Toronto & Region Area of Concern Restrictions on Fish Consumption Beneficial Use Assessment Report

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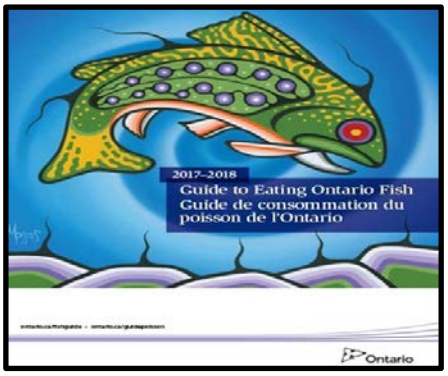

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Executive Summary

This report provides an assessment of the Restrictions on Fish Consumption Beneficial Use Impairment (BUI #1) for the Toronto and Region Area of Concern (AOC) and updates a similar assessment conducted in 2016.

The 2016 assessment recommended a precautionary decision of "requires further assessment" based on continued high PCBs in common carp and white sucker. Since the 2016 assessment, new information on locally consumed fish from the AOC and angler consumption rates of different fish species were obtained from recent angler surveys from the region. This enabled an update of the recommended indicator species and derivation of a set of species specific unrestricted monthly meal allowance criteria tailored to the consumption patterns reported by the local angler community. New records of fish contamination from the AOC and Lake Ontario reference sites were incorporated that were not available for the 2016 report. Finally, the current assessment adopted recommended changes to the BUI #1 Tiered Assessment Framework based on workshops sponsored by Ontario Ministry of Environment, Conservation and Parks (MECP) held in 2021. This workshop harmonized the assessment framework across Canadian AOCs.

There were 13 indicator fish species used for the assessment coupled with additional evidence lines used to assess BUI #1 that considered Young-of-Year forage fish contamination, sediment chemistry, restoration actions and consideration of the residency status of indicator fish in the AOC. Tier 1 and Tier 2, which are based on official fish consumption information issued by Ontario Ministry of Environment, Conservation and Parks (MECP), failed the tier criteria for six of thirteen indicator fish species. Tier 2 failed species included: Brown Trout, Common Carp, Rainbow Trout, Northern Pike, Walleye and White Sucker. Tiers 3 and 4 adopted multiple evidence lines in their respective assessment culminating in a weight-of-evidence decision being generated for each tier. The Tier 3 assessment passed for several indicator species that failed Tiers 1 and 2 but continued for the largest size class of White Sucker while data were insufficient to evaluate current contamination of Rainbow Trout.

For Rainbow Trout there were only 2 records of PCB and Hg contamination for this indicator collected between 2000-2019 and indicates that the official fish consumption advisories issued for this species in the AOC are based on older data. The two fish samples for which data were available had low PCB and Hg levels but because of limited data precluded firm conclusions be drawn about current levels of contamination in this indicator. The Tier 4 assessment of Rainbow Trout mobility identified this species as a transient species in the waters of the AOC. As a cold water species, Rainbow Trout utilizes nearshore waters of the AOC primarily in the fall and therefore contaminant residues in rainbow trout are expected to more broadly reflect regional contamination of Lake Ontario. Therefore, despite this species being captured and reportedly consumed from AOC waters, it was excluded from the final BUI #1 decision.

White Sucker failed two of three evidence lines assessed in Tier 3. PCBs were the primary driver of fish consumption restrictions for White Sucker. PCBs in fish sized >40 cm tended to exceed contaminant levels found in the same indicator from reference sites of Lake Ontario.

However, there was some positive evidence to indicate that PCB residues in this species are improving through time. Based on observed decreases in PCB residues in this species, White Sucker is expected to meet current Tier 1 and 2 criteria within a decade. The residence status of this species addressed in Tier 4 suggested some mobility both within and outside of the AOC. However, the number of fish tagged to assess residence status of White Sucker was limited and Department of Fisheries and Oceans recommended follow-up fish telemetry studies to better resolve White Sucker movements particularly as it relates to this species use of AOC tributaries during spawning. Some tagged fish of this species were observed in proximity to the Don River outlet during spawning and upstream sections of the Don River near the G. Ross Lord Reservoir and Dam are known to generate very high PCB concentrations in forage fish.

Tier 4 evidence lines considered sediment remediation activities conducted in Etobicoke Creek, overall sediment chemistry of Toronto Harbour and AOC tributaries, young-of-the-year forage fish trends and migration movements of sport fish indicator species within and outside of the AOC. On balance, Tier 4 evidence lines were supportive of delisting BUI #1. Sediment PCBs in Toronto Harbour are consistent with those reported for Lake Ontario although conditions in the harbour exceed the most recent near shore Lake Ontario sediment reference. Two of 25 stations in Toronto Harbour from an Environment and Climate Change Canada 2018 sampling survey exceeded the CCME Probable Effect Level for PCBs but such exceedances were limited and highly localized. Sediment restoration in Etobicoke Creek resulted in tangible declines of PCBs in water, sediment and forage fish bringing it in line with other tributaries draining into the AOC. Young of the year forage fish PCB contamination showed general declining trends with time across most tributaries and in most cases PCBs fell to less than 200 ng/g near the tributary mouths. The exceptions were reservoirs present in west Humber and Don Rivers which produced very high forage fish PCB concentrations exceeding the 'Do Not Eat' threshold used for generating sport fish consumption advice. In both tributaries, PCBs in forage fish tended to decline downstream of the sampled reservoirs. In the Humber River, PCBs dropped below 200 ng/g at the river mouth where it drains into Lake Ontario. In the Don River, forage fish PCBs decreased from well above 2000 ng/g to 250 ng/g at a station 2.5 km downstream of the G. Ross Lord Dam. This station was more than 25 km upstream of the Don River mouth where it drains into the eastern portion of Toronto Harbour. Sediment samples taken approximately 5 km upstream of the tributary mouth were low in PCBs with triplicate samples each having 10 ng/g total PCBs on a dry weight basis. Thus, while further track-down studies for PCB sources in the Claireville and G. Ross Lord Reservoirs may be warranted, in both cases it downstream dilution of such loads would appear to attenuate the effects on sport fish bioaccumulation within Toronto Harbour and Lake Ontario.

On balance the majority of evidence lines from Tier 3 and 4 support a recommendation for delisting BUI #1 in Toronto and Region AOC. The only indicator species failing Tier 3 criteria was White Sucker and this was restricted to the larger size classes of this species. Furthermore, temporal trends suggest PCB residues are declining in this species and likely to achieve the current Tier 2 criteria within a decade.

Although BUI #1 is recommended as unimpaired, information gaps remain that should be addressed in order to better refine our understanding of the causes and possible corrective actions

of fish contamination in the Toronto and Region Area of Concern. Fish collection efforts should prioritize obtaining Rainbow Trout from the AOC to resolve data gaps on recent trends of fish contamination from the region and provide the necessary data needed to update the official consumption advisories issued for this species in Ontario's Guide to Eating Fish. Additionally, PCBs in White Sucker, coupled with fish movement assessment and potential application of spatially explicit bioaccumulation models would be useful to better delineate possible sources of elevated PCBs in this indicator. More recent information on PCBs in water, sediments and forage fish from downstream sections of the Don River coupled with fish movements in this area would be required to parameterize such models. Angler surveys to better identify which size classes of White Sucker are consumed by sport anglers and how frequently this species is actually consumed from the AOC could shed light about whether angler exposures are indeed elevated as the result of consumption of the larger size classes of this species. Finally, continued tracking and confirmation of the declining trend of PCBs in White Sucker and in other indicator species should occur as part of the AOC recovery monitoring plan.

The preliminary findings of this BUI #1 assessment were reported to the Toronto and Region Fish Consumption Technical Advisory Committee on March 15, 2022 and the final report was revised based on comments generated during this consultation.

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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 1 of the agreement, 42 AOCs were initially identified by the International Joint Commission (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. AOCs are designated when 1 or more beneficial uses across 14 standardized beneficial use categories are deemed to be impaired referred to as a beneficial use impairment (BUI).

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, 2013b). 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. The AOCs that are shared with the United States are: St. Mary's River, St. Clair River, Detroit River, Niagara River and St. Lawrence River at Cornwall.

Each AOC establishes a Remedial Action Plan (RAP) composed of Lead Agencies, and local stakeholders to implement a restoration plan until most, or all, formerly assessed BUIs achieve an unimpaired status. AOC specific RAPs are in charge of defining beneficial use redesignation criteria, establishing causes of impairments and identifying monitoring and restoration actions to achieve delisting and completing BUI reassessments. The RAP follows a 3 stage process:

- 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. RAPs provide an opportunity for engaging in collaborative environmental stewardship and measuring the progress towards meeting the delisting criteria defined for each AOC. During stage 2, previously impaired BUI's are re-assessed regularly in association with restoration actions to evaluate progress in response to remedial actions. 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.

To date the following AOCs have been de-listed: Collingwood Harbour (Georgian Bay), Severn Sound (Georgian Bay) and Wheatley Harbour (Lake Erie) in Canada, 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 2013b).

1.1 Beneficial Use Impairments (BUIs)

A Beneficial Use Impairment (BUI) under the GLWQA [Annex 1, section 1(b)] 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). The BUIs were developed in a collaborative effort between the Great Lakes Water Quality Board, and many stakeholders including the general public. The BUIs provide a structural guideline and a reference point for the development of Remedial Action Plans (RAPs) that serves to focus and direct 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. The 14 Beneficial Uses identified include the following:

1. restrictions on fish and wildlife consumption;
2. tainting of fish and wildlife flavour;
3. degradation of fish and wildlife populations;
4. fish tumours or other deformities;
5. bird or animal deformities or reproduction problems;
6. degradation of benthos;
7. restrictions on dredging activities;
8. eutrophication or undesirable algae;
9. restrictions on drinking water consumption, or taste and odour problems;
10. beach closings;
11. degradation of aesthetics;
12. added costs to agriculture or industry;
13. degradation of phytoplankton and zooplankton populations; and
14. loss of fish and wildlife habitat.

Each RAP is responsible for providing guidance on the approach used for each BUI assessment and establishing the criteria for delisting identified in the AOC specific BUI delisting statement. This ensures flexibility and adaptive management of BUI assessments tailored to the individual needs and forms of ecological stressors present in each AOC. However, some BUIs benefit from

RAPs adopting well documented and proven approaches shown to be widely applicable across multiple AOCs. These include adopting Great Lakes reference data sets made available to different AOCs as well as adopting standardized procedural steps to the design of sample collections, sample handling and statistical interpretation enabling AOC/Reference comparisons. An example of a standardized approach to BUI assessment and delisting criteria is given by BUI # 4 Fish Tumours or Other Deformities, whereby multiple Canadian AOCs adopted the same Great Lakes Tumour Prevalence reference data set and conformed to similar assessment methodologies. Some efforts have been made to provide similar standardized practices relating to BUI #1 Fish and Wildlife Consumption Restrictions as described in Section 1.3.

1.2. Toronto and Region AOC

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 1). There are six 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 2011). However, with a growing population and increasing urbanization, restoration and remediation of the Toronto and Region AOC remains a challenge.

At Stage 2 of the RAP, many key actions were completed to improve BUIs within 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 and (4) identification and reduction of a source of PCBs into Etobicoke Creek via a PCB track down coupled with removal of 2077.7 m^3 of PCB contaminated materials from the creek channel (Ministry of The Environment, Conservation and Parks, 2017); 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).

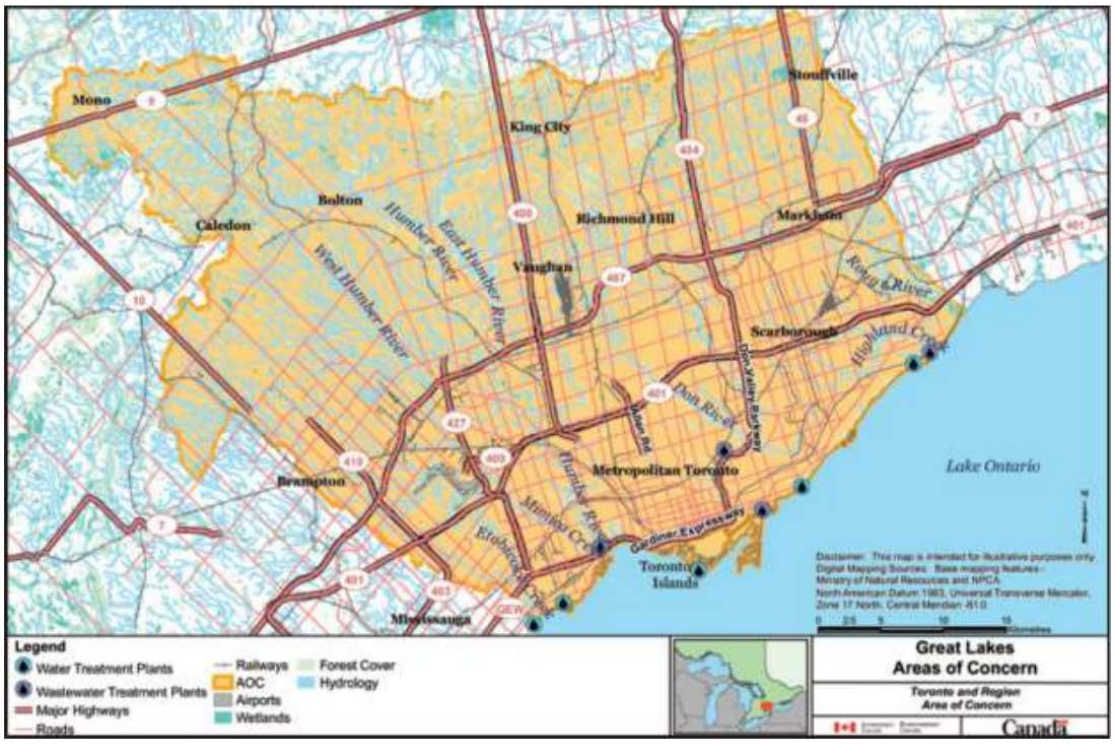

Figure 1. Map of Toronto and Region AOC. Figure from Bhavsar (2016).

According to the Toronto and Region Area Concern 2020-2025 workplan there remains 5 impaired BUI's (BUI #s 1, 3, 8, 10, 14) and one (BUI #13) that requires further assessment reflecting substantive improvement over the Stage 1 RAP assessments that identified 11 of 14 impaired BUIs in 1987 (Figure 2).

1.3. Fish and Wildlife Consumption BUI

In the Toronto and Region AOC there are no available restrictions on the consumption of wildlife. In addition, hunting and trapping permits for the purpose of game consumption are considered limited in this highly urbanized region. Therefore, BUI #1 as applied to the Toronto and Region AOC is restricted in its scope to Fish Consumption Restrictions and does not include assessment of restrictions on the consumption of wildlife from the AOC.

BUI #1 has proved to be a highly challenging beneficial use to address for many Great Lakes AOCs. These challenges are related to changes to programs that issue fish consumption advice which occurred between the time of initial AOC establishment (1987) through the Stage 2 Restoration and BUI re-assessment process. These changes include: designation of two sub-populations (General Population and Sensitive Population) over which separate fish consumption advisories are issued; addition of new chemicals being monitored and used to establish fish consumption advisories; changes in the number of monthly meal allowance categories over which fish advisories are issued and changes to Health Canada benchmarks used to establish maximum monthly meal recommendations. For example, the benchmark used for PCB concentrations in edible fish tissues to initiate the least restrictive fish consumption advisory decreased by 77 fold from 1987 to the present. In addition, early in the Ontario Sportfish Advisory Program, the least restrictive monthly meal recommendation category was 8 meals per month whereas the program now issues meal consumption advice for as many as 32 meals per month. Owing to these program changes, most water bodies in Ontario now have some form of fish consumption restrictions in place for one or more fish species and size classes. As a result, the simple presence of fish consumption restrictions issued for an AOC is no longer exceptional to AOCs nor an indication of high degree of contamination of the local environment.

Beyond programmatic changes to Fish Consumption Advisory Programs, chemical contamination of edible fish tissues is also influenced by large number of factors. This includes sources and loads of priority chemicals to the AOC coupled with the on-going presence of legacy pollution in sediments. Bioaccumulation of chemicals by fish is not only affected by water and sediment chemical contamination, but also influenced by fish ecology (e.g. spatial movements of fish within and outside of the AOC and species specific feeding ecology) as well fish physiology (tissue composition, body size and age of sampled fish). These ecological and physiological factors can further mediate chemical residues achieved in edible fish tissues that can confound cause-effect linkages between fish contamination and AOC restoration initiatives, especially when ecological and/or physiological factors change through time.

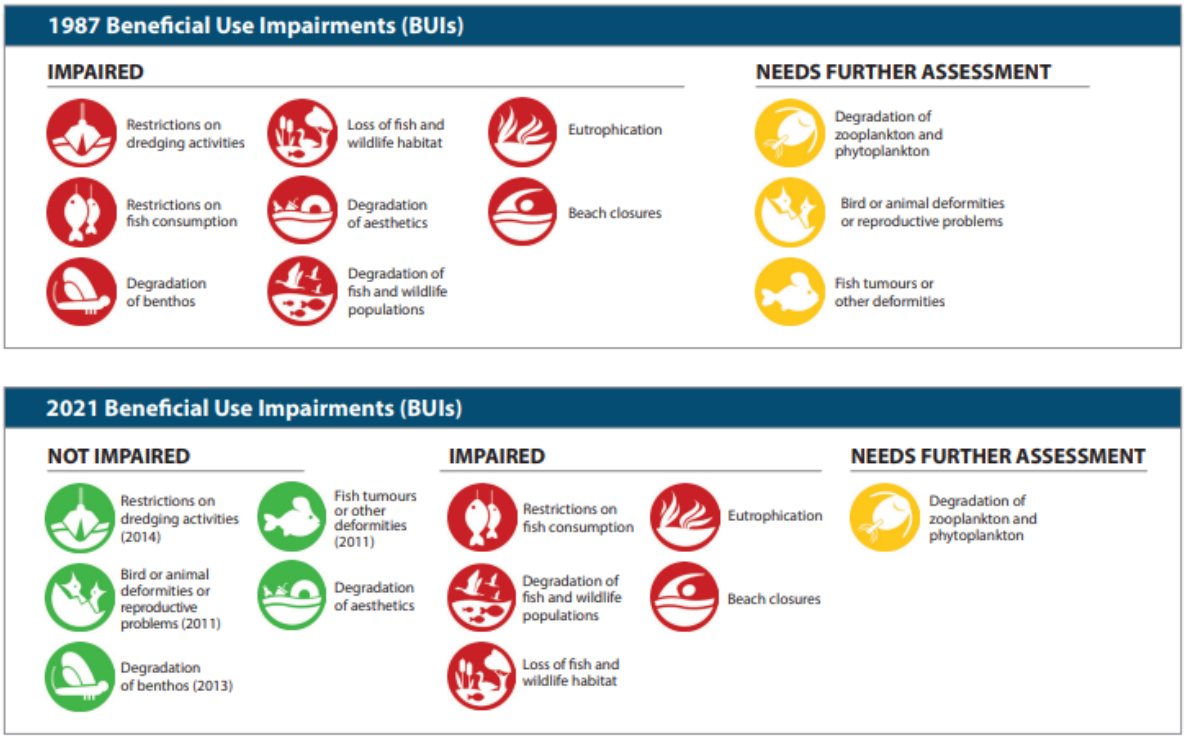

Figure 2. Comparison BUI Status Assessments in the Toronto and Region AOC in 1987 (top graphic) and 2021 (bottom graphic). Toronto & Region Remedial Action Plan Work Plan 2020-2025.

To facilitate a more harmonized approach to BUI #1 assessment across Canadian AOCs, Environment and Climate Change Canada (ECCC) and Ontario Ministry of Environment Conservation and Parks (MECP) initiated virtual and in-person workshops in 2016 to develop a generic delisting criteria statement for BUI #1 that could be adopted by multiple AOCs. The outcomes of this workshop generated the following generic delisting statement:

> *Consumption advisories for fish of interest in the AOC are unrestricted or no more restrictive than the advisories for suitable reference site(s) due to contaminants from locally-controllable sources*.

The above generic delisting statement was applied in a preliminary reassessment of BUI #1 for the Toronto and Region AOC in October 2016 (Bhavsar, 2016; Bhavsar et al., 2018). In addition, the Toronto and Region RAP team introduced a new three tier assessment framework for assessing BUI #1 (Figure 3). 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 the 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. 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.

Tier 2 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.

Tier 3 Criteria of the Toronto BUI Evaluation framework examines the status of the BUI using a 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".

In 2016, the preliminary assessment of BUI #1 for the Toronto and Region AOC (Bhavsar 2016) generated the following conclusions:

> "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."

The report authors further noted that "It may be advisable to take a precautionary approach and consider the BUI requires further assessment". Assessment recommendations included "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".

Since the 2016 preliminary assessment, there has been progress to further refine the BUI #1 Generic Delisting Statement and the structure of the Tiered BUI #1 Assessment Framework. New restoration actions have been completed in Etobicoke Creek (Benoit, 2019). Additional information was obtained via updated Angler Surveys conducted by the Toronto and Region Conservation Authority (2018/2019) and by MECP (Bhavsar, personal communication, 2022) that shed light on regionally consumed fish species and fish consumption frequency of AOC caught fish. This allowed a refined Tier 1 assessment by redefining indicator fish species based on updated fish consumption information and establishing species-specific unrestricted monthly meal criteria based on the reported maximum fish consumption meal frequencies reported by the local angler community. New data on fish contamination within the AOC and across Lake Ontario reference sites generated since 2014 allows an update to the original Tier 2 assessment. Finally, data from fish telemetry studies tracking fish movements within and outside the AOC have been completed by Department of Fisheries and Oceans Canada (Mildwood et. al., 2019) along with more recent information about young-of-the-year forage fish contamination in tributaries draining into the AOC.

This report presents an application of the BUI re-designation framework originally developed by the Toronto and Region RAP team and refined in 2021 BUI #1 MECP/ECCC workshops to investigate the status of the Fish Consumption BUI at the Toronto and Region AOC. This assessment builds on the effort invested by Toronto and Region Conservation Authority, MECP and ECCC to gather updated fish contaminant datasets for the Toronto AOC during the last few years and updates of Angler Survey fish consumption information.

