Detroit River Area of Concern: Fish Population Assessment Report 2022 Update

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Contents

Executive Summary

The Detroit River is a 51 km connecting channel linking Lake St. Clair and Lake Erie. A long history of industrial, urban, and agricultural development has significantly degraded the river's physical, chemical, and biological integrity. In 1987, the Great Lakes Water Quality Agreement (GLWQA) listed the Detroit River as an Area of Concern (AOC). Over the past 30+ years, while significant progress has been made addressing the environmental issues in the Detroit River, four beneficial use impairments (BUIs) remain, one of which is the *degradation of fish and wildlife populations* BUI (BUI #3). The delisting criterion for this BUI stipulated that fish populations be self-sustaining and healthy communities as demonstrated by the five specific, measurable, achievable, relevant, and time-bound (or SMART) sub-criteria developed in 2021. The five sub-criteria are:

1. Fish communities in wetland coastal areas are comparable to fish communities in unimpaired coastal wetlands.
2. The number of adult Lake sturgeon populations are greater than 750.
3. There is no evidence of benthification of fish communities.
4. Walleye and Smallmouth bass catch and effort by anglers are at or above the long-term average.
5. There is ongoing and/or increased spawning activity for fishes since 2006.

The Ontario Ministry of Natural Resources and Forestry (OMNRF), the lead provincial agency in fisheries management, compiled and evaluated data and study findings pertaining to the five sub-criteria and as detailed in this report, each has been met. This indicates that the fish population within the Detroit River is diverse, healthy, and self-sustaining and that the delisting criteria established for fish populations has been achieved. This report provides a solid scientific foundation to recommend the redesignation of fish populations to a *not impaired* status within the Detroit River Area of Concern.

List of Acronyms

AOC	Area of Concern
BEF	Boat Electrofishing
BUI	Beneficial Use Impairment
CUE	Catch per Unit Effort (referred to as CPUE in some figures)
DFO	Department of Fisheries and Oceans or Fisheries and Oceans Canada
DNR	Department of Natural Resources
DR	Detroit River
DRCC	Detroit River Canadian Cleanup
GLWQA	Great Lakes Water Quality Agreement
HUE	Harvest per Unit Effort
IBI	Index of Biotic Integrity
IJC	International Joint Commission
MDNR	Michigan Department of Natural Resources
OMNRF	Ontario Ministry of Natural Resources and Forestry
OMOE	Ontario Ministry of the Environment
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
RAP	Remedial Action Plan
SCDRS	St. Clair Detroit River System
SMART	Specific. Measurable. Achievable. Relevant. Time bound.
T/I	Tolerant/Invasive
USFWS	United States Fish and Wildlife Service

Introduction

The Detroit River is a 51 km connecting channel, flowing from Lake St. Clair to Lake Erie. The river is part of the traditional territory of the Anishinaabe First Nations who used it for hunting, fishing, and a water source, prior to European settlement (Ryerson n.d.). During the early part of the 1900s, rapidly rising steel, auto, chemical, and refining industries introduced toxic contaminants such as pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals into the water and accumulated in the river sediments (MDNR and OMOE 1991). Urban centers of Detroit, Michigan, and Windsor, Ontario developed, adding sources of pollution to the river (MDNR and OMOE 1991) and the extensive dredging to create shipping channels, destroyed and altered fish habitat. By the 1980s the chemical, physical and biological integrity of the Detroit River were significantly impaired. In 1987 the Detroit River was listed as one of 43 Areas of Concern (AOC) based on the assessment of fourteen specific beneficial uses identified in the GLWQA, one of which was the *degradation of fish and wildlife populations* (BUI #3). In accordance with the GLWQA, each AOC developed and implemented a Remedial Action Plan in stages: the first stage identified the sources of pollution and impacts; the second stage established restoration goals for impaired BUIs and recommended restorative actions; and the third stage is actively restoring BUIs until all fourteen are not impaired. Once this is achieved, the AOC can be removed from the list of AOCs under the GLWQA, a process known as “AOC de-listing”.

The 1991 Stage 1 RAP was a binational report however each country developed domestic action plans. In the Stage 1 RAP Report, the fish populations were designated as “not impaired”, because the fishery objectives were being met, the river provided productive recreational fisheries, and habitat for over 60 fish species (MDNR and OMOE 1991). The Stage 1 Report noted shifts towards a benthivores dominated in the fish community due increased presences of invasive species and loss of habitat but noted a return to historical fish communities, was unrealistic. In the 1999 Detroit River RAP Update report, fish populations were identified as “impaired” (DRCC 1999) due to concerns for high contaminant levels and habitat loss impacts documented in a 1996 RAP Report (MDEQ 1996). Nearly a decade later, a report on the status of all BUIs in the Detroit maintained the impaired status and suggested restoration goals include diverse, self-sustaining and healthy communities by incorporating bioassays assess toxicological effects (Leney and Hafner 2006) (Table 1). The continued impaired designation was largely attributed to evidence of ecosystem degradation including large populations of coarse fish species such as Common carp (*Cyprinus carpio*), White sucker (*Catostomus commersonii*), Bowfin (*Amia calva*) and Freshwater drum (*Aplodinotus grunniens*), and the increasing prevalence of invasive species such as Round goby (*Neogobius melanostomus*; MacInnis and Corkum 2000; Gannon 2001). While there was some evidence of ecological recovery such as high angler catch rates of Walleye (0.85 fish/angler hour) and spawning of Lake whitefish (*Coregonus clupeaformis*) and Lake Sturgeon (*Acipenser fulvescens*) (Caswell et al. 2004; Johnson et al. 2005; USFWS and USGS 2006). The 2010 Stage 2 Report maintained the impaired status for BUI 3 and again refocused BUI #3 delisting criteria to ensure that “environmental conditions support self-sustaining and healthy communities of indicator fish (e.g., Walleye, Bass, Lake Sturgeon, Brown Bullhead)” (Green et al. 2010). The impaired designation in this report was attributed to the continued potential impacts of sediment and water quality issues (including mercury, pesticides, PCBs, and PAHs) on fish health and from estimates of Lake Sturgeon populations at 1% of their historical size (DRCC 1999; Green et al. 2010). The report also noted continued signs of recovery, including: captures of over 54 fish species, the presences of a strong 2003 Walleye year class, and evidence of spawning by Lake whitefish, Lake sturgeon and 34 other species in the river (Hartig et al. 2007; Haas and Towns 2009; Edwards et al. 2006). With conflicting indication of ecosystem health, this report further recommended that the restoration criteria for fish populations be revised to include indicator species and community diversity.

Over the past two decades, a definitive evaluation on whether the river is supporting healthy, diverse, and self-sustaining fish populations has proven difficult due to three key factors. First, the Detroit River AOC continues to face the same pressures, including broadscale land use changes, invasive species, and climate change being experienced across the broader Great Lakes Basin. These pressures have shifted baseline habitat conditions which now must be incorporated into the baseline for healthy, diverse and self-sustaining fish populations in the Detroit River. For example invasive species such as *Dreissenid* mussels, Round gobies and Phragmites (*Phragmites australis*) have basin wide impacts on native species. Second, traditional fisheries assessment techniques (e.g. electrofishing, gillnetting and trawling) have proved difficult for assessing the fish community in the deep, flowing waters of connecting channels (e.g. St. Clair River, Detroit River and Niagara River). This likely led to sampling errors and contributed to the conflicting signals observed in some previous assessments. Finally, BUI #3 has lacked specific, measurable, achievable, relevant, and time-bound (SMART) criteria. Without SMART criteria, subjective interpretation of assessments has led to a lack of consensus among field experts on the status of fish populations. To overcome these challenges, the following five SMART sub-criteria for fish populations were established in 2021 and are the focus of this assessment.

1. Fish communities in wetland coastal areas are comparable to fish communities in unimpaired coastal wetlands.
2. The number of adult Lake sturgeon is greater than 750.
3. There is no evidence of benthification of fish communities in the Detroit River.
4. Creel and Catch Per Unit Effort (CUE) surveys of Walleye and Bass indicate angler catch and efforts are at or above the long-term average.
5. There is evidence of ongoing and/or increased spawning activity for fishes since 2006.

This assessment uses the weight of evidence from a contemporary review of relevant peer-reviewed literature and agency assessment data to evaluate status of each sub-criteria. Each sub-criteria section has been written to be standalone. Additional information not directly contributing to the sub-criteria but providing information on fish populations is also presented. Finally, an overall of evaluation of fish populations is brought together in the conclusion.

This report is intended to be a technical document, that will be incorporated into the status report for degradation of fish and wildlife populations (BUI #3) on the Canadian side of the Detroit River AOC from “impaired to “not impaired”.

Summary of Fish Populations BUI in the Detroit River

Currently, the RAP Stage 2 report designates the BUI #3 as “Impaired” for both the fish and wildlife components (Green et al. 2010). Since the establishment of the Detroit River as an AOC, the criteria for designating the status of fish populations within BUI #3 has remained consistent. It is that, the Detroit River can support a healthy, diverse, and self-sustaining fish community. However, the evaluation of this criteria and the subsequent designation of the fish population status has changed over time (Table 1).

Table 1. Chronology of Detroit River Area of Concern (AOC) Fish Populations Beneficial Use Impairment criteria**.**

Year	Report	Delisting Criteria	Explanation
1991	Detroit River Remedial Action Plan Stage 1 Report	To maintain a healthy, diverse, and self-sustaining fish community.	This was the initial water quality goal associated with degraded fish populations.
2006	2006 Status of Beneficial Use Impairments in the Detroit River	1) Environmental conditions should support self-sustaining, healthy, and genetically diverse communities of most sensitive indicator species at levels of abundance and biodiversity that would be expected from the amount and quality of suitable physical, chemical, and biological habitat present. The objectives for this AOC should be consistent with Great Lakes ecosystem objectives, the Great Lakes Fishery Commission's fish community goals for adjoining waters, and the conservation vision for the lower Detroit River. 2) Scientifically defensible fish and wildlife bioassays confirm that there is no significant toxicity from water column or sediment contaminants. 3) As much as is possible in a connecting channel, programs should be in place to discourage further proliferation of existing non-native species, and the prevention of future introductions.	Delisting criteria were updated in the 2005 "Delisting Criteria for the Canadian Portion of the Detroit River Area of Concern" report. In 2006, the AOC was assessed with these new delisting criteria. They found the AOC to be "impaired", but suggest more detailed delisting criteria be used, especially regarding criteria 1. They argue the criteria must be specific and measurable or it will be impossible to determine when they are met.
2010	Detroit River Canadian Remedial Action Plan Stage 2 Report	When environmental conditions support self-sustaining and healthy communities of indicator fish (e.g., Walleye, Bass, Lake Sturgeon, Brown Bullhead)	Authors suggest using measures of diversity along with indicator species to assess the health of the Detroit River fish population.
2021	N/A	When environmental conditions support self-sustaining and healthy communities of indicator fish (e.g., Walleye, Bass, Lake Sturgeon, Brown Bullhead). 1. Fish communities in wetland coastal areas is comparable to fish communities in unimpaired coastal wetlands. 2. The number of adult Lake sturgeon is greater than 750. 3. There is no evidence of benthification of fish communities in the Detroit River. 4. Creel and Catch Per Unit Effort (CUE) surveys of Walleye and Bass indicate angler catch and efforts are at or above the long-term average. 5. There is evidence of ongoing and/or increased spawning activity for fishes since 2006.	In 2021, recommendations from the 2006 report were integrated by the creation of sub-criteria to assess the Detroit River fish populations. These sub-criteria were made to be SMART, allowing for it to be easily known when they are met, and the BUI can be removed.

BUI Sub-Criteria Assessments

1. Coastal Wetlands Fish Diversity

Sub-criterion #1: Fish community in wetland coastal areas are comparable to fish communities in unimpaired coastal wetlands

The heterogeneous structures of coastal wetlands provide key spawning and nursery habitats for fish by providing protection from wave action, refuge from predators and optimal foraging habitat (Scheimer et al. 2001; Grenouillet et al. 2002; Francis et al. 2014). The Nature Conservancy estimated that 80% of the 200 Great Lakes fish species use nearshore areas and coastal wetlands during some part of their life cycles (Chow-Fraser and Albert 1999; Wei et al. 2004).

In 1815, the Detroit River was home to a continuous coastal wetland complex covering the entire 51 km river length and extending up to 2 km inland. These wetland habitats were home to abundant fish and wildlife populations (USGS 1999). In the ensuing 200 years, industrial, urban, and agricultural development reduced the once contiguous coastal wetlands by over 96% (MDNR and OMOE 1991; DRCC 1999). Natural coastline habitats were filled for agricultural and urban development and/or replaced with hardened bulkhead shorelines (Green et al. 2010). By 1982 extensive land use changes had left approximately 1200 hectares of wetland habitat (DRCC 1996; Environment Canada and OMNR 2003). Since that time, there has been little change to the wetlands along the Detroit River (Green et al. 2010). The majority of the remaining coastal wetlands are found along the margins of the islands. While restoration of wetlands falls under the Fish and Wildlife Habitat Beneficial Use Impairment (BUI; i.e. BUI #14), maintaining healthy fish populations in remnant wetlands provide important sources of species for newly restored habitat and increase the likelihood of successful habitat restoration efforts. For this reason, maintaining wetland fish populations was identified as a high priority during the 1991 Stage 1 report (MDNR and OMOE 1991) and the 1999 DRCC evaluation (DRCC 1999) and an important component of the fish populations BUI (i.e. BUI #3).

Review of Publications

In the review of relevant literature and agency assessments that supported the assessment of sub-criterion #1, five papers were found focusing on the Detroit River coastal wetland and nearshore fish communities:

- Midwood et al. 2020. Application of a fish IBI to costal wetlands in the St. Clair and Detroit River Areas of Concern. DFO Technical Report.
- Lapointe et al. 2010. Macrohabitat associations of fishes in shallow waters of the Detroit River. Journal of fish biology.

- Francis et al. 2014. A description of the nearshore fish communities in the Huron–Erie Corridor using multiple gear types. Journal of Great Lakes Research.
- Currie and Victor. 2020. Assessing long-term changes to benthivorous fish community structure in the Detroit River AOC. DFO report
- Hilling et al. 2021. Nearshore Fish Species Richness and Species–Habitat Associations in the St. Clair–Detroit River System. Water.

Midwood et al. (2020) used Index of Biotic Integrity (IBI) scores from boat electrofishing (BEF) and fyke net surveys to compare sites found throughout the St. Clair-Detroit River System (SCDRS) to the Walpole Island Delta. IBIs integrate complex ecological variables that are perceived to reflect ecological health into a single number that facilitate comparisons and tracking changes over time. This study used the Walpole Island Delta as a reference site because it was felt to reflect a non-Area of Concern (AOC) coastal wetland in proximity to both the Detroit and St. Clair River AOCs. Wetland fish community surveys were completed on the Walpole Island Delta in 2015 with similar surveys completed in later years in the Detroit River (2017). Eight sites were repeatedly sampled on the Detroit River using BEF and two using fyke nets. The IBI for each site within sampling method (i.e. BEF or Fyke net) and year was calculated based on the average IBI scores of individual sampling events. Through the application of IBI scores, the health of the Detroit River AOC sites were compared to reference wetland sites. Comparisons were only made between sites with similar sampling methods because BEF and fyke net surveys do not produce directly comparable catches (Ruetz et al. 2007).

Over 4000 fish representing 49 different species were collected throughout the Detroit River, including federally and provincially listed species-at-risk (Grass pickerel *E. americanus vermiculatus*, Pugnose minnow *Opsopoeodus emiliae*, Spotted sucker *Minytrema melanops* and Northern sunfish *Lepomis peltastes*). The IBI scores for the Detroit River and Walpole Island Delta BEF sites ranged between 60 and 80 with mean IBI scores of 68.3 ± 14.8 and 66.5 ± 11.5, respectively. These IBI sources were not significantly different (Kruskal-Wallis $\chi2 = 0.22$, df = 1, p = 0.64; Figure 1). The robustness of these results were further confirmed with similar IBI scores (between 75 and 85) at fyke net sites in the Detroit River and Walpole Island Delta. The Detroit River IBI scores were higher than those observed in other AOCs such as Hamilton Harbour (48.0) and Toronto Harbour (45.1), and comparable to the Bay of Quinte AOC (69.5) where the fish populations BUI is listed as “not impaired” (Hoyle et al. 2018).

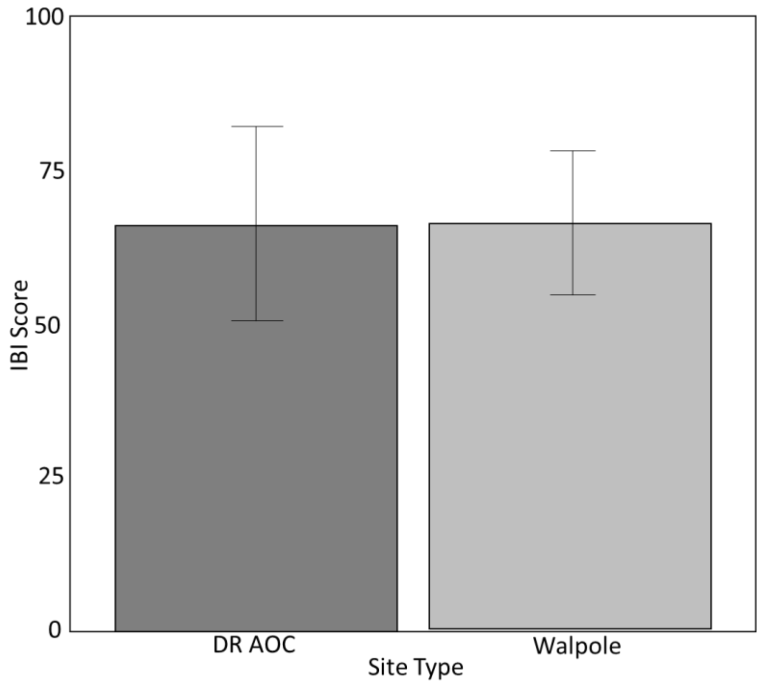

Figure 1. Mean Index of Biotic Integrity (IBI) scores among sites in the Detroit River Area of Concern (DR AOC) and Walpole Island Delta (Walpole). Error bars represent standard deviation. Adapted from Midwood et al. (2020).

While these results on their own appear to demonstrate that sub-criterion #1 has been met, Midwood et al. (2020) raised concerns that IBIs may mask differences in fish community composition because they aggregate fish community information. They suggested an evaluation of differences in fish community composition between the AOCs, and reference wetlands may be warranted to ensure important species-specific variations were not masked. The LaPointe et al. (2010), Francis et al. (2014), Currie and Victor (2020), and Hilling et. al. (2021), studies provided important insight into these concerns.

LaPointe et al. (2010) assessed seasonal differences of fish species richness, abundance, and assemblages from inshore and offshore sites along the Detroit River. Findings showed all sections of the Detroit River contain uncommon native species, with nearshore environments being home to the majority (59%). Most remnant coastal wetlands are found in the middle section of the river (River Canard to Turkey Creek). This section had the highest species richness, abundance, and was home to the greatest proportion of uncommon native species (57%) compared to the upper (35%) and lower river (11%) segments.

Francis et al. (2014) described the nearshore fish communities in the Detroit River, St. Clair Delta (also referred to as the Walpole Island Delta), and Western Lake Erie. Fish community sampling was conducted using electrofishing, seining, and fyke netting between 2004 and 2008 (Table 2)

Table 2. Summary of Francis et al. (2014) nearshore fish communities sampling efforts in the SCDRS 2004-2008.

Location	Date sampled	Gear and effort	Total catch	Number of species
Detroit River	July 12-22, 2004	10 Seines	1,753	42
		6 day electrofishing (one-run)		
		2 night electrofishing (one-run)		
	July 24-28, 2006	11 seines	12,494	54
		21 night electrofishing (two-run)		
		28 fyke net lifts		
	July 14-17, 2008	15 seines	8,289	51
		24 night electrofishing (two-run)		
		21 fyke nets		
Western Lake Erie	September 12-15, 2005	17 seines	4,804	47
		24 night electrofishing (two-run)		
St. Clair Delta	August 21-Sept. 17, 2007	16 seines	15,494	56
		27 night electrofishing (two-run)		
		25 fyke net lifts		
Total		69 seines	42,834	69
		104 electrofishing transects		
		74 fyke nets		

In total, 42,834 fish across 69 different species were caught during the 5-year study. In the Detroit River 63 species were caught with 80% of the catch consisting of shiners, Centrarchids, and Bluntnose minnows *Pimephales notatus* (Table 3). The Detroit River showed greater species diversity than the St. Clair/Walpole Island Delta (56 species) and Western Lake Erie (47 species) sites. The fish-based IBIs in this study revealed that Western Lake Erie was more indicative of a degraded ecosystem than the St. Clair or Detroit Rivers. Compared to the Western Lake Erie, the Detroit River contained proportionally fewer invasive and turbidity tolerant species(43% and <1% of total catch respectively), such as Common carp (*Cyprinus carpio)*, Gizzard shad (*Dorosoma cepedianum)*, and White perch (*Morone americana),* that would be indicative of degraded ecosystems. The fish community in the Detroit River was also composed of a higher proportion of pollution intolerant species such as Trout-perch (*Percopsis omiscomaycus)*, Black-chin shiner (*Notropis heterodon)*, and River redhorse (*Moxostoma carinatum),* compared to Western Lake Erie (13% and 4% of total catch respectively). Overall, the study concluded that the Detroit River and St Clair/Walpole Island Delta wetlands were complex, species rich environments (Francis et al. 2014).

Table 3. Species caught counts in Detroit River wetlands using all gear types by Francis et al. (2014).

Species	**Number Caught**
Silver lamprey (*Ichthyomyzon unicuspis*)	1
Longnose gar (*Lepisosteus osseus*)	86
Bowfin (*Amia calva*)	22
Alewife (*Alosa pseudoharengus*)	1
Gizzard shad (*Dorosoma cepedianum*)	434
Goldfish (*Carassius auratus*)	136
Common carp (*Cyprinus carpio*)	253
Spotfin shiner (*Cyprinella spiloptera*)	121
Striped shiner (*Luxilus chrysocephalus*)	227
Common shiner (*Luxilus cornutus*)	56
Redfin shiner (*Lythrurus umbratilis*)	166
Hornyhead chub (*Nocomis biguttatu*s)	15
River chub (*Nocomis micropogon*)	8
Golden shiner (*Notemigonus crysoleucas*)	258
Blackchin shiner (*Notropis heterodon*)	133
Blacknose shiner (*Notropis heterolepis*)	13
Sand shiner (*Notropis stramineus*)	907
Mimic shiner (*Notropis volucellus*)	2574
Emerald shiner (Notropis atherinoides)	1706
Spottail shiner (*Notropis hudsonius*)	1306
Fathead minnow (*Pimephales promelas*)	1
Bluntnose minnow (Pimephales notatus)	4840
White sucker (*Catostomus commersoni*)	226
Quillback (*Carpiodes cyprinus*)	610
Northern hog sucker (*Hypentelium nigricans*)	51
Bigmouth buffalo (*Ictiobus cyprinellus*)	26
Black buffalo (*Ictiobus niger*)	8
Silver redhorse (*Moxostoma anisurum*)	24
Golden redhorse (*Moxostoma erythrurum*)	39
Shorthead redhorse (*Moxostoma macrolepidotum*)	203
Spotted sucker (*Minytrema melanops*)	42
Greater redhorse (*Moxostoma valenciennesi*)	1
Black bullhead (*Ameiurus melas*)	33
Yellow bullhead (*Ameiurus natalis*)	6
Channel catfish (*Ictalurus punctatus*)	2
Tadpole madtom (*Noturus gyrinus*)	2
Brindled madtom (*Noturus miurus*)	1
Brown bullhead (*Ameiurus nebulosus*)	38
Northern pike (*Esox lucius)*	15
Muskellunge (*Esox masquinongy*)	4
Rainbow trout (*Oncorhynchus mykiss*)	4
Banded killifish (*Fundulus diaphanus*)	49
Brook silverside (*Labidesthes sicculus*)	288
White perch (*Morone americana*)	155
White bass (*Morone chrysops*)	7
Rock bass (*Ambloplites rupestris*)	838

Table 3: continued

Species	**Number Caught**
Hybrid sunfish	15
Green sunfish (*Lepomis cyanellus*)	44
Orangespotted sunfish (*Lepomis humilis*)	3
Pumpkinseed (*Lepomis gibbosus*)	427
Bluegill (*Lepomis macrochirus*)	1181
Northern sunfish (*Lepomis peltastes*)	67
Smallmouth bass (*Micropterus dolomieu*)	1273
Largemouth bass (*Micropterus salmoides*)	2639
White crappie (*Pomoxis annularis*)	1
Black crappie (*Pomoxis nigromaculatus*)	5
Greenside darter (*Etheostoma blennioides*)	2
Yellow perch (*Perca flavescens*)	399
Logperch (*Percina caprodes*)	60
Walleye (*Sander vitreus*)	31
Freshwater drum (*Aplodinotus grunniens*)	79
Round goby (*Neogobius melanostomus*)	299
Tubenose goby (*Proterorhinus semilunaris*)	59

Currie and Victor (2020) assessed the benthification of fish assemblages in the Detroit River. This study will be examined in more detail under sub-criterion #3 but it does provide additional context to the Midwood et al. (2020) concerns with IBI methods described above. Using Department of Fisheries and Oceans and Ontario Ministry of Natural Resources and Forestry fish assessment data from 1989 to 2018, they found no evidence of shifts in the fish community structure towards benthic species, expected in degraded habitats. The study concluded that the fish community assemblages in the Detroit River were healthy when compared to other AOCs such as the Bay of Quinte and St. Clair River that have removed or are in the process of removing the "impaired" status of their fish populations BUI.

Hilling et al. (2021) established an ecological baseline of species and habitat associations in nearshore environments throughout the SCDRS. Over a seven-year study period (2013-2019), five seine tows were targeted annually at ten sites throughout the SCDRS, with 4 sites in the Detroit River. During this study 38,451 fish representing 60 species were collected throughout the SCDRS, with 10,909 of those coming from the Detroit River. Sixteen species were found to be unique to the Detroit River compared to nine in the St. Clair River. The authors of the study concluded that although shoreline habitats were historically degraded, the SCDRS including the Detroit River supported a diverse shoreline fish community.

Synthesis of Findings and Status

The study by Midwood et al. (2020) provides strong evidence that the Detroit River wetland fish communities are at least as healthy as a nearby unimpaired wetland complex (i.e. Walpole Island Delta wetlands) and has higher IBI scores than those observed in other AOCs. Furthermore, the studies by Lapointe et al. (2010), Francis et al. (2014), Currie and Victor (2020), and Hilling et. al. (2021) do not provide any evidence of differences in fish community composition that the IBI could be masking. All studies reviewed found the Detroit River wetland and coastal fish communities to be at least as diverse and abundant as those from neighbouring waterbodies and other AOCs with unimpaired fish populations. These studies also provide evidence that the Detroit River wetlands and coastal areas are healthy and vibrant ecosystems, lacking species related to degraded habitats and provide habitat to uncommon native species. When examined together these studies provide compelling evidence that the fish communities in wetland and coastal areas of the Detroit River are comparable to fish communities in unimpaired coastal wetlands. Thus, these findings support the conclusion that sub-criterion #1 has been met.

2. Sturgeon Populations

Sub-criterion #2: The number of adult Lake Sturgeon is greater than 750.

Lake sturgeon (*Acipenser fulvescens*; hereafter referred to as Sturgeon) are native to the Detroit River and an important indicator of ecosystem health due to their sensitivity to environmental disturbances. Sturgeon mature at a late age (12-15 yrs for males and 18-27 yrs for females) and spawn infrequently (every 1-3 yrs for males and 4-9 yrs for females; Peterson et al. 2007). This slow life-history strategy provides protection for populations against short term environmental disturbances because it promotes complex age structure of spawning populations and minimizes effects of single year spawning failures (Peterson et al. 2007). However, long term human disturbances that continuously inhibit spawning (e.g. dams that prevent access to spawning habitats or dredging that destroys spawning habitat) and overharvest can have negative effects. Furthermore, studies have shown Sturgeon to be sensitive to Polychlorinated Biphenyls (PCBs) which can result in developmental toxicity in embryos and reductions in swimming performance (Tillit et al. 2017).

Over the past two centuries Sturgeon populations in the Detroit River experienced drastic declines. In the early to mid-1800s, Sturgeon were seen as nuisance and often killed upon capture by fishers (Hartman 1973; Regier and Hartman 1973). During the late 1800s and early 1900s, targeted fisheries for Sturgeon increased in response to their popularity as a delicacy. Additionally during this time, channelization to create shipping lanes in the Detroit River destroyed large areas of spawning habitat and the high industrial use of PCBs contaminated Great Lakes food-webs (Bennion and Manny 2011; Tillit et al. 2017). By the early 1900s, Detroit River Sturgeon populations were crashing as a cumulative response to reduced spawning habitat, pollution, and historical overfishing (Figure 2; Chiotti and Boase 2020). By 2010 estimates suggested that the once abundant Sturgeon population had been reduced to about 1% of its historic size (Green et al. 2010).

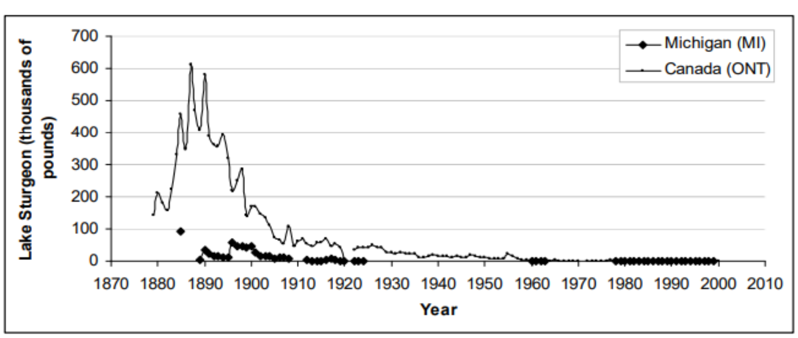

Figure 2. Lake Sturgeon commercial fish catch in Michigan and Ontario waters of Lake Erie between 1879 and 2000 (Chiotti and Boase, 2020).

In response to the declines of Sturgeon during the mid to late 1900s, commercial and recreational fisheries for the species were heavily restricted and work was undertaken to address the habitat and pollution issues. These efforts appeared successful with spawning documented on coal cinders near Zug Island in 2001 (Caswell et al. 2004). In the early 2000s, research suggested that increasing Sturgeon spawning was limited by the amount of suitable spawning habitat rather than water quality issues (Manny and Kennedy 2002). In response, between 2003 and 2018, seven artificial spawning reefs were created (Figure 3). Subsequent monitoring confirmed that all restored spawning sites attracted spawning Sturgeon and other fish including Walleye (*Sander vitreus)* and Lake whitefish (*Coregonus clupeaformis*; Roseman et al. 2011; Prichard et al. 2017; Fischer et al. 2018; Hartig et al. 2018).

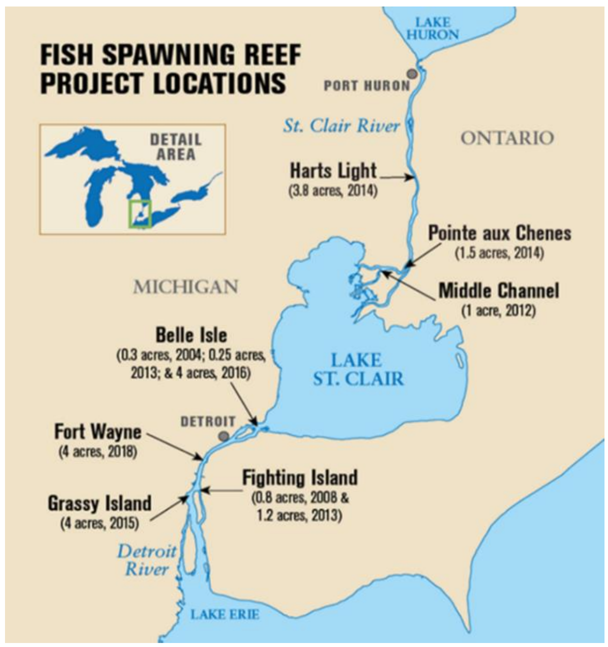

Figure 3. Locations of major artificial spawning reefs in the St. Clair-Detroit River System including the Detroit River. (Michigan Graham Sustainability Institute., n.d.).

Historical Sturgeon declines in the Detroit River were so severe there were concerns that the population might experienced a genetic bottleneck. Genetic bottlenecks can occur when populations decline to levels too low to maintain genetic diversity. The reduction in the number of different, potentially advantageous, genes in a population may impede a population’s resilience to stochastic events (e.g. storms, water levels/temperatures, spills, disease, etc.) and inhibit its ability to adapt to broader environmental changes (e.g. climate change). Welsh et al. (2010) concluded that the Detroit River population needed at least 750 adults for the population to be stable and avoid a genetic bottleneck. It was this evaluation from which the sub-criterion #2 was derived.

Review of Publications

In the review of relevant literature and agency assessments that supported the assessment of sub criterion #2, two related estimates of the Detroit River Sturgeon population size were found:

- Chiotti and Boase. 2020. 7.28 Lake Sturgeon Population. CHECKUP: Assessing Ecosystem Health of the Detroit River and Western Lake Erie. Pg. 253.
- Chiotti et al. (In Review). Lake Sturgeon Population Trends in the St. Clair – Detroit River System, 2001 – 2019

Chiotti and Boase (2020) used standard mark-and-recapture data from 2006 to 2017 to estimate the population size. This evaluation estimated the population to be 4,422 individuals. This assessment concluded that the population appeared to be large and stable and that the seven constructed spawning reefs were adding resilience to the population (Figure 3; Chiotti and Boase 2020).

Chiotti et al. (In Review) updated the previous population estimate using additional mark-and-recapture data. This estimate used the same methods and model as Chiotti and Boase (2020) with additional data from 2007-2019, including an additional 160 tagged fish and 2 additional years of recapture data (Figure 4). With this new data the estimated population size increased to 6,416 individuals in the Detroit River and 33,123 in the broader St. Clair-Detroit River System. Furthermore, a significant annual positive trend was observed in Sturgeon captures (Figure 4), which may indicate continued population recovery.

Sub-criterion #2 specifically refers to adult fish and the population estimate from Chiotti et al. (In Review) did not separate adults and sub-adult life stages. However, their data showed that the majority (94%) of Sturgeon captured over the study period were adult fish (618 adults and 38 sub-adults) and adult captures continued to show a positive trend year over year (Figure 4). Thus, an adult population exceeding 750 individuals is still highly probable for the system.

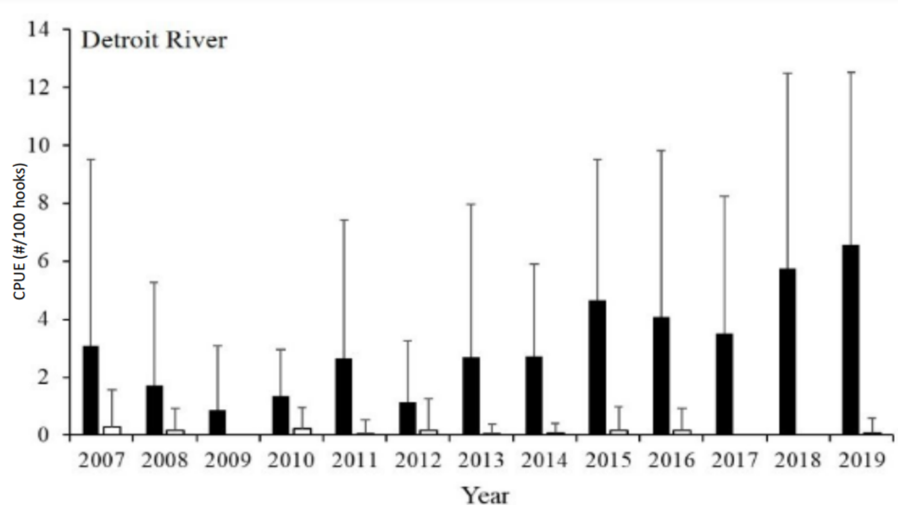

Figure 4. Setline catch rates (#/100 hooks) of Lake Lake Sturgeon in the Detroit River, 2007 – 2019. Black bars indicate adult captures, white bars indicate sub-adults captures (Chiotti et al., In Review).

Synthesis of Findings and Status

Based on the findings reported by the U.S. Fish and Wildlife Service (Choitti et al. In Review), the current estimate of Sturgeon in the Detroit River is 6,416, fish (95% confidence interval 4,065 – 8,767), with the majority of individuals being adults. In fact, researchers have physically handled 618 adult Sturgeon as part of their research and new adult individuals are captured each year. These observations suggest that the population far exceeds the 750-minimum specified in sub-criterion #2 and indicates that the Detroit River is supporting a relatively large and healthy Sturgeon population. Thus, these findings support the conclusion that sub-criterion #2 has been met.

3. Benthification of Fish Species

Sub-criterion #3: There is no evidence of benthification of fish communities in the Detroit River

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Sub-criterion #3 was established to address concerns that fish communities in the Detroit River had undergone benthification. Benthification of the fish community was defined as an overabundance of benthic and benthivorous fish species, which would be an indicator of a degraded ecosystem. Benthification affects the structure and function of ecosystems with potential to alter species composition, food-web energy flow, and the spatial distributions of primary producers and consumers (Mayer et al. 2014; Adapted from Currie and Victor 2020).

The invasion of *Dreissenid* mussels to the Great Lakes introduced changes to nutrient cycling, water quality, and habitat (Vanderploeg et al. 2002). *Dreissenid* mussels caused increased water clarity and sunlight penetration, allowing for better foraging efficiency by benthic fish, and increased benthic primary production (Mayer et al. 2014; Currie and Victor 2020). The subsequent invasion of Round gobies (*Neogobius melanostomus*) furthered benthification by displacing native species and becoming an abundant benthic food source (Vanderploeg et al. 2002).

Hamilton Harbour is an example of an Area of Concern (AOC) with benthified fish communities. It is dominated by non-native and pollution tolerant species such as Bullhead catfish *(Ameiurus sp*.), Round gobies *(Neogobius melanostomus)*, and Goldfish (*Carassius auratus;* Boston et al. 2016; Currie and Victor 2020). With changes in benthic habitat in the Detroit River, a shift in fish communities towards benthic species was suspected. Concerns of benthification were voiced in the MDNR and OMOE (1991), DRCC (1996) and Leney and Haffner (2006) reports.

Review of Publications

In the review of relevant literature and agency assessments that supported for the assessment of sub criterion #3, one purposely designed study was found:

- Currie and Victor. 2020. Assessing long-term changes to benthivorous fish community structure in the Detroit River AOC. DFO Report.

Currie and Victor (2020) explicitly examined fish communities in the Detroit River to look for signs of benthification. Fisheries and Oceans Canada (DFO) and Ontario Ministry of Natural Resources and Forestry (OMNRF) fish assessment data spanning 1989 to 2018 were compiled for the Detroit River (Table 4). The data was standardized to allow comparisons among gear types and sampling efforts. This dataset was used to test for changes in the prevalence of benthivorous fishes over time.

Table 4: Summary of assessment data used by Currie and Victor (2020) to evaluated benthification of the Detroit River fish community .

Data used (general description, report title, journal title)	Agency	Years sampled	Data source
DFO fish database	DFO	2002-2004, 2007, 2011, 2013-2018	Biodiversity Science, Asian carp Program, Fish Habitat Science
Applications of a fish IBI to coastal wetlands in the St. Clair and River Areas of Concern	DFO	2017	Fish Habitat Science
Lake St. Clair Fisheries Assessment Unit Report 1992/RAP fish community monitoring, Detroit River, 1989 and 1990	OMNRF	1989, 1990	Richard Drouin OMNRF
Site Survey of Proposed Restoration Sites in Detroit River	OMNRF	2015	Richard Drouin OMNRF

Fish were grouped according to trophic status, habitat use, and behavior. All benthic species group (‘all benthic species’) contained two subgroups, tolerant/invasive (T/I) and non-T/I benthic species. The T/I group was the key benthification indicator. These species were obligate benthivores that included invasive species, pollution tolerant species (e.g. Bullhead catfish, Gobies, and Goldfish) and species that impact ecosystems (e.g. Common carp *Cyprinus carpio* and its ability to uproot submerged aquatic vegetation). The non-T/I group included benthic and bentho-pelagic species such as Lake whitefish (*Coregonus clupeaformis)*, Burbot (*Lota lota)*, Yellow perch (*Perca flavescens*) and Freshwater drum (*Aplodinotus grunniens*). These species are associated with or consume prey within the benthic food-web but do not necessarily have detrimental ecosystem impacts. Finally, an ‘all fish’ group represented the total fish catch with the ‘all non-benthic’ group representing any species not in the ‘all benthic’ group.

For boat electrofishing (BEF) surveys were assessed pre and post 2010. Total catches increased 46%, benthic species catches increased 18% and non-benthic catches increased 53%. T/I species did not experience a statistically significant change. The catch of benthivorous species decreased from 37% of the total catch pre-2010 to 22% post-2010. In comparison to the other AOCs, the Detroit River had the lowest T/I proportion and the second lowest BEF catch rates (Table 5). Only the low productivity Niagara River had a lower T/I species catch rate than the Detroit River. It should also be noted that fish populations in the Bay of Quinte and St. Clair River AOCs are considered “not impaired”[1].

[1] At the time of writing this report the St. Clair River fish populations component of BUI #3 was in the process of being removed. All criteria had been met.

Table 5. Comparison of Catch rates (CUE, catch / stocking second) for 'tolerant/invasive (T/I) fishes from Department of Fisheries and Ocean Canada boat electrofishing programs across selected Area of Concerns. The catch rate standard error (SE), comparative magnitude to the Detroit River (xDR) and percentage of 'benthic' fish catch rates of total catch rate are also presented. Adapted from Currie and Victor (2020)

Site	Years of Sampling in 2000s	CUE	SE	xDR	% Benthic
Detroit River	1989, 2002, 03, 04, 07, 11, 13-18	0.00491	0.00026	-	33
Niagara River	2015	0.00138	0.00014	0.3	60
St. Clair River	2003, 04, 12	0.00833	0.00210	1.8	44
Bay of Quinte	2001, 04, 07, 09, 11, 15, 17	0.00886	0.00047	1.8	57
Hamilton Harbor	2002, 04, 06, 08, 10, 12, 13, 16, 18, 19	0.16950	0.00059	3.5	45

Benthic trawl data from 2009-2011 was compared to 2012-2018. The 2012-2018 results showed 56% of fish were non-benthic species, and only 23% were T/I species. The most notable observation was the lack of change in benthic species catch, and a lack of statistically significant change in T/I species.

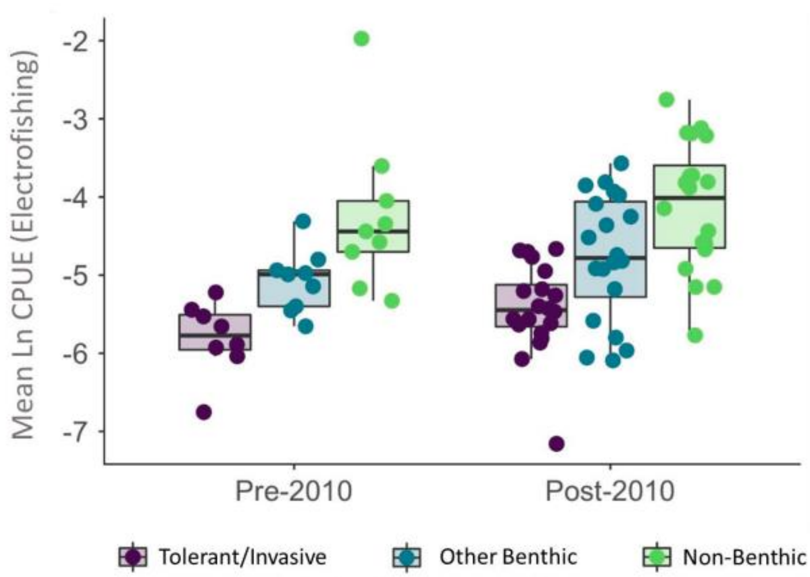

Figure 5. Ln transformed mean annual boat electrofishing catch rates (CPUE, Ln [catch / stocking second]) box and whisker plots pre vs. post 2010 for 'tolerant/invasive (T/I) fishes, other benthic fishes, and non-benthic fishes. Adapted from Currie and Victor (2020).

Across all sampling years and types, there were more pelagic than benthic fish in Detroit River catches. Benthic fish varied from 23% to 49% with an average 33%, which was a lower than proportions observed in four other reference AOCs (Table 5). Notwithstanding these findings, the authors emphasized that benthivores are vital for food-webs, linking benthic productivity to piscivores and that many species in the "all benthic" group are ecologically, recreationally, and commercially valuable such as Yellow perch, Walleye (*Sander vitreus)*, and Northern madtom (*Noturus stigmosus*).

Synthesis of Findings and Status

Based on the findings reported by Currie and Victor (2020), there is no evidence of benthification in the Detroit River. Important for evaluating sub-criterion #3 was the absence of statistically significant change in the prevalence of T/I species between the study periods (Figure 5) and T/I species proportion and catch rates compared to other reference AOCs (Table 5). The study provides strong evidence that the Detroit River provides habitat to a diverse and complex fish community, showing no evidence of benthification, but instead continued signs of recovery. Thus, these findings support the conclusion that sub-criterion #3 has been met.

4. Walleye and Smallmouth bass Creel and CUE

Sub-criterion #4: Creel and Catch per Unit Effort (CUE) surveys of Walleye and Bass indicate angler catch and efforts are at or above the long-term average.

Walleye (*Sander vitreus*) and Smallmouth bass (*Micropterus dolomieu*) were selected as indicator species for sub-criterion #4 because, as top predators in the Detroit River food web, they act as good indicators of aquatic ecosystem health. While Walleye have comprehensive historical datasets, a drawback as an indicator species is the presences of migratory and resident fish in the river. A large portion of the population is believed to be migratory and use the river for spawning before returning to Lake Erie or Lake St. Clair for the remainder of the year. However, a small, but unknown, portion of the population likely remain resident in the river year-round. With the large migratory component of Detroit River Walleye, Smallmouth bass were selected as a secondary indicator species for this sub-criterion. Smallmouth bass were believed to be less migratory and have sufficient historical data available for a status assessment. Other candidate indicator species were also considered, including Largemouth bass (*Micropterus salmoides*) and White bass (*Morone chrysops*), but lacked historical data for an assessment.

Catch per Unit Effort (CUE) provides a proxy measurement for absolute abundance of fish because there is a direct relationship among catch, catchability, effort and abundance, (Equation 1, Hubert and Fabrizio 2007). By rearranging the formula (Equation 2) and solving for abundance (N; Equation 3), we see that abundance is related to CUE and catchability (q). While catchability of recreational fisheries is unknown, we assume it to be relatively constant within angler surveys. A constant catchability means that the CUE estimates among years are comparable and changes in CUE represent relevant changes in population abundance.

Equation 1: Catch = catchability(q) x effort x abundance(N)

Equation 2: *Catch/effort (CUE)= qN*

Equation 3: *N = CUE/q*

Where:

Catch Per Unit Effort (CUE)= A ratio of catch to one unit of effort.

Catchability (q)= efficiency coefficient that describes the relationship between the number of fish caught in the gear and the absolute abundance of the population.

Population size/Abundance (N)= absolute abundance of fish in the stock.

Historical CUE data for Walleye and Smallmouth bass in the Detroit River existed through three primary surveys: Ontario Ministry of Natural Resources and Forestry (OMNRF) creel surveys, Michigan Department of Natural Resources (MDNR) creel surveys and, the Ontario Federation of Anglers and Hunters/ OMNRF angler diary program. These surveys reported time-series data on angler catch rates of targeted and non-targeted species. The OMNRF (or preceding ministries) creel surveys were conducted in 1956-1958, 1975-1980, 1992, 2002, 2009, and 2015 (Sztramko 1979; Sztramko 1980; Witzel 1981; Sztramko and Paine 1984; Soper and Locke 2010; MDNR personal communication 2015). Prior to 1980, these creel surveys occurred in the lower portion of the river (northern tip of Fighting Island to Lake Erie). Since 1980, the entire river has been surveyed. All CUE values from OMNRF creel surveys were reported in fish per rod-hr except for 2015, which used fish per angler hr. However, in Canadian waters of the Detroit River rod-hrs are equivalent to angler-hours because anglers are limited to one rod (MNRF 2023). The MDNR creel surveys were completed in 2002, 2004 and 2015 with CUE reported in fish per angler hr (Castle 2018). The St. Clair System Sport Fishery Diary Program (i.e. angler diary program) tracked annual trends in catch rates (fish/rod hr) in Lake St. Clair, Detroit River and St. Clair River between 1995-2018 (OMNRF 2019).

There are several important considerations when using these data sources. First, these data sources relied heavily on the recall abilities of anglers to accurately report daily catches and fishing activity. This made them susceptible to recall error which could be further compounded in the extrapolated catch and activity estimates. It was assumed that reporting error remained relatively constant within each survey. Furthermore, the angler diary program tended to have higher catch rates (i.e. CUE) than creel surveys. This was attributed to angler diary participants being more avid anglers compared to the general/average anglers sampled by the creels surveys. For these reasons, the data from these assessments were examined for time-series trends only.

Secondly, the creel surveys vary in the type (e.g. roving, aerial, access point), timeframe (e.g. June to August vs March to October) and spatial extents (lower portion of the river, vs whole river). These differences likely led to increased variability of catch and activity estimates. Unfortunately, the raw data from many of these surveys no longer exists which prevents standardization of estimates. Estimates are presented in this report with these caveats.

Finally, all data was collected following the degradation of the ecosystem, with no pre-degradation reference data. The creel surveys began in the 1950s following the significant environmental degradation during the early 1900s. The angler diary programs began in 1995 following the designation of the Detroit River Area of Concern in the 1980s. This limited our ability to draw conclusion around the pre and post degraded state to only examining trends over a relatively short time frame.

Given the above considerations the Walleye and Smallmouth bass CUE data are presented as a line-of-evidence and not a rigorous scientifically robust assessment of population status. Also, it is important to note that fish population abundances vary naturally over time. A single or even several points below the long-term mean do not necessarily indicate impairment or even long-term population abundance declines. For the purpose of this assessment, significant and consistent declines in CUE signalling a long-term population decline was used as a sign of impairment. Mean CUE was used as the long-term average in this analysis.

Review and Analysis of Creel and CUE data

Walleye

Walleye creel catch rates (i.e. CUE) in the 1950 - 80s were at or below the long-term mean with catch rates in recent years (2002, 2009, and 2015) well above the mean (Figure 6). Regression analysis was not performed due to the sporadic nature of creel surveys. The MDNR creel surveys also observed higher catch rates in recent years with a 25% higher CUE in 2015 (0.227 fish/angler hr) compared to 2002-2004 (0.171 fish/angler) (Castle 2018). Annual Walleye catch rates in the angler diary program (1995-2018) fluctuate around the time series mean (Figure 6). Regression analysis of the angler diary data showed a slightly positive and statistically significant slope ($y=0.016x-31.6$, $P<0.05$) indicating a slight increase in catch rates over time. High angler diary catch rates observed in 2006, 2017 and 2018 (Figure 6) were consistent with peaks in harvest rates observed in the broader Lake Erie Walleye sport fishery (Walleye Task Group 2022, Figure 7). Overall, the angler catch rate data suggested an increase in Walleye abundance in recent years, reflective of a similar patterns observed in broader Lake Erie Walleye population (Walleye Task Group 2022, Figure 7).

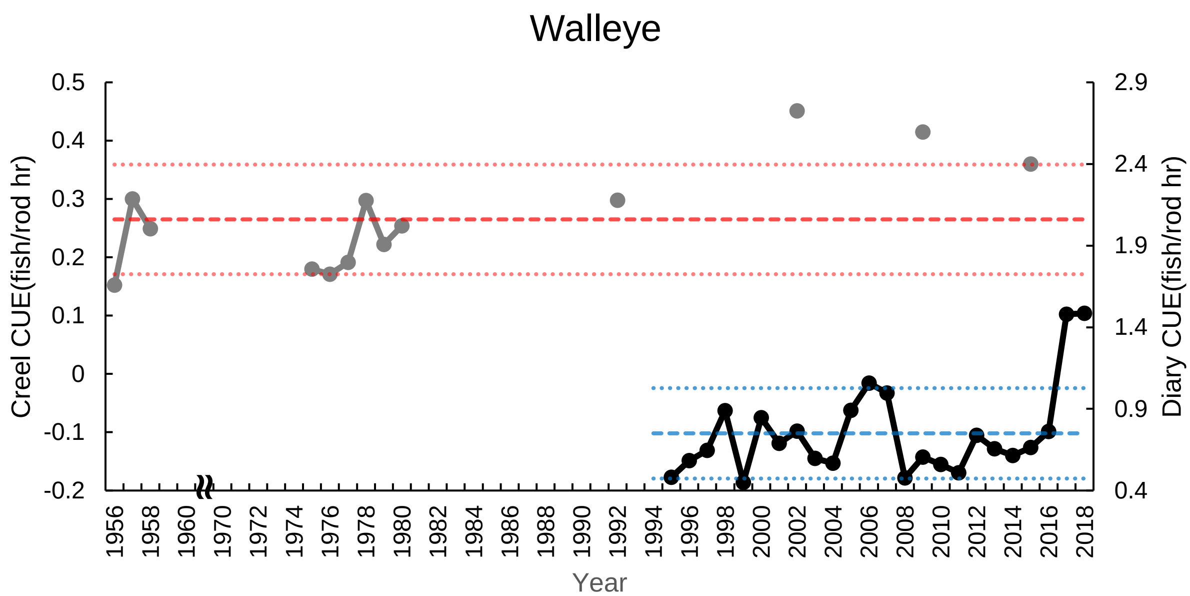

Figure 6. Walleye catch rates (CUE, fish/rod hr) in the Detroit River from Ontario Ministry of Natural Resources and Forestry (OMNRF) creel surveys (1956-2015) and Ontario Federation of Anglers and hunters/ OMNRF angler diary program (1995-2018) (Soper and Locke 2010). Dashed line represents the long term mean and the dotted lines represent the 95% confidence interval (CI). Grey line with red mean and CI intervals represents creel surveys, Black line with blue mean and CI intervals represents angler diary program.

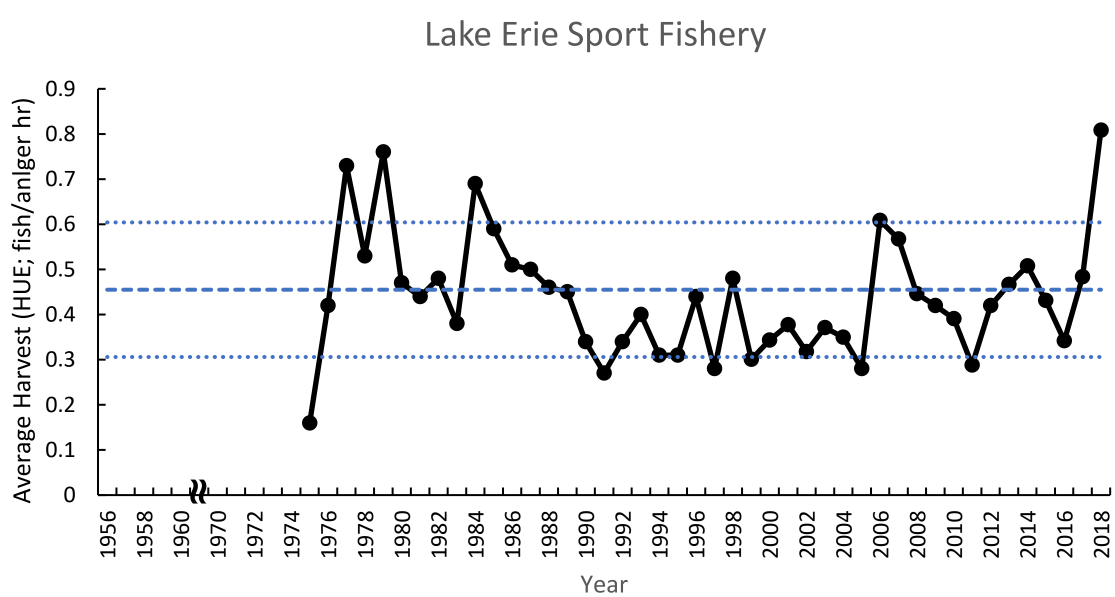

Figure 7. Lake wide harvest per unit effort (HUE, fish/ angler hr) for Lake Erie sport Walleye fishery from 1975-2021. Blue dashed line represents the long term mean and the dotted lines represent the 95% confidence interval(CI). Adapted from Walleye Task Group (2022).

Smallmouth bass

Smallmouth bass creel catch rate in the 1950 - 80s were at or below the long-term mean with catch rates after 1994 well above the mean (Figure 8). Soper and Locke (2010) found that the June to August catch rate were four times higher in 2009 (0.207 fish/rod-hr) and) than the 1975-2002 average (0.050 fish/rod-hr) and almost 3 times more fish were caught (11,278 fish and 3,985 fish, respectively). The MDNR creel surveys also observed a 100% increase in catch rates in 2009 (0.064 fish/angler hr) compared to 2002-2004 (0.0 fish/angler) (Castle 2018). Smallmouth bass was not identified as a target species for the 2015 survey so catch rates were not calculated for the combined OMNRF and MDNR creel survey that year (MDNR personal communication 2015). Annual Smallmouth bass catch rates in the angler diary program (1995- 2018) fluctuated around the time series mean (Figure 8). Regression analysis resulted in no statistically significant slope (y=0.0082x -16.14, p=0.232), indicating relative stable long-term catch rates. Overall, the angler catch rate data suggested that Smallmouth bass abundance appeared to be relatively stable fluctuating around a long term average with some evidence of increased abundances in recent years.

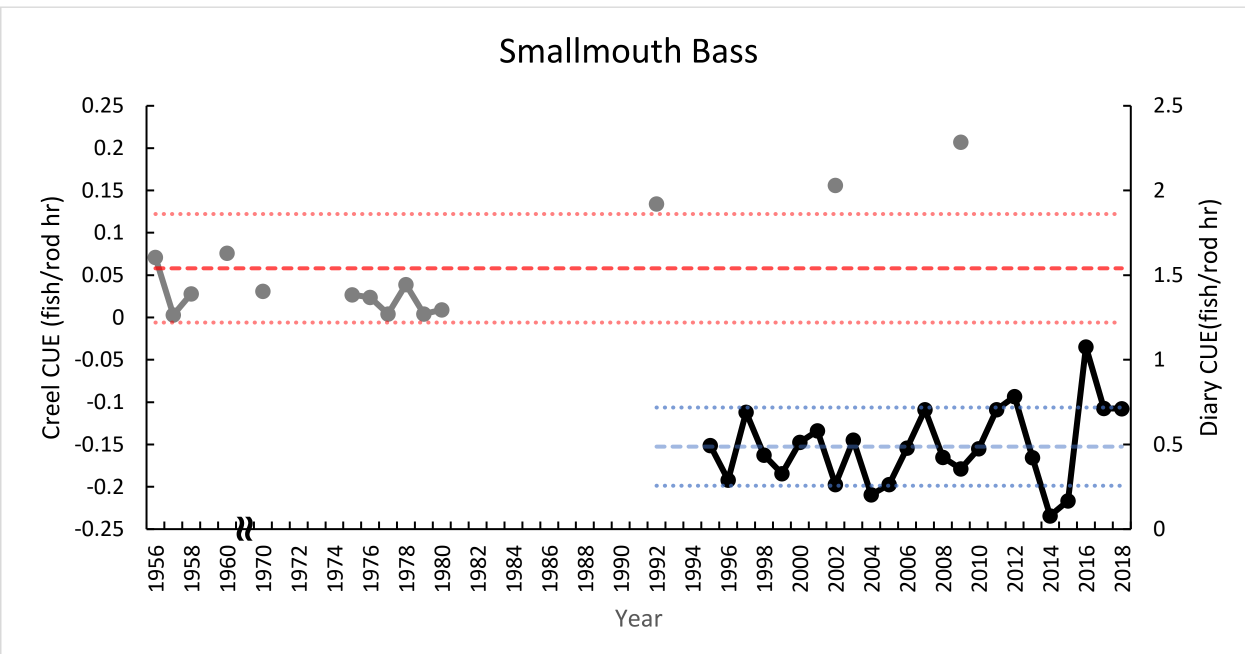

Figure 8. Smallmouth Bass catch rates (CUE, fish/rod hr) in the Detroit River from Ontario Ministry of Natural Resources and Forestry (OMNRF) creel surveys (1956-2015) and Ontario Federation of Anglers and hunters/ OMNRF angler diary program (1995-2018) (Soper and Locke 2010). Dashed line represents the long term mean and the dotted lines represent the 95% confidence interval (CI). Grey line with red mean and CI intervals represents creel surveys, Black line with blue mean and CI intervals represents angler diary program.

Synthesis of Findings and Status

Creel and angler diary data show slight increases in the catch rates of Walleye and relatively stable catch rates of Smallmouth bass in the Detroit River. In the case of Walleye, catch rates fluctuations in the river reflect similar patterns observed in broader Lake Erie Walleye population[2]. Because of the strong relationship between catch rates and abundances (equation 1-3), these results provide support that Detroit River Walleye and Smallmouth bass populations are relatively stable if not increasing. These findings support the conclusion that sub-criterion #4 has been met.

[2] The Great Lakes Water Quality Agreement, State of the Lakes -2022 report assessed Lake Erie Walleye as “good and improving” (GLWQA 2022).

5. Fish Spawning Activity

Sub-criterion #5: There is evidence of ongoing and/or increased spawning activity for fishes since 2006.

Spawning is an incredibly sensitive life history stage that can be used as a key indicator of population and ecosystem health. Impairment to spawning can arise from habitat alterations that prevent access to suitable spawning habitats; pollutants and poor water quality that can affect spawning behaviours and fecundity; and/or overfishing that can reduce population size.

Concerns surrounding fish spawning activity in the Detroit River originate from the history of habitat degradation, water quality/point source pollution issues, and overfishing. The river once supported large spawning populations of Lake whitefish (*Coregonus clupeaformis)* and Lake sturgeon (*Acipenser fulvescens),* hereafter referred to as Whitefish and Sturgeon respectively (Roseman et al. 2012; Chiotti and Boase 2020). However, during the first half of the 1900s, destruction of spawning habitat for shipping channels and the pressure of commercial fisheries caused population of both species to crash (Roseman et al. 2007; Chiotti and Boase 2020). In the subsequent century, there was little to no evidence of recovery for either species. It was not until the completion of artificial spawning reef in the early 2000s that Whitefish and Sturgeon populations started to showed signs of improvement (Roseman et al. 2007; Chiotti and Boase 2020). The concern of “impaired” spawning activities extends to all species in the Detroit River and has been a key priority for Detroit River Canadian Cleanup (DRCC) since its formation in the 1980s.

The evaluation of spawning activities has changed over time. The 1991 Stage 1 report, authors concluded that evidence of spawning by 32 species and general habitat use of over 60 species was sufficient to describe fish populations as “not impaired” (MDNR and OMOE, 1991). The status was changed to “impaired” in the 2006 Status of the Beneficial Use Impairments (BUIs) report and remined impaired in the 2010 Stage 2 report, despite signs of spawning Whitefish, Sturgeon, and 34 other fish species (Leney and Hafner 2006; Green et al. 2010).

The present assessment used three lines of evidence. First, presence of spawn ready adults (i.e. males expressing milt, females with eggs) near known or suspected spawning locations. Second, presence of eggs and larval fish in the river, which provided evidence of successful spawning. This line of evidence provides an indication that the river provides sufficient food, habitat quality, habitat quantity, and water quality to support spawning adults and the early life stages (Sprague 1971; Secor and Houde 1995; Scheimer et al. 2001; Grenouillet et al. 2002; Francis et al. 2014). Finally, population dynamics and structure evidence through genetic analysis. The degree to which data was available to assess each line of evidence varied, depending on species.

Review of Publications

The review of relevant literature and agency assessments to support assessment of sub-criterion #5, focused on 14 papers. The evidence is summarized through the three lines of evidence a) spawning adults, b) presence of eggs or larvae, and c) genetic stock structure.

a) Spawning adults

Recent scientific literature providing evidence of adult spawning activity include:

- Roseman et al. 2011. Lake sturgeon response to a spawning reef constructed in the Detroit River. Journal of Applied Ichthyology.
- Roseman et al. 2012. Life history characteristics of a recovering Lake whitefish Coregonus clupeaformis stock in the Detroit River, North America. Advances in Limnology.
- Sullivan and Stepien. 2014. Genetic diversity and divergence of yellow perch spawning populations across the Huron–Erie Corridor, from Lake Huron through western Lake Erie. Journal of Great Lakes Research.
- Haponski and Stepien. 2014. Genetic connectivity and diversity of walleye (Sander vitreus) spawning groups in the Huron–Erie Corridor. Journal of Great Lakes Research.
- Manny et al. 2014. Occurrence, habitat, and movements of the endangered northern madtom (Noturus stigmosus) in the Detroit River, 2003–2011. Journal of Great Lakes Research.
- Hessenauer et al. 2021. Seasonal movements of muskellunge in the St. Clair–Detroit River System: Implications for multi-jurisdictional fisheries management. Journal of Great Lakes Research.

Roseman et al. (2011) found adult Sturgeon in spawning condition near or on the newly constructed Fighting Island spawning reef. Roseman et al. (2012) captured fifteen spawning Whitefish ranging in age from 4 to 18 in the Detroit River between 2005-2007. Sullivan and Stepien (2014), and Haponski and Stepien (2014) conducted genetic surveys of Yellow perch (*Perca flavescens*) and Walleye (*Sander vitreus*) spawning populations in the St. Clair-Detroit River System (SCDRS), respectively. These studies will be further discussed in the genetic stock structure section but both sampled “spawning-condition” fish over known spawning grounds. Manny et al. (2014) found three spawn ready males during a survey of Northern madtom (*Noturus stigmosus*) between 2003 and 2011. Finally, Hessenauer et al. 2021 caught and acoustically tagged Muskellunge *(Esox masquinongy*) at known spawning locations in the river. At the time of tagging these fish were in spawning condition and subsequently displayed annual migration back to these locations during spawning times (April-June). Combined, these studies provide evidence of spawn ready adult Sturgeon, Whitefish, Walleye, Yellow perch, Northern madtom and Muskellunge using the Detroit River.

b) Eggs and larval

Recent examples of egg and/or larval surveys in the scientific literature include:

- Roseman et al. 2007. Evidence of lake whitefish spawning in the Detroit River: implications for habitat and population recovery. *Journal of Great Lakes Research*.
- Roseman et al. 2012. Life history characteristics of a recovering Lake whitefish Coregonus clupeaformis stock in the Detroit River, North America. Advances in Limnology.
- Fischer et al. 2018. Lake Sturgeon, Lake Whitefish, and Walleye egg deposition patterns with response to fish spawning substrate restoration in the St. Clair–Detroit River system. *Transactions of the American Fisheries Society*.
- Prichard et al. 2017. Egg deposition by lithophilic-spawning fishes in the Detroit and Saint Clair Rivers, 2005–14.
- McDonald et al. 2014. Use of main channel and two backwater habitats by larval fishes in the Detroit River. *Journal of Great Lakes Research*.
- Tucker et al. 2018. Long-term assessment of ichthyoplankton in a large North American river system reveals changes in fish community dynamics. *Canadian Journal of Fisheries and Aquatic Sciences*.
- Pritt et al. 2015. Using larval fish community structure to guide long-term monitoring of fish spawning activity. *North American Journal of Fisheries Management*.

Roseman et al. (2007) evaluated the recovery of Whitefish in the Detroit River. Using a diaphragm pump this study sampled eggs during Whitefish spawning period (November to December) in 2005. At three study sites, 179 eggs were collected and confirmed through larval identification in the lab. Larval Whitefish were also collected in ichthyoplankton (i.e. larval fish and egg) sampling between March and April 2006. Densities ranged from 1 to 48.8 fish/1000m^3 with peak densities occurring in early April. Roseman et al. (2012) follow up study captured eggs in 2006 and 2007 confirming the annual Whitefish spawning activity in the river.

Fischer et al. (2018) examined the effectiveness of artificial spawning reefs in the SCDRS for Sturgeon, Whitefish, and Walleye between 2005 and 2016. This study deployed egg matts each spring and fall at 75 sites. The study collected 127,694 Walleye eggs, with most being collected in the Detroit River, 5,575 Whitefish eggs from the Detroit River sites, and 2,859 Sturgeon eggs across the SCDRS. The large numbers of eggs indicated spawning occurred throughout the SCDRS with greater activity observed in the Detroit River compared to the St. Clair River. The study also confirmed the artificial spawning reefs successfully enhanced Sturgeon spawning.

Prichard et al. (2017) sampled a variety of lithophilic fish at historic and artificial reef spawning sites in the Detroit River between 2005 and 2014. Eggs mats were deployed from mid-March to June and October to mid-December in each year. Results found Walleye (0.33–5902 eggs/mat), Whitefish (0–110 eggs/mat), Sturgeon (0–117 eggs/mat), Suckers (*Catostomidae Sp*.; 0–61 eggs/mat), and Trout-perch (*Percopsis omiscomaycus;* 0–14 eggs/mat) eggs at the Detroit River sites.

McDonald et al. (2014) used light traps, bongo samplers, and ichthyoplankton nets to sample backwater and main channel habitats throughout the Detroit River in 2007. This study found eggs and larvae of at least 33 species from 13 families (Table A1).

Tucker et al. (2018) compared ichthyoplankton in the Detroit River between 1977-1978 and 2006-2015. The sampling in the 1970s collected ichthyoplankton weekly between ice-out (March) and August. The sampling used three, three-minute tows of a conical ichthyoplankton net in the upper 1m of the water column at each site. In the 2000s, sampling occurred bi-weekly between April and September using paired bongo samplers towed in the upper 2m of the water column. Significant spawning activity was observed in both time periods and larval species richness increased by 14 species in the 2000s (Table A1). Furthermore, decreases in the densities of non-native Alewife, (*Alosa pseudoharengus)* and, Rainbow smelt (*Osmerus mordax*) were noted. DeBruyne et al. (2019) used the Tucker et al. (2018) data to estimates of Whitefish larvae densities in the Detroit River. Peak larval Whitefish densities were 10-25/1000m^3 in the upper Detroit River and 50-75/1000m^3 in the lower Detroit River.

Valuable evidence of spawning in the Detroit River was also provided in a study completed to optimize sampling methods (Pritt et al. 2015). This study used paired bongo nets with 500 micrometer mesh in the upper 2m of the water column. Pritt et al. (2015) observed stable and ongoing larval genus richness of 15-25 species in the Detroit River between 2006 and 2013. This demonstrated the persistent presence of many spawning fish species in the river (Figure 9).

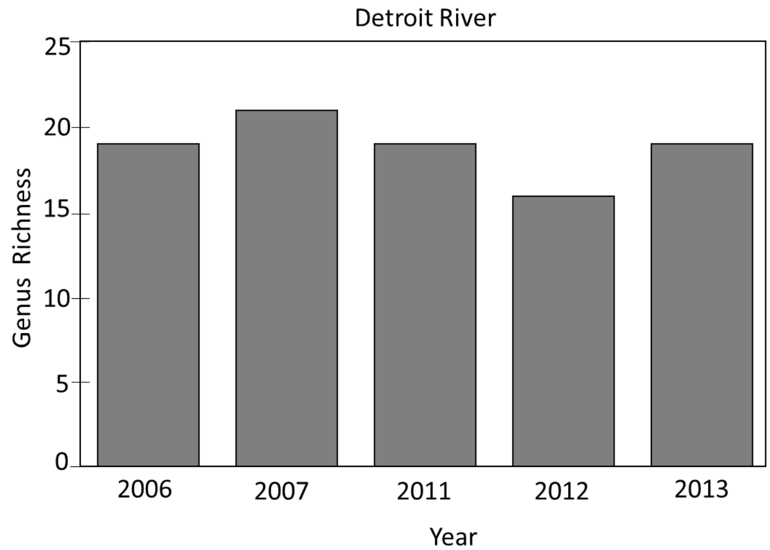

Figure 9. Observed Larval fish genus richness in the Detroit River 2006-2013. Adapted from Pritt et al. (2015).

c) Genetic stock structure:

Recent evidence from the scientific literature of genetic diversity and stock structure within Detroit River fish populations includes:

- Hunter et al. 2020. Genetic family reconstruction characterizes Lake Sturgeon use of newly constructed spawning habitat and larval dispersal. Transactions of the American Fisheries Society.
- Welsh et al. 2008. Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. North American Journal of Fisheries Management.
- Sullivan and Stepien 2014. Genetic diversity and divergence of yellow perch spawning populations across the Huron–Erie Corridor, from Lake Huron through western Lake Erie. Journal of Great Lakes Research.
- Haponski and Stepien. 2014. Genetic connectivity and diversity of walleye (Sander vitreus) spawning groups in the Huron–Erie Corridor. Journal of Great Lakes Research.

Hunter et al. (2020) used egg matts and larval D-frame nets to capture Sturgeon eggs and larvae. St. Clair River sampling took place in 2015 and 2016 and Detroit River sampling took place in 2015. This study estimated the number of spawners contributing to sampled offspring (N_s), and the effective number of breeders (N_b) at SCDRS spawning sites following artificial spawning reef construction. Results found evidence that Sturgeon spawned at more than one site within a spawning season. Across all reefs, estimates of N_s were 151 in 2015 and 208 in 2016, N_b were similar with 158 in 2015 and 198 in 2016. Genetic analysis of recruited offspring showed that >50 adult Sturgeon contributed to juvenile production across all sites each year. The study concluded that the complex spawning dynamics of Sturgeon in the Detroit River will minimize risk of spawning failures and promote long term resilience on the population.

The three remaining genetic structure studies all examined allelic heterozygosity. Heterozygosity is a measurement of genetic diversity, measured as the fraction of individuals that are heterozygous at a given allele (University of Wyoming n.d). Two types of inferences can be drawn from this type of analysis: 1) the presence of high heterozygosity (e.g. close to 1) provides evidence that the spawning habitat supports a self-sustaining population with low risk of inbreeding depression; 2) the presence of several spawning groups (i.e., genetically divergent) suggests that the system supports multiple spawning sub-populations. High or low heterozygosity is a relative measurement made through comparisons among populations. For this assessment, heterozygosity scores drastically lower than other locations in the Great Lakes or surrounding region would provide evidence of impairment.

Welsh et al. (2008) conducted genetic analysis on Great Lake Sturgeon populations. Sturgeon fin clips were analysed at 13 microsatellite loci. Results did not give specific heterozygosity score for the Detroit River population but concluded the heterozygosity scores averaged 0.56 and were consistent between the 27 Great Lake spawning groups. This heterozygosity score was consistent with those observed in other freshwater fish species. Researchers found that most Great Lakes Sturgeon spawning groups were genetically distinct, however, there was little differentiation between Detroit River and St. Clair River Sturgeon, indicating that these are not likely reproductively distinct groups. These findings were further verified through telemetry and sturgeon movement work by Kessel et al. (2018).

Haponski and Stepien (2014) examined the connectivity, diversity, and divergence patterns of Walleye in the SCDRS between 1998 and 2010. DNA extracted from 311 fish from seven known spawning sites was examined at nine microsatellite loci. Genetic diversity across spawning sites was typical of Walleye spawning groups. The mean heterozygosity across sites was 0.722 ± 0.009, which was slightly greater than that observed across Lake Erie (0.704 ± 0.011), the Great Lakes (0.711±0.011) and North America (0.684±0.02; Strange and Stepien, 2007; Stepien et al. 2009; 2010). The heterozygosity observed in Detroit River Walleye population provided evidence that the river was composed of healthy and abundant Walleye spawning aggregations. Further analysis indicated high connectivity between groups of Walleye spawning through the SCDRS. The authors conclude that the genetically distinct Walleye spawning aggregations in the Detroit River and high genetic diversity across the SCDRS was inconsistent with populations impaired by habitat loss, fragmentation, and degradation.

Sullivan and Stepien (2014) conducted a similar study on Yellow perch from 2003-2011. In the study, 248 Yellow perch were captured at seven spawning sites and DNA was examined at 15 microsatellite loci. Results showed lower levels of heterozygosity compared to the Walleye study (Haponski and Stepien, 2014) which likely reflected differences in movement patterns between the species. The observed heterozygosity for Yellow perch across sites was 0.637±0.020, which was slightly higher than Lake Erie (0.533±0.010), the Great Lakes (0.551±0.013) and North America (0.533±0.016; Sepulveda-Villet and Stepien 2011; 2012). The authors concluded that the genetically distinct spawning aggregations and high genetic diversity observed in the SCDRS was inconsistent with the belief that Yellow perch population were impaired by habitat loss, fragmentation, and degradation.

Synthesis of Findings and Status

Overall, there is strong evidence of spawning activities in the Detroit River, with some indications of increasing spawning activity over time (e.g. Tucker et al. 2018; Pritt et al. 2015). However, the lack of long-term longitudinal studies, make proper quantitative evaluation of the magnitude of spawning activity pre and post 2006 difficult. Regardless, the evidence of adult spawning and the presences of eggs and larval fish demonstrate that the river supports spawning populations of at least 42 species (Table A1). Additionally, genetic evidence demonstrates diverse populations and sub-population structure within the river for several species. Further, there was no evidence that current genetic diversity or population viability has been affected by previous populations depressions. While the availability of data for each line of evidence is inconsistent across species, there are no signs of impairment to spawning for any of the species that were examined in Detroit River. These findings support the conclusion that sub-criterion #5 has been met.

6. Additional Documents

Through the review of peer-reviewed literature and agency assessments to support the assessment of fish population, a couple studies provided information on fish populations but did not directly contribute to the 5 sub-criteria. These included:

- Kindree and Mandrak. 2020. Fish Assemblage Survey of the Detroit and St. Clair rivers: 2007-2014. DFO report.
- Hunt et al. 2023. 2020 recreational fishing survey in Ontario: results for select fishing destinations Ontario Ministry of Natural Resources and Forestry; Science and Research Branch; Peterborough, ON. *Science and Research Technical Report.*

Kindree and Mandrak (2020) examined changes to fish assemblages in the Detroit River and the effects of different gear types on Index of Biotic Integrity (IBI) scores. Boat Electrofishing (BEF) and benthic trawls were used to collect fish across six sites in 2007 (May, July, and September), 2011 (July, August, September, and October), and 2013 (July, August, October, and November) to compare to Ontario Ministry of Natural Resources and Forestry (OMNRF) surveys from 1990, 2003 and 2004 at the same sites. IBIs were calculated using three different methods: Minns (1994), Hamilton (1987) and Edwards (2006). A total of 23,532 individuals were captured across 60 species among all three sampling years. IBI scores did not differ from each other between 2007, 2011, and 2013 using the Hamilton and Edwards ($p=0.547$), or Minns ($p=0.0501$) methods (Figure 9). The IBI scores varied based on sample timing and IBI method used, however all results fell between the categories of “very poor” to “fair”, potentially indicating some level on impairment in the Detroit River fish populations. However, the IBI scores did not changed significantly between the 1990s and their sampling in 2007-2014, indicating some level of ecosystem stability.

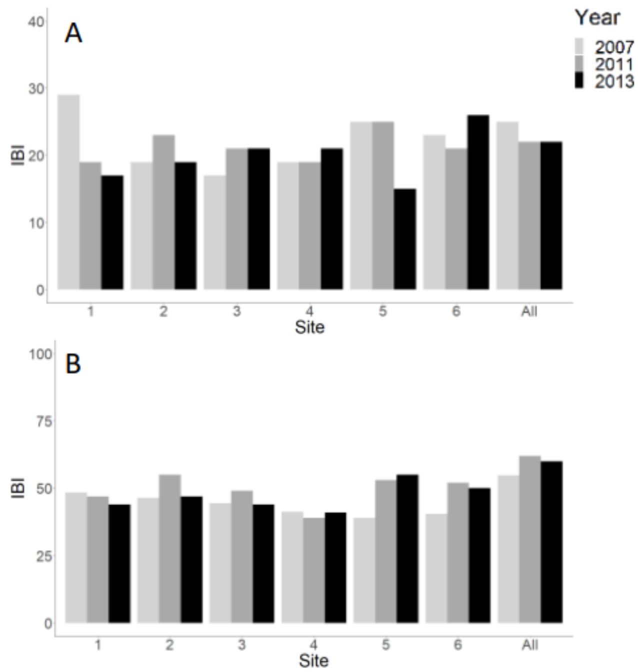

Figure 10. Mean Hamilton and Edwards (A) and Minns (B) Index of Biological Integrity (IBI) scores for 2007, 2011, and 2013 from Detroit River sites sampled for in the Kindree and Mandrak (2020) study.

Low IBI scores were attributed to large numbers of generalist and invasive species with low proportions of specialist species compared to reference conditions in healthy ecosystems. These results are in direct contrast to other studies from the Detroit River which found high biodiversity, high presence of rare native species and higher proportion of pollution/disturbance intolerant species (Lapoint et al. 2010; Francis et al. 2014; Currie and Victor 2020; Midwood et al. 2021; Hilling et al. 2021).

Part of the disparity of results in the Kindree and Mandrak (2020) paper may be explained by the fishing method's ability to effectively sample the key fish community component needed for the IBIs. Since the time of that study, work completed by OMNRF (2020) has shown that BEF and trawl are not particularly effective at capturing some classes of fish (e.g. pelagic Walleye; *Sander vitreus*, *esocids, salmonids*, and benthic Lake sturgeon; *Acipenser fulvescens*) in the deep and high flow environments of connecting channels including Detroit River. Choice of IBI metrics needs to account for both sensitivity to environmental change in question and the ability for them to be effectively sampled. The IBIs used by Kindree and Mandrak (2020) placed high value on species that are either hard to capture (e.g. Walleye, Lake Sturgeon, and salmonids) or make ephemeral use (*coregonids*) of the river outside the sampling timeframe (e.g. Whitefish; *Coregonus clupeaformis*, spawn in mid-Nov to Dec, sampling ended by late

Oct/early Nov, [Roseman et al. 2012; OMNRF unpublish data]). Regardless, the low IBI scores found in this study are outweighed by the many other lines of evidence in this assessment report.

The other additional report was OMNRF's 2020 recreational fishing survey in Ontario (Hunt et al. 2022). These reports were historically completed every 5 years in coordination with the Department of Fisheries and Oceans as part of the Canada-wide recreational fishing surveys. For the 2020 Ontario-focused survey, a finer spatial examination was completed. This provided the first Detroit River summaries and an ability to compare the river to other locations across the Great Lakes. The fishing activity and total number of fish caught in the Detroit River exceeded the St. Clair and Niagara Rivers (Table 6). In fact, the total catches in the Detroit River were comparable to Lake Huron, despite fishing activity being more than double in the lake compared to the river. Walleye catches in the Detroit River are greater than or comparable to those seen in the upper and lower Niagara River, Lake Huron, St. Clair River, and the Bay of Quinte. Yellow perch (*Perca flavescens*) catches were comparable to the St. Clair River, and Lake Huron. This survey also demonstrated notable Smallmouth bass (*Micropterus dolomieu*), Largemouth bass (*Micropterus salmonids*), Black crappie (*Pomoxis nigromaculatus*), Muskellunge (*Esox masquinongy*), and Sunfish (*Centrarchidae sp.*) fisheries in the Detroit River. This report offers unique insight into the health and productivity of the Detroit River compared to other significant locations across the Great Lakes. It provides evidence that the fish populations are indeed providing beneficial uses in the Detroit River through recreational fishing opportunities that are comparable to locations across the province.

Table 6. Selected fishing effort and catch by species estimates from the 2020 recreational fishing survey in Ontario (Adapted from Hunt et al. 2023).

Waterbody	Total days fished (000s)	Catch (000s of fish)								
		Total	Walleye	Yellow perch	Northern pike	Smallmouth bass	Largemouth bass	Black crappie	Muskellunge	Sunfish
Detroit River	**100**	**437**	118.4	159.5	4.8	38.0	28.0	4.8	2.2	45.9
St. Clair River	83	315	130.1	119.1	4.4	29.0	6.3	1.9	0.6	14.8
Lake St. Clair	194	1,590	217.8	669.4	35.0	287.8	141.5	70.0	35.0	93.8
Niagara River (Up)	14	28	4.8	5.2	0.0	11.4	0.4	0.0	0.1	0.0
Niagara River (Low)	50	83	8.5	3.8	1.0	11.7	2.7	0.0	0.3	0.8
Lake Erie west/central	343	1,913	878.1	420.9	23.0	61.2	101.4	93.7	0.0	111.0
Lake Erie east	374	1,834	207.2	884.0	75.2	324.6	95.4	25.7	1.8	163.2
Lake Huron	208	441	68.8	88.6	13.7	122.6	21.6	2.2	0.4	37.0
Bay of Quinte	242	947	172.4	271.8	45.5	87.1	144.9	21.8	0.9	161.9
St. Lawrence River	154	812	37.4	287.4	65.8	177.8	78.0	2.4	8.1	128.3
Lake St. Francis	36	164	43.0	72.7	5.6	17.7	11.0	8.9	0.8	0.8

Synthesis of Findings

While these additional sources of information did not directly contribute to assessment of the five sub-criteria, they provide insight into status of fish population in the Detroit River. The Kindree and Mandrak (2020) assessments provides evidence of some level of impairment to fish populations. However, the weight of evidence throughout the present assessment supports the opposite conclusion. At least part of this contrary result can be attributed to field sampling efficacy of IBI metrics. Despite these concerns, Kindree and Mandrak (2020) demonstrate stability in the sampled fish community. The 2020 recreational fishing survey in Ontario demonstrates the health of the Detroit River fisheries compared to other significant locations across the Great Lakes. This study confirms that Detroit River fish populations are indeed providing beneficial uses through recreational fishing opportunities. While some conflicting evidence exists about the status of the Detroit River fish populations, it does not outweigh the weight-of-evidence cited in the present assessment supporting the conclusion that these populations are unimpaired.

Conclusions and overall assessment of fish populations status

The purpose of the Area of Concern (AOC) program is to focus attention and resources on the restoration of the physical, chemical, and biological integrity of areas across the Great Lakes that experienced disproportional ecological degradation. Over the past 30+ years the Detroit River has greatly benefited from the AOC program and is now at a turning point with only 4 of 14 Beneficial Use Impairments (BUI) remaining. One challenge for the assessment of the fish populations component of Fish and Wildlife populations BUI (i.e. BUI#3) has been the unique sampling constraints in connecting channels and the lack of SMART (Specific, Measurable, Achievable, Relevant, and Time-Bound) delisting criteria. The 2021 sub-criteria reflect the concerns for fish populations in the Detroit River AOC and brought the delisting criteria into a SMART framework. This enabled a thorough assessment of fish populations and a recommendation that fish populations be designated as not impaired within the Detroit River AOC as all five criteria have been met (Table 8).

Table 8: Summary conclusion by sub-criteria for the Detroit River AOC Fish Populations BUI assessment

Sub-criterion #1: *Fish communities in wetland coastal areas are comparable to fish communities in unimpaired coastal wetlands.*
Assessment: Sub-criterion has been met. Index of Biological Integrity (IBI) scores in the Detroit River AOC are comparable to those found in the Walpole Island Delta, a non-AOC reference site (Midwood et al. 2020). Furthermore, fish communities in wetland and coastal areas of the Detroit River are diverse and healthy (Lapointe et al. 2010, Francis et al. 2014; Currie and Victor 2020; Hilling et. al. 2021).
Sub-criterion #2: *The number of adult Lake Sturgeon is greater than 750.*
Assessment: Sub-criterion has been met. The most recent USFWS estimate of the Detroit River Lake sturgeon (*Acipenser fulvescens*) population size is 6,416 individuals (Chiotti et al. In Review). Furthermore, researchers have physically handled at least 618 adult Lake Sturgeon.
Sub-criterion #3: *There is no evidence of benthification of fish communities in the Detroit River.*
Assessment: Sub-criterion has been met. The proportion of benthic fish species (33%) and catch rates of tolerant/invasive species have not changed significantly from 1989 to 2018 and are lower in the Detroit River than in other AOCs with healthy fish populations (Currie and Victor, 2020).
Sub-criterion #4: *Creel and Catch Per Unit Effort (CUE) surveys of walleye and bass indicate angler catch and efforts are at or above the long-term average.*
Assessment: Sub-criterion has been met. Walleye (*Sander vitreus*) creel rates (CUE) from 2015 (0.359 fish/ rod hr), 2009 (0.415 fish/ rod hr), and 2002 (0.451 r fish/ rod hr) are well above the long-term (1956-2015) average (0.265 fish/ rod hr). More recent (1996-2018) angler diary CUE fluctuates around the long-term average with increase since 2015. These findings are consistent with those of MDNR creel surveys (2015-0.227 fish/angler hr compared to 2002-2004 - 0.171 fish/angler). Smallmouth bass (*Micropterus dolomieu*) creel CUE values from 2009 (0.207 fish/ rod hr) and 2002 (0.122 fish/ rod hr) are well above the long-term average (0.058 fish/ rod hr). The angler diary CUE fluctuates around the mean with recent years showing increases in CUE. These findings are consistent with those of MDNR creel surveys (2009 - 0.064 fish/angler hr compared to 2002-2004 - 0.0 fish/angler; Sztramko 1979; Sztramko 1980; Witzel 1981; Sztramko and Paine 1984; Soper and Locke 2010; MDNR personal communication 2015; Castle et al. 2018; OMNRF 2019).
Sub-criterion #5: *There is evidence of ongoing and/or increased spawning activity for fishes since 2006.*
Assessment: Sub-criterion has been met. There is direct evidence with the presence of spawning condition adults, and/or the presence of egg or larval fish of at least 42 species from 17 families (Table A1). Furthermore, genetic evidence suggests that Yellow perch (*Perca flavescens*), Walleye, and Lake sturgeon populations are genetically diversity and the river likely supports dynamic sub-population structures for these species with no indication that past population decreases were to levels that had significant lasting effects on genetic diversity or long-term genetic viability of the populations. See Table A1 for a list of species found and their sources.

References

Bennion, D. H. and B. A. Manny. 2011. Construction of the shipping channels in the Detroit River - History and environmental consequences. U.S. Geological Survey Scientific Investigations Report 2011-5122.

Boston, C.M., Randall, R.G., Hoyle, J.A., Mossman, J.L. and Bowlby, J.N., 2016. The fish community of Hamilton Harbour, Lake Ontario: Status, stressors, and remediation over 25 years. *Aquatic Ecosystem Health and Management*, 19(2):206-218.

Castle, D. 2018. *Fishing for answers: restoration in the St. Clair-Detroit river system improves angling opportunities* (Doctoral dissertation, Central Michigan University).

Caswell, N.M., Peterson, D.L., Manny, B.A., and Kennedy, G.W. 2004. Spawning by lake sturgeon (*Acipenser fulvescens*) in the Detroit River. *Journal of Applied Ichthyology*, 20: 1-6.

Chiotti, J. A., and Boase, J. C. 2020. 7.28 Lake Sturgeon Population. CHECKUP: Assessing Ecosystem Health of the Detroit River and Western Lake Erie. Pg. 253.

Chiotti, J. A., and Boase, J. C., Briggs, A. S., Davis, C., Drouin, R., Hondorp, D. W., Mohr, L., Roseman, E. F., Thomas, M. V., Wills, T. C. In Review. Lake Sturgeon Population Trends in the St. Clair – Detroit River System, 2001 – 2019 (in review). U.S. Fish and Wildlife Service, Alpena Fish and Wildlife Conservation Office – Detroit River Substation

Chow-Fraser, P., and Albert, D.A., 1999. Coastal wetland ecosystems: biodiversity investment areas. State of the Lake Ecosystem Conference 1998.

Currie, W.J., and Victor, J. 2020. Assessing long-term changes to benthivorous fish community structure in the Detroit River AOC. Department of Fisheries and Oceans.

DeBruyne, R.L., Roseman, E.F., Ross, J.E., Newman, K.R., and Strach, R.M., 2019, Contemporary environmental assessment using a viability analysis in a large river system to inform restoration and adaptive management decisions: U.S. Geological Survey Scientific Investigations Report 2019–5002, 59 p., https://doi.org/10.3133/sir20195002.

Detroit River Canadian Cleanup (DRCC). 2022. Pathway to Delisting: Detroit River Canadian AOC Delisting Strategy. Publication No. 2, Essex, Ontario, Canada.

Detroit River Canadian Cleanup (DRCC). 2005. Delisting Criteria for the Canadian Portion of the Detroit River Area of Concern. Final draft: June 27, 2005.

Detroit River Canadian Cleanup (DRCC). 1999. Detroit River Update Report. Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario.

Edwards, A., Barnucz, J. and N.E. Mandrak. 2006. Boat electrofishing survey of the fish assemblages of the St. Clair River, Ontario. Can. Manuscr. Rpt. *Fisheries Aquaic. Sci*ence 2742. v + 57p.

Environment Canada and Ontario Ministry of Natural Resources. 2003. The Ontario Great Lakes coastal wetland atlas: A summary of information (1983-1997).

Fischer, J.L., Pritt, J.J., Roseman, E.F., Prichard, C.G., Craig, J.M., Kennedy, G.W., and Manny, B.A. 2018. Lake sturgeon, lake whitefish, and walleye egg deposition patterns with response to fish spawning substrate restoration in the St. Clair-Detroit River System. *Transactions of the American Fisheries Society,* 147: 79-93.

Francis, J. T., Chiotti, J. A., Boase, J. C., Thomas, M. V., Manny, B. A., and Roseman, E. F. 2014. A description of the nearshore fish communities in the Huron–Erie Corridor using multiple gear types. *Journal of Great Lakes Research*, 40: 52-61.

Gannon, J.E. 2001. Changes in river biota over time. In: State of the Strait: Status and Trends of the Detroit River Ecosystem Conference Proceedings. March 27, 2001, University of Windsor, Windsor, Ontario.

Great Lakes Water Quality Agreement (GLWQA). 2022. State of the Great Lakes 2022 Report. International Joint Commission United States and Canada.

Great Lakes Water Quality Agreement (GLWQA). 1987. Great Lakes Water Quality Agreement of 1978. International Joint Commission United States and Canada.

Green N.D., Cargnelli L., Briggs T., Drouin R., Child M., Esbjerg J., Valiante M., Henderson T., McGregor D., and D. Munro, eds. 2010. Detroit River Canadian Remedial Action Plan: Stage 2 Report. Detroit River Canadian Cleanup, Publication No. 1, Essex, Ontario, Canada. 2006 DRCC

Grenouillet, G.; Pont, D., and Seip, K.L. 2002. Abundance and Species Richness as a Function of Food Resources and Vegetation Structure: Juvenile Fish Assemblages in Rivers. *Ecography*, *25*: 641–650.

Haas R.C. and G. Towns. 2009. Walleye Movement Patterns and Fishery in Huron-Erie Corridor. State of the Lake Presentation to Lake Erie Committee, Great Lakes Fish Commission, Ypsilanti, Michigan, U.S.A.

Hamilton, J.G. 1987. Survey of critical fish habitat within International Joint Commission designated Areas of Concern, August-November, 1986. Ontario Ministry of Natural Resources, Fisheries Branch, Toronto. 119pp.

Haponski, A. E., and Stepien, C. A. 2014. Genetic connectivity and diversity of walleye (*Sander vitreus*) spawning groups in the Huron–Erie Corridor. *Journal of Great Lakes Research*, 40: 89-100.

Hartig, J.H., Sanders, C., Wyma, R.J.H., Boase, J.C., and Roseman, E.F., 2018. Habitat rehabilitation in the Detroit River Area of Concern, Aquatic Ecosystem Health and Management. 21, 4: 458-469.

Hartig J.H., Zarull M.A., Ciborowski J.J.H., Gannon J.E., Wilke E., Norwood G., and A. Vincent, eds. 2007. State of the Strait: Status and Trends of Key Indicators. Great Lakes Institute for Environmental Research, Occasional Publication No. 5, University of Windsor, Ontario, Canada.

Hartman, W.L., 1973. Effects of Exploitation, Environmental Changes, and New Species on the Fish Habitats and Resources of Lake Erie. Great Lakes Fishery Commission, Technical Report Number 22. Ann Arbor, Michigan, USA.

Hessenauer, J. M., Harris, C., Marklevitz, S., Faust, M. D., Thorn, M. W., Utrup, B., and Hondorp, D. 2021. Seasonal movements of muskellunge in the St. Clair–Detroit River System: Implications for multi-jurisdictional fisheries management. *Journal of Great Lakes Research*, 47(2): 475-485.

Hilling, C. D., Fischer, J. L., Ross, J., Tucker, T. R., DeBruyne, R. L., Mayer, C. M., and Roseman, E. F. 2021. Nearshore Fish Species Richness and Species–Habitat Associations in the St. Clair–Detroit River System. *Water*, 13(12): 1616.

Hoyle, J. A., Boston, C. M., Chu, C., Yuille, M. J., Portiss, R., and Randall, R. G. 2018. Fish community indices of ecosystem health: How does Toronto Harbour compare to other Lake Ontario nearshore areas?. *Aquatic Ecosystem Health and Management*, 21:3.

Hubert, W. A., and Fabrizio, M. C. 2007. Relative Abundance and Catch per Unit Effort. In Analysis and Interpretation of Freshwater Fisheries Data. Edited by Christopher S. Guy and Michael L. Brown. Chapter 7. *American Fisheries Society*, September 2007.

Hunt, L. M., H. Ball, A. Ecclestone, and M. Wiebe. 2022. 2020 recreational fishing survey in Ontario: results for select fishing destinations Ontario Ministry of Natural Resources and Forestry; Science and Research Branch; Peterborough, ON. Science and Research Technical Report.

Hunter, R. D., Roseman, E. F., Sard, N. M., DeBruyne, R. L., Wang, J., and Scribner, K. T. 2020. Genetic family reconstruction characterizes Lake Sturgeon use of newly constructed spawning habitat and larval dispersal. *Transactions of the American Fisheries Society*, 149(3): 266-283.

International Joint Commission. 2012. Canada-U.S. Great Lakes Water Quality Agreement: Protocol Amending the Agreement between Canada and the United State of America on Great Lakes Water Quality, 1978, as Amended on October 16, 1983, and on November 18, 1987. Washington, USA

Johnson, T.B., Haas, R.C., MacLennan, D., and Powell, S. 2005. Fish and fisheries of the Detroit River. In: Eedy, R., Hartig, J., Bristol, C., Coulter, M., Mabee, T., and Ciborowski,

J. 2005. State of the Strait: Monitoring for Sound Management. Great Lakes Institute for Environmental Research, Occasional Publication No. 4, University of Windsor, Windsor, Ontario.

Kessel, S. T., Hondorp, D. W., Holbrook, C. M., Boase, J. C., Chiotti, J. A., Thomas, M. V., ... and Krueger, C. C. 2018. Divergent migration within lake sturgeon (A cipenser fulvescens) populations: multiple distinct patterns exist across an unrestricted migration corridor. *Journal of Animal Ecology*, *87*(1): 259-273.

Kindree, M. M., and Mandrak, N. E. 2020. Fish Assemblage Survey of the Detroit and St. Clair rivers: 2007-2014. Department of Fisheries and Oceans Canada.

Lapointe, N. W. R., Corkum, L. D., and Mandrak, N. E. 2010. Macrohabitat associations of fishes in shallow waters of the Detroit River. *Journal of fish biology*, 76(3): 446-466.

Leney J., and Haffner D.G. 2006. 2006 Status of Beneficial Use Impairments in the Detroit River. Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario.

MacInnis, A.J., and Corkum, L.D. 2000. Fecundity and reproductive season of the round goby (*Neogobius melanostomus*) in the upper Detroit River. *Transactions of the American Fisheries Society,* 129: 136-144.

Manny, B. A., and Kennedy, G. W. 2002. Known lake sturgeon (Acipenser fulvescens) spawning habitat in the channel between lakes Huron and Erie in the Laurentian Great Lakes. *Journal of Applied Ichthyology*, 18(4-6): 486-490.

Manny, B. A., Daley, B. A., Boase, J. C., Horne, A. N., and Chiotti, J. A. 2014. Occurrence, habitat, and movements of the endangered northern madtom (*Noturus stigmosus*) in the Detroit River, 2003–2011. *Journal of Great Lakes Research*, *40*, 118-124.

Manny, B.A., T.A. Edsall, and E. Jaworski. 1988. The Detroit River, Michigan: An ecological profile biological report. U.S. Fish and Wildlife Service, U.S. Department of Interior, Contribution No. 683 of the National Fisheries Research Center-Great Lakes. Ann Arbor, MI.

Mayer, C.M., Burlakova, L.E., Eklöv, P., Fitzgerald, D., Karatayev, A.Y., Ludsin, S.A., Millard, S., Mills, E.L., Ostapenya, A.P., Rudstam, L.G. and Zhu, B. 2014. Benthification of freshwater lakes: exotic mussels turning ecosystems upside down.Quagga and Zebra mussels: Biology, Impacts, and Control, 2nd edn.,Lewis Publishers, Boca Raton, FL, pp.575-586.

McDonald, E. A., McNaught, A. S., and Roseman, E. F. 2014. Use of main channel and two backwater habitats by larval fishes in the Detroit River. *Journal of Great Lakes Research*, 40: 69-80.

Michigan Department of Environmental Quality (MDEQ). 1996. 1996 Detroit River. Remedial Action Plan Report. Surface Water Quality Division, Lansing, MI.

Michigan Department of Natural Resources (MDNR), Ontario Ministry of the Environment (OMOE), 1991. Detroit River Remedial Action Plan, Stage I. Report issued June 3, 1991

Michigan Graham Sustainability Institute. n.d. Restoring fish spawning habitat in the St. Clair and Detroit rivers. Restoring Fish Spawning Habitat in the St. Clair and Detroit Rivers | Graham Sustainability Institute. Retrieved January 9, 2023, from https://graham.umich.edu/project/restoring-fish-spawning-habitat-st-clair-and-detroit-rivers

Midwood, J.D., Budgell, E., and Reddick, D. 2020 Application of a fish IBI to costal wetlands in the St. Clair and Detroit River Areas of Concern. DFO Technical Report.

Minns, C. K., Cairns, V.W., Randall, R.G., and J.E. Moore. 1994. An index of biotic integrity (IBI) for fish assemblages in the littoral zone of Great Lakes' areas of concern. Can. J. Fish. *Aquatic Science*, 51 (8):1804-1822.

MNRF. 2023. Fisheries Management Zone 19. ontario.ca. Retrieved January 30, 2023, from https://www.ontario.ca/document/ontario-fishing-regulations-summary/fisheries-management-zone-19

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2019. 2018 Annual Report, Ontario Ministry of Natural Resources and Forestry, Lake Erie Management Unit, ISSN 1715-8087 (Print), ISBN 978-1-4868-3196-8 (Print, 2019 ed.), ISSN 1925-539X (Online), ISBN 978-1-4868-3197-5 (PDF, 2019 ed.). 71 pp.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2020. 2019 Annual Report, Ontario Ministry of Natural Resources and Forestry, Lake Erie Management Unit, ISSN 1715-8087 (Print), ISBN 978-1-4868-4110-3 (Print, 2020 ed.), ISSN 1925-539X (Online), ISBN 978-1-4868-4111-0 (PDF, 2020 ed.). 86 pp. page 49-51

Paine, J., and Witherspoon, N. 1977. Summer Creel census in the Canadian waters of the Western Basin of Lake Erie, 1976. Ontario Ministry of Natural Resources, London, Ontario, 71pp.

Peterson, D. L., Vecsei, P., and Jennings, C. A. 2007. Ecology and biology of the lake sturgeon: a synthesis of current knowledge of a threatened North American Acipenseridae. *Reviews in Fish Biology and Fisheries*, 17(1): 59-76.

Prichard, C. G., Craig, J. M., Roseman, E. F., Fischer, J. L., Manny, B. A., and Kennedy, G. W. 2017. *Egg deposition by lithophilic-spawning fishes in the Detroit and Saint Clair Rivers, 2005–14* (No. 2017-5003). US Geological Survey.

Pritt, J. J., Roseman, E. F., Ross, J. E., and DeBruyne, R. L. 2015. Using larval fish community structure to guide long-term monitoring of fish spawning activity. *North American Journal of Fisheries Management*, *35*(2): 241-252.

Regier, H.A., Hartman, W.L., 1973. Lake Erie's Fish Community: 150 Years of Cultural Stresses. *Science,* 180, 4092: 1248-1255.

Ricciardi, A., and MacIsaac, H. J. 2000. Recent mass invasion of the North American Great Lakes by Ponto–Caspian species. *Trends in Ecology and Evolution*, 15(2): 62-65.

Roseman, E. F., Kennedy, G. W., Boase, J., Manny, B. A., Todd, T. N., and Stott, W. 2007. Evidence of lake whitefish spawning in the Detroit River: implications for habitat and population recovery. *Journal of Great Lakes Research*, 33(2): 397-406.

Roseman, E. F., Kennedy, G., Manny, B. A., Boase, J., and McFee, J. 2012. Life history characteristics of a recovering lake whitefish *Coregonus clupeaformis* stock in the Detroit River, North America. *Advances in Limnology*, 477-501.

Roseman, E. F., Manny, B., Boase, J., Child, M., Kennedy, G., Craig, J., ... and Drouin, R. 2011. Lake sturgeon response to a spawning reef constructed in the Detroit River. *Journal of Applied Ichthyology*, *27:* 66-76.

Ruetz III, C. R., Uzarski, D. G., Krueger, D. M., and Rutherford, E. S. 2007. Sampling a littoral fish assemblage: comparison of small-mesh fyke netting and boat electrofishing. *North American Journal of Fisheries Management*, 27(3): 825-831.

Ryerson, J. N.d. "Native American History in Detroit. (U.S. National Park Service). U.S. Department of the Interior, www.nps.gov/articles/000/native-american-history-in-detroit.htm.

Schiemer, F.; Keckeis, H.; Reckendorfer, and W.; Winkler, G. 2001. The "Inshore Retention Concept" and Its Significance for Large Rivers. *Archive for Hydrobiology Supplement Large Rivers*, *135*: 509–516.

Secor, D. H., and Houde, E. D. 1995. Temperature effects on the timing of striped bass egg production, larval viability, and recruitment potential in the Patuxent River (Chesapeake Bay). *Estuaries*, 18: 527-544.

Sepulveda-Villet, O.J., and Stepien, C.A., 2012. Waterscape genetics of the yellow perch (*Perca flavescens*) from two genomes: patterns across large connected ecosystems and isolated relict opulations. *Molecular Ecology,* 21: 5795–5826

Sepulveda-Villet, O.J., and Stepien, C.A., 2011. Fine-scale population genetic structure of the yellow perch *Perca flavescens* in Lake Erie. Can. J. *Fisheries Aquatic Science*, 68: 1435–1453.

Strange, R.M., and Stepien, C.A., 2007. Genetic divergence and connectivity among river and reef spawning populations of walleye (*Sander vitreus*) in Lake Erie. Can. J. *Fisheries Aquatic Science,* 64: 437–448.

Sullivan, T. J., and Stepien, C. A. 2014. Genetic diversity and divergence of yellow perch spawning populations across the Huron–Erie Corridor, from Lake Huron through western Lake Erie. *Journal of Great Lakes Research*, 40: 101-109.

Soper,K. and Locke, B. 2010. Summer angler survey in the Canadian waters of the Detroit River, 2009; A summary. Ontario Ministry of Natural Resources.

Sprague, J. B. 1971. Measurement of pollutant toxicity to fish—III: Sublethal effects and “safe” concentrations. *Water research*, 5(6): 245-266.

Stepien, C.A., Murphy, D.J., Lohner, R.N., Haponski, A.E., and Sepulveda-Villet, O.J., 2010. Status and delineation of walleye (*Sander vitreus*) genetic stock structure across the Great Lakes. In: Roseman, E., Kocovsky, P., Vandergoot, C. (Eds.), Status of Walleye in the Great Lakes: Proceedings of the 2006 Symposium: Great Lakes Fish. Comm. Tech. Rep., 69, pp. 189–223.

Stepien, C.A., Murphy, D.J., Lohner, R.N., Sepulveda-Villet, O.J., and Haponski, A.E., 2009. Signatures of vicariance, postglacial dispersal, and spawning philopatry: population genetics and biogeography of the walleye *Sander vitreus*. *Moecular Ecology,* 18: 3411–3428.

Sztramko, L. 1980. Summer Creel census in the Canadian waters of the Detroit River, 1979. Ontario Ministry of Natural Resources, Lake Erie Fisheries Assessment Unit Report 1980-2.

Sztramko, L. 1979. Summer Creel census in the Canadian waters of the Detroit River, 1978. Ontario Ministry of Natural Resources, Lake Erie Fisheries Assessment Unit Report 1979-2.

Sztramko, L., and Paine, J. R. 1984. (rep.). (K. H. Loftus, Ed.) Sport Fisheries in the Canadian Portion of Lake Erie and Connecting Waters, 1948-1980. Ontario Ministry of natural Resources.

Tillitt, D.E., Buckler, J.A., Nicks, D.K., Candrl, J.S., Claunch, R.A., Gale, R.W., Puglis, H.J., Little, E.E., Linbo, T.L. and Baker, M. 2017, Sensitivity of lake sturgeon (*Acipenser fulvescens*) early life stages to 2,3,7,8-tetrachlorodibenzo-*P*-dioxin and 3,3′,4,4′,5-pentachlorobiphenyl. *Environmental Toxicology and Chemistry*, 36: 988-998. https://doi.org/10.1002/etc.3614

Tucker, T. R., Roseman, E. F., DeBruyne, R. L., Pritt, J. J., Bennion, D. H., Hondorp, D. W., and Boase, J. C. 2018. Long-term assessment of ichthyoplankton in a large North American river system reveals changes in fish community dynamics. *Canadian Journal of Fisheries and Aquatic Sciences*, 75(12): 2255-2270.

University of Wyoming. n.d.. Population Genetics: Heterozygosity, Hexp (or gene diversity, D). Lect 4. Heterozygosity. Retrieved January 18, 2023, from http://www.uwyo.edu/dbmcd/molmark/lect04/lect4.html

U.S. Fish and Wildlife Service and USGS (U.S. Geological Survey). 2006. Lake Whitefish Returning to the Detroit River to Spawn; Federal Scientists Document First Reproducing Population of Whitefish in the River since 1916. News Release, May 19, 2006.

USGS (U.S. Geological Survey). 1999. Detroit River corridor, preliminary assessment of land use change. Moffett Field, California, U.S. Geological Survey, Urban Dynamics Research Program.

Vanderploeg, H.A., Nalepa, T.F., Jude, D.J., Mills, E.L., Holeck, K.T., Liebig, J.R., Grigorovich, I.A. and Ojaveer, H. 2002. Dispersal and emerging ecological impacts of Ponto-Caspian species in the Laurentian Great Lakes. *Fisheries Aquatic Science*, 59(7):1209-1228.

Walleye Task Group. 2022. Update to the 2022 Report by the Lake Erie Walleye Task Group, June 2022. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

Wei, A., Chow-Fraser, P., and Albert, D., 2004. Influence of shoreline features on fish distribution in the Laurentian Great Lakes. Can. J. *Fisheries Aquatic Science,* 61 (7): 1113–1123.

Welsh, A.B., Elliott, R.F., Scribner, K.T., Quinlan, H.R., Baker, E.A., Eggold, B.T., Holtgren, J.M., and Krueger, C.C., May, B. 2010. Genetic guidelines for the stocking of lake sturgeon (*Acipenser fulvescens*) in the Great Lakes basin. Great Lakes Fish. Comm. Misc.

Welsh, A., Hill, T., Quinlan, H., Robinson, C., and May, B. 2008. Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. *North American Journal of Fisheries Management*, *28*(2), 572-591.

Witzel, L. 1981. Summer Creel census in the Canadian waters of the Detroit River, 1980. Ontario Minstry of Natural Resources, Lake Erie Fisheries Assessment Unit Report 1981-2.

APPENDIX A: Spawning Species List

Table A1: List of identified spawning species using the Detroit River by life stage (Egg = E, Larvae = L, Adult = A,) of available evidence and associated reference (numbers correspond to provided list).

Family	Binomial nomenclature	Common name	Life stage	Reference
Atherinidae	*Labidesthes sicculus*	Brook silverside	L	4, 5
Catostomidae	*Hypentelium nigricans*	Northern hog sucker	E, L	4, 5, 7
	Carpiodes cyprinus	Quillback	L	4, 5
	Moxostoma spp.	Redhorse spp.	E, L	4, 5, 7
	Catostomus commersonii	White sucker	E, L	4, 5, 7
	Minytrema melanops	Spotted Sucker	L	5
Centrarchidae	*Pomoxis spp.*	Black/white crappie	L	4, 5
	Lepomis macrochirus	Bluegill	L	4, 5
	Micropterus salmoides	Largemouth bass	L	4, 5
	Lepomis gibbosus	Pumpkinseed	L	4, 5
	Ambloplites rubestris	Rock bass	L	4
	Micropterus dolomieu	Smallmouth bass	L	4, 5
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	L	4, 5
Cyprinidae	*Pimephales notatus*	Bluntnose minnow	L	4, 5
	Pimephales spp.	Unidentified minnow	L	4, 5
	Cyprinus carpio	Common carp	L	4, 5
	Luxilus cornutus	Common shiner	L	4, 5
	Notropis atherinoides	Emerald shiner	L	4, 5
	Notemigonus crysoleucas	Golden shiner	L	4, 5
	Notropis volucellus	Mimic shiner	L	4, 5
	Notropis stramineus	Sand shiner	L	4, 5
	Macrhybopsis storeriana	Silver chub	L	4, 5
	Notropis hudsonius	Spottail shiner	L	4, 5
Esocidae	*Esox masquinongy*	Muskellunge	L, A	3, 4, 5
Gobiidae	*Neogobius melanostomus*	Round goby	L	4, 5
	Proterorhinus marmoratus	Tubenose goby	L	5
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	L	4, 5
Osmeridae	*Osmerus mordax*	Rainbow smelt	L	4, 5
Moronidae	*Morone chrysops*	White bass/perch	L	4, 5
Percidae	*Etheostoma nigrum*	Johnny darter	L	4, 5
	Percina caprodes	Logperch	L	4, 5
	Sander vitreus	Walleye	E, L, A	4, 5, 6, 7, 11
	Perca flavescens	Yellow perch	L, A	4, 5, 12
Percopsidae	*Percopsis omiscomaycus*	Trout-perch	E, L	4, 5, 7
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	L	4, 5
Cottidae	*Myoxocephalus thompsonii*	Deepwater sculpin	L	5
Gadidae	*Lota lota*	Burbot	L	5
Salmonidae	*Coregonus hoyi*	Bloater	L	5
	Coregonus sp.		L	5
	Coregonus artedi	Cisco	L	5
	Coregonus clupeaformis	Lake Whitefish	E, L, A	1, 5, 6, 7
Acipenseridae	*Acipenser fulvescens*	Lake Sturgeon	E, L, A	2, 6, 7, 9, 10
Ictaluridae	*Noturus stigmosus*	Northern Madtom	A	13

Table A1 references

1. Roseman, E. F., Kennedy, G., Manny, B. A., Boase, J., and McFee, J. (2012). Life history characteristics of a recovering lake whitefish Coregonus *clupeaformis* stock in the Detroit River, North America. *Advances in Limnology*, 477-501.

2. Roseman, E. F., Manny, B., Boase, J., Child, M., Kennedy, G., Craig, J., ... and Drouin, R. (2011). Lake sturgeon response to a spawning reef constructed in the Detroit River. *Journal of Applied Ichthyology*, *27*, 66-76.

3. Hessenauer, J. M., Harris, C., Marklevitz, S., Faust, M. D., Thorn, M. W., Utrup, B., and Hondorp, D. (2021). Seasonal movements of muskellunge in the St. Clair–Detroit River System: Implications for multi-jurisdictional fisheries management. *Journal of Great Lakes Research*, *47*(2), 475-485.

4. McDonald, E. A., McNaught, A. S., and Roseman, E. F. (2014). Use of main channel and two backwater habitats by larval fishes in the Detroit River. *Journal of Great Lakes Research*, *40*, 69-80.

5. Tucker, T. R., Roseman, E. F., DeBruyne, R. L., Pritt, J. J., Bennion, D. H., Hondorp, D. W., and Boase, J. C. (2018). Long-term assessment of ichthyoplankton in a large North American river system reveals changes in fish community dynamics. *Canadian Journal of Fisheries and Aquatic Sciences*, *75*(12), 2255-2270.

6. Fischer, J. L., Pritt, J. J., Roseman, E. F., Prichard, C. G., Craig, J. M., Kennedy, G. W., and Manny, B. A. (2018). Lake Sturgeon, Lake Whitefish, and Walleye egg deposition patterns with response to fish spawning substrate restoration in the St. Clair–Detroit River system. *Transactions of the American Fisheries Society*, *147*(1), 79-93.

7. Prichard, C. G., Craig, J. M., Roseman, E. F., Fischer, J. L., Manny, B. A., and Kennedy, G. W. (2017). Egg deposition by lithophilic-spawning fishes in the Detroit and Saint Clair Rivers, 2005–14 (No. 2017-5003). US Geological Survey.

8. Pritt, J. J., Roseman, E. F., Ross, J. E., and DeBruyne, R. L. (2015). Using larval fish community structure to guide long-term monitoring of fish spawning activity. *North American Journal of Fisheries Management*, *35*(2), 241-252.

9. Hunter, R. D., Roseman, E. F., Sard, N. M., DeBruyne, R. L., Wang, J., and Scribner, K. T. (2020). Genetic family reconstruction characterizes Lake Sturgeon use of newly constructed spawning habitat and larval dispersal. *Transactions of the American Fisheries Society*, *149*(3), 266-283.

10. Welsh, A., Hill, T., Quinlan, H., Robinson, C., and May, B. (2008). Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. *North American Journal of Fisheries Management*, *28*(2), 572-591.

11. Sullivan, T. J., and Stepien, C. A. (2014). Genetic diversity and divergence of yellow perch spawning populations across the Huron–Erie Corridor, from Lake Huron through western Lake Erie. *Journal of Great Lakes Research*, *40*, 101-109.

12. Haponski, A. E., and Stepien, C. A. (2014). Genetic connectivity and diversity of walleye (*Sander vitreus*) spawning groups in the Huron–Erie Corridor. *Journal of Great Lakes Research*, *40*, 89-100.

13. Manny, B. A., Daley, B. A., Boase, J. C., Horne, A. N., and Chiotti, J. A. (2014). Occurrence, habitat, and movements of the endangered northern madtom (*Noturus stigmosus*) in the Detroit River, 2003–2011. *Journal of Great Lakes Research*, *40*, 118-124.

APPENDIX B: Assessment Framework

Sub-Criteria 1) Fish communities in wetland coastal areas are comparable to fish communities in unimpaired coastal wetlands

Source	Topic	Approach	Major Findings	Fish population status
Midwood, J.D., Budgell, E., and Reddick, D. (2020) Application of a fish Index of Biotic Integrity (IBI) to costal wetlands in the St. Clair and Detroit River Areas of Concern	Use of IBI to assess fish communities in coastal wetlands	Electrofishing and fyke net survey for DR compared to Walpole Island wetlands- non-AOC site	-No statistically significant difference was noted for IBI scores from Walpole and DR. -IBI was between 60 to 80 for both, which was comparable to other AOC's like Bay of Quinte that has met its fish community goals and removed BUI. -DR IBI was comparable to reference non-AOC conditions.	Not impaired
Lapointe, N. W. R., Corkum, L. D., and Mandrak, N. E. 2010. Macrohabitat associations of fishes in shallow waters of the Detroit River. Journal of fish biology, 76(3), 446-466.	Assessed seasonal differences of fish species richness, abundance, and assemblages from inshore and offshore sites along the Detroit River (DR)	Seine net	-Nearshore environments being home to the majority of uncommon native species (59%). -Middle section of river had the highest species richness, abundance and was home to the greatest proportion of uncommon native species (57%) compared to the upper (35%) and lower river (11%) segments.	Not impaired
Francis, J. T., Chiotti, J. A., Boase, J. C., Thomas, M. V., Manny, B. A., and Roseman, E. F. (2014). A description of the nearshore fish communities in the Huron–Erie Corridor using multiple gear types. *Journal of Great Lakes Research*, *40*, 52-61.	Description of the nearshore fish communities in the DR	Seine net, electrofishing, fyke net	-Nearshore fish communities in DR were comparable with fish communities in other areas of the Great Lakes. -DR contained a high diversity of fish species (63 DR, 47 western Lake Erie, 56 St. Clair Delta).	Not impaired

Source	Topic	Approach	Major Findings	Fish population status
Hilling, C. D., Fischer, J. L., Ross, J., Tucker, T. R., DeBruyne, R. L., Mayer, C. M., and Roseman, E. F. (2021). Nearshore Fish Species Richness and Species–Habitat Associations in the St. Clair–Detroit River System. *Water*, *13*(12), 1616.	Nearshore fish community richness and species habitat associations	Seine net	- "Shoreline habitats have been degraded over time in the SCDRS, but this study supports that a diverse shoreline fish community exists." -Over the seven-year study period, 38,451 fish representing 60 species were collected -Figure 5 shows species richness at DR sites vs St. Clair River over time.	Not impaired
Currie, W.J., and Victor, J. (2020) Assessing long-term changes to benthivorous fish community structure in the Detroit River AOC	Benthivorous fish community and evidence of change	Long term data set from Ministry of Natural Resources and Forestry and Department of Fisheries and Oceans containing information from electrofishing, trap net, fyke net, trawling	-No evidence of shifts in the fish community structure towards benthic species which might be expected in degraded habitats. -Fish community assemblages in the DR were healthy compared to other AOCs: Bay of Quinte and St. Clair River that have removed or are in the process of removing the "impaired" status of their Fish Populations BUI.	Not impaired

Sub-Criteria 2) The number of adult Lake Sturgeon is greater than 750

Source	Topic	Approach	Major Findings	Fish population status
Chiotti, J. A., and Boase, J. C. (2020) 7.28 Lake Sturgeon Population. *CHECKUP*, 253.	Sturgeon populations and restoration efforts	Tagging and mark recapture	-Lake sturgeon populations were limited by available spawning habitat. -7 artificial reefs had been constructed to aid with Sturgeon populations. -Current estimates suggest the DR Sturgeon population was at 4422 individuals- which is a large and stable population	Not impaired
Chiotti, J.A. et al. (In Review) Lake Sturgeon Population Trends in the St. Clair – Detroit River System, 2001 – 2019. (in review)	SCDRS Sturgeon populations	Tagging and mark recapture	-DR Lake sturgeon estimate of 6,416. -618 adult Lake sturgeon captured -Large, stable population in SCDRS	Not impaired

Sub-Criteria 3) There is no evidence of benthification of fish communities in the Detroit River

Source	Topic	Approach	Major Findings	Fish population status
Currie, W.J., and Victor, J. (2020) Assessing long-term changes to benthivorous fish community structure in the Detroit River AOC	Benthivorous fish community and evidence of change	Long term data set from Ministry of Natural Resources and Forestry and Department of Fisheries and Oceans containing information from electrofishing, trap net, fyke net, trawling	-No evidence of substantial benthification of DR in study period (1989-2018). Catch of all fish improved with time which may indicate habitat improvements. -Benthic fish made up an average of 33.2% of total fish community in the DR based on study -CUE percentage of fishes classified as benthivorous from electrofishing was 37% of the total pre 2010 and only 22% post 2010. -Any increase in benthic CUE was accompanied by a proportional increase in pelagic CUE in electrofishing after 2010 which could indicate an increase in fish abundance. -Prevalence of tolerant/invasive sp. which are indicative of degraded and benthified ecosystems (i.e. Hamilton Harbor) stayed the same throughout the study period and is markedly low compared to other AOCs.	Not impaired

Sub-Criteria 4) Creel and Catch Per Unit Effort (CUE) surveys of walleye and bass indicate angler catch and efforts are at or above the long-term average

Source	Topic	Approach	Major Findings	Fish population status
OMNRF Creel Survey	Creel	Aerial/ access point/ roving creel (1956-1958, 1975-1980, 1992, 2002, 2009, and 2015)	-Walleye creel rates (CUE) from 2015 (0.359fish/ rod hr), 2009 (0.415fish/rod hr), and 2002 (0.451 fish/rod hr) were well above the long-term (1956-2015) average (0.265 fish/ rod hr). -Smallmouth bass creel CUE values from 2009 (0.207 fish/ rod hr), and 2002 (0.122/ rod hr) were well above the long-term average of (0.058 fish/ rod hr)	Not impaired
OFAH/OMNRF Angler Diary Program	Angler Diary	Angler diary (1996-2018)	-Angler diary CUE fluctuated around mean with increase since 2015. - Smallmouth bass angler diary CUE fluctuated around mean with recent years showing increases in CUE.	Not impaired

Sub-Criteria 5) There is evidence of ongoing and/or increased spawning activity for fishes since 2006.

Source	Topic	Approach	Major Findings	Fish population status
Roseman, E. F., Manny, B., Boase, J., Child, M., Kennedy, G., Craig, J., ... and Drouin, R. (2011). Lake sturgeon response to a spawning reef constructed in the Detroit River. Journal of Applied Ichthyology, 27, 66-76.	Spawning of lake Sturgeon	Setline over spawning reefs in DR	-Ripe spawning adult Lake Sturgeon were captured in the areas surrounding the new reef locations.	Not impaired
Roseman, E. F., Kennedy, G., Manny, B. A., Boase, J., and McFee, J. 2012. Life history characteristics of a recovering lake whitefish Coregonus *clupeaformis* stock in the Detroit River, North America. Advances in Limnology, 477-501.	Spawning study of Lake whitefish	Gillnet	-Fifteen 4-18 year-old fish in spawning condition were captured in the DR.	Not impaired
Hessenauer et al. 2021. Seasonal movements of muskellunge in the St. Clair–Detroit River System: Implications for multi-jurisdictional fisheries management. Journal of Great Lakes Research.	Spawning and telemetry study of Muskellunge	Volunteer anglers, electrofishing, trap-netting	-Muskie were caught and tagged in the Detroit River at known spawning locations. -These fish were in spawning conditions (males expressing milk, females releasing eggs). -Tagged Muskellunge showed annual seasonal migration back to these known spawning locations during spawning times (April-June). -Muskellunge were spawning in the DR and contribute to the world class Lake St. Clair fishery.	Not impaired
McDonald, E. A., McNaught, A. S., and Roseman, E. F. (2014). Use of main channel and two backwater habitats by larval fishes in the Detroit River. *Journal of Great Lakes Research*, *40*, 69-80.	Suitability of protected wetland areas vs main channel versus unprotected nearshore areas for larval fish retention and growth	Captured using light traps and ichthyoplankton nets	-Central channels had many larval species (27), more than backwater (17 and 13). This could be due to its suitability for certain species i.e. Lake Whitefish, or because species get stuck in the main channel with no way out due to channelization and dredging. -This study highlighted habitat diversity in the DR which provides niches for different species.	Not impaired - Will improve as BUI #14 improves

Source	Topic	Approach	Major Findings	Fish population status
Tucker, T. R., Roseman, E. F., DeBruyne, R. L., Pritt, J. J., Bennion, D. H., Hondorp, D. W., and Boase, J. C. (2018). Long-term assessment of ichthyoplankton in a large North American river system reveals changes in fish community dynamics. *Canadian Journal of Fisheries and Aquatic Sciences*, *75*(12), 2255-2270.	Compare contemporary ichthyoplankton to historical data to see differences	Paired bongo sampler	-Study noted increased larval fish richness (14 more species observed in 2000s vs 1970s) and decreased densities of invasive species which is consistent with the improvements to environmental conditions. -Larval species richness was indicative of diverse composition of species spawning in the DR. -Figure 10 compares 1970s vs 2000s for various metrics.	Not impaired
Roseman, E. F., Kennedy, G. W., Boase, J., Manny, B. A., Todd, T. N., and Stott, W. (2007). Evidence of lake whitefish spawning in the Detroit River: implications for habitat and population recovery. *Journal of Great Lakes Research*, *33*(2), 397-406.	Lake Whitefish spawning in the DR.	Gillnetting for adults and sampling for deposited eggs	-Densities of larvae indicated there may be many Lake whitefish spawning withing the DR. (Max of 48.8/1,000 m^3).	Not impaired
Prichard, C. G., Craig, J. M., Roseman, E. F., Fischer, J. L., Manny, B. A., and Kennedy, G. W. (2017). *Egg deposition by lithophilic-spawning fishes in the Detroit and Saint Clair Rivers, 2005–14* (No. 2017-5003). US Geological Survey.	Long term fish egg sampling 2009-2014	Fish egg mats	-Found widespread evidence of spawning by a number of lithophilic species including Walleye, Lake whitefish, Lake sturgeon, various Suckers and Trout perch. -Eggs were often found in areas with low interstitial space to protect eggs, thus this system would benefit from the addition of rocks/gravel. -Table 1-4: cue of Walleye, Suckers, Trout perch and Whitefish eggs over study period (eggs/mat).	Not impaired

Source	Topic	Approach	Major Findings	Fish population status
Pritt, J. J., Roseman, E. F., Ross, J. E., and DeBruyne, R. L. (2015). Using larval fish community structure to guide long-term monitoring of fish spawning activity. *North American Journal of Fisheries Management*, *35*(2), 241-252.	Larval fish sampling in the DR from 2006-2013	Paired bongo nets towed at 3km/h for 3-5 minutes	-Main focus of study was testing different methods of studying larval fish in DR, what combination of limited spatial and temporal sampling best mimicked full sampling. -Information provided in Table 3 show steady ongoing larval genus richness in all of their models which indicated ongoing spawning activity between the years of 2006 and 2013. -Same is true for lithophilic and invasive species in the Detroit.	Not impaired
Hunter, R. D., Roseman, E. F., Sard, N. M., DeBruyne, R. L., Wang, J., and Scribner, K. T. (2020). Genetic family reconstruction characterizes Lake Sturgeon use of newly constructed spawning habitat and larval dispersal. Transactions of the American Fisheries Society, 149(3), 266-283.	Number of spawners contributing to DR populations per spawning site	Egg mats and larval D-frame nets	-Sturgeon spawned at more than one site in a given spawning season. -Across all reefs, estimates of number of spawners were 151 in 2015 and 208 in 2016. -Analysis showed that recruited offspring were from >50 adult Sturgeon at all sites in all years. -Results showed sufficient Sturgeon spawning at multiple spawning sites over the reproductive period to mitigate depensatory effects.	Not impaired
Welsh, A., Hill, T., Quinlan, H., Robinson, C., and May, B. 2008. Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. North American Journal of Fisheries Management, 28(2), 572-591.	Genetic diversity of Great Lakes Sturgeon populations	Used 13 microsatellite loci to analyze 27 Great Lake Sturgeon populations	-Average heterozygosity score of 0.56, which was consistent with those observed in other freshwater fish species. -Most Great Lakes Sturgeon spawning groups were genetically distinct; however, analysis did show little differentiation between DR and St. Clair River Sturgeon, indicating that these were likely reproductively distinct groups but had some interbreed between them.	Not impaired

Source	Topic	Approach	Major Findings	Fish population status
Sullivan, T. J., and Stepien, C. A. (2014). Genetic diversity and divergence of Yellow perch spawning populations across the Huron–Erie Corridor, from Lake Huron through western Lake Erie. *Journal of Great Lakes Research*, *40*, 101-109.	Yellow perch spawning groups and genetic diversity	Used microsatellite markers to differentiate between 7 spawning groups that use the HEC, Lake Huron and Western Lake Erie	-Evidence of spawning adult Yellow perch by capture over spawning grounds during spawning period. -Appreciable genetic diversity between the 7 spawning populations of Yellow perch in the SCDRS despite habitat loss, degradation and fragmentation. -Maintenance of these discrete spawning stocks despite hardships was indicative of sufficient continued spawning to support each population. -Yellow perch likely had site fidelity, little straying between sites, and potential kin recognition. With the addition of more spawning habitat as DR is restored, this will contribute to a very stable DR Yellow Perch population.	Not impaired
Haponski, A. E., and Stepien, C. A. (2014). Genetic connectivity and diversity of walleye (*Sander vitreus*) spawning groups in the Huron–Erie Corridor. *Journal of Great Lakes Research*, *40*, 89-100.	Walleye spawning groups and genetic diversity	Used microsatellite markers and MtDNA from walleye to differentiate between 7 spawning groups	- Evidence of spawning adult Walleye by capture over spawning grounds during spawning period. -Despite pollution and habitat destruction, historical Walleye spawning groups had remained discrete and conservations efforts should take this into consideration. -The fact that the 7 spawning groups remained discrete in the Huron Erie Corridor indicated these populations persisted through the degradation of the DR and showed no to low interbreeding between spawning populations. -The maintenance of these 7 spawning groups was indicative of sufficient continued spawning to support each population. -Figure 2. shows haplotypes from the 7 DR spawning groups.	Not impaired

Additional Sources of Information

Source	Topic	Approach	Major Findings	Fish population status
Kindree, M. M., and Mandrak, N. E. (2020). Fish Assemblage Survey of the Detroit and St. Clair rivers: 2007-2014. Department of Fisheries and Oceans Canada.	IBI of DR to assess fish assemblage	Electrofishing and benthic trawl at same sites DFO used in 1990 with DR stage 1 rap	-This report found IBI scores had not changed significantly in SCDRS between the 1990s and now. Some variation in species richness was noted. - "IBI scores in both rivers have remained low because of the large number of generalist and invasive species captured within each site. The proportion of specialist species required to indicate a healthy ecosystem is low compared to reference conditions". -IBI scores did not differ from another between 2007, 2011, and 2013 in the DR using the Hamilton and Edwards (p=0.547), and Minns (p=0.0501). This showed stability in the ecosystem. - One concern that could account for the differences in conclusion to other studies was the capture efficiency of boat electrofishing and benthic trawling and timing for the selected IBI metrics. These methods are not particularly good at capturing larger pelagic predators such as Walleye or large benthic species such as sturgeon, and sample timing missed runs of Lake whitefish into the DR for spawning).	Impaired

Source	Topic	Approach	Major Findings	Fish population status
Hunt, L. M., H. Ball, A. Ecclestone, and M. Wiebe. 2022. 2020 recreational fishing survey in Ontario: results for select fishing destinations Ontario Ministry of Natural Resources and Forestry; Science and Research Branch; Peterborough, ON. Science and Research Technical Report.	Ontario Recreational fishing survey	Mail in survey	-The fishing activity and total numbers of fish caught in the DR exceeded the St. Clair and Niagara Rivers. -Total catches in the DR were comparable to Lake Huron, despite over twice the fishing activity reported in the lake. -Walleye catches in the river exceed those seen in Lake St. Clair, Niagara River, East Basin of Lake Erie, Lake Huron, and the Bay of Quinte. -Yellow Perch catches were comparable to the St. Clair River, and Lake St. Clair. -Notable and strong Smallmouth and Largemouth Bass, Black Crappie. -report demonstrated beneficial use of river through recreational fishing.	Not impaired