Smelt; 25, 40, 55 cm for White Sucker; and 20, 25, 30 cm for Yellow Perch. To prevent over-extrapolation of fish contaminant values, sampling events with fish lengths plus or minus 10 cm of the three standardized sizes were selected.

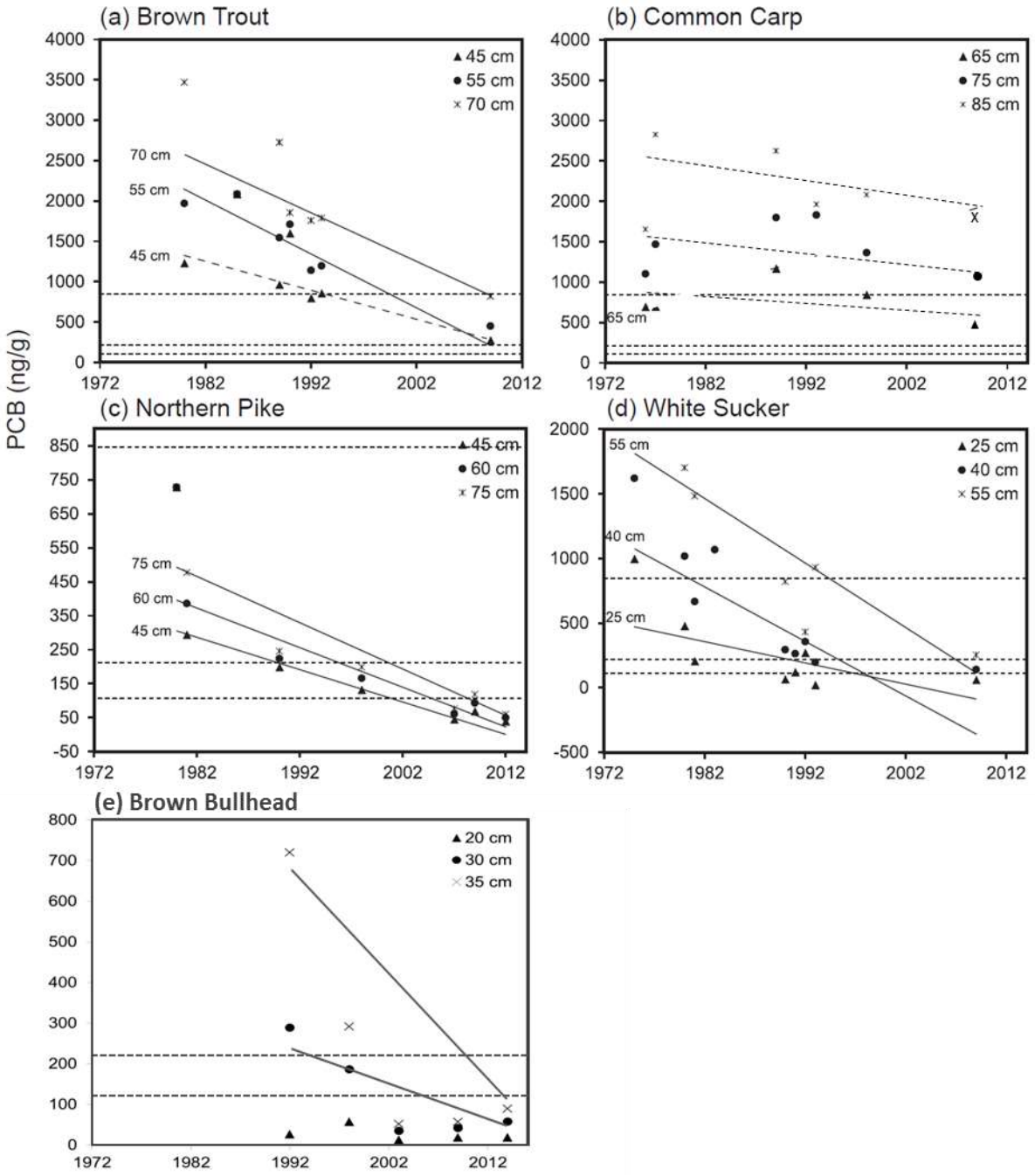


Figure 9. Temporal trends of PCB in fish from the Toronto Waterfront (LO4a).

Between 1972 and 2012 for (a) Brown Trout, (b) Common Carp, (c) Northern Pike, and (e) White Sucker. Sen's Slope estimates are indicated by a solid regression line when the trend is significant ($p<0.05$) and indicated by a dashed line when trend is not significant ($p<0.1$). Any Sen's Slope estimates with $p>0.1$ are not indicated in the Figure. OMOECC consumption advisory benchmarks for PCB are indicated with horizontal dashed lines.

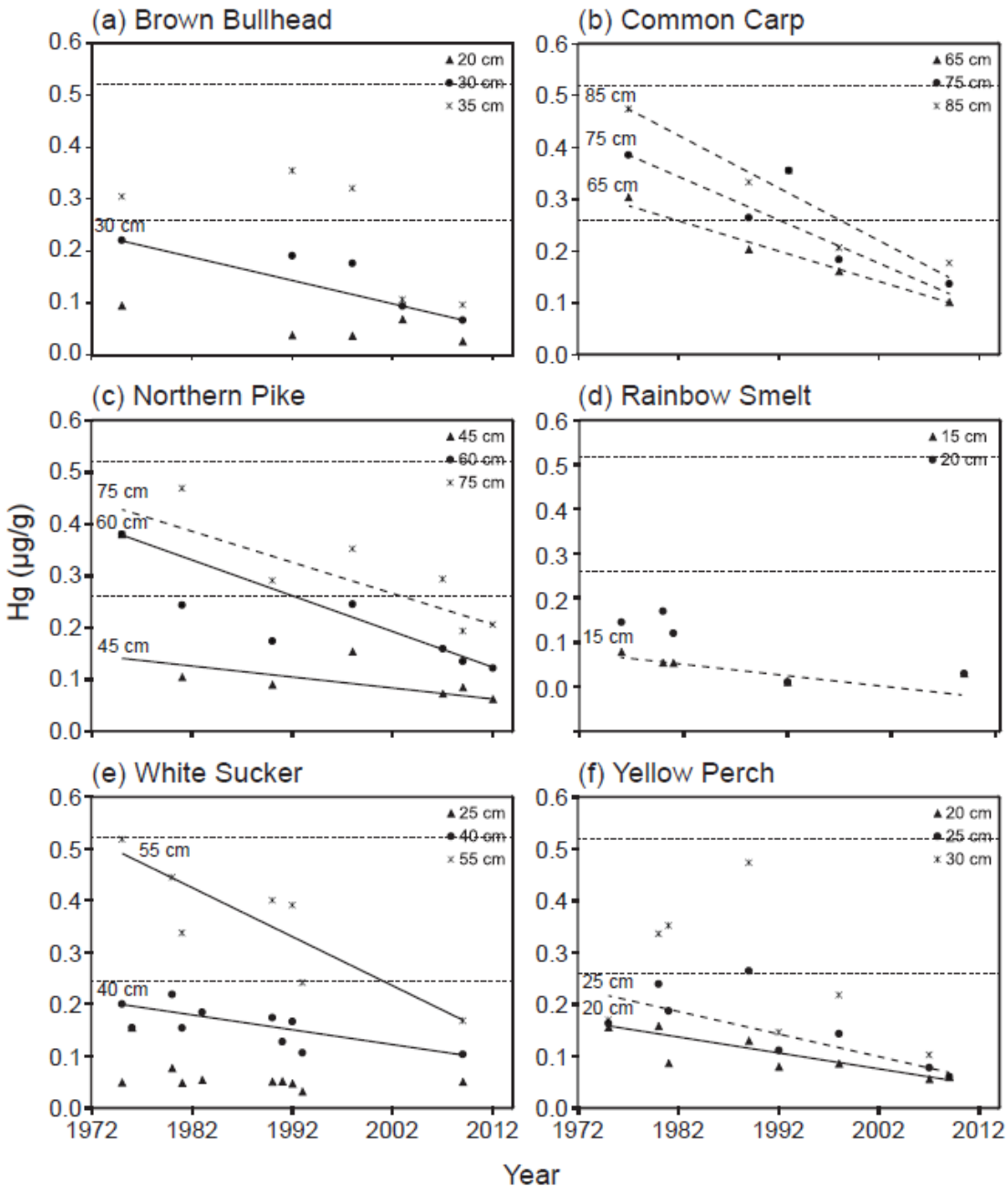


Figure 10. Temporal trends of mercury in fish from the Toronto Waterfront (LO4a).

Between 1972 and 2012 for (a) Brown Bullhead, (b) Common Carp, (c) Northern Pike, (d) Rainbow Smelt, (e) White Sucker, and (f) Yellow Perch. Sen's Slope estimates are indicated by a solid regression line when the trend is significant ($p<0.05$) and indicated by a dashed line when trend is not significant ($p<0.1$). Any Sen's Slope estimates with $p>0.1$ are not indicated in the Figure. OMOECC consumption advisory benchmarks for mercury are indicated with horizontal dashed lines.

Temporal Changes

Temporal trends of contaminant levels in selected Toronto Harbour fish were analyzed using Mann-Kendall test with Sen's slope estimate (Salmi et al. 2002), using species with good temporal data coverage of greater than 4 years. Statistically significant trends were indicated by $p<0.05$, insignificant trends were indicated as $p<0.1$, and non-significant trends were with $p>0.1$.

Temporal analysis showed that PCB (Figure 9) and mercury (Figure 10) concentrations in fish from the Toronto harbour have declined dramatically between 1972 and 2012 in all of the studied species. However, the rates at which the concentrations declined varied among species and sizes. Trends for selected species from the Toronto Waterfront are discussed below.

Brown Bullhead

Brown Bullhead can be considered a sentinel species for a PCB contamination. There were substantial (80-90%) declines in PCB concentrations in Brown Bullhead from the Toronto Waterfront between the 1990s and 2010s (Figure 9). Recent PCB concentrations are well within the "unrestricted" advisory category (<105 ng/g) at 20-90 ng/g. Mercury concentrations in Brown Bullhead have declined by 70% between 1970s and 2012 (Figure 10). The decline was statistically significant in the 30 cm size class ($p<0.05$). Recent mean mercury concentrations for Brown Bullhead are well within the "unrestricted" advisory range (Figure 10).

Brown Trout

PCB concentrations showed substantial (76-78%) decline over time (Figure 9); however, recent PCB levels for Brown Trout are still in the "partially restricted" advisory classification (105-844 ng/g) at 451-820 ng/g. Mercury concentration in Brown Trout showed no significant trend over the last 30 years in all size classes. However, recent levels are well within the range for the "unrestricted" advisory classification.

Common Carp

Common Carp showed a general decline in PCB, but the trend was not statistically significant ($p>0.05$, Figure 9). This is likely due to limited data points for the analysis. Mercury concentrations showed steady decline in all sizes since the 1970s. Recent data showed mercury levels are currently in the "unrestricted" advisory category (Figure 10).

Northern Pike

For PCB, all three size classes of Northern Pike showed significant declining trends since the 1970s. Overall, average PCB concentrations in Northern Pike declined by 92-95%.

Additionally, recent PCB concentrations are well within the "unrestricted" advisory category (<105 ng/g) at 39-60 ng/g. Mercury concentrations of small (45 cm) and medium sized (60 cm) Northern Pike showed a significant decline since the early 1970s (Figure 10). Although the trend was statistically insignificant ($p<0.1$) in large size Northern Pike (75 cm), a general declining trend was observed. Over time, mercury concentration decline by 46-84% between 1972 and 2012. In 2012, all 3 size classes were well within the "unrestricted" advisory category (<0.25 μg/g) at 0.06-0.12 μg/g.

Rainbow Smelt

PCB concentrations did not exhibit any temporal trends; however, recent PCB concentrations were well within the "unrestricted" advisory category (<105 ng/g). Mercury concentrations in small size Rainbow Smelt (15 cm) showed a general decline since the 1970s, and recent mercury levels were well within the "unrestricted" advisory category (<0.25 μg/g) (Figure 10).

White Sucker

All three size classes of White Sucker showed a significant (85-94%) decline in PCB since the 1970s (Figure 9). Recent 25 cm (small size) fish levels are well within the "unrestricted" advisory category (<105 ng/g) at 60 ng/g (Figure 9). Mercury concentrations showed a significant declining trend for medium and large sized White Sucker (Figure 10). Mercury concentrations declined by 48-76% over the last 30 years. Moreover, recent mercury levels were well within the "unrestricted" advisory category (<0.25 μg/g) at 0.1-0.17 μg/g.

Yellow Perch

PCB concentrations in Yellow Perch did not show any observable temporal trends in any class sizes; however, recent PCB concentrations are within the "unrestricted" advisory category (<105 ng/g). Small sized (20 cm) Yellow Perch mercury concentrations declined by 61-63% between the 1970s and 2010s (Figure 10). Like many other species, Yellow Perch's most recent mercury concentrations are well within the "unrestricted" advisory category (<0.25 μg/g) at 0.06 μg/g in small size fish (Figure 10).

Overall, the levels of PCB and mercury in examined fish species from the Toronto harbour have declined substantially over the last 30+ years.

3.4.2. Time to reach target

Persistence of a contaminant can be described by a half-life, which is the amount of time required for a contaminant to decline to half of the original concentration. The half-life can be used to estimate the time required for the levels to decline to a target level. Since PCB is the only contaminant that consistently remains above the fish consumption advisory benchmark for the "unrestricted" category, the half-lives of PCB in fish from the Toronto Harbour were calculated using an empirical exponential decay model. Half-lives of PCB in Brown Trout, Northern Pike, White Sucker and Yellow Perch range from 8 to 14 years.

Temporal trends for PCB in Carp suggest that it will take longer for the levels to fall within the "unrestricted" advisory category for all sizes. **PCB levels in White Sucker, a mostly non-migratory species that has restrictive advisories due to elevated PCB levels, are estimated to be within the "unrestricted" advisory category (<105 ng/g) within about a decade.**

3.4.3. PCB in sediment

Elevated levels of PCB in sediment can contribute to elevated concentrations in fish (Lotufo 1998, Pickard et al. 2001, Geffard et al. 2003). Accumulation of PCB in the harbour sediment was likely due to a combination of urban runoff, storm water drainage and atmospheric deposition. There are currently no known direct inputs of PCB to the Toronto Harbour from industrial or municipal sources (Boyd et al. 2001).

PCB levels in sediments from Toronto Inner Harbour declined following the ban on PCB in 1977; however, there is little change in the sediment PCB levels over the past 25 years (Figure 11) suggesting recirculation and/or ongoing sources (T. Labencki, Presentation at Lake Ontario Evenings: The Food Web Edition; March 2013). However, in general, the levels are comparable to average lake wide Lake Ontario concentrations of 100 ng/g (Figure 12; Marvin et al., 2003; T. Labencki, Presentation at Lake Ontario Evenings: The Food Web Edition, March 2013). The Toronto and Region RAP intend to address sediment contamination through natural recovery (Boyd et al. 2001, Toronto and Region Conservation Authority 2009) and via reduction of runoff and waste water management.

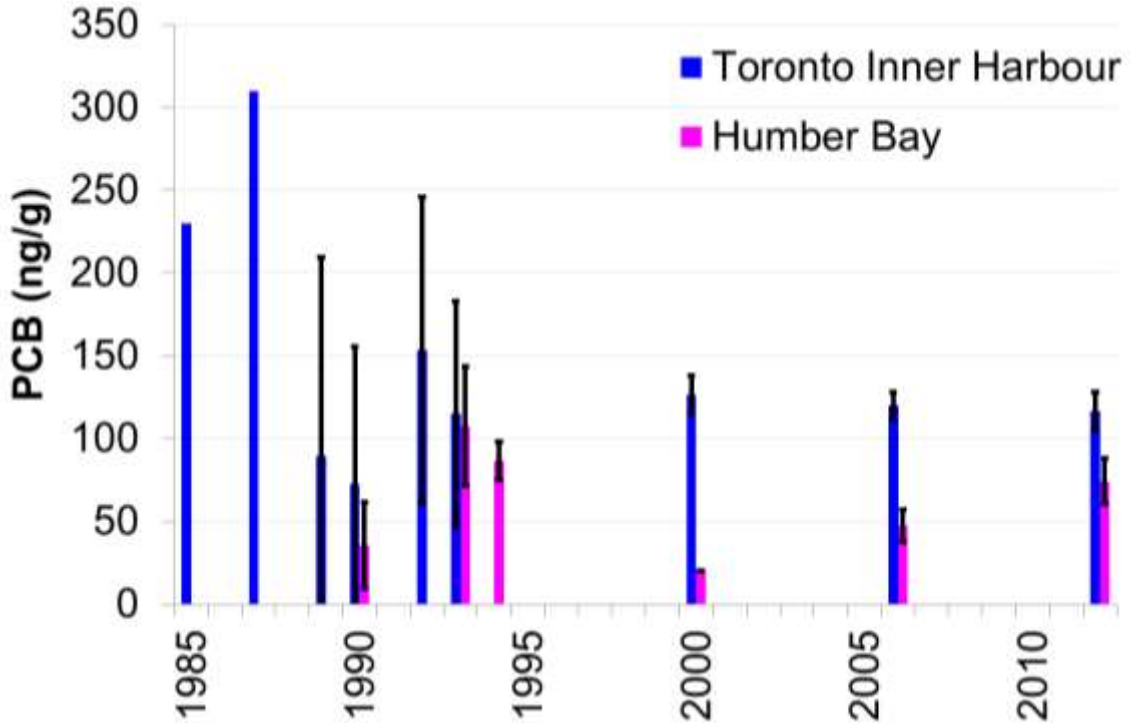


Figure 11. Temporal trends of PCB in sediments from Toronto Inner Harbour and Humber Bay. *Source: Great Lakes Unit, OMOECC; T Labencki, Lake Ontario Evenings: The Food Web Ed, March 2013.*

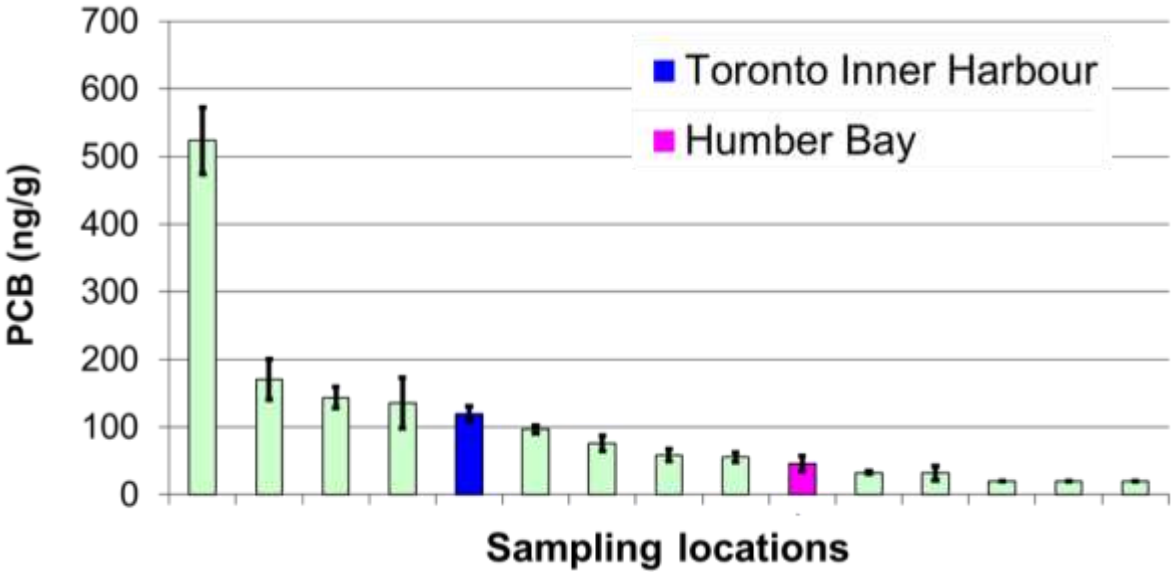


Figure 12. Spatial trend of PCB in sediments from various locations in Lake Ontario. *Measurements are for surface sediments collected in 2006. Source: T Labencki, Presentation at Lake Ontario Evenings: The Food Web Edition, March 2013.*

3.4.4. Levels and trends for Young-of-the-Year (YOY) or forage fish

Monitoring data

The Fish Contaminant Monitoring Program of the OMOECC has monitored forage fish from five river systems – Etobicoke Creek, Mimico Creek, Humber River, Don River and Rouge River – in the GTA since the late 1970s, for both targeted studies as well as routine monitoring (Figure 13). Forage fish species have been collected at multiple sites within each river system with varying frequency, and analyzed for one or more of a wide range of contaminants. The available PCB and mercury data were filtered for those sampling sites within each river system with adequate temporal coverage. The final data set included nine species, collected at 16 sites in Etobicoke Creek, 7 sites in Mimico Creek, 19 sites in the Humber River, 13 sites in the Don River, and 12 sites in the Rouge River (Figure 13).

Data screening

While the relationship between fish size and contaminant concentrations is well-documented for larger fish, the relationship is less consistent for forage fish. The range of fish lengths represented in the data set varied by river and species. Prior to statistical analyses, the relationship between fish length and contaminant concentration was investigated. The data set was divided into individual sites within each river, and for each species in each year, linear regression was performed on untransformed fish length and contaminant concentration, as well as log-transformed length and log-transformed contaminant concentration. The vast majority of these regressions (92%) were not significant, suggesting that differences in fish length within a sample year for a particular species at a site would not influence contaminant concentrations. This is likely due to the fact that these fish were young-of-the-year (i.e., <1 year old) and exposure was similar.

Sufficient data for temporal trend analysis of forage fish PCB concentrations was available for six Don River sites (D4, D6, D9, D10, and D12), four Etobicoke Creek sites (E3, E13, E15, and E16), two Mimico Creek sites (M6, M7), seven Humber River sites (H4, H6, H8, H13, H14, H18, H19), and three Rouge River sites (R1, R8 and R11). Additionally, there were sufficient data for analysis of temporal trends in forage fish mercury concentrations for two sites in Etobicoke Creek (E15, E16), two sites in the Humber River (H18, H19), and two sites in the Rouge River (R1, R11). At many sites, multiple species (e.g., Spottail Shiner, Fathead Minnow and Blacknose Dace) were collected in the same year, and for all sites, no single species was consistently collected over the entire time period. Thus, for each sampling site, if data from multiple species was present in a sampling year, ANOVA was used to test for significant differences in contaminant concentrations among species. In all cases, these differences were statistically insignificant ($p>0.05$), and thus, the data was pooled to calculate

the mean contaminant concentration for forage fish in that year at that site. Once the data were pooled, differences in fish length were compared between years at each site, to ensure that fish for a particular year were not significantly larger or smaller than other years for that site. If significant differences were detected, very large or very small samples were discarded.

Temporal trend analysis

Temporal trends in forage fish contaminant concentrations were analyzed with Mann-Kendall test and Sen's slope estimate. Concentrations were natural log-transformed prior to analysis, and statistical significance was set at $p<0.05$. The Kruskal-Wallis test was used to test for significant differences in recent (2000-2012) forage fish PCB concentrations among sites within each river. While there were statistically significant differences in fish length between sites within each of Etobicoke Creek and Humber River (ANOVA, $p<0.001$), there were no significant pairwise difference (Tukey's test, $p>0.05$). There were no significant differences in fish length among sites in the Don River or Mimico Creek (ANOVA with Tukey's test, $p>0.05$).

Spatial comparison

For a spatial comparison, the analysis was restricted to a single species that was well represented at all sites within a river system. The analysis was restricted to Blacknose Dace for Don River sites, and to Common Shiner for Etobicoke Creek. For the Humber River, Common Shiner was used for all sites except H9, which had only Fathead Minnow data. Mimico Creek was the most variable, including Creek Chub, Common Shiner, Fathead Minnow and Emerald Shiner, but without a species that was well-represented at the majority of sampling sites. For Mimico Creek, species were examined separately across sites.

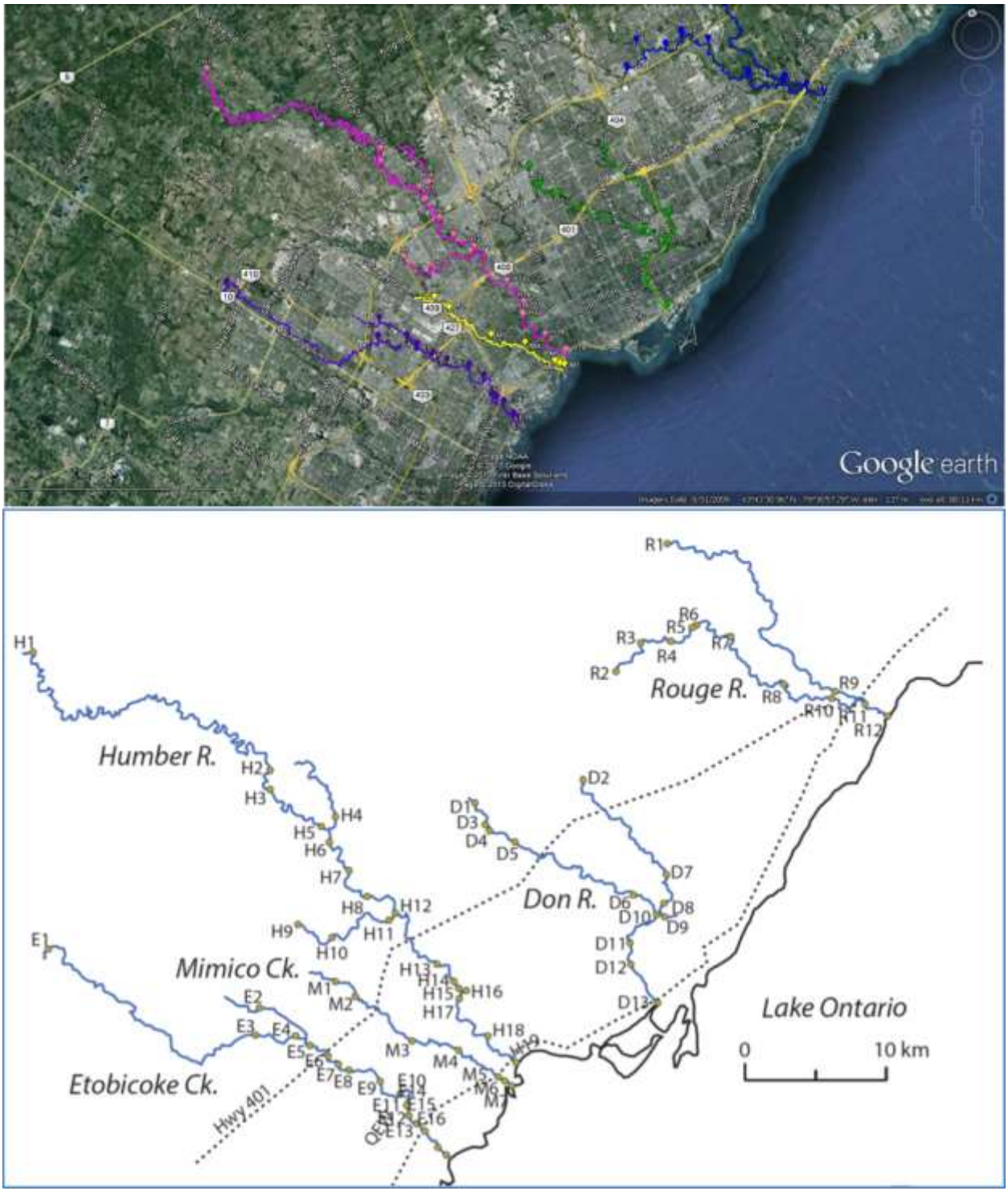


Figure 13. Map of Lake Ontario tributaries in the GTA monitored for fish contaminant levels.

Etobicoke Creek, Mimico Creek, Humber River, Don River and Rouge River. Yellow points indicate sites where forage fish have been collected and analyzed at least once since the 1970s.

Findings

Concentrations of PCB in forage fish from the five tributaries show substantial declines with time at many sites (Figure 14). Particularly in the Humber River, the levels have declined by as much as 90% from above 2800 ng/g to below 200 ng/g. For most of the sites, PCB levels are now below 200 ng/g; however, some individual sites still exhibited much higher PCB values. One example is downstream of G. Ross Lord Dam and reservoir on the Don River (D4; Figure 15). Another such site is downstream of Clairville Dam and reservoir on the Humber River (H9; Figure 15). A site in Etobicoke Creek (E10) also exhibited elevated PCB levels (Figure 15), which was a result of a targeted track down study and reductions are anticipated due to a cleanup (Nadine Benoit, MOECC, personal communication).

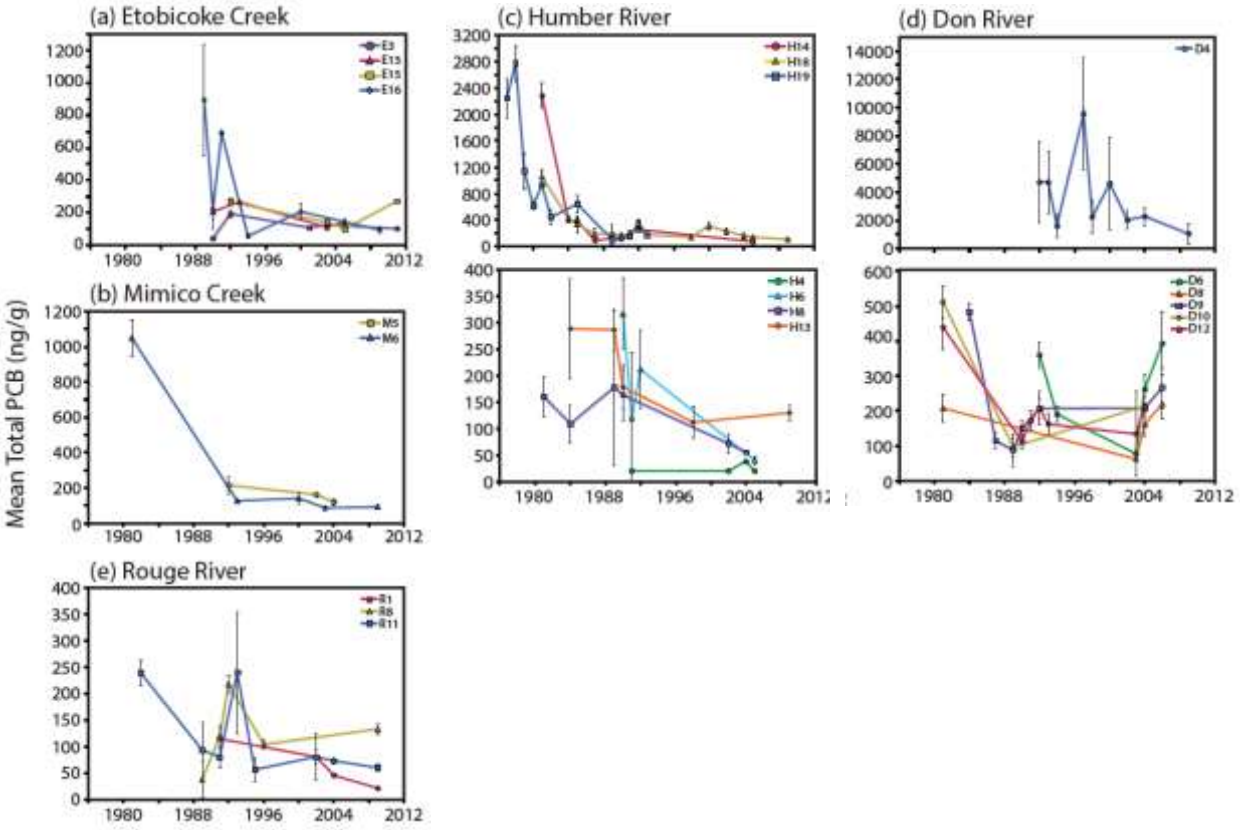


Figure 14. Temporal trends in PCB in forage fish from five Lake Ontario tributaries in the GTA.

Split panels were used for the Humber and Don Rivers due to large variance in PCB concentrations among some sites.

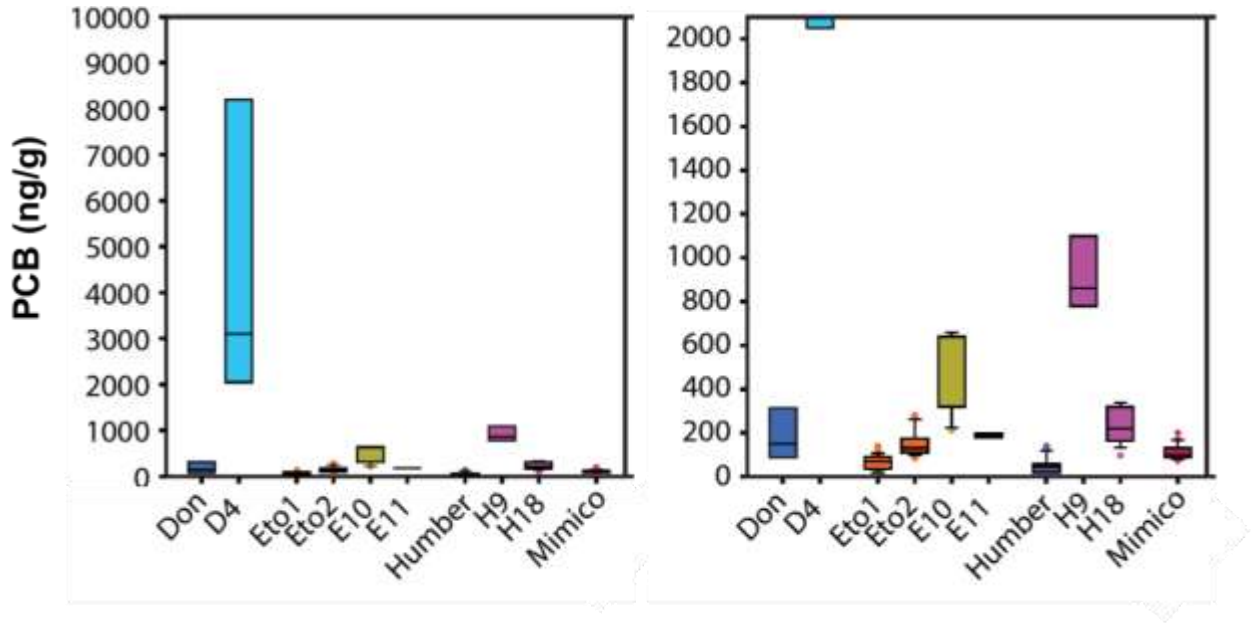


Figure 15. PCB concentrations in forage fish from the Lake Ontario tributaries in the GTA.

The left panel shows the full scale of PCB values; the right panel is on a truncated scale to better illustrate differences among the sites. The measurements were collected between 2000 and 2012.

As per the updates in the 2012 GLWQA, the Agreement is applicable to the Waters of the Great Lakes, which may include the tributaries to the extent that they have a direct link with an identified impairment in the Great Lakes. The contribution of the high PCB levels downstream of the G. Ross Lord Dam and Clairville Dam, on the Don River and Humber River, respectively, to sustained elevated PCB levels in fish from the Toronto Harbour is unclear at present, and may be outside the scope of the Toronto and Region RAP. Nevertheless, it may be advisable to conduct an investigation at these GTA tributary locations with high fish PCB levels for possible on-going sources of contamination.

3.4.5. Possible changes in food web structure

A study investigated how PCB concentrations in a forage fish, Spottail Shiner, changed between 1975 and 2007 in the lower Great Lakes (French et al. 2011). Three major trends were observed: (1) concentrations declined until a break year and then increased (Lake St. Clair, eastern Lake Erie, and upper NiagaraRiver); (2) concentrations declined until a break year and then continue to decrease albeit at a slower pace (western Lake Erie and Niagara River's Tonawanda Channel); and (3) concentrations declined at a constant rate across the entire time period (lower Niagara River and western Lake Ontario). The break years in the trends were generally observed for shallow areas that are susceptible to full water column mixing whereas

constant declines were generally found for deeper areas. The break year typically occurred between 1988 and 1992, and coincided with two major events: (1) a sustained shift towards warming summer temperatures and (2) the proliferation of dreissenid mussels. Based on the weight-of-evidence, the study concluded that the dreissenid invasions were a more likely driving factor behind the observed breaks in the trends. Since the trends for the western Lake Ontario did not appear to be influenced by the mussel invasion, there is a possibility that changes in food web structure have not substantially affected the PCB trends for fish from the Toronto Waterfront. However, this observation may change with time as the presence of mussels become more prevalent in the nearshore area of Lake Ontario. Such an impact may sustain elevated PCB levels in fish along the Toronto Waterfront for a longer time period. However, this regional type of change, driven by invasive dreissenid mussels, would be beyond the scope of the Toronto and Region RAP and should not prevent designating the BUI as "Not Impaired".

3.4.6. Rate of fish consumption

The analysis conducted in Tiers 1 and 2 of the BUI Assessment Framework application to the Toronto AOC did not consider 8+ meals per month advisories as restricting consumption of fish. This approach was based on the *province wide* angler surveys, which showed that >90% of the anglers do not consume locally caught fish more often (Awad, 2006). However, it is possible that anglers in the GTA are consuming fish more often, which may have to be accounted for in the assessment.

An angler survey was conducted from 1995 to 1997 along the Lake Ontario shoreline, from Duffin's Creek (Ajax) in the east to the Credit River in the West including the Toronto Islands and Tommy Thompson Park and Harbourfront in the central region of the city as well as some other locations in the GTA (e.g., Bronte Creek in Oakville, Rouge River Marsh, Grenadier Pond, Humber River at Old Mill, the Credit River at Erindale Park) (Kraft, 1998). The survey results showed that 77% of more than 1500 survey participants did not eat fish caught from the area, and only 1% of the participants consumed fish at more than 8 meals per month (Table 11). These findings support our approach of considering 8+ meals per month advisories as not impairing beneficial use of fish consumption. However, it should be noted that majority of the surveyed anglers who did not eat fish from the area expressed concerns about contaminated water/fish (Table 11). It is reasonable to expect that the fish consumption frequency of the anglers in the area will increase with time in light of improved water and fish quality (Kraft, 1998); however, high frequency consumers (eating 8+ meals per month) will still likely be only a small percentage of the group. Further, there are many sizes of a variety of fish found along

the Toronto Waterfront that can be consumed at 8+ meals per month and may serve the needs of the high frequency consumers.

Table 11. Rate of local fish consumption, and reasons for not consuming locally caught fish. *Source: Taken from Kraft, 1998.*

	TORONTO	
	N	%
NON-EATERS	1,186	77%
1-11 MEALS (LOW)	208	14%
12-25 MEALS (MODERATE)	66	4%
26-95 MEALS (HIGH)	51	4%
96 OR MORE MEALS (V. HIGH)	20	1%
TOTAL	1,531	

	METRO TORONTO (N=1152)	
WATER POLLUTED OR DIRTY	619	54%
FISH DIRTY OR CONTAMINATED	421	37%
DON'T LIKE FISH	162	14%
FISH TOO SMALL	65	6%
FISH STOCKS DWINDLING	48	4%
SPORT ONLY / NO KILLING	39	4%
NOTHING CAUGHT	24	2%
DON'T LIKE CLEANING/ COOKING	22	2%
TUMOURS/DEFORMITIES	10	1%
FISH TOO BIG/OLD	12	1%
FISH TASTE OR SMELL BAD**	8	

3.4.7. Preferred species for consumption

The angler survey conducted from 1995 to 1997 along the Lake Ontario shoreline and other locations in the GTA also identified preferred species for consumption for those participants who reported eating some or all of their catch (Kraft, 1998). Rainbow Trout was the most popular species, while Largemouth Bass, Smallmouth Bass, Common Carp and Brown Trout were among the top 5 (Table 12). Among these fish, Common Carp can be considered at least partially resident fish that also has severely restrictive fish consumption advisories, some of which can be considered more restrictive than other locations in Lake Ontario. White Sucker, a resident species identified with restrictive advisories that were in some cases more severe than other available locations in Lake Ontario (Table 7 and Table 8), was consumed by only a small percentage of the respondents (Table 12).

The priority species for consumption were based on both their availability and desirability. Carp and White Sucker were described by many fishers as “ugly”, “bottom feeders” and “garbage eating fish”, but Carp could be more appealing to sub-populations such as some immigrants (Kraft, 1998). The listing of Carp as one of the top 5 preferred species for consumption reflects the great cultural diversity of the anglers at the Toronto shoreline (Kraft, 1998).

Table 12. Rate of consumption for different types of fish in the GTA and surrounding area
Source: Taken from Kraft, 1998. Ranked by number of participants reporting. N = 345. Meals consumed in the past 12 months. S.D. means standard deviation.

SPECIES	1995-96-97 NUMBER OF MEALS MEAN	S.D.	MAXIMUM	TOTAL	# OF EATERS N
RAINBOW TROUT	7.7	11.2	64	921	119
LARGEMOUTH BASS	6.7	7.5	42	648	97
SMALLMOUTH BASS	6.6	8.5	55	579	88
COMMON CARP	7.0	13.2	100	464	66
BROWN TROUT	4.5	5.0	20	295	66
CHINOOK SALMON	6.6	9.1	52	422	64
CATFISH	6.4	8.7	50	405	63
YELLOW PERCH	8.3	16.2	110	491	59
NORTHERN PIKE	5.4	9.0	40	290	54
WALLEYE	9.0	12.0	54	433	48
ROCK BASS	10.6	15.6	65	475	45
COHO SALMON	7.4	18.9	121	331	45
SUNFISH	7.3	9.8	50	227	31
FRESHWATER DRUM	5.4	9.5	50	162	30
LAKE TROUT	6.2	13.6	75	179	29
WHITE BASS	15.7	42.1	220	425	27
UNKNOWN SALMON	6.0	8.6	42	149	25
CRAPPIE	6.5	6.6	24	143	22
WHITE PERCH	8.1	11.3	40	178	22
RAINBOW SMELT	4.9	4.5	20	97	20
BROWN BULLHEAD	6.3	9.0	28	88	14
WHITE SUCKER	5.1	6.8	26	71	14
MUSKELLUNGE (MUSKIE)*	25.6	85.4	322	358	14
BLUEGILL	12.7	13.2	42	114	9
LAKE WHITEFISH*	7.6	5.2	16	61	8
AMERICAN EEL*	3.2	4.4	11	16	5
ALL SPECIES	**8.0**	**14.0**		**8022**	

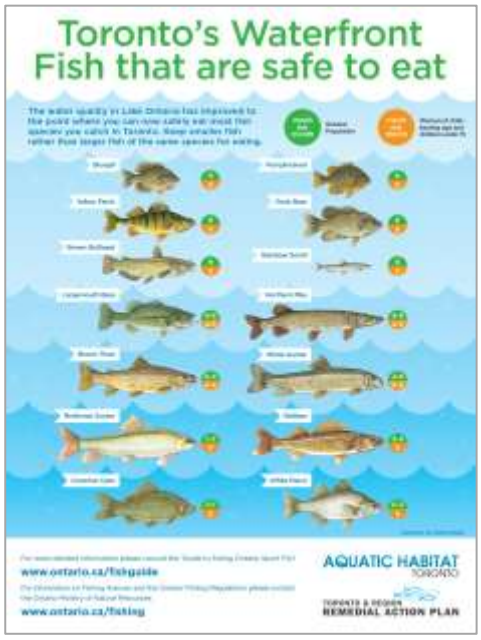
Overall average consumption of fish was about 8 meals per year, translating into less than a meal per month (Table 12). For 95% of the anglers, the range was 1 to 36 meals per year (based on mean 8, S.D. 14) (Table 12), which translates into <1 to 3 meals per month. Again, these reports support our approach of using 8+ meals per month advisories as not impairing the beneficial use of fish consumption. However, it should also be noted that consumption of Carp could be as high as 100 meals per year (8+ meals per month) (Table 12), whereas typically they should not be consumed at all as per the recent advisories in the Guide to Eating Ontario Fish (OMOECC, 2015). Nevertheless, consumption of Carp is largely low at average 7 meals per year (or less than 1 meal a month) to an upper range for most anglers at 34 meals per year (or less than 3 meals a month). Similarly, consumption of White Sucker typically ranges from <1 to 19 meals per year, with the maximum of 26 meals per year or about 2 meals a month (Table 12). Accordingly, although restrictive in some cases, the White Sucker advisories may not be overly compromising the beneficial use of fish consumption, especially for the general

population for which the advisories when restrictive are 2-4 meals per month (Tables 5, 7, 8). Of course, it remains to be seen how these fish consumption patterns will change if the fish consumption frequency of the anglers in the area increases with time in light of improved water and fish quality, as discussed in the section 3.4.6.

Given that this Health Canada study is now over 20 years old and fishing and consumption patterns may have changed in that time, it is worth considering updating this study to understand the current risks posed to anglers of the Toronto and Region.

3.4.8. Risk communication

Fish consumption advisories are issued on a biennial basis by the OMOECC to protect human health and provide guidance on choosing cleaner fish as well as how to reduce exposure to contaminants in fish. The advisories are available through the Guide to Eating Ontario Fish and also online at www.ontario.ca/fishguide. Separate advisories have been provided for the Toronto Waterfront area. These advisories can help in selecting fish that are safe to eat.



The TRCA, in partnership with other agencies, has increased the outreach efforts in the recent years on practices of safe consumption of fish. For example, TRCA posted signs on fish consumption advisories at Toronto waterfront. The OMOECC is planning to install generic advisory signs at various locations in GTA. These risk communication efforts are expected to minimize human exposure to contaminated fish by providing guidance on which fish species and sizes are safe to eat.

3.4.9. Summary of Tier 3 assessment

The above discussions on various quantitative and qualitative measures related to the Fish Consumption BUI for the Toronto and Region AOC is summarised in Table 13. The measures in each category have been arranged in the decreasing order of weight in the assessment. The outcomes of the measures (whether they favour a re-designation of the BUI as "Not Impaired" or not) were based on best professional judgement. For the quantitative measures, three of the five analyses favoured "Not Impaired" status and the other two were not conclusive (Table 13). For the qualitative measures, one of the three measures favoured "Not Impaired", while the other two were not conclusive.

Table 13. Outcome of Tier 3 assessment of various measures.

	Not applicable
positive	Favours "Not Impaired"
neutral	Not conclusive – Requires further assessment
negative	Favours "Impaired"

Quantitative Measures	Qualitative measures
Fish Contaminant trends for the AOC	Preferred species for consumption
Levels and trends for contaminant in forage fish from the GTA tributaries	Risk communication
Projected time for contaminant levels in fish to decline to reference/target levels	Possible changes in AOC food web structure & impact on contaminant accumulation in fish
Rate of fish consumption for the area	
Contaminant levels and trends for the AOC sediments	

The levels of PCB and mercury in fish, which are contaminants of concern for the AOC, have declined substantially (as much or more than 90%) over the last 30+ years. Mercury concentrations in most species and size of fish are now within the "unrestricted" advisory classification. Brown Bullhead, which can be considered a sentinel species for PCB, demonstrated substantial (80-90%) declines in PCB concentrations during the last 20 years and recent levels are well within the "unrestricted" advisory category (<105 ng/g). White Sucker, which can be considered mostly non-migratory species, has restrictive advisories at present due to elevated PCB levels. The current levels and half-life of PCB in White Sucker indicate that the levels will fall to within the "unrestricted" advisory classification within about a decade. This time period provides a favourable outlook with respect to re-designation of this BUI.

Overall, declines in the contaminant levels have been substantial and are likely to continue. Despite the positive declines, levels of PCB remain elevated in some species, most of

which are migratory. Although the PCB levels of the migratory fish could have been influenced by their exposure from the AOC, these fish may not provide true reflection of the AOC conditions due to their large home ranges. PCB levels in White Sucker and Carp, which can be considered mostly local residents but also migratory in some cases, have also declined substantially over time. However, their levels still remain above the advisory benchmarks for some/all sizes.

Similar to the Toronto Waterfront, substantial declines in PCB levels in forage fish at many locations in the GTA tributaries have been observed. However, there were some locations with elevated PCB levels suggesting continued significance of historical sources or on-going releases. Clean up activities conducted at some locations with elevated PCB levels (e.g., Etobicoke Creek) may aid in continued declines in fish PCB levels at the Waterfront. However, contribution of these tributaries to the contaminant levels in fish at the Toronto Waterfront is unclear at present and may be outside the scope of the Toronto and Region RAP. Nevertheless, it may be advisable to conduct an investigation at these GTA tributary locations with high fish PCB levels for possible on-going sources of contamination. Overall, this measure remains neutral or not conclusive on the status of the BUI.

An angler survey conducted about 20 years ago suggests that most anglers in the region do not consume locally caught fish on a very frequent basis. The report supports the use of 8+ meals per month advisory as an uncompromised fish consumption beneficial use. Although it is reasonable to expect that the fish consumption frequency of the anglers in the area will increase with time due to improved water and fish quality, high frequency consumers eating 8+ meals per month will still likely be only a small percentage of the group.

Among the survey's top 5 preferred fish for the consumption, Rainbow and Brown Trout are migratory species and restriction on their consumption has been advised. There are restrictions on consumption of large sized Largemouth Bass, but most advisories are "unrestrictive". Carp, which could be migratory in some cases but not others, remain elevated in PCB levels and consumption is completely restricted. White Sucker is largely a local resident and has restriction on consumption for large sizes; however, it is not one of the most preferred fish for consumption. There are a number of types of fish available along the Toronto Waterfront that can be consumed without any meaningful restriction, but they are not the most popular among the anglers. As this angler survey is somewhat dated, it is recommended that a new survey be undertaken which may provide important insight into current consumption patterns and perceptions in the AOC. Overall, this measure remains neutral or not conclusive on the status of the BUI.

PCB concentrations in the Toronto Waterfront sediments have declined since the 1970s, but the levels have changed little in the last 25 years. PCB levels in the sediments at the Toronto Waterfront are generally similar to the Lake Ontario wide average.

Overall, the Tier 3 assessment of the BUI Evaluation Framework ranges from a neutral or not conclusive to a “Not impaired” outcome (Figure 16). It is advisable for the Toronto RAP team to examine if all reasonable actions have been completed and there is no other viable action that could be undertaken to further improve conditions of the AOC to aid in improvement of this BUI.

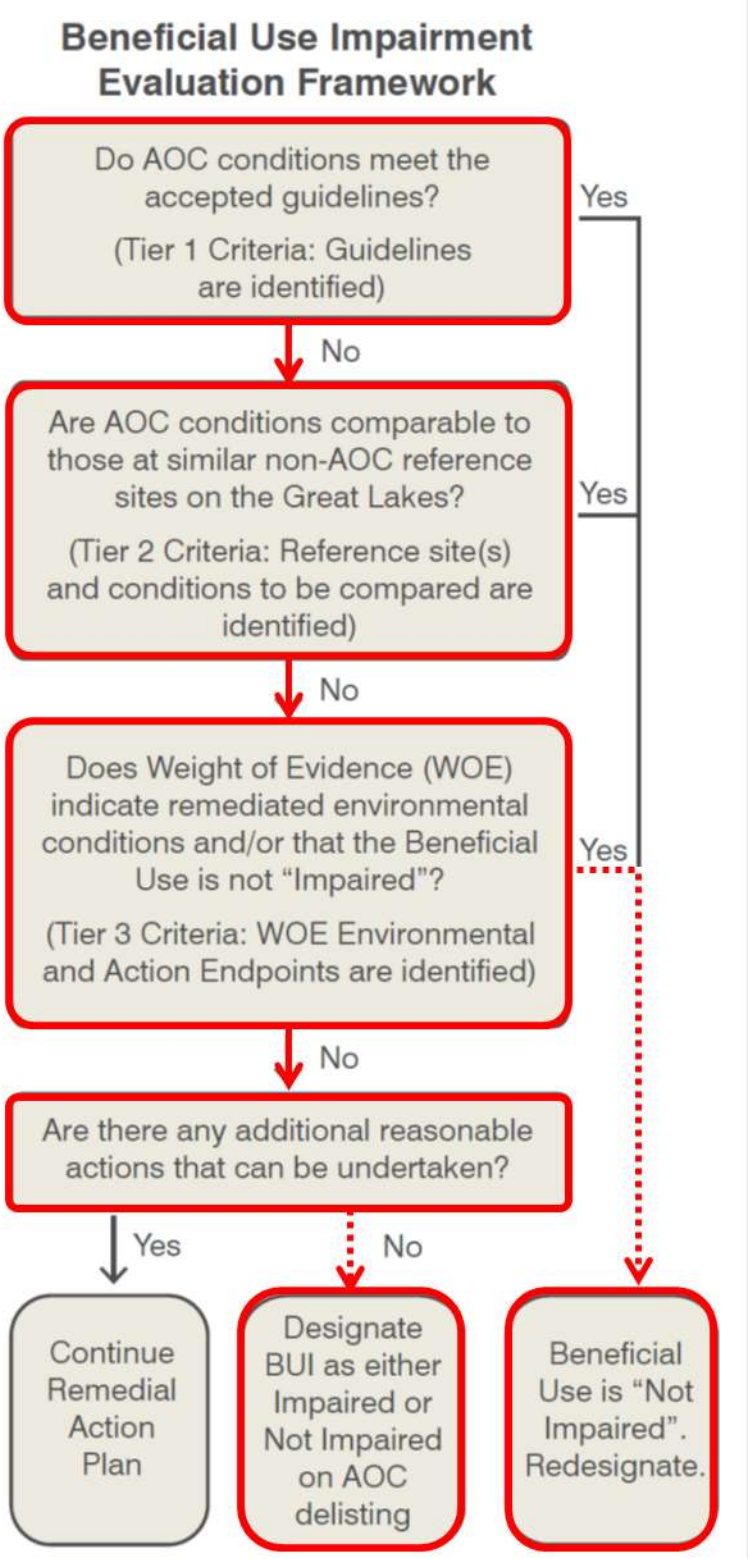


Figure 16. Outcome of Tier 3 application to the Fish Consumption BUI at the Toronto AOC.

In the illustration, it is presumed that there are no additional reasonable actions that can be undertaken.

4. Summary and Recommendations

The fish consumption beneficial use at the Toronto AOC was deemed impaired in 1989. Using the BUI Assessment Framework developed by the Toronto and Region RAP team, this report assessed if the status of the Fish Consumption BUI at the AOC can be re-designated as "Not impaired". Fish consumption advisories are dependent on contaminant levels and advisory benchmarks. The advisory benchmarks have generally become more stringent over time; nevertheless, restrictions on fish consumption due to elevated levels of contaminants from controllable sources within the AOC would imply an impairment of the beneficial use.

The recent (2015-2016) advisories published by OMOECC through the Guide to Eating Ontario Fish recommends "unrestricted" (8+ meals per month) consumption of many fish found along the Toronto Waterfront. However, the Guide also recommends restricting consumption of most migratory fish for the Toronto Waterfront and a few resident species. Although contaminant burden of migratory species could have been influenced by their exposure at the Waterfront, these fish may not appropriately reflect true conditions of the AOC. Overall, the published and simulated advisories show that the consumption is restricted for not only many migratory fish but also a few local fish found along the Toronto Waterfront.

Next, advisories of the AOC were compared to other non-AOC locations in Lake Ontario using the measurements collected in recent years. The analysis highlighted that mercury is not a major contaminant of concern for the AOC fish. Some advisories for White Sucker and most advisories for Common Carp were more restrictive than the reference locations due to elevated PCB levels. It should be noted though that PCB levels in Carp from Frenchman Bay, Lynde Creek Marsh, Whitby Harbour and Hamilton Harbour are also high. Since Carp could be migratory as discussed earlier, it is possible that Carp captured from the Toronto Waterfront area were influenced by these other locations. However, more restrictive advisories for the Toronto Waterfront compared to other non-AOC Lake Ontario locations is of concern. Overall, some PCB related advisories for White Sucker and Carp are still a little more restrictive than other non-AOC locations in Lake Ontario, which prevents us from recommending re-designation of the BUI to "Not impaired" at this stage of the assessment.

Finally, as per the BUI Evaluation Framework, a detailed analysis of other lines of evidence along with best professional judgement was conducted.

- A temporal trend analysis showed that the levels of both PCB and mercury in fish from the Toronto Waterfront have declined substantially (as much as above 90%) over the last 30+ years. Mercury concentrations in most species and sizes of fish are now within the

"unrestricted" advisory classification. Despite the declines, levels of PCB remain elevated in many species, most of which are migratory.

- Substantial declines in PCB levels of forage fish at many locations in the GTA tributaries have also been observed. Although there were some locations with elevated PCB levels suggesting continued significance of historical sources or on-going releases, contribution of these tributaries to the contaminant levels in fish at the Toronto Waterfront is unclear at present and may be outside the scope of the RAP. Recent PCB trackdown and remediation activities in Etobicoke Creek may lead to continued declines in contaminant levels in tributary fish. It may be advisable for the MOECC to conduct an investigation at these GTA tributary locations with high fish PCB levels for possible on-going sources of contamination. Sampling of young of the year (YOY) fish near the mouths of the major tributaries shall be considered to gather the most up-to-date information on potential contaminant loading to the AOC.

- Brown Bullhead, a sentinel species for PCB, demonstrated substantial (80-90%) declines in PCB concentrations and the recent levels are well within the "unrestricted" advisory category. The current levels and half-life of PCB in White Sucker indicate that the levels will fall within the "unrestricted" advisory classification within about a decade. This time period provides a favourable outlook for the re-designation of this BUI to "Not impaired".

- A 1995-1997 angler survey suggests that most anglers in the region do not consume locally caught fish on a very frequent basis. Many fish present at the Toronto Waterfront can be consumed without any (meaningful) restriction, but the survey suggests that they are not the most popular among the anglers. Minor to severe restrictions have been advised on consumption of the five most popular fish; however, two fish (Rainbow and Brown Trout) are migratory, and most advisories for Largemouth Bass are "unrestrictive". Carp, which could be migratory in some cases but not all, remains elevated in PCB levels and consumption is completely restricted. White Sucker, which is largely a local resident and has restriction on consumption for large sizes, but is not one of the most preferred fish for consumption. It is recommended that this angler survey be updated to reflect current fishing and consumption patterns.

- PCB concentrations in the Toronto Waterfront sediments have declined since the 1970s, but the levels have remained largely unchanged in the last 25 years. However, PCB levels in the sediments at the Toronto Waterfront are generally similar to the Lake Ontario wide average.

Using the BUI Evaluation Framework, the balance of evidence shows that the restrictions on fish consumption for most resident fish species have improved along with environmental

conditions such that they can be considered “Not Impaired”. This conclusion, unfortunately, is confounded by the continued high PCB burdens in Carp and larger sizes of White Sucker, consumption of which clearly remain impaired in the AOC. Overall, evaluation results ranged from “impaired” to neutral (not conclusive; requires further assessment) to “Not impaired”. However, no compelling reasons can be identified to consider it as “Impaired”, especially if we presume that there is no additional practical local action that can be undertaken to further improve the AOC conditions leading to “unrestrictive” advisories for all types of fish found along the Toronto Waterfront. It may be advisable to take a precautionary approach and consider the BUI “requires further assessment”, gather new data in a few years to ensure continued declines in fish contaminant levels and improvements in the fish consumption advisories, and meanwhile assess if there is any additional action that can be undertaken to improve the BUI.

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