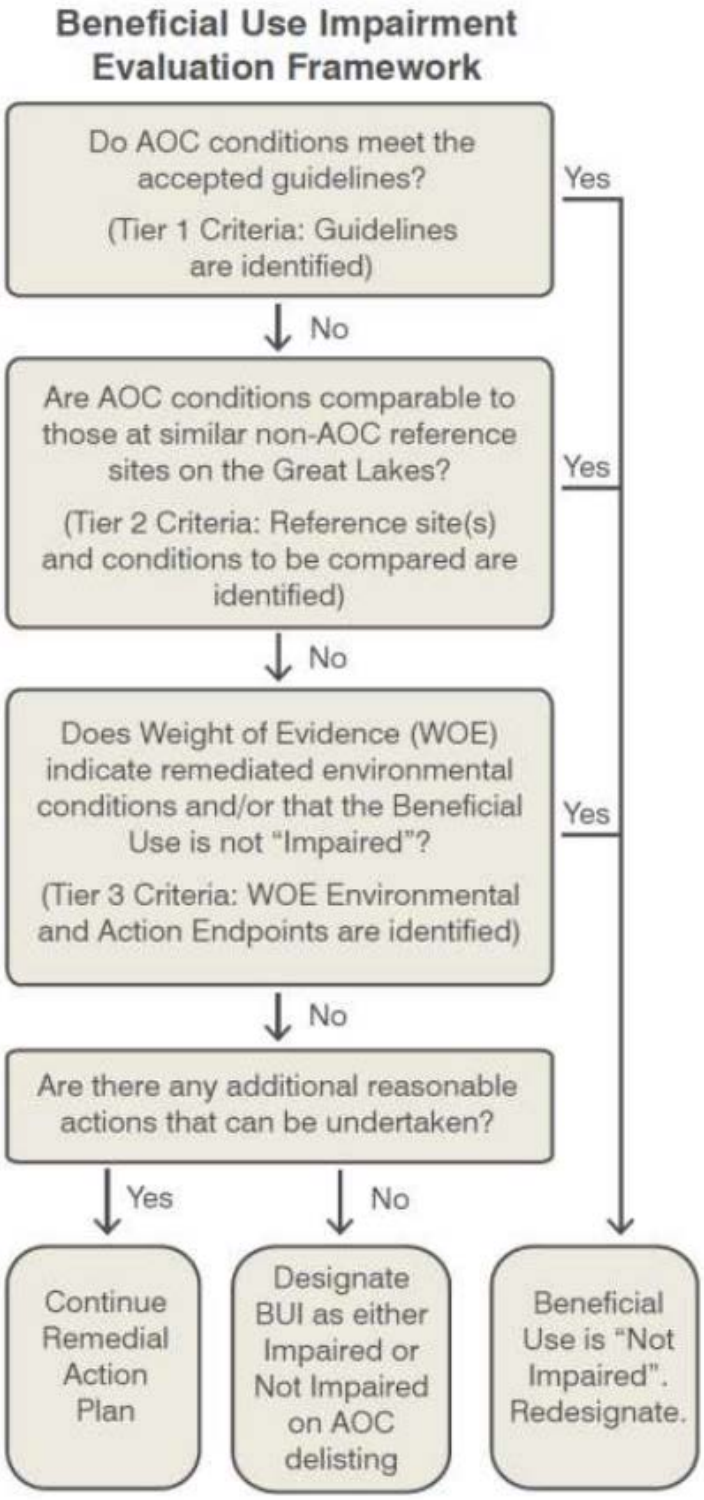

Figure 3. Toronto RAP's Tiered Beneficial Use Impairment Evaluation Framework applied in the 2016 BUI #1 assessment. Figure from Bhavsar (2016)

2. BUI #1 Re-designation Framework

2.1. Toronto AOC delisting criteria statement and "Tiered" Framework

In 2021, a series of workshops attended by Canadian AOC RAP Coordinators, Great Lakes Managers from ECCC and MECP, academic researchers and other stakeholders were held to review and revise the generic BUI #1 delisting statement and tiered framework. The intent of these workshops was to draw upon experiences gained from the implementing the original BUI #1 framework (Figure 3) and modified forms of the framework implemented across three AOCs: Toronto and Region AOC, Niagara River and the Canadian portion of the Detroit River AOC. In addition, the workshops deliberated and generated a set of recommended operating guidelines to help standardized the types of data and approach to data interpretation applied in each tier of the framework. Following consultation with the Fish Consumption Technical Working Group for the Toronto and Region Remedial Action Plan in 2022, these new standard approaches were adopted in the current BUI #1 Assessment for the Toronto and Region AOC.

The 2016 preliminary assessment (Bhavsar 2016) utilized the following delisting statement as part of its BUI #1 assessment:

> "*Consumption advisories for fish of interest in the AOC are unrestricted or no more restrictive than the advisories for suitable reference site(s) due to contaminants from locally-controllable sources*."

This was modified to the following:

> *"Consumption advisories for fish of interest in the AOC are unrestricted or no more restrictive than advisories for suitable reference site(s), demonstrate fish contamination not different from reference(s), are improving through time or cannot be improved by additional restoration actions within the AOC."*

The modified delisting statement provides stronger linkage between sub-statements contained within the criteria that link directly to each tier of the recommended BUI #1 framework. Tier 1 of the framework determines whether official fish consumption advice issued for the AOC is considered restrictive or not as captured by the sub-statement: 'Consumption advisories for fish of interest in the AOC are unrestricted'. Tier 2 examines if fish consumption advisories are less restrictive or equivalent in their monthly meal allowances to reference sites as indicated by 'unrestricted or no more restrictive than advisories for suitable reference site(s)'. The sub-statement '*demonstrate fish contamination not different from reference(s), are improving through time* point to evidence lines that are included in Tier 3. Finally, the sub-statement '*or cannot be improved by additional restoration actions within the AOC'* focusses on whether or not additional restoration actions conducted within the AOC are capable of improving fish contamination and lowering fish consumption restriction advice corresponding to Tier 4.

The modified 4-tier BUI #1 assessment framework is summarized in Figure 4. There are many similarities between the original Toronto and Region AOC three-tier framework implemented in 2016 and the revised four tier framework recommended by the 2021 virtual workshops. In the

revised framework, the separation of Tier 4 and Tier 3 is intended to separate evidence lines related to recovery of the beneficial use from evidence lines focused on cause-effect linkages between past and feasible future local restoration actions that can restore the beneficial use. Given that each tier is capable of redesignating the BUI on its own, separating Tiers 3 and 4 can be advantageous when multiple evidence lines are available for each of the two lower tiers. This ensures that each set of evidence lines are considered independently and do not confound one another, i.e. lack of evidence of recovery does not override a decision on evidence lines demonstrating a lack of feasible additional local restoration that can decrease fish contamination to the point of restoring the beneficial use to Tier 1 and Tier 2 criteria.

Briefly:

> Tier 1. Uses fish consumption advice generated by the appropriate regulatory framework within the AOC as the main source for data interpretation. Data are collated for official fish consumption advice issued for selected indicator fish species for both the sensitive and general population and evaluated against an unrestricted monthly meal allowance criteria. Angler surveys administered within the AOC and region are used to identify which indicator species are appropriate for the Tier 1 criteria and also the unrestricted monthly meal allowance threshold. Where one or more advisories are found to be more restrictive than the monthly meal allowance criteria, Tier 1 is deemed to fail and analysis proceeds to the next tier.
>
> Tier 2. The Tier 2 assessment, similar to Tier 1, focusses on official fish consumption advice and uses the same indicator species adopted in Tier 1. However, indicator species that passed the Tier 1 criteria are omitted from further consideration in the Tier 2 assessment. A set of appropriate reference sites are assigned to compare degree of restrictiveness of monthly meal allowances in the AOC against reference locations. Semi-quantitative methods are then used to compare the monthly recommended meals in the AOC against the reference dataset. Typically, this involves comparing the median monthly meal allowance for a given indicator and size class across the selected reference sites against the monthly meal recommendation issued for the same size class/species in the AOC. Cases where the monthly meal recommendation is more stringent than that of the reference result in failure of the Tier 2 criteria.

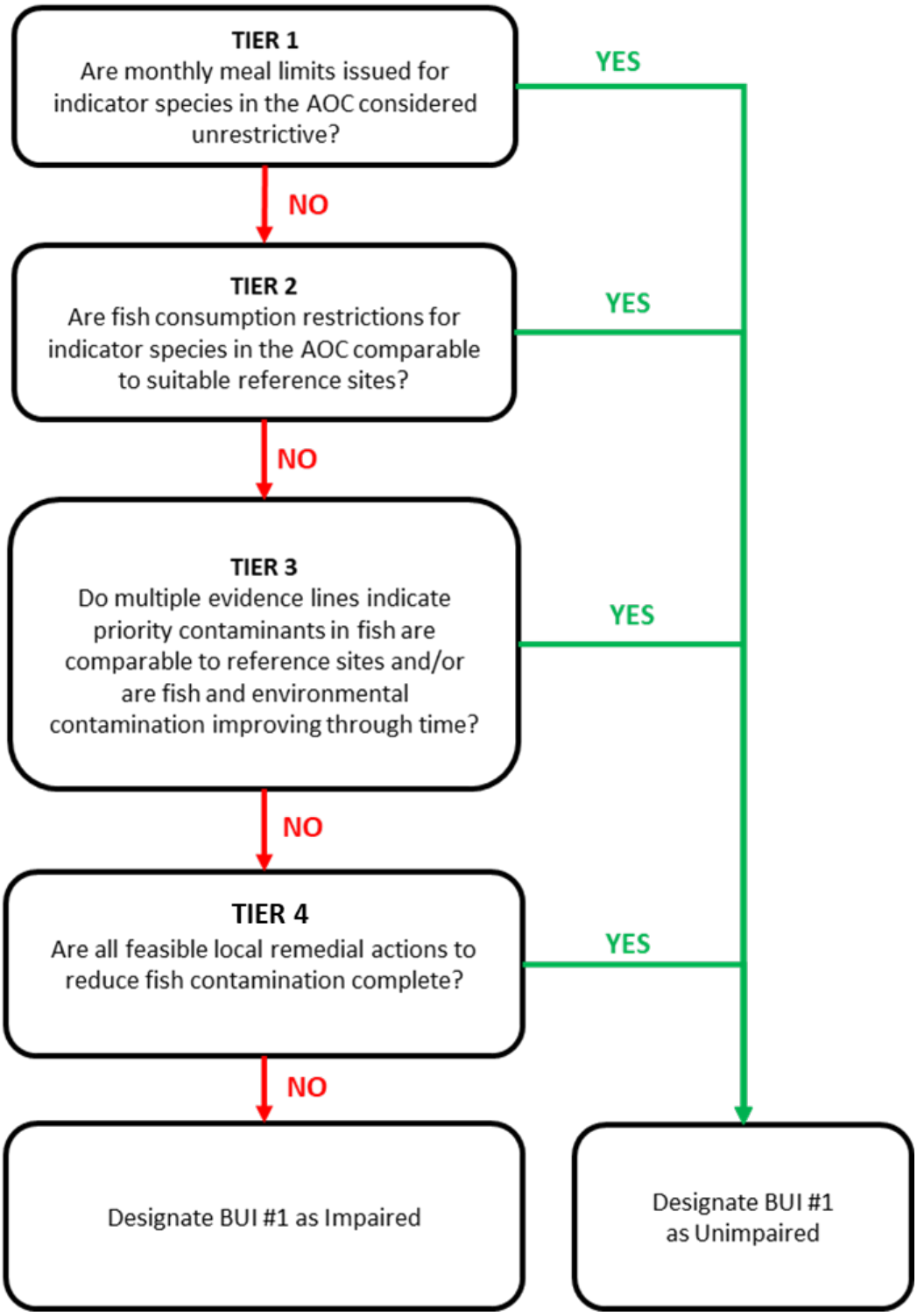

Figure 4. Modified 4 tiered evaluation framework applied in the 2022 BUI #1 Assessment for the Toronto and Region AOC.

Tier 3. The Tier 3 assessment adopts several evidence lines to ascertain if the beneficial use is recovering through time. Tier 3 deviates from Tier 1 and 2 in that it compiles varying types of data beyond fish consumption restrictions that can be derived from different sources. The evidence lines that are considered include 1) generating virtual fish consumption advice based on the most recent data on fish contamination in the AOC and comparing this against Tier 1 and 2 criteria; 2) measuring differences between priority concentrations in fish tissues between the AOC and reference sites and 3) examining for temporal trends in fish contamination through time and computing number of years to achieve Tier 1 or Tier 2 criteria. Each evidence line is evaluated separately to determine if it supports or refutes an impaired decision. Given that different evidence lines may conflict in their assessment support, an overall weighting of evidence across the lines is used in conjunction with a decision matrix of evidence line outcomes to generate an overall decision for Tier 3. Where Tier 3 is judged to fail the assessment, Tier 4 may be further evaluated.

Tier 4. The Tier 4 assessment, like Tier 3, adopts several evidence lines. Evidence lines are compiled to address past and prospective restoration actions in the AOC and their impact on environmental quality and degree of fish contamination. Within this tier, evidence lines compiled may include 1) listing of the restoration actions identified in the Stage 2 RAP report and assessing the completion status of identified actions and 2) evaluating temporal declines in water, sediment or other environmental media linked to restoration actions and natural environmental recovery occurring within the AOC. In addition, the feasibility of restoration actions to reduce fish contamination may be partially dependent on fish movements within and outside of the AOC boundaries. In this case, data on chemical tracers or external studies of fish movements such as fish telemetry studies may be compiled for indicator species and used to evaluate fish residency in the AOC. In cases where indicator species are shown to spend a majority of their time outside of the AOC boundaries, it can be argued that further restoration within the AOC are likely to have minimal impacts on contaminant bioaccumulation by the study species. Tier 4 evidence lines on fish movements may therefore be used to exclude highly mobile species from inclusion as indicator species to facilitate a re-evaluation of Tier 3 based on exclusion of mobile species. Other evidence lines may include source track down studies involving water, sediment and forage fish contamination used to infer spatial patterns of environmental contamination and how this relates to restoration actions. In addition to the above Tier 4 may include use modelling tools, isotopic tracer studies or other tools as appropriate to uncover priority contaminant source-fish contaminant linkages within the AOC and beyond the AOC boundaries.

2.2. Application of Framework to Fish Consumption BUI

This section discusses technical points to consider while conducting the Four -Tier BUI #1 assessment framework to the Toronto and Region AOC.

2.2.1. Data sources for fish consumption restrictions

Tier 1 and Tier 2 of the BUI #1 Assessment Framework rely on official fish consumption advisories issued for the AOC and for suitable reference sites. Ontario Ministry of Environment, Conservation and Parks (MECP) is the regulating authority for fish consumption restrictions for the Province of Ontario where the Toronto and Region AOC is situated. Fish consumption advisories were compiled from the most recent Ontario Guide to Eating Ontario Fish (2017-2018) published by MECP available at https://www.ontario.ca/page/eating-ontario-fish-2017-18. Monthly meal recommendations for the AOC correspond to advisory tables issued for Lake Ontario 4a – Toronto Waterfront Area available from: https://www.ontario.ca/page/fish-consumption-report?id=43397919. Advice information was compiled for all available indicator species to which advice is issued, all size classes and across the two populations: General Population and Sensitive Population.

Fish consumption advisories issued to the Sensitive Population are intended to be used by women of childbearing age and children under the age of 15. Generally, fish consumption advisories tend to be more stringent for the Sensitive Population because some contaminants such as mercury use different sets of benchmarks for the Sensitive and General Populations, the former being more stringent due to the greater sensitivity of this population to toxic contaminant human health effects. Maximum monthly meal recommendation categories for the Sensitive Population include 32, 16, 12, 8, 4 and 0 meals/month. Maximum monthly meal recommendation categories for the General Population include 32, 16, 12, 8, 4, 2, 1 and 0 meals per month. For the purpose of this assessment advisories issued for both populations are subject to assessment under the Tier 1 and Tier 2 crtiera.

2.2.2. Selection of indicator fish species and unrestricted monthly meal allowance criteria

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 the type of fish. For example, hydrophobic (low water soluble) 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. 2011), 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 the amount of 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. Selection of indicator species needs to be consistent

with advisories in place for the AOC otherwise there will be insufficient data on which to complete the Tier 1 and Tier 2 assessments.

Where possible, the selection of indicator species assessed should incorporate credible, recent local information drawn from the angler community and reflective of all individuals potentially consuming fish derived from the AOC. Species identified as indicator species should be highly sought after and frequently reported as being consumed. Use of Angler Surveys that capture a large enough representation of the community who consume fish from the AOC should be evaluated and referenced against inclusivity criteria (e.g. ethnicity, Indigenous fish consumers, gender and ages) of survey participants to justify indicator selection. Finally, newer information with high local relevance is preferred over older surveys and surveys that have broad regional coverage transcending the regional AOC boundaries.

In order to evaluate Tier 1 an unrestricted monthly meal allowance criteria needs to be established. The unrestricted monthly meal allowance should be based on locally derived data and be protective of a substantive portion of the angling community that consumes fish captured from the AOC. Many AOCs use historical benchmarks or justify the unrestricted criteria from data derived from MECP Angler Surveys conducted across Ontario that may not be directly applicable to the AOC itself. For example, during 1987 when the Toronto and Region AOC was first established, the least restrictive monthly meal allowance category was 8 meals per month. Thus, some AOCs have applied 8 or above meals per month as the unrestricted monthly meal criteria since at the time of AOC formation, monthly meals greater than 8 meals per month were not assigned any type of consumption restriction. As with indicator species selection, the selection of the unrestricted monthly meal allowance criteria should be based on credible, local and recent information obtained from fish consumers who utilize AOC-caught fish.

More commonly, most AOCs adopt a single unrestricted monthly meal allowance criteria that is applied to all indicator species, and size classes for which monthly meal consumption advice is issued. However, this need not be the case and species specific or even size-specific unrestricted monthly meal allowances could be adopted based on the availability of such information. For example, some species may be identified and consumed in the AOC but at a much less frequent rate compared to the most sought after species. Provided information is available from Angler Surveys, lower monthly meal restrictions may be assigned to those species that are rarely caught and eaten but may nonetheless be selected as indicator species used in the BUI #1 assessment. Finally, based on fish permits issued within the boundaries of AOCs, there may be exclusion criteria that can be used as part of issuing a species specific unrestricted monthly meal allowance. For example, some species may have slot sizes that require fish permit holders to restrict their activities towards catch and release and therefore are unlikely to be consumed.

The most common data interpretation approach for Tier 1 is to use all fish species where fish advisories are issued within the AOC and contrast this with an unrestricted monthly meal allowance criteria (or species specific unrestricted monthly meal allowance criteria). Where 1 or more officially administered fish consumption restrictions exceed the unrestricted monthly meal allowance criteria, the Tier is deemed to have failed the Tier 1 assessment. However, a subset of

indicator species and size classes may pass the Tier 1 criteria. These species and respective size classes may subsequently be excluded from further assessment in lower tiers within the framework.

2.2.3. Selection of appropriate reference sites for Tier 2 contrasts

The Tier 2 assessment requires comparison of fish consumption restrictions in the AOC against fish consumption restrictions generated for appropriate reference sites. Appropriate reference sites need to have fish consumption advisories available for the selected indicator species as well as overlapping size ranges of each indicator with that of the AOC to facilitate the Tier 2 comparisons.

The number of reference sites chosen and their locations need also be considered. Having only a single reference site makes comparison of the degree of restrictiveness relative to the AOC simplistic but subjects the BUI #1 assessment to potential bias and error related to the choice of the reference. When there are only one or two reference sites to compare against advisories issued in the AOC, the decision can be subject to bias owing to either selecting a relatively contaminated reference area or selecting a reference site that is unusual with respect having much lower than background fish contamination. When a large number of reference sites are incorporated into the tier 2 evaluation, individual reference site selections are less likely to confound the Tier 2 interpretation. Many AOCs tend to restrict reference sites to non-AOC fishing zones within the Great Lakes. Some AOCs prefer to identify fishing zones in the associated Great Lake while others may expand reference sites to include both non-AOC Great Lakes and in-land lake locations.

After data are compiled for Tier 2, the data must be interpreted to determine if the monthly meal advice for a given size bin and indicator species in the AOC differs from the monthly meal advice issued for the reference dataset. Given that multiple advisories are used to formulate the reference set, semi-quantitative approaches can be adopted to facilitate this interpretation. With regards to fish monthly meal allowance categories, the data follow discrete categories (0, 1, 2, 4, 8, 16, or 32 meals per month for the General Population or 0, 4, 8, 16 or 32 meals per month for the Sensitive population). Given the above data are categorical, means are not an appropriate measure of central tendency for the reference sites. It is recommended to use either the mode or median of monthly meal advice across the reference sites as the appropriate criteria to compare against the advisory issued in the reference. Data interpretation proceeds by comparing the AOC fish advisory in a given indicator species and size class to the median monthly meal allowance generated for the same species and size class across reference sites. This exercise is performed for each indicator species, size class and for advisories issued for the two human populations. Typically, if one or more advisories in the AOC exceed the criteria, then Tier 2 is considered to have failed the criteria and a Tier 3 assessment is completed. As in the case of Tier 1, any species which passes the Tier 2 criteria across its size range is not further assessed in the lower tiers.

2.2.4. Contaminant(s) of interest and sources of fish contaminant data for Tier 3 contrasts

Tier 3 evidence lines include direct analysis of fish contaminant data and consideration of other monitoring data sets relevant to priority contaminants in environmental media of the AOC. The selection is guided by the contaminants responsible for causing restrictions on fish consumption.

The MECP has been monitoring fish contaminant levels in the Great Lakes since the 1970s. The 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. Fifteen contaminants are commonly monitored in collected sport fish species including mercury, PCBs (includes dioxin like PCBs), dioxin-like compounds, DDT, toxaphene, mirex, photomirex, other pesticides, trace metals and emerging contaminants. Initially, the data are used to issue fish consumption advisories on a chemical by chemical basis. The most stringent monthly meal advice is then selected from among the chemical specific advisories for use in official fish consumption restriction reporting. The identification of chemicals contributing to the most stringent fish advice is reported in the Guide to Eating Ontario Sportfish. However, different chemicals may contribute to fish consumption advice for different species and even between different sizes of the same species. Therefore, priority contaminants selected for the BUI #1 assessment should consist of chemicals identified in the Guide to Eating Ontario Sportfish as contributors to fish consumption restrictions. AOC Coordinators or consultants working on BUI #1 assessments can request data on fish chemistry directly from MECP which manages the Ontario sportfish contaminant database used to generate fish consumption advice.

For spatial comparisons of fish contamination in the AOC and reference sites, the year intervals of data requests should be constrained. It is commonly recommended that data over at least 20 years from the AOC and reference sites are requested to permit a robust spatial analysis. This will account for variation in the number of samples collected for a given year for any given indicator from the AOC and references sites to ensure sufficient data are available to complete a robust statistical analysis. However, data may be processed prior to the spatial interpretation to reflect a shorter year interval reflective of the most recent conditions in the AOC. Once data are compiled for priority chemicals in indicator species from the AOC, a statistical analysis is completed to determine if chemical contamination in the AOC are statistically elevated compared to the reference sites. Commonly, data are transformed to ensure statistical assumptions about data distributions are met and data quality checks need to ensure sufficient samples are available to complete the analysis with appropriate statistical power. In some cases, statistical approaches to size standardization followed by AOC/reference comparison can be completed. In cases where statistical assumptions related to size standardization cannot be met, data analysis may be restricted to a sub-set of common size classes based on total length for matched samples from the AOC and reference. In preference, comparisons with larger size classes should be emphasized given that larger size classes typically generate the most stringent fish consumption advice.

For temporal comparisons, the temporal analysis is restricted to datasets contained within the AOC. As in the case of spatial comparison, data are pre-evaluated to determine if factors such as fish size need to be adjusted and accounted for prior to analysis. Commonly, linear regression analysis of log transformed fish contaminant concentrations versus time (year of sampling) are performed on selected size intervals of indicator fish from the AOC. The regression slope is tested for statistical significance of a declining trend. Where a valid statistical model is established, the regression can be used to estimate the number of years required to achieve either Tier 1 or Tier 2 acceptable criteria.

2.2.5. Advisory benchmarks and calculation of virtual fish consumption advisories

Tier 3 evidence lines may involve computing and comparing virtual advisories generated for the AOC against official advisories issued for the reference. Virtual advisories are calculated to control the temporal range of samples included in the advisory calculation and to standardize it to the most recent data for the AOC. Official fish consumption advisories do not describe the year interval over which the latest advice has been computed. Official fish consumption advisories may include a mixture of old and new data and the year intervals of sample information included in official advisories vary across different fishing zones and even between different species of fish from the same fishing zone. This is because not all fish species or size classes from a given species for which fish consumption advisories are issued are captured at every sampling point and the number of fish samples collected from a given fishing zone can vary from year to year.

When computing virtual advisories, parallel approaches to the official regulatory program are adopted. Virtual fish advisories are not intended to be used to provide fish consumption advice or replace official advisories. Their utility is restricted to use as an evidence line in the Tier 3 BUI #1 assessment. Fish consumption advisory benchmarks used by MECP are generally based on tolerable daily intake levels established by the Food Directorate of Health Canada. The MECP 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. MECP calculates advisories for each contaminant, location, fish species and 5 cm size interval between the smallest and largest fish sample collected up to the 75+ cm category. 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).

