

Fish Assemblage Survey of the Detroit and St. Clair Rivers: 2007-2014

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ABSTRACT

Kindree, M.M. and Mandrak, N.E. 2020. Fish Assemblage Survey of the Detroit and St. Clair rivers: 2007-2014. Can. Manuscr. Rep. Fish. Aquat. Sci. 3204: viii + 70 p.

Fisheries and Oceans Canada (DFO) conducted boat electrofishing surveys in the Detroit and St. Clair rivers Areas of Concern (AOC) in 2007, 2011-2014. In addition to boat electrofishing, benthic trawling surveys were included in the 2011 to 2014 sampling to determine if gear type bias IBI scores. Sampling sites along the Canadian portion of both AOCs were chosen to replicate Remedial Action Plan (RAP) sites during surveys conducted by the Ontario Ministry of Natural Resources in the 1990s. Implementation of RAPs required aquatic monitoring of AOCs using the Index of Biotic Integrity (IBI), a multimetric index for biological assessment. In this study, three methods of calculating the IBI; including Hamilton (1987), Edwards et al. (2006), and Minns et al. (1994), were applied to the fish community assemblage to examine annual variation, seasonal variation, and changes in the IBI scores relating to gear type. IBI scores in both rivers ranged from 'Very Poor' to 'Fair' showing no improvement from historical monitoring of these sites for all IBI calculation methods. A designation of 'Good' was only achieved when all sites are pooled, which removed site-specific changes in fish community composition and abundance. There was no significant difference found between annual IBIs in both rivers, although there were variations in site IBI between years. There were significant seasonal differences in the IBI scores within years but not among them in both rivers. Finally, the results revealed that the IBI was not sensitive to changes in gear type in both rivers due to varying catchability of species for each gear type.

RÉSUMÉ

Kindree, M.M. and Mandrak, N.E. 2020. Fish Assemblage Survey of the Detroit and St. Clair rivers: 2007-2014. Can. Manuscr. Rep. Fish. Aquat. Sci. 3204: viii + 70 p.

En 2007 et de 2011 à 2014, Pêches et Océans Canada (MPO) a mené des relevés par pêche à l'électricité à partir d'un bateau dans les secteurs préoccupants des rivières Détroit et Sainte-Claire. Des relevés par chalutage en zone benthique ont aussi été inclus dans les échantillonnages de 2011 à 2014 afin de déterminer si le type d'engin entraînait un biais dans l'indice de l'intégrité biotique. Les sites d'échantillonnage le long de la partie canadienne des deux secteurs préoccupants ont été choisis de façon à reproduire les sites du plan d'assainissement utilisés dans le cadre des relevés menés par le ministère des Richesses naturelles de l'Ontario dans les années 1990. La mise en œuvre de plans d'assainissement exige la surveillance aquatique des secteurs préoccupants à l'aide de l'indice de l'intégrité biotique, un indice multimétrique pour l'évaluation écologique. Dans la présente étude, trois méthodes de calcul de l'indice de l'intégrité biotique, à savoir celles dans Hamilton (1987), Edwards *et al.* (2006) et Minns *et al.* (1994), ont été appliquées aux assemblages des communautés de poissons afin d'étudier la variation annuelle, la variation saisonnière et les changements dans l'indice de l'intégrité biotique liés au type d'engins. L'indice de l'intégrité biotique dans les deux rivières variait de « très faible » à « passable », et n'affichait aucune amélioration par rapport à la surveillance historique de ces sites selon toutes les méthodes de calcul de l'indice de l'intégrité biotique. La désignation de « bon » est seulement obtenue lorsque tous les sites sont regroupés, de sorte à éliminer les changements propres au site dans la composition et l'abondance des communautés de poissons. Aucune différence importante n'a été relevée entre les indices annuels de l'intégrité biotique des deux rivières, bien qu'il y ait des écarts dans l'indice de l'intégrité biotique de chaque site d'une année à l'autre. Pour les deux rivières, il existe des différences saisonnières importantes dans les indices de l'intégrité biotique au cours d'une année donnée, mais pas d'une année à l'autre. Finalement, les résultats révèlent que l'indice de l'intégrité biotique n'est pas sensible aux changements du type d'engin dans les deux rivières, compte tenu de la capturabilité variable des espèces pour chaque type d'engin.

INTRODUCTION

The Great Lakes Water Quality Agreement (GLWQA), signed in 1972, is a binational agreement between Canada and the United States aimed at resolving water-quality issues involving the Great Lakes and the international portion of the St. Lawrence River (IJC 1987). Encompassing an area of 245,000 km², the Laurentian Great Lakes support important fish and wildlife habitat and the economy of both Canada and the United States through agriculture, commercial fisheries, recreation, and industries. This area has a large intrinsic and extrinsic value that requires a high level of ecological protection. The 2012 amendment of the GLWQA by the International Joint Commission (IJC) identified 43 Areas of Concern (AOC) within the Great Lakes basin, including 12 in Canada and five shared binationally (IJC 2005). AOCs are geographic areas that have suffered degradation that impairs the ability to provide beneficial uses, such as supporting aquatic life (IJC 2005). The GLWQA Annex 1 was designed to focus remedial and restoration efforts at specific locations within the Great Lakes basin that exhibit severely degraded habitats. This was to create site-specific management and conservation strategies based on the beneficial-use impairment (BUI) targets that contributed to the degradation of the ecosystems. BUIs were defined as an impairment of an environmental feature such as public beaches, drinking water, or fish and wildlife populations that relate to economic, sociological, and recreational benefits to society (Edwards et al. 2007; MacLennan and Hyatt 1996). Among the 14 BUIs, five directly refer to fishes: restrictions on consumption, tainting, degradation to habitat, reduction of populations, tumors and other deformities, and loss of habitat (Minns et al. 1994).

The St. Clair and Detroit rivers, two rivers within the Huron-Erie Corridor (HEC), were identified as AOCs under the 1987 amendment of the GLWQA due to the identification of nine and 11 BUIs, respectively (Hartig 2003; Green et al. 2010). In both rivers, loss of fish and wildlife habitat was identified as a concern due to the development of large industries and use as shipping channels, causing the shorelines and riverbeds to have been altered (Dutz 1998). Population growth has also led to an increase in sewage outflows into the rivers. The combination of habitat loss and influx of deleterious substances has led to a decline in species richness and abundance (Granados 2010). Programs have been implemented in both rivers to facilitate recovery, such as remedial action plans (RAP) and the Great Lakes Action Plan (GLAP) under Annex 2 of the 1987 GLWQA Protocol. Habitat-recovery studies in the Great Lakes AOCs after the implementation of RAP adopted an ecosystem approach that directly measured the biological community as a proxy for habitat condition (Minns et al. 1994). This was accomplished using a multimetric IBI score over multiple sampling periods to evaluate changes in response to RAPs (Granados 2010).

Prior to this study, Index of Biotic Integrity (IBI) scores for both the Detroit and St. Clair rivers were calculated using fish catch data based on boat electrofishing techniques conventionally employed across all AOCs. Boat electrofishing surveys in 1990, 2003, and 2004 were used to calculate IBI scores in the Detroit River (Edwards et al. 2007). Boat electrofishing surveys in the St. Clair River were conducted in 1994 and 2004 (Edwards et al. 2006). Despite implementation of habitat improvement programs (Mayne 2006; Granados 2010), the IBI did not change in St. Clair and Detroit River AOCs (Edwards et al. 2007; Granados 2010). The HEC AOCs are very large rivers with significant amounts of habitat that are not suitable for boat electrofishing (e.g., >3 m deep, fast current); therefore, using only boat electrofishing may bias the fish community

data used in the calculation of the IBI. To examine potential bias in sampling methods, DFO conducted a fish community survey including boat electrofishing (2007, 2011-2014) and benthic trawls (2011-2014) in both rivers. Therefore, a primary objective of this study was to assess the changes in fish assemblage and the influence of seasonality and gear type on the IBI.

Given the importance of the IBI in determining ecological health of AOCs, which are an important criterion of delisting BUIs, evaluating the influence of gear type on the IBI scores is critical. As shown in previous studies, each gear type has inherent selectivity and bias when sampling nonwadeable rivers (Neebling and Quist 2011). These biases may result in different IBI scores, which influence the perception of ecological health of AOCs. As such, the objective of this research is to determine how the use of different gear types to sample the fish community will affect the IBI score for sties in the Detroit and St. Clair rivers. It is hypothesized that gear selectivity and bias in community sampling will influence the resulting IBI score (Jackson and Harvey 1997). Understanding how gear and seasonality influences IBI scores is imperative to quantitatively describing the impact on composition and abundance of the fishes captured in a given habitat.

METHODS

Site selection

As part of the Remedial Action Plan, DFO conducted monitoring of the fish communities at Canadian sites in the Detroit and St. Clair rivers. Six sites sampled on the Canadian side of the Detroit River during the 1990 Ontario Ministry of Natural Resources and Forestry (OMNRF) RAP fish survey were resampled in 2007, 2011, and 2013 (Appendix 1). In 2007, sites were sampled during May, July, and September. In 2011, sites were sampled in July, August, September, and October. These sites were re-sampled in July, August, October, and November 2013. Eight sites on the St. Clair River surveyed during the 1994 RAP survey by OMNRF were re-sampled in 2007, 2012 and 2014 (Appendix 2). In 2007, sites were sampled in May, July, August, and September. In 2012, fish surveys were conducted in July, August, and October. Community surveys in 2014 only occurred during July and August. The sampling dates of surveys, which represent summer and fall sampling periods, were chosen to examine the influence of seasonality on IBI scores. In 2007, a spring sampling period was also implemented. During the 2011 to 2014 sampling periods, benthic trawls were used to survey the fish community in addition to boat electrofishing. Each site on both rivers was one kilometer in length separated into ten 100 m transects. Species richness and abundance from each transect were pooled to calculate IBI scores for each site. All sampling was performed between the hours of 08:00 and 16:00. Site maps for the Detroit and St. Clair AOCs are found in Figure 1 and 2, respectively.

Collection of fishes

Electrofishing was conducted using a 6.35 m Model SR-20 Smith-Root dual-boom electrofishing boat, equipped with a 7.5 kW Smith-Root generator, and a 7.5 GPP control box with two foot pedals and three kick plates. Sampling data collected at each site included site coordinates, capture method, sampling effort, and electrofishing settings. Two netters retrieved stunned fishes and all captured fishes were held within a 300 l live-well. Captured fishes were identified, counted, and released. Minimum and maximum

lengths were recorded for each species at each sampling location. A subset of fishes were kept as voucher specimens for subsequent laboratory verification. For larger specimens, a photo voucher was taken.

Benthic trawl surveys for each site were conducted using a mini-Missouri Trawl. The Missouri Trawl is a dual-mesh trawl which has a 2.4 m head rope and 3.7 m foot rope. The entire trawl is 4.4 m in length. The internal mesh is 19 mm bar mesh and the outer mesh is 3 mm delta heavy-duty mesh (Guy et al. 2009). Trawls were deployed from the bow of the survey vessel while travelling downstream in reverse. Each trawl was towed the entire distance of the 100 m survey transect. Trawling speeds were maintained at approximately 2 km/h. Towlines for the trawl were set according to transect depth following the general rule of seven metres of towline for each metre of water depth (Guy et al. 2009). Captured fishes were processed and vouchered retained using the same methods as the electrofishing surveys.

Habitat assessment

Habitat was assessed at each of the sites sampled in 2007, 2011-2014 and was collected upon the completion of fish collection at each transect by a designated habitat survey vessel. The following habitat characteristics were collected at the mid-point of each 100 m transect, air temperature (°C), water temperature (°C), conductivity (µS), dissolved oxygen (mg/L), pH, turbidity (ntu), and wind speed (km/h). The water chemistry variables and water temperature were collected using an EXO2 multi-parameter sonde. Wind speed was collected using a Kestrel 2000.

Dominate floodplain use, channel cover, bank slope, and aquatic vegetation were collected by summarizing the habitat characteristics of the entire transect. Channel cover is a percentage of the transect that is covered by riparian vegetation. Bank slope is a percentage, with 90° equalling 100%. Finally, aquatic vegetation is a percentage observed of emergent, floating, submerged aquatic vegetation and open water.

Finally, substrate, stream depth, and water velocity were measured at the beginning, midpoint, and end of each transect. Substrate was collected by a ponar grab and combined from each collection location in the transect. The percentage of each substrate type (organic, clay, silt, sand, gravel, cobble, boulder, bedrock, hardpan, rubble, concrete, unknown, and none) was recorded. The survey vessel was anchored, and stream depth was measured using depth sounder and water velocity was measured with a Swoffer Model 2100 Current Velocity Meter.

Index of biotic integrity

To examine how different scoring methods influence the IBI, the IBI scores for each of the Detroit and St. Clair AOC sites were calculated using three different methods: Hamilton's (1987) adaptation of Karr (1981) IBI (Appendix 3); Edwards et al. (2006) adaptation of Hamilton's (1987) IBI (Appendix 4); and Minns et al. (1994) method (Appendix 5). For convenience, these methods henceforth will be referred to as the Hamilton, Edwards, and Minns IBI or method. The Hamilton IBI utilizes eight metrics divided into three categories: species richness and composition; trophic composition; and fish abundance and health. Metrics are assigned an integer score of 0, 1, 3, or 5 according to defined ranges and thresholds of each metric. The trophic guild classification for each method was determined using the Coker et al. (2001)

classification system (Table 1). Fish species were classified as generalist, specialists, or piscivores based on the number of high-preference food items. Each metric is summed and given a narrative rank from no fish (0) to excellent (score or 37-40, where 40 is the maximum score). The Edwards IBI adaptation of the Hamilton method includes only native naturally spawned salmonids and coregonine species, which down-weights the influence of non-native species.

The Minns IBI is a continuous scoring system that reduces the variance of individual metric values. This method includes 12 metrics, eight positive metrics and four negative metrics. Fish species were identified as intolerant, or sensitive, species based on Mandrak and Bouvier (2014). The metrics used in this method contribute equally to the summed IBI score of 0-100. Raw metrics (M_R) are converted to a standardized metric (M_S) using Equation 1.

$$M_S = A + B \cdot M_R \quad (\text{Equation 1})$$

Where, A is the intercept and B is the slope delineated by the minimum and maximum values of the raw metric (M_R). The minimum and maximum threshold of each metric define the bottom and top threshold of the standardized metric. The bottom should be a zero value for positive metrics and the top is the 95th percentile of the dataset. When A is high value and B is a negative number a negative function exists where large raw metric values indicates low biotic integrity, which produces a low standardized metric score. Once all standardized metric scores are calculated, the standardized metrics are summed and multiplied by 10/N, where N is the number of metrics, to produce an IBI score between 0 and 100. The Minns method assumes that there is an acceptable reference condition to standardize the raw metrics. No acceptable reference condition exists for the Detroit and St. Clair rivers because of long-term anthropogenic disturbances throughout the Great Lakes basin. Therefore, a best professional judgement list of species that should be present in the HEC was used to determine a species-composition reference condition (Appendix 6). Granados (2010) created a database of species composition based on eight experts with knowledge of the fish community in the HEC. IBI scores were calculated for species agreements of ≥ 2 , ≥ 3 , and ≥ 4 respondents and averaged to produce an overall Minns IBI score.

Length-to-biomass transformations

The Minns method requires biomass measurements to calculate four metrics. The data collected during field surveys only included fish lengths; therefore, it was necessary to transform the length (mm) to biomass (g) for each fish species at each site. A geometric mean of the minimum and maximum length of each species at each site was calculated. Length-to-biomass transformations were calculated using Equation 2.

$$X = a + b \cdot L \quad (\text{Equation 2})$$

Where, X is the weight, a is the intercept, b is the slope, and L is length. The calculated weight (X) was then multiplied by species abundance at each site. Intercept and slope values were compiled from Coker et al. (2001), Fishbase (Froese and Pauly 2015), and Schneider et al. (2000) (Appendix 7). If no a and b coefficients were available in the literature, values from the most closely related species were used (e.g., shared genus, then family, and so on). Fishes were measured using total length; therefore length-to-

biomass equations using standard length required the geometric mean length to be transformed to standard length using Equation 3 (n=15 species).

$$SL = a + b \cdot TL \quad (\text{Equation 3})$$

Where, SL is the calculated standard length, a is the intercept, b is the slope, and TL is geometric mean of the total length. Coefficient values a and b for the standard length to total length values and their transformation are listed in Appendix 8.

Statistical analysis

IBI scores were calculated for each year, season, and gear type to assess changes in the fish community under different sampling scenarios. These data were tested for normality at each comparison level using the Shapiro-Wilk test. Data were considered to be normal above an alpha value of 0.05. All comparisons and analysis of variance statistics were tested using the Bonferroni significance level of $\alpha'=0.01$ to account for multiple comparisons of the same dataset. Parametric IBI score groupings with two variables were tested for significant differences using a paired t-test. Non-parametric IBI score groupings with two variables were tested for significant differences using a paired Mann-Whitney U test. Normally distributed IBI score groupings with more than two variables were tested for significance using a repeated-measures ANOVA. IBI score and groupings not normally distributed with greater than two variables were tested for significant differences using a Friedman Rank-Sum test. To test for differences between the Hamilton, Edwards, and Minns IBI, a two-factor repeated-measures ANOVA was used.

RESULTS

Sampling results

A total of 64 and 72 sites were included in the analyses for the Detroit and St. Clair rivers, respectively. A combined total of 73 species were collected within both rivers over all sampling years and seasons.

Electrofishing effort

In the Detroit River, there was large disparity in electrofishing effort expended in each sampling season. Effort was highest in 2007 with 841.9 minutes sampled, while in 2011 and 2013 total effort was 393.7 and 260.1 minutes, respectively (Table 2). Mean effort per site was also not comparable between all sampling years with 2004 having the largest mean effort (140.3 minutes) and 2013 having the lowest (43.3 minutes). The mean catch per unit effort (CPUE) for 2007, 2011, and 2013 was 3.98, 12.55, and 7.70, respectively. The mean CPUE was highest in fall 2011 with 16.75 fishes captured per minute of sampling effort. Individual site CPUE for each year and season are summarized in Appendix 9 and a summary of sampling effort is found in Appendix 10.

In the St. Clair River, total electrofishing effort between sampling periods ranged from 164.97 to 866.07 minutes (Table 3). Total sampling effort was highest in 2007 and lowest in 2014, which is attributed to the single sampling season (Table 3). Mean effort

per site was also highest in 2007 (108.26 minutes), then 2012 (51.30 minutes) and 2014 (20.62 minutes). Mean CPUE was highest in fall 2012 with 6.45 fish per minute sampled. Individual site CPUE for each year and season are summarized in Appendix 9 and a summary of total sampling effort at each site is found in Appendix 11.

Detroit River

Six sites in the Detroit River were sampled during summer and fall in 2007, 2011, and 2013. An additional spring sampling season was completed in 2007. In 2013, trawling surveys of site 5 were not completed because of several large obstructions (i.e. pilings, submerged docks) had made trawling hazardous at this site. A total of 23,532 individuals across 60 species were captured across sampling years in the Detroit River (Table 4). The highest number of fishes were captured in 2011 during summer and fall combined (n=11,528) and the lowest number captured in 2007, with spring, summer, and fall sampling seasons combined (n=3,308) (Table 4). The mean number of fishes per site was lowest in 2013 using boat electrofishing (n=168) and highest in 2011 using benthic trawls (n=549.7) (Table 4). The species richness of each sampling year and season are displayed in Table 5 with the highest number of species captured in summer 2011 (n=42) and the lowest number captured in spring 2007 (n=22). No unique species were captured in spring 2007 and summer 2013 (Table 5). Four unique species were captured in summer 2013, which was the highest number of unique species captured among all sampling periods (Table 5). Of the 60 total species captured 14 were common across all sampling periods (Table 5).

In 2011 and 2013, benthic trawling was included to assess the biases introduced by gear type. During this period, boat electrofishing captured 34% (n=6,948) of the total individuals caught in the Detroit River and 90% of the biomass (Table 6). The most abundant species captured using boat electrofishing were Gizzard Shad (*Dorosoma cepedianum*) (n=2,266) and Emerald Shiner (*Notropis atherinoides*) (n=2,230). Forty species were captured using boat electrofishing in the Detroit River and 11 species were unique to this gear type. Those species included Bigmouth Buffalo (*Ictiobus cyprinellus*), Bowfin (*Amia calva*), Cisco (*Coregonus artedii*), Common Shiner (*Luxilus cornutus*), Goldfish (*Carassius auratus*), Goldfish X Common Carp hybrid (*Carassius auratus* X *Cyprinus carpio*), Sand Shiner (*Notropis stramineus*), Spotfin Shiner (*Cyprinella spiloptera*), Striped Shiner (*Luxilus chrysocephalus*), and Yellow Bullhead (*Ameiurus natalis*). Benthic trawl surveys in the Detroit River captured 66% of the total individuals in 2011 and 2013 sampling periods but only 10% of the biomass. The most abundant species captured using trawls were Round Goby (*Neogobius melanostomus*) (n=2,873) and Mimic Shiner (*Notropis volucellus*) (n=2,426). Benthic trawling captured 14 unique species including Banded Killifish (*Fundulus diaphanus*), Channel Catfish (*Ictalurus punctatus*), Channel Darter (*Percina copelandi*), Eastern Sand Darter (*Ammocrypta pellucida*), Green Sunfish (*Lepomis cyanellus*), Johnny Darter (*Etheostoma nigrum*), Least Darter (*Etheostoma microperca*), Northern Madtom (*Noturus stigmosus*), Orangespotted Sunfish (*Lepomis humilis*), Pugnose Shiner (*Notropis anogenus*), Rainbow Darter (*Etheostoma caeruleum*), Round Goby, Tubenose Goby (*Proterorhinus semilunaris*), and White Sucker (*Catostomus commersonii*). The species richness and trophic structure metrics used to calculate the IBI scores are summarized in Table 6. There was a higher percentage of native species and cyprinids captured using boat electrofishing (96.5% and 42.4%, respectively). Benthic trawling captured a higher number of percid species, specialists, and a higher percentage of centrarchid species (7, 14, and 22.1%, respectively). However, benthic trawling resulted in 23.4% more of the

total catch being composed of nonindigenous species compared to boat electrofishing (Table 6).

In 2007, the Hamilton and Edwards IBI scores were the same because no non-native salmonids were captured during this sampling year. Site 1 (29, Fair) had the highest IBI score using the Hamilton and Edwards IBI, while site 3 had the lowest with a score of 17 (Very Poor to Poor) (Figure 3, Table 7). In 2007, using the Minns IBI, site 5 had the lowest IBI score (39, Poor) and site 1 (48, Fair) had the highest IBI score (Figure 3, Table 7). IBI scores were also calculated for each season in 2007. In spring, using the Hamilton and Edwards methods, sites 1 and 3 were tied for the lowest IBI score among seasons with a score of 13 (Very Poor) (Figure 4, Table 8). Fall Site 5 had the highest IBI score between all seasons using the Hamilton and Edwards et al. methods with a score of 29 (Fair) (Table 8). Using the Minns IBI, summer site 5 (30, Poor) and fall site 5 (60, Fair) had the highest and lowest IBI scores, respectively (Figure 4, Table 8).

In 2011, the Hamilton and Edwards IBI yielded the same scores because of the absence of non-native salmonid species. Within 2011 scores, site 1 (19, Poor) had the lowest IBI score while site 5 (25, Fair) had the highest score (Figure 3, Table 7). However, when calculated using the Minns IBI, site 2 (55, Fair) had the highest IBI score and site 4 (39, Poor) had the lowest IBI score (Figure 3, Table 7). When IBI scores were calculated for each season within 2011 using the Hamilton and Edwards methods, summer site 4 and 5 (19, Poor) had the lowest score, while fall site 5 had the highest score (29, Fair) (Table 8). For the Minns method, site 4 (31, Poor) had the lowest IBI score, while site 2 had the highest (59, Fair) (Figure 4, Table 8).

In 2013 the Hamilton and Edwards IBI yielded the same scores because of the absence of non-native salmonid species. Site 5 yielded the lowest Hamilton and Edwards IBI score with 15 (Very Poor), and site 6 had the highest score (26, Fair) (Figure 3, Table 7). Using the Minns method, site 4 produced the lowest IBI score (41, Fair) and site 5 had the highest (55, Fair) (Figure 3, Table 7). Summer site 5, fall site 1, and fall site 5 tied for the lowest IBI score of 15 (Very Poor), while fall site 6 had the highest IBI score of 25 (Fair) when calculated with the Hamilton and Edwards methods (Figure 4, Table 8). The Minns method, site 1 produced the lowest IBI score (34, Poor) and site 5 had the highest IBI scores (48, Fair) (Figure 4, Table 8).

Generally, the largest decline in the IBI score occurred in site 1 that decreased from 29 (Fair) in 2007 to 17 (Very Poor) in 2013; this was a result of a low species richness and a small CPUE ratio. All sites within the Detroit River were categorized as “Very Poor”, “Poor”, or “Fair” for all methods, except the sites pooled in 2011 using the Minns method had a categorization of “Good” (Figure 3, Table 7). There were no notably large decreases or increases in the Minns IBI scores over time although on average, 2011 had a higher score as a result of lower nonindigenous individuals captured and total biomass.

The boat electrofishing and benthic trawling IBI scores are summarized in Table 9 and 10. Between 2011 and 2013, 2014 using the Hamilton and Edwards IBI methods, the boat electrofishing surveys had the lowest pooled IBI score between sites (20, Poor) while boat electrofishing surveys in 2011 had the highest score (25, Fair) (Figure 5, Table 9). The lowest mean IBI score for the Minns method was 2013 trawling surveys (56, Fair), while 2013 boat electrofishing had the highest score (60, Fair). Between

seasons, fall boat electrofishing surveys had the highest IBI score across all three methods (Hamilton and Edwards: 28, Fair; Minns: 63, Good) (Figure 6, Table 10).

St. Clair River

Eight sites in the St. Clair River were sampled during summer and fall in 2007 and 2012, while 2014 was only sampled in summer. In 2007, there was an additional spring sampling season. A total of 18,692 fishes were captured across 52 species in the St. Clair River (Table 11). The highest number of fish were captured in 2012 (summer and fall combined) with 11,592 fishes recorded. The lowest number of fish were captured in 2007 (spring, summer, and fall pooled) with 2,194 fishes caught (Table 11). Benthic trawling in 2014 resulted in the lowest mean number of fishes captured ($n=48.8$), while benthic trawls in 2014 resulting in the highest ($n=567.5$) (Table 11). Species richness for each sampling year and season are displayed in Table 12. The highest number of species were captured in summer of 2012 with 37 species, and spring 2007 had the lowest species richness ($n=14$). Of the 52 species captured, there were eight species common among all sampling periods in the St. Clair River (Table 12). There were no unique species captured in spring 2007 and summer 2014, with summer 2014 having the largest number of unique species captured ($n=7$).

A total of 16,497 individuals across 47 species were captured during 2012 and 2014 between both sampling gears (Table 13). Using boat electrofishing, 13.7% ($n=2,258$) of the total individuals caught were captured encompassing 94% of the biomass. The most abundant species captured with this gear type were Yellow Perch ($n=613$) and Emerald Shiner ($n=571$). Thirty-four species were captured using boat electrofishing including 12 unique species: Gizzard Shad, Bowfin, Brook Silverside (*Culaea inconstans*), Common Carp (*Cyprinus carpio*), Freshwater Drum (*Aplodinotus grunniens*), Golden Redhorse (*Moxostoma erythrurum*), Longnose Gar (*Lepisosteus osseus*), Muskellunge (*Esox masquinongy*), Pumpkinseed (*Lepomis gibbosus*), Rainbow Trout (*Oncorhynchus mykiss*), Silver Lamprey (*Ichthyomyzon unicuspis*), and Spotted Sucker (*Minytrema melanops*). Benthic trawl surveys captured 86.3% ($n=14,240$) of the total individuals captured while only representing 6% of the total biomass. The most abundant species captured using the benthic trawl were Round Goby ($n=6,350$) and Hornyhead Chub (*Nocomis biguttatus*) ($n=1,924$). Thirteen unique species were caught using the benthic trawl including Black Crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), Brook Silverside, Channel Catfish, Channel Darter, Creek Chub (*Semotilus atromaculatus*), Iowa Darter (*Etheostoma exile*), Mottled Sculpin (*Cottus bairdii*), Northern Madtom, Pugnose Shiner, Rainbow Smelt (*Osmerus mordax*), Slimy Sculpin (*Cottus cognatus*), and Threespine Stickleback (*Gasterosteus aculeatus*). The species richness and trophic structure metrics used to calculate the IBI scores are summarized in Table 12 and 13, respectively. Boat electrofishing captured a higher percentage of native individuals (96.9%) and the only salmonid species (Rainbow Trout) collected in the St. Clair River. Benthic trawling surveys collected 30 native species and only 5 nonindigenous species; however, the abundance of each group was almost equal due to a high abundance of Round Goby captured. There was a high percentage of generalist species captured with electrofishing and benthic trawling, respectively (52.1% and 88.4%, respectively; Table 13).

IBI scores calculated in 2007 for the St. Clair River using the Hamilton and Edwards methods did not differ because all underlying metric values were equal (Figure 7, Table 14). During this period, site 6 had the lowest IBI score of 15 (Very Poor) and site 3 and 4

were tied for the highest score of 23 (Poor) (Figure 7, Table 14). Site 6 also had the lowest IBI score when calculated using the Minns. (1994) method (19, Very Poor). Site 4 also resulted in the highest Minns IBI score of 44 (Fair) (Figure 7, Table 14). In spring, using the Hamilton and Edwards methods, site 2 had the lowest IBI score (8, Very Poor), while summer site 8 had the highest IBI score (27, Fair) (Figure 8, Table 15). Using the Minns method, fall site 3 and summer site 6 had the highest and lowest scores, respectively (56, Fair and 13, Very Poor) (Figure 8, Table 15).

In 2012, the Hamilton and Edwards IBI scores in sites 1 and 4 were different by a value of 1 with the Edwards method resulting in the lower score (Figure 7, Table 14). For all calculation methods in 2012, site 2 resulted in the lowest IBI score (15, Very Poor and 27, Poor), while site 3 resulted in the highest (23, Poor, and 53, Fair). Between seasons, using all methods, fall site 8 had the lowest IBI score (15, Very Poor) (Figure 8, Table 15). For the Hamilton and Edwards methods, summer site 5 and fall site 3 were tied for the highest IBI score of 23 (Poor), while site 3 had the highest score of 60 (Fair) based on the Minns method (Figure 8, Table 15).

The St. Clair River was only sampled in the summer season of 2014. The IBI scores calculated with the Hamilton and Edwards methods did not differ during this period due to no salmonid species being captured. Using those methods, Site 4 and 6 were equivalent, having the lowest score of 15 (Very Poor), while Site 2 had the highest score (21, Poor) (Figures 7 and 8, Tables 14 and 15). Using the Minns methods Site 1 and Site 6 had the lowest and highest scores, respectively (Figures 7 and 8, Tables 14 and 15).

Generally, scores for the St. Clair River surveys from the Hamilton and Edwards methods ranged from 15 to 23 (Figure 7), all the scores were categorized as “Very Poor” or “Poor”. The Hamilton and Edwards IBI scores were not equal in the St. Clair River because a Rainbow Trout captured in Site 1 and 4 in 2012 reduced the metric score of “native naturally-spawned salmonid species present in the area” (Appendix 3 and 4). The Minns IBI scores ranged from 27 to 58 (Poor to Fair) (Figure 7, Table 14).

During the sampling periods of 2012 and 2014, benthic trawling was also conducted. The boat electrofishing and benthic trawling IBI scores are summarized in Table 16 and 17. Between annual sampling periods, using the Hamilton and Edwards methods, the 2014 boat electrofishing survey site 2 had the lowest IBI score (8, Very Poor), while 2012 boat electrofishing site 7 had the highest IBI score (29, Fair) (Figure 9, Table 16). The lowest IBI score using the Minns method was at site 8 during the 2014 trawling surveys (16, Very Poor), while the highest IBI score was at the 2012 boat electrofishing site 7 and 2014 sites 6 and 8 (50, Fair) (Figure 9, Table 16). Between seasons, boat electrofishing resulted in equal (Minns, summer) or higher IBI scores across all three methods (Figure 10, Table 17).

Statistical analysis

Inter-annual IBI

The IBI scores did not differ from another between 2007, 2011, and 2013 in the Detroit River using the Hamilton and Edwards ($p=0.547$), and Minns ($p=0.0501$) methods at the revised alpha-level 0.01 (Figure 3). Similarly, the IBI scores in the St. Clair River did not differ from each between sampling years using all three methods (Hamilton, $p=0.257$; Edwards, $p=0.277$; Minns, $p=0.135$) (Figure 4). While there was no significant difference

between annual IBI scores in the Detroit and St. Clair rivers, however, there was variation in the site IBI scores between years when the IBI was calculated using all three methods (Figures 3-7). In the Detroit River, the scores for all sites ranged from 15 to 25 and decreases from 2007 to 2013 when calculated using the Hamilton (1987) and Edwards et al. (2006) methods (Figure 3, Table 7).

Seasonal IBI

Seasonal differences within years was also tested, there was no significant difference between spring, summer, and fall surveys in the Detroit 2007 sampling at the revised alpha-level 0.01 (Hamilton and Edwards $p=0.449$, Minns $p=0.034$) (Figure 5). Additionally, there were no significant difference between summer and fall sampling seasons in 2011 and 2013 when IBI scores are calculated using the Hamilton and Edwards IBI methods ($p=0.118$ and $p=0.311$, respectively). However, there was a significant difference in Minns IBI scores between summer and fall in 2011 ($p=0.004$) but not in 2013 ($p=0.241$).

In the St. Clair River within years, there was a significant difference between spring and summer in 2007 using the Hamilton and Edwards ($p=0.026$, $p=0.009$, respectively) (Figure 5). No significant difference was found when 2007 IBIs were calculated using the Minns method ($p=0.137$). There were no seasonal differences in 2012 using all methods (Hamilton, $p=0.321$; Edwards, $p=0.321$; Minns, $p=0.126$). In 2014, fish surveys only occurred in summer, therefore no seasonal comparison can be made.

Differences among seasons in each year were tested for significance in the Detroit River (2007, 2011, and 2013) and the St. Clair River (2007 and 2012). In the Detroit River, between years there was no significant difference between seasons calculated using the Hamilton, Edwards and Minns methods ($p>0.01$). No significant difference was found between seasons among all years using all methods in the St. Clair River ($p>0.01$).

Gear type IBI

Benthic trawling and boat electrofishing surveys were conducted in the Detroit River and St. Clair Rivers from 2011-2014 (Figure 7 and 8). In the Detroit and St. Clair rivers, there were no significant differences between boat electrofishing and benthic trawling surveys IBIs in each year for all methods ($p>0.1$). Similarly, there were no significant differences between gear types in each season ($p>0.01$) (Figure 9 and 10).

IBI calculation method

Three IBI calculation methods developed for Canadian rivers were used in the study. The IBI score differences between IBI calculation methods were determined at each level of analysis. To allow for comparisons between methods the Hamilton and Edwards IBI scores were rescaled to 100. In the Detroit River there was no significant difference between methods in annual IBI scores ($p=0.02$). While in the St. Clair River, the annual Hamilton and Edwards IBI scores were significantly different from the Minns scores in 2007 and 2014 ($p<0.001$). The difference in annual IBI scores in the St. Clair River was driven by the consistently lower Minns IBI.

The within year season IBI scores were compared to determine if calculation method resulted in a different IBI score. There was no difference in seasonal IBI scores between

all methods in each year ($p > 0.01$) (Figure 9). In the St. Clair River, there was a significant difference between methods for season IBI scores in each year ($p < 0.001$). Post-hoc analysis shows that summer IBI scores in 2007 and 2012 are different between Hamilton and Minns ($p < 0.001$) and Edwards and Minns ($p < 0.001$) methods.

In the Detroit River, there were no significant differences between gears sampled in each year for all methods (Hamilton and Edwards, $p = 0.428$; Minns, $p = 0.570$). Similarly, there were no significant differences between gear types in each season (Hamilton and Edwards $p = 0.082$, Minns $p = 0.310$). Finally, there were no significant differences found between gears in each season and year (Hamilton and Edwards, $p = 0.019$; Minns, $p = 0.191$). Finally, in the St. Clair, similar results were found. The IBI scores were not significantly different when calculated using each method for year and gear types (Hamilton and Edwards $p = 0.560$; Minns $p = 0.396$). Similarly, no significant differences were found between season and gear type for each method (Hamilton, $p = 0.768$, Edwards, $p = 0.170$; Minns, $p = 0.557$). Finally, there were no significant differences between any year, season, or gear type sampling period in the St. Clair River for each method of IBI calculation (Hamilton and Edwards, $p = 0.768$; Minns $p = 0.394$).

DISCUSSION

Inter-annual IBI comparison

IBI scores have not changed significantly in the HEC since monitoring of the fish community with IBIs began in 1990 (Edwards et al. 2006, 2007). This report shows the same trend, there have been no significant change in IBI scores over time. While there have been variations in species richness over time, those differences have not reflected in the IBI score. Surveys in the Detroit River in 2007 resulted in the highest species richness ($n = 43$), which can be attributed to the higher total effort as the total sampling effort in 2007 which was more than double the sampling effort in the 2011 and 2013 surveys (841.9 minutes vs. 393.7 and 260.1 minutes, respectively) (Table 2). While the larger sampling effort resulted in the largest richness among the Detroit River sampling periods, the mean CPUE for 2007 was the lowest (3.98 fish/minute). The increased species richness in 2007 cannot be explained by the increased number of sampling seasons as the spring season resulting in no unique species being captured during this season. Limited habitat data were collected in 2007, therefore, no habitat related conclusion for higher catch can be made. In the St. Clair River, sampling effort can explain the difference in total catch between years. In 2007 total effort was 866.07 minutes, while 2012 and 2014, total effort was 575.37 minutes and 164.97 minutes, respectively (Table 3). The total catch in each year follows the same general pattern of 2007 having the highest species richness (35) and total catch (2194 fishes) and 2014 having the lowest (species richness: 17, and total catch: 366) (Table 11).

Generally, the IBI scores decreased from 2007 to 2014. A lower annual IBI score in 2014 can be explained by the lower CPUE, with only one season being sampled compared to three in 2007 and two in 2012, although large CPUE does not always directly cause a higher IBI score as exhibited in the Detroit River. If CPUE is high, the number of nonindigenous species can have a negative effect on the IBI score. Overall, the 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 (Appendix 3, 4, and 6).

Seasonal IBI comparison

Seasonal movement of fishes in the Detroit and St. Clair rivers resulted in variations of species composition and richness. Spring sampling only occurred in 2007, resulting in the lowest abundance of fishes captured during this period, while total effort was comparable to sampling efforts in 2011 and 2013 sampling (Table 2). Excluding spring, the lowest number of fishes were captured in fall 2013 (999 fishes) and the highest number of fishes were captured in fall 2011 (3349, 30 species) (Table 11). When seasons are compared between years, summer and fall 2007 and 2011 sampling captured unique species (Summer 2007- Black Bullhead (*Ameiurus melas*), Burbot (*Lota lota*); Fall 2007- Blacknose Shiner (*Notropis heterolepis*), Quillback (*Carpionodes cyprinus*); Summer 2011- Green Sunfish, Least Darter, and Rainbow Darter; Fall 2011- Orangespotted sunfish) (Table 5). Sampling effort between seasons was comparable, with summer in 2007 having the largest total sampling effort of 384.5 minutes (Table 2). Sampling effort alone cannot explain the differences between season and number of fishes sampled. Fall 2011 had the highest CPUE (16.75 catch/min) but not the largest total sampling effort. Seasonal movement of fishes, such as Gizzard Shad and Emerald Shiner, caused the increase in abundances of individuals captured during fall, which is consistent with Scott and Crossman (1998), which reported that both species are known to aggregate near the shore in fall. These seasonal changes in certain species abundance and individual fish size can inflate the Minns IBI score, which includes biomass metrics as a measure of health.

There were significant seasonal differences between IBI scores within years in the Detroit and St. Clair rivers. In the Detroit River, there was no significant difference in the IBIs between summer and fall seasons based on Hamilton and Edwards methods (Figure 8), while there was a significant difference found in Minns IBI scores (Figure 9). Minns et al. IBI scores ranged from 34 (poor) to 72 (good). Fall IBI scores were consistently higher than those in summer. Seasonal fish movements in fall allowed for higher abundances and species richness to be observed in the fish community. The larger biomass of specialist and piscivore species, compared to summer, resulted in higher metric scores. In 2012, there was no significant difference between seasonal IBI scores, while there was a difference found in 2007 in the St. Clair River (Figure 8). The surveys in spring resulted in Hamilton and Edwards et al. IBI scores being significant different from summer and fall. IBI scores in spring ranged from 4 to 23 (very poor to poor), while summer and fall ranged from 15 to 27 (very poor to fair) and 13 to 25 (very poor and fair), respectively (Table 15). IBI scores for site 2 (8, very poor) and 5 (4, very poor) in spring have two of the lowest Hamilton and Edwards IBI scores. Summer and fall in 2007 are not significantly different from each other. Low CPUE in spring resulted in low abundances and species richness metrics in each IBI. When years are pooled and seasons are compared in the St. Clair, there was no significant difference in the Minns scores.

Between years, there was no significant difference in seasonal IBI scores in both rivers. while there are variations in CPUE and effort between years, the seasonal IBI scores are not significantly different. All sites were given a score of 'Very Poor' to 'Fair' with a IBI category of 'Good' only being achieved with all sites are pooled together thus masking any spatial differences in IBI scores within each river, which is not reasonable when

considering ecosystem health of a large river such as those sampled in this report. These results suggest even with seasonal and annual variations in the fish community, the Detroit and St. Clair rivers' ecosystem health is low.

Gear-Influenced variation in IBI scores

There is an inherent bias of each gear type with different species more likely to be caught by different gear types (Harris and Silveria 1999). When boat electrofishing and benthic trawling surveys were compared, it was found that there was no significant difference between IBI for either gear type in the Detroit and St. Clair rivers (Figure 5, 6, 9, 10). Gear selection is particularly important in areas that may be introducing bias into the fish assemblage dataset through limitations of the standard gear. Boat electrofishing and benthic trawling capture distinctly different subsets of the fish community; however, this was not reflected in the IBI scores of this study. Previous studies have shown that reliance on one method to consistently underestimate species richness in lentic habitats (Jackson and Harvey 1997). Therefore, it was important to determine the influence of gear type on IBI scores. Boat electrofishing was found to perform better than other gear types in large river systems (Mercado-Silva and Escandon-Sandoval 2008; Neebling and Quist 2011). Contrary to those results, benthic trawling in the Detroit River captured 64% of the total individuals and 86.3% in the St. Clair River, respectively. Trawl nets are not limited by depth however, they can be subject to obstructions, such as woody debris and boulders, that would influence their efficacy. Some sites in the Detroit River posed such difficulties; for example, site 5 could not be sampled with trawling techniques because of submerged obstructions. Mini-Missouri trawls have been shown to be effective at capturing small-bodied species in the lotic environment with a high percentage of rare fishes captured (Neebling and Quist 2011; Fischer and Quist 2014). Benthic fishes, such as darters, have been shown to have an increased abundance when trawling gear was used (Fischer and Quist 2014). In this study, trawling was more effective at capturing darter species than boat electrofishing. There was no significant difference in native cyprinids between boat electrofishing and benthic trawling, suggesting that there is not a high degree of gear selectivity for native cyprinids. A higher percentage of nonindigenous species were also captured using a benthic trawl in the Detroit and St. Clair rivers (Tables 6, 13). Round Goby was the most abundant species captured by trawling in both rivers, explaining the high percentage of nonindigenous species. Choice of gear type was also shown to be important depending on sampling season (Fischer and Quist 2014). It is unrealistic to assume that all species present will be captured using a combination of sampling gears, although it provides a more complete characterization of the fish assemblage (Fischer and Quist 2014). Using the Hamilton and Edwards methods, boat electrofishing captures contribute to a high metric value for specialists and percid species, whereas trawling results in a higher metric for species richness.

When using the Minns method, boat electrofishing captures had lower abundances of nonindigenous species, while trawling had high centrarchid species richness and low biomass of nonindigenous species. These differences in community composition do not significantly affect IBI scores because metrics that would have low scores in boat electrofishing will be high for trawling communities and vice versa. This would create a masking effect and the resulting IBI scores would not reflect the differences in the fish assemblage. When boat electrofishing and benthic trawl data were pooled, there was an increase in the IBI score indicating that a larger proportion of the fish assemblage was captured using two gears.

In some instances, a combination of boat electrofishing and benthic trawling provides a higher IBI score because of a more complete estimate of the fish assemblage. When designing protocols, and choosing fish sampling methods, there is a trade-off between logistics (time and cost) and the precision and accuracy required to answer research and management questions (Hughes and Peck 2008, Fischer and Quist 2014). Boat electrofishing is restricted to shallow (<3 m), clear, and slow-moving water. Even small changes to depth, turbidity, and flow can alter the catchability of species using boat electrofishing (Harris and Silveria 1999). Boat electrofishing is less efficient for smaller-bodied fishes and more efficient for large-bodied, mobile fishes (Gizzard Shad) (Fischer and Quist 2014). In the Detroit River, Gizzard Shad was the most abundant species caught by the boat electrofisher. Gammon and Simon (2000) proposed removing Gizzard Shad from their IBI calculations because of their highly fluctuating population levels, resulting in variable capture abundances. As Gizzard Shad is the most abundant species captured in the Detroit River sites, removal of this species would have an impact on abundance and trophic composition IBI metrics.

The Index of Biotic Integrity

The IBI can be a useful tool to assess the health of an ecosystem, if applied correctly. It provides a framework to standardize the results of fish sampling such that studies can be compared and data from equivalent reference sites can be used for large-scale analysis (De Kerckhove et al. 2008). Relevant metrics, which are neither confounding nor redundant, are required to create a useful IBI, allowing ecosystem health to be determined. While there is no objective method for determining the number and types of metrics that should be included when developing and applying the IBI, IBIs comprising more metrics are assumed to have greater utility (Angermeir and Karr 1986). A critical shortcoming of the IBI is that a single score representing the ecological condition of an area does not identify the cause of impairment, as they do not convey causal relationships (Bhagat et al. 2007). This shortcoming makes the interpretation difficult because of variable masking, as occurred in the gear analysis of this study.

In this study, three methods are used to calculate IBI scores for fish community data collected from the Detroit and St. Clair rivers. The Hamilton (1987) IBI method was modified from Karr (1981) to allow for comparison between Canadian Great Lakes AOCs. Edwards et al. (2006) further modified the Hamilton method to include only native naturally spawned salmonid species in the metric composition. The Minns (1994) IBI method was derived to assess the fish assemblage collected by electrofishing surveys in littoral habitats of the Great Lakes AOCs. Previous studies examined the effect of using the Hamilton and Edwards methods of IBI calculation and found similar results (Edwards et al. 2006, 2007). It was expected that Hamilton and Edwards methods would not be significantly different because they only differ by one metric, number of naturally spawned salmonid and coregonine species. Only one species of salmonid was captured during the entire sampling period resulting in IBI scores being affected only at a few sites. The Minns method is unique in that it uses a continuous scoring system from 0-10 for each metric instead of 0, 1, 3, and 5 like the Hamilton and Edwards methods. This method also required a reference condition to standardize each metric. There was a significant difference between methods, driven by the Minns IBI scores being consistently lower than Hamilton and Edwards IBIs. This could be caused by the way metrics are calculated with the reliance of scaling metrics from 0-10 based on a reference condition values. Since no suitable reference condition is available for the Detroit and St. Clair rivers, the reliance on best available information from queried

scientists is needed. This method of creating a reference condition for IBI calculations does introduce a wide range of biases. By averaging different levels of agreement between respondents, we can minimize but not eliminate these biases. The lack of a defined reference condition for the HEC could reduce the effectiveness of the Minns method when standardizing species richness metrics.

RECOMMENDATIONS

This study examined the annual and seasonal variation as well as the influence of gear type on the IBI; these results demonstrate that the IBI is not sensitive to species differences between gear types. Further research is needed to determine if IBI scores are the best method of determining habitat health from fish community surveys in the HEC. For example, future work in the HEC could include day and night sampling to capture fish diurnal movements and typically nocturnal species (Emery 1973). Gammon and Simon (2000) reported that natural variation, hydrological cycles, and chronic human-induced variations into the environment may influence the IBI scores through time. Future monitoring should include extensive habitat data collection to allow for comparison of the relationship between IBI scores and habitat quality criteria listed in the GLWQA. Alternatively, other methodologies should be considered to quantify ecosystem health for example, multivariate methods have been shown to be more sensitive to changes in the environmental health of a location based on the fish community (Adams and Ryon 1994; Granados 2010; Pinto and Maheshwari 2011). Additionally, the influence of gear type should be examined using multivariate analysis to incorporate habitat and fish data simultaneously for more meaningful descriptions of ecosystem health. In future, multivariate approaches should be considered as a viable substitute for multimetric indices as they overcome many shortcomings of the IBI discussed in this paper.

Finally, sampling large rivers while obtaining a representative sample of the fish community is a difficult task. A more appropriate method to assess ecosystem health within the Detroit and St. Clair rivers may involve the use of other taxa, such as benthic invertebrates, that are less mobile. Ideally biological monitoring programs would be based on an integrative approach that involved evaluating more than one major taxa, as suggested by Karr (1981) (Edwards et al. 2006).

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Table 1. Species assignments for all fishes captured in 2007, 2011 – 2014. Trophic classification: Spe- specialist; Gen- generalist Pis- piscivore (Coker et al. 2001); Intolerant species (from Mandrak and Bouvier 2014); Taxa: Cen- centrarchid; NatCyp- native cyprinid; Perc- percoid; Cor- native coregonine. See Appendix 6 for scientific names of all species.

Common name	Native?	Trophic classification	Intolerant?	Taxa
Alewife	N	Spe	Tolerant	
Banded Killifish	Y	Spe	Tolerant	
Bigmouth Buffalo	Y	Gen	Tolerant	
Black Bullhead	Y	Gen	Tolerant	
Black Crappie	Y	Pis	Tolerant	Cen
Bluegill	Y	Gen	Tolerant	Cen
Bluntnose Minnow	Y	Gen	Tolerant	NatCyp
Bowfin	Y	Pis	Tolerant	
Brook Silverside	Y	Spe	Tolerant	
Brook Stickleback	Y	Spe	Tolerant	
Brown Bullhead	Y	Gen	Tolerant	
Burbot	Y	Gen	Tolerant	
Channel Catfish	Y	Gen	Tolerant	
Channel Darter	Y	Spe	Sensitive	Perc
Cisco	Y	Spe	Sensitive	Cor
Common Carp	N	Gen	Tolerant	
Common Shiner	Y	Gen	Tolerant	NatCyp
Creek Chub	Y	Gen	Tolerant	NatCyp
Eastern Sand Darter	Y	Spe	Sensitive	Perc
Emerald Shiner	Y	Gen	Tolerant	NatCyp
Freshwater Drum	Y	Gen	Tolerant	
Gizzard Shad	Y	Spe	Tolerant	
Golden Redhorse	Y	Gen	Tolerant	
Golden Shiner	Y	Gen	Tolerant	NatCyp
Goldfish	N	Gen	Tolerant	
Goldfish X Common Carp	N	Gen	Tolerant	
Greater Redhorse	Y	Gen	Sensitive	
Green Sunfish	Y	Pis	Tolerant	Cen
Hornyhead Chub	Y	Gen	Sensitive	NatCyp
Iowa Darter	Y	Spe	Tolerant	Perc
Johnny Darter	Y	Spe	Tolerant	Perc
Largemouth Bass	Y	Pis	Tolerant	Cen
Least Darter	Y	Spe	Tolerant	Perc
Logperch	Y	Spe	Tolerant	Perc
Longnose Gar	Y	Pis	Tolerant	
Longnose Sucker	Y	Gen	Sensitive	
Mimic Shiner	Y	Gen	Tolerant	NatCyp

Common name	Native?	Trophic classification	Intolerant?	Taxa
Mottled Sculpin	Y	Gen	Sensitive	
Muskellunge	Y	Pis	Tolerant	
Northern Hogsucker	Y	Gen	Sensitive	
Northern Madtom	Y	Spe	Sensitive	
Northern Pike	Y	Pis	Tolerant	
Orangespotted Sunfish	N	Gen	Tolerant	Cen
Pugnose Shiner	Y	Spe	Sensitive	NatCyp
Pumpkinseed	Y	Gen	Tolerant	Cen
Quillback	Y	Gen	Tolerant	
Rainbow Darter	Y	Spe	Sensitive	Perc
Rainbow Smelt	N	Gen	Tolerant	Salm
Rainbow Trout	N	Pis	Sensitive	
River Redhorse	Y	Gen	Sensitive	
Rock Bass	Y	Gen	Tolerant	Cen
Round Goby	N	Gen	Tolerant	
Sand Shiner	Y	Spe	Tolerant	NatCyp
Shorthead Redhorse	Y	Gen	Tolerant	
Silver Lamprey	Y	Spe	Sensitive	
Silver Redhorse	Y	Gen	Tolerant	
Slimy Sculpin	Y	Gen	Sensitive	
Smallmouth Bass	Y	Pis	Tolerant	Cen
Spotfin Shiner	Y	Gen	Tolerant	NatCyp
Spottail Shiner	Y	Gen	Tolerant	NatCyp
Spotted Sucker	Y	Gen	Sensitive	
Striped Shiner	Y	Gen	Tolerant	NatCyp
Threespine Stickleback	N	Gen	Tolerant	
Trout-perch	Y	Spe	Sensitive	
Tubenose Goby	N	Spe	Tolerant	
Walleye	Y	Pis	Tolerant	Perc
White Bass	Y	Pis	Tolerant	
White Perch	N	Pis	Tolerant	
White Sucker	Y	Gen	Tolerant	
Yellow Bullhead	Y	Gen	Tolerant	
Yellow Perch	Y	Pis	Tolerant	Perc

Table 2. Summary of DFO boat-electrofishing effort on the Detroit River in 2007, 2011, and 2013 sampling seasons.

Sampling Effort	2007				2011			2013		
	Spring	Summer	Fall	Total	Summer	Fall	Total	Summer	Fall	Total
Mean CPUE (catch/min)	3.13	2.86	6.21	3.99	8.61	16.75	12.55	7.46	7.96	7.70
Mean effort/site	32.71	64.09	43.52	140.32	24.21	25.00	65.61	17.16	15.35	43.34
Total sampling effort (min)	196.25	384.53	261.13	841.92	193.65	200.00	393.67	137.28	122.78	260.07

Table 3. Summary of DFO boat-electrofishing effort on the St. Clair River in 2007, 2012, and 2014 sampling seasons.

Sampling Effort	2007				2012			2014
	Spring	Summer	Fall	Total	Summer	Fall	Total	Summer
Mean CPUE (catch/min)	3.53	2.09	1.65	2.48	1.86	6.45	4.47	2.12
Mean effort/Site	35.14	36.36	36.76	108.26	51.19	20.73	51.30	20.62
Total sampling effort (min)	281.08	290.90	294.08	866.07	409.52	165.85	574.37	164.97

Table 4. Summary of catch data for all 2007, 2011, and 2013 Detroit River sites.

Catch data	2007				2011						2013					
	Spring	Summer	Fall	All	Summer		Fall		All		Summer		Fall		All	
	BEF				BEF	TRL	BEF	TRL	BEF	TRL	BEF	TRL	BEF	TRL	BEF	TRL
Total fishes captured	540	1186	1582	3308	1583	3289	3349	3307	4932	6596	1017	3631	999	3049	2016	6680
Mean number of fishes captured/Site	90	197.7	263.7	183.8	263.8	548.2	558.2	551.2	411	549.7	169.5	726.2	166.5	609.8	168	668
Minimum number of fishes captured (among sites)	7	27	131	165	56	154	113	164	169	318	19	372	20	337	39	909
Maximum number of fishes captured (among sites)	149	620	364	1099	585	788	1143	939	1099	1099	387	1611	299	846	1099	1099
Number of species detected	22	31	38	43	32	29	30	31	37	37	29	29	29	31	34	36

Table 5. Species captured by DFO during 2007, 2011 and 2013 surveys of the Detroit River. Species presence and absence are shown with 1 and 0, respectively. See Appendix 6 for scientific names of all species.

Common name	2007			2011		2013	
	Spring	Summer	Fall	Summer	Fall	Summer	Fall
Alewife	0	1	1	0	0	1	1
Banded Killifish	0	0	0	1	1	0	1
Blacknose Shiner	0	0	1	0	0	0	0
Bigmouth Buffalo	0	0	1	1	1	0	1
Black Bullhead	0	1	0	0	0	0	0
Bluegill	0	1	1	1	1	1	1
Bluntnose Minnow	1	1	1	1	1	1	1
Bowfin	0	1	1	1	1	1	1
Brook Silverside	1	1	1	1	1	1	1
Brown Bullhead	1	0	1	1	1	1	1
Burbot	0	1	0	0	0	0	0
Channel Catfish	0	0	1	1	0	0	0
Channel Darter	0	0	0	1	1	1	1
Cisco	0	0	0	0	0	0	1
Common Carp	1	1	1	1	1	1	1
Common Shiner	0	1	0	0	1	0	0
Eastern Sand Darter	0	0	0	0	0	0	1
Emerald Shiner	1	1	1	1	1	1	1
Freshwater Drum	1	1	1	1	1	1	1
Gizzard Shad	1	1	1	1	1	1	1
Golden Redhorse	0	0	1	1	0	1	1
Golden Shiner	0	1	1	1	0	1	0
Goldfish	0	1	1	1	1	0	0
Goldfish X Common Carp	0	1	1	1	0	0	0
Green Sunfish	0	0	0	1	0	0	0
Hornyhead Chub	0	0	1	1	1	1	1
Johnny Darter	0	0	0	1	1	1	1
Largemouth Bass	1	1	1	1	1	1	1
Least Darter	0	0	0	1	0	0	0
Logperch	0	1	1	1	1	1	1
Longnose Gar	0	1	1	0	0	0	0
Mimic Shiner	0	1	1	1	1	1	1
Muskellunge	0	0	1	0	1	1	1
Northern Hogsucker	0	0	0	1	1	1	1
Northern Madtom	0	0	0	1	1	1	1
Northern Pike	1	0	0	0	1	1	1
Orangespotted Sunfish	0	0	0	0	1	0	0

Common name	2007			2011		2013	
	Spring	Summer	Fall	Summer	Fall	Summer	Fall
Pugnose Shiner	0	0	0	0	1	0	0
Pumpkinseed	1	1	1	1	1	1	1
Quillback	1	0	1	0	0	0	0
Rainbow Darter	0	0	0	1	0	0	0
Rainbow Smelt	0	0	0	0	1	0	1
Rock Bass	0	1	1	1	1	1	1
Round Goby	0	0	0		1	1	1
Sand Shiner	0	0	0	1	0	0	0
Shorthead Redhorse	1	1	1	1	1	1	1
Silver Redhorse	1	1	1	1	1	1	1
Smallmouth Bass	1	1	1	1	1	1	1
Spotfin Shiner	0	0	0	0	1	0	0
Spottail Shiner	1	1	1	1	1	1	1
Spotted Sucker	1	0	1	0	0	0	0
Striped Shiner	1	1	1	1	1	0	1
Trout-perch	1	0	0	1	1	1	1
Tubenose Goby	0	0	1	1	1	1	1
Walleye	1	1	1	0	0	0	0
White Bass	1	1	1	1	0	1	0
White Perch	0	1	1	1	1	1	1
White Sucker	1	1	1	1	1	1	1
Yellow Bullhead	0	0	0	0	1	0	1
Yellow Perch	1	1	1	1	1	1	1
Species Richness	22	31	38	42	41	35	40
Unique Species	0	2	1	4	3	0	2
Common Species	14						

Table 6. Pooled annual and seasonal fish catch of relevant groups and trophic classifications in the Detroit River using boat electrofishing and benthic trawling. The number of species, individuals and percent total of individuals captured by each gear type are summarized.

Metric		Boat electrofishing			Benthic trawl		
		No. species captured	No. individuals captured	% of total individuals	No. species captured	No. individuals captured	% of total individuals
Species richness	Native species	34	6705	96.5	35	9703	73.1
	Nonindigenous species	6	243	3.5	7	3573	26.9
	Percids	2	544	7.8	7	1328	10
	Salmonids	0	0	0	0	0	0
	Coregonines	0	0	0	0	0	0
	Native cyprinids	10	2946	42.4	6	4465	33.6
	Centrarchids	5	308	4.4	7	2932	22.1
	Intolerant species	4	35	0.5	8	938	7.1
Trophic structure	Generalists	25	3399	48.9	20	9310	70.1
	Specialists	7	2807	40.4	14	2033	15.3
	Piscivores	8	742	10.7	8	1933	14.6

Table 7. IBI scores for Detroit River 2007, 2011, and 2013 data. IBI scores were calculated using the Hamilton*, Edwards, and Minns IBI-score adaptations

Method	Year	1	2	3	4	5	6	All
Hamilton*	2007	29	19	17	19	25	23	25
Hamilton*	2011	19	23	21	19	25	21	22
Hamilton*	2013	17	19	21	21	15	26	22
Edwards*	2007	29	19	17	19	25	23	25
Edwards*	2011	19	23	21	19	25	21	22
Edwards*	2013	17	19	21	21	15	26	22
Minns**	2007	48	46	44	41	39	41	55
Minns**	2011	47	55	49	39	53	52	62
Minns**	2013	44	47	44	41	55	50	60

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 8. IBI scores for Detroit River 2007, 2011, and 2013 data. IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Year	Season	1	2	3	4	5	6	All
Hamilton*	2007	Spring	13	20	13	14	18	18	21
Hamilton*	2007	Summer	25	17	21	17	15	17	27
Hamilton*	2007	Fall	23	21	17	21	29	21	25
Hamilton*	2011	Summer	23	23	17	19	19	21	21
Hamilton*	2011	Fall	21	21	21	21	29	25	25
Hamilton*	2013	Summer	19	21	19	21	15	25	23
Hamilton*	2013	Fall	15	19	21	23	15	20	22
Edwards*	2007	Spring	13	20	13	14	18	18	21
Edwards*	2007	Summer	25	17	21	17	15	17	27
Edwards*	2007	Fall	23	21	17	21	29	21	25
Edwards*	2011	Summer	23	23	17	19	19	21	21
Edwards*	2011	Fall	21	21	21	21	29	25	25
Edwards*	2013	Summer	19	21	19	21	15	25	23
Edwards*	2013	Fall	15	19	21	23	15	20	22
Minns**	2007	Spring	39	53	38	43	54	42	50
Minns**	2007	Summer	43	41	36	37	30	46	44
Minns**	2007	Fall	50	57	38	47	60	39	72
Minns**	2011	Summer	43	48	38	31	46	44	55
Minns**	2011	Fall	45	59	51	47	57	55	65
Minns**	2013	Summer	34	43	42	39	52	45	54
Minns**	2013	Fall	37	46	41	40	48	46	62

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 9. IBI scores in the Detroit River based on DFO 2011 and 2013 surveys using boat electrofishing (BEF) and benthic trawling (TRL). IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Year	Gear	1	2	3	4	5	6	All
Hamilton*	2011	BEF	23	21	23	17	31	21	25
Hamilton*	2011	TRL	21	21	19	21	21	21	21
Hamilton*	2013	BEF	13	21	19	19	17	18	20
Hamilton*	2013	TRL	19	19	19	21	NA	25	21
Edwards*	2011	BEF	23	21	23	17	31	21	25
Edwards*	2011	TRL	21	21	19	21	21	21	21
Edwards*	2013	BEF	13	21	19	19	17	18	20
Edwards*	2013	TRL	19	19	19	21	NA	25	21
Minns**	2011	BEF	43	51	50	37	56	49	58
Minns**	2011	TRL	46	49	50	46	33	43	56
Minns**	2013	BEF	36	46	45	32	55	47	60
Minns**	2013	TRL	34	48	47	47	NA	40	58

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 10. IBI scores in the Detroit River based on DFO 2011 and 2013, summer and fall surveys using boat electrofishing (BEF) and benthic trawling (TRL). IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Season	Gear	1	2	3	4	5	6	All
Hamilton*	Summer	BEF	19	23	17	15	19	17	21
Hamilton*	Summer	TRL	21	21	19	23	19	25	21
Hamilton*	Fall	BEF	23	21	21	19	31	20	28
Hamilton*	Fall	TRL	19	21	19	19	19	23	21
Edwards*	Summer	BEF	19	23	17	15	19	17	21
Edwards*	Summer	TRL	21	21	19	23	19	25	21
Edwards*	Fall	BEF	23	21	21	19	31	20	28
Edwards*	Fall	TRL	19	21	19	19	19	23	21
Minns**	Summer	BEF	31	45	45	29	48	46	54
Minns**	Summer	TRL	45	53	48	50	40	41	54
Minns**	Fall	BEF	46	54	50	39	61	58	63
Minns**	Fall	TRL	40	53	50	44	27	41	55

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 11. Summary of catch data for all 2007, 2012, and 2014 St. Clair River sites.

Catch data	2007			2012						2014	
	Spring	Summer	Fall	Summer		Fall		All		Summer	
	BEF			BEF	TRL	BEF	TRL	BEF	TRL	BEF	TRL
Total fishes captured	1012	678	504	779	3989	1113	5711	1892	9700	366	4540
Mean number of fishes captured/site	126.5	84.8	63	97.4	498.6	139.1	713.9	118.3	606.3	45.8	567.5
Minimum number of fishes captured (among sites)	13	18	14	21	78	6	102	27	213	3	76
Maximum number of fishes captured (among sites)	277	332	131	177	946	350	1781	493	2477	156	2694
Number of species detected	14	26	26	28	23	29	19	33	29	17	21

Table 12. Species detected by DFO during 2007, 2012, 2014 surveys of the St. Clair River. Species presence and absence are shown with 1 and 0, respectively.

Common name	2007			2012		2014
	Spring	Summer	Fall	Summer	Fall	Summer
Black Crappie	0	0	0	0	0	1
Bluegill	0	0	0	1	0	0
Bluntnose Minnow	0	1	1	1	1	1
Bowfin	0	0	1	1	1	0
Brook Silverside	1	1	1	1	1	1
Brook Stickleback	0	0	0	1	0	0
Channel Catfish	0	0	0	1	0	0
Channel Darter	0	0	0	0	0	1
Common Carp	1	1	1	1	1	1
Common Shiner	0	1	0	1	1	0
Creek Chub	0	0	0	1	0	0
Emerald Shiner	1	1	1	1	1	1
Freshwater Drum	0	1	1	1	1	0
Gizzard Shad	1	0	1	0	1	1
Golden Redhorse	1	1	0	1	0	1
Greater Redhorse	0	1	0	0	0	0
Hornyhead Chub	0	1	1	1	1	1
Iowa Darter	0	0	0	0	0	1
Largemouth Bass	0	0	1	1	1	1
Logperch	0	1	1	1	1	1
Longnose Gar	0	0	0	0	0	1
Longose Sucker	0	1	0	0	0	0
Mimic Shiner	0	0	0	1	1	1
Mottled Sculpin	0	0	0	0	0	1
Muskellunge	0	0	0	1	0	0
Northern Hogsucker	0	1	1	1	1	0
Northern Pike	0	1	1	1	1	0
Nothern Madtom	0	0	0	1	1	1
Pugnose Shiner	0	0	0	1	0	0
Pumpkinseed	1	0	0	0	1	0
Quillback	0	1	1	0	0	0
Rainbow Smelt	1	0	1	0	1	0
Rainbow Trout	0	0	0	1	1	0
River Redhorse	0	1	0	0	0	0
Rock Bass	0	0	1	1	1	1
Round Goby	1	1	0	1	1	1
Shorthead Redhorse	1	1	1	1	1	1

Common name	2007			2012		2014
	Spring	Summer	Fall	Summer	Fall	Summer
Silver Lamprey	0	1	0	1	1	1
Silver Redhorse	1	0	1	1	1	1
Slimy Sculpin	0	0	0	0	0	1
Smallmouth Bass	0	1	1	1	1	1
Spotfin Shiner	0	0	1	0	0	0
Spottail Shiner	1	0	1	1	1	1
Spotted Sucker	0	1	1	0	0	0
Striped Shiner	0	1	1	1	1	1
Threespine Stickleback	0	0	0	0	0	1
Tube-nose Goby	0	0	0	1	1	1
Walleye	0	0	1	1	1	1
White Bass	0	1	0	1	1	1
White Perch	0	1	1	1	1	0
White Sucker	1	1	1	1	1	1
Yellow Perch	1	1	1	1	1	1
Species Richness	14	26	26	37	33	32
Unique Species	0	3	1	6	0	7
Common Species	8					

Table 13. Pooled annual and seasonal fish catch of relevant groups and trophic classifications in the St. Clair River using boat electrofishing and benthic trawling. The number of species, individuals, and percent total of individuals captured by each gear are summarized.

Metric		Boat electrofishing			Benthic trawl		
		No. species captured	No. individuals captured	% of total individuals	No. species captured	No. individuals captured	% of total individuals
Species richness	Native species	29	2187	96.9	30	7262	51
	Nonindigenous species	5	71	3.1	5	6978	49
	Percids	3	717	31.8	5	961	6.8
	Salmonids	1	2	0.1	0	0	0
	Coregonines	0	0	0	0	0	0
	Native cyprinids	7	782	34.6	9	4937	34.7
	Centrarchids	4	75	3.3	5	1282	9
	Intolerant species	5	162	7.2	7	1985	13.9
Trophic structure	Generalists	18	1176	52.1	20	12581	88.4
	Specialists	5	377	16.7	7	1197	8.4
	Piscivores	11	705	31.2	8	462	3.2

Table 14. IBI scores for St. Clair 2007, 2012, and 2014 data. IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Year	1	2	3	4	5	6	7	8	All
Hamilton*	2007	17	19	23	23	17	15	21	17	23
Hamilton*	2012	18	15	23	20	21	19	19	13	22
Hamilton*	2014	17	21	17	17	17	15	19	15	21
Edwards*	2012	17	19	23	23	17	15	21	17	23
Edwards*	2012	17	15	23	19	21	19	19	13	21
Edwards*	2014	17	21	17	17	17	15	19	15	21
Minns**	2007	27	35	43	44	35	19	40	35	53
Minns**	2012	38	27	53	48	49	43	50	28	58
Minns**	2014	26	32	35	28	29	40	28	31	42

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 15. IBI scores for St. Clair River 2007, 2012, and 2014 sampling season data. IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Year	Season	1	2	3	4	5	6	7	8	All
Hamilton*	2007	Spring	10	8	23	21	4	14	12	12	19
Hamilton*	2007	Summer	21	15	21	21	21	17	19	27	27
Hamilton*	2007	Fall	15	17	25	21	21	13	25	14	21
Hamilton*	2012	Summer	17	17	19	22	23	21	19	15	22
Hamilton*	2012	Fall	18	15	23	21	19	19	19	11	22
Hamilton*	2014	Summer	17	21	17	15	17	15	19	15	21
Edwards*	2007	Spring	10	8	23	21	4	14	12	12	19
Edwards*	2007	Summer	21	15	21	21	21	17	19	27	27
Edwards*	2007	Fall	15	17	25	21	21	13	25	14	21
Edwards*	2012	Summer	17	17	19	21	23	21	19	15	21
Edwards*	2012	Fall	17	15	23	21	19	19	19	11	21
Edwards*	2014	Summer	17	21	17	15	17	15	19	15	21
Minns**	2007	Spring	30	26	43	46	29	42	41	33	45
Minns**	2007	Summer	28	28	42	33	32	13	36	29	47
Minns**	2007	Fall	25	39	56	35	46	18	44	39	51
Minns**	2012	Summer	29	26	31	33	40	38	44	33	52
Minns**	2012	Fall	39	33	60	57	45	39	46	15	63
Minns**	2014	Summer	27	32	36	29	29	40	29	31	44

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 16. IBI scores in the St. Clair River based on DFO 2012 and 2014, summer and fall surveys using boat electrofishing (BEF) and benthic trawling (TRL). IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Year	Gear	1	2	3	4	5	6	7	8	All
Hamilton*	2012	BEF	20	19	23	24	25	21	29	17	24
Hamilton*	2012	TRL	17	15	15	17	17	17	15	11	19
Hamilton*	2014	BEF	18	8	21	21	16	14	21	14	21
Hamilton*	2014	TRL	19	23	17	15	17	17	19	15	21
Edwards*	2012	BEF	19	19	23	23	25	21	29	17	23
Edwards*	2012	TRL	17	15	15	17	17	17	15	11	19
Edwards*	2014	BEF	18	8	21	21	16	14	21	14	21
Edwards*	2014	TRL	19	23	17	15	17	17	19	15	21
Minns**	2012	BEF	38	30	49	46	40	41	50	33	66
Minns**	2012	TRL	35	43	43	36	49	39	40	25	62
Minns**	2014	BEF	34	26	40	29	32	50	31	50	47
Minns**	2014	TRL	19	43	37	38	33	39	26	16	39

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

Table 17. IBI scores in the St. Clair River based on DFO 2012 and 2014, summer and fall surveys using boat electrofishing (BEF) and benthic trawling (TRL). IBI scores were calculated using the Hamilton, Edwards, and Minns IBI-score adaptations.

Method	Season	Gear	1	2	3	4	5	6	7	8	All
Hamilton*	Summer	BEF	17	21	23	22	29	15	23	15	24
Hamilton*	Summer	TRL	19	19	15	17	17	17	19	15	19
Hamilton*	Fall	BEF	20	13	23	23	19	21	25	13	26
Hamilton*	Fall	TRL	17	13	17	19	17	13	13	13	15
Edwards*	Summer	BEF	17	21	23	21	29	15	23	15	23
Edwards*	Summer	TRL	19	19	15	17	17	17	19	15	19
Edwards*	Fall	BEF	19	13	23	23	19	21	25	13	25
Edwards*	Fall	TRL	17	13	17	19	17	13	13	13	15
Minns**	Summer	BEF	35	32	44	39	34	35	41	38	51
Minns**	Summer	TRL	28	40	31	33	42	46	34	23	51
Minns**	Fall	BEF	38	32	52	56	41	38	44	18	64
Minns**	Fall	TRL	28	40	46	38	44	30	37	22	44

*Rating system: < 15 = very poor, 18-23 = poor, 25-29 = fair, 31-34 = good, and 37-40 = excellent

**Rating system: 0 = no fish, >0-20 = very poor, >20-40 = poor, >40-60 = fair, >60-80 = good, and >80 = excellent

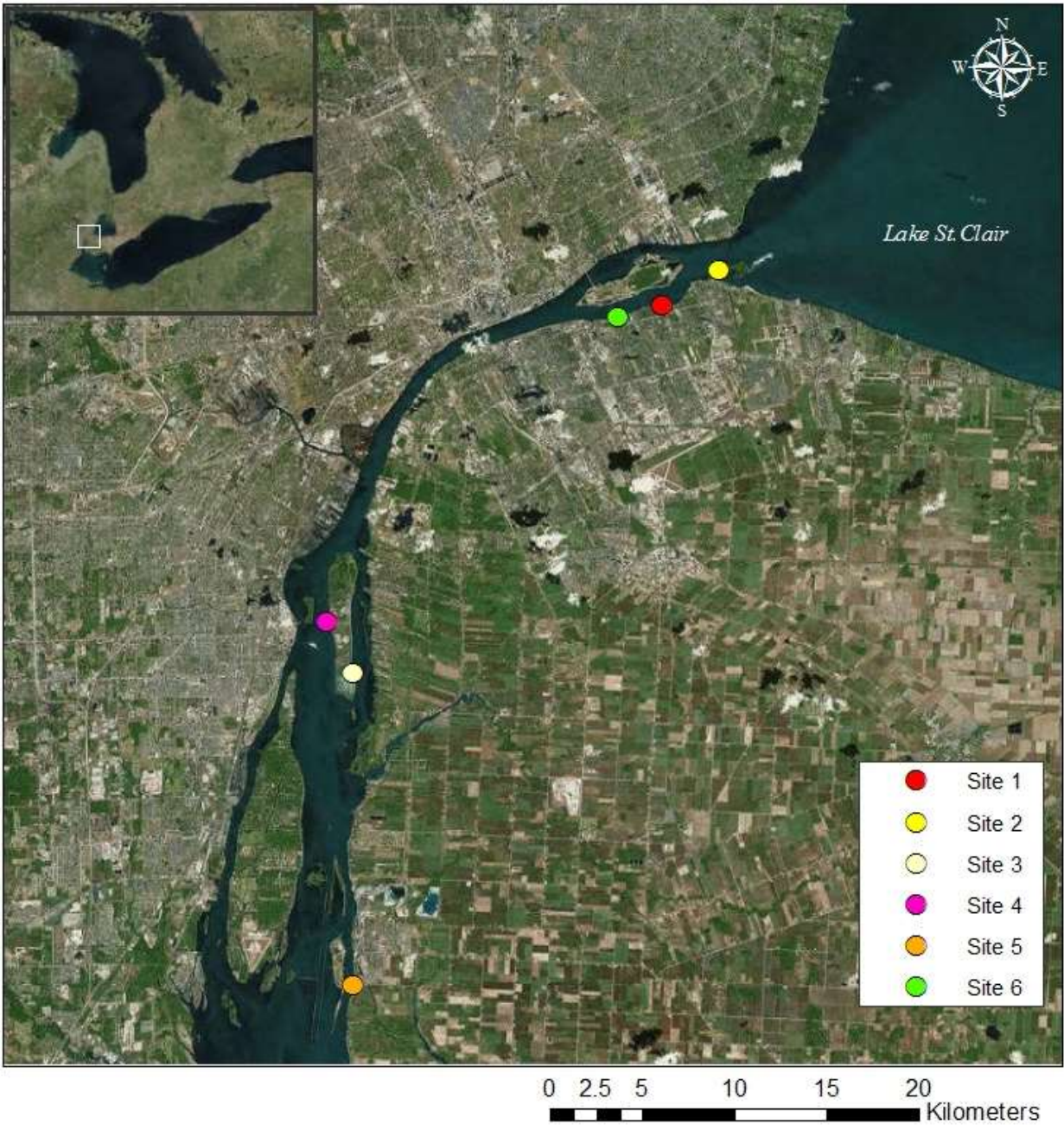


Figure 1. Sampling sites on the Detroit River in 2007, 2011, and 2013. See Appendix 1 for site names and coordinates



Figure 2. Sampling sites on the St. Clair River in 2007, 2012, and 2014. See Appendix 2 for site names and coordinates.

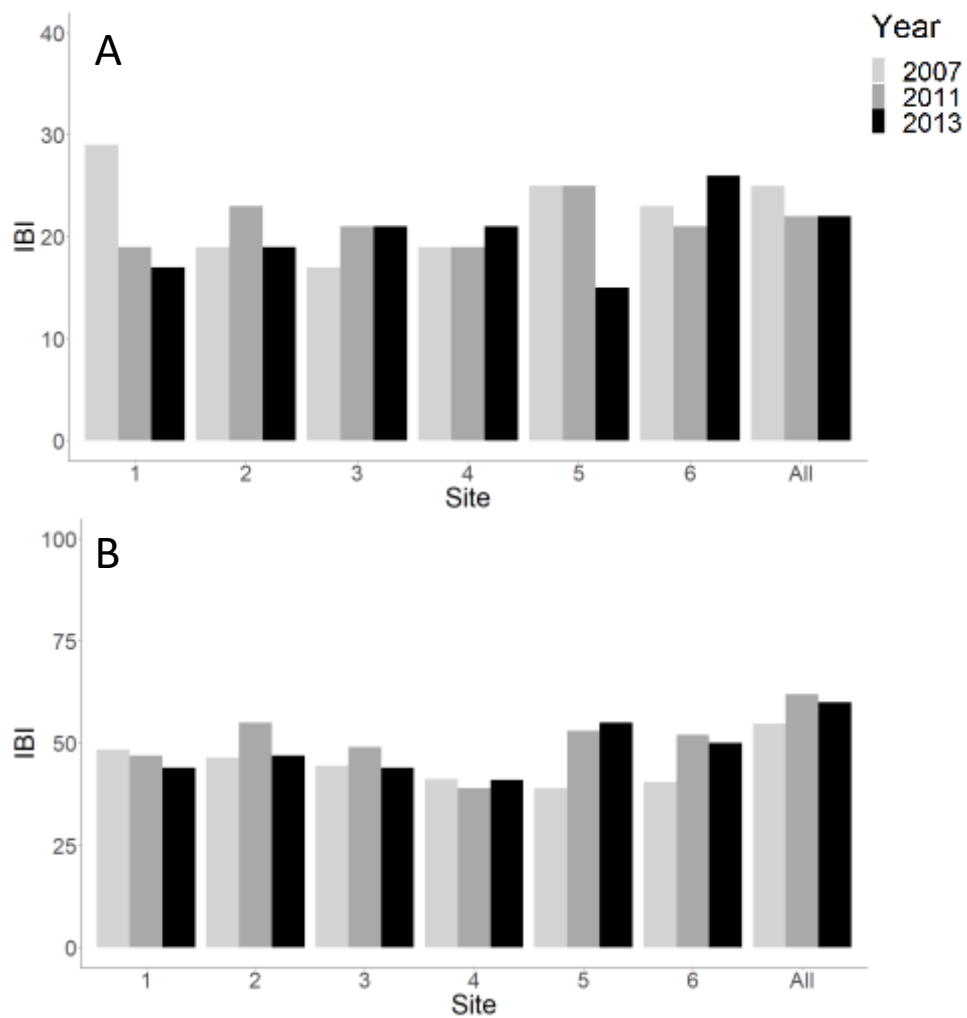


Figure 3. IBI scores for 2007, 2011, and 2013 Detroit River sites based on DFO data using the Hamilton and Edwards (A) and Minns (B) IBI methods.

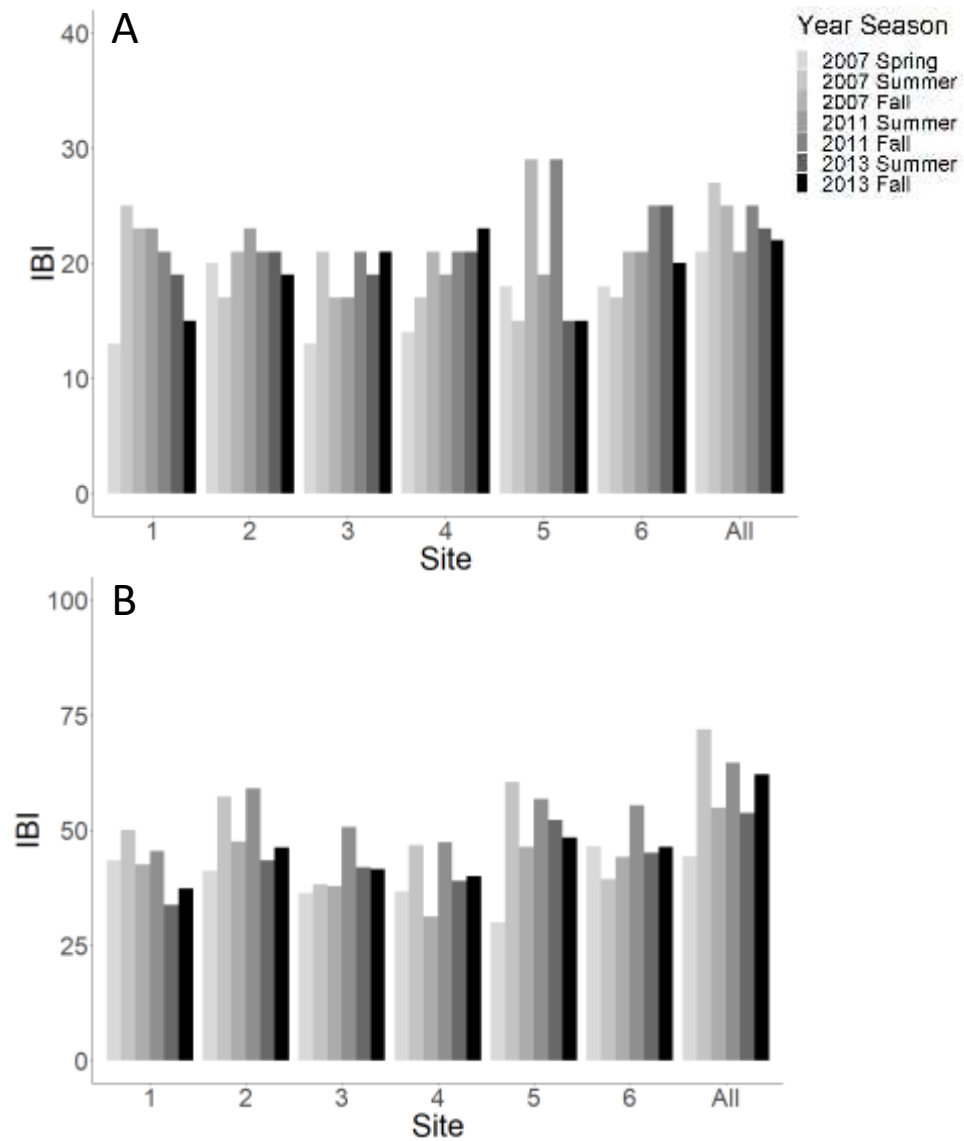


Figure 4. Seasonal IBI scores for Detroit River sites in each year based on DFO data, using the Hamilton and Edwards (A) and Minns IBI (B).

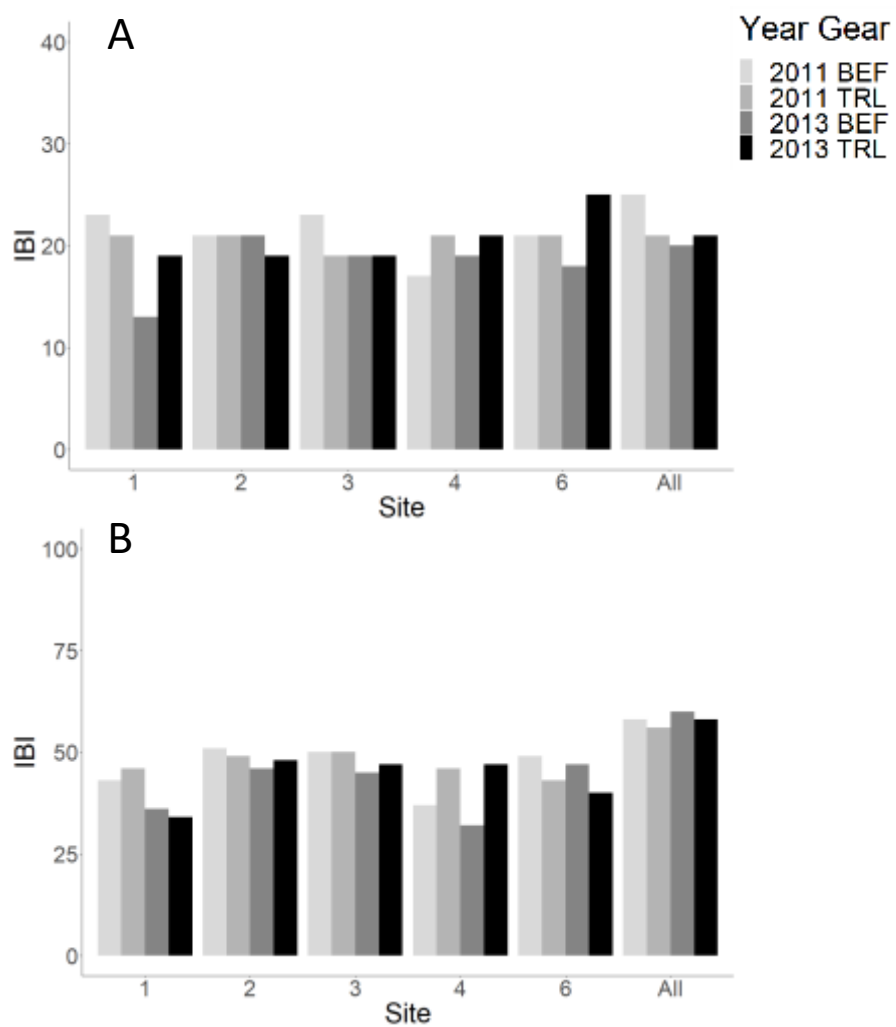


Figure 5. IBI scores for each gear in the Detroit River sites based on annual DFO data using the Hamilton and Edwards (A) and Minns (B) methods. BEF- Boat electrofishing, TRL- Benthic Trawling.

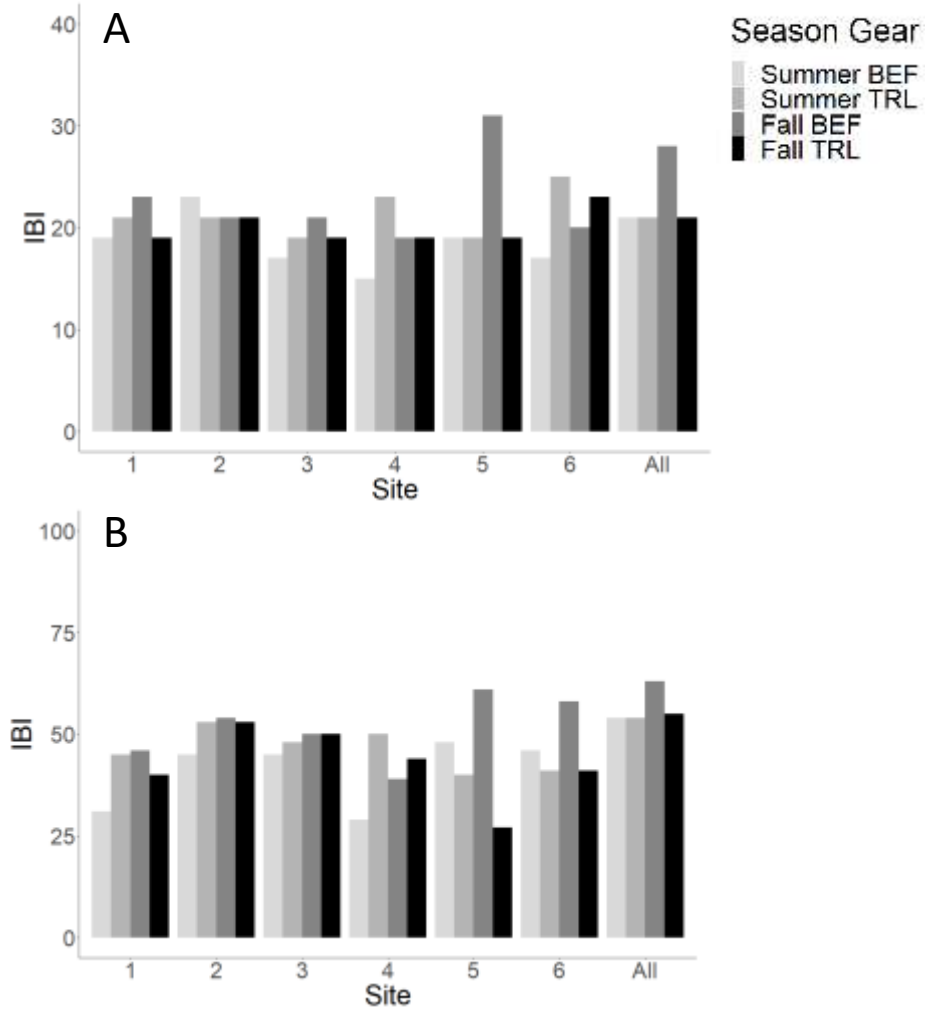


Figure 6. IBI scores for seasonal gear type Detroit River DFO data, using the Hamilton and Edwards (A) and Minns (B) IBI. BEF= Boat electrofishing, TRL= Benthic Trawling.

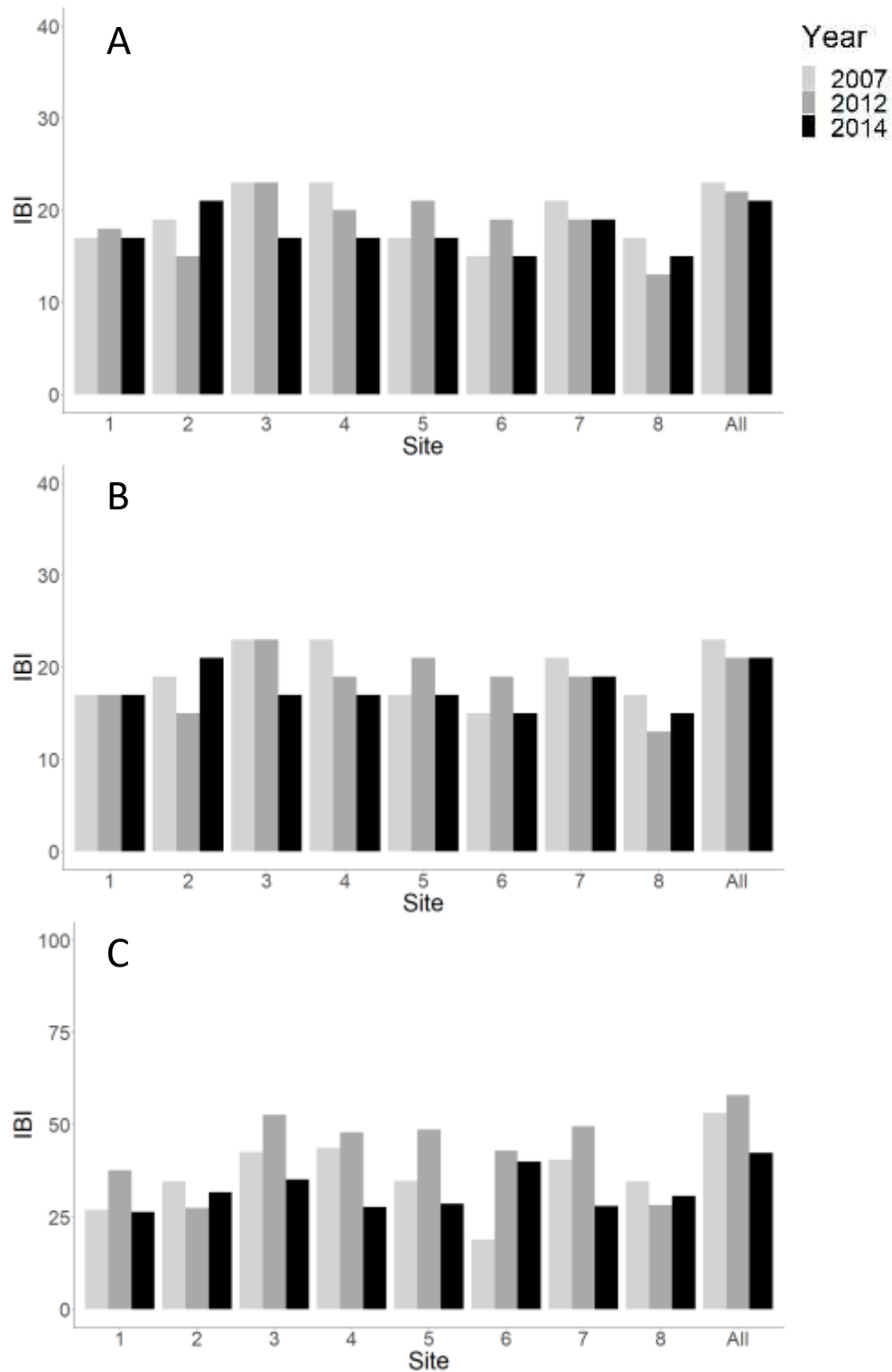


Figure 7. IBI scores for 2007, 2012, and 2014 St. Clair River sites based on DFO data using the Hamilton (A), Edwards (B), and Minns (C) IBI methods.

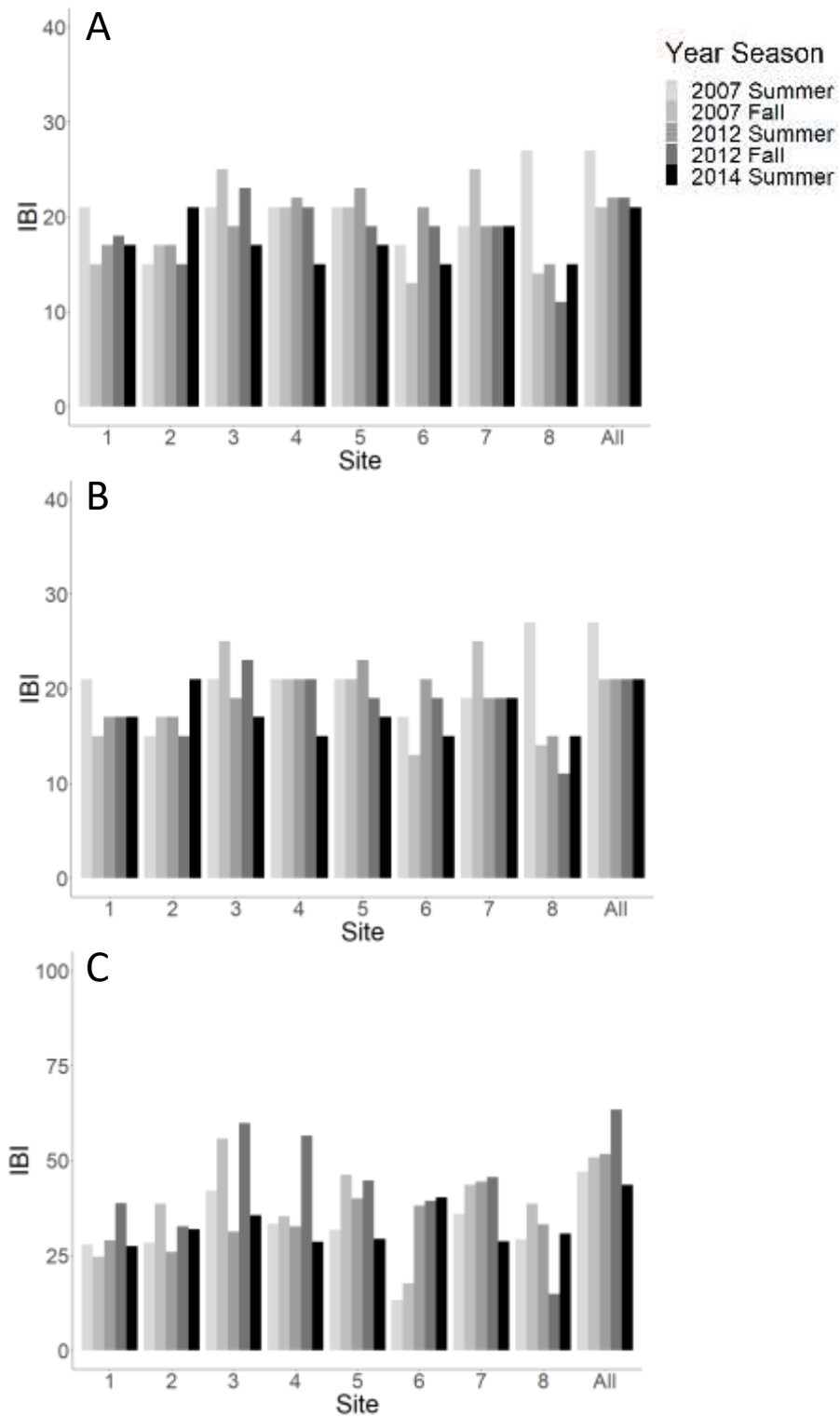


Figure 8. Seasonal IBI scores for St. Clair River sites in each year based on DFO data, using the Hamilton (A), Edwards (B), and Minns IBI (C).

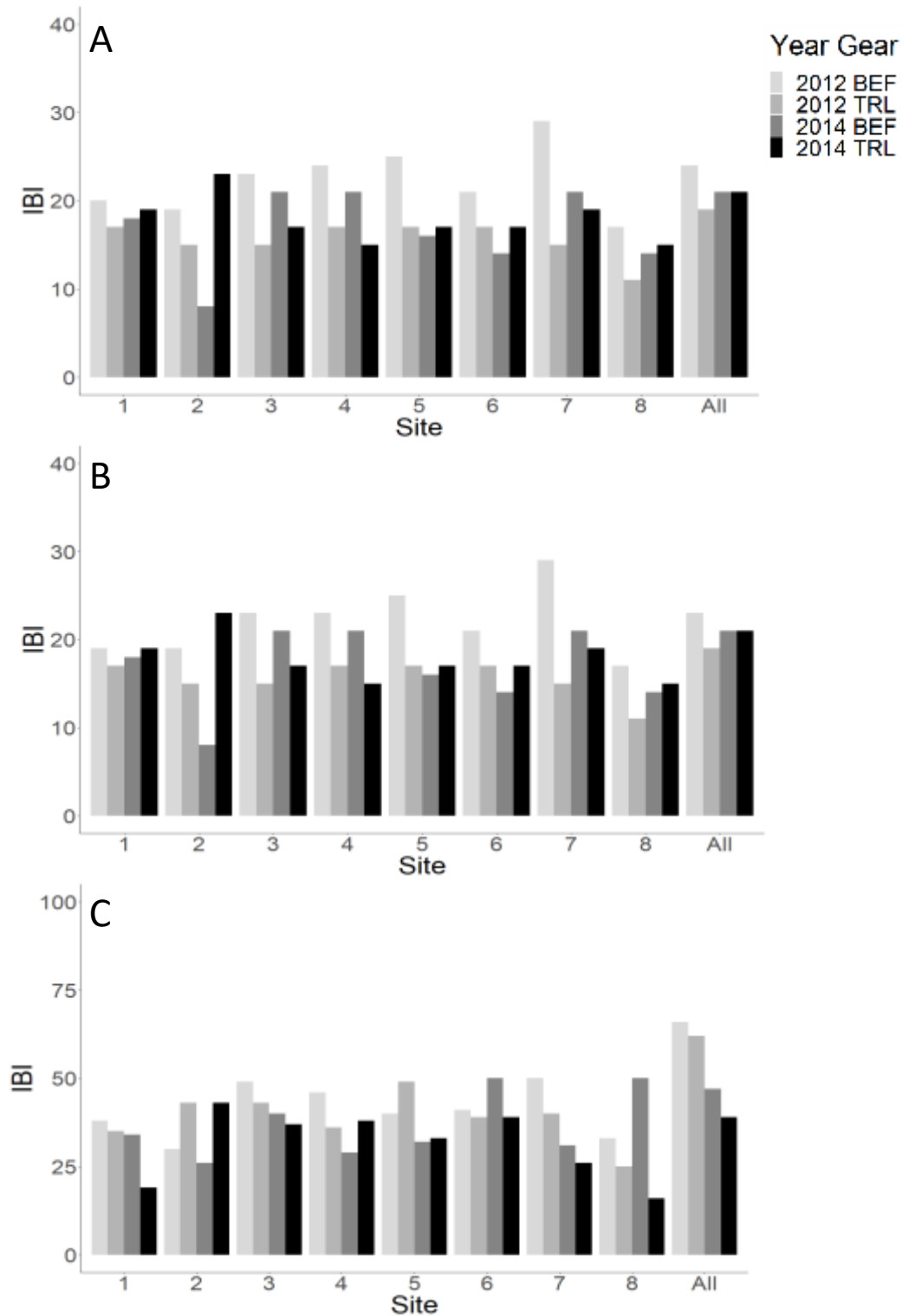


Figure 9. IBI scores for each gear in the St. Clair River sites based on annual DFO data using the Hamilton (A), Edwards (B), and Minns (C) methods. BEF- Boat electrofishing, TRL- Benthic Trawling.

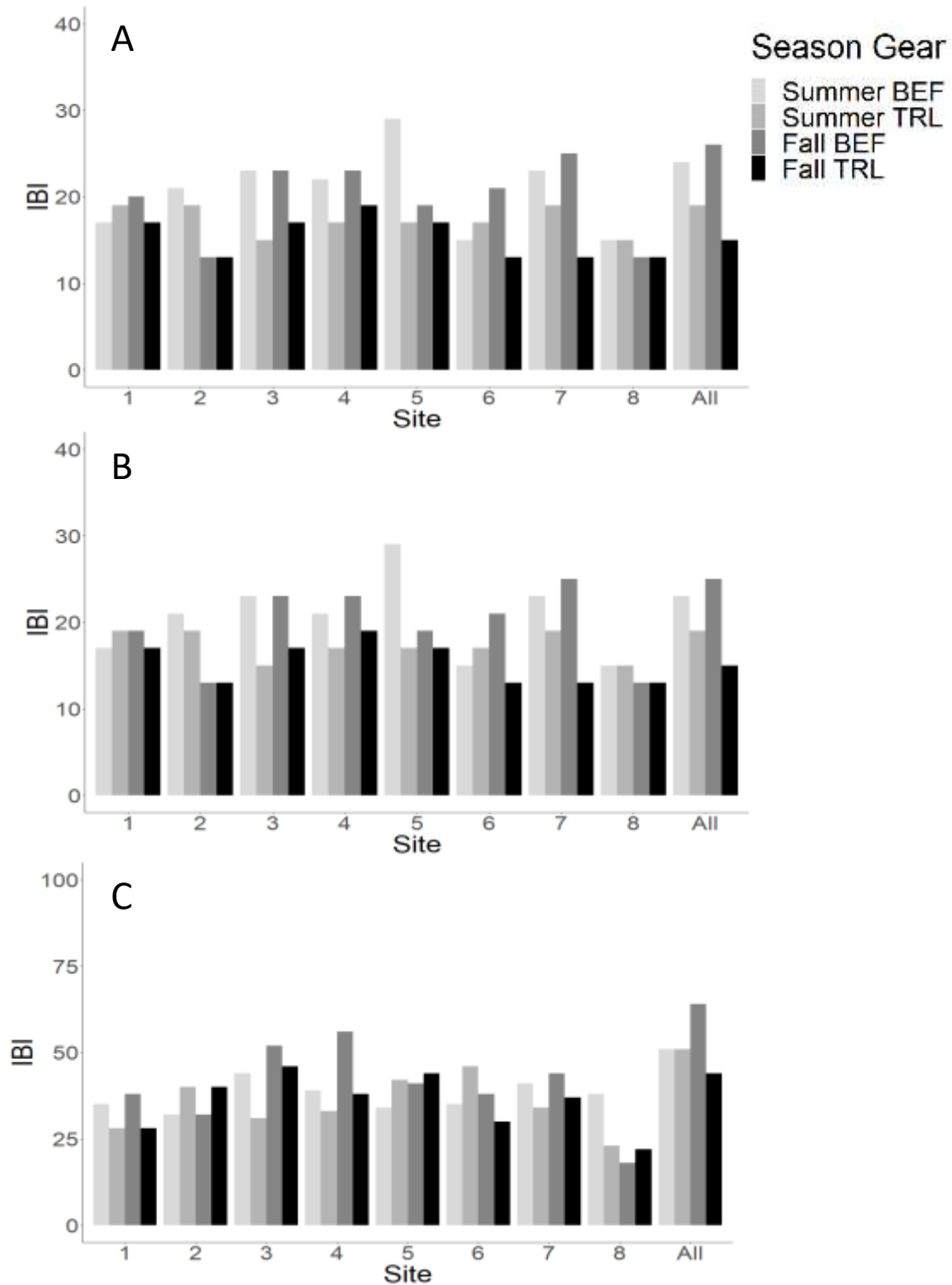


Figure 10. IBI scores for seasonal gear type St. Clair River DFO data, using the Hamilton (A), Edwards (B), and Minns (C) IBI. BEF= Boat electrofishing, TRL= Benthic Trawling.

Appendix 1. Descriptions of sites sampled by DFO in the Detroit River in 2007, 2011, and 2013.

Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
1	2007	2007-GLAP-DTR-160507-111A	16-May-07	42.33355	-82.95832	Belle Island - Nearshore	BEF
	2007	2007-GLAP-DTR-160507-121A	16-May-07	42.33480	-82.9589	Belle Island - Offshore	BEF
	2007	2007-GLAP-DTR-100707-111A	10-Jul-07	42.33355	-82.95832	Belle Island - Nearshore	BEF
	2007	2007-GLAP-DTR-100707-121A	10-Jul-07	42.33480	-82.9589	Belle Island - Offshore	BEF
	2007	2007-GLAP-DTR-180907-111A	18-Sep-07	42.33355	-82.95832	Belle Island - Nearshore	BEF
	2007	2007-GLAP-DTR-180907-112A	18-Sep-07	42.33355	-82.95832	Belle Island - Offshore	BEF
2	2007	2007-GLAP-DTR-160507-211A	16-May-07	42.34365	-82.9293	Pecche Island - Nearshore	BEF
	2007	2007-GLAP-DTR-160507-221A	16-May-07	42.34298	-82.92849	Pecche Island - Offshore	BEF
	2007	2007-GLAP-DTR-110707-211A	11-Jul-07	42.34365	-82.9293	Pecche Island - Nearshore	BEF
	2007	2007-GLAP-DTR-110707-221A	11-Jul-07	42.34298	-82.92849	Pecche Island - Offshore	BEF
	2007	2007-GLAP-DTR-200907-211A	20-Sep-07	42.34365	-82.9293	Pecche Island - Nearshore	BEF
	2007	2007-GLAP-DTR-200907-221A	20-Sep-07	42.34298	-82.92849	Pecche Island - Offshore	BEF
3	2007	2007-GLAP-DTR-150507-311A	15-May-07	42.20439	-83.11398	Fighting Island: East shore- Nearshore	BEF
	2007	2007-GLAP-DTR-150507-321A	15-May-07	42.20480	-83.11341	Fighting Island: East Shore - Offshore	BEF
	2007	2007-GLAP-DTR-090707-311A	09-Jul-07	42.20439	-83.11398	Fighting Island: East shore- Nearshore	BEF
	2007	2007-GLAP-DTR-090707-321A	09-Jul-07	42.20480	-83.11341	Fighting Island: East Shore - Offshore	BEF
	2007	2007-GLAP-DTR-180907-311A	18-Sep-07	42.20439	-83.11398	Fighting Island: East shore- Nearshore	BEF
	2007	2007-GLAP-DTR-180907-321A	18-Sep-07	42.20480	-83.11341	Fighting Island: East Shore - Offshore	BEF
4	2007	2007-GLAP-DTR-170507-411A	17-May-07	42.22285	-83.1257	Fighting Island: West shore - Nearshore	BEF
	2007	2007-GLAP-DTR-170507-421A	17-May-07	42.22287	-83.12732	Fighting Island: West shore - Offshore	BEF
	2007	2007-GLAP-DTR-120707-411A	12-Jul-07	42.22285	-83.1257	Fighting Island: West shore - Nearshore	BEF
	2007	2007-GLAP-DTR-120707-421A	12-Jul-07	42.22287	-83.12732	Fighting Island: West shore - Offshore	BEF
	2007	2007-GLAP-DTR-180907-411A	18-Sep-07	42.22285	-83.1257	Fighting Island: West shore - Nearshore	BEF
	2007	2007-GLAP-DTR-180907-421A	18-Sep-07	42.22287	-83.12732	Fighting Island: West shore - Offshore	BEF
5	2007	2007-GLAP-DTR-140507-511A	14-May-07	42.09156	-83.1134	CCG Amherstburg - Nearshore	BEF
	2007	2007-GLAP-DTR-170507-521A	17-May-07	42.09001	-83.11346	CCG Amherstburg - Offshore	BEF
	2007	2007-GLAP-DTR-200707-511A	20-Jul-07	42.09156	-83.1134	CCG Amherstburg - nearshore	BEF
	2007	2007-GLAP-DTR-200707-521A	20-Jul-07	42.09001	-83.11346	CCG Amherstburg - Offshore	BEF

Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
5	2007	2007-GLAP-DTR-170907-511A	17-Sep-07	42.09156	-83.1134	CCG Amherstburg - nearshore	BEF
	2007	2007-GLAP-DTR-170907-521A	17-Sep-07	42.09001	-83.11346	CCG Amherstburg - Offshore	BEF
6	2007	2007-GLAP-DTR-160507-611A	16-May-07	42.32990	-82.97944	Windsor Fountain - Nearshore	BEF
	2007	2007-GLAP-DTR-130707-611A	13-Jul-07	42.32990	-82.97944	Windsor Fountain - Nearshore	BEF
	2007	2007-GLAP-DTR-130707-621A	13-Jul-07	42.32999	-82.97945	Windsor Fountain - Offshore	BEF
	2007	2007-GLAP-DTR-190907-611A	19-Sep-07	42.32990	-82.97944	Windsor Fountain - Nearshore	BEF
	2007	2007-GLAP-DTR-190907-621A	19-Sep-07	42.32999	-82.97945	Windsor Fountain - Offshore	BEF
	2007	2007-GLAP-DTR-190907-621A	19-Sep-07	42.32999	-82.97945	Windsor Fountain - Offshore	BEF
1	2011	GLAP-DTR-2011-280711-111A	28-Jul-11	42.33362	-82.95786	Belle Island - Nearshore	BEF
	2011	GLAP-DTR-2011-280711-121A	28-Jul-11	42.33501	-82.95798	Belle Island - Offshore	BEF
	2011	GLAP-DTR-2011-100811-111A	10-Aug-11	42.33355	-82.95832	Belle Island - Nearshore	TRL
	2011	GLAP-DTR-2011-100811-121A	10-Aug-11	42.3348	-82.9589	Belle Island - Offshore	TRL
	2011	GLAP-DTR-2011-270911-111A	27-Sep-11	42.33362	-82.95786	Belle Island - Nearshore	TRL
	2011	GLAP-DTR-2011-270911-121A	27-Sep-11	42.33501	-82.95798	Belle Island - Offshore	TRL
	2011	GLAP-DTR-2011-051011-111A	05-Oct-11	42.33362	-82.95786	Belle Island - Nearshore	BEF
	2011	GLAP-DTR-2011-051011-121A	05-Oct-11	42.33501	-82.95798	Belle Island - Offshore	BEF
2	2011	GLAP-DTR-2011-280711-211A	28-Jul-11	42.34468	-82.92975	Pecche Island - Nearshore	BEF
	2011	GLAP-DTR-2011-280711-221A	28-Jul-11	42.34368	-82.92928	Pecche Island - Offshore	BEF
	2011	GLAP-DTR-2011-090811-211A	09-Aug-11	42.34365	-82.9293	Pecche Island - Nearshore	TRL
	2011	GLAP-DTR-2011-090811-221A	09-Aug-11	42.34298	-82.92849	Pecche Island - Offshore	TRL
	2011	GLAP-DTR-2011-260911-221A	26-Sep-11	42.34406	-82.93182	Pecche Island - Nearshore	TRL
	2011	GLAP-DTR-2011-300911-211A	30-Sep-11	42.34468	-82.92975	Pecche Island - Offshore	TRL
	2011	GLAP-DTR-2011-051011-211A	05-Oct-11	42.34468	-82.92975	Pecche Island - Nearshore	BEF
	2011	GLAP-DTR-2011-051011-221A	05-Oct-11	42.34317	-82.9296	Pecche Island - Offshore	BEF
3	2011	GLAP-DTR-2011-180711-311A	18-Jul-11	42.20439	-83.11398	Fighting Island: East shore- Nearshore	TRL
	2011	GLAP-DTR-2011-190711-321A	19-Jul-11	42.2048	-83.11341	Fighting Island: East Shore - Offshore	TRL
	2011	GLAP-DTR-2011-290711-311A	29-Jul-11	42.20439	-83.11398	Fighting Island: East shore- Nearshore	BEF
	2011	GLAP-DTR-2011-290711-321A	29-Jul-11	42.2048	-83.11341	Fighting Island: East Shore - Offshore	BEF
	2011	GLAP-DTR-2011-280911-311A	28-Sep-11	42.20439	-83.11398	Fighting Island: East shore- Nearshore	TRL
	2011	GLAP-DTR-2011-280911-321A	28-Sep-11	42.2048	-83.11341	Fighting Island: East Shore - Offshore	TRL
	2011	GLAP-DTR-2011-061011-311A	06-Oct-11	42.20439	-83.11398	Fighting Island: East shore- Nearshore	BEF

Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
3	2011	GLAP-DTR-2011-061011-321A	06-Oct-11	42.2048	-83.11341	Fighting Island: East Shore - Offshore	BEF
4	2011	GLAP-DTR-2011-190711-411A	19-Jul-11	42.22285	-83.1257	Fighting Island: West shore - Nearshore	TRL
	2011	GLAP-DTR-2011-190711-421A	19-Jul-11	42.22287	-83.12732	Fighting Island: West shore - Offshore	TRL
	2011	GLAP-DTR-2011-290711-411A	29-Jul-11	42.22285	-83.1257	Fighting Island: West shore - Nearshore	BEF
	2011	GLAP-DTR-2011-290711-421A	29-Jul-11	42.22287	-83.12732	Fighting Island: West shore - Offshore	BEF
	2011	GLAP-DTR-2011-280911-411A	28-Sep-11	42.22285	-83.1257	Fighting Island: West shore - Nearshore	TRL
	2011	GLAP-DTR-2011-280911-421A	28-Sep-11	42.22287	-83.12732	Fighting Island: West shore - Offshore	TRL
	2011	GLAP-DTR-2011-061011-411A	06-Oct-11	42.22285	-83.1257	Fighting Island: West shore - Nearshore	BEF
	2011	GLAP-DTR-2011-061011-421A	06-Oct-11	42.22287	-83.12732	Fighting Island: West shore - Offshore	BEF
5	2011	GLAP-DTR-2011-140711-511A	14-Jul-11	42.09156	-83.1134	CCG Amherstburg - Nearshore	TRL
	2011	GLAP-DTR-2011-140711-521A	14-Jul-11	42.09001	-83.11346	CCG Amherstburg - Offshore	TRL
	2011	GLAP-DTR-2011-260711-511A	26-Jul-11	42.09156	-83.1134	CCG Amherstburg - Nearshore	BEF
	2011	GLAP-DTR-2011-260711-521A	26-Jul-11	42.09001	-83.11346	CCG Amherstburg - Offshore	BEF
	2011	GLAP-DTR-2011-290911-511A	29-Sep-11	42.09064	-83.1132	CCG Amherstburg - Nearshore	TRL
	2011	GLAP-DTR-2011-290911-521A	29-Sep-11	42.09001	-83.11346	CCG Amherstburg - Offshore	TRL
	2011	GLAP-DTR-2011-041011-511A	04-Oct-11	42.09064	-83.1132	CCG Amherstburg - Nearshore	BEF
	2011	GLAP-DTR-2011-041011-521A	04-Oct-11	42.09001	-83.11346	CCG Amherstburg - Offshore	BEF
6	2011	GLAP-DTR-2011-280711-611A	28-Jul-11	42.32989	-82.97956	Windsor Fountain - Nearshore	BEF
	2011	GLAP-DTR-2011-280711-621A	28-Jul-11	42.32988	-82.97991	Windsor Fountain - Offshore	BEF
	2011	GLAP-DTR-2011-110811-611A	11-Aug-11	42.3299	-82.97944	Windsor Fountain - Nearshore	TRL
	2011	GLAP-DTR-2011-110811-621A	11-Aug-11	42.32999	-82.97945	Windsor Fountain - Offshore	TRL
	2011	GLAP-DTR-2011-270911-611A	27-Sep-11	42.32989	-82.97936	Windsor Fountain - Nearshore	TRL
	2011	GLAP-DTR-2011-270911-621A	27-Sep-11	42.32988	-82.97991	Windsor Fountain - Offshore	TRL
	2011	GLAP-DTR-2011-051011-611A	05-Oct-11	42.32989	-82.97956	Windsor Fountain - Nearshore	BEF
	2011	GLAP-DTR-2011-051011-621A	05-Oct-11	42.32988	-82.97991	Windsor Fountain - Offshore	BEF
1	2013	2013-GLAP-DTR240713-111A	24-Jul-13	42.33353	-82.95838	Belle Island - Nearshore	TRL
	2013	2013-GLAP-DTR240713-121A	24-Jul-13	42.3348	-82.95895	Belle Island - Offshore	TRL
	2013	2013-GLAP-DTR070813-111A	07-Aug-13	42.33355	-82.95832	Belle Island - Nearshore	BEF
	2013	2013-GLAP-DTR070813-121A	07-Aug-13	42.3348	-82.9589	Belle Island - Offshore	BEF
	2013	2013-GLAP-DTR171013-111A	17-Oct-13	42.33353	-82.95838	Belle Island - Nearshore	TRL

Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
1	2013	2013-GLAP-DTR171013-121A	17-Oct-13	42.3348	-82.95895	Belle Island - Offshore	TRL
	2013	2013-GLAP-DTR061113-111A	06-Nov-13	42.33353	-82.95838	Belle Island - Nearshore	BEF
	2013	2013-GLAP-DTR061113-121A	06-Nov-13	42.3348	-82.95895	Belle Island - Offshore	BEF
2	2013	2013-GLAP-DTR230713-221A	23-Jul-13	42.34324	-82.92975	Pecche Island - Offshore	TRL
	2013	2013-GLAP-DTR240713-211A	24-Jul-13	42.34368	-82.92929	Pecche Island - Nearshore	TRL
	2013	2013-GLAP-DTR070813-211A	07-Aug-13	42.34365	-82.9293	Pecche Island - Offshore	BEF
	2013	2013-GLAP-DTR070813-221A	07-Aug-13	42.34298	-82.92849	Pecche Island - Nearshore	BEF
	2013	2013-GLAP-DTR151013-211A	15-Oct-13	42.34368	-82.92929	Pecche Island - Offshore	TRL
	2013	2013-GLAP-DTR151013-221A	15-Oct-13	42.34324	-82.92975	Pecche Island - Nearshore	TRL
	2013	2013-GLAP-DTR061113-211A	06-Nov-13	42.34368	-82.92929	Pecche Island - Offshore	BEF
	2013	2013-GLAP-DTR061113-221A	06-Nov-13	42.34324	-82.92975	Pecche Island - Nearshore	BEF
3	2013	2013-GLAP-DTR250713-311A	25-Jul-13	42.20498	-83.11396	Fighting Island: East shore- Nearshore	TRL
	2013	2013-GLAP-DTR250713-321A	25-Jul-13	42.205	-83.1136	Fighting Island: East Shore - Offshore	TRL
	2013	2013-GLAP-DTR080813-311A	08-Aug-13	42.20439	-83.11398	Fighting Island: East shore- Nearshore	BEF
	2013	2013-GLAP-DTR080813-321A	08-Aug-13	42.2048	-83.11341	Fighting Island: East Shore - Offshore	BEF
	2013	2013-GLAP-DTR161013-311A	16-Oct-13	42.20498	-83.11396	Fighting Island: East shore- Nearshore	TRL
	2013	2013-GLAP-DTR161013-321A	16-Oct-13	42.205	-83.1136	Fighting Island: East Shore - Offshore	TRL
	2013	2013-GLAP-DTR051113-311A	05-Nov-13	42.20498	-83.11396	Fighting Island: East shore- Nearshore	BEF
	2013	2013-GLAP-DTR051113-321A	05-Nov-13	42.205	-83.1136	Fighting Island: East Shore - Offshore	BEF
4	2013	2013-GLAP-DTR250713-411A	25-Jul-13	42.22288	-83.12573	Fighting Island: West shore - Nearshore	TRL
	2013	2013-GLAP-DTