Assessment of Beneficial Use Impairment (BUI) #1: Fish and Consumption Advisories in the Detroit River

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Executive Summary

Beneficial Use #1 (BUI #1): Restrictions of Fish Consumption was evaluated for Canadian waters of the Detroit River Area of Concern assessed against the DRCC approved delisting criteria:

> *When Consumption advisories for indicator fish species (e.g. walleye, brown bullhead, and largemouth bass) given for the sensitive population in the AOC are similar to upstream and downstream non-AOC Great Lakes reference areas due to contaminants from locally-controllable sources.*

BUI #1 was evaluated using a tiered BUI framework to compile and interpret multiple evidence lines in support of the delisting statement. Tier 1 of the framework evaluated official fish consumption advice issued by Ontario Ministry of Environment, Conservation and Parks (MECP) for Canadian waters of the Detroit River Area of Concern against an unrestricted consumption benchmark of 8 meals per month. Tier 2 evaluated whether fish consumption restrictions in the AOC were more stringent compared to non-AOC Great Lakes reference areas. Tier 3 adopted multiple evidence lines on fish contamination coupled with a weight of evidence interpretation to evaluate how individual contaminants contribute to fish consumption restrictions. Tier 4 compiled evidence lines concerning environmental contamination of priority pollutants within and outside of the AOC to examine for evidence of temporal recovery of the AOC through time and to discern local from regional sources of contamination contributing to fish consumption restrictions.

Across the indicator species, brown bullhead passed Tier 1 criteria. Largemouth bass passed tier 3 criteria while walleye failed criteria related to Tiers 1, 2 and 3. For Largemouth bass, the main pollutant contributing to elevated fish consumption restrictions was mercury. The evaluation of fish movements in this species indicated a substantive fraction of fish caught (35.3%) from Canadian waters the AOC are migrating between the AOC and Lake St. Clair which has higher overall mercury contamination compared to Canadian zones of the AOC. For the walleye indicator, fish movement assessments indicated that walleye caught within the Detroit River consists of multiple sub-populations including fish migrants from Lake St. Clair, western Lake Erie and fish with different degrees of residency in Canadian and U.S. waters of the AOC. Only 32.2% of walleye caught from Canadian waters of the AOC were assigned as Canadian AOC residents according to a discriminant functions model examining unique chemical signatures of fish from different fishing zones. However, walleye identified as likely Canadian resident fish still contained elevated mercury and PCB residues in certain size classes compared to the Great Lakes Reference.

Tier 4 evidence lines were compiled to address whether further restoration actions taken in Canadian waters of the AOC are likely to benefit fish contamination of Canadian caught fish. Evidence lines focussed on spatial and temporal trends of the two priority pollutants, mercury and PCBs, that contribute to excess fish restrictions in AOC caught indicator species. Mercury contamination of suspended solids collected from sediment traps in Canadian waters of the AOC showed declining trends with mercury half lives in this environmental compartment ranging from 13.4 to 23.9 years. Multiple

evidence lines on spatial patterns of mercury contamination within and outside of the AOC point to on-going upstream (Lake St. Clair) sources of mercury contaminated particles entering Canadian waters of the AOC. Evidence for this included stable isotopes of mercury in bottom sediments, comparable mercury residues in suspended solids as those present in Lake St. Clair sediment trapping stations and similar temporal recovery of mercury in suspended solids from different trapping locations over time. Mercury residues were also elevated in bottom sediments of Canadian portions of Lake St. Clair as well as in U.S. nearshore designated restoration areas of the AOC as contrasted against Canadian areas of the Detroit River. Taken together, mercury was observed to be declining in some compartments of the AOC including suspended solids and in indicator fish (walleye) with little evidence for local mercury sources contributing to excess fish consumption restrictions. On-going and planned sediment restoration activities taking place in nearshore U.S. portions of the Detroit River AOC are likely to contribute to lowering the overall AOC mercury mass balance and are anticipated to have positive benefits to fish contamination for certain species of Canadian caught fish such as walleye that undergo routine cross channel movements. Therefore Tier 4 was considered to pass the criteria, i.e. there was a lack of evidence for locally controllable mercury sources in Canadian portions of the AOC that contribute to heightened fish consumption restrictions in indicator fish.

PCBs showed evidence for declining residues in water and suspended sediments but were stable to slightly increasing in concentrations within sediments. PCB concentrations in Canadian water and sediments of the AOC were much lower than U.S. nearshore regions designated for restoration and statistically equivalent in concentration to Lake St. Clair and western Lake Erie. Exceedances of low effect level sediment quality guidelines were rare (<10% of sampling stations) and no exceedances of severe effect level concentrations were observed. The combined features of declining PCBs in environmental media, lack of evidence for local sources to Canadian waters of the AOC coupled with declining trends in Canadian AOC resident fish residues indicate no substantive locally controllable sources for this priority pollutant. As in the case of mercury, on-going and planned U.S. sediment restoration initiatives in U.S. portions of the AOC are likely to contribute to reductions in the system wide PCB mass balance and further result in reductions in fish PCB contamination of mobile species such as walleye. Therefor Tier 4 was considered to pass the criteria for PCBs.

Based on combined evidence from the tiered assessment framework, it is recommended that BUI #1 be redesignated as unimpaired for Canadian waters of the Detroit River Area of Concern.

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1.0 INTRODUCTION

The beneficial use impairment (BUI), *Restrictions on Fish and Wildlife Consumption* (*BUI #1*), was designated impaired for the Detroit River Area of Concern (AOC) in the Stage 1 Remedial Action Plan Report (MDNR and OMOE, 1991) and in subsequent Canadian re-assessments of this BUI completed in 1996 (MDEQ, 1996) and 2006 (Leney and Haffner, 2006). The primary driver of BUI #1 impairment is chemical contamination of waters and sediments of the Detroit River. To some extent BUI #1 is also related to chemical contamination of water and sediments outside of the AOC given that the Detroit River receives inflow from two upstream AOCs (St. Clair River and Clinton River) and the Rouge River AOC, coupled with the fact that different species of fish have different movement profiles than can expose them to contaminants from both inside and outside of the AOC boundaries.

Restrictions on Fish and Wildlife Consumption refer to government issued advice to the public on the number of meals per month of angler-caught fish or wildlife harvested from a local region that the public can safely consume in order to minimize risks of human exposure to toxic contaminants. As an international AOC, the Detroit River is issued advice on fish consumption restrictions from two jurisdictions, the Province of Ontario and the State of Michigan. Ontario fish consumption advisories are issued by the Ontario Ministry of Environment, Conservation and Parks (MECP) and publicly disseminated through its on-line platforms and the Guide to Eating Ontario Fish program. Michigan advice information is provided by the states' Department of Health and Human Services (DHHS). Currently there are no advisories in place warning the public against consumption of wildlife from the Detroit River by Ontario or Michigan. However, both jurisdictions have current advice information concerning recommended meal restrictions for fish harvested from the Detroit River. Both Ontario and Michigan offer two sets of advisories intended for different public groups: The Sensitive Population, consists of women of childbearing age and children under the age of 15 and the General Population consists of groups not classified under the Sensitive Population. In most cases, advice information issued for the Sensitive Population is more restrictive, i.e. recommending fewer meals per month compared to the General Population. Fish consumption advice issued for the Detroit River under both jurisdictions is also specific to the species of harvest and incorporates different allowable monthly meal recommendations depending on the size of fish caught.

The Detroit River AOC is an international AOC, however, its Remedial Action Plan process is divided between Canadian and U.S. implementation groups with each country operating a separate Stage 2

Remedial Action Plans (Greene et al. 2010; Michigan Stage 2 Plan). This report is intended to provide information for the Detroit River Canadian Clean-Up Committee (DRCC) which directs the Canadian Stage 2 RAP process. As such, information contained in this report is confined in its scope to assessing BUI #1 in Canadian waters of the AOC and using Canadian issued fish consumption restrictions as the basis for the assessment. Figure 1 provides a map of the AOC and the two Canadian fishing zones to which fish consumption restrictions are issued (See Figure 1). Most references to fish consumption advice, advice computation approaches and monitoring data (including Great Lakes reference data sets) are restricted to information gathered from Canadian waters of the Detroit River and Canadian Great Lakes reference locations. However, given that some fish species exhibit wide spatial movements and can integrate chemical exposures across Canadian and U.S. waters of the AOC, additional considerations are made in the tiered BUI #1 assessment framework concerning potential exposures by Canadian caught fish in the adjacent U.S. jurisdictions of the AOC as well as in upstream and downstream waterbodies.

1.1. Ontario Fish Consumption Advisories

MECP provides regular updates to its fish advisory program issuing new advisories for each of the two Detroit River fishing zones approximately every 2 years. The upper Detroit River fishing zone (Zone 5a; Figure 1) includes all Ontario waters of the Detroit River from its head waters at Lake St. Clair to a transect dividing the river by width at the northern point of Fighting Island. The lower Detroit River fishing zone (Zone 5 b) includes all Ontario waters of the Detroit River below the north tip of Fighting island down to the river mouth at the mixing zone with Lake Erie (Figure 1).

During each re-assessment, MECP reviews the available records for a given waterbody using its Ontario Fish Contaminant Database and re-issues a new set of advisories across its various fishing zones. The fish consumption advice computation process assumes a standard body size and meal portion (1 meal = 226 g of skinless dorsal fillet) in conjunction with benchmarks for human risk assessment consisting of contaminant specific tolerable daily intakes (TDI's) issued by Health Canada. Example benchmark concentrations for mercury and polychlorinated biphenyls (PCBs) used to generate monthly meal allowances are provided in Table 1.

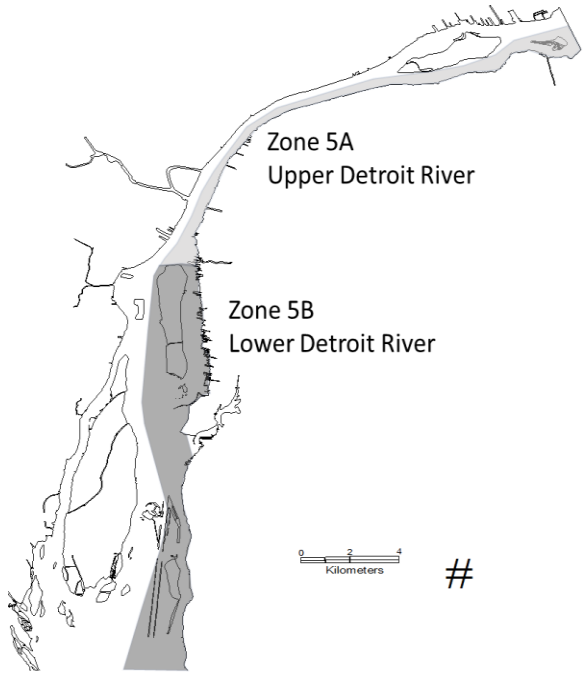

Figure 1. Ontario Fishing Zones in the Detroit River Area of Concern. Light shaded area provides boundary of MECP Fishing Zone 5a Upper Detroit River, Dark shaded area provides boundary of Fishing Zone 5b, Lower Detroit River. Non-shaded, open water areas indicate U.S. waters of the AOC. Canadian waters are shaded.

Monthly meal recommendations are computed for each fishing zone, population, sport fish species, multiple size intervals of each fish species and for across 15 contaminants of study. The number of fish advisories issued for a given fishing zone is data dependent and restricted to fish species and size ranges for which empirical data from the fishing zone are available. For each species and contaminant combination a power regression (log chemical concentration vs fish total length) is generated to compute the geometric mean concentration of the contaminant at the mid-point of each 5 cm size interval over the range of fish sizes available for the fishing zone. The power regression generated size interval mid-point concentration for each size bin is then used in conjunction with benchmarks (Table 1) to assign a chemical specific recommended monthly meal allowance. Monthly meal recommendations are computed independently for all 15 chemicals monitored in the fishing zone. The most restrictive monthly meal allowance across the chemicals is then selected and used as the official monthly meal recommendation. Chemicals contributing to the most stringent meal allowance across size categories are identified in the Guide to Eating Ontario fish.

Table 1. MECP fish consumption advisory benchmarks for priority chemicals mercury and PCBs used to generate fish consumption advice.

Meals/Month	Mercury (µg/g) Sensitive Population	Mercury (µg/g) General Population	PCBs (µg/g) Sensitive Population	PCBs (µg/g) General Population
0	>0.5	>1.8	>422	
1				
2		1.2-1.8	211-422	211-422
4	0.25-0.5	0.6-1.2	105-211	105-211
8	0.16-0.25	0.4-0.6	70-105	70-105
12	0.12-0.16	0.3-0.4	53-70	53-70
16	0.06-0.12	0.15-0.3	26-53	26-53
32	<0.06	<0.15	<26	<26

Meal advice categories are assigned as 0, 1, 2, 4, 8, 16 or 32 meals/month for the General Population and 0, 4, 8, 16 and 32 meal/month for the Sensitive population. Health Canada TDIs and chemical benchmarks are subject to periodic revision and updating when new scientific information becomes available. Most often such updates result in more stringent advice being issued for a given level of chemical contamination, i.e. downward adjustment of TDIs for a given contaminant, or addition of new chemicals of emerging concern to the advisory process when new TDI benchmarks are developed and monitoring data generated.

Data records used in the fish advisory computation process typically include multiple years of fish contaminant data. The time period over which data records are used to compute any given fish consumption advisory is not reported in the Guide to Eating Ontario Sportfish. This time integrated period will vary from location to location and even between species from the same location dependent on the number and frequency of record updates available in Ontario's fish contaminant database. For example, a larger number of years may need to be incorporated in a given species' power regression dependent on the quantity and variation in contaminant concentrations across records required to generate a statistically significant concentration vs size relationship. Thus, the re-issuing of new advisories every 2 years is an incremental process with the latest advisory accommodating changes to the advisory computation process (i.e. changes in chemical specific TDI's or addition of new pollutants to the advisory program) and new data records generated since the last set of advisories were issued. However, advisories issued for a given fishing zone in different years are not independent since both sets of advisories may use over-lapping fish contaminant records in their respective computations. These features of advice computation, i.e. changes in the chemical benchmarks through time and potential overlap in the use of the same data records for advisories issued in different years complicate

the use of fish consumption advice to directly assess recovery of BUI #1 impairments through time. For example, fish contamination may be declining in the AOC but if the decline in fish contamination does not keep pace with downward revision in benchmarks, then intensity of restrictions may remain constant or even increase as a function of time.

Currently, MECP monitors for 15 priority pollutants identified in Table 2. Not all fish samples collected in MECP fishing zones are analyzed for the full suite of compounds and MECP prioritizes which analytes are examined in sets of samples based on prior assessments of risk and other considerations that take into account the likelihood of a contaminant being present at high concentrations in the fishing zone of interest, analyte costs and laboratory turnaround times. New contaminants may be added to the Ontario advisory program following the introduction of new TDI benchmarks by Health Canada.

Table 2. Chemicals routinely monitored in fish and causes of Detroit River fish consumption restrictions.

Chemical	Causes an FCA for Upper Detroit River Fish Species (Zone 5A)	Causes an FCA for Upper Detroit River Fish Species (Zone 5B)
Mercury (Hg)	Bluegill, Brown Bullhead, Freshwater Drum, Goldfish, Largemouth Bass, Rock Bass, Walleye, Yellow Perch	Bluegill, Freshwater Drum, Largemouth Bass, Rock Bass, Walleye, Yellow Perch
Polychlorinated biphenyls (PCBs)	Brown Bullhead, Channel Catfish, Common Carp, Gizzard Shad, Northern Pike, Walleye, White Bass, White Perch, Yellow Perch	Channel Catfish, Common Carp, Freshwater Drum, Rock Bass, Walleye, White Bass, White Perch,
Dioxins and Furans (and Dioxin-like chemicals)	Common Carp, Largemouth Bass, Walleye, White Bass	Largemouth Bass
Toxaphene	Not Identified	Not Identified
PerFluoroAlkyl and PolyFluoroAlkyl Substances (PFAS)	Not Identified	Not Identified
Selenium	Not Identified	Not Identified
Arsenic	Not Identified	Not Identified
PolyBrominated Diphenyl Ethers (PBDEs)	Not Identified	Not Identified
PolyChlorinated Naphthalenes (PCNs)	Not Identified	Not Identified
Chromium	Not Identified	Not Identified
Mirex and Photomirex	Not Identified	Not Identified
Lead	Not Identified	Not Identified
Cadmium	Not Identified	Not Identified

Often different pollutants will drive fish consumption advisories for different species in a given fishing zone and in some cases different pollutants will drive fish advice in different size bins for the same species in a given water body. The major contributing pollutants to fish advice are identified by species for each fishing zone in the Ontario Guide to Eating Sport Fish. Table 2 further identifies the contributing pollutants to fish consumption advice for different fish species issued in the most recent advisories for the AOC. The main contributing pollutants to AOC advisories are mercury, polychlorinated biphenyls and dioxins and furans (and dioxin-like chemicals). Both mercury and PCBs are identified as priority pollutants in the Stage 2 RAP report for the Detroit River Area of Concern. Although dioxins and furans also contribute to some advice information issued for the AOC, in many cases, the actual cause of restrictions is related to dioxin-like PCB congeners which are strongly correlated with total PCBs. This is the case for advisories issued for Common Carp, Largemouth Bass, Walleye and White Bass. Some advice for certain size intervals of Largemouth Bass are also attributed to dioxins and furan concentrations. Often, Ontario estimates Dioxin and Furan toxic equivalency factors based on PCBs measured in fish samples (Bhavsar et al. 2008; Gandhi et al. 2015; Gandhi et al. 2019). As such, the BUI #1 assessment components referring to chemical contamination in fish in the present report focussed on mercury and PCBs as the priority pollutants of evaluation.

1.2. Delisting Criteria for BUI #1

In 2010, the Detroit River Stage 2 RAP report recommended omitting wildlife consumption advisories from its BUI #1 assessment. The rationale for this decision is outlined in Green et al. (2010) and is premised on a) a lack of Canadian wildlife consumption advisories issued for the region, b) past assessments of contaminants in waterfowl from the AOC indicated low toxicant concentrations and c) the low overall likelihood of public exposure to toxic contaminants through consumption of wildlife tissues from the region. As such, and on recommendation of the DRCC, this report focuses on assessment of fish consumption advisories and fish contaminant patterns as part of its BUI #1 assessment strategy.

In 2016, MECP and ECCC reviewed BUI #1 delisting criteria across Canadian AOCs and recommended a generic delisting criteria statement written as follows:

> *When 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 recommended generic delisting criteria statement adopts multiple elements that necessitate consideration in the assessment process that include presence of advisories, AOC-reference comparisons and locally controllable sources. The Canadian Stage 2 Detroit River RAP report recommended the following BUI #1 delisting statement:

> *When Consumption advisories for indicator fish species (e.g. walleye, brown bullhead, and smallmouth bass) given for the sensitive population in the AOC are similar to upstream and downstream non-AOC Great Lakes reference areas.*

This delisting criteria explicitly adopts an indicator species approach and retains the AOC/Reference comparison components of the generic statement. However, the Stage 2 RAP delisting statement did not include the 'locally controllable source' element and is restricted in its focus on restrictions issued for the Sensitive Population.

With regard to the indicator species approach, the following rationale was offered for the three suggested indicator species (Green et al. 2010): Brown bullhead and smallmouth bass were identified as likely resident fish species that remain within the AOC for most of their life spans. Both these species have different feeding ecologies that translate into different potential chemical exposures. Brown bullhead are benthic feeders and are more closely affiliated with sediments which provide them with greater exposure to sediment associated contaminants. Fish consumption advisories are currently in place for the Detroit River for this species. However, brown bullhead were not listed among the most frequently consumed fish by Canadian anglers of the Detroit River AOC (Dawson, 2000; Kalkirtz et al., 2010). Yet the most recent angler surveys confirmed that 12% (6/49 survey participants) reported consuming brown bullhead within the past year (Serran et al. 2019 Personal Communication). Brown bullhead was ranked 10th among the most consumed fish species from the Detroit River in a 2019 angler survey (Serran et al., 2019 Personal Communication).

Smallmouth bass occupy a higher trophic status and have a more pelagic diet composition that includes larger aquatic invertebrates and fish resulting in higher biomagnification potentials compared to brown bullhead. This species has also been identified as consumed by the local angling community (Dawson, 2000; Kalkirtz et al., 2010). Saran et al. (2019 Personal Communication) reported that 41% of anglers surveyed reported consuming smallmouth bass from the Detroit River within the past year. Unfortunately, there are no fish consumption advisories in place for this species in the Detroit River. Although smallmouth bass consumption advisories are not issued, advisories are provided by MECP for

largemouth bass species which is in the same genus as the suggested indicator. Largemouth bass have a somewhat different habitat preference, capable of tolerating warmer waters and exhibit stronger associations with macrophyte bed margins. These life history features make them potentially more philopatric (exhibit less spatial movements) compared to smallmouth bass. Largemouth and smallmouth bass are considered to occupy similar trophic status as one another although owing to different habitats there are undoubtably differences in diet composition between two species that can lead to differences in bioaccumulated chemical concentrations. Both smallmouth and largemouth bass were reportedly consumed by anglers in the local region (Dawson, 2000; Kalkirtz et al., 2010). Serran et al. (2019 Personal Communication) reported largemouth bass was the 5th ranked most consumed in fish species from the Detroit River closely following smallmouth bass (ranked fourth). An assessment was completed to determine if smallmouth and largemouth bass from the same water bodies generate similar levels of fish consumption restrictions. Fish advisories were compiled across 174 lakes where advice was given in both species over similar size ranges. This generated 719 matched fish of the same size and waterbody. Meal advice in largemouth bass was significantly correlated (Spearman's rank correlation coefficient of 0.75 (advice issued to Sensitive Population) with recommended meals per month generated for smallmouth bass. However, smallmouth bass tended to generate more restrictive advice (be one fewer meal category) than largemouth bass in more contaminated systems. In the absence of smallmouth bass data for the Detroit River AOC, and upon evaluating suitability of largemouth bass as an alternate indicator, the DRCC recommended changing the smallmouth bass indicator to largemouth bass in November 2022.

Walleye was identified in the Detroit River BUI #1 delisting statement because this species is near the top of the aquatic food web and as a sport fish is among the most sought after species for both angling sport and for consumption (Dawson, 2000; Kalkirtz et al. 2010). Serran et al. (2019 Personal Communication) reported that 78% of angler survey respondents reported consuming walleye from the Detroit River in the past year and it was ranked as the most frequently consumed fish species from the Detroit River by Canadian anglers surveyed. Fish consumption advisories are currently in place for Walleye in the Detroit River and this species has a comprehensive monitoring data set associated with it. Unlike brown bullhead and smallmouth bass, walleye are considered more mobile and potentially spend time both within and in waters outside the AOC boundaries. In addition, cross channel fish movements between U.S. and Canadian waters of the AOC are more likely for this mobile species, meaning that Canadian caught walleye may have accumulated some of its contaminant burdens from U.S. portions of the AOC as well as potentially outside of the AOC. The broad spatial movements associated with this

indicator make addressing the 'locally controllable sources' element of the generic delisting criteria statement more difficult and this should be considered as part of the weight of evidence strategy utilized in the tiered assessment framework.

Although identified as indicator species in the Stage 2 RAP report, the 2019 Detroit River Angler Survey identified other fish species as being consumed from the Detroit River. These included yellow perch (2nd ranked fish species), white perch (3rd ranked), black crappie and white bass (tied for 6th ranked), northern pike (8th ranked) and channel catfish (9th ranked).

The Stage 2 delisting criteria refers to upstream and downstream non-AOC Great Lakes reference areas. Previous assessments of BUI #1 in the AOC have used Lake St. Clair (upstream non-AOC reference) and western Lake Erie (downstream non-AOC reference) as reference sites on which to compare fish advice in the Detroit River. However, the use of these two reference sites in isolation may present its own set of problems. When reference sites selected for comparison have abnormally high or low contaminant levels it will bias the comparison. Therefore, it is recommended to utilize a larger number of reference sites instead of one or two in order to provide the most representative contrast of conditions in the AOC versus the Great Lakes as a whole. Lake St. Clair has a higher overall environmental mercury contamination compared to many non-AOC Great Lakes sites. Lake St. Clair was the first Great Lake waterbody to have its commercial fishery closed owing to elevated mercury contamination in fish from this waterbody. In contrast, Lake Erie is generally more contaminated with PCBs and dioxin-like PCBs compared to Lake St. Clair. These geographic differences in contamination and contaminant type between reference regions can generate contradicting conclusions when fish advisories and fish chemistry data from the Detroit River are compared against the two reference areas. Figure 2 provides an example of this by plotting mercury concentrations across all species of fish (y-axis) against PCBs concentrations in fish (x-axis) generated by the MECP and Michigan Environment, Great Lakes and Energy (EGLE) sport fish monitoring programs (2000-2017). It can be shown that Detroit River fish are commonly intermediate in degree of contamination between upstream and downstream waterbodies dependent on which chemical (mercury or PCBs) is being examined.

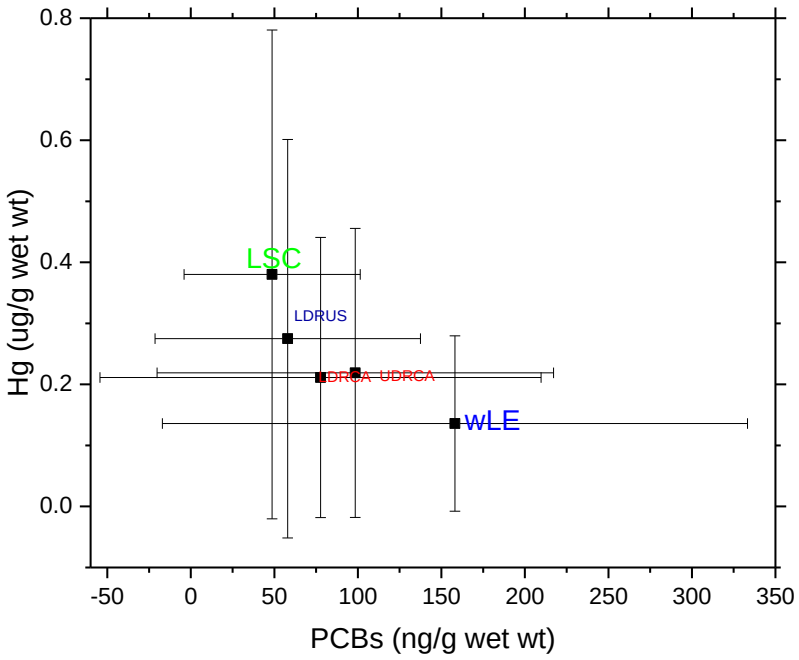

Figure 2. Mercury and polychlorinated biphenyl (PCB) concentrations in Canadian and U.S. sport fish from Lake St. Clair, Detroit River and western Lake Erie. Squares represent the geometric mean concentration of all fish samples (including different sizes and species), error bars represent 95% confidence intervals. LSC = Lake St. Clair, LDRUS = US. Lower Detroit River, LDRCa = Canadian Lower Detroit River caught fish, UDRCA = Candian Upper Detroit River caught fish, wLE = western Lake Erie fish.

Based on data presented in Figure 2, the Detroit River exhibits overall intermediate degree of contamination for Hg and PCBs relative to each of the immediate upstream and downstream waterbodies. In addition, some mobile fish species such as walleye are likely to move between these hydraulically connected systems. It would be inappropriate to make AOC/reference area contrasts if the reference water body supports the same effective population of fish as the AOC. Given that neither Lake St. Clair nor western Lake Erie are considered pristine reference locations, the DRCCC in 2019 recommended expansion of the list of Great Lakes reference areas to be included in the BUI #1 delisting assessment. The committee recommended that the delisting assessment should include all available MECP Great Lakes fishing zones which contained monitoring data for the selected indicator species. Based on this advice, all MECP Great Lakes fishing zones were considered with the exclusion of AOCs (both current and delisted AOCs were excluded from the reference fishing zones considered).

The Stage 2 BUI #1 delisting statement does not explicitly identify 'locally controllable sources' in a comparable fashion to the recommended generic BUI #1 delisting criteria. However, the Stage 2 RAP Report does state that the cause of the impairment must originate within the Detroit River AOC and not from a regional source (Green et al., 2010). This assessment element requires establishing cause-effect linkages between environmental contamination and the BUI as well as restoration initiatives, both past and future, that could lead to further improvement and/or restoration of the BUI. As an international AOC with two separate Stage 2 RAP plans operating, the 'locally controllable source' is important to consider especially given that spatial integration of fish through their migration and foraging movements could expose them to water and sediment contamination across both sides of the AOC in addition to outside of the AOC boundaries. Addressing whether additional restoration actions in Canadian waters of the AOC are likely to restore BUI #1 requires supporting evidence to address the question of whether joint exposures of fish in U.S. portions of the AOC (or outside of the AOC) will counteract local Canadian restoration efforts. Alternatively, U.S. restoration actions, even though these actions take place outside of Canadian waters, have the possibility of generating benefits to some species of Canadian caught fish that are moving between U.S. and Canadian waters (Li et al. 2019). Adopting the 'locally controllable sources' element of the generic delisting criteria into the modified Detroit River BUI#1 delisting statement generates the following proposed delisting statement:

> *When Consumption advisories for indicator fish species (e.g. walleye, brown bullhead, and largemouth bass) given for the sensitive population in the AOC are similar to upstream and downstream non-AOC Great Lakes reference areas due to contaminants from locally-controllable sources.*

1.3 Tiered BUI #1 Delisting Framework

Bhavsar et al. (2018) presented a 3 tiered assessment framework for BUI #1 using the Toronto Harbour AOC as a case study. The tiered framework recognizes that assessing the individual elements of BUI #1 is both complex and multifaceted and frequently requires compilation of several qualitative and quantitative evidence lines that are interpreted at each stage through a weight of evidence (WOE) approach. Within the framework, data are collected and evaluated in a hierarchical manner. At each Tier an unimpaired status conclusion is possible based on the quality and outcome of tests and WOE conclusion. The individual Tiers are structured to evaluate specific elements of the delisting statement. Tier 1 is simply concerned with the presence of fish or wildlife consumption restrictions exceeding a

benchmark level of number of allowable meals per month appropriate to the local region. Tier 2 compares the degree of restrictiveness of fish consumption recommendations in the AOC compared to reference. Tier 3 compiles multiple evidence lines to address whether past mitigation actions in the AOC have contributed to recovery of the BUI with time. The reasonable action and locally controllable source element was incorporated as an additional modifier of the Tier 3 assessment.

For the present BUI #1 assessment the tiered framework of Bhavsar et al. (2018) was adapted with some modifications based on a series of workshops held in 2021 to examine the application of the tiered framework as generated across several Canadian case studies. Based on the outcome of these workshops, the original tiered framework was modified with evidence lines associated with each tier explained in detail below. In addition, a 4th tier was added to provide additional evidence lines that can be used to facilitate understanding of environmental recovery within the AOC and address the need for additional restoration actions leading to reduction in fish contamination and hence fish consumption restrictions. Figure 3 provides a schematic of the 4 Tiered assessment framework used in the evaluation of BUI #1. The data sources and evidence lines compiled for each tier are described in detail below.

1.3.1. Tier 1 Assessment and Evidence Lines

Tier 1 is the most straight forward evidence line and asks whether or not fish or wildlife consumption restrictions are more restrictive than an unrestricted meal allowance benchmark. Given that virtually all fishing zones in Ontario now contain some type of fish consumption restriction, there is a need to specify a benchmark for the degree of restrictiveness within the framework as opposed to simply asking if fish restrictions are in place or not. Bhavsar et al. (2018) recommended that the benchmark of 8 meal/month or higher be used to define non-restrictive fish consumption in the absence of AOC specific information. This recommendation was based on prior assessments by MECP that indicated more than 90% of Ontario Anglers do not consume wild caught fish at a frequency of more than 8 meals/month. Additional supporting evidence in the Toronto region indicated that less than 1% of anglers from this area consumed more then the 8 meals per month.

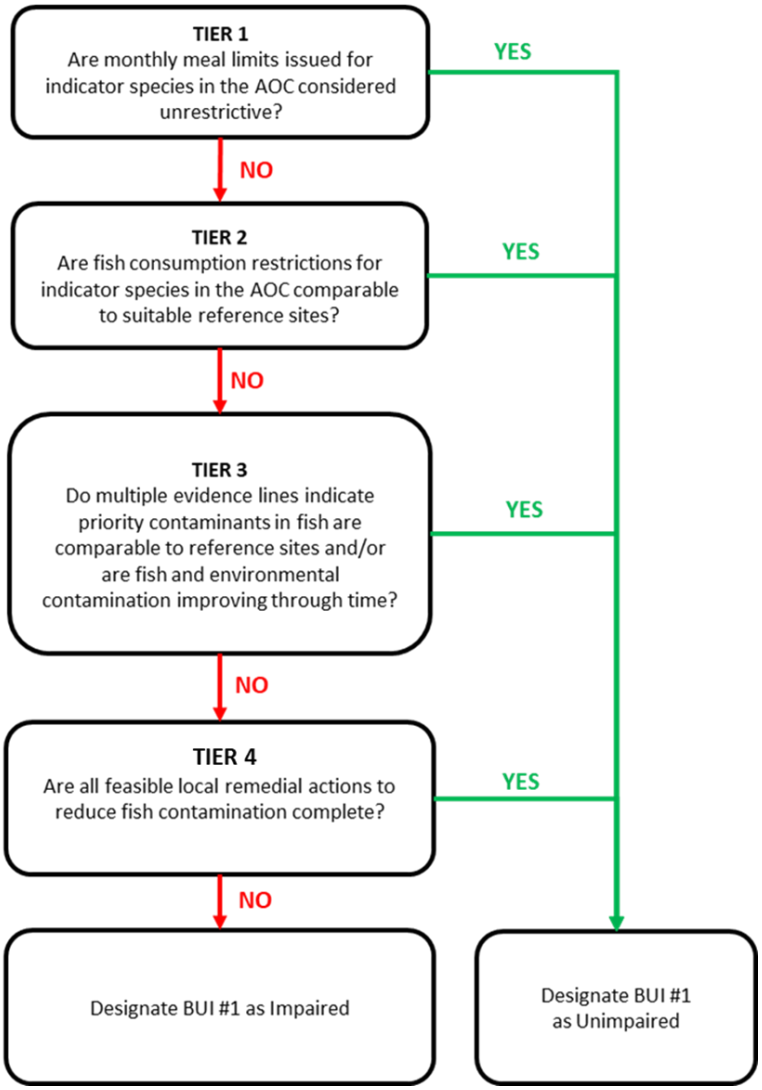

Figure 3. Tiered framework for addressing BUI #1 assessment in an Area of Concern.

Dawson (2001) reported that among Detroit River shoreline anglers, 52% of surveyed anglers consumed wild fish caught from the region but only 5% of surveyed fish eaters were categorized as very frequent wild fish consumers consuming more than 8 meal/month. Angler survey preferences are currently being re-examined by the DRCCC and newer information on desired level of wild fish consumption from the Detroit River is anticipated to become available in 2023. *For the present report, fish consumption restrictions equal to or greater than 8 meal/month are considered non-restrictive to the local population*.

The data sources used for the evaluation of Tier 1 are based on the most recent official monthly meal recommendations issued for the Sensitive Population by Ontario's Guide to Eating Ontario fish for the

two Detroit River fishing zones (zones 5a and 5b; Figure 1). Priority was given to the indicator species identified in the delisting statement to examine monthly meal allowances more restrictive than 8 meals/mo.

1.3.2. Tier 2 Assessment and Evidence Lines

Tier 2 of the framework addresses the AOC vs reference comparison. As with Tier 1, the data used for the Tier 2 assessment is comprised exclusively of fish consumption advice issued by MECP. Rather than comparing recommended monthly meal restrictions to the unrestricted benchmark, Tier 2 compares the degree of restrictiveness of meal recommendations in the AOC against reference sites. Owing to different fish assemblages across Great Lakes fishing zones, there may be variable numbers of reference locations where advice information is available for the selected indicator species. In addition, advisories are size specific and therefore care must be taken to compare fish advice between reference areas and the AOC for the same size bins of fish.

Quantitative comparisons concerning the degree of restrictiveness were performed by determining the median meal advice for each size bin/indicator across the Great Lakes reference locations. *Where monthly meal advice in the AOC was lower (i.e. more restrictive) than the median monthly meal advice generated across the reference fishing zones, the advisory was considered impaired.* An exception to the above impairment designation is made for cases where the restrictiveness of monthly meal allowance in the AOC exceeds the Great Lakes reference, but meal allowances are 8 meals per month or above and therefore the advice issued still passes the unrestricted benchmark. As part of the WOE for Tier 2, fish consumption advisory comparisons between the AOC and Great Lakes reference were extended to advisories issued for the General Population. The reason the General Population was included in the WOE assessment is because there are a larger number of monthly meal categories (i.e. 0, 1, 2, 4, 8, 12, 16 and 32 meal/mo) whereas meal advice for the Sensitive Population is limited to 4+ meal per month categories. The availability of additional meal allowance categories enables better resolution to distinguish differences between advisory restrictiveness between AOC and the reference particularly among the larger size classes of fish. Data sources for Tier 2 evidence lines include MECP derived fish consumption advice information for the 2020/21 year period for the Detroit River and all Non-AOC Great Lakes reference sites identified in the most recent Ontario Guide to Eating Sport Fish. In keeping with the delisting criteria statement, data on fish advice in the AOC and Great Lakes Reference fishing zones were restricted to the three indicator species.

1.3.3. Tier 3 Assessment and Evidence Lines

Tier 3 of the assessment uses available data on fish contamination for the indicator species to determine if AOC differs from reference and to examine for temporal recovery of fish contamination from the AOC over time. Tier 3 generates 4 evidence lines of information generated for each indicator fish species and priority contaminant (PCBs and mercury). A weight of evidence interpretation is generated to complete the Tier 3 assessment outcome. Indicator fish species that pass either Tier 1 and Tier 2 are not subjected to Tier 3 assessments.

Tier 3a adopts a virtual meal advice approach to compare contaminant-specific fish consumption advisories in the AOC relative to Tier 1 and Tier 2 criteria. Tier 3a differs from Tier 1 and Tier 2 in that fish chemistry data are used to generate virtual meal advice rather than adopting the official fish consumption advisories issued by MECP. In this case, data used to generate virtual fish advice are restricted to recent data generated in AOC, i.e. only including fish contaminant records generated within the last 10 years of the most recent available fish record for the species in question (2007-2017). Official fish consumption advice adopts different temporal ranges across species and sample locations dependent on data availability and therefore the temporal integration of Tier 1 and Tier 2 evaluations are unknown. In contrast, Tier 3a ensures a standardized and consistent temporal range for its evaluation. Virtual meal advice is generated for individual size intervals (5 cm increments) in each of the indicator species (restricted to those that fail Tier 1 or Tier 2) and separately for PCBs and Hg using the same risk assessment procedure adopted by MECP for issuing its official advice. Where there is a statistically significant relationship between chemical concentration and fish size, a power regression (log Concentration vs total length) relationship is used to predict chemical concentrations at the mid-point of each size interval covering the range of sizes collected for the species from the AOC. The predicted concentration in each size interval is then compared to the monthly meal allowance benchmarks described in Table 1 to compute chemical specific virtual meal advice. The same approach is applied across the reference data set after combining contaminant records in fish from reference zones. Reference data are censored to generated a matched temporal and size range of fish as the AOC data set and virtual advice generated. The virtual meal advice generated in AOC and Great Lakes reference are then compared against Tier 1 and Tier 2 criteria. In cases where there is no statistical relationship between chemical concentrations and fish size, fish are divided into multiple size intervals based on the distribution of records available from the AOC. All size intervals in 5 cm increments where there are 4 or more records available are considered. For each size interval, the geometric mean

concentration is computed and compared to the advisory benchmarks and contrasted against Tier 1 and 2 criteria.

Tier 3b examines for statistical differences in priority chemical concentrations in fish from the AOC compared to the Great Lakes Reference. Data used for this evidence line include fish chemistry records generated from MECP as well as GLIER, University of Windsor. Both MECP's analytical laboratory and GLIER's laboratory are accredited laboratories undergoing routine laboratory audits and round robin inter-laboratory testing comparisons. However, there are differences in the analytical protocols used in their respective analysis. Notably, GLIER's PCB detection limits are much lower (0.05 ng/g) compared to the MECP minimum reporting limit of 20 ng/g. Therefore, any PCB data from the GLIER data less than 20 ng/g was replaced with the 20 ng/g MECP reporting limit. Both MECP and GLIER adopt similar approaches for mercury analysis using a direct mercury analyser in the quantitation of this priority chemical. Records of fish body length were retained to facilitate size-standardized contrasts in the AOC vs reference comparison. Fish records from the two Detroit River fishing zones and various timepoints (2007-2017) were combined as the AOC treatment, while records from all Non-AOC Great Lakes Fishing zones were grouped together as reference. Where data passed normality by Lilefor's test, analysis of covariance (ANCOVA) was used to examine for differences in the slope of chemical concentration vs total length between AOC and reference. Where ANCOVA revealed similar slopes, the analysis proceeded to examine differences between treatments following size standardization of the data. This statistical procedure adopts the common chemical concentration vs body size slope for the two data sets and examines for differences between the intercepts. In cases where the concentration vs size slope is statistically different between AOC and reference, fish are divided up into two or three size intervals (5 cm intervals) that have sufficient replicates in both AOC and reference. Non-parametric Kruskal-Wallis test are used to examine for differences in chemical concentration between the AOC and reference for each size interval separately. Tests are repeated for mercury and PCBs in each indicator species and size interval separately. The evidence line is considered to fail when priority chemical concentrations in equivalent sized AOC fish are statistically higher than the reference with a probability value of 0.05 or lower.

The Tier 3c examines for temporal recovery of priority contaminants (PCBs or mercury) in indicator fish from the AOC over time. All MECP fish records in indicator species from the AOC (1987-2017) along with supplementary GLIER data 2000-2016 were compiled to facilitate the temporal contrast. Data quality criteria were generated as a quality assurance procedure to ensure that the data were sufficiently

robust to test for temporal trends. For each indicator species the records by year were evaluated to ensure the following conditions were met: 1) the time period between the first record and last record of the data was at least 15 years apart; 2) there were at least 5 different years over the time period where records of fish contamination were available; 3) there were at least 5 records available for 5 or more of the years where fish records were available. Where data were normal, a multiple regression was performed to test for effects of year, total length and the year x length interaction on $\log_2$ transformed chemical concentrations in fish. If the interaction and length terms were non-significant, they were removed from the model and the linear regression reported. If the interaction was non-significant but year and length were, ANCOVA was used to test the effect of time while adjusting for size. In cases where data were non-normal or the interaction was significant then fish were divided into size intervals and linear regression performed to test the effect of year for each size interval separately. Size intervals selected for analysis required that sample replicates meet data quality procedures described above. Where temporal trends were significantly declining the half life of the pollutant in fish was computed.

Tier 3d included an assessment of fish movements using chemical signatures of fish collected from adjacent water bodies to the AOC and contrasted against those present in fish from the AOC. Tier 3c takes advantage of the fact that different waterbodies (Lake St. Clair and western Lake Erie) have pronounced differences in legacy sources of priority contaminants which leads to different chemical signatures present in fish inhabiting these systems. Fish movement profiles were evaluated using discriminant functions analysis (DFA). DFA is a multivariate statistical technique used to recognize patterns of dependent variables (i.e. chemical signatures) and calibrate a model which can then assign the most likely classification of a set of samples. Fish records collected from Lake St. Clair, western Lake Erie and U.S. and Canadian portions of the Detroit River were used to calibrate a DFA model to enable it to recognize diagnostic chemical signatures present in fish from the different sub-populations. For Tier 3c, data records on fish chemistry were expanded to include U. Windsor, MECP and Michigan DNR data used for the Michigan fish consumption advisory program. Records of fish contamination were censored to include only records containing both PCB and mercury concentration in matched samples. Given that Michigan DNR fish used skin-on and in some cases whole fish samples, PCB concentrations were expressed on a lipid normalized basis to remove the effect of different lipids (and co-varying hydrophobic contaminants) in different tissues used for analysis. Following calibration of the DFA model and evaluating the robustness of its prediction for the training dataset (applied to Lake Erie and Lake St. Clair data in isolation), the DFA was then applied to assign the most probable classification of fish

records captured from Canadian waters of the AOC. This led to 4 potential assignments: LSC-type, wLE-type, Detroit River US- type or Detroit River Canadian-type. After Canadian caught Detroit River fish (largemouth bass or walleye) were classified into their respective sub-populations, the Tier 3a,b and c contrasts were repeated on the subset of fish caught from Canadian waters of the AOC and classified as Canadian-type.

After compiling evidence lines from Tiers 3a-d, an Evidence Matrix was compiled to facilitate decision of the Tier Impairment Status by contrasting the outcomes of each evidence line. Some degree of expert judgement is needed in this Tier because individual evidence lines can generate contradicting information. For example, where Tier 3d generated a robust model of fish spatial movements, its outcome was used in priority of Tier 3a,b when the two evidence lines were in conflict with one another. Weighting of Tier 3c was premised on the strength of temporal recovery observations and anticipated timelines required for criteria to be met.

1.3.4. Tier 4 Assessment and Evidence Lines

Tier 4 of the framework compiles evidence lines to address questions about the extent of environmental contamination recovery in the AOC and whether or not additional remedial actions performed in Canadian waters of the AOC are needed to further improve the beneficial use. This tier extends data beyond fish contamination to consider environmental media such as contamination of water, suspended sediments and sediments coupled with assessments of spatial patterns of contaminations throughout the Lake St. Clair – Lake Erie Corridor to discern local vs regional sources of contamination.

Tier2 4a-f considered evidence for environmental recovery and spatial contamination of mercury in abiotic components of the Lake St. Clair-Lake Erie corridor. Tiers 4a, b and c considered evidence for environmental recovery of mercury in water, suspended sediments and bottom sediments from the AOC. Tiers 4d-e contrast mercury in suspended solids and bottom sediments from the AOC against concentrations found in Lake St. Clair and U.S. portions of the Detroit River. Tier 4f contrasts mercury residues in sediments from the AOC against sediment quality guidelines while Tier 4g examines mercury isotopes as source tracers of mercury entering Canadian waters of the AOC. Tiers 4h-m provide complimentary lines of evidence related to PCB temporal and spatial patterns as described for mercury.

Weight of evidence across individual evidence lines are then interpreted for each priority contaminant separately to determine 1) if multiple environmental media are showing signs of environmental

recovery through time and 2) if there is evidence for locally enhanced environmental contamination within Canadian waters of the AOC relative to regional contamination (Lake St. Clair, western Lake Erie and/or U.S. waters of the AOC) causing enhanced chemical bioaccumulation in fish.

2.0 BUI #1 Assessment Results

2.1. Tier 1 Fish Consumption Restrictions in the AOC

In 2020/21 there were 112 fish consumption advisories issued by MECP for Canadian waters of the Detroit River AOC. MECP advisories are issued for 14 fish species and 13 fish size categories for the two human populations. Table 3 summarizes the 2020/21 MECP fish consumption advisories issued for the Sensitive Population in each fishing zone. Among these advisories, 88 (76.7%) had meal advice more restrictive than 8 meals per month that would be considered restrictive under the Tier 1 unrestricted benchmark. There were 50 advisories (44.6%) that recommended “no consumption”, the most stringent level of restriction possible. The recommendation against any consumption of fish for the Sensitive Population are issued for following species: Channel Catfish, Common Carp, Freshwater Drum, Gizzard Shad, Largemouth Bass, Rock Bass, Walleye, White Bass, White Perch and Yellow Perch. Two advisories for consumption of brown bullhead were not considered restrictive according to the Tier 1 criteria.

Two of the three indicator species (walleye and largemouth bass) are included in the above list. For largemouth bass, advisories were issued for 4 size classes of this species that recommend either no fish consumption or monthly meals of less than 8 meal/month. For the walleye indictor, there were nine size categories where the monthly meal allowance was less than 8 meal/month, of which 5 were of the most stringent advice type ‘no consumption’.

Overall, official fish consumption advisories are in place for all three indicator species in the OAC. For the brown bullhead, fish consumption advisories were 8 meal/month and considered non-restrictive. Given this species passes the unrestricted consumption benchmark, it was not considered in any of the other tiers used in the assessment. Walleye and largemouth bass had monthly meal allowances less than 8 meal/month for several size categories of fish in the two AOC fishing zones. Furthermore, for the largest size bins of both indicators were of the most restrictive possible category of meal advice available. Therefore, Tier 1 is considered impaired for walleye and largemouth bass indicators.

Table 3. 2020/21 Ontario Fish Consumption Advisories in the Upper (Zone 5a) and Lower (Zone 5b) of the Detroit River Issued for the Sensitive Population (SP).

Species	**Size Category (cm)/Recommended Maximum Number of Meals Per Month**												
Zone/Population	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75
Bluegill													
Zone 5a	16	16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Brown Bullhead													
Zone 5a	NA	NA	**8**	**8**	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Channel Catfish													
Zone 5a	NA	NA	0	0	0	0	0	0	NA	NA	NA	NA	NA
Zone 5b	NA	NA	0	0	0	0	NA	NA	NA	NA	NA	NA	NA
Common Carp													
Zone 5a	NA	NA	NA	NA	8	4	2	2	1	0	0	NA	NA
Zone 5b	NA	NA	NA	NA	NA	4	0	0	0	0	0	0	0
Freshwater Drum													
Zone 5a	NA	12	8	4	4	4	0	0	0	NA	NA	NA	NA
Zone 5b	NA	NA	NA	8	8	4	0	0	0	NA	NA	NA	NA
Gizzard Shad													
Zone 5a	NA	NA	NA	NA	0	0	0	NA	NA	NA	NA	NA	NA
Zone 5b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Goldfish													
Zone 5a	NA	NA	8	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Largemouth Bass													
Zone 5a	NA	12	8	**4**	**4**	**0**	NA	NA	NA	NA	NA	NA	NA
Zone 5b	16	12	8	**4**	**4**	**0**	**0**	NA	NA	NA	NA	NA	NA
Northern Pike													
Zone 5a	NA	NA	NA	NA	NA	4	4	4	4	4	NA	NA	NA
Zone 5b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rock Bass													
Zone 5a	8	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	8	4	4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Walleye													
Zone 5a	NA	NA	12	8	**4**	**4**	**4**	**4**	**0**	**0**	**0**	**0**	NA
Zone 5b	NA	NA	12	8	**4**	**4**	**4**	**4**	**0**	**0**	NA	NA	NA
White Bass													
Zone 5a	NA	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	NA	4	4	4	4	NA	NA	NA	NA	NA	NA	NA	NA
White Perch													
Zone 5a	4	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	4	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Yellow Perch													
Zone 5a	12	8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zone 5b	16	8	4	0	0	NA	NA	NA	NA	NA	NA	NA	NA

NA = no advisory issued for the species and/or size class. Species in bold are identified as indicator species used in BUI #1 assessment. Note largemouth bass is substituted for smallmouth bass in the assessment owing to lack of advisories in place for smallmouth bass. Meal restrictions for indicator species above 8 meal/month are highlighted in green bold text. Meal restrictions for indicator species less than 8 meal/month are highlighted in red bold text.

2.2. Tier 2 Assessment Results

Tier 2 provides assessment of the intensity of fish consumption advisories for indicator species in the AOC compared to a Great Lakes reference. The Tier 2 criteria were examined for both the Sensitive Population and General Population separately.

2.2.1. Tier 2 Assessed for the Sensitive Population

Table 4 identifies fish advisories issued for the sensitive population consuming largemouth bass from the AOC and non-AOC Great Lakes reference fishing zones. There were eight reference fishing zones where largemouth bass advisories were issued with meal allowances ranging from 0 to 16 meals per month depending on fish size. For the AOC, meal allowances ranged from 0 to 16 meals per month in the two fishing zones and across size categories. Fish advisories issued for largemouth bass in the AOC were equivalent to the reference data for 15-20 cm, 35-40 cm, 40-45 cm and 45-50 cm sized fish. However, recommended monthly meal allowances in the AOC exceeded the median reference advice for fish sized 20-25 cm, 25-30 cm and 30-35 cm in both AOC fishing zones. Overall, 6 of 12 advisories issued for the largemouth bass indicator were more restrictive than the median restrictiveness of Great Lakes reference zones. However, 4 of the above advisories recommended 8 meals per month consistent with the Tier 1 benchmark and only 2 advisories were more restrictive than reference and less than 8 meals per month. Tier 2 fails for the largemouth bass indicator for the Sensitive Population.

Table 5 identifies fish consumption advisories issued for the sensitive population consuming walleye from the AOC and reference sites across various size bins. There were 23 non-AOC Great Lakes fishing zones for which advisories were issued for walleye by MECP. The median of monthly meal recommendations for the same size categories of walleye among the reference fishing zones ranged from 0 to 16 meals/month and between 0 to 12 meals per month in the AOC. For walleye, 14/18 advisories issued for this indicator exceeded the median monthly meal recommendation in the Great Lakes reference data set. However, four of the above advisories achieved the Tier 1 criteria leaving 10/18 advisories failing the combined Tier 1 and Tier 2 criteria. Thus Tier 2 fails for the walleye indicator for the Sensitive Population.

Table 4. Recommended number of meals per month for the Sensitive Population for largemouth bass in non-AOC Great Lakes Reference Zones and the Detroit River AOC.

Location	Fish body length (cm) category						
	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Lake Huron							
GB3 – Georgian Bay	12	12	12	8	8	8	
GB4 – Georgian Bay		16	12	8	4	4	0
Lake Ontario							
2a – Jordan Harbour		16	12	8	4	4	
6a – Frenchman Bay	16	16	16	12	8		
Lake Erie							
1 – Western Lake Erie				1	1	0	
2a – Rondeau Bay	16	12	8	4	4	0	0
3 – Long Point Bay	8	8	8	8	4	0	
Lake St. Clair	16	16	8	4	4	0	0
Median –Great Lakes Reference	**16**	**16**	**12**	**8**	**4**	**0**	**0**
Detroit River AOC							
5a Upper Detroit River		**12**	**8**	**4**	**4**	**0**	
5b Lower Detroit River	**16**	**12**	**8**	**4**	**4**	**0**	**0**
Impairment Status (I = Impaired; NI= Not Impaired)	**NI**	**NI**	**NI**	**I**	**NI**	**NI**	**NI**

Table 5. Recommended number of meals per month for the Sensitive Population for Walleye in non-AOC Great Lakes Reference Zones and the Detroit River AOC.

Location	Fish body length (cm) category									
	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75
Lake Superior										
S4- Black Bay	16	12	12	8	4	4	0	0		
S7 – Schreiber Point	8	8	8	8	4	4	0			
S10 – Agawa and Bachwana					0	0	0	0	0	0
S11 – Goulais Bay	8	8	8	4	4	4	4	4		
Lake Huron										
GB1 – Georgian Bay	16	16	12	8	8	8	4	4	4	
GB3 – Georgian Bay	12	8	8	4	4	4	4	0	0	0
GB4 – Georgian Bay		12	12	12	8	4	4	0	0	0
H3 – Lake Huron		16	16	12	8	4	4	0	0	
H4 – Lake Huron	32	16	16	4	4	0				
H5 – Lake Huron	16	16	12	8	8	8	4	0	0	
NC1 – North Channel	16	16	12	8	8	4	4	4	4	0
NC2 – North Channel	16	16	12	12	8	8	8	4	4	
NC2a- North Channel			4	0	0	0				
Lake Ontario										
2 – Western Lake Ontario	16	16	16	16	12	8	4	0	0	0
6 – Northwestern Ontario			0	0	0	0	0	0	0	0
6a – Frenchman Bay		16	16	16						
6B – Whitby Harbour		12	12	8	4	4	4	0	0	0
Northeastern Lake Ontario	16	16	12	8	8	4	4	0	0	0
Lake Erie										
1 – Western Lake Erie	16	16	16	12	8	8	4	0	0	
2 – Central Lake Erie	16	16	12	12	8	4	4	0	0	
3 – Long Point Bay		16	12	8	8	4	4	0	0	0
4 – Eastern Lake Erie	16	16	12	12	8	8	4	0	0	0
Lake St. Clair	4	4	0	0						
Median –Great Lakes Sites	**16**	**16**	**12**	**8**	**8**	**4**	**4**	**4**	**0**	**0**
Detroit River AOC										
5a Upper Detroit River	**12**	**8**	**4**	**4**	**4**	**4**	**0**	**0**	**0**	**0**
5b Lower Detroit River	**12**	**8**	**4**	**4**	**4**	**4**	**0**	**0**		
Impairment Status (I = Impaired; NI= Not Impaired)	**NI**	**NI**	**I**	**I**	**I**	NI	**I**	**I**	NI	NI

2.2.2. Tier 2 Assessed for the General Population

The analyses presented in Section 2.2.1 was repeated for advice issued to the General Population. Table 6 identifies fish advisories issued to the General Population for largemouth bass in the AOC as compared to reference sites. All twelve advisories issued to the General Population for this species were similar or less restrictive than the median of consumption advice issued across the Great Lakes Reference. Tier 2 passes for the largemouth bass indicator for the General Population.

Table 6. Recommended number of meals per month for the General Population for largemouth bass in non-AOC Great Lakes Reference Zones and the Detroit River AOC

Location	Fish both length (cm) category						
	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Lake Huron							
GB3 – Georgian Bay	32	16	12	12	12	12	
GB4 – Georgian Bay		32	32	16	12	8	8
Lake Ontario							
2a – Jordan Harbour		16	16	16	16	12	4
6a – Frenchman Bay	16	16	16	16	16		
Lake Erie							
1 – Western Lake Erie			1	1	0		
2a – Rondeau Bay	32	32	16	12	8	8	8
3 – Long Point Bay	16	13	16	16	8	4	
Lake St. Clair	16	16	12	8	8	2	2
Median –Great Lakes Reference	16	16	16	12	8	8	4
Detroit River AOC							
5a Upper Detroit River		16	16	16	12	8	
5b Lower Detroit River	16	16	16	12	8	8	4
Impairment Status (I = Impaired; NI= Not Impaired)	**NI**	**NI**	**NI**	**NI**	**NI**	**NI**	**NI**

Table 7 summarizes fish consumption advisories issued for walleye to the General population in Great Lakes reference fishing zones and the AOC. Monthly meal advice issued for the reference zones ranged from 2 to 16 meals per month and in the AOC it ranged from 4 to 32 meals month. A total of 15/18 advisories issued for Walleye in the AOC were more restrictive than the median meal allowance for equivalent size bins in the reference. However, 3 of these advisories recommended 8 or more meal per month or more and were subsequently deemed non-impaired according to the Tier 1. After removal of these, 12 advisories remained restrictive relative to Tier 1 and 2 criteria. Thus 2 fails for walleye for the General Population.

Table 7. Recommended number of meals per month for the General Population for Walleye in non-AOC Great Lakes Reference Zones and the Detroit River AOC

Location	Fish both length (cm) category									
	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75
Lake Superior										
S4- Black Bay	32	16	16	16	16	8	8	4		
S7 – Schreiber PoInt	16	16	16	16	12	8	8			
S10 – Agawa and Bachwana				2	2	2	2	2	2	2
S11 – Goulais Bay	16	16	16	16	12	12	12	8	8	
Lake Huron										
GB1 – Georgian Bay	2	32	32	16	16	16	16	12	12	8
GB3 – Georgian Bay	32	16	16	16	12	12	8	8	8	4
GB4 – Georgian Bay		32	32	32	16	16	8	8	4	4
H3 – Lake Huron		32	16	16	16	12	8	4	4	4
H4 – Lake Huron		32	16	16	8	4	2			
H5 – Lake Huron	32	32	16	16	16	16	12	8	4	4
NC1 – North Channel	32	32	16	16	16	16	12	8	8	8
NC2 – North Channel	32	16	16	16	16	12	12	12	8	8
NC2a- North Channel	16	16	16	16	16	12	12	8	8	
Lake Ontario										
2 – Western Lake Ontario	32	32	32	32	16	16	16	12	4	4
6 – Northwestern Ontario			2	2	2	2	2	2	2	2
6a – Frenchman Bay		16	16	16						
6B – Whitby Harbour		12	12	12	12	12	8	8	4	4
Northeastern Lake Ontario	32	16	16	16	12	12	8	8	8	4
Lake Erie										
1 – Western Lake Erie	16	16	16	16	12	12	8	8	2	2
2 – Central Lake Erie	16	16	12	12	12	12	12	8	8	4
3 – Long Point Bay		32	16	12	12	12	12	8	8	4
4 – Eastern Lake Erie	16	16	16	16	16	16	12	12	8	4
Lake St. Clair	16	16	16	16	12	8	8	4	4	4
Median –Great Lakes Reference	16	16	16	16	12	12	8	8	8	4
Detroit River AOC										
5a Upper Detroit River	**12**	**8**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
5b Lower Detroit River	**32**	**16**	**8**	**4**	**4**	**4**	**4**	**4**		
Impairment Status (I = Impaired; NI= Not Impaired)	**NI**	**NI**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**NI**

Table 8 summarizes the Tier 2 evidence lines. Brown bullhead was not assessed for Tier 2 because it had previously passed the Tier 1 criteria and is considered unimpaired. Tier 2 failed to meet criteria for the Sensitive Population for Largemouth Bass and Walleye Indicators. In addition, Tier 2 failed the criteria for Walleye advice issued to the General Population. Overall, Tier 2 is considered to Fail for Largemouth Bass and Walleye.

Table 8 Weight of Evidence Decision Support Matrix for Tier 2 Evidence Lines

Tier 2 Lines of Evidence	Brown Bullhead	Largemouth Bass	Walleye
Intensity of fish consumption restrictions in AOC vs Ref for Sensitive Population	Passed Tier 1	**Impaired**	**Impaired**
Intensity of fish consumption restrictions in AOC vs Ref for General Population	Passed Tier 1	**Unimpaired**	**Impaired**
Weighted Tier 2 Assessment	**Unimpaired**	**Impaired**	**Impaired**

2.3 Tier 3 Assessments

Tier 3 was assessed across four evidence lines for both largemouth bass and walleye indicator species. The Tier 3 assessment evidence lines considered both PCBs and mercury as priority contaminants of interest for the AOC and therefore each pollutant was assessed across each evidence line.

2.3.1 Tier 3a Virtual meal advice contrasts between the AOC and Reference.

Tier 3a used recent data (within the last decade) from the AOC to generate chemical specific virtual advice information in the AOC and reference. Virtual advisories were generated for each priority chemical and indicator fish species over an appropriate set of size intervals conforming to available empirical data from the AOC. All virtual advice information used benchmarks for monthly meal allowances associated with the Sensitive Population.

2.3.1.1 Virtual meal advice related to mercury Largemouth Bass. There were 45 records of mercury contamination available for largemouth bass from the AOC over the period of 2003-2016. The data were truncated to 2008-2016 (n=39 records) to ensure contrasts of Tier 3b were made using only the most recent data available for the AOC. Data from the reference were truncated to the years 2007-2017 to facilitate comparable temporal scope. In the case of the reference, year intervals were extended by 1 year at both interval ranges to increase the reference record availability given the large number of replicates available for 2007 and 2017. This increased the statistical power of Tier 3a contrasts. After censoring data outside the above temporal range, there were 200 reference records on which to generate virtual meal advice.

Mercury relationships in AOC bass were examined with respect to fish length and shown to be statistically dependent on body size ($p<0.001$; ANOVA). A power regression was used to estimate mercury concentrations and virtual meal advice for fish over the 15-20 cm size interval through to 45-50 cm size intervals. The same approach was applied to the reference set. Table 9 presents a summary of virtual advice associated with mercury for AOC and reference fish. Across the 7 size intervals of fish examined, virtual meal advice in the AOC met Tier 1 and Tier 2 criteria for 6 size intervals but failed the criteria for the 40-45 cm sized fish.

Table 9. Virtual advice related to mercury in largemouth bass from the AOC and Great Lakes reference restricted to the 2008-2016 time period (AOC) and 2007-2017 time period (reference).

Size Interval	Hg Content AOC (µg/g wet wt)	Hg Content in Reference (µg/g wet wt)	Virtual advice due to Hg in AOC (meals per month)	Virtual advice due to Hg in Reference (meals per month)
15-20	0.08	0.06	**16**	16
20-25	0.12	0.09	**12**	16
25-30	0.17	0.13	**8**	12
30-35	0.24	0.20	**8**	8
35-40	0.35	0.30	**4**	4
40-45	0.51	0.45	**0**	4
45-50	0.73	0.68	**0**	0

2.3.1.2 Virtual meal advice related to mercury in Walleye. There were 31 records of mercury for walleye from the AOC over the period of 2008-2016 and 60 records over the 2005-2016 duration. To improve statistical power the 2005-2016 (11 year interval) was selected for the Tier 3a spatial contrast. The power regression indicated a highly significant relationship with size ($p<0.001$; ANOVA). The power regression was then used to estimate mercury concentrations and virtual meal advice for fish over the 20-25 cm size interval through to 70-75 cm size intervals. There were 1416 reference records censored to 2005-2016 year interval. Similar to the AOC data set, there was a highly significant effect of fish size ($p<0.001$). The same method was used to compute virtual advisories in walleye due to mercury and virtual advice contrasted between the AOC and reference is provided in Table 10. Across the 11 size

intervals, virtual meal advice failed the Tier 1 and 2 criteria for 2 size classes (45-50 cm and 60-65 cm fish in the walleye indicator.

Table 10. Virtual advice related to mercury in walleye from the AOC and Great Lakes reference restricted to the 2005-2016 time period.

Size Interval	Hg Content AOC (µg/g wet wt)	Hg Content in Reference (µg/g wet wt)	Virtual advice due to Hg in AOC (meals per month)	Virtual advice due to Hg in Reference (meals per month)
20-25	0.08	0.07	**16**	16
25-30	0.10	0.08	**16**	16
30-35	0.13	0.11	**12**	16
35-40	0.17	0.13	**8**	12
40-45	0.22	0.17	**8**	8
45-50	0.28	0.21	**4**	8
50-55	0.36	0.27	**4**	4
55-60	0.47	0.34	**4**	4
60-65	0.60	0.42	**0**	4
65-70	0.77	0.53	**0**	0
70-75	0.99	0.67	**0**	0

2.3.1.3 Virtual meal advice related to PCBs in Largemouth Bass. There were 25 records of PCB contamination available for largemouth bass from the AOC over the period of 2008-2016 and 81 records for the reference over the same year interval. PCB concentrations in AOC largemouth bass were not significantly related to fish length ($p>0.1$; ANOVA). However, to facilitate size interval analysis, fish were divided into 5 cm size intervals having 4 or more replicates per interval. The size classes tested were classes 30-35 cm, 35-40 cm and 40-45 cm fish each with between six to seven records per size. The geometric mean PCB concentration was computed for each size interval and compared to the meal advisory benchmarks to generate virtual meal advice. The same size intervals were examined in reference fish and used to compute virtual meal allowances due to PCBs as summarized in Table 11. For each of the three size classes, virtual meal advice due to PCBs in largemouth bass were found to meet Tier 1 as well as Tier 2 criteria.

Table 11. Virtual advice related to PCBs in Largemouth Bass from the AOC and Great Lakes reference restricted to the 2005-2016 time period.

Size Interval	PCB Content AOC (µg/g wet wt)	PCB Content in Reference (µg/g wet wt)	Virtual advice due to PCBs in AOC (meals per month)	Virtual advice due to PCBs in Reference (meals per month)
30-35	32	29	**16**	16
35-40	31	32	**16**	16
40-45	32	37	**16**	16

2.3.1.4 Virtual meal advice related to PCBs in Walleye. There were 60 records of PCB contamination available for walleye from the AOC over the period of 2005-2016 and 951 records for the reference over the same year interval. PCB concentrations in AOC Walleye were significantly related to fish length ($p<0.05$; ANOVA) and therefore a power regression was used to generate virtual advice across fish size intervals from 20-25 cm to 70-75 cm. A similar approach was used for PCB concentrations in reference walleye. Table 12 summarizes the virtual advice generated for PCBs in walleye from the AOC and Reference. Virtual advice due to PCBs in walleye met Tier 1 or Tier 2 criteria for 10/12 size intervals but failed the criteria for fish greater than 65 cm in size.

Table 12. Virtual advice related to PCBs in walleye from the AOC and Great Lakes reference restricted to the 2005-2016 time period.

Size Interval	PCB content AOC (ng/g wet wt)	PCB Content in Reference (ng/g wet wt)	Virtual advice due to PCB in AOC (meals per month)	Virtual advice due to PCB in Reference (meals per month)
20-25	32	25	**16**	32
25-30	37	29	**16**	16
30-35	43	33	**16**	16
35-40	50	38	**16**	16
40-45	58	44	**12**	16
45-50	67	50	**12**	16
50-55	77	58	**8**	12
55-60	90	67	**8**	12
60-65	104	77	**8**	8
65-70	120	88	**4**	8
70-75	139	102	**4**	8

2.3.2 Tier 3b Priority pollutant concentrations in fish from the AOC and reference.

Tier 3b evidence lines directly compared contaminant residues in fish from the AOC vs reference. Contrasts were made for both indicator species and the two priority contaminants. Size standardization was performed either by statistical approach (ANCOVA) or by separate analysis of AOC vs reference differences across selected size intervals for each species using non-parametric statistical tests.

2.3.2.1 Mercury concentrations in Largemouth Bass. Fish mercury concentration records were available for 45 largemouth bass from 2008-2016. For temporal standardization, the reference records were truncated to the 2007-2016 interval to better match those from the AOC yielding 197 reference records. Analysis of covariance indicated there was no-significant difference in the mercury concentration vs body size relationship between reference and AOC data. Analysis of covariance (ANCOVA) was therefore performed on size standardized data and revealed significantly ($p<0.05$) higher mercury concentrations in AOC largemouth bass compared to reference. Figure 4 presents mercury concentration data in AOC and reference data sets as a function of fish total length.

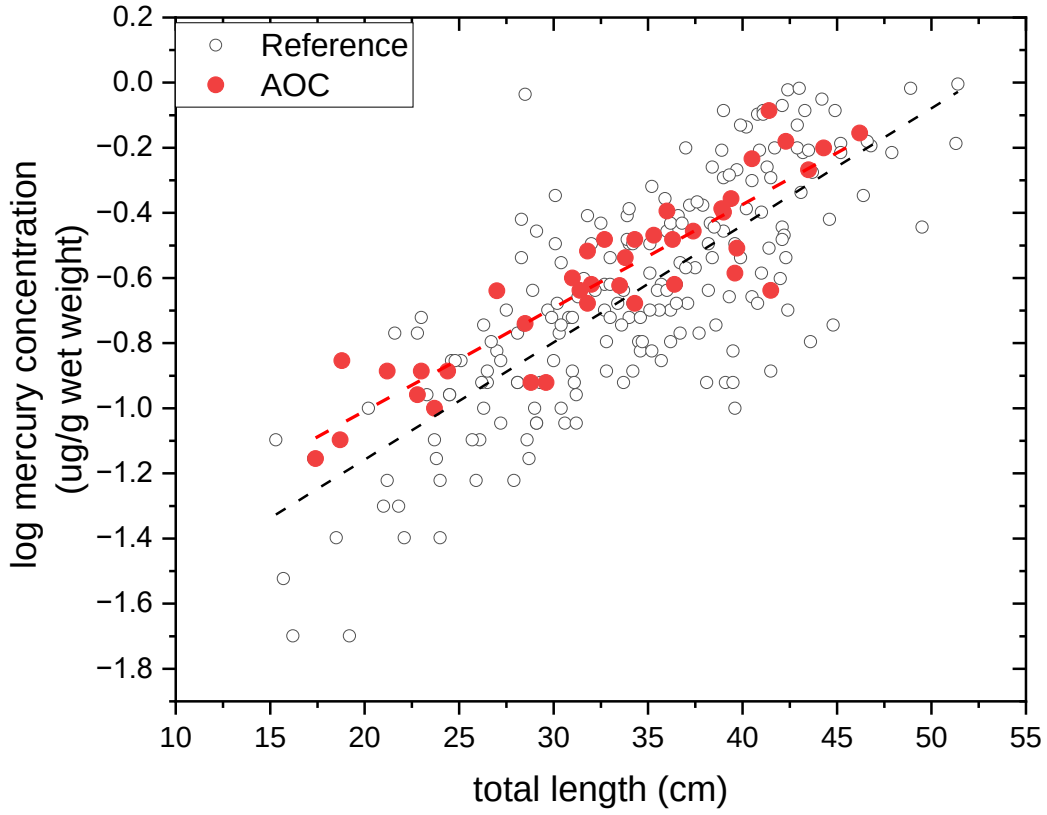

Figure 4. Mercury concentration in largemouth bass as a function of body size in AOC and reference data set. Dashed lines present linear regression fit to each data. ANCOVA revealed significantly elevated mercury concentrations in AOC fish compared to reference after size standardization.

2.3.2.2. Mercury concentrations in Walleye. Fish mercury concentration records were available for 60 Walleye samples over the 2005-2016 period and 1416 records from temporally matched reference zones. Data were non-normal preventing use of ANCOVAs to test for differences after size standardization. Fish were subsequently divided into size intervals having at least 4 replicates per size interval and individually tested against same sized fish of the reference using Kruskal-Wallis tests. The available size intervals for testing were 25-30, 30-35, 35-40, 40-45, 45-50, 50-55 and 60-65 cm sized fish. Mercury concentrations in AOC walleye were not-significantly different ($p>0.1$) for 25-30, 30-35, 35-40, 40-45 and 60-65 cm size intervals. Mercury was significantly elevated ($p<0.05$) in AOC fish compared to reference for the 45-50 and 50-55 cm size classes (Figure 5).

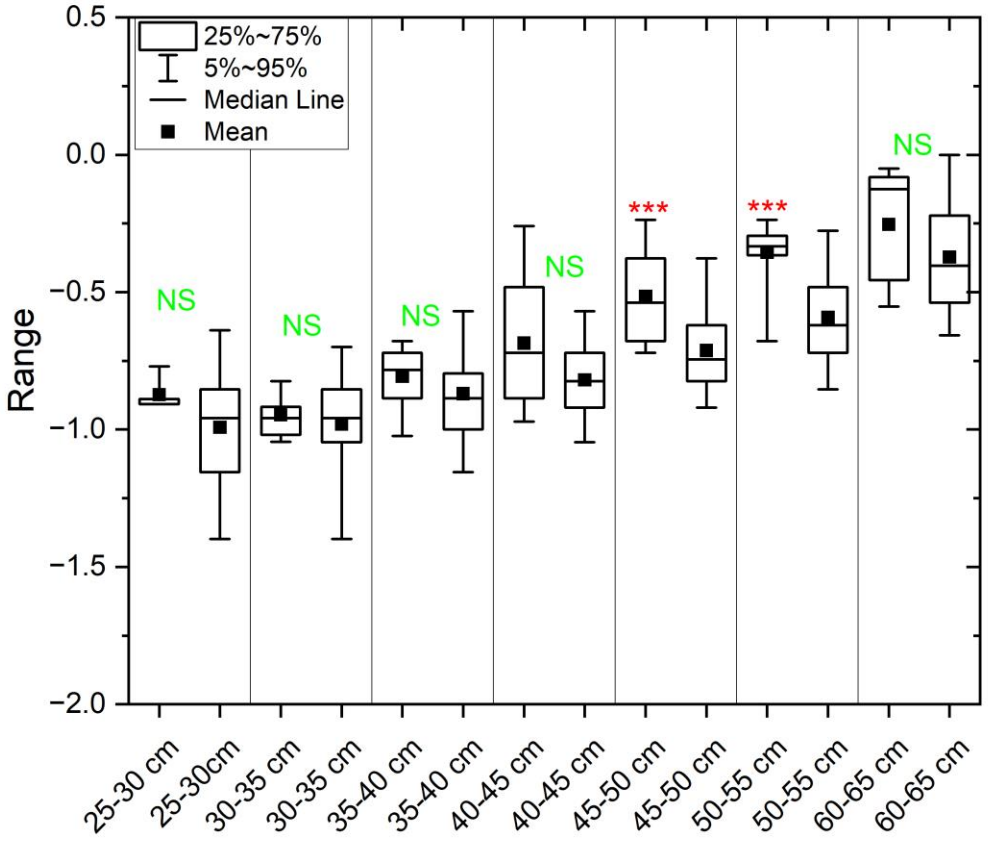

Figure 5. Log_{10} mercury concentrations (µg/g) in walleye from AOC and reference zones across size intervals. First box in each series presents AOC data, next box reference. NS = not significantly different. * indicates significant differences between AOC and reference for that size interval.**

2.3.2.3. PCB concentrations in Largemouth Bass. There were 25 records of PCBs in walleye from the AOC over the 2008-2015 interval and 81 reference records over the 2007-2016 time interval. Data were non-normal and therefore fish were divided into size intervals of 30-35, 35-40 and 40-45 cm fish with sufficient replicates to permit statistical contrasts. Following testing for AOC and reference differences by Kruskal-Wallis tests, all three size classes were not significantly different in their PCB concentrations between AOC largemouth bass and reference (Table 13).

Table 13. PCB concentrations in largemouth bass from AOC and reference

Size	AOC Geomean (range) ng/g wet weight	Reference Geomean (Range) ng/g wet weight	Statistical Test Result
30-35 cm	33.4 (20-92)	28.3 (20-82)	Kruskal-Wallis, NS
35-40 cm	41.2 (20-67)	31.9 (20-130)	Kruskal-Wallis, NS
40-45 cm	39.3 (20-62)	36.6 (20-200)	Kruskal-Wallis, NS

2.3.2.4. PCB concentrations in Walleye. There were 60 records of PCBs in Walleye from the AOC over the 2005-2016 period and 951 records from temporally matched reference zones. Data were non-normal preventing use of ANCOVAs to test for differences after size standardization. Fish were subsequently divided into size intervals of 25-30, 30-35, 35-40, 40-45, 45-50, 50-55 and 60-65 cm sized fish and tested between AOC and reference by Kruskal-Wallis tests. PCB concentrations in AOC walleye were not significantly different ($p>0.05$) from reference for size classes: 25-30, 40-45, 50-55 and 60-65 cm fish. PCBs were significantly elevated in AOC for the 30-35, 35-40 and 45-50 cm size classes (Figure 6).

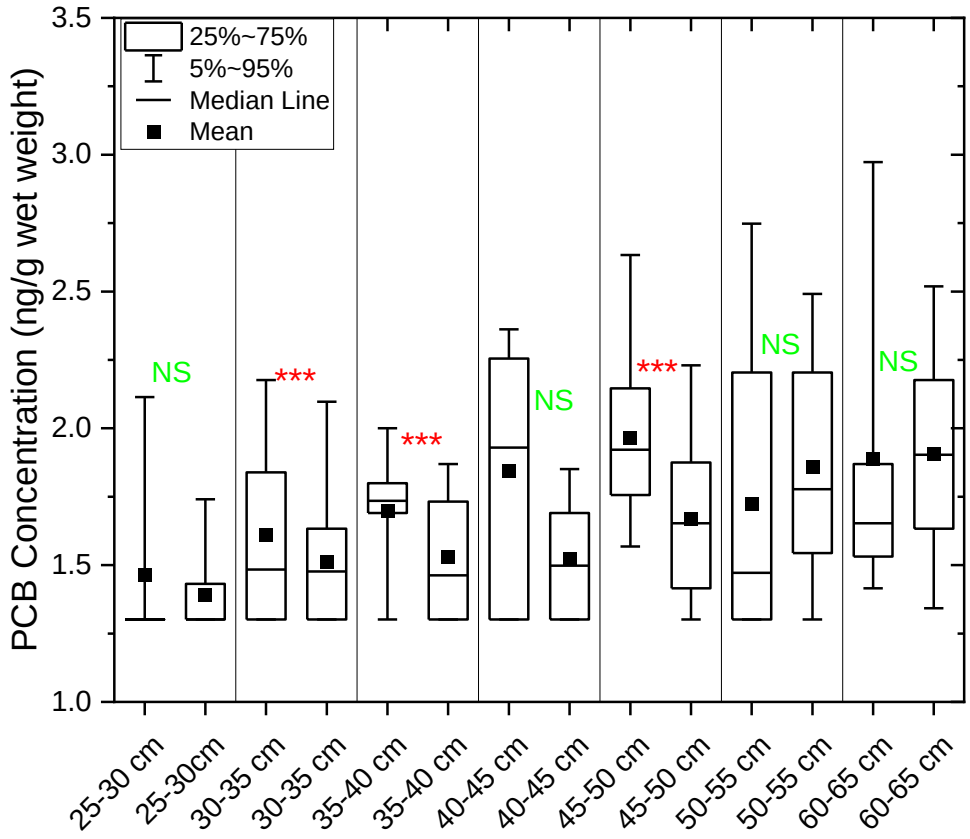

Figure 6. Log$_{10}$ PCB concentrations (ng/g) in walleye from AOC and reference across size classes. First box in each size interval presents AOC data, second box for the reference. NS refers to non-significant difference between AOC and reference. * indicates a significant difference.**

2.3.3 Tier 3c Evaluation of temporal trends of priority contaminants in indicator species

2.3.3.1 Temporal trends of mercury and PCBs in Largemouth Bass. Data records for mercury in largemouth bass were limited to n=45 records obtained over the period of 2003-2016. There were only four years where samples were available and three years with 5 or more fish records taken. The data did not meet quality control standards for being sufficiently robust to test for temporal trends in the AOC. Similarly, PCB data were available only for years 2008-2016 with only two years having more than 5 records of fish. Given the limited data availability for this species, temporal trends of priority pollutants were could not be examined.

2.3.3.2 Temporal trends of mercury in Walleye. There were 416 records of walleye mercury concentrations from the Detroit River over the period of 1987 to 2016. Data met quality control standards with 16 years having more than 5 samples of fish including the end member years of 1987 and 2016. Data were non-normal precluding size standardization by ANCOVA. Fish were divided up into size intervals and individual size intervals examined to determine if they met temporal quality control criteria. Size intervals partially meeting criteria (>15 years, more than 5 individual years but less than 5 replicates per year (n=4) across 5 years) were available for 30-35, 35-40, 50-55 and 55-60 cm fish. Size intervals fully meeting criteria included: 40-45 and 45-50 cm fish. Table 14 summarizes linear regression fits describing temporal relationships of mercury concentrations in individual size intervals of fish. Mercury exhibited a significant declining trend in 3 size classes (30-35, 35-40 and 55-60 cm fish). However, for the 45-50 cm size class mercury residues were increasing with time and non-significant for the 40-45 cm sizes.

Table 14. Mercury concentration versus time and half lives in different size intervals of Walleye

Size interval	Linear Regression Equation	Half life (years)
30-35	Ln Hg = -0.0197·year + 37.51; R^2=0.22; p<0.01	35
35-40	Ln Hg = -0.0296·year + 57.54; R^2=0.09; p<0.05	23
40-45	Non-Significant relationship with time	NA
45-50	Significant increasing trend with time	NA
50-55	Non-Significant relationship with time	NA
55-60	Ln Hg = -0.0387·year + 76.48; R^2=0.15; p<0.01	18

2.3.3.3 Temporal trends of PCBs in Walleye. There were 198 records of walleye PCB concentrations from Canadian waters of the Detroit River over the period of 1987 to 2016. Data met quality control standards for the temporal analysis. Data were normal and ANCOVA revealed a non-significant differences in the year x length interaction enabling temporal trends to be examined following size standardization. Both year (p<0.001) and total length (p<0.001) were highly significant predictors of PCB concentrations in Detroit River walleye and described by the equation:

$$\text{Ln } PCB_{walleye} = -0.0383\pm0.008\cdot\text{Year} + 0.036\pm0.008\cdot\text{Length(cm)} + 79.46\pm16.25;\ R^2 = 0.22;\ p<0.001$$

The goodness of fit of the model to the measured data is provided in Figure 7. Based on the above relationship, the half life of PCBs in walleye is estimated at 18.1 years.

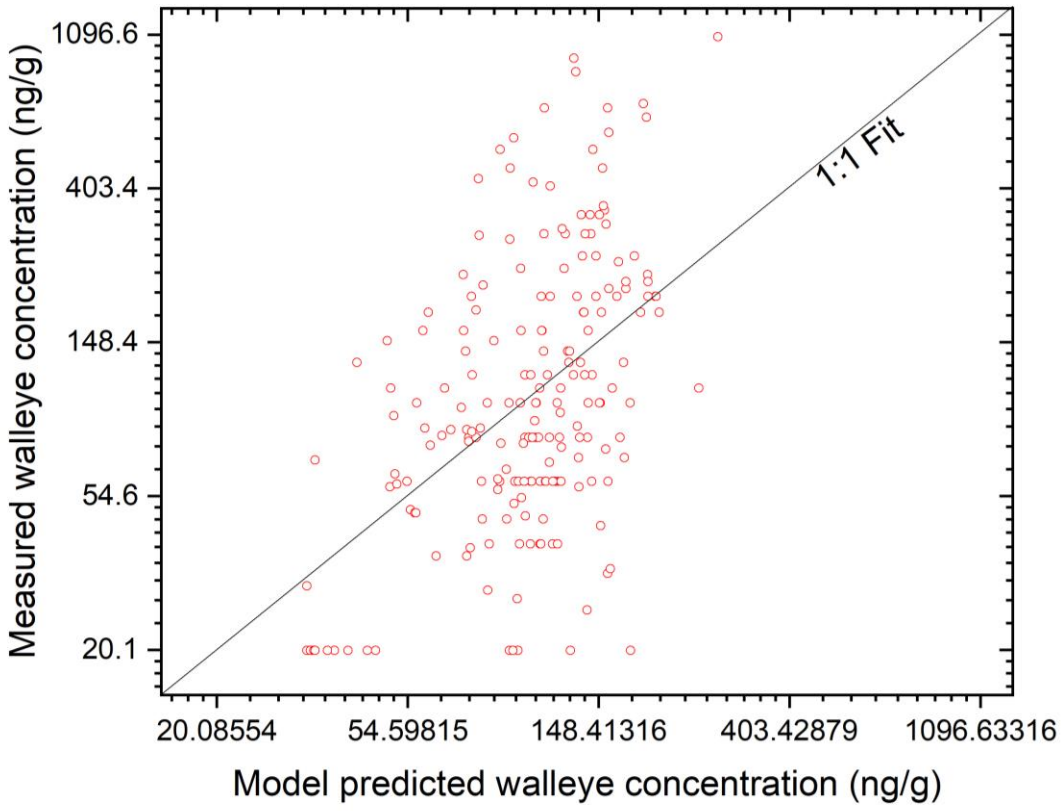

Figure 7. Goodness of fit test for model predicting PCB concentrations in walleye based on collection year and total length. Model describes 22% of the variation in the empirical data set.

2.3.4 Tier 3d Evaluation of fish movements within and outside of the AOC.

Tier 3c used discriminant function analysis of mercury and PCB chemical signatures in fish to provide supporting evidence for fish spatial movements outside of the AOC boundaries and between Canadian and U.S. waters of the AOC. Discriminant function models with low discriminatory power implies a high degree of movement of fish across waterbodies and zones and will have lower confidence for assigning fish residency status. In these cases, the model can be used to infer a high degree of spatial movements for the indicator. Models with high discriminatory power between the calibration data sets generate stronger confidence in model assigned residency status.

2.3.4.1 Discriminant functions analysis applied to Largemouth Bass. The initial training data sets for the DFA model included fish caught from Lake St. Clair (n=28; LSC) or the western basin of Lake Erie

(n=20;WLE). When applied to the training data set in isolation, the DFA model was able to correctly classify 95.8% of fish according to their capture location. This high degree of discrimination indicates little to no between lake migrations of Largemouth Bass. Next, Detroit River fish collected from US waters (n=16) and Canadian waters (n=25) were added to the model. Congruent classifications with Detroit River fish added to the model dropped to 64.2% across datasets. The revised DFA model generated the most congruent assignments for western Lake Erie fish which were correctly assigned in 75% of fish from that location. All remaining fish from western Lake Erie fish were assigned as DR-US-like which was similar to the reciprocal misclassifications of US Detroit River fish (18.8%) being assigned as WLE-like. A total of 64.3% of Lake St. Clair caught fish had congruent assignments with their capture location, followed by 25% as DRCA-like, 7.1% as DRUS-like and 3.6% as WLE-like. For Detroit River caught fish, those from Canadian waters of the AOC had 58.8% correct assignments followed by 35.3% as being LSC-like and 5.9% as DRUS like. The U.S. caught fish were assigned with a similar degree of congruency to capture location (56.3% correct) and a more equal spread of fish across DRCA, WLE and LSC (12.5, 18.8 and 12.5%, respectively) compared to Canadian caught fish. Figure 8 presents the DFA plot with confidence ellipses generated around congruent assignments for fish caught from the different fishing zones. Despite limited DRCA caught fish being assigned as DRUS like, the high degree of overlap in congruent assignment confidence ellipses between Canadian and US caught Detroit River fish implies some potential for cross-channel mixing for this species. Relative to Walleye (See section 2.3.4.2), largemouth basses appear to exhibit less movements consistent with the high degree of habitat affiliation typically described for this species. The majority of largemouth bass caught within Canadian waters of the AOC have a unique Canadian-AOC signature or one more closely resembling that of Lake St. Clair.

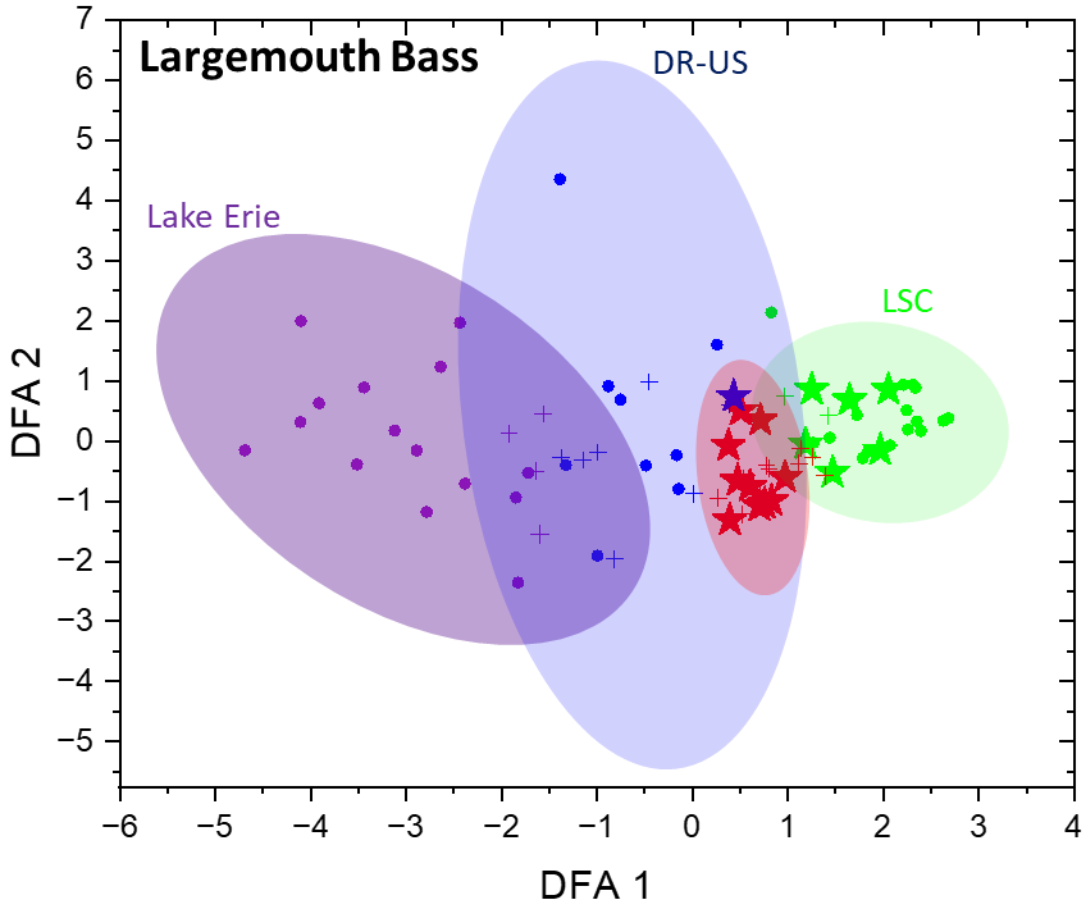

Figure 8. Discriminant functions analysis applied to Largemouth Bass populations. Shaded ellipses present 95% confidence intervals around correctly assigned fish from the training data set for Lake Erie (purple), US Detroit River (blue) and Lake St. Clair fish (green). Star symbols designated DFA classification of Canadian caught Detroit River fish, blue are DRUS-like fish, red are DR-CA residents, green are LSC-Like fish and grey are uncertain assignments. Crosses designated incorrectly assigned training data set fish (purple are WLE-like), blue (DRUS-like) and green (LSC-like).

Tier 3A and Tier 3B evidence lines were then re-evaluated using a subset of Canadian caught largemouth bass that consisted of 1) fish that were caught in Canadian waters of the AOC and 2) fish that were assigned by the DFA model as DRCA-like fish. Mercury concentrations in the 10 designated Canadian AOC resident fish were not significantly dependent on length ($p>0.2$, ANOVA) and therefore fish were divided into size intervals of 30-35 cm (n=3) and 35-40 cm (n=4) fish. Geometric mean mercury concentrations in each size interval were 0.26 and 0.27 µg/g with associated virtual meal advice of 4 and 4 meals per month respectively (Table 15). The reference had geometric mean concentrations of 0.21 and 0.29 ug/g with virtual meal advice of 8 and 4 meals/month. The virtual meal advice failed the Tier 2

criteria for the 30-35 cm fish for mercury. However, it should be noted that observed mercury concentrations in Canadian resident fish were within the range of mercury concentrations observed in the same size class from the reference. Furthermore, geometric mean residues of mercury in the 30-35cm size class of fish (0.26 ug/g) were very similar to those from Lake St. Clair (geometric mean of 0.27 µg/g).

Table 15. Geometric mean mercury concentrations in selected size classes of Canadian resident largemouth bass compared to reference and associated virtual consumption advice.

Size	Geomean Mercury Concentration in AOC Fish (ug/g)	Geomean Mercury Concentration in Reference fish (ug/g)	Virtual Advice due to mercury in AOC fish	Virtual Advice due to mercury in Reference
30-35 cm	0.26 (0.21-0.30)	0.21 (0.09-0.45)	4	8
35-40 cm	0.27 (0.24-0.31)	0.29 (0.12 – 0.82)	4	4

With respect to Tier 3b criteria, fish categorized as Canadian resident fish by DFA were compared with respect to their mercury contamination with the reference data set. In this case, the combined AOC_{CDN} and reference data conformed to normality assumptions and exhibited a similar length x mercury concentration slope permitting size standardization by ANCOVA. ANCOVA revealed no significant differences in the size standardized mercury concentration in Canadian resident categorized largemouth bass compared to the reference. Figure 9 provides a summary of the Tier 3B contrast restricted to Canadian resident Detroit River fish and Great Lakes reference data.

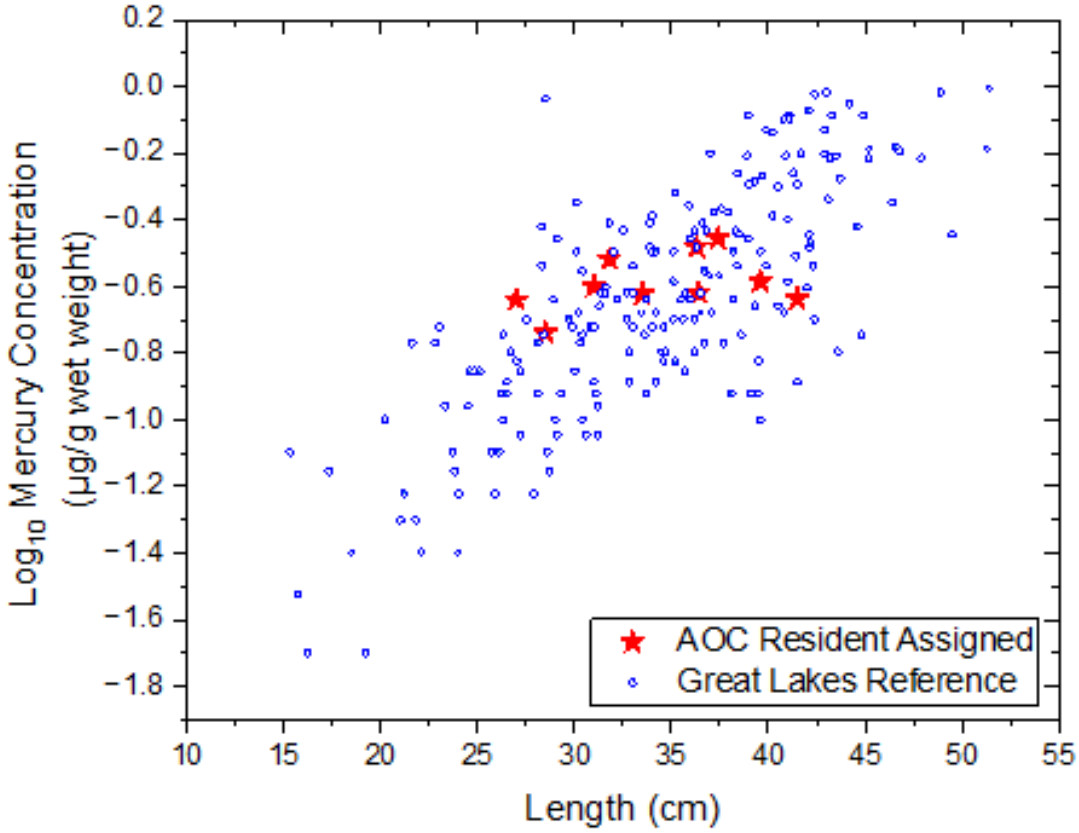

Figure 9. Comparison of mercury residues in Canadian caught fish assigned as being resident according to discriminant functions analysis compared to the Great Lakes Reference.

PCB concentrations in the 10 designated Canadian AOC resident fish were significantly dependent on length ($p<0.01$) and therefore the power regression was applied to predict fish PCB concentrations across size intervals of 25-30, 30-35, 35-40 and 40-45 cm fish. Predicted geometric mean PCB concentrations in each size interval were 19, 27, 38 and 53 ng/g with associated virtual meal advice of 32, 16 and 16 and 12 meals per month respectively. The virtual meal advice associated with PCBs conformed to the Tier 1 criteria for all size classes and therefore met the Tier 3a test. For Tier 3b criteria, data on log PCB concentrations in the combined AOC (resident) and reference set were not normal and therefore were divided up into size intervals of 30-35 and 35-40 cm sized fish. In both size intervals of fish PCB concentrations were not significantly different ($p>0.2$; Kruskal-Wallis tests) than reference. Figure 10 presents distributions of PCBs in Canadian resident categorized fish compared to reference for each size interval described above.

Tier 3C could not be evaluated for either mercury of PCBs in largemouth bass due to the small number of samples of Canadian resident classified fish, limited years and replicates across years necessary to generate a robust temporal relationship.

Overall, when Canadian caught fish from the AOC were classified by discriminant functions analysis, fish identified as resident in Canadian waters of the AOC were found to meet Tier 3B criteria for the two priority contaminants. Data failed to meet tier 3a for mercury in the 30-35 cm size class but given the lack of statistical difference in contamination of fish from AOC and lower maximum concentrations in fish from this size range compared to reference, the data were deemed acceptable to pass the tier 3 criteria. Overall, Tier 3 is considered to pass for the largemouth indicator.

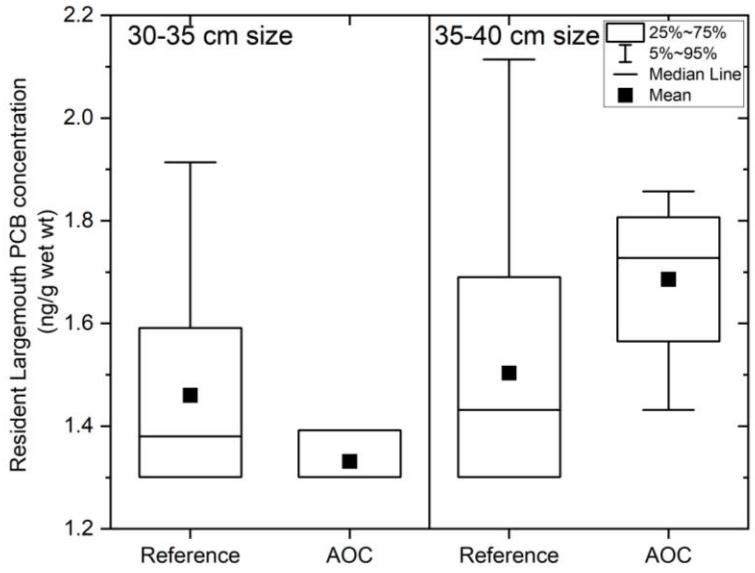

Figure 10. PCB concentrations in Canadian caught largemouth bass assigned as resident fish by DFA analysis compared against the Great Lakes Reference data set.

2.3.4.2 Discriminant functions analysis applied to Walleye. The walleye DFA model included fish caught (1987-2018) from Lake St. Clair (n=160; LSC including lower St. Clair River), western basin of Lake Erie (n= 251; WLE, including US and Canadian caught fish), U.S. waters of the Detroit River (n=68; DRUS) and Canadian waters of Detroit River (n=199; DRCA). Given that some of the U.S. caught fish were based on whole body residues with higher lipids, the DFA was performed on lipid normalized PCB concentrations

(ug/g lipid weight followed by log10 transformation) whereas mercury concentrations were expressed on a wet weight basis (ng/g wet weight and log10 transformed).

An initial pilot DFA was run using just WLE and LSC data to demonstrate the ability of the model to discriminate chemical signatures in fish from the upstream and downstream water bodies. The pilot DFA was able to correctly assign 82.73% of fish into lake of origin with high degree of confidence implying limited between lake movements of fish. Next, data from fish caught from both US portions of the Detroit River and Canadian jurisdictions of the Detroit River fish were added to the model and the DFA was recalibrated. In this case, the DFA model assignments were consistent with capture location of fish for just under half of samples (49.7%). The highest assignment congruence was for LSC which assigned 69.4% of fish collected from LSC to their correct capture location. The non-congruent assignments of LSC caught fish were distributed to DRCA (16.9%) and WLE (12.5%) with only 2 fish assigned as DRUS-like. For western Lake Erie, 56.6% of fish were correctly assigned to their location of capture. Non-congruent assignments from WLE were primarily DRUS-like (21.5%), DRCA-like (12.0%) or LSC-like (10.0%).

Fish captured from the US or Canadian waters of the Detroit River showed low overall congruence with actual capture location. Among fish caught from Canadian waters of the Detroit River, 32.2% were assigned as DRCA, 27.6% as DRUS, 24.6% as WLE and 17.6% as LSC. DRUS-captured walleye showed a very similar distribution as Canadian caught fish with 35.3% congruent assignments to DRUS, 23.5% assigned as DRCA, 24.6% WLE and 17.6% as LSC. Overall, the second DFA provides strong support for a high degree of mobility of the walleye indicator within the Huron Erie corridor. Walleye captured from the Detroit River represent a broadly mixed population inclusive of fish moving outside of the AOC boundaries as well as exhibiting substantial cross channel movements. Figure 11 presents the DFA plot highlighting Canadian caught Detroit River fish and their assignments within the confidence ellipses of correctly assigned fish from across the calibrated fishing zones.

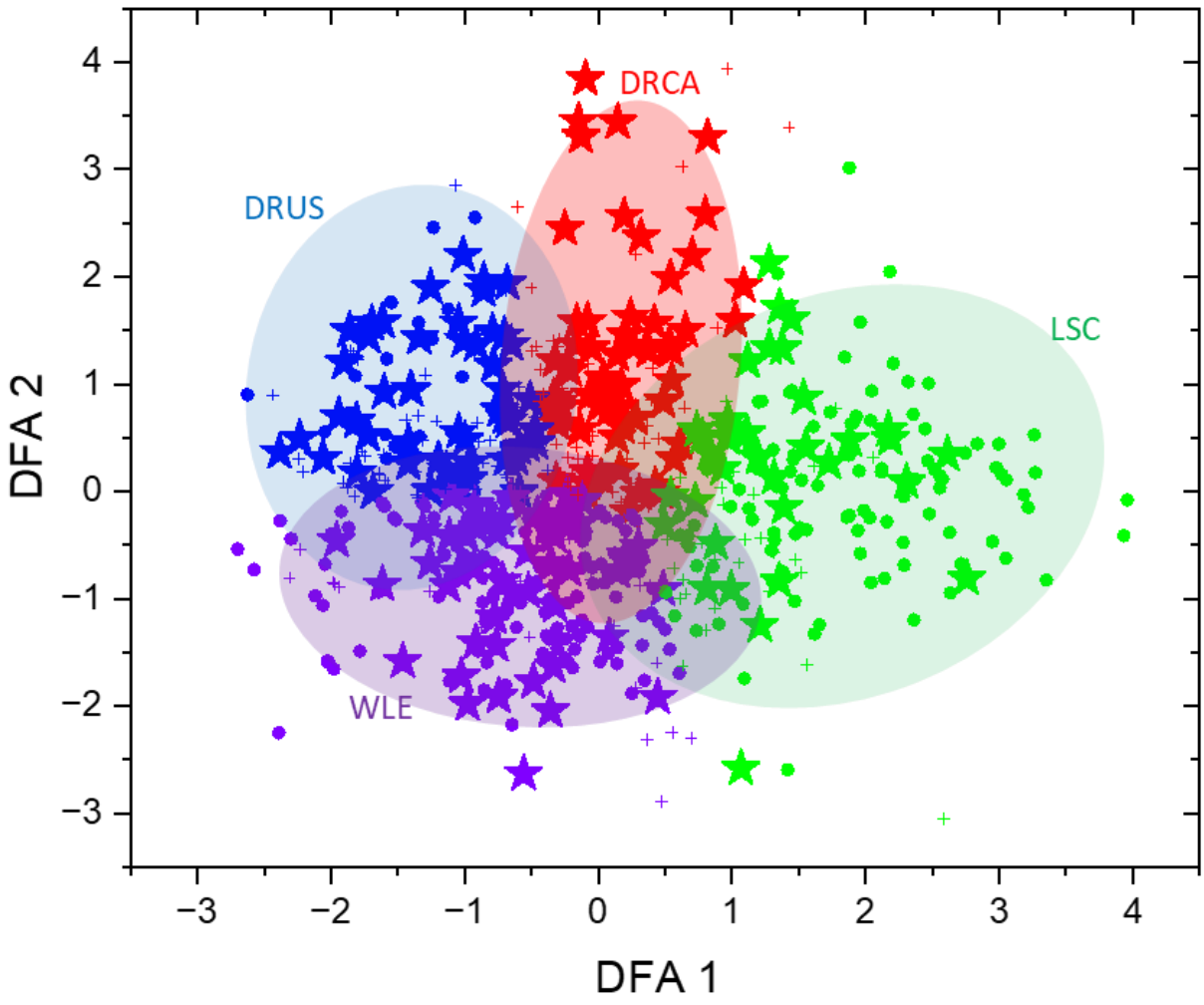

Figure 11. Discriminant functions analysis applied to walleye populations in the Huron-Erie corridor. Shaded ellipses present 95% confidence intervals around correctly assigned fish from Canadian waters of the Detroit River (red), US waters of the Detroit River (blue), Lake Erie (purple), and Lake St. Clair fish (green). Stars indicated Canadian caught Detroit River fish classification red as DRCA, blue are DRUS-like fish, green are LSC-Like fish and purple are WLE-like fish. Crosses are non-congruent assignments of fish caught from USDR, LSC or WLE data placed into assignment domains by colour scheme.

The remaining analysis focussed on the 60 samples of fish that were 1) collected from Canadian waters of the Detroit River and 2) also classified as Canadian Detroit River fish by the DFA model. These fish were re-subjected to Tier 3a,b and c contrasts with respective reference data sets. Given the high degree of movement of walleye and connectivity to WLE and LSC waters, MECP caught fish from the upstream and downstream water bodies were also examined and contrasted separately from the Great Lakes Reference data sets.

For the re-evaluation of Tier 3a, the Canadian resident classified fish were further censored to the 2000-2010 period (n=33 fish) to remove temporal variation. Neither mercury nor PCBs were significantly associated with fish length (range 42.2-59.6 cm). Fish were subsequently divided into size intervals of 45-50, 50-55 and 55-60 cm, each with greater than 8 replicates per size class. Tables 16 and 17 summarize geometric mean mercury and PCB concentrations and associated virtual meal advice for each contaminant in the AOC resident fish as well as LSC, WLE and the Great Lakes Reference. For mercury, walleye virtual advice exceeded the reference in 2 of 3 size categories but was equivalent or better (50-60 cm sized fish) than LSC for all three size categories. For PCBs, walleye had virtual meal advice that were more stringent than reference for all three size classes, was equal to WLE for the 50-55 cm size class but still more stringent than WLE fish for the 40-45 and 55-60 cm size classes.

Table 16 – Mercury Concentrations in Canadian Resident Walleye relative to reference

Geomean Mercury Concentrations (ug/g ww)				
Size	Hg in AOC_{CDN}	Hg in LSC	Hg in WLE	Hg in GL Ref
45-50	0.41	0.30	0.20	0.18
50-55	0.39	0.42	0.23	0.22
55-60	0.35	0.57	0.25	0.29
Virtual Meal Advice (meals per month) due to Mercury				
45-50	**4**	**4**	**8**	8
50-55	**4**	**4**	**8**	8
55-60	**4**	**0**	**4**	4

Table 17. PCB Concentrations in Canadian Resident Walleye relative to reference

Geomean PCB Concentrations (ng/g ww)				
Size	PCB in AOC_{CDN}	PCB in LSC	PCB in WLE	PCB in GL Ref
45-50	131	39	66	39
50-55	105	51	113	69
55-60	132	41	103	85
Virtual Meal Advice (meals per month) due to PCBs				
45-50	**4**	**16**	**12**	16
50-55	**4**	**16**	**4**	12
55-60	**4**	**16**	**8**	8

Tier 3b performed a statistical comparison of Canadian resident fish collected between 2000-2010 against reference fish, LSC and WLE fish from the same size classes described for Tier 3a. Figure 12 summarizes the data as a series of box and whisker plots. For the 45-50 cm and 50-55 cm size intervals, the AOC Canadian residents were significantly elevated in mercury contamination relative to WLE and the GL Reference samples but statistically similar to LSC. The CDN resident fish in the 55-60 cm class was statistically similar to the Great Lakes Reference as well as LSC.

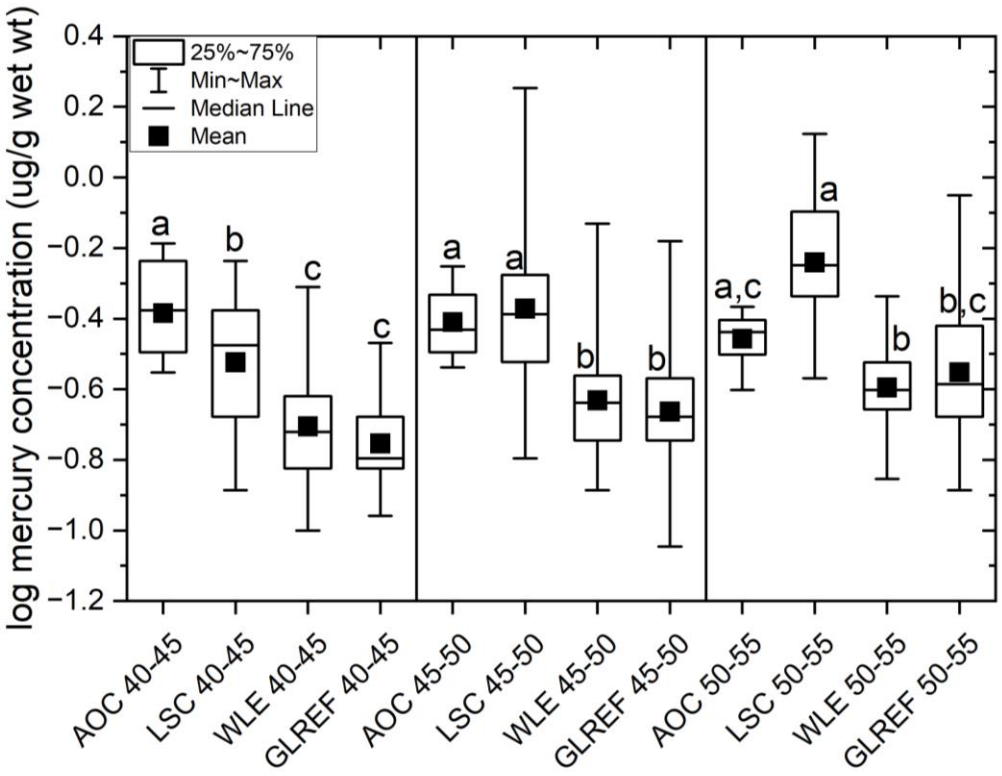

Figure 12. Mercury concentrations in individual size intervals of fish classified as AOC Canadian Residents compared to fish caught from LSC, WLE and Great Lakes Reference (GLREF). Boxes with different letters in a given size interval are significantly different from one another (Kruskal-Wallis test).

Tier 3B was then applied to PCBs in the same manner as described for mercury. The box and whisker plot is provided in Figure 13. For the 45-50 cm size interval, there was a significant enrichment of PCBs in AOC resident classified walleye compared to reference, LSC and WLE. However, the PCB residues in AOC residents were not different from reference for either the 50-55 cm or 55-60 cm size classes. In these size intervals, PCBs in AOC residents were similar to western Lake Erie classified fish but enriched relative to LSC fish which generally had the lowest PCB concentrations.

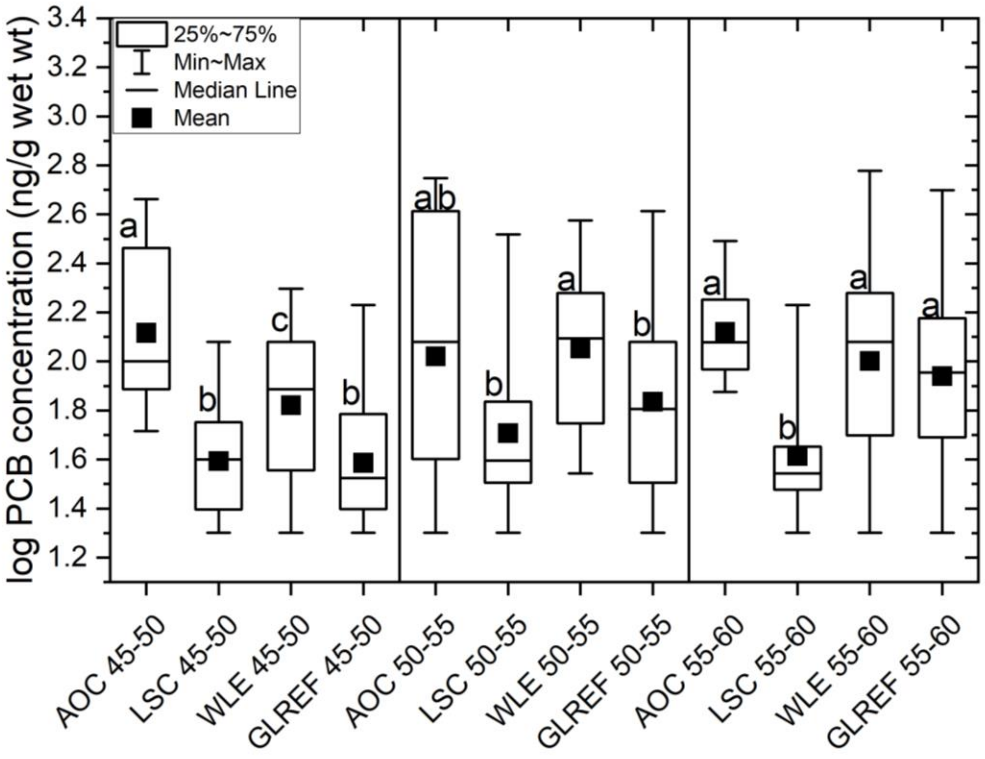

Figure 13. PCB concentrations in individual size intervals of fish classified as AOC Canadian Residents compared to fish caught from LSC, WLE and Great Lakes Reference (GLREF). Boxes with different letters in a given size interval are significantly different from one another (Kruskal-Wallis test).

Tier 3 C was re-evaluated in DFA classified Canadian Detroit River resident fish identified over the period of 1991-2010. Mercury residues in the Canadian classified fish from the AOC demonstrated no difference in the length x year interaction or significant effect of length permitting linear regression analysis on collection year alone. There was a significant declining trend in mercury residues with time according to the relationship:

$$\text{Ln } Hg_{DRCA(resident)} = -0.0318 \pm 0.009 \text{ x year } +62.82 \pm 17.84 \text{ ; } R^2=0.17; p<0.001$$

Based on the slope, the estimated half life of mercury in DRCA resident fish is estimated to be 21.8 years. Figure 14 presents temporal trends in mercury in CDN classified fish as compared to the complete DRCA walleye and LSC mercury data sets.

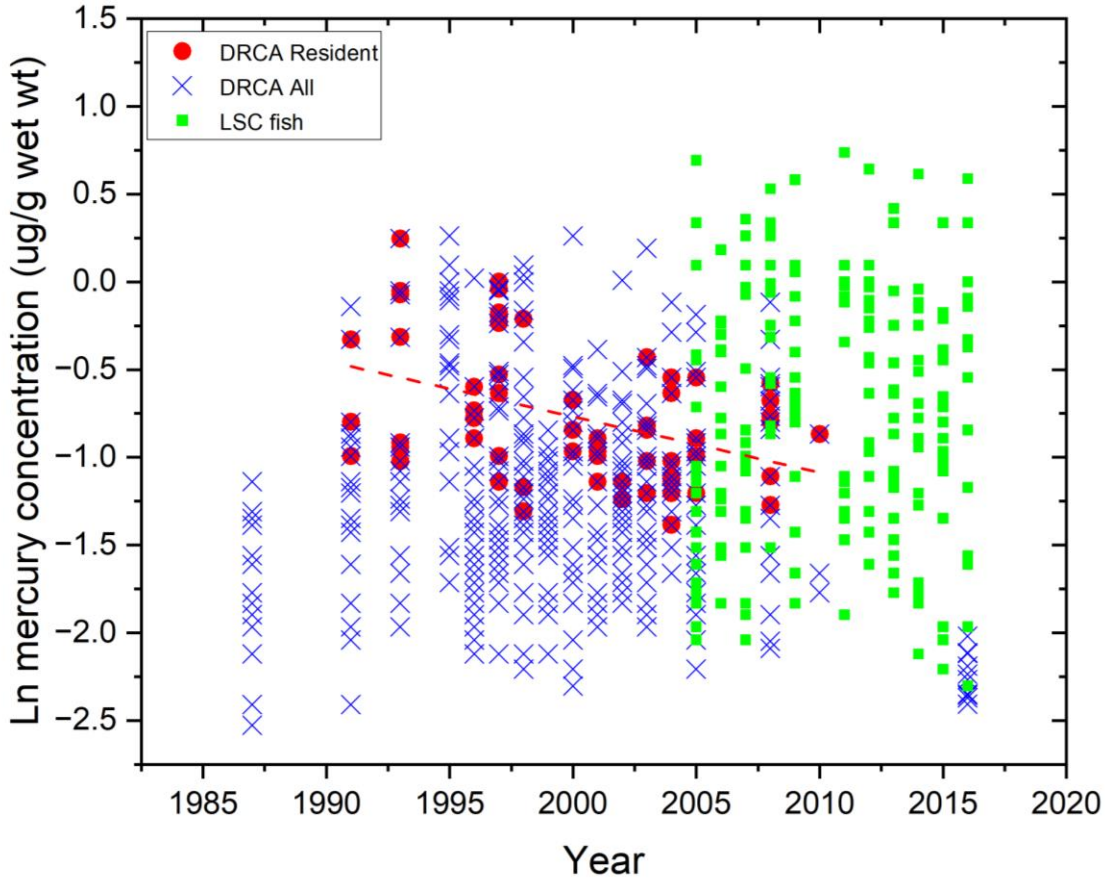

Figure 14. Mercury concentrations in fish from Detroit River classified as Canadian residents (red squares), all fish from Canadian waters of the Detroit River (blue x's) and all fish from Lake St. Clair waters (green squares). Dashed line presents the linear regression fit to DRCA resident temporal data.

Temporal trend analysis was repeated for PCBs in the Canadian resident classified fish. Similar to mercury, the ANCOVA demonstrated a non-significant year x length interaction and non-significant effect of length permitting examination of the data by year alone. PCBs in Canadian resident classified fish showed a highly significant declining trend with time according to the relationship:

Ln PCBs = -0.0735±0.0190x year + 152.09±38.39 ; R^2=0.19; p<0.001

Based on the above slope, the half life of PCBs in Canadian resident walleye is 9.4 years. Figure 15 presents trends in PCBs with time for Detroit River resident classified fish, all Canadian caught Detroit River fish and western Lake Erie fish.

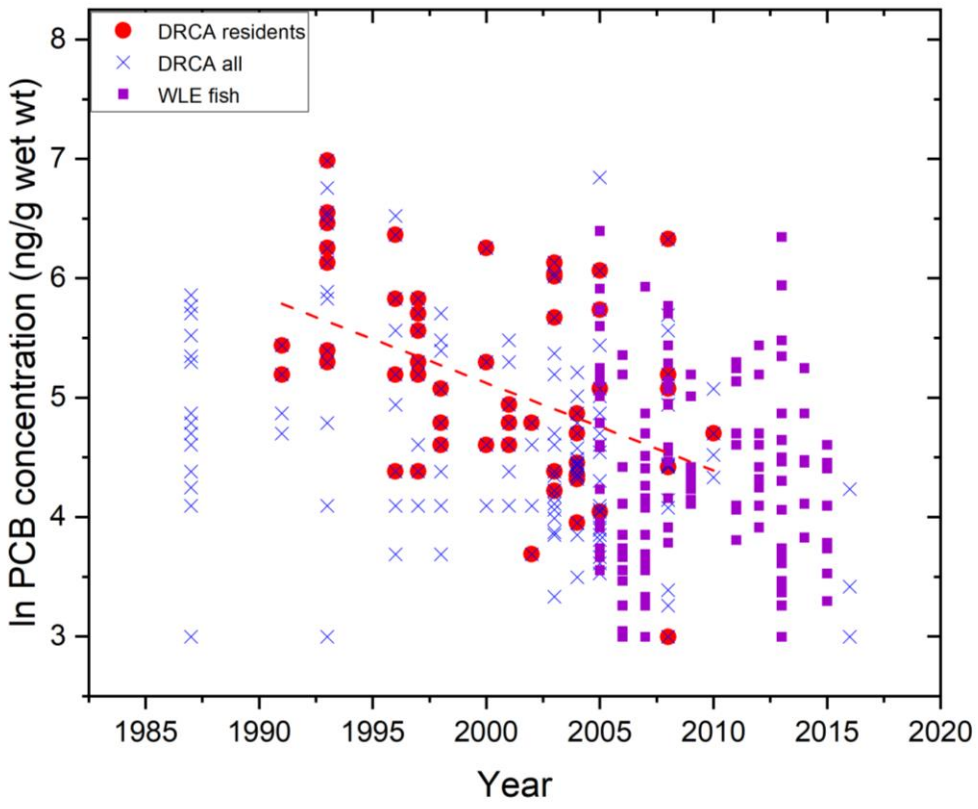

Figure 15. PCB concentrations in fish from Detroit River classified as Canadian residents (red squares), all fish from Canadian waters of the Detroit River (blue x's) and all fish from western Lake Erie waters (purple squares). Dashed line presents the linear regression fit to DRCA resident temporal data.

For mercury, Tier 3A fails to meet criteria based on reference but was equivalent to LSC data. Tier B fails the criteria for 1/3 size intervals. Tier C passes the criteria for temporal recovery in the AOC. For PCBs, Tier 3A and 3B fails criteria for 1/3 size intervals but passes criteria for temporal recovery.

2.3.5 Tier 3 Weight of Evidence Assessment

Evidence lines across Tier 3 are compiled in Table 18 below. For largemouth bass, all tiers with sufficient data availability met the criteria for this indicator for PCBs. Some evidence lines failed for mercury in largemouth bass but when fish samples were separated into likely Canadian AOC resident fish, mercury concentrations where not found to be different from the reference. Virtual advisories due to mercury in

the 30-35 cm size class were higher in AOC resident fish compared to reference. However, the range of mercury concentrations in the AOC was lower than present in reference and the statistical analysis show no differences in mercury contamination across zones. Finally, the DFA indicated that largemouth bass have a greater likelihood of movements into Lake St Clair than to any other zone. The geometric mean mercury concentration in 30-35 cm fish from Canadian resident AOC fish was similar to that of Lake St. Clair fish of the same size. Taken together, the largemouth bass are considered to meet delisting criteria for Tier 3.

Walleye exhibited mixed results for Tier 3a,b,c for mercury and Tier 3ab for PCBs, but passed for temporal recovery evidence lines. When data were subsampled into Canadian designated fish using the DFA, the mixed assessments continued to persist for both priority contaminants except for temporal recovery which was evident for both mercury and PCBs. Overall, walleye is judged to fail the Tier 3 category. Figure 16 provides a graphical summary of the Tier 3 assessment outcomes.

Table 18. Weight of evidence assessment matrix for Tier 3 evidence lines

Evidence Line	Largemouth Bass Mercury	Largemouth Bass PCBs	Walleye Mercury	Walleye PCBs
Tier 3A	Fails (40-45 cm) Passes for 6 sizes	Passes 3 for sizes	Fails (45-50 and 60-65 cm fish) Passes for 9 sizes	Fails (65-70 and 70+ cm fish); Passes for 9 sizes
Tier 3B	Elevated Hg in AOC fish compared to reference across size range (ANCOVA)	Passes 3 for sizes	Fails (45-50 and 50-55 cm fish); Passes for 5 sizes	Fails (30-35, 35-40 and 45-50 cm fish); Passes for 4 sizes
Tier 3C	Insufficient Data	Insufficient Data	Fails (40-45, 45-50 and 50-55 cm fish), Improving in 3 sizes with half lives 18-35 years	Passes across sizes; half life of 18.1 years
Tier 3D	3a resident fish. Fails for 30-35 cm but contamination within range of reference. Passes for 35-40 cm fish. 3b resident fish. No statistical differences across size classes between resident fish and reference. 3c Insufficient data	3a resident fish – passes criteria 3b res – passes criteria.	3a resident fish. Fails for 45-50 and 50-55 cm fish. Passes for 55-60 cm fish. 3b resident fish. Fails for 40-45, 45-50 cm fish. Passes for 50-55 cm fish. 3c resident fish. Improving with half life of 21.8 years.	3a resident fish. Fails for 45-50, 50-55 and 55-60 cm fish. 3b resident fish. Fails for 45-50 cm fish. Passes for 50-55 and 55-60 cm fish. 3c resident fish. Declining with half life of 9.4 years.
WOE	Pass. Canadian resident fish not statistically different than reference and just above threshold for 8 meal/month. Canadian resident virtual advice similar to same size class from Lake St. Clair.	Passes majority of evidence lines	Fails criteria across multiple evidence lines	Fails criteria across multiple evidence lines

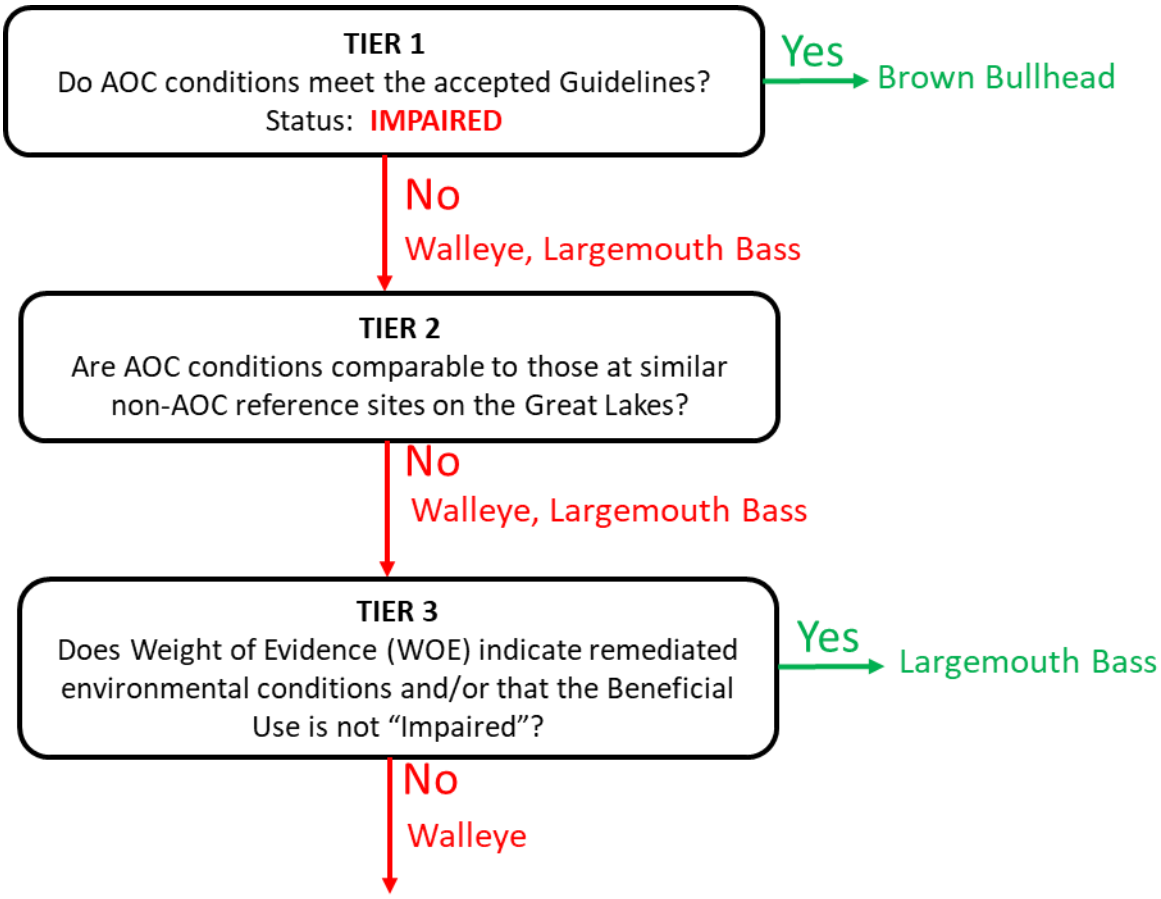

Figure 16. Tier 3 assessment outcome summary.

2.4 Tier 4 Evidence Lines.

Tier 4 evidence lines examined for temporal and spatial trends of priority contaminants in environmental media (water, suspended sediments and bottom sediments) from the AOC given that restoration actions completed in the AOC more directly influence these environmental matrices. Evidence in support of declining concentrations of priority chemicals in environmental media imply success of past restoration actions (source control and environmental clean-up strategies) that are expected to translate into further reductions in fish contamination. Spatial patterns of contamination are examined with respect to local vs regional sources of contamination and interpreted in the context of fish movements (cross channel and between water body movements) identified in the Tier 3d assessments.

2.4.1 Tier 4a - Temporal Trends of Mercury in water of the AOC.

Long term temporal trends of mercury in water from Canadian waters of the AOC were not available at the time of writing. McCrea (2005) reported 2001 whole water mercury concentrations of 2.65 ng/L at the U.S. upstream site of Fleming Channel just located adjacent to Peche Island and 4.74 ng/L in Amherstburg Channel. Dove et al. (2012) provided an update of mercury concentrations in water at these and other AOC stations from 2004 measurements. In this case the Lake St. Clair mercury concentration in water was 3.13±0.25 ng/L, Fleming Channel 3.28±0.43 ng/L, Amherstburg Channel 6.18±0.74 ng/L and the most downstream station below Livingston Channel was 3.38 ng/L. Although Amherstburg channel had consistently elevated levels of mercury compared to upstream locations, the corridor wide gradient was less than a factor of 2. There was insufficient evidence to document changes in mercury concentrations in water from the AOC over time.

2.4.2 Tier 4b - Temporal trends of mercury in suspended solids at AOC monitoring stations.

Environment and Climate Change Canada implemented monitoring program for tracking contaminants in suspended solids by deployment of sediment traps throughout various locations of the Huron Erie Corridor including Canadian waters of the AOC (Ref Marvin's papers). Suspended solids provide a measure of mobile particles and are diagnostic of upstream replenishment of surface sediments by contaminant sources. Temporal trend data were made available for mercury residues at three Canadian

stations (Site 803, 804 and 1156) representative of upstream, midstream and downstream sample sites. Of these three stations, data were most complete for station 1156 with measurements taken over the 1999-2014 time period. Figure 17 presents data on mercury concentrations in suspended solids collected in traps from the AOC over time. For each station, there was a significant declining trend ($p<0.05$; linear regression) observed with associated mercury half lives of 13.4, 18.3 and 23.9 years for the upstream, midstream and downstream stations, respectively.

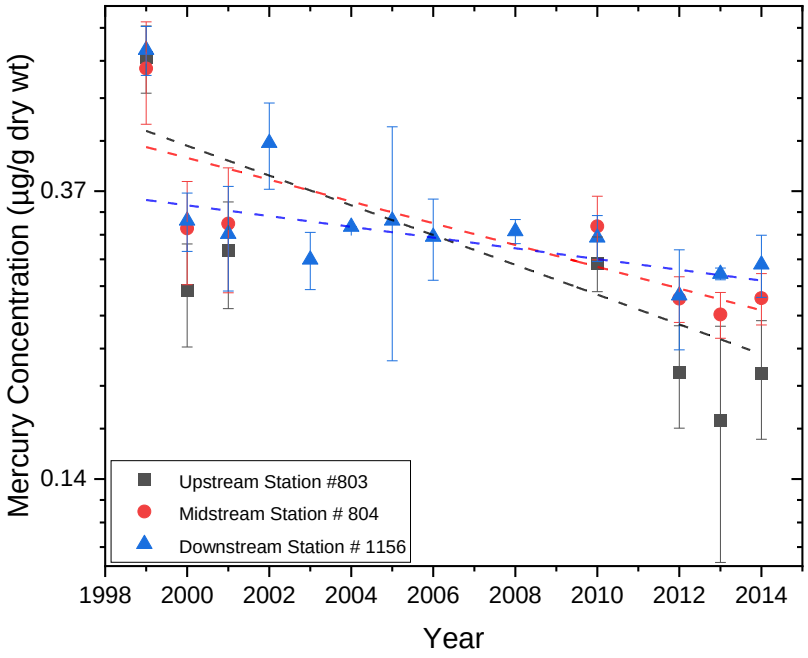

Figure 17. Temporal trends of mercury concentrations in suspended solids from Canadian AOC monitoring stations. Figure adapted from data provided by Marvin (2021, Personal Communication).

2.4.3 Tier 4c - Temporal trends of mercury in sediments of the AOC through time.

Sediment mercury concentrations from Canadian waters of the AOC were compiled from the GLIER data set based on surveys completed in 1999, 2004, 2008/09 and 2013. GLIER sediment surveys adopted a common stratified random sampling design across the entire boundary of the AOC. For this component of the report, sediment chemistry data were truncated to Canadian waters of the AOC and were combined across all river reaches of the AOC. A more detailed temporal interpretation of this data can be found in Drouillard et al. (2020). Trend analysis was performed by linear regression on ln transformed

data and is summarized in Figure 10. Linear regression analysis indicated a non-significant effect of time (p>0.3; ANOVA) for AOC-wide mercury residues in sediments. The authors note that sediment monitoring data are likely insufficient in the duration of monitoring to fully assess temporal recovery of the AOC. Sediments provide much longer time integration than other environmental media such as water and UGLCCS (1988) recommended that sediment monitoring be completed across 10 year intervals. Continued monitoring of mercury in sediments of the AOC should be adopted to compare against baseline data generated in 1999 and later survey year intervals.

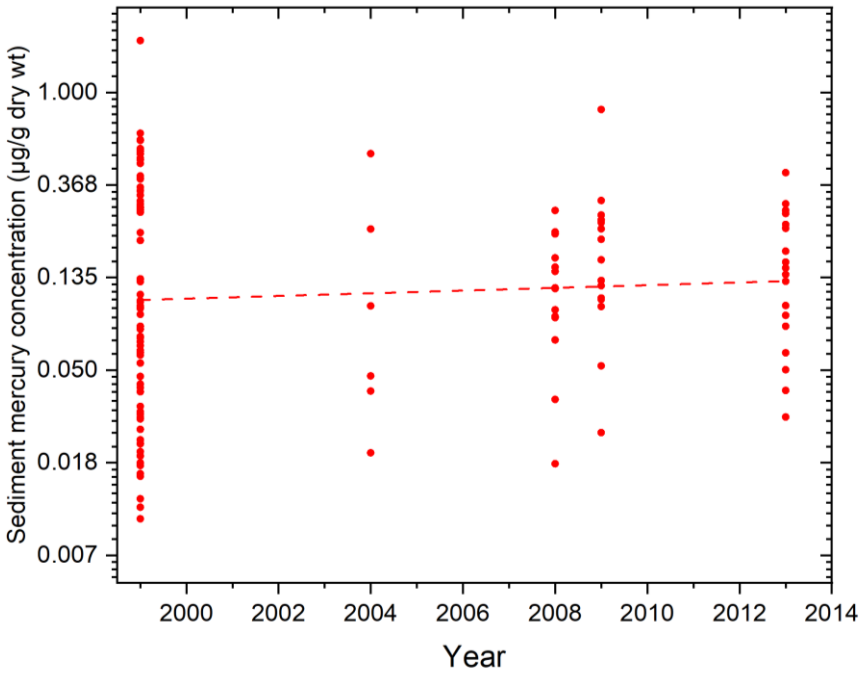

Figure 18. Mercury concentrations in sediments from Canadian waters of the AOC across time.

2.4.4 Tier 4d – Spatial patterns of mercury in suspended solids from Lake St. Clair and Detroit River

More than 95% of water entering the Detroit River is derived from Lake St. Clair (UGGLCS, 1988) which was historically contaminated by mercury resulting in the first closure of a commercial fishery in the Great Lakes. Although mercury contamination in Lake St. Clair and its fish have been demonstrated to improve through time (Gewurtz et al. 2007, 2010) legacy contamination of sediments in the Lake could remain a source of contaminated particles to the Detroit River.

Marvin et al. (personal communication, 2020) provided evidence of mercury concentrations in suspended solids collected from sediment traps positioned in Lake St. Clair and at 3 Canadian stations reflecting upstream, midstream and downstream locations in the AOC. Mercury concentrations in suspended solids at the last collection time point (2014) were 0.2 μg/g for Lake St. Clair, 0.20±0.04 μg/g for the upper Detroit River, 0.25±0.02 μg/g for middle Detroit River and 0.28±0.03 μg/g for the lower station. These data reinforce a marginal increase in mercury contamination in downstream waters of the AOC that somewhat exceed the baseline value by less then a factor of 2. However, temporal trends of mercury in suspended solids were consistent between sampling locations in Lake St. Clair and Detroit River. Mercury residues in Lake St. Clair suspended solids significantly declined with time ($p<0.01$; regression) with a half life of 16 years. Significant declines in mercury suspended solids concentrations were also evident at Canadian Detroit River upstream, midstream and downstream locations with half lives of 14, 4 and 24 years, respectively (Figure 19). Analysis of covariance indicated there was no significant difference ($p>0.3$; ANCOVA) in the recovery rate of mercury concentrations of suspended solids from Lake St. Clair and the downstream Canadian station. ANCOVA also failed to detect site specific differences ($p>0.05$; ANCOVA) in geomean mercury concentrations between Lake St. Clair and the downstream Canadian station. The observed declines in Lake St. Clair mercury residues corresponding to similar recovery at Canadian AOC trap locations provides support for the interpretation that recovery of Lake St. Clair both influences and generates positive benefits to mercury residues present in Canadian portions of AOC sediments.

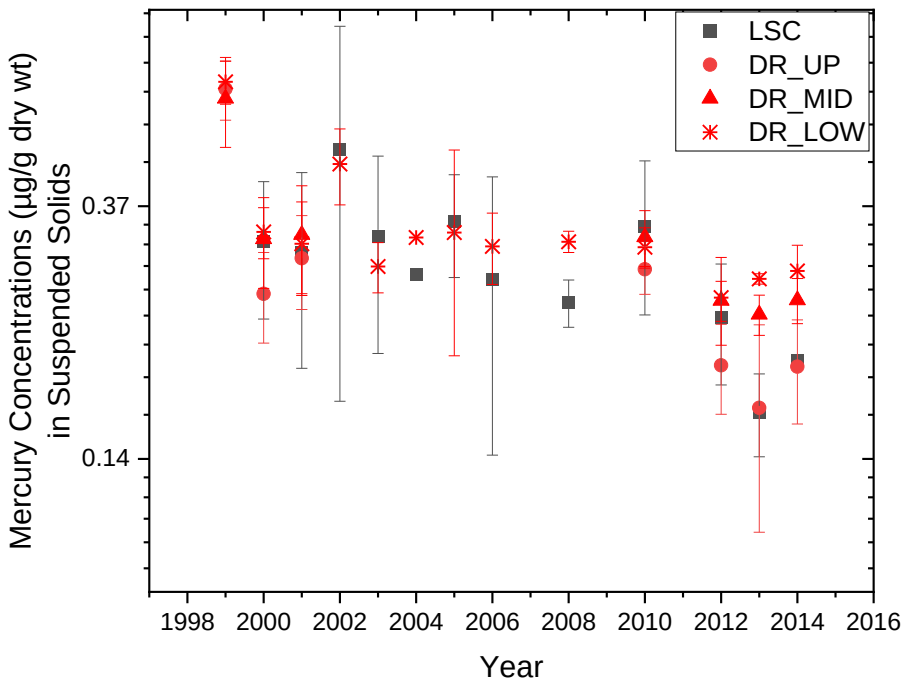

Figure 19. Mercury concentrations in suspended solids moving through Lake St. Clair and at 3 Canadian stations in the AOC.

2.4.5 Tier 4e – Spatial patterns of mercury in surficial sediments

Mercury distributions in sediments from the Lake St Clair-Erie Corridor are presented in Figure 20 using data from GLIER sediment chemistry surveys (1999-2013), Environment and Climate Change Canada (2013/2014) and Michigan EPA/EAGLE 2000-2017. Data generated by EPA/EGLE in the nearshore designated sediment restoration zones are separated in the figure given that these samples are located in known/suspected enriched contamination areas of the AOC. Mercury concentrations were highest in the nearshore U.S. zones of the Detroit River, areas designated for future sediment restoration activities. This was followed by enriched mercury in Canadian waters of Lake St. Clair that were equal to U.S. Detroit River and Canadian portions of western Lake Erie. The lowest mercury concentrations were observed in U.S. waters of Lake St. Clair followed by Canadian waters of the Detroit River. Sediment mercury content in Canadian waters of the AOC were statistically lower than Canadian waters of Lake St. Clair, U.S waters of the Detroit River and Canadian waters of western Lake Erie but similar to U.S. waters of western Lake Erie.

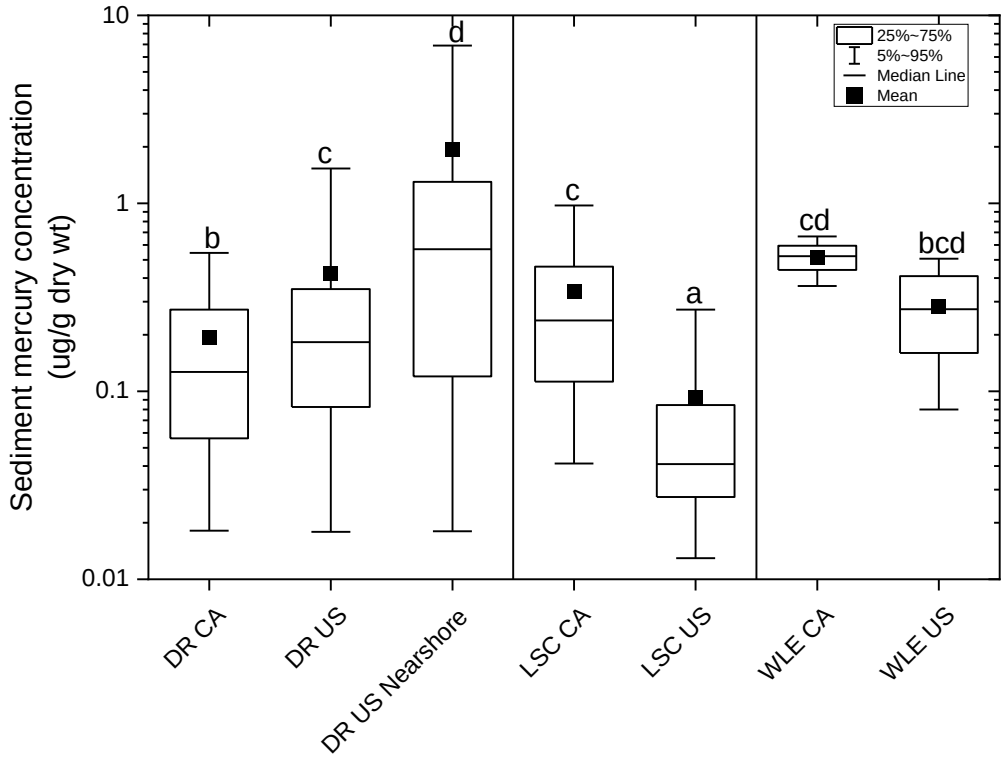

Figure 20. Mercury concentrations in Lake St. Clair and upstream, midstream and downstream Canadian reaches of the AOC.

2.4.5 Tier 4f – Exceedance of mercury sediment quality guidelines in the AOC

Mercury concentrations in sediments were examined with respect to MECP Lowest Effect Level (LEL) and Sever Effect Level (SEL) sediment quality guidelines. There were no exceedances of mercury SEL concentrations (2 µg/g dry weight) at any Canadian stations (1999-2013) in the Detroit River over time. Exceedance of LEL values (0.2 µg/g dry weight) occurred at 57 stations (36.3%) of stations with approximate equal percentages of LEL exceedances when data were broken up into 1999-2007 (39%) and 2008-2013 (33%) year intervals. Given the lack of SEL exceedances but routine detection of mercury above LEL in the Canadian portions of the AOC, this is considered a mixed evidence line with respect to sediment quality.

2.4.6 Tier 4g – Stable isotopes of mercury as source tracers of mercury to the AOC

Mercury isotopes were determined in sediment samples from Lake St. Clair and Canadian and U.S. waters of the AOC by Dr. Jason Deemers, University of Michigan. The study used archived sediments from the GLIER 2012/2013 sediment chemistry surveys and are reported by Spencer et al. (2017). Isotopes of ^{199}Hg and ^{202}Hg were able to discriminate against U.S. and Canadian mercury sources within the AOC and further demonstrated that downstream Canadian reaches of the AOC resembled the mercury isotopic signature found in Lake St. Clair. Figure 21 presents mercury isotope trends in surface sediment samples collected at selected stations within the Huron-Erie corridor. The orange shaded area in the upper and lower graphics of Figure 21 delineates the mercury isotopic space associated with Lake St. Clair sediments. Notably, all Canadian downstream sediment samples exhibited strong overlap in their mercury isotope signatures with those from Lake St. Clair. The isotopes and total mercury content of sediment suggest that Lake St. Clair is a past and likely on-going source of mercury contamination via transport of legacy contaminated particles to Canadian portions of the AOC. In addition, mercury in sediments from U.S. waters of the AOC, particularly downstream sections of the Detroit River, appears to be derived from different sources than Lake St. Clair. When coupled with Tier 4d, comparable temporal and spatial trends of mercury in suspended sediments from Lake St. Clair and Canadian waters of the Detroit River, the evidence lines point to Lake St. Clair as a source of contaminated mercury particles to the AOC.

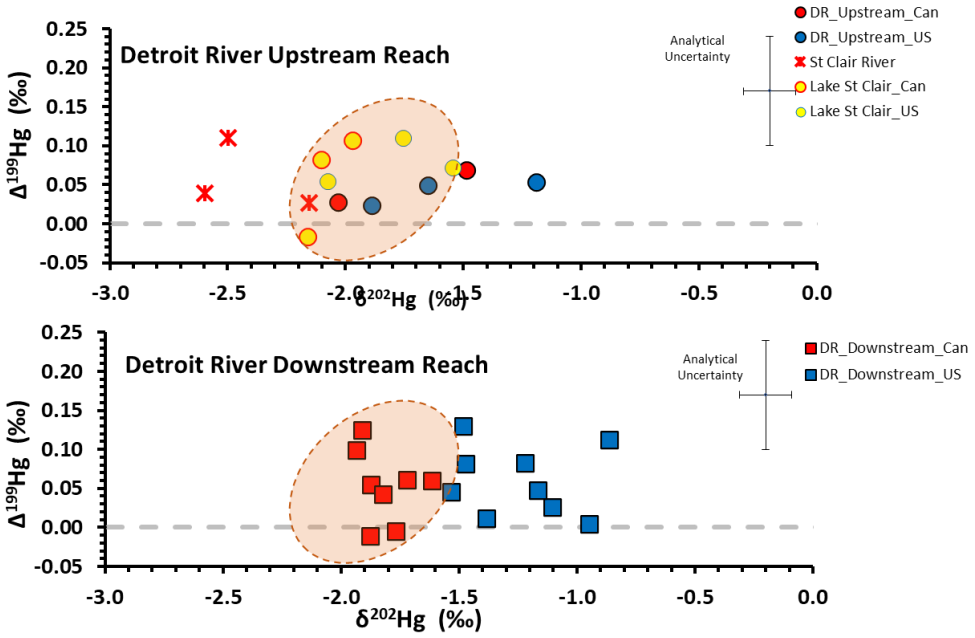

Figure 21. Mercury isotopes in selected surface sediment samples from the Huron Erie corridor. Orange shaded zone highlights the mercury isotope signature observed for Lake St. Clair sediments and its overlap with surface sediments from the Canadian portion of the AOC. Figure taken from GLSF Report (2018).

Overall, mercury contamination of sediments in Canadian portions of the Detroit River are lower then sediments from the upstream waterbody as well as adjacent U.S. waters of the AOC. In addition, data on suspended sediments coupled with sediment mercury isotope signatures provide supporting evidence to indicate Lake St. Clair as an on-going source of mercury contaminated particles. In addition, both largemouth bass, and to a much greater extent walleye, undergo movements into waters of Lake St. Clair and U.S. portions of the Detroit River based on DFA analysis. These movements into adjacent water bodies, having higher overall mercury contamination, would attenuate any positive benefits associated with further sediment clean-up actions taken in Canadian waters of the AOC to remove mercury from the environment.

2.4.6 Tier 4h - Temporal trends of PCBs in water of the AOC.

McCrea (2005) reported whole water PCB concentrations in 2002 for the upstream U.S. Fleming Channel station of 0.238 ng/L with an approximate 3 fold enrichment at the downstream Amherstburg Channel monitoring site of 0.635 ng/L. Additional data on whole water PCB concentrations from Canadian waters of the Detroit River generated by the ECCC water monitoring program were not made available to the authors precluding assessment of temporal patterns.

Mussel biomonitoring data capable of generating bioavailable PCB concentrations in water were available based on the City of Windsor's long running wastewater treatment biomonitoring program implemented in Canadian waters of the AOC from 1996 to present. This program involves caging native freshwater mussels (*Elliptio complanta*) collected from a reference location (Balsam Lake, Lindsey, ON) at individual sites followed by sampling deployed mussels after 3, 6, 9, 18 and 26 weeks of Detroit River exposures. Deployment locations include upstream and downstream locations of wastewater effluent plumes surrounding the Little River and Lou Romano wastewater treatment plants. Drouillard et al. (2007; 2013; 2016) and Raeside et al. (2009) summarized models used to steady state correct and extrapolate mussel bioaccumulated residues into bioavailable PCB water concentration estimates. Figure 22 provides a summary of bioavailable PCB concentrations in water determined at three sampling locations including the upstream Riverside Marina located along the Canadian shoreline adjacent to Peche Island and the Lou Romano outlet and Goyer's Marina located at the midstream section of the Detroit River upstream of Fighting Island. For each location, there was a significant decline ($p<0.001$; ANOVA) in bioaccumulated PCB restudies with half lives of 24.4, 29.0 and 13.2 years for the upstream and two mid-stream locations, respectively. *The available evidence indicates that the AOC is undergoing recovery with respect to PCB concentrations in water through time.* Furthermore, these patterns are consistent with the PCB half lives measured in Canadian caught fish from the AOC identified in Tier 3c and 3d.

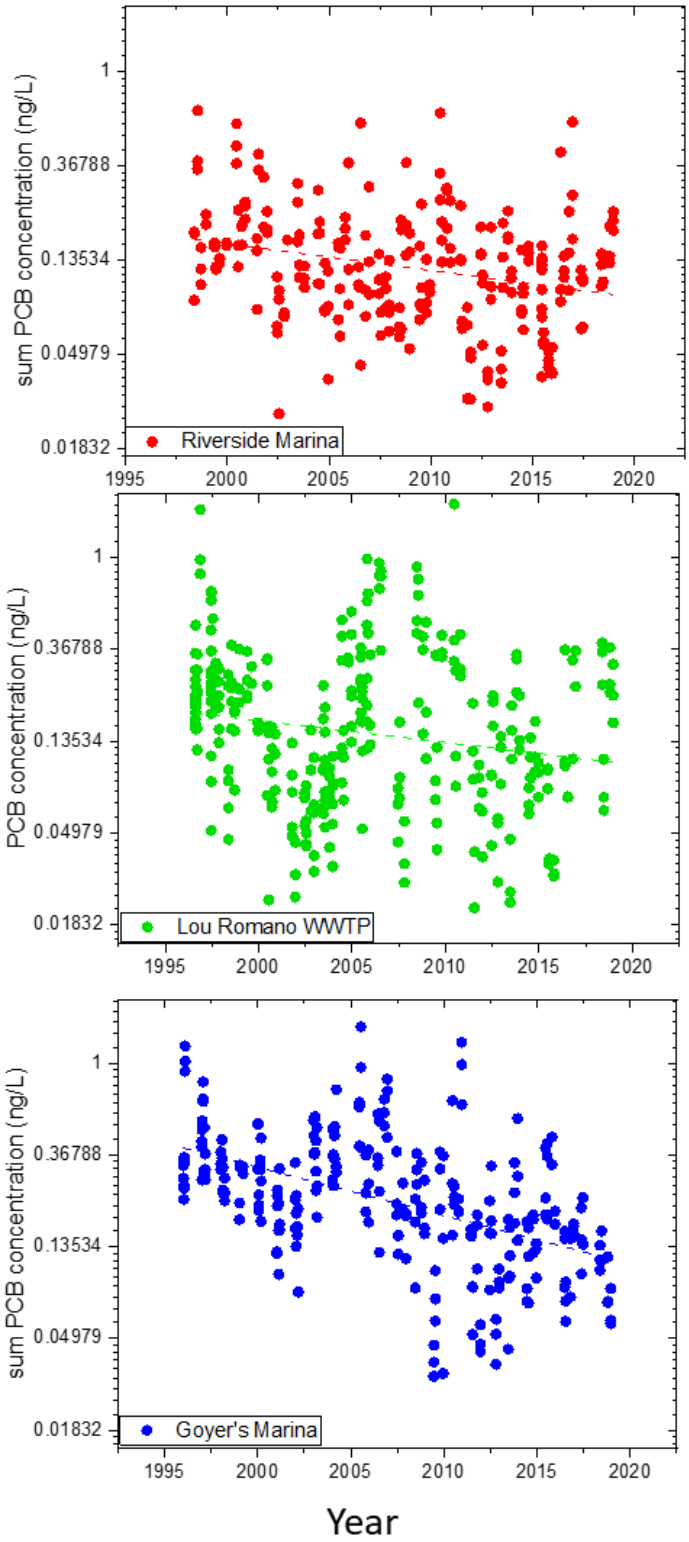

Figure 22. Bioavailable PCB concentrations in water derived from the City of Windsor Mussel Biomonitoring Program (1996-1999). Riverside marine is the upstream deployment station, Lou Romano and Goyer's Marina are the midstream sampling stations.

2.4.7 Tier 4i - Temporal trends of PCBs in suspended solids at AOC monitoring stations

The same ECCC traps described for mercury had total PCB concentrations measured within them. Temporal trend data for Canadian stations in the AOC were available for at stations 803, 804 and 1156 representative of upstream, midstream and downstream sample sites. Non-detected PCB concentrations were substituted with a value of 2 ng/g as an estimate reflective of GC-MS detections. None of the collected material in traps had detectable PCB residues in 2012, 2013 and 2014. Figure 23 presents PCB in suspended solids collected in traps from the AOC over time. Given that PCB residues could only be measured in suspended solids between 2000 and 2010 and became non-detected after 2012, the data support decreases in PCBs in suspended solids within the Detroit River over time.

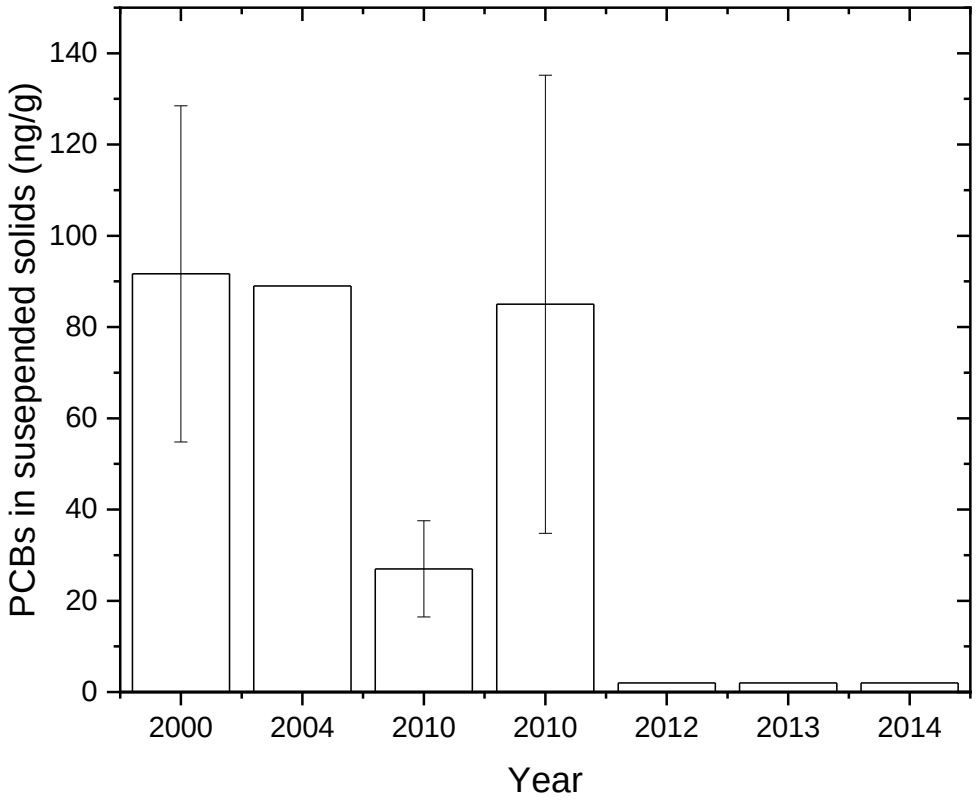

Figure 23. Mean±standard error PCB concentrations in suspended solids from three sediment trap stations added to Canadian waters of the AOC. Concentrations in 2012-2014 were non-detected across samples and given a detection limit of 2 ng/g.

2.4.8 Tier 4j - Temporal trends of PCB contamination in sediments of the AOC time

Sediment PCB concentrations from Canadian waters of the AOC were compiled from the same GLIER data set described for mercury. For the compiled data, PCBs exhibited a significant increasing trend in sediments with time ($p<0.05$; $R^2=0.031$; Figure 13). Authors note that this increase is likely a statistical artifact related to the large differences in sample replication effort across time points. Between the different survey years, replicate sediments samples ranged from a low of 6 stations (2004) to 73 stations in 1999. The very high sampling resolution in the early year time point coupled with wide variation in measured PCB residues across stations (Figure 24) appears to have a strong influence on the linear regression analysis. Drouillard et al. (2020) provided a more thorough multi-variate interpretation of this sediment chemistry data and concluded that priority contaminant groups inclusive of PCBs did not show temporal trends for Canadian waters of the AOC or in the upstream waterbodies over the 1999-2013 duration. Drouillard et al. (2006; 2020) did conclude that temporal recovery of PCBs in sediments from the lower U.S. portions of the Detroit River was apparent between the mid-1980's to 2013. As noted earlier, sediments provide a long term integration of both legacy and on-going pollutant sources and given their slow turnover, temporal recovery is expected to occur over multi-decadal time periods (Szalinska et al. 2008). The relatively short time interval (14 years) over which survey data were available is likely too small to detect true changes in sediment contamination in the AOC with time. PCB monitoring in AOC sediments should be continued through time in order to evaluate long term recovery of this important environmental compartment.

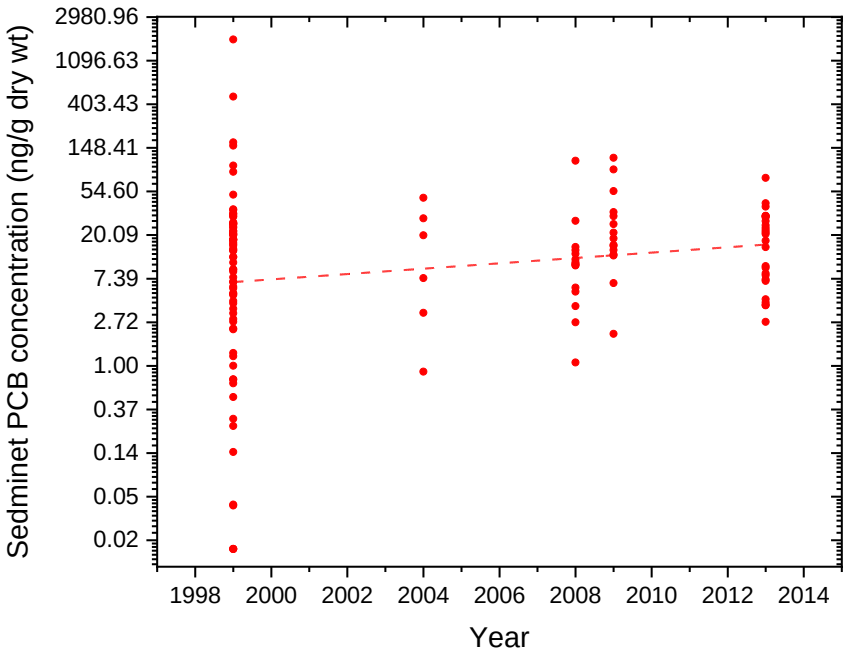

Figure 24. PCB concentrations in surface sediments in Canadian portions of the Detroit River Area of Concern.

2.4.9 Tier 4k - Spatial patterns of PCBs in Canadian and US waters of the AOC

Differences in PCB concentrations between U.S. and Canadian waters of the AOC were inferred using caged mussel biomonitoring data. Drouillard et al. (2013) compared mussel extrapolated bioavailable PCB water concentrations from caged mussels deployed at 14 Canadian and 12 U.S. stations in 2002 that covered upstream, midstream and downstream locations throughout the river. The mean seasonally averaged bioavailable PCB water concentration at Canadian locations was 0.09 ng/L compared to 0.63 ng/L in the U.S., a 7 fold higher US gradient compared to Canada (Figure 25).

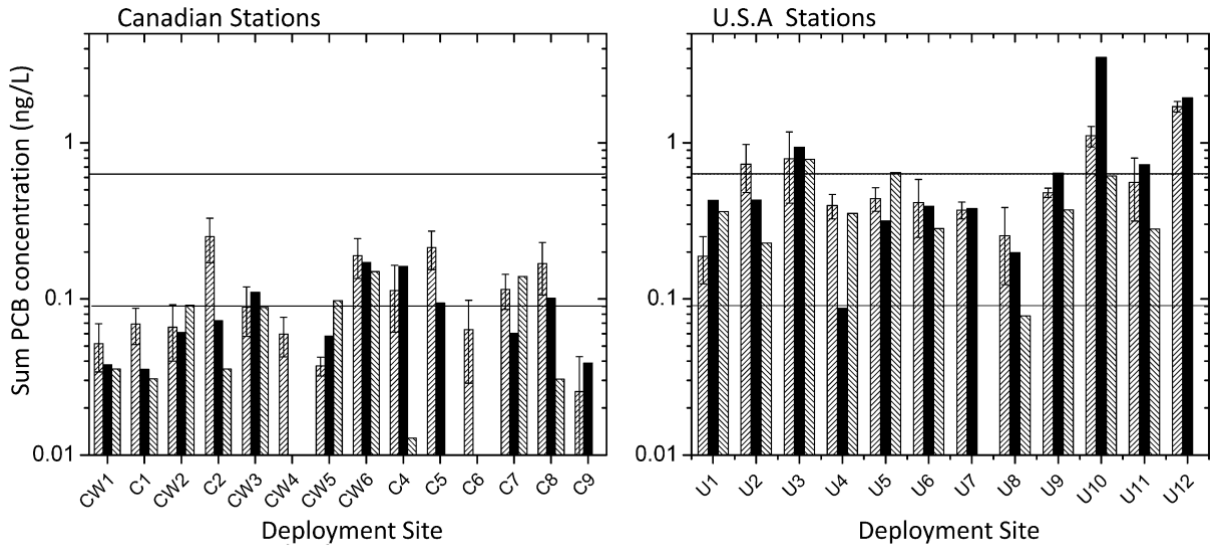

Figure 25. Bioavailable PCB concentrations in water at U.S. and Canadian deployment stations determined in 2002. Figure taken from Drouillard et al., 2013. Top horizontal line refers to the geometric mean PCB concentration measured across U.S. stations and lower horizontal line refers to the geometric mean PCB concentration measured across Canadian stations.

2.4.10. Tier 4l - Spatial patterns of PCBs in sediments of the Lake St. Clair-Erie Corridor

PCB distributions in sediments from the Lake St Clair-Erie Corridor are presented in Figure 26 using data from GLIER, Environment and Climate Change Canada (2013/2014) and Michigan EPA/EAGLE 2000-2017. Similar to mercury, PCBs were highest and significantly enriched in the U.S. nearshore sediment restoration zones. These areas of the river had median PCB concentrations approaching 40 times those observed in Canadian waters of the AOC. Although no significant differences in geomean PCB concentrations were observed across the other strata, the overall trend was western Lake Erie = U.S. Detroit River waters > Canadian waters of the AOC > Lake St. Clair sediments. As with mercury, sediment PCB concentrations in Canadian zones of the AOC are not exceptional compared to adjacent waters in the US nor downstream waters of western Lake Erie.

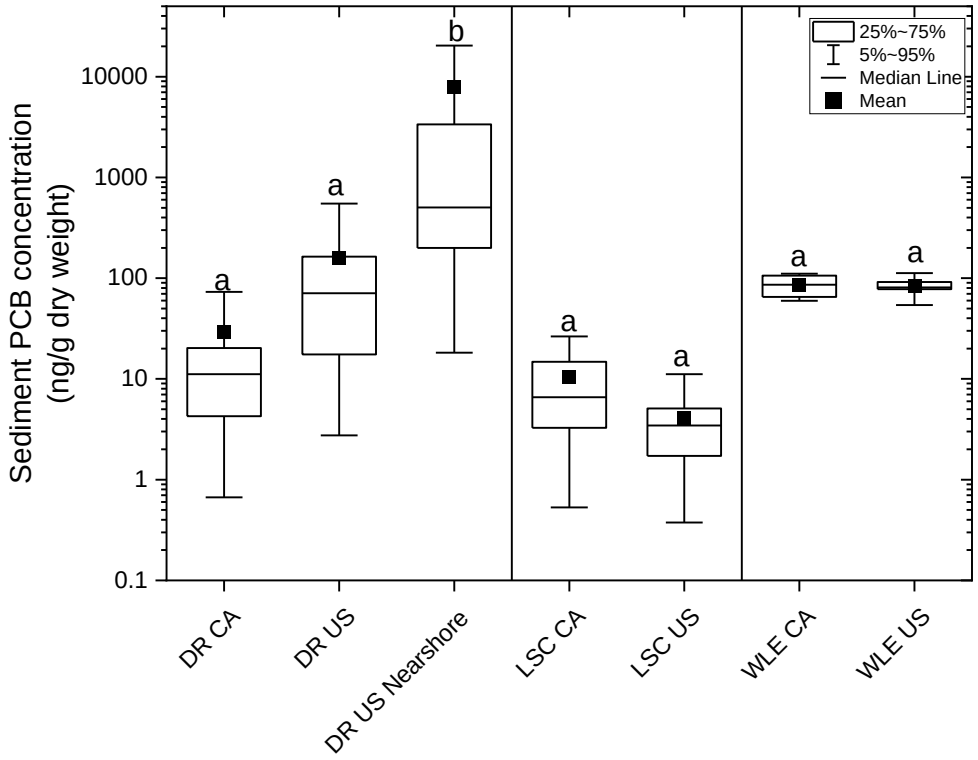

Figure 26. PCB concentrations in different zones of the Lake St. Clair – Erie Corridor.

When water and sediment PCB spatial contamination patterns are coupled with the fish movements assigned by the DFA analysis, the data do not provide strong support for local sources of PCB contamination within Canadian waters of the AOC. For walleye, only 32% of fish captured in Canadian waters of the AOC had a unique Canadian AOC chemical signature whereas the majority of fish from this species show high degree of movement either to adjacent to US waters or outside of AOC boundaries. Between 24-28% of walleye were identified as moving being U.S. and Canadian portions AOC. This indicates that a proportion of Canadian caught walleye are likely to respond to ongoing and planned US sediment restoration activities occurring in US portions of the AOC. Alternatively, actions taken to further reduce the already low environmental PCB contamination in Canadian waters and sediments would only be expected to affect 1/3 fish caught from Canadian waters. The temporal analysis further indicates that PCBs are declining in both water (half lives of 13-30 years), suspended solids and Canadian caught walleye (half lives of 9.4 years for assigned Canadian residents and 18.2 years for all Canadian caught walleye). Among the Canadian resident walleye, the 45-50 cm size class had geomean PCB

concentrations of 131 ng/g wet weight. Based on the temporal recovery, after 10 years, PCB concentrations are expected to be less than 70 ng/g and would pass the Tier 1 unrestricted benchmark of 8 meals per month. Thus, weight of evidence for Tier 4 suggests that additional remedial actions in Canadian waters to address local sources of PCB contamination would not strongly benefit fish contamination for this species and that natural recovery of PCBs in these waters are occurring causing reductions in PCB contamination of fish.

2.4.11. Tier 4m – Exceedance of PCB sediment quality guidelines in the AOC

PCB concentrations in Canadian AOC sediments were examined with respect to MECP Lowest Effect Level (LEL) and Sever Effect Kevek (SEL) sediment quality guidelines. There were no exceedances of the PCB SEL concentrations (530 μg/g TOC weight) in any Canadian stations (1999-2013) in the Detroit River over time. Exceedance of LEL values (70 ng/g dry weight) occurred at 10 stations (6.4%) of stations with approximate equal percentages of LEL exceedances when data were broken up into 1999-2007 (6.9%) and 2008-2013 (5.7%) year intervals. Given the lack of SEL exceedances and rare exceedance of PCB LELs in the Canadian portions of the AOC, this evidence line is considered unimpaired line with respect to sediment quality.

2.4.12 Tier 4 Weight of Evidence

The weight of evidence decision matrix for Tier 4 is summarized in Table 19. A majority of evidence lines support decreasing environmental contamination of mercury and PCBs in Canadian environmental compartments of the AOC. The exception is for sediments which were stable or slightly increasing over 1999-2013. The latter increasing trend was considered a statistical artifact of major differences in sampling resolution between early and late years of AOC sediment sampling campaigns and short time frame over which to assess temporal recovery in this environmental phase. With respect to spatial patterns, there is no evidence to suggest that Canadian portions of the AOC have enriched mercury or PCBs relative to U.S. waters or relative to upstream and downstream waters of the Lake St. Clair – Lake Erie corridor. However, high concentrations of mercury and PCBs are present in surface sediments from U.S. nearshore areas along U.S. portions of the Detroit River that are designated for future restoration actions. Given that walleye show pronounced cross channel movements by the DFA model (Tier 3d), the above planed restoration activities are likely to benefit fish contamination of Canadian caught fish. Largemouth bass were not predicted to undergo substantive cross channel movements according to the

DFA model. However, a large fraction (18%) of Canadian AOC caught largemouth bass were assigned as Lake St. Clair-like based on their chemical signatures. The main contaminant driving fish advice in largemouth bass was mercury and not PCBs. Mercury concentrations are higher in sediments from Canadian portions of Lake St. Clair compared to Canadian portions of the Detroit River. The sediment mercury content in the AOC can be traced to originating from Lake St. Clair based on mercury isotope signatures along with suspended solids that show comparable concentrations and temporal recovery in the AOC relative to the Lake St. Clair monitoring station. These combined features indicate that mercury residues in environmental phases of the Detroit River are partially being controlled by the upstream water body, and both are subject to the natural recovery of mercury residues in Lake St. Clair as particles slowly export out of the system towards Lake Erie. Given these circumstances, it is unlikely that restoration actions performed in Canadian waters of the AOC to remove mercury would likely impact largemouth bass or walleye mercury residues. Clean-up actions taken to remove mercury in Canadian sediments of the AOC may also be undermined by replenishment of contaminated particles arising from Lake St. Clair. Alternatively, mercury residues in nearshore U.S. zones designated for restoration are considerably elevated relative to Lake St. Clair and therefore particle settling from the upstream waterbody would not strongly undermine the planned restoration actions for U.S. areas of the AOC. The overall weight of evidence from Tier 4 evidence lines suggests that additional restoration actions in Canadian waters of the AOC are not required to improve fish contamination. Natural recovery observed to be taking place coupled with planned restoration actions in U.S. portions of the Detroit River are expected to generate improvements in the fish consumption restriction BUI over time.

Table 19. Weight of evidence decision matrix for Tier 4 evidence lines.

Evidence Line	Evidence Line description	Mercury	PCBs
Tier 4a,h	**Temporal trends in water of AOC**	**Insufficient Data**	**Declining with half lives of 13.2-29 years**
Tier 4b,i	**Temporal trends in suspended solids of AOC**	**Declining with half lives of 13.4-23.9 years**	**Supporting evidence for declines from 2000 – 2010.**
Tier 4c, j	**Temporal trends in bottom sediments of AOC**	**Stable**	**Increasing/Stable**
Tier 4 k	**Spatial patterns in water**	**Insufficient data**	**PCBs lower and CDN waters compared to US waters of AOC**
Tier 4d	**Spatial patterns in suspended solids**	**Conditions in AOC = Lake St. Clair, both declining with similar half lives**	**Insufficient Data**
Tier 4e,j	**Spatial patterns in bottom sediments**	**Conditions in AOC < DR-US & LSC CA, <<<DR US Restoration Zones < wLE CA**	**Conditions in AOC <<< DR-US Restoration zones, equivalent to DRUS, LSC CA and wLE**
Tier 4f,m	**Exceedance of SQGs**	**36.3-39% exceedance of LELs** **0% exceedance of SELs**	**Rare exceedance of LELs (<10%)** **0 Exceedance of SELs**
Tier 4g	**Isotope tracers of mercury sources**	**Sediment isotopes point to Lake St Clair as main source of contaminated particles to Canadian zones of AOC**	**No Data available**
WOE		**Declining in suspended sediments and no evidence for local sources in Canadian waters of AOC compared to regional contamination**	**Declining in water and suspended sediments of AOC. No evidence for local sources in Canadian waters of AOC compared to regional contamination.**

3.0 BUI #1 Assessment Conclusions

Beneficial Use #1: Restrictions of Fish Consumption was evaluated for the Detroit River Area of Concern. The use impairment as assessed against the delisting criteria statement:

> *When Consumption advisories for indicator fish species (e.g. walleye, brown bullhead, and largemouth bass) given for the sensitive population in the AOC are similar to upstream and downstream non-AOC Great Lakes reference areas due to contaminants from locally-controllable sources.*

The beneficial use was evaluated using a tiered BUI framework to compile and interpret multiple evidence lines in support of the delisting statement. Tier 1 of the framework evaluated official fish consumption advice issued by Ontario Ministry of Environment, Conservation and Parks (MECP) for Canadian waters of the Detroit River Area of Concern against an unrestricted consumption benchmark of 8 meals per month. Tier 1 passed the unrestricted consumption criteria for brown bullhead but failed for 4 size classes of largemouth bass and 8 size classes of walleye which advised between 4 and 0 meals per month for the Sensitive Population.

Tier 2 evaluated whether fish consumption restrictions in the AOC were more stringent compared to non-AOC Great Lakes reference areas. Official MECP advice for largemouth bass and walleye were compiled for all Great Lakes fishing zones excluding Great Lakes AOCs and the median monthly meal advice was computed for each size interval of fish to which advice was also available in the AOC. Fish consumption advice for 30-35 cm largemouth bass issued to the Sensitive Population from the AOC was more restrictive than Great Lakes reference. For walleye, there were 5 size classes where Tier 2 advisories issued for the AOC were more restrictive than the Great Lakes Reference. Fish advice issued for largemouth bass to the General Population were similar to the reference whereas advice for walleye issued to the General Population were considered impaired relative to reference.

Tier 3 adopted four evidence lines coupled with a weight of evidence framework to evaluate how individual contaminants contribute to fish consumption restrictions. The four evidence lines evaluated chemical-specific virtual advisories after standardizing the temporal range of fish contaminant records in both reference and AOC, examined for statistical differences in fish contamination of priority pollutants between AOC and reference fish, temporal recovery of priority pollutants in AOC fish and evaluated fish movements within and outside of the AOC boundaries to assess local sources of fish contamination.

For largemouth bass, all tested evidence lines associated with PCBs passed their criteria and therefore PCBs were not contributing to elevated fish contamination nor restrictive fish advice for this indicator within the AOC. However, mercury residues were elevated in AOC caught largemouth bass and exceeded concentrations observed in reference fish. After evaluating fish movements, 58.8% of fish caught from the AOC were assigned as Canadian AOC resident fish while 35.3% were assigned as having a chemical signature similar to Lake St. Clair caught fish. When the Canadian AOC resident assigned fish were evaluated against Tier 3 criteria in isolation, virtual fish advice in one size class was more stringent than the reference by one meal category but mercury concentrations in these fish did not statistically differ from the reference. Given that the fish movement model indicated a strong propensity for fish movements into Lake St. Clair coupled with environmental assessment of mercury contamination in Lake St. Clair versus Canadian waters of the AOC (see Tier 4), the weight of evidence assessment for Tier 3 for largemouth bass was considered to pass the criteria.

For walleye, virtual advice due to mercury and PCBs were more stringent in AOC caught fish compared to the reference. In addition, PCB and mercury concentrations of Canadian AOC-caught fish were statistically elevated compared to reference. However, there was evidence for declining PCB concentrations in walleye with a half life of 18.1 years. For mercury, 3 size classes showed declining trends in mercury residues with time (half lives of 18-35 years) but 3 size classes showed no change or increasing trends (50-55 cm fish) with time. The fish movement assessment indicated a high degree of mobility of this indicator species. Only 32.2% of fish were assigned as Canadian AOC resident fish, 27.6% as U.S. AOC-like, 24.6% as western Lake Erie-like and 17.6% of fish as Lake St. Clair-Like. Similar assignments were generated for walleye caught from U.S. waters of the AOC indicating that walleye from the Detroit River are composed of highly mixed sub-populations inclusive of upstream and downstream waterbodies as well as undergoing cross channel mixing within the AOC. The Canadian-AOC resident fish were re-examined with respect to Tier 3 criteria, virtual advice and fish contamination of mercury and PCBs and still found to exceed the Great Lakes Reference. However, both PCBs and mercury in Canadian-AOC resident fish were undergoing declining trends in fish contamination with half lives of 21.8 years (mercury) and 9.4 years (PCBs). Based on the evaluation of fish contamination evident lines alone, walleye were assessed to fail Tier 3 criteria.

Tier 4 evidence lines evaluated environmental contamination in the AOC to examine for evidence of temporal recovery in the AOC through time and to evaluate spatial patterns of water, suspended

sediment and bottom sediment contamination to discern local sources of PCBs and mercury from regional sources of contamination in the area. With regard to mercury, mercury contamination of suspended solids collected from sediment traps at three sites in Canadian waters of the AOC showed declining trends with half lives ranging from 13.4 to 23.9 years. Sediment mercury residues were stable in time. In terms of spatial trends, multiple evidence lines pointed to upstream (Lake St. Clair) sources of mercury contaminated particles to Canadian waters of the AOC. These included stable isotopes of mercury in bottom sediments, comparable mercury residues in suspended solids as those present in Lake St. Clair sediment trapping stations and similar temporal recovery of mercury residues in suspended solids from different trapping locations over time. Mercury residues were also elevated in Canadian bottom sediments of Lake St. Clair as well as in U.S. nearshore designated restoration areas of the AOC compared to Canadian areas of the AOC. Taken together, mercury was observed to be declining in some compartments of the AOC including suspended solids and fish residues with little evidence for local mercury sources directly entering into Canadian portions of the AOC. Furthermore, on-going and planned sediment restoration activities taking place in nearshore U.S. portions of the Detroit River AOC are likely to contribute to lower overall mercury mass balance within the system and will have positive benefits to fish contamination for certain species of Canadian caught fish such as walleye which undergo substantive cross channel movements. Therefore Tier 4 was considered to pass the criteria for mercury given a lack of evidence for locally controllable sources within Canadian portions of the AOC.

PCBs showed evidence for declining residues in water and suspended sediments but stable to slightly increasing concentrations in sediments. PCB concentrations in Canadian water and sediments of the AOC were much lower than U.S. nearshore regions designated for restoration and statistically equivalent in concentration to Lake St. Clair and western Lake Erie. The combined features of declining PCBs in environmental media, lack of evidence for local sources to Canadian waters of the AOC coupled with declining trends in PCBs from Canadian AOC resident fish imply a lack of locally controllable sources for this priority pollutant. As in the case of mercury, on-going and planned U.S. sediment restoration initiatives in U.S. portions of the AOC are likely to contribute to reductions in the system wide PCB mass balance and result in reductions in fish PCB contamination for mobile species of Canadian caught fish. Therefor Tier 4 was considered to pass the criteria for PCBs.

Overall, this report concludes that BUI #1 should be redesignated as unimpaired according to the Weight of Evidence Assessment according to the Tiered BUI #1 assessment framework (Figure 27). Even though

degree of fish contamination and meal per month restrictions are greater in Canadian fishing zones of the AOC compared to the Non-AOC Great Lakes references, the degree of restrictiveness is not a result of locally controllable sources but rather a result of regional contamination (Lake St. Clair and western Lake Erie) and high degree of cross channel movements for some indicator species such as walleye which can bioaccumulate priority contaminants from the more contaminated U.S. waters of the AOC. Lake St. Clair continues to contribute mercury contaminated particles via suspended sediments to Canadian waters of the AOC negating the potential effectiveness of future sediment restoration actions to address mercury in sediments from Canadian portions of the AOC. Furthermore, much of the mass of PCBs and mercury in the Detroit River Area of Concern is found in the nearshore U.S. zones of the AOC. These highly contaminated areas have already been designated for restoration actions by the U.S. State and Federal Governments. The anticipated outcomes of the U.S. cleanup initiatives, once completed, are that they will benefit fish contamination, including mobile species caught by anglers fishing within Canadian waters of the AOC. Thus U.S. restoration initiatives should be prioritized over actions taken in Canadian waters of the AOC given that these actions have the greatest potential to directly benefit BUI #1 coupled with the natural recovery of mercury and PCBs being observed in Lake St. Clair and Canadian portions of the AOC.

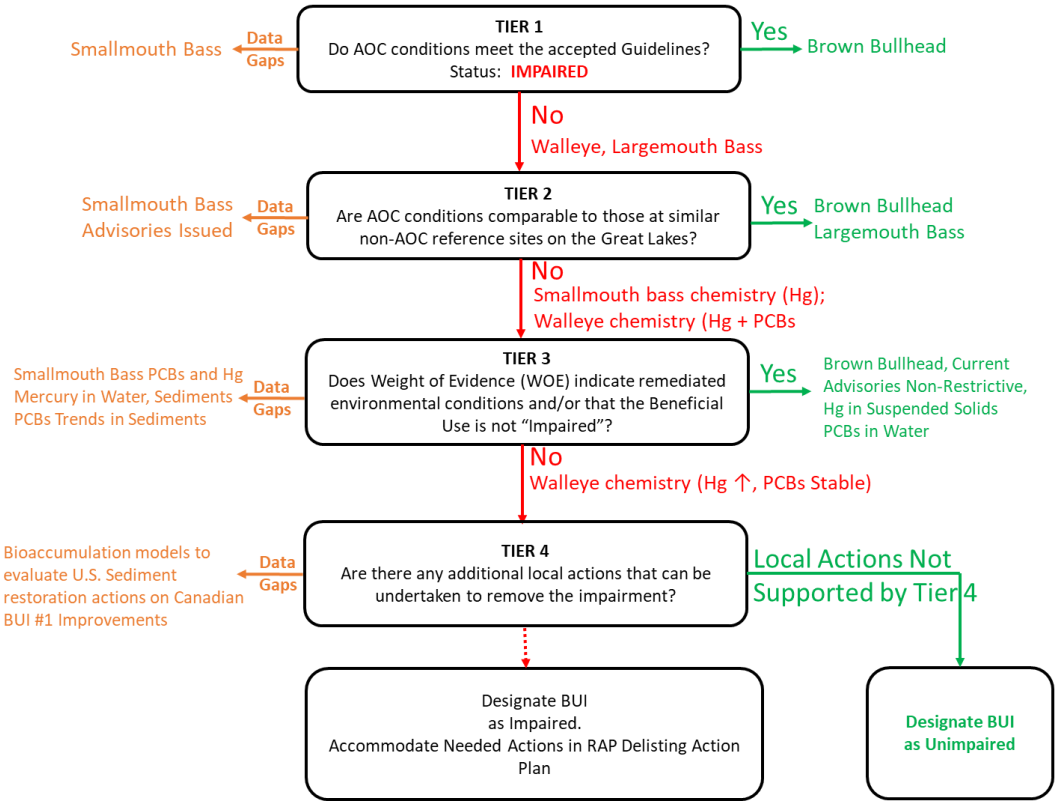

Figure 27. Tier 4 assessment outcome summary

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