Table 1. Current MECP fish consumption advisory benchmarks used to formulate monthly meal recommendations related to mercury (Hg) and PCBs.

	Hg (ug/g)		PCB
Meals/ month	**Sensitive**	**General**	**ng/g**
0	>0.5	>1.8	>844
1			422-844
2		1.2-1.8	211-422
4	0.25-0.5	0.6-1.2	105-211
8	0.16-0.25	0.4-0.6	70-105
12	0.12-0.16	0.3-0.4	53-70
16	0.06-0.12	0.15-0.3	26-53
32	<0.06	<0.15	<26

Virtual fish consumption advisories are calculated using the method employed by the MECP and described in Bhavsar et al. (2018). A set of power series regressions for contaminant level versus fish length for each location/species/contaminant/period combination are conducted (e.g., Figure 5). These regressions are then used to calculate mean 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. For contaminants showing no statistical relationship with fish size, a mean concentration for each size interval tested is computed and used to assign the chemical-specific virtual advisory for each size class. Chemical specific virtual advisories are then tabulated for each priority chemical considered and the most stringent monthly meal advice across contaminants is selected as the virtual advise used for a given size interval and indicator species.

Virtual advisories can be interpreted in the same manner as identified for Official Advisories in Tier 1 and Tier 2.

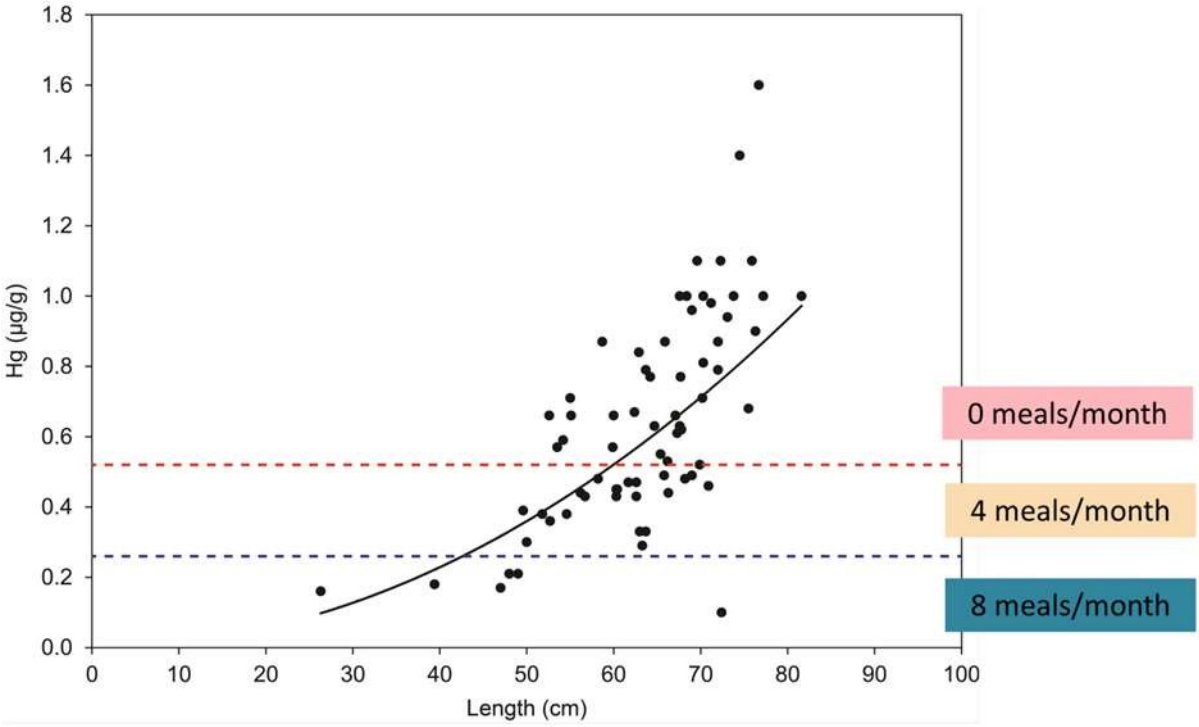

Figure 5. Example of a power regression for calculating fish consumption advisories. Figure from Bhavsar (2016).

2.2.6. Other Tier 3 evidence lines

In addition to virtual fish advisories, spatial comparisons of fish contamination and evaluation of decreases in fish contamination through time, Tier 3 may adopt other evidence lines to show improvement in priority pollutant contamination within the AOC. These evidence lines may draw from MECP, ECCC or other sources of data as identified by the RAP coordinator and RAP technical committees for inclusion and consideration in the BUI #1 assessment. 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 the integrity of the assessment.

2.2.7. Weight of evidence evaluation

Given that Tiers 3 and 4 adopt multiple evidence lines, a weight of evidence (WOE) approach is used to reach a final decision independently in each tier. 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. 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.

The Tier 3 decision matrix will summarize outcomes from each of the quantifiable and qualitative measures. The matrix is interpreted to conclude if the BUI is still impaired or it can be re-designated to “Not Impaired”. Assessors may weigh some evidence lines in priority. For example, data on spatial and temporal comparisons of fish contamination should factor more strongly in the Tier decision than qualitative or quantitative data that indirectly supports improved contaminant recovery in sought after sport fish tissues.

2.2.8. Assessing feasible local restoration actions

Tier 4 is intended to examine evidence lines associated with completed and prospective restoration actions that have been, or can be, undertaken in the AOC to decrease fish contamination and restore the fish consumption beneficial use. In some cases, evidence lines related to Tier 4 simply ask if the restoration actions identified by the AOC Stage 2 report and or Pathways to Delisting document have all been completed or not. For cases where this is a simple binary yes/no question, the restoration actions completed answer can be incorporated into the Tier 3 decision support matrix as another evidence line instead of a separate fourth Tier. In this

case, all actions completed should be weighted in the decision matrix as a support to other Tier 3 evidence lines demonstrating environmental recovery within the AOC.

In some cases, multiple evidence lines may be compiled to support an evaluation of whether or not additional restoration actions in the AOC should be considered. If several evidence lines are to be developed related to prospective restoration activities, it is then recommended to adopt the 4-Tier framework. The focus of these inquiries are to determine if additional restoration actions will have a strong likelihood of reducing fish consumption restrictions or not.

For example, completion of actions removing previously identified sources and/or sediment restoration actions can be interpreted in the context of declining contaminant trends in water, sediments or young-of-the-year forage fish. These evidence lines may be used to infer future patterns of AOC recovery in the context of regional environmental contamination.

Another common evidence line used in Tier 4 assessments relate to fish movements. All fish species have foraging ranges and move over different geographic distances. For some species, these movements may take them out of the AOC, at which point they may be subject to contaminant exposures that are independent of the AOC condition. Recent advances in fish telemetry and placement of telemetry arrays throughout the Great Lakes have created much stronger data sets on fish movements. Where such studies have been completed and interpreted to determine proportion of residency of chosen indicators within and outside the AOC, such information can be incorporated into the Tier 4 assessment. For example, if more than half of tagged individuals released into the AOC are observed to move outside of the AOC, or estimates of time spent inside the AOC are less than 50%, the feasibility of local actions to restore the beneficial use is diminished. Other AOCs have adopted a chemical signature approach to measure fish movements outside of the AOC by calibrating multivariate models to recognize unique chemical signatures in fish caught in adjacent water bodies of the AOC. The multivariate model is then applied to AOC captured fish to assign residency/non-residency status of AOC caught fish.

Other evidence lines related to Tier 4 may be considered at the discretion of the RAP and BUI #1 assessor. For example, in some AOCs, an upstream water body may be shown to be an active source of contamination to the AOC. In such cases, local clean-up actions may be undone by continued influx of contaminated water and/or particles from the adjacent water body.

Where multiple evidence lines are adopted in Tier 4, a decision support matrix and weight of evidence assessment approach is adopted to come to a final decision about the Tier 4 outcome.

2.2.9. Other considerations and potential challenges of BUI #1 assessments

In addition to the framework for a re-designation of the BUI, a number of other factors and potential challenges may be encountered during the assessment.

Limited availability of data can pose a challenge in conducting a thorough assessment of the BUI status or degree of completeness of individual evidence lines used across the tiers. 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.

If temporal trends differ among species within the same location/block, an interpretation of the results would be challenging without examining other ecological or environmental factors such change in fish trophic position and traits. Data gaps uncovered in the assessment should be highlighted and included in Assessment Summaries to guide future data collection efforts and inform future reassessments of the BUI.

By the same taken, BUI #1 assessors should not take an overly pre-cautionary approach. Fully completed data sets across all desired indicator species, size classes, identification of on-going sources, locations of all legacy sediment hots spots and full understanding of ecological profiles of each indicator species will never be fully realized. In addition, outcomes of some evidence lines will likely conflict with others with some supporting and other not supporting a delisting decision. Consultation with RAP technical sub-groups throughout the assessment process can help guide assessor's questions or concerns about data completeness, whether identified data gaps can be feasibly fulfilled in a reasonable amount of time or not, and if there exists sufficient lines of evidence to facilitate an final decision about the BUI status.

3. Toronto and Region BUI #1 Assessment results

3.1 Tier 1 assessment

3.1.1 Identification of sport fish indicator species for the Toronto and Region AOC

Angler surveys conducted by the Toronto and Region Conservation Authority and updates to the MECP province wide angler survey conducted in 2010 were incorporated into the Tier 1 assessment to identify indicator species and species-specific unrestricted monthly meal allowance criteria. AOC specific surveys were conducted in 2018-19 angler surveys and consisted of 95 participants in 2018 and 57 participants in 2019 who identified consuming fish from the Toronto waterfront area. In addition, the province wide MECP 2010 angler survey consisting of more than 12,000 survey responses, was used to extract data for anglers residing from the GTA area and supplement the AOC specific survey information.

Survey questions from both survey sets provided information to help identify frequently sought after fish from the region and monthly meal frequencies were extracted and co-interpreted. Fourteen categories of fish type were identified across the two surveys as being sought after and/or consumed in the GTA and Toronto waterfront area. For the surveys, the percent of

respondents who mentioned consuming a given fish type was compiled and ranked across species. In order to enable direct comparison between the surveys and reduce angler mistakes in self-identified fish identification, species type was categorized into broad categories as opposed to being defined by species. Species type included: Bass, Salmon, Trout, Common Carp, Sunfish, Pike, Yellow Perch, Catfish, Walleye, White Sucker, Crappie, Freshwater Drum, Whitefish or other fish. Bass consisted of Largemouth, Smallmouth and Rock Bass. Salmon consists of Chinook and Coho, Trout consists of Brown, Brook, Lake and Rainbow trout. Sunfish consists of Bluegill, Pumpkinseed and species described as "panfish". Pike consists of Northern Pike and Muskellunge. Catfish consists of Brown Bullhead and Channel Catfish.

Table 2 summarizes the frequency by which each fish type was mentioned as being consumed in the AOC or by anglers from the MECP GTA survey. For the MECP surveys, frequency of fish captures was assessed as the percent of respondents who identified one of the fish types as part of their top 3 most frequently sought after fish. The top eleven categories of fish type were mentioned as being consumed by 1% or more of survey participants. These included: Bass, Salmon, Trout, Common Carp, Sunfish, Pike, Yellow Perch, Catfish, Walleye, White Sucker and Crappie. Freshwater Drum and Whitefish were excluded since they were infrequently reported as being consumed by either GTA or AOC anglers.

Some of the fish species identified as consumed fish categories did not have any official fish consumption advisories in place for the AOC. For example, no official advisories are issued for either of the two salmon species even though these were mentioned as being consumed from the region. For Trout, fish advisories are available for Brown Trout and Rainbow Trout but not Brook or Lake Trout. Likewise, no AOC specific advice information was available for Channel Catfish, Crappie or Muskellunge. Thus, selection of indicator species was limited to those species for which official fish consumption restrictions are in place and for species identified as being consumed by local anglers or anglers from the GTA area by more than 1% of survey respondents. Based on this 13 species were identified as AOC indicators listed below : *Smallmouth Bass, Largemouth Bass, Rock Bass, Brown Trout, Rainbow Trout, Common Carp, Bluegill Sunfish, Pumpkinseed, Northern Pike, Yellow Perch, Brown Bullhead, Walleye and White Sucker*

Table 2. Identification of frequently captured and consumed fish from the AOC and by GTA anglers.

Species	AOC (% respondents that mentioned consuming the fish species)	GTA (% or respondents who identified fish among top 3 most consumed fish)
Bass (Smallmouth, Largemouth, Rock)	**21.6%**	**31%**
Salmon (Chinook, Coho)	**14.8%**	**4.6%**
Trout (Brown, Brook, Lake, Rainbow)	**14.2%**	**12.7%**
Common Carp	**11.7%**	0.2%
Sunfish (bluegill, pumpkinseed, panfish)	**6.8%**	**2.7%**
Pike (Northern pike, Muskellunge)	**6.8%**	**8.5%**
Yellow Perch	**6.2%**	**11.6%**
Catfish (Channel catfish, Brown bullhead)	**4.3%**	**2.2%**
Walleye	**4.3%**	**18.7%**
White Sucker	**3.1%**	NA
Crappie	1.2%	**3.2%**
Freshwater Drum	0.6%	NA
Whitefish	NA	**1.3%**
Other fish	4.3%	3.0%

AOC data generated from Toronto and Region Conservation Authority (Little and Liznick, 2018 and 2019)
GTA data generated from 2010 MECP Fish Angler Survey – data censored to GTA residents.

3.1.2 Species specific unrestricted monthly meal allowance criteria

Given available recent information on fish consumption frequency estimates from the AOC and GTA angler surveys, a species-specific set of unrestricted monthly meal allowance criteria were evaluated for the Tier 1 assessment. Based on the AOC angler survey anglers were asked to identify how often they consumed their top sought after fish and mean monthly frequencies of each fish type were determined. In addition, we compiled the maximum response for monthly meal frequencies identified by AOC anglers and compared it to the closest MECP monthly meal allowance categories used by the Guide to Eating Fish. Data from the MECP angler survey of GTA residents were used to compile how frequently fish identified as among the top 3 most sought after fish were consumed per month. Table 3 summaries the results by species for each survey. Where both surveys differed in maximum monthly meal frequency reported, the highest estimate was taken and used to designate the most appropriate unrestricted meal allowance criteria to be adopted for that species.

Seven of the 13 identified indicator species were identified to have an unrestricted monthly meal allowance criteria of 8 meals per month. This is the same unrestricted criteria adopted in the 2016 assessment report but applied across all species assessed. The remaining 4 species: Common Carp, Bluegill Sunfish, Pumpkinseed and Brown Bullhead had fewer reported monthly meal consumptions by anglers from the region. For these species, the unrestricted monthly meal allowance criteria was set to 4 meals per month. The authors note large discrepancy between the AOC and MECP angler surveys in maximum meal consumption of Walleye. The AOC survey indicates local anglers consume up to 2 meal/month while the more general MECP-GTA respondents indicated up to 8 meal/month consumption of this species. The discrepancy likely results from more generalized geographic fishing regions incorporated by GTA respondents compared to anglers from the AOC survey. For purposes of this assessment, the more conservative unrestricted monthly meal target of 8 meals per month was selected for this species.

Table 3. Reported monthly meal frequencies by AOC and GTA Anglers of indicator species and assigned species specific unrestricted monthly meal allowance criteria.

Species	AOC 2018/19 Max Reported Meals/Month	GTA – MECP 2010 Survey Max Meal Category with > 1% participants consuming from top 3 most sought after fish	Assigned Species Unrestricted Threshold
Bass (Smallmouth, Largemouth, Rock)	**5 (smallmouth, largemouth)**	**8 (16.8% 2nd fish)**	**8**
Salmon (Chinook, Coho)	**5 (chinook)**	**2-3 (Chinook 5.8%, 3rd fish); 1 (Coho; 7.5%; 2nd)**	**8**
Trout (Brown, Brook, Lake, Rainbow)	**5 (rainbow)**	**2-3 (Brook; 6.7%, 2nd); 2-3 (Brown; 6.5%; 1st)** **2-3 (Lake; 1.1%; 2nd); 1 (Rainbow 7.9%; 1st)**	**8**
Common Carp	**4**	2-3 (2.5%; 1st)	**4**
Sunfish (bluegill, pumpkinseed, panfish)	**2**	**Rarely <1/month (Bluegill; Pumpkinseed); 2-3 (Panfish 6.5%, 2nd)**	**4**
Pike (Northern, Musk.)	**5**	**8 (N. Pike 12.7%, 2nd); 4 (Muskellunge; 16.8% 3rd)**	**8**
Yellow Perch	**5**	**8 (11.9%; 3rd)**	**8**
Bullhead/Catfish	**1**	**2-3 (6.8%; 2nd)**	**4**
Walleye	**2**	**8 (39.5%; 1st)**	**8**
White Sucker	**2**	Not Identified	**4**

3.1.3 Tier 1 data interpretation

Table 4 summarizes the official MECP monthly meal advice issued to the sensitive population for all species for which advisories are issued. Species and size classes highlighted in red have monthly meals advice more restrictive than the species specific unrestrictive meal allowance. Indicator species: Brown Trout, Common Carp, Rainbow Trout, Largemouth Bass, Northern Pike, Smallmouth Bass, Walleye, White Sucker and Yellow Perch failed to meet the unrestricted threshold criteria. Species highlighted in green met the unrestricted criteria. These included: Bluegill Sunfish, Brown Bullhead, Pumpkinseed and Rock Bass. Non-highlighted species include species for which fish advice is issued but are not frequently consumed by the local angler community and were excluded from the Tier 1 assessment.

Table 5 summarizes the official MECP monthly meal advice issued to the general population. Species failing the Tier 1 General Population assessment included: Brown Trout, Common Carp, Rainbow Trout, Largemouth Bass, Walleye and White Sucker. Indicators that met the criteria for the General Population included Bluegill Sunfish, Brown Bullhead, Pumpkinseed and Rock Bass.

3.1.4 Tier 1 conclusion

Table 6 provides a summary of pass/fail status of the Tier 1 criteria across each indicator species evaluated. Several fish consumption advisories issued to selected indicator species in the Toronto and Region AOC failed to meet the Tier 1 criteria. For the Sensitive Population, 45.5% (35/77) of advisories issued were more restrictive than the species specific unrestricted monthly meal allowance criteria. For the General Population, 36.3% (28/77) of advisories issued to indicator species were more restrictive than the unrestricted monthly meal allowance criteria. However, four species: Bluegill Sunfish, Brown Bullhead, Pumpkinseed and Rock Bass passed the Tier 1 criteria for both the sensitive and general populations. The latter species were therefore removed from further consideration in Tier 2 assessments. *Overall, Tier 1 is judged to Fail the general Tier 1 criteria for the AOC.*

Table 4. Fish consumption restrictions for the sensitive population for indicator species in the Toronto and Region AOC

Tier 1 Data Interpretation Sensitive Population													
Published fish consumption advisories for the Toronto waterfront Area. Values are in meals/month, for the sensitive populations. Superscripts 1, 2, 3 and 51 are for advisories caused by mercury, PCB, dioxin-like PCB and Hg-PCB respectively.													
Tier 1 Sensitive	**(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** [2]	16	12											
***Brown Bullhead** [2,3]	32	16	12	8	4								
***Brown Trout** [2,3]		12	8	4	4	0	0	0	0	0	0	0	0
***Common Carp** [2]					0	0	0	0	0	0	0	0	0
Freshwater Drum [2]								0	0	0	0		
Gizzard Shad [2]					0	0	0	0					
***Pumpkinseed**	16												
***Rainbow Trout**		0	0	0	0	0	0						
***Largemouth** [2,51]	16	16	12	12	8	4	0						
***Northern Pike** [2.51]		16	16	16	16	16	16	16	12	12	8	8	0
Rainbow Smelt [2]	0	0	0										
Redhorse Sucker [2]						0	0						
***Rock Bass** [2]	16	12											
***Smallmouth Bass**		**8**	**8**	8	4								
***Walleye** [1,51]									4	0	0	0	
White Bass [2]		0	0	0	0								
White Perch [2]	4	0											
***White Sucker** [2]	16	12	12	12	12	12	8	8	0				
***Yellow Perch** [2]	32	16	16	4									
* Indicator Species – among top 10 consumed fish from AOC													

Table 5. Fish consumption restrictions for the sensitive population for indicator species in the Toronto and Region AOC

Tier 1 Data Interpretation General Population													
Published fish consumption advisories for the Toronto waterfront Area. Values are in meals/month, for the general populations. Superscripts 1, 2, 3 and 51 are for advisories caused by mercury, PCB, dioxin-like PCB and Hg-PCB respectively.													
Tier 1 General	**(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** [2]	16	16											
***Brown Bullhead** [2,3]	32	16	12	8	4								
Brown Trout [2,3]		12	8	4	4	2	2	1	1	1	1	0	0
***Common Carp** [2]					2	0	0	0	0	0	0	0	0
Freshwater Drum [2]								1	1	0	0		
Gizzard Shad [2]					0	0	0	0					
***Pumpkinseed**	32												
***Rainbow Trout**		2	2	1	1	0	0						
***Largemouth** [2,51]	32	16	16	16	8	8	4						
***Northern Pike** [2.51]		16	16	16	16	16	16	16	16	16	12	12	8
Rainbow Smelt [2]	1	0	0										
Redhorse Sucker [2]						2	1						
***Rock Bass** [2]	16	12											
***Smallmouth Bass**		**8**	**8**	8	8								
***Walleye** [1,51]									12	8	4	4	
White Bass [2]		0	0	0	0								
White Perch [2]	4	1											
***White Sucker** [2]	16	12	12	12	12	12	8	8	2				
***Yellow Perch** [2]	32	32	16	12									

Table 6. Tier 1 assessment by indicator species summary.

Species	Tier 1 General Pass/Fail	Tier 1 Sensitive Pass/Fail
Bluegill	☑	☑
Brown Bullhead	☑	☑
Brown Trout	☒	☒
Common Carp	☒	☒
Pumpkinseed	☑	☑
Rainbow Trout	☒	☒
Northern Pike	☑	☒
Largemouth	☒	☒
Rock Bass	☑	☑
Smallmouth Bass	☑	☒
Walleye	☒	☒
White Sucker	☒	☒
Yellow Perch	☑	☒

3.2 Tier 2 assessment

Tier 2 addresses degree of fish consumption restrictiveness in the AOC compared to reference sites. For the purpose of this report all MECP fishing zones from Lake Ontario were utilized with the exception of fishing zones that are designated as AOCs. Figure 6 demonstrates the fishing zone locations used for reference. The MECP fishing zones included as references correspond to zones: 1a, 2a, 2z, 2, 4, 5, 5z, 6a, 6b, 6v, 6w, 6x, 6,y, 6z, 6, 8, 10, 11 and 12. Excluded from the reference site list were zones 3 (Hamilton Harbour); 1b (Lower Niagara River) and zones 9, 9a and 9b which correspond to the Bay of Quinte AOC. Data on fish consumption advisories for each indicator species and their respective size classes were compiled across the references and the median monthly meal allowance across the reference sites for a given size interval of fish were computed. This computed median monthly meal advice for reference sites was then compared to the MECP fish consumption restriction for the same indicator species and size interval in the AOC. Where the fish consumption advisory was more restrictive than the reference criteria, the condition was considered to fail the criteria. The analysis was repeated separately for fish consumption advisories issued to both the Sensitive and General Populations.

3.2.1 Tier 2 data interpretation:

A set of 18 tables were compiled (2 tables for each of the nine indicator species that failed Tier 1 across for each of the two populations, Sensitive and General populations). An example table for fish advisories issued for the general population for Yellow Perch is provided by Table 7. In this example, fish advisories for Yellow Perch in the AOC were issued to the General population for 4 size classes of fish. The monthly meal allowances in the AOC ranged from 12 to 32 meals per month. The median reference monthly meal allowances ranged from 8 to 32 meals per month. There were no size classes where the advisory in the AOC was more restrictive than the median monthly meal allowance across the reference sites. Therefore, the Tier 2 criteria passes for Yellow Perch for the general population.

3.2.2 Tier 2 conclusion

Table 8 provides a summary of the Tier 2 assessment across the indicator species and populations. There were three species that passed the Tier 2 criteria for both populations. These included Largemouth Bass, Smallmouth Bass and Yellow Perch. These species were therefore excluded from subsequent assessments in Tier 3. The remaining indicator species failed for one or both populations. Tier 2 failed for Brown Trout, Common Carp, Rainbow Trout, Northern Pike, Walleye and White Sucker. *Overall, Tier 2 is judged to fail the general criteria.*

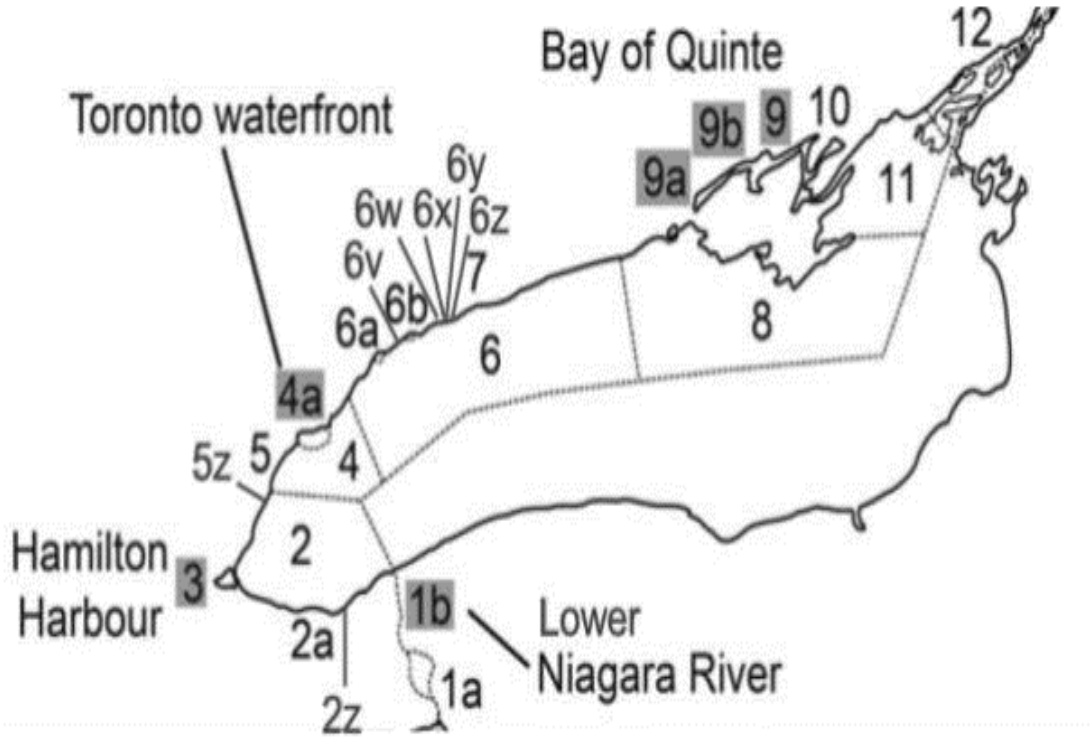

Figure 6. Reference sites used for Tier 2 Assessment. Fishing zone numbers correspond to MECP Guide to Eating Fish zone identification scheme. Fishing zones highlighted in grey are designated AOCs and excluded from the reference data set used in Tier 2.

Table 7. Example of Tier 2 assessment table for yellow perch advisories issued for the general population.

	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)	Size (cm)
Location	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
01a Upper Niagara River	32	32	16	16									
2a Jordan Harbour	12												
2z Martindale Pond	32	16	16										
2 western Lake Ontario	8	8	8	8									
04 Toronto Offshore Area	16	16	16	8									
05a Rattray Marsh													
06 Northwestern Lake Ontario	12	12	12										
06a Frenchman Bay	16	16	16										
06v - Lynde Creek Marsh	16												
06w - Oshawa Harbour	32	32											
06x - McLaughlin Bay	32												
06y - Weside Marsh	32	32											
07 Lake Ontario Ganaraska River													
10 - Middle Bay of Quinte	32	32	16										
11 Lower Bay of Quinte/East L. Ontario	32	32	16										
Number of Advisories	13	10	8	3	0	0	0	0	0	0	0	0	0
Median	32	24	16	8	NA	NA	NA	NA	NA	NA	NA	NA	NA
04a Toronto Waterfront Area	32	32	16	12									
Fails Median # Ref Meals	0	0	0	0									

Table 8. Summary of Tier 2 assessment across Toronto and Region AOC indicator species

Indicator Species	General Population Median Allowable Meals Across References	Sensitive Population Median Allowable Meals Across References
Brown Trout	Fails (1/12 Sizes)	Passes
Common Carp	Fails (8/9 Sizes)	Fails (5/9 Sizes)
Largemouth Bass	Passes	Passes
Smallmouth Bass	Passes	Passes
Yellow Perch	Passes	Passes
Rainbow Trout	Fails (6/6 Sizes)	Fails (6/6 Sizes)
Northern Pike	Passes	Fails (1/12 Sizes)
Walleye	Passes	Fails (1/5 Sizes)
White Sucker	Fails (1/9 Sizes)	Fails (1/9 Sizes)

3.3 Tier 3 assessment

Six indicator species which failed at the Tier 2 assessment level were further assessed at the Tier 3 level. The Tier 3 assessment included 3 evidence lines as described below:

3A – Recompute Virtual Advisories based on the most recent (2009-2021 fish contaminant data from the AOC) and compare virtual fish consumption advisories against Tier 1 and Tier 2 criteria.

3B – Compare Hg and PCBs concentrations in indicator fish species over the 2009-2021 year interval and determine if statistical differences occur between the AOC and reference.

3C –Examine for Temporal declines in mercury or PCBs in indicator fish species from the AOC with time.

3.3.1 Tier 3A evidence line:

Virtual monthly meal advisories were calculated for each indicator species using the most recent contaminant records generated between 2009-2021. For each species, MECP contaminant records for mercury and PCBs and fish total length (cm) were compiled from a given indicator collected from the AOC. Linear regressions were performed on log transformed contaminant concentrations (mercury or PCBs separately) as a function of fish total length. Where there was a significant positive relationship between fish size and fish contamination, the regression model was used to estimate the mean contaminant concentration at the mid-point length for each 5 cm size interval over the range of sizes over which fish samples were available. Where there was a non-significant relationship between fish size and contamination, the mean chemical concentration for each 5 cm size interval was computed across size intervals where data were available. The mean concentration for each size interval was then translated into a chemical-specific virtual monthly meal allowance using the MECP benchmark values (Table 1). Chemical specific virtual advisories for a given size class were contrasted and the most stringent monthly meal allowance between the two priority contaminants was applied as the virtual monthly meal allowance for that size class and species. This virtual monthly meal allowance was then compared to Tier 2 criteria described in Section 3.2.

3.3.1.1 Tier 3A Brown Trout

For Brown Trout there were 17 records for mercury and 19 records for PCBs collected from the AOC from 2009-2019. Both contaminants exhibited a highly significant ($p<0.001$; ANOVA) positive relationship between fish contaminant concentration and body size. For mercury, the regression between total length (cm) and log mercury concentration (ug/g) was provided by the following regression model:

$$\text{Log Hg}_{(\text{brown trout})} = 0.0129 \cdot \text{Length (cm)} - 1.701;\ R^2 = 0.74;\quad P < 0.001$$

For PCBs the regression between total length (cm) and log PCB concentration (ug/g) was:

$$\text{Log PCBs}_{(\text{brown trout})} = 0.0226 \cdot \text{Length (cm)} + 1.303;\ R^2 = 0.37;\ P<0.01$$

For all size classes, PCBs generated the most stringent virtual meal advice for this species. Table 9 summarizes the virtual meal allowances by size class for the Brown Trout indicator referenced against the median of reference site monthly meal allowances generated in the Tier 2 assessment. *All of the virtual meal allowances for Brown Trout passed the Tier 3A criteria.*

3.3.1.2 Tier 3A Common Carp

For Common Carp there were 33 records available for mercury and 39 records for PCBs from indicator fish over the 2009-2017 time interval. For mercury, there was a highly significant relationship between mercury concentration and fish size described by:

$$\text{Log Hg}_{(\text{carp})} = 0.009 \cdot \text{Length (cm)} - 1.569;\ R^2 = 0.22; \qquad P < 0.01$$

However, for PCBs the relationship between fish size and PCB contamination was non-significant. Closer analysis revealed that the lack of statistical relationship was driven by a single high outlier fish from the 42 cm size interval which had the highest recorded PCB concentration 4600 ng/g across samples collected. Exclusion of this outlier yielded a highly significant relationship between fish size and PCB concentration. The PCB concentration in Common Carp vs fish size relationship and outlier identification is provided in Figure 7.

The outlier fish was removed from the power regression relationship and the regression used to compute virtual advisories for PCBs in this indicator according to the relationship:

$$\text{Log PCB}_{(\text{carp})} = 0.0239 \cdot \text{Length (cm)} + 0.940;\ R^2 = 0.20; \qquad P < 0.01$$

Similar to Brown Trout, PCBs contributed to the most stringent virtual advice information for all size classes of Common Carp. Virtual advisories for Common Carp relative to Tier 2 criteria are summarized in Table 10. *For all size classes, the virtual meal advisories in this indicator species were less or equivalent to the Tier 2 criteria indicating that this species passes Tier 3A.*

Table 9. Comparison of virtual meal advisories for Brown Trout based on 2009-2019 PCB and Hg concentrations in AOC fish against the official monthly meal allowances in Lake Ontario reference locations.

Brown Trout (2009-19)	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70
Tier 2 Ref GP	4	4	4	4	2	2	2	1	1	0
Tier 2 Ref SP	4	4	4	4	0	0	0	0	0	0
AOC Virt GP	**12**	**8**	**4**	**4**	**4**	**2**	**2**	**2**	**1**	**1**
AOC Virt SP	**12**	**8**	**4**	**4**	**4**	**0**	**0**	**0**	**0**	**0**

Ref = median reference site official MECP advisories for General Population (GP) and Sensitive Population (SP). Virt GP = Virtual advisory calculated for a given population.

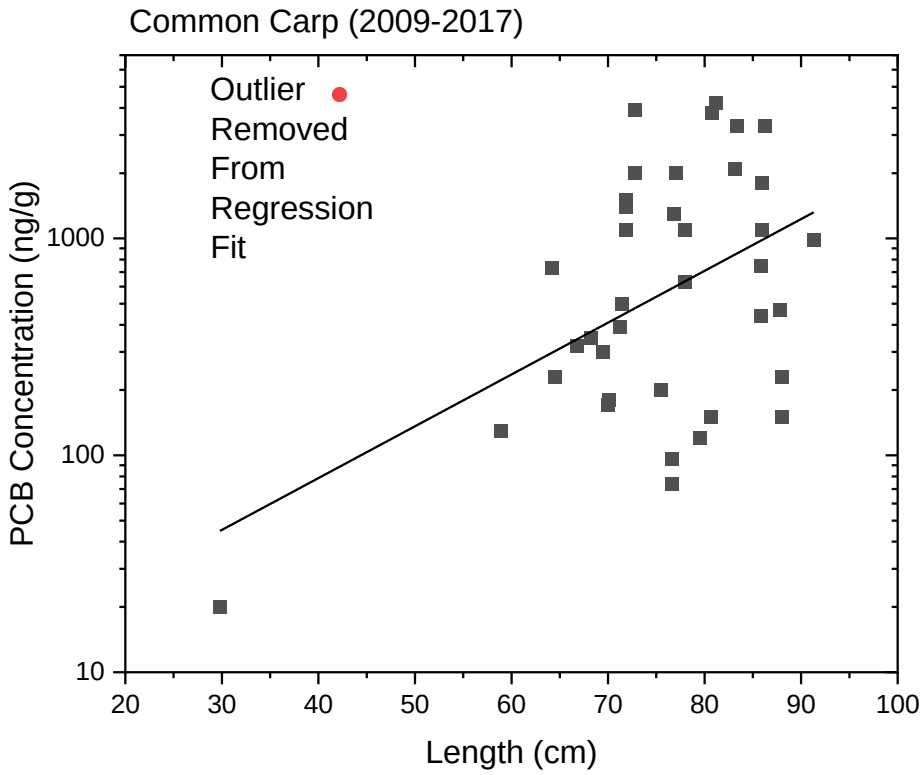

Figure 7. PCBs in common carp from the AOC as a function of fish length. Red circle indicates outlier fish removed from the regression relationship specified by the solid black line.

Table 10. Comparison of virtual meal advisories for Common Carp based on 2009-2017 PCB and Hg concentrations in AOC fish against the Tier 2 criteria.

Common Carp (2009-17)	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-70	75+
Tier 2 Ref GP	16	16	12	8	4	4	2	2	2	1	0
Tier 2 Ref SP	16	16	12	8	4	4	0	0	0	0	0
AOC Virt GP	**16**	**16**	**8**	**8**	**4**	**4**	**4**	**2**	**2**	**1**	**1**
AOC Virt SP	**16**	**16**	**8**	**8**	**4**	**4**	**4**	**0**	**0**	**0**	**0**

Ref = median reference site official MECP advisories for General Population (GP) and Sensitive Population (SP). Virt GP = Virtual advisory calculated for a given population.

3.3.1.3 Tier 3A Northern Pike

For Northern Pike there were 68 records for mercury and 58 records for PCBs collected over the 2009-2017 year interval. Fish contamination versus size relationships were highly significant for both mercury and PCBs and therefore the power regression relationships were used to compute virtual advice information. For mercury the regression between fish size and log mercury concentration was given by:

$$\text{Log Hg}_{(\text{Pike})} = 0.0168 \cdot \text{Length (cm)} - 1.961;\ R^2 = 0.63; \qquad P < 0.001$$

For PCBs the regression relationship was:

$$\text{Log PCBs}_{(\text{Pike})} = 0.00915 \cdot \text{Length (cm)} + 1.241;\ R^2 = 0.16; \qquad P < 0.01$$

As shown in the Table 11, Northern Pike passes at the tier 3A virtual advisories analysis for both the general and sensitive populations.

3.3.1.4 Tier 3A Rainbow Trout

For Rainbow Trout, there were only 2 mercury and 2 PCB records available over the 2009-2019 interval. The two records corresponded to 21.3 and 43.1 cm fish, respectively. Mercury concentrations ranged from 0.01 to 0.09 ug/g corresponding to 16 and 32 meals/month virtual advisories at the highest measured concentration. PCB concentrations in the two records were 40 and 43 ng/g corresponding to 16 meals/month virtual advice related to PCB concentrations. However, the data on this indicator species was considered insufficient to generate virtual fish advice information.

3.3.1.5 Tier 3A Walleye

For the Walleye, there were 12 records available for both mercury and PCBs collected between 2014-2019. There was a significant relationship between mercury concentration in walleye and fish size according to the relationship:

$$\text{Log Hg}_{(\text{walleye})} = 0.0264 \cdot \text{Length (cm)} - 2.145;\ R^2 = 0.51; \qquad P < 0.01$$

However, there was no significant relationship between walleye PCB concentration with size. As such, mean PCB concentrations were computed for each size interval where records were available. This included 35-40 cm, 40-45 cm, 45-50 cm, 65-70 cm and 70-75 cm fish which had mean PCB concentrations ranging from 28 ng/g to 58.3 ng/g, respectively. Computed virtual advisories were generated by mercury for all size classes of fish. Table 12 summarizes the Tier 3A assessment for the walleye indicator. All size classes passed the Tier 3A criteria, however, the authors do note that the analysis for this indicator would be improved as more records become available.

Table 11. Comparison of virtual meal advisories for Northern pike based on 2009-2017 PCB and Hg concentrations in AOC fish against the Tier 2 criteria.

Northern Pike (2009-17)	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-70	75+
Tier 2 Ref GP	12	8	8	8	8	12	8	8	8	8	8	8
Tier 2 Ref SP	12	8	8	8	8	8	8	4	4	4	4	4
AOC Virt GP	**16**	**16**	**16**	**16**	**16**	**16**	**16**	**12**	**12**	**8**	**8**	**8**
AOC Virt SP	**16**	**16**	**16**	**16**	**16**	**16**	**16**	**12**	**12**	**8**	**8**	**8**

Ref = median reference site official MECP advisories for General Population (GP) and Sensitive Population (SP). Virt GP = Virtual advisory calculated for a given population.

Table 12. Comparison of virtual meal advisories for Walleye based on 2014-2019 PCB and Hg concentrations in AOC fish against the Tier 2 criteria.

Walleye (2009-19)	35-40	40-45	45-50	50-60	55-60	60-65	65-70	70-72
Tier 2 Ref GP	12	12	8	8		4	2	2
Tier 2 Ref SP	12	8	4	4		4	0	0
AOC Virt GP	**16**	**16**	**12**	**12**	**12**	**12**	**8**	**8**
AOC Virt SP	**16**	**16**	**12**	**8**	**8**	**4**	**4**	**0**

Ref = median reference site official MECP advisories for General Population (GP) and Sensitive Population (SP). Virt GP = Virtual advisory calculated for a given population.

3.3.1.6 Tier 3A White Sucker

For White Sucker there were 55 records for mercury and 47 records for PCBs. Both contaminants demonstrated a highly significant relationship between fish contamination and fish size. For mercury, the relationship was given by:

$$\text{Log Hg}_{(\text{wh sucker})} = 0.0226 \cdot \text{Length (cm)} - 2.106;\ R^2 = 0.38;\quad P < 0.001$$

For PCBs, the relationship was given by:

$$\text{Log PCB}_{(\text{wh sucker})} = 0.0198 \cdot \text{Length (cm)} + 1.20;\ R^2 = 0.36;\quad P < 0.001$$

Virtual meal advisories in White Sucker were driven by PCBs for all size classes of fish and ranged from 2 to 16 meals per month. Table 13 summarizes the virtual advisories in White Sucker compared to the Tier 2 criteria. All size classes except the 55-60 cm size passed the tier 1 criteria. Fish from the 25-55 cm size intervals had more stringent advice than the median reference monthly meal allowance but because they passed Tier 1 criteria, the exceedances in these intervals did were deemed to not fail. However, the largest size class failed the Tier 3A criteria with a virtual meal advice of 2 and 0 meals per month for the General and Sensitive populations relative to 4 meals per month criteria for the reference. *Therefore, White Sucker fails the Tier 3A criteria.*

3.3.2 Tier 3B evidence line:

Tier 3B uses statistical approaches to test for differences in fish contamination between the AOC and reference for individual priority pollutants and indicator species. In this portion of the report, tests were performed on PCB and mercury fish contamination and compared between AOC and reference. Fish chemistry data records were limited to the time interval between 2009-2019. Data were compiled on fish contaminant records from the MECP sport fish database for each indicator species from both the AOC and from across Lake Ontario reference zones described in section 3.2. Fish records from different reference sites were combined together as a single 'reference' treatment to facilitate statistical comparisons.

Data were first examined to establish if a fish contamination with fish size relationship was present in the data sets. Where there were statistically similar slopes between fish contamination of a given priority pollutant vs fish size between the AOC and reference, an analysis of covariance (ANCOVA) was used to test for differences in the size adjusted fish contamination within the AOC compared to reference. For cases where the slopes between fish contamination and fish body length were statistically different for the AOC and reference, selected sizes from the upper size range of the indicator species were examined separately using analysis of variance (ANOVA). The largest size interval was selected for testing because this size interval generally produces the most stringent fish restrictions. Size intervals were kept to 5 cm size intervals where statistical power permitted (n>5 fish from the AOC), however, where insufficient sample

Table 13. Comparison of virtual meal advisories for White Sucker based on 2009-2017 PCB and Hg concentrations in AOC fish against the Tier 2 criteria.

White Sucker (2009-17)	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Tier 2 Ref GP	16	16	16	16	16	12	12	8	4
Tier 2 Ref SP	16	16	16	16	16	8	8	4	4
AOC Virt GP	**16**	**16**	**12**	**12**	**8**	**4**	**4**	**4**	**2**
AOC Virt SP	**16**	**16**	**12**	**12**	**8**	**4**	**4**	**4**	**0**

Ref = median reference site official MECP advisories for General Population (GP) and Sensitive Population (SP). Virt GP = Virtual advisory calculated for a given population. *Note size intervals 25-55 cm had virtual advisories that exceeded the reference site but were equal or less stringent then the Tier 1 unrestricted meal allowance criteria for white sucker. Only 55+ cm fish exceeded the Tier 1 critieria as well as the median reference monthly meal advice.

size was available, the interval was expanded to 10 or 15 cm size intervals. In each case, a probability of <0.05 was used to establish the criteria for significant differences.

3.3.2.1 Tier 3B Brown Trout

There were 182 records of mercury concentrations in Brown Trout from reference sites over the 2009-2019 year interval (22.1-69 cm size range) and 17 records (21.6 – 67.2 cm) from the AOC. Analysis of covariance revealed no significant differences in the mercury concentration vs size relationship between the AOC and reference (Figure 8). After adjusting for size, ANCOVA revealed no significant difference ($p>0.8$) in mercury contamination in AOC fish compared to the reference.

For PCBs, there were 183 records of Brown Trout (19.6 – 80.2 cm size range) and 19 records (21.6 – 67.2 cm) from the AOC. There were significant differences between the PCB vs fish body length slope between the AOC and reference precluding use of ANCOVA to perform statistical size adjustment (Figure 9). There were only 3 fish in the largest AOC size interval (65-70 cm) and therefore the tested size interval was expanded to 60-70 cm fish to enable ANOVA to be performed with higher statistical power. Across the 60-70 cm size interval there were n=8 fish from the AOC and n=42 fish from the reference. For the tested size interval, there was a highly significant difference ($p<0.002$) between AOC and reference, with PCB concentrations being elevated in the AOC at the highest size range compared to the reference.

The mean±standard deviation concentration of PCBs in 65-65 cm and 65-70 cm fish was 1066±637 and 540±259 ng/g. The above concentrations correspond to a no consumption virtual advisory for both size classes in the sensitive population and a no consumption virtual advisory for the 60-65 cm interval for the general population and 1 meal/mo for the 65-70 cm interval. The deviation between these results and those of Tier 3A for the general population in this species is due to the use of computed mean concentrations for the size interval as opposed to the power regression approach adopted for virtual advice calculations.

Close inspection of Figure 9 reveals that the differences in PCB concentrations in AOC vs reference are driven by a minority of samples (3 fish; 2 in the 60-65 cm size range and 1 fish that was 42.5 cm) that lie well outside the range of PCB contamination values present in combined reference data. Two of these outlier fish fell within the tested size interval and had an undo influence on the statistical test. For example, if the data are restricted to testing the largest size class (65-70 cm), there would be no statistical differences between the AOC and reference. *Authors note that 16/19 records (i.e. 84% of AOC records) fall within the range of PCB concentrations measured in reference for Brown Trout samples. However, Tier 3b fails the criteria for Brown Trout.*

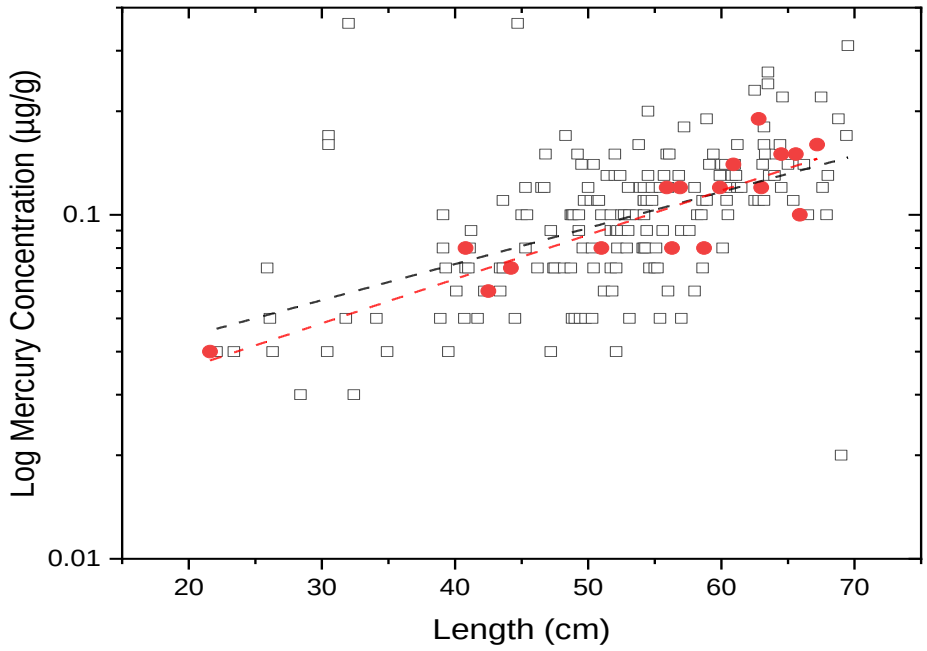

Figure 8. Mercury concentration as a function of size in brown trout from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits for AOC and reference datasets.

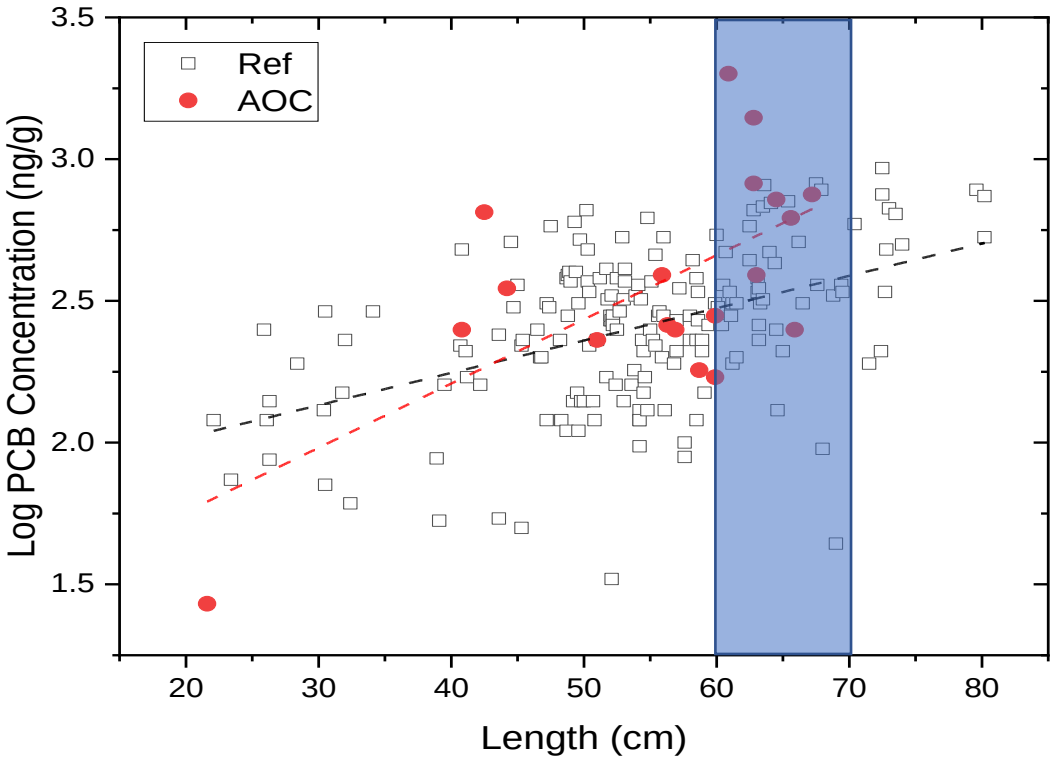

Figure 9. PCB concentration as a function of size in brown trout from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits for AOC and reference datasets. Shaded area represents the size interval selected for performing statistical comparisons between PCB concentrations in AOC and Reference.

3.3.2.2 Tier 3B Common Carp

For Common Carp there 132 records (17 – 93 cm size range) of mercury contamination from the combined reference data sets and 32 records (42.2 – 91.3 cm) from the AOC. The slope of the mercury vs size relationship was significantly different for the AOC and reference necessitating that specific size intervals be selected for comparison (Figure 10). The largest size class of fish from the AOC was 85+ cm fish with n=6 records from the AOC and n=4 records from the reference. To increase statistical power, the size interval was expanded to 80-90 cm sized fish yielding n=11 fish from the AOC and 14 fish from the reference. ANOVA revealed a non-significant difference between mercury concentrations of Common Carp from the AOC and reference for the 80-90 cm size interval of fish.

For PCBs, there were 130 records (17 – 93 cm size range) from the combined reference sites and 39 records (29.8- 91.3 cm) from the AOC. Analysis of covariance revealed a non-significant difference between the PCB concentration vs fish size relationship for the AOC and reference (Figure 11). After adjusting for size, there was a non-significant difference in PCB concentrations in common carp from the AOC and reference. *Overall, Common Carp passes the Tier 3B criteria.*

3.3.2.3 Tier 3B Northern Pike

For Northern Pike there 130 records (22-97.7 cm size range) of mercury contamination from 2009-2019 from the reference and 68 records (21.4- 86.2 cm) from the AOC. Analysis of covariance revealed no significant differences in the slopes of the mercury contamination vs fish body length relationship between the AOC and Reference (Figure 12). After size adjustment, mercury concentrations in the AOC were highly significantly lower than the reference.

For PCBs, there were 78 records (26.7 – 89 cm size range) from the reference and 57 records (21.4 – 86.2 cm) from the AOC. Analysis of covariance revealed significant differences between the PCB vs fish body size slope from the AOC and reference. The 75-90 cm size interval was selected for examination contained n=6 records from the AOC and n=17 records from the reference. Analysis of variance revealed a significant difference between the AOC and reference, with the AOC having a higher overall concentration than the reference (Figure 13). *However, the PCB concentration in 75+ cm sized fish, the largest size interval in the Guide to eating sportfish was 76.5±30.8 ng/g corresponding to a virtual fish advisory of 8 meal/mo for both the Sensitive and General population*. This concentration would meet the Tier 1 unrestricted meal allowance category. *Given the weight of evidence, Northern Pike is recommended to pass the Tier 3B criteria.*

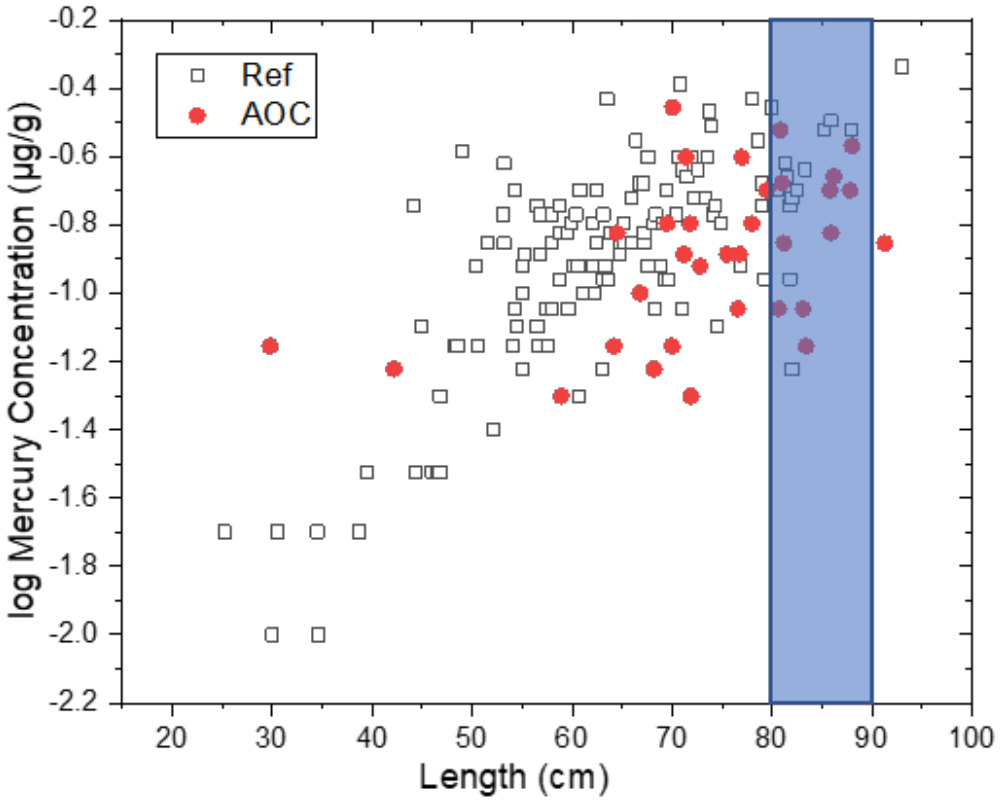

Figure 10. Mercury concentration as a function of size in common carp from the reference (hollow squares) and AOC (solid circles). Shaded area represents the size interval selected for performing statistical comparisons of mercury contamination differences between AOC and Reference.

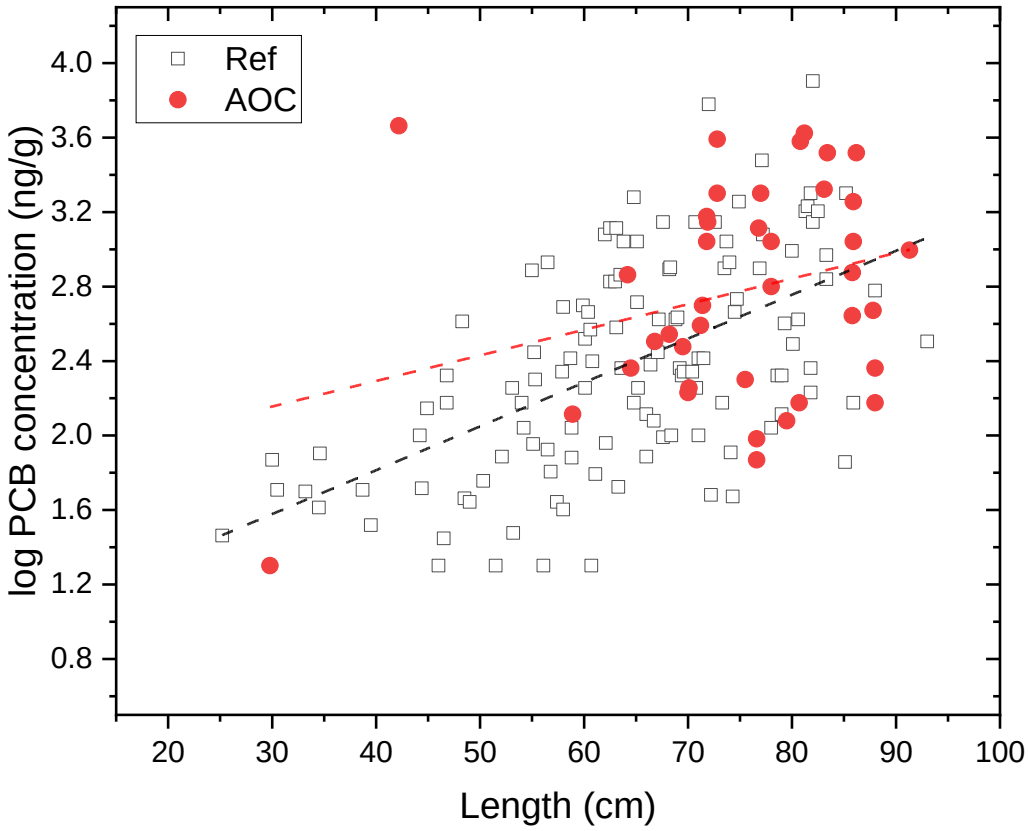

Figure 11. PCB concentration as a function of size in common carp from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits to each data set.

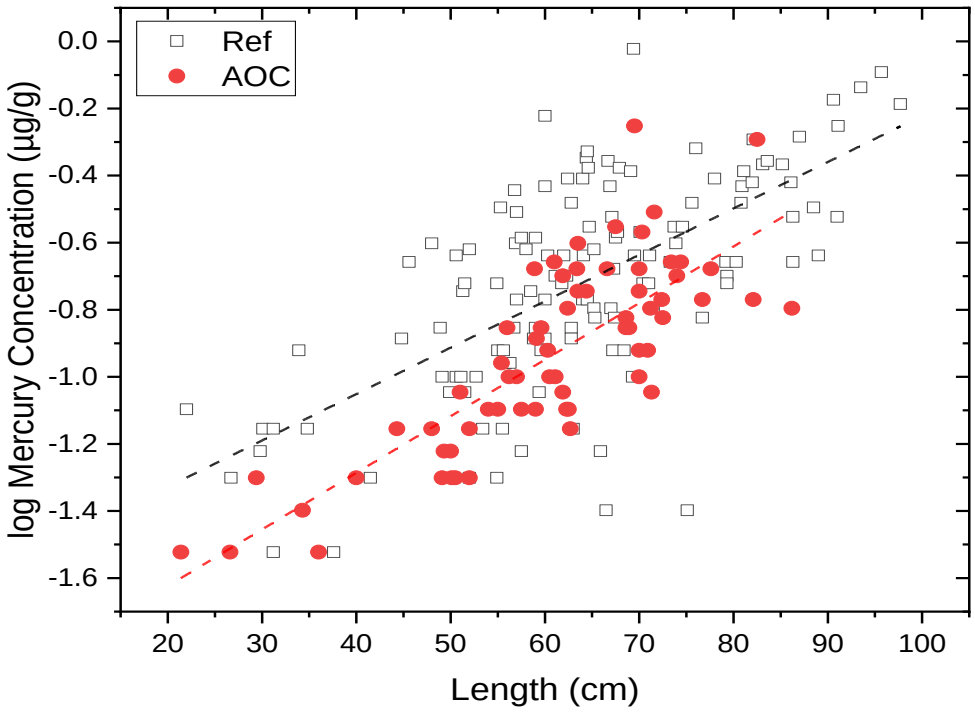

Figure 12. Mercury concentration as a function of size in northern pike from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits to each data set.

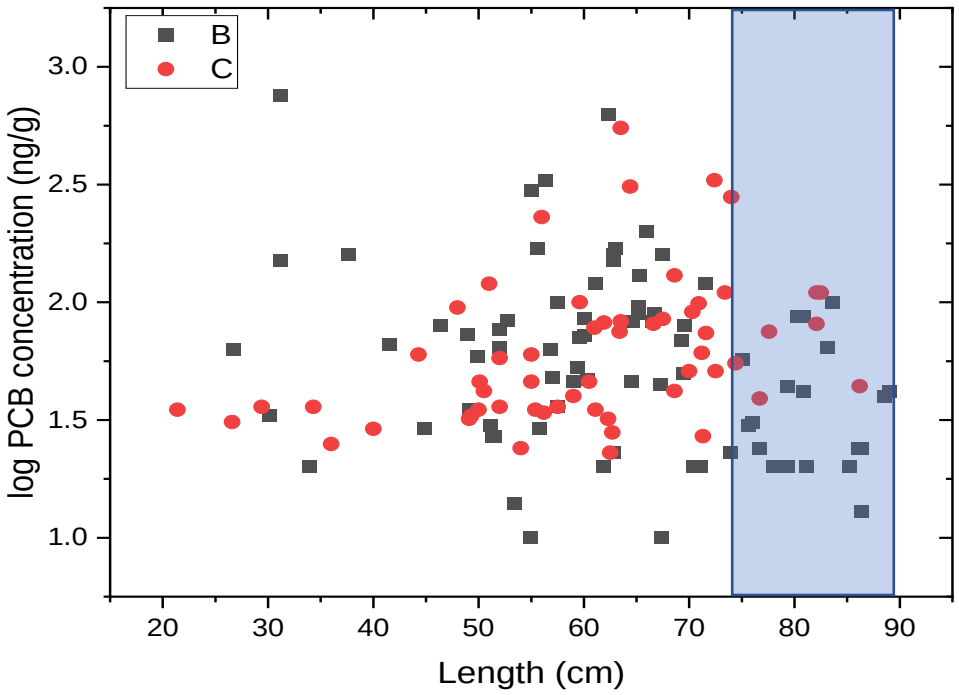

Figure 13. PCB concentration as a function of size in northern pike from the reference (squares) and AOC (circles). Shaded region represents the size interval selected for statistical comparisons between the AOC and reference.

3.3.2.4. Tier 3B Rainbow trout

There were only 2 records of mercury and PCB concentrations in Rainbow Trout over the 2000-2019 time interval. The data were considered insufficient to perform a Tier 3B analysis for this indicator species.

3.3.2.5 Tier 3B Walleye

For Walleye there 82 records (37.6 -80.3 cm size range) of mercury contamination in fish from reference sites and 12 records (38.6-74.1 cm) in the AOC. Analysis of covariance indicated a non-significant difference between the slopes of mercury contamination and fish length from the AOC and combined reference sites (Figure 14). After size adjustment, mercury concentrations *were significantly lower in AOC Walleye compared to reference*.

There were 86 records (18.6 – 83 cm size range) of PCBs in walleye from the reference and 14 records (38.6-74.1 cm) from the AOC. There was a non-significant difference in the relationship between PCB concentration in fish and body length between the reference and AOC (Figure 15). After size adjustment, there was a non-significant difference in PCB concentrations between the AOC and reference data set. *Walleye passes the Tier 3B criteria.*

3.3.2.6 Tier 3B White Sucker

There were 114 records (17-58 cm size range) of mercury concentrations in White Sucker from the reference and 55 records (16.2-59.2 cm size range) in the AOC. There was a non-significant difference between the mercury contamination vs White Sucker body length between the reference and AOC. After size adjustment, ANCOVA revealed non-significant differences in mercury contamination of AOC fish compared to the reference (Figure 16).

For PCBs, there were 108 records (17.4-58 cm size range) of White Sucker in the 2009-2019 year interval from the reference and 47 records (16.2-59.2 cm) in AOC collected fish. There was a non-significant difference between the PCB contamination vs White Sucker body length between the reference and AOC (Figure 17). After size adjustment, the ANCOVA indicated that PCBs were highly significantly elevated in AOC fish compared to the reference. *Overall, White Sucker fails Tier 3B.* However, it is noted that elevated PCBs in individual white sucker relative to reference were more common for fish specimens >40 cm in length (Figure 17).

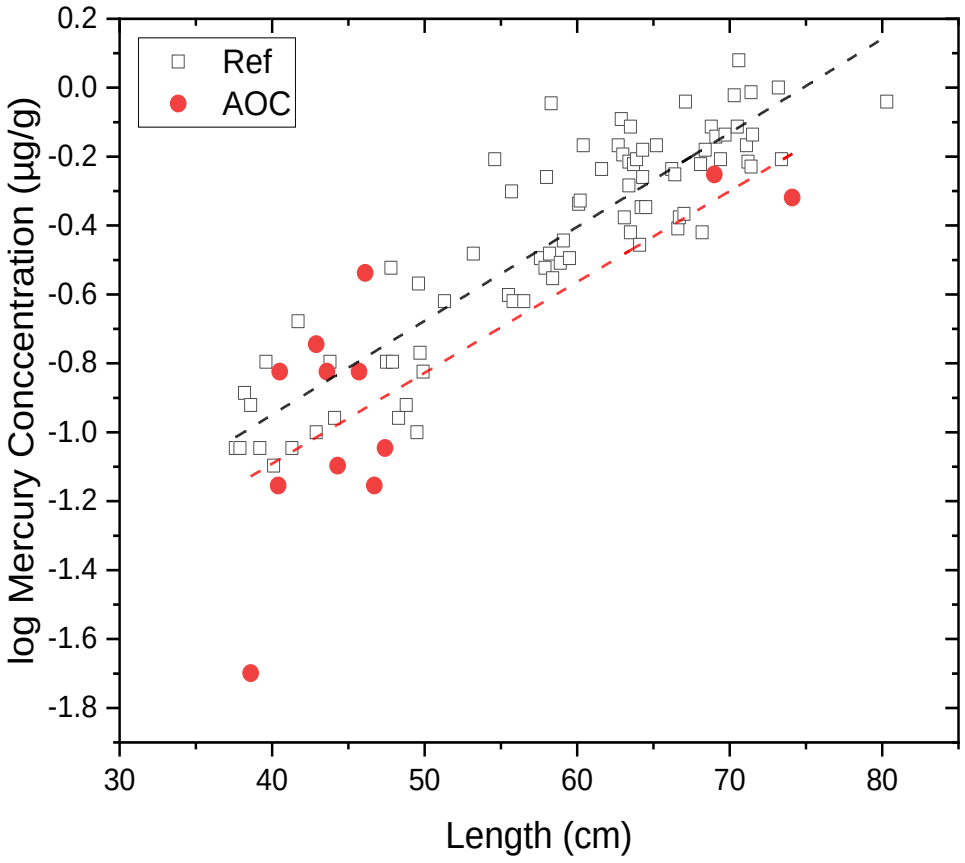

Figure 14. Mercury concentration as a function of size in walleye from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits to each data set.

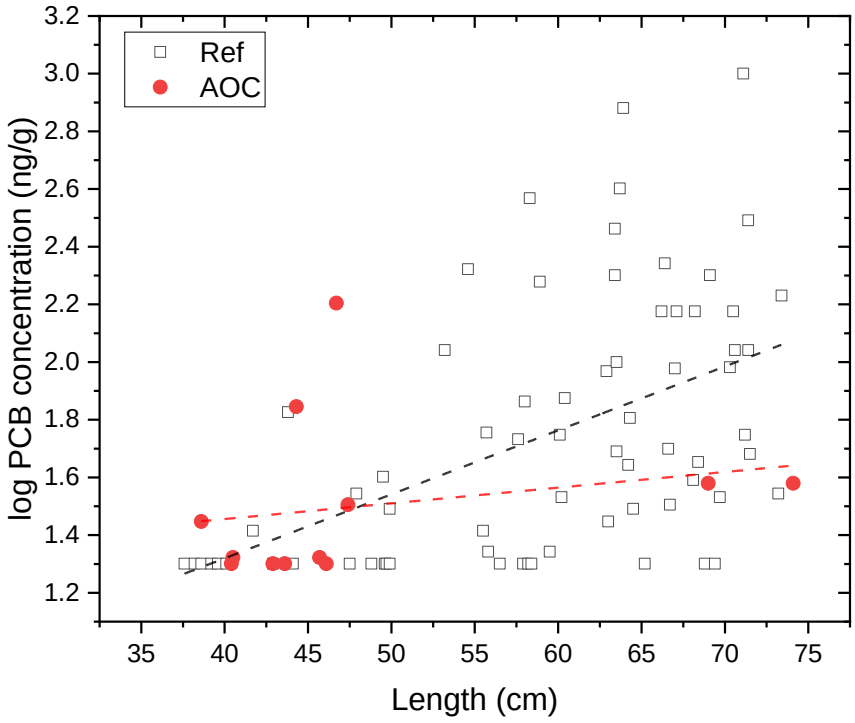

Figure 15. PCB concentrations as a function of size in walleye from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits to each data set.

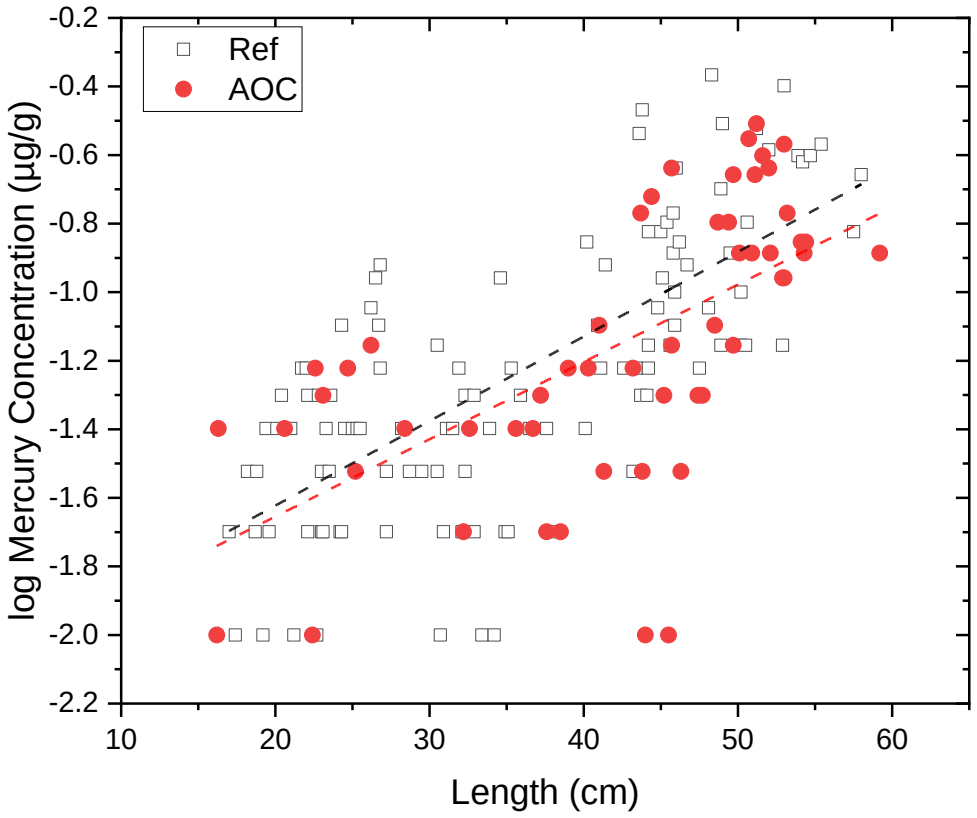

Figure 16. Mercury concentration as a function of size in white sucker from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits to each data set.

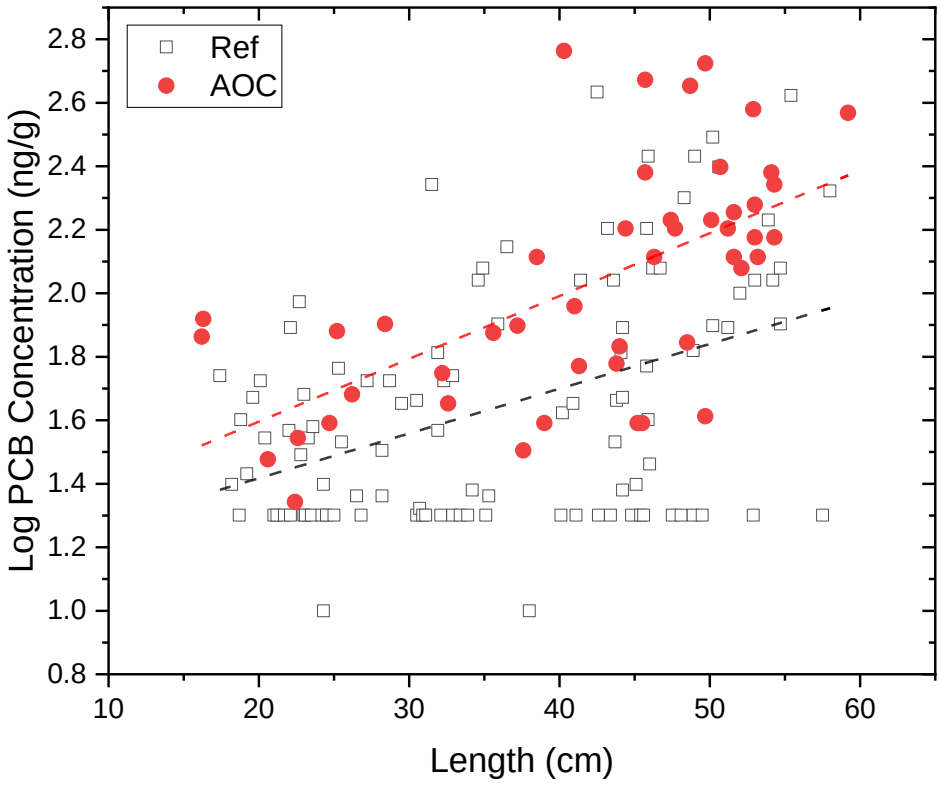

Figure 17. PCB concentration as a function of size in white sucker from the reference (hollow squares) and AOC (solid circles). Dashed lines present linear regression fits to each data set.

3.3.3 Tier 3C Evidence Line

The Tier 3C evidence line identifies temporal trends in the indicator species that failed Tier 2 across time. Given that data requests for long term temporal data for the 6 indicator species from MECP were not available at the time of completing this report, appropriate sections from the 2016 assessment are reported here.

The 2016 Toronto and Region BUI #1 assessment report compiled temporal trends for 4 of the 6 indicator species that failed the Tier 2 criteria. These included Brown Trout, Common Carp, Northern Pike and White Sucker. For each species the most abundant size classes were examined for size trends. For Brown Trout this included 45, 55 and 70 cm fish; for Common Carp 65, 75 and 85 cm fish; Northern Pike 45, 60 and 75 cm fish and White Sucker 25, 40, and 55 cm sized fish were tested for temporal trends. Figure 18 presents temporal trends for PCBs in each of the four indicator species as reported by Bhavsar (2016).

Brown Trout showed no significant declines for Hg in the past 30 years. However, mercury residues in Brown Trout are below the unrestricted advisory categorization. PCBs in Brown Trout significantly declined for 55 cm and 70 cm fish but exhibited a non-significant decline for 45 cm fish owing to limited numbers of samples. According to the 2016 decay model, the PCB half-life in Brown Trout is between 8-14 years. After one half life, PCB concentrations in the two largest size class of fish would be expected to achieve mean concentrations consistent with 2 meals/month which would meet the Tier 2 Criteria. Mercury concentrations in brown trout remain unrestricted relative to the Tier 1 criteria for all size classes. *Therefore, Brown Trout is considered to pass Tier 3C.*

Common Carp showed a general decline in PCBs, but the trend was not statistically significant ($p>0.05$). 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. Although common carp exhibits a general trend of PCB decline with time there is insufficient information to support a pass for Tier 3C.

Northern Pike demonstrated significant declining trends for PCBs for all three size classes (45, 60 and 75 cm) tested. PCB half lives computed from the 2016 assessment report for this species was 8-14 years. Based on the Tier 3A assessment, recent northern pike records imply unrestricted meal allowance at current mercury and PCB concentrations for the two populations. Therefore, Tier 3C is considered to pass for this indicator species.

White Sucker demonstrated significant declining trends for the 25, 40 and 55 cm size classes of fish for PCBs and for the 55 and 40 cm size classes for mercury but not for the 25 cm size class. White Sucker fish consumption advisories are dominated by PCBs. According to the 2016 BUI assessment, the PCB decay model predicts that White Sucker will achieve an 8 meal per month virtual meal allowance after approximately one decade. Based on the most recent PCB records in White Sucker (2009-2019), after 1 half-life, PCB concentrations in the 55 cm size class are predicted to be 109 ug/g wet weight consistent with Tier 2 reference criteria. Therefore, Tier 3C is considered to pass for this indicator species.

Data were unavailable to test temporal trends in Rainbow Trout or Walleye.

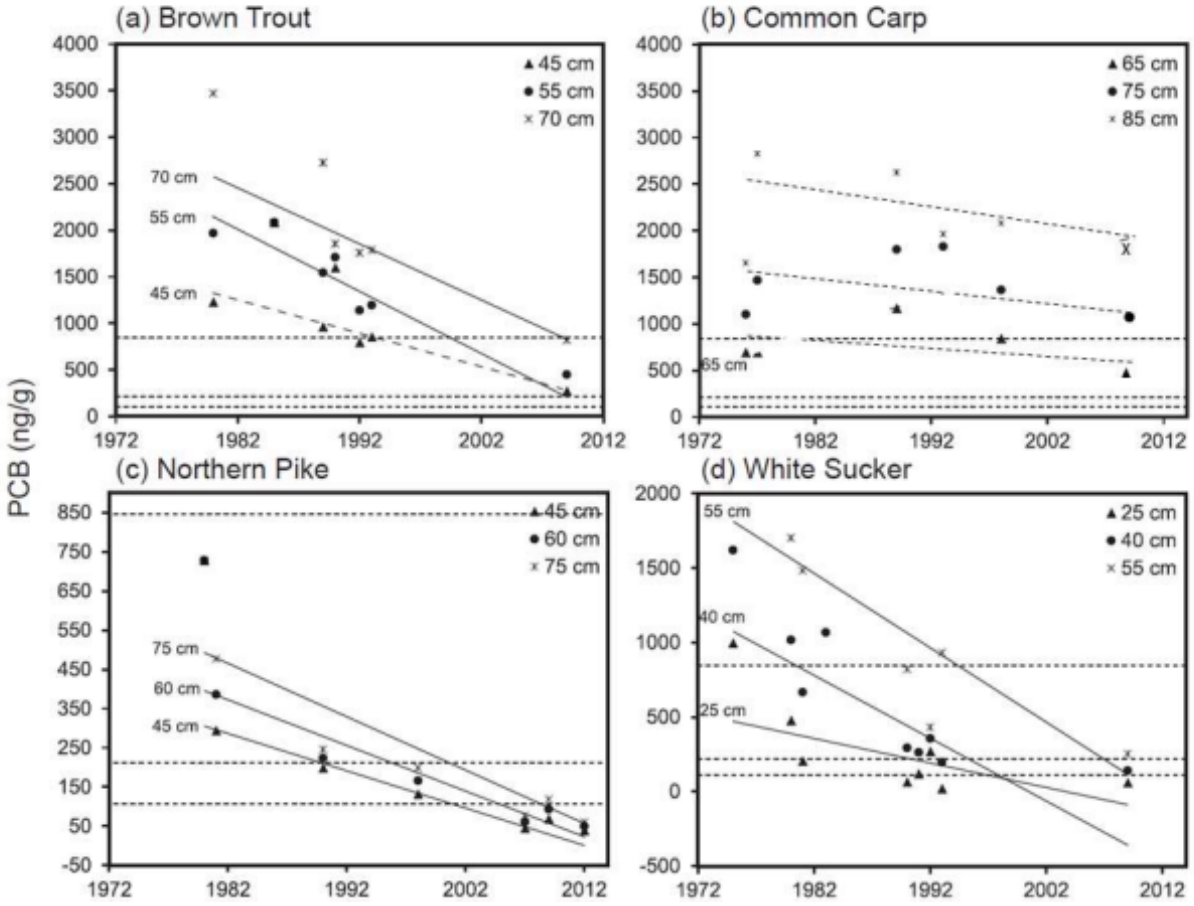

Figure 18. Temporal trends of PCBs in brown trout, common carp, northern pike and white sucker. Figure from Bhavsar (2016).

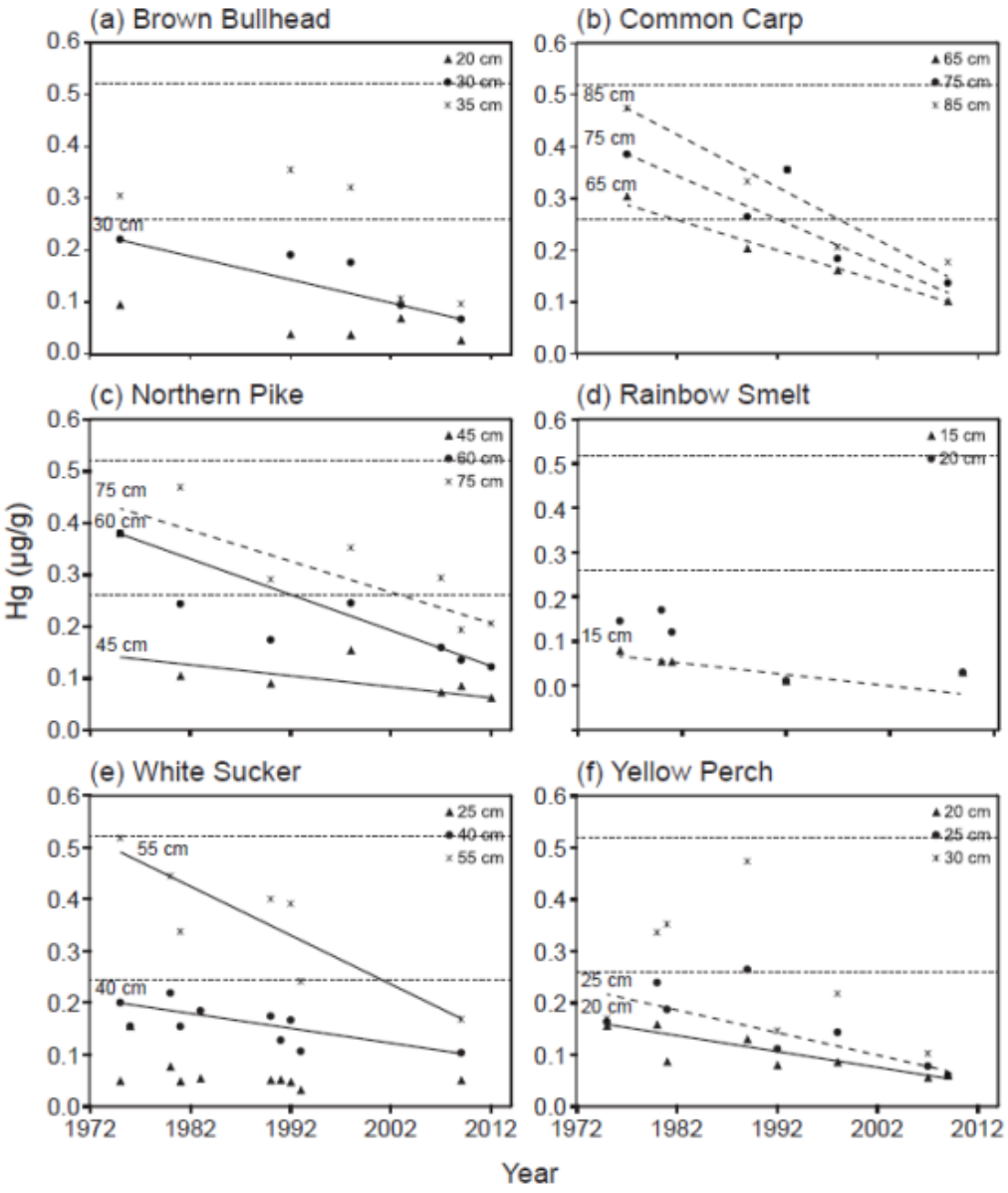

Figure 19. Temporal trends of mercury in fish species from the Toronto and region AOC. Figure from Bhavsar (2016).

3.3.4 Tier 3 conclusion

A decision matrix was generated to summarize Tier 3 evidence line outcomes for each indicator species. Equal weights were assigned to each evidence line. The results are provided in Table 14. Weight of evidence across indicator species evidence lines indicates overall pass of Tier 3 for Brown Trout, Common Carp, Northern Pike and Walleye. There was insufficient information on Rainbow Trout to reach a decision however the 2 recent records of fish showed low PCB contamination. *White Sucker Fails the Tier 3 Criteria for 2/3 evidence lines and therefore Tier 3 Fails for this indicator species.*

Table 14. Decision Support Matrix for Tier 3 Evidence Lines

Indicator	Tier 3A	Tier 3B	Tier 3C	Weight of Evidence
Brown Trout	Pass	Fail. Note 84% of records in range of reference	Pass	**Passes**
Common Carp	Pass	Pass	Insufficient data	**Passes**
Northern Pike	Pass	Pass. Note: Failed statistical test for PCBs, but virtual meal allowance at largest size interval was 8 meal/month meeting Tier 1 criteria	Pass	**Passes**
Rainbow Trout	Insufficient Data. Note 2 records correspond to > 16 meal/month virtual advisories.	Insufficient Data	Insufficient Data	**Insufficient Data**
Walleye	Pass	Pass	Insufficient Data	**Passes**
White Sucker	Fails For 55+ cm fish	Fail For 40+ cm fish	Pass Will meet Tier 1 criteria within 10 years	**Fails**

4.0 Tier 4 assessment

The Tier 4 assessment focuses on restoration actions completed within the AOC, fish movements and whether or not additional restoration actions are required to expedite reduction in fish contamination and degree of restrictiveness of fish consumption advice issued within the AOC.

4.1. Tier 4A - sediment contamination in the Toronto and Region AOC and tributaries

This portion of the sediment chemistry assessment was taken from the 2016 BUI #1 preliminary assessment by Bhavsar, 2016.

Accumulation of PCB in Toronto Harbour sediments was likely due to a combination of urban runoff, storm water drainage and atmospheric deposition. There are currently no known direct inputs of PCBd 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 was little change in the sediment PCB levels over the past 25 years (Figure 20) 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 21; Marvin et al., 2003; T. Labencki, Presentation at Lake Ontario Evenings: The Food Web Edition, March 2013 reported by Bhavsar (2016).

Updates to sediment chemistry work since 2016 are reported by Long et al. (2021) who performed additional temporal analysis of Lake Ontario sediment chemistry in the AOC and another 2018 ECCC study conducted to determine spatial patterns of PCBs and other contaminants within Toronto Harbour.

Based on Long et al.'s (2021) work, a single sampling station 1364 (Lat/Long 43^{o}37.53.7"N, 79^{o}22'11.8"W) located in the approximate center of Toronto Harbour was sampled in 1997, 2000, 2006, 2012 and 2018. PCBs in surface sediments at this station averaged 406.7±83.3 ng/g in 1994 but significantly declined ($p<0.05$; Long et al. 2021) by five-fold to 81.3±19.6 ng/g in 2018. The 2018 concentration still exceeded the Lake Ontario nearshore median PCB concentration of 37 ng/g but was commensurate with the previously stated Lake Ontario mean of 100 ng/g from Marvin et al. (2003). PCBs in suspended sediments collected from the same station exhibited a non-significant decrease by three-fold over the sampling period (from 180 ng/g in 1997 to 58 ng/g in 2018). Lower concentrations of PCBs in suspended sediments compared to surface sediments indicate sediment dilution is a continuing and on-going process. Declines of PCBs in both surface and suspended sediments at Station 1364 are provided in Figure 22. Excluding the 1990's time points, a non-significant declining trend was observed for both surficial and suspended sediments with corresponding half-lives of 56 and 13 years, respectively.

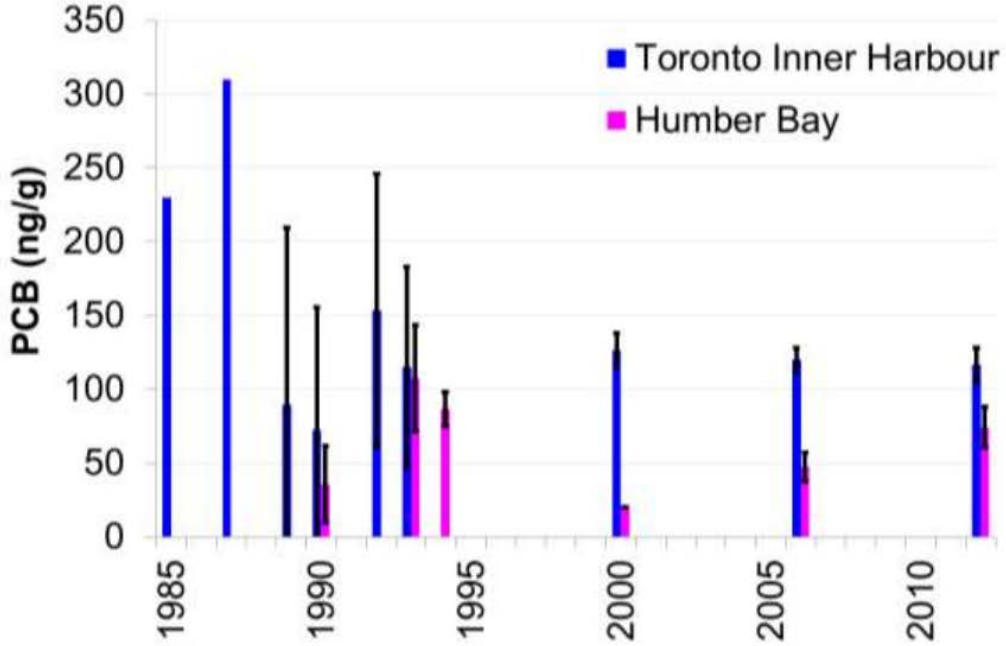

Figure 20. Temporal trends of PCBs in sediments from Toronto Harbour and Humber Bay. Figure from Bhavsar (2016).

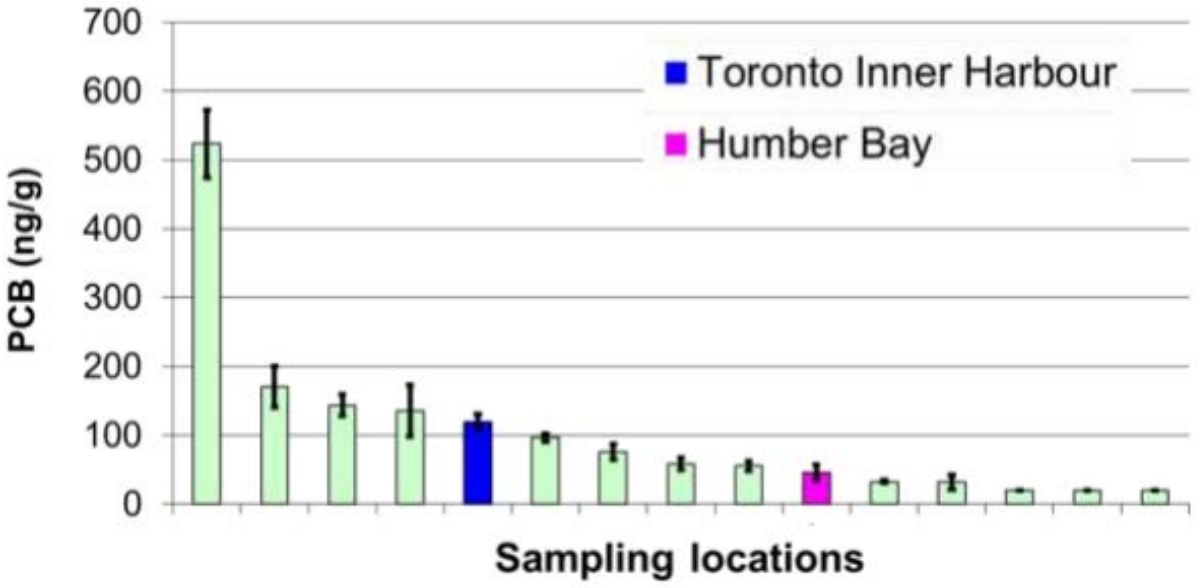

Figure 21. Spatial trend of PCBs in sediments from various locations in Lake Ontario. Figure from Bhavsar (2016).

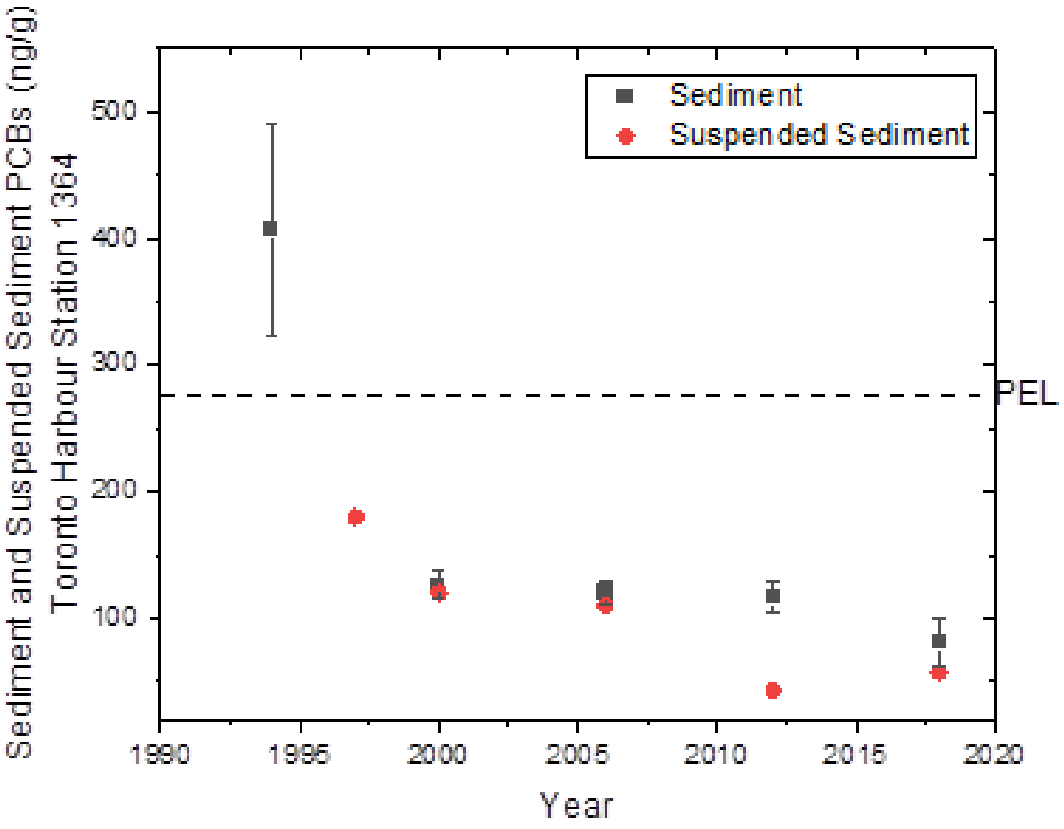

Figure 22. Surface and suspended sediment concentrations at a Toronto Harbour station (station 1364) over time. Data from Long et al. (2021).

Nearshore Lake Ontario surface sediment PCBs within the AOC boundary, but outside of Toronto Harbour, were reported by Long et al. (2021) for 3 stations 708 (Lat/Long 43^{o}47'37"N, 79^{o}05'06"W; Pickering), 2047 (Lat/Long 43^{o}37'23.9"N, 79^{o}26'48.5"W; Humber Bay) and 9173 (Lat/Long 43^{o}25'32.9"N, 79^{o}39'38.4"W; Oakville). The mean±standard deviation PCB concentrations in surface sediments at these stations were <10, 12.7±4.6 and 130±17.3 ng/g, respectively.

An unpublished report from Burniston, D. (ECCC) sampled 25 stations for surface sediments that were distributed throughout the Toronto Harbour (Figure 23) in 2018. The combined Toronto Harbour mean±standard deviation PCB concentration was 126.5±107.7 ng/g and was similar to that reported by Long et al. (2018) and the 100 ng/g Lake Ontario mean reported by Marvin et al. (2003). However, two stations from the 2018 ECCC Toronto Harbour sediment study exceeded the CCME PEL value of 277 ng/g. Station 1384 located in the turning basin of the Ship Canal had a PCB concentration of 523.7 ng/g. Station 1346 located in the vicinity of Ireland Park contained a sediment PCB concentration of 341.2 ng/g.

Sediment samples at selected sites in tributaries draining into the AOC were generated by MECP in Oct of 2018 at Etobicoke Creek, Mimico Creek, Humber River Marshes, Don River and Highland Creek and Rouge Rivers. Sediment mercury concentrations ranged between 0.01-0.03 ug/g dry weight across sites and PCBs from 9 to 62 ng/g dry weight, respectively. The highest PCB concentration was measured in the Humber River at Humber Marshes Park at 62 ng/g dry weight and averaged 27.0± 17.5 ng/g dry weight (n=3 samples) followed by Mimico Creek which averaged 27.3±4.1 ng/g (n=3 samples). All monitored tributary stations were well below the Lake Ontario mean of 100 ng/g reported by Marvin et al. (2003) and less than the Lake Ontario Nearshore median PCB concentration of 37 ng/g reported by Long et al. (2021).

Overall, Toronto Harbour and some of the tributaries (e.g. upstream Etobicoke Creek; see Section 4.2) still contain localized sample stations with elevated PCBs presumably as a result of legacy deposition at these locations. *Given the highly localized distribution of these elevated samples, mean samples in Toronto Harbour corresponding to Lake Ontario mean values, and low downstream tributary sediment chemistry, the data is broadly supportive of passing the Tier 4A criteria.*

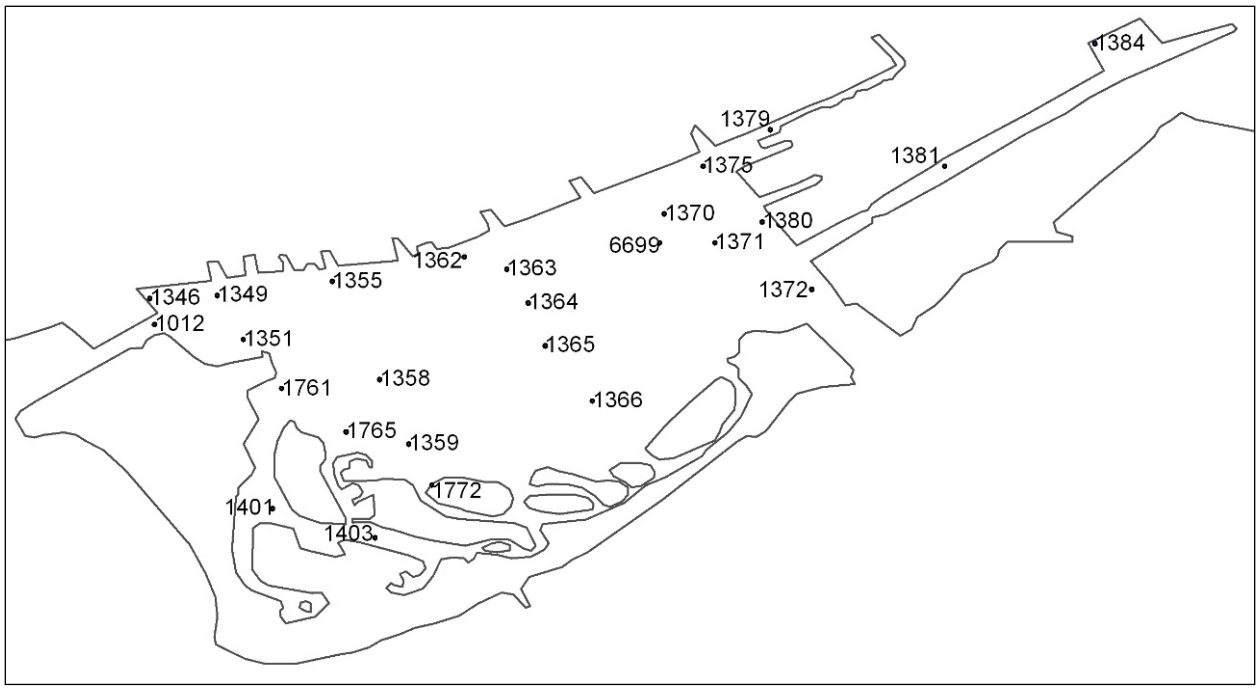

Figure 23. Sediment sampling stations from ECCC 2018 Toronto Harvour Stations (Courtesy of D. Burniston). Stations 1384 and 1346 had PCBs exceeding the CCME PEL of 277 ng/g.

4.2. Tier 4B restoration actions completed in the AOC

Etobicoke Creek was previously identified as having higher PCB concentrations compared to other tributaries within the Toronto and Region AOC based on young-of-year forage fish samples (See Section 3.3.4). PCB track down studies within Etobicoke Creek were initiated between 2001-2008 coupled with restoration actions conducted in 2014-2015 and follow up MECP monitoring and post-restoration assessment in 2017 (Benoit, 2021).

MECP track-down studies determined PCB concentrations within the creek water, sediments, young-of-year forage fish, caged mussels and passive samplers (semi-permeable membrane devices). Initial 2002 studies showed that none of the 11 sediment samples exceeded CCME probable effect levels (PEL; 277 ng/g; CCME, 2001), although some samples approached the PEL at 180-210 ng/g sediment PCBs. Caged mussels and young-of-year forage fish verified elevated PCBs in the same regions as identified for sediment PCBs implicating that enriched sediment PCBs were bioavailable near Markland and Mill Roads. The highest PCB concentrations were identified near Fairway 11 sewer outfall, where mussels accumulated upwards of 1892 ng/g PCBs, 35 fold greater than an upstream Etobicoke reference station. Passive sampler accumulated PCBs were 600-fold greater at this same site compared to the upstream reference. Follow-up studies in 2005-2006 revealed elevated PCBs across multiple environmental media (water, surface sediment, caged mussels, SPMDs and young-of-year forage fish) over a region between Universal Drive to the Fairway 11 outfall. However, the storm

outfalls were ruled out as potential sources, but instead soils from the banks of the easement leading to Fairway 11 were identified as having high PCB concentrations and further confirmed in 2006 and 2008 follow up soil track down studies.

Sediment remediation was conducted in soils and the channel between 2014-2015 from the Universal Drive easement to Fairway 11. Seventy m^3 of soil classified as PCB waste was removed along with 2008 m^3 of non-PCB waste soil and sediments from the banks and channel. Engineered capping to a 0.15 m thickness was completed over the restored areas. Some portions of the site could not be remediated owing to obstructions. Sediment PCB concentrations at the restored areas ranged from <0.1 to 2.4 µg/g after restoration, 50 fold lower than Toronto Harbour mean.

Post-restoration assessments of PCB contamination were conducted in 2017 in deployed sampled passive samplers (polyethylene devices; PEDs), water, sediment and young-of year forage fish at 7 locations in the restoration region as well as upstream and downstream locations in Etobicoke Creek. Young-of-year forage fish were shown to significantly decrease in their PCB residues between the 2002-2008 and 2017 and were also highly significantly lower compared to pre-track down forage fish contamination (Figure 24). For example, downstream common shiner concentrations pre-restoration were as high at 1500 ng/g with a median value of just under 200 ng/g and declined to approximately 80 ng/g by 2017. Thus, YOY-forage fish in Etobicoke Creek now fall in-line with other tributaries except for reservoirs in Don and Humber Rivers. Passive samplers deployed in 2017 also indicated a five-fold decrease in PCB water concentrations compared to the 2002-2008 track down studies.

Sediments PCBs reportedly declined in the region during 2017 with high sediment PCBs above the CCME PEL at three stations ranging from 400 to 1600 ng/g which could not be remediated in 2014-2015 due to obstructions. However, downstream stations #295 and #396 contained < 75 ng/g PCBs in sediment, less than Toronto Harbour mean. These downstream concentrations were comparable to previous studies of Toronto and Region tributary sediment PCBs reported for the Don River (160 ng/g), Tecumseh Creek (100 ng/g) and Humber River (80 ng/g) in 2002 (Dove et al., 2003). Even lower sediment contamination was reported for Etibicoke Creek sediment samples collected by MECI in 2018 near Lakshore Rd which with triplicate samples all having PCB concentrations of 10 ng/g dry weight.

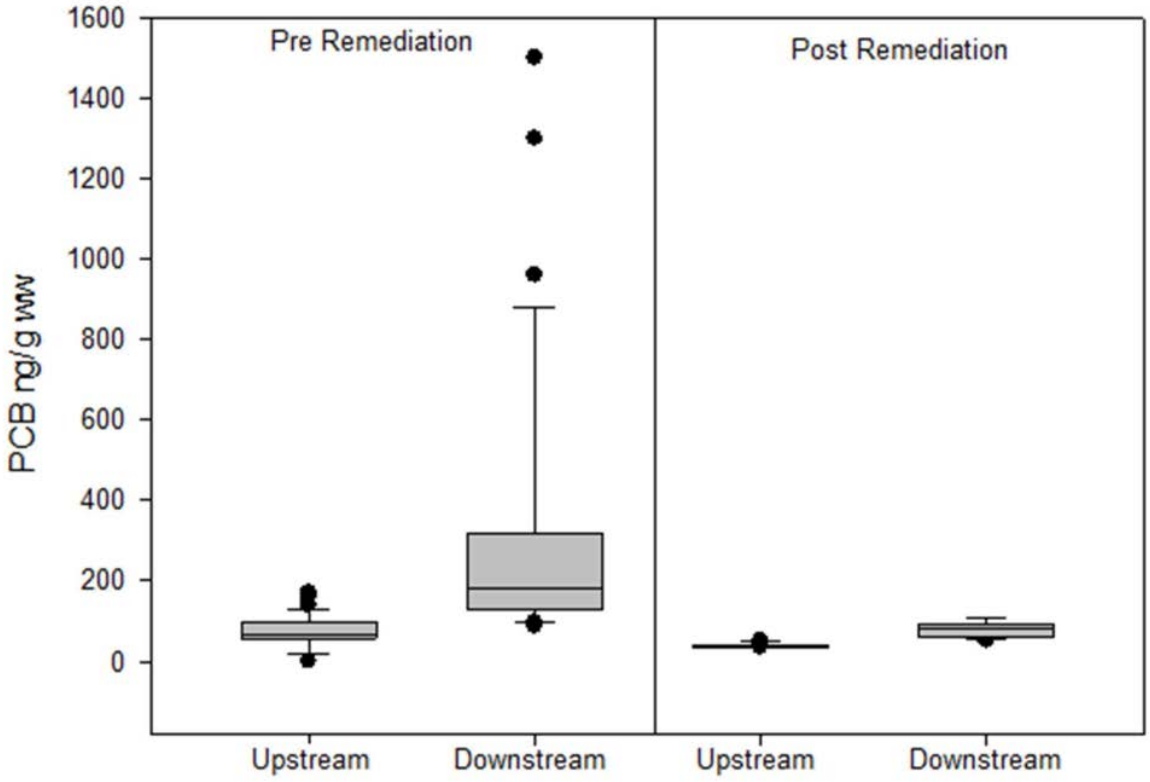

Figure 24. Comparison of PCB concentrations in common shiner from upstream and downstream areas of Etobicoke Creek pre and post remediation. Figure taken from Benoit (2021).

4.3. Tier 4C trends in young-of-the-year forage fish contamination in AOC tributaries

Tier 4C examined levels and trends in young-of-year (YOY) forage fish collected from different tributaries draining into the AOCs. Prior temporal analysis was taken from the 2016 report (Bhavsar, 2016). Spatial trends data focused on the most recent YOY forage fish data collected between 2016-and 2019 are further interpreted.

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. 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 25).

Temporal Trends in Forage Fish Contamination

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, contaminant concentration differences between forage fish species 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 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, $p>0.05$) in PCB concentrations. There were no significant differences in fish length among sites in the Don River or Mimico Creek (ANOVA with Tukey's test, $p>0.05$). Concentrations of PCB in forage fish from the five tributaries show substantial declines with time at many sites (Figure 26). For equivalently monitored stations 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 in proximity to tributary mouths draining into the AOC.

Spatial Trends in Forage Fish Contamination

Data on forage fish contaminant trends from individual tributaries over the most recent 2016-2019 data set are described on a tributary by tributary basis below.

Etobicoke Creek. There were 43 records of Common Shiner and 5 records of Emerald Shiner collected from Etobicoke Creek between 2016-2019. The mean±standard deviation total mercury and total PCB concentration in YOY forage fish was 0.016±0.005 µg/g and 75.5 ± 31.7 ng/g, respectively consistent with temporal trends in this tributary. PCBs were highest at the mouth and most downstream site at Lakeshore Rd averaging 104±2.4 ng/g in Common Shiner (Lakeshore Rd) and 142±5.8 ng/g in Emerald Shiner (Creek mouth). Similar concentrations were observed at Mimico Creek where PCBs in Fathead Minnow averaged 92.4±1.3 ng/g and mercury concentrations were less than 0.01µg/g.

Humber River. High PCBs were present in YOY forage fish from west Humber River just below the Claireville Reservoir. PCB concentrations in Common Shiner averaged 1233.3±66.7 ng/g (n=3) and in Bluntnose Minnow PCBs were 1280±20 ng/g (n=5). These concentrations exceeded thresholds used to establish a "No Consumption" advisory for the general population in sport fish. Upstream of the Claireville Reservoir, PCBs were low averaging 41.4±3.4 ng/g, suggestive of PCB contamination in the reservoir. Mercury concentrations remained low (<0.04 µg/g) in fish from both the reservoir and upstream monitoring stations. PCB concentrations at downstream sections of the Humber River were more moderate. The mean PCB concentrations in Common Shiner from Old Mill was 99.3±3.7 ng/g and in two Emerald Shiner samples

captured at the Humber River mouth PCBs averaged 175 ng/g consistent with forage fish PCB contamination described in the temporal analysis.

Don River. Extremely high PCB concentrations were observed at sampling stations in the Don River associated with the G. Ross Lord Reservoir and just below the G. Ross Lord Dam. PCBs in Fathead Minnow collected from the reservoir averaged 3520±74 ng and were 2160±50 just below the dam outlet, nearly triple the 'No Consumption' advisory threshold PCB concentration used for sport fish advice calculation. PCBs in Fathead Minnow upstream of the reservoir at Steeles Road average 47.3±5.9 ng/g implying PCBs sources within the reservoir and or associated with the dam. Earlier studies identified sealants used in building construction between 1950 to 1980's as potential sources of PCBs in the Toronto region (Diamond et al., 2010). The G Ross Lord Dam was constructed in 1973 and may have incorporated PCB sealants in its construction although additional track-down studies are warranted to evaluate this and/or reservoir sediments themselves as the source of bioavailable PCB residues. The most downstream station of the reservoir was at Bathurst located approximately 2.5 km away from the dam outlet. PCBs in a single Fathead Minnow dropped to 250 ng/g and in Creek Chub averaged 200±7.1 ng/g, respectively reflective of an order of magnitude decrease in PCB concentrations relative to those measured in the reservoir and just below the dam. These concentrations were approximately double the PCB concentrations measured in downstream sections of other tributaries draining into the Toronto and Region Area of Concern. Monitoring stations related to forage fish further downstream of the Bathhurst sampling station were not available. The Bathhurst site is approximately 25 km upstream from Don River mouth where it drains into the east end of Toronto Harbour. One downstream station at Danforth generated 2 samples of Creek Chub and Fathead Minnow but these samples were only analyzed for mercury and not PCBs. Sediment samples taken 17 km downstream of the dam and approximately 5 km upstream of the Don River mouth remained low for PCBs with triplicate samples each having a PCB concentration of 10 ng/g dry. Given the observed decline of PCBs between the reservoir and Bathhurst Street sampling area and large distance between this site and the river mouth, it is anticipated that PCBs in forage fish at distant locations of the Don River would approach those observed for Humber River. Further study of forage fish in downstream sections of the Don River are warranted as are documentation of PCB sources in the G. Ross Reservoir.

Highland Creek and Rouge Rivers. Both these tributaries are located well to the East of Toronto Harbour. PCBs in Common Shiner, Creek Chub and Fathead Minnow from Highland Creek averaged 48.4±1.5, 44.0±2.1 and 26.2±1.5 ng/g, respectively while total mercury concentrations ranged from 0.01 to 0.03 µg/g. For the Rouge River, Common Shiner collected near Highway 401 had average±standard error mercury and PCB concentrations of 0.036±0.005 µg/g and 43.8±5.6 ng/g, respectively. Both the eastern tributaries were considered low in their overall contamination.

4.3.1 Tier 4C young-of-the-year forage fish conclusions

Temporal patterns of PCBs in young-of-the-year forage fish suggest improvements in most tributaries through time and most of the forage fish tributary data suggest that mercury is not an issue in the AOC. However, some of the reservoirs associated with AOC tributaries remain considerably elevated in to PCBs. The G. Ross Reservoir and Dam of the Don River continues to yield very high forage fish PCBs well above thresholds for a 'Do Not Eat' consumption advisory. Similarly, the Claireville Reservoir of Humber River contained PCBs above 1 µg/g that fell below 200 ng/g at downstream stations including the Humber tributary mouth. The contribution of the high PCB levels downstream of the G. Ross Lord Dam and Claireville Reservoirs on the Don and Humber Rivers, respectively, to sustained elevated PCB levels in sport fish from the Toronto Harbour remains unclear at present. Restoration actions conducted at Etobicoke Creek generated reductions in forage fish concentrations after 2017. Heightened concentrations of PCBs in forage fish therefore require further investigation at upstream locations of the Don and Humber Rivers. Feasibility studies for remedial actions at the impacted reservoirs of the Don and Humber Rivers should be considered to determine if restoration actions as completed for Etobicoke Creek are possible. Given the general observed declines in PCBs in forage fish from most tributaries draining into the AOC, there is partial support for this Tier 4 evidence line.

4.4 Tier 4D residency status of indicator species in the Toronto and Region AOC

Midwood et al. (2019) provided an assessment of fish movements within- and outside of Toronto Harbour for a number of indicator species of the AOC based on acoustic telemetry studies. Species specific results were provided for Northern Pike, Largemouth Bass, Common Carp, Walleye, White Sucker, Brown Bullhead and Yellow Perch. Of the above indicators, Northern Pike, Common Carp, Walleye and White Sucker failed the Tier 1 and Tier 2 criteria. Only White Sucker failed the Tier 3 criteria. No information was available for movements of Rainbow Trout, which had insufficient information to complete the Tier 3 assessment. There was also no recent telemetry information available concerning Brown Trout but this species passed the Tier 3 criteria.

A summary of telemetry results for species failing Tier1 and 2 criteria are provided below. Additional information concerning Common Carp movements was obtained from Piczak et al., (2022).

Common Carp. Common Carp passed Tier 3 criteria. For telemetry studies, a total of 59 fish were tagged between 2010-2015. Nine out of 57 tagged fish left the harbour completely after 60 days and another 14 individuals made movements out of the harbour for more than 1 week. Two tagged fish released in Toronto Harbour were identified to move to another AOC (Hamilton Harbour) approximately 60 km away. According to Piczak et. al. (2022), movements of common carp are more extensive than previously thought with individuals moving throughout the Lake Ontario basin. Larger individuals tend to move further than smaller individuals. Overall, 40% of tagged fish were observed to move outside of the harbour and therefore this species, particularly larger individuals which accumulate higher PCB concentrations, are likely to integrate spatial exposures well beyond the boundaries of the AOC.

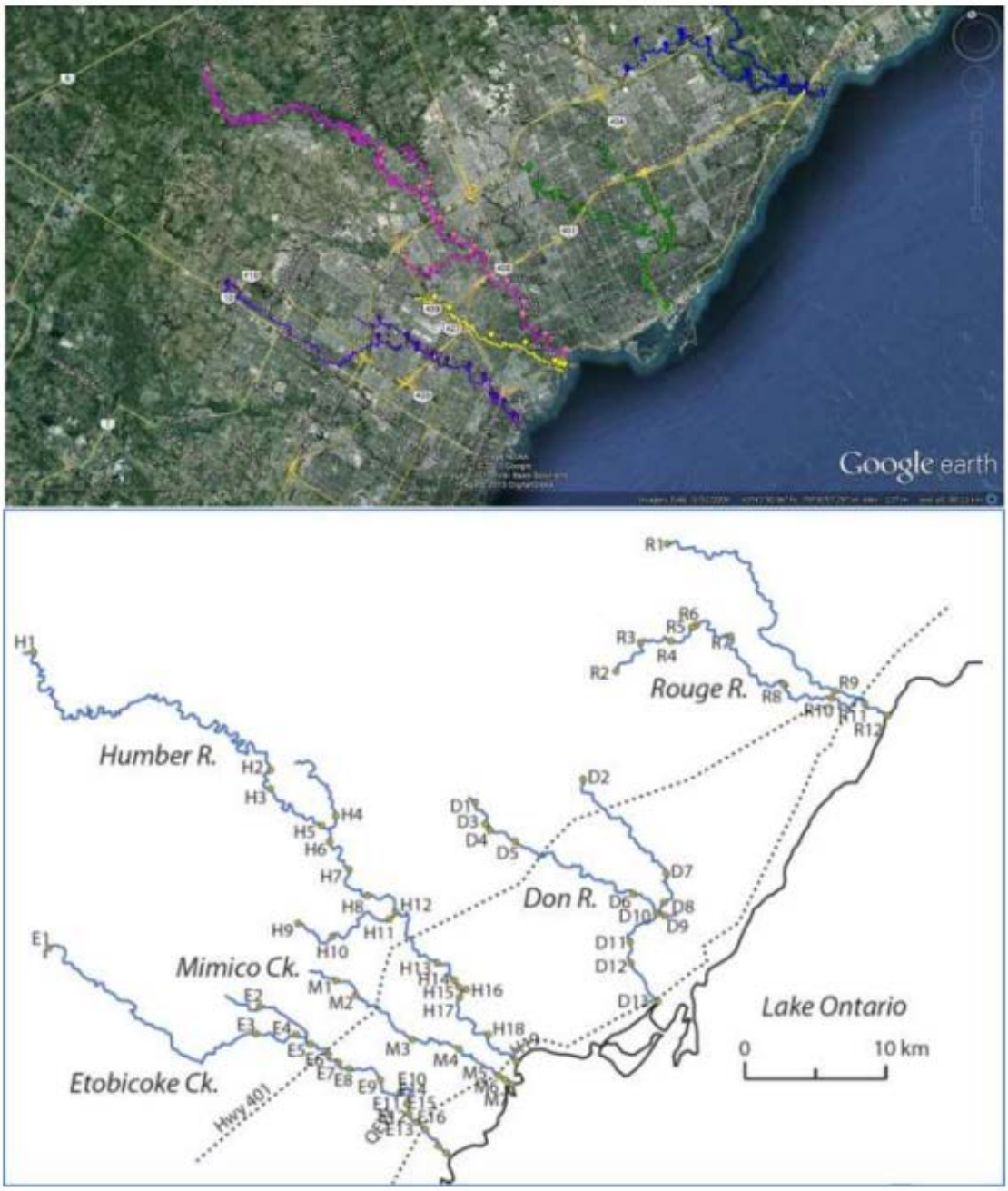

Figure 25. Map of Lake Ontario tributaries in the GTA and forage fish collection sites. Figure from Bhavsar (2016).

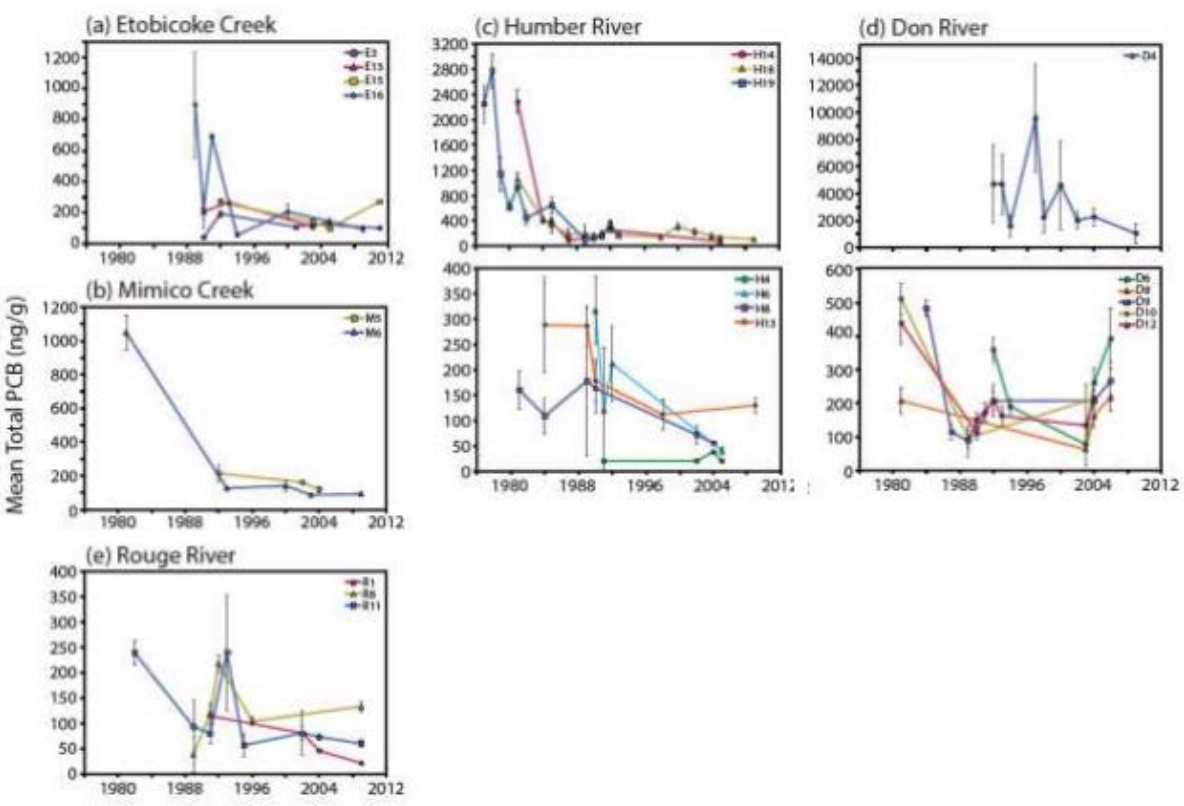

Figure 26. Temporal trends in PCBs in forage fish from AOC tributaries. Figure from Bhavsar (2016).

Northern Pike. Northern Pike passed Tier 3 criteria. For telemetry studies, fish were tagged between 2010-2015 and released into Toronto Harbour. A total of 124 fish were tagged over the study period. There were 19 fish that reportedly left the harbour and vanished from the array representing only 15% of the tagged population. Smaller individuals tended to stay within the harbour. Overall this species can be considered highly resident to the waters of the AOC.

Walleye. Walleye passed the Tier 3 criteria. Telemetry studies were limited to 13 tagged individuals but only 11 tagged individuals generated long term data. Eight of 11 individuals made extensive forays out of the harbour. Most individuals left the harbour in the fall and did not return until early Spring of the following year. One individual, released in Toronto Harbour, was later identified to move to the Hamilton Harbour AOC. Similar to Common Carp, walleye can be considered a largely transient species within the system and will integrate contaminant exposures across much larger geographic ranges than within the AOC.

White Sucker. White Sucker is the only species which failed Tier 3 criteria. Failure of the Tier 3 criteria was restricted to the largest size class of fish (55 cm and above). A total of 10 fish were tagged in 2013. Three individuals made regular movements in and out of Toronto Harbour, one of which was over an extended period. Notably, during the spring some tagged individuals were detected at the mouth of the Don River which also had elevated PCB accumulation in YOY forage fish at distant upstream locations. Midwood et al. (2019) commented: "Regardless, it is clear that White Sucker in Toronto Harbour are highly mobile". The authors recommended expanded tracking of this species to further substantiate potential sources of PCB contamination including movements and time spent in AOC tributaries such as the Don River.

Brown Trout and Rainbow Trout. Brown Trout passed the Tier 3 criteria but there was insufficient information to evaluate Tier 3 for Rainbow Trout. Both species are classified as cold water fish species and considered transients in Toronto Harbour migrating into the system in the fall (Barnes et al. 2020). Brown Trout have a warmer thermal tolerance compared to Rainbow Trout and may therefore spend more time in the vicinity of the AOC. Based on these evidence lines, Brown Trout and Rainbow Trout are not likely to strongly respond to restoration actions conducted within the AOC or its tributaries. Therefore, these species should be excluded from decisions regarding the delisting status of BUI #1.

4.5 Tier 4 conclusions

The Tier 4 decision support matrix is provided in Table 15 below. Tier 4 focused on PCB contamination and restoration actions within the AOC because this is the priority contaminant that drove failure of Tier 3 for the White Sucker indicator species. Sediment PCBs within the AOC appears to be broadly commensurate with regional concentrations measured for Lake Ontario but exceeds the near shore Lake Ontario reference by a factor of 3. Two of 25 stations within the Toronto Harbour exceeded the CCME PEL for PCBs in 2018 but these stations are considered localized and possibly representative of legacy contamination and local deposition. Sediment restoration studies were successfully completed in Etobicoke Creek to remove PCBs from the system resulting in declines in sediment, water and forage fish contamination. Data on

forage fish contamination suggests temporal improvement to PCB concentrations at most of the tributaries monitored. However, reservoirs in the Don and Humber Rivers still contain elevated PCBs in forage fish that warrant further assessment and source track down studies. In both cases these reservoirs are located in upstream waters of the tributary distant from the tributary mouth. In the case of the Humber River, forage fish concentrations dropped to less than 200 ng/g at the tributary mouth. Tributary mouth data for Don River forage fish were not available, but PCBs dropped to approximately 250 ng/g after 2.5 km downstream distance from the G. Ross Lord Dam and are anticipated to become diluted further down the tributary towards the river mouth.

The final evidence line considered in Tier 4 examined fish residency status within the AOC given that transient fish are likely to have a lower response to additional restoration actions conducted within AOC waters and will more broadly reflect regional contamination in Lake Ontario. Some of the indicator species including Walleye and Common Carp were observed to exhibit extensive movements outside of the AOC after their release to the system with some individuals moving to another AOC (Hamilton Harbour) located 60 km away. Rainbow Trout, which had insufficient information available to complete the Tier 3 assessment, was assessed as a transient species because this species (and Brown Trout's) cold water thermal profile which implies that these species inhabit AOC waters only over short periods primarily during the fall. Therefore, additional restoration actions at local areas within the AOC are likely to have little impacts on PCB and/or mercury residues in Common Carp, Walleye, Rainbow Trout and Brown Trout. White Sucker was considered somewhat transient but the limited number of tagged fish precluded broad conclusions about its AOC residency. At least 3 of 10 individuals demonstrated regular movements inside and outside of Toronto Harbour. However, some individuals were identified in the vicinity of the Don River during spring migrations indicating a potential that this indicator species may be influenced by elevated PCBs observed in the upstream waters of this tributary. Additional information to track use of Don River by White Sucker and distance upstream travelled by this species would be necessary to determine if the Don River is a cause for high PCB contamination observed in the large size class of this species.

Acknowledging some of the data gaps related to white sucker and a small number of local sediment stations with PCB concentrations above the CCME PEL guideline, *the preponderance of evidence from Tier 4 supports a passing decision for Tier 4.*

Table 15. Decision Support Matrix for Tier 4 Evidence Lines

	Main Findings	Decision
Tier 4A Sediment Chemistry	Toronto Harbour sediment quality is commensurate with Lake Ontario as a whole but elevated compared to Lake Ontario nearshore references. Two of 25 stations in Toronto Harbour exceed CCME PEL but contamination is localized.	Supports passing Tier 4
Tier 4B Restoration Actions	Etobicoke Creek underwent sediment remediation in 2014-15. Follow up studies showed decline in forage fish concentrations at the downstream areas commensurate with other tributaries. A part from a few stations, sediment contamination in Etobicoke Creek is generally commensurate with Toronto Harbour and Lake Ontario as a whole.	Supports passing of Tier 4
TIER 4C Forage Fish Contamination	Temporal trends support declining PCBs and low mercury in most tributaries draining into the AOC. However, excessive PCBs were observed in forage fish from the Claireville Reservoir of the Humber River and the G Ross Lord Reservoir of the Don River. PCBs tend to drop in forage fish downstream of these reservoirs. In the Humber River, PCBs at the river mouth approach those of other tributaries. PCBs in forage fish at the Don River mouth are lacking.	Partial support with additional follow up warranted in Humber and Don River reservoirs where forage fish PCB concentrations are elevated.
Tier 4D Species Residency	Among the species characterized by telemetry, Northern Pike and Large mouth Bass are considered residents. Both these species pass Tier 1 and/or 2 criteria. Highly transient species include Common Carp and Walleye. A number of White Sucker were found to move in and out of Toronto Harbour with some fish identified in the vicinity of Don River during spawning. Rainbow Trout lacked sufficient recent information to	Additional information required to follow up White Sucker movements and association with tributaries particularly the Don River.

	complete Tier 3 assessment but is considered a transient species.	
Overall Weight of Evidence Tier 4:	Supports Delisting but follow up work on large White Sucker movements and continued monitoring of PCB decline in this species through time is recommended.	

5.0 Toronto and Region BUI #1 Assessment Conclusions

This report provides a tiered assessment for the Restriction on Fish Consumption beneficial use impairment of the Toronto and Region Area of Concern. A graphical representation of the Tiered Framework and assessment outcomes for each is presented in Figure 27. The assessment is an update of a prior BUI #1 assessment completed for the AOC in 2016. There were 13 indicator fish species assessed for BUI #1 along with additional evidence lines concerning Young-of-Year forage fish contamination, sediment chemistry, restoration actions and consideration of fish residency status within the AOC.

Tier 1 failed for nine species (Brown Trout, Common Carp, Rainbow Trout, Largemouth Bass, Smallmouth Bass, Northern Pike, Walleye, White Sucker and Yellow Perch) but passed for 4 species. Three species that failed Tier 1 passed the Tier 2 assessment. However, Tier 2 failed for the remaining six species (Brown Trout, Common Carp, Rainbow Trout, Northern Pike, Walleye and White Sucker). The later species were further examined using a multiple evidence line approach in Tier 3. Tier 3 was found to pass for 4 of the previously failed species but contained insufficient information on Rainbow Trout. Tier 3 failed for White Sucker primarily as a result of elevated PCB accumulation in fish greater than 40 cm in length compared to reference and for virtual advisories generated for the 55+ cm size class. Three percent of anglers who utilize the AOC for fishing report consuming White Sucker and the maximum monthly meal frequency for this species is up to 4 meals per month based on GTA angler's surveyed. However, temporal analysis indicates that PCB concentrations in this species are declining with half-lives of between 8 to 14 years. It is therefore expected that this species will achieve current Tier 1 and 2 criteria within approximately a decade.

The Tier 4 assessment considered sediment contamination, restoration actions, trends in forage fish contamination of AOC tributaries and the overall residence status of indicator fish assessed in Tier 3. On balance, Tier 4 evidence lines were supportive of delisting BUI #1. Sediment PCBs within Toronto Harbour are shown to be generally consistent with those reported for Lake Ontario but exceed the near shore Lake Ontario reference. Two of 25 stations within the Toronto Harbour exceeded the CCME PEL for PCBs in 2018 but these stations appear highly localized. Sediment restoration in Etobicoke Creek resulted in declines in PCBs from sediment, water and forage fish. Most tributaries showed declining patterns in forage fish contamination with time and one tributary with historically high forage fish PCB contamination underwent sediment restoration actions that successfully lowered PCB contamination in water, sediments and forage fish. However, continued elevated PCBs in forage fish from upstream locations of the Don and Humber Rivers warrant follow up studies for these systems. Finally, fish residency studies demonstrate that species mainly resident to the AOC typically passed Tier 1, 2 or 3 criteria. Some species were shown to move out of the AOC with individual Common Carp and Walleye moving between Toronto Harbour and another AOC located 60 km away. Rainbow Trout, which did not have sufficient information to complete a Tier 3 assessment was designated a transient species and therefore is recommended to be excluded from further consideration in the final BUI #1 decision. The lack of recent data records on fish contamination for this species from the past two decades indicates that the current fish advice issued for this species by the

Province of Ontario is based on older data that may not reflect current conditions in the AOC. White Sucker, the only species to fail Tier 3, had telemetry evidence to indicate some movements outside of the Toronto Harbour Area for a limited number of tagged individuals (30% of tagged fish). However, the identification of fish movements in tributaries such as the Don River during spawning may be a cause for elevated PCB exposure in this species.

On balance the majority of evidence lines examined across Tier 3 and 4 support a recommendation for delisting BUI #1 in the Toronto and Region Area of Concern. The only indicator species failing the Tier 3 criteria was White Sucker ; however, declining trends in its PCB residues suggest it will meet Tier 1 and 2 conditions within a decade. The failure for both Tier 2 and Tier 3A (Virtural Advisories) was restricted to only the largest size class of this species (55-60 cm fish) and fish in this size category are rarely caught across reference locations.

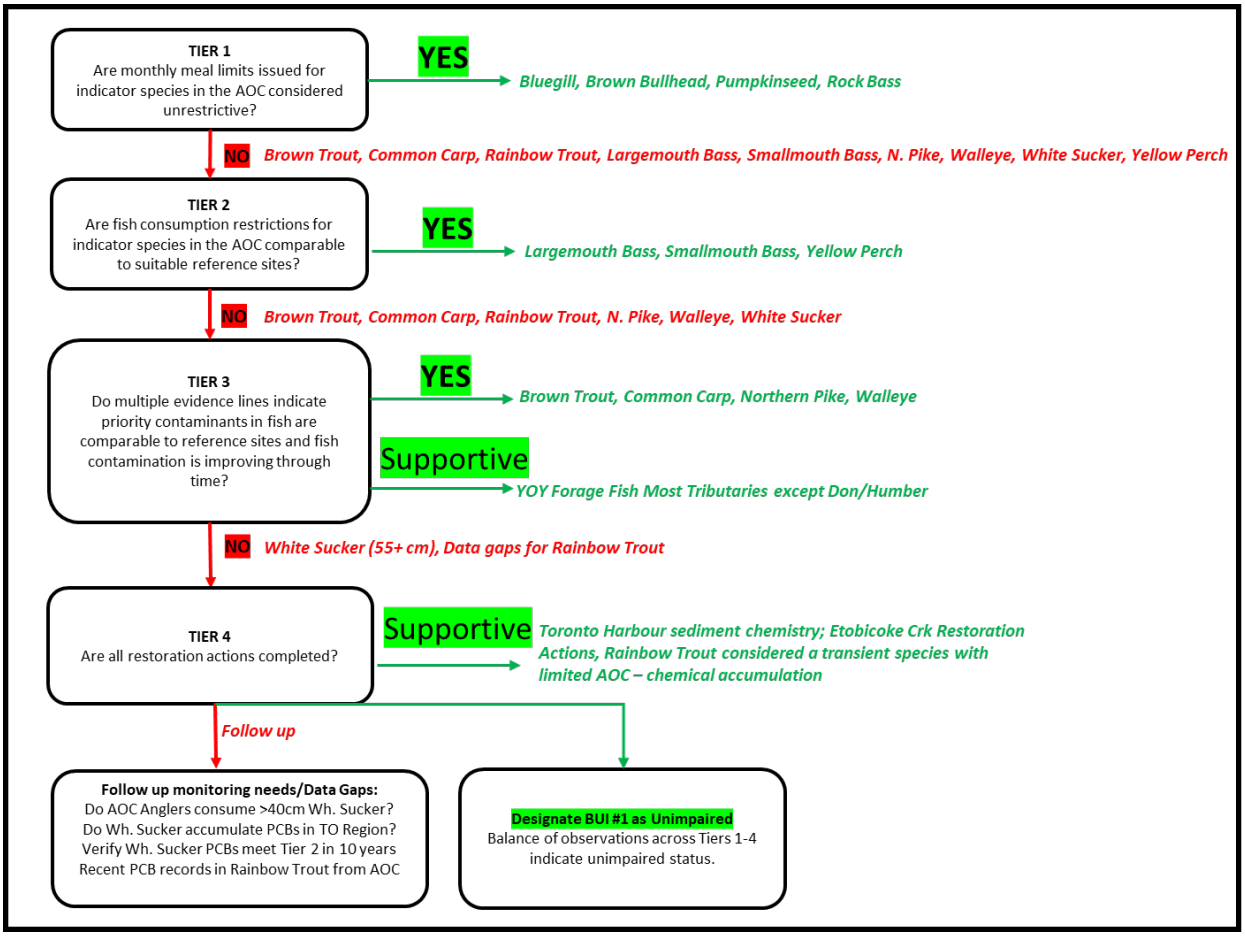

Figure 27. Overview of BUI #1 Tiered Assessment Outcomes for Toronto and Region AOC

6.0 Recommendations

Although data analyzed in this report provide overall support for delisting BUI #1, it is recommended that additional monitoring be performed in order to continue to track improvements in PCB contamination of the AOC over time.

Specifically, the following information and data gaps should be addressed through follow up studies in the region:

1) Angler surveys revealed approximately 3% of anglers reported consuming White Sucker from the AOC. Additional information about which size classes are captured and consumed from the area would be useful. The maximum monthly consumption frequency of White Sucker was drawn from the MECP provincial angler survey from the larger GTA area. Additional effort should be made to ascertain how often White Sucker are actually and/or desired to be consumed on a monthly basis. Additional outreach and communication may be warranted to discourage the Angler community from consuming larger White Sucker >55 cm based on elevated PCB contamination.

2) Three size classes of White Sucker demonstrated statistically significant declining trends through time for PCBs with half-lives on the order of 8-14 years. Continued monitoring and analysis of PCBs in tissues of this species should be completed to confirm further anticipated declines in contamination. White sucker from the AOC are expected to achieve the Tier 1 criteria within a decade.

3) Department of Fisheries and Oceans Canada recommended that follow-up telemetry studies on White Sucker be completed to tag a larger compliment of fish and to better understand fish associations with AOC tributaries such as the Don River. We support this recommendation.

4) Follow up studies on PCB contamination in young-of-year forage fish and potentially water and sediment contamination in the Don and Humber Rivers coupled with information about white sucker use of these regions (see recommendation 3) should be performed. There is a current lack of information on PCBs in forage fish from the mouth of the Don River necessary to determine if loadings arising from the G Ross Lord reservoir contribute to PCBs of Toronto Harbour. Furthermore, feasibility studies on potential restoration actions in the G Ross Lord Reservoir and Claireville Reservoir of the Don and Humber Rivers should be considered.

5) Information on White Sucker movements and use of Toronto and Region tributaries such as the Don River coupled with water and sediment contamination in these areas would enable application of modelling studies of fish PCB bioaccumulation to be developed to compute relative contributions of PCBs from tributaries and the AOC

to overall PCB burdens in AOC caught White Sucker to further establish cause-effect linkages between tributary sources of PCBs and sport fish advisories.

6) Additional collection of Rainbow Trout from the AOC region should be encouraged to address data gaps about current levels of contamination in this indicator species and enable MECP to update its fish consumption advice based on information reflective of current conditions in the AOC.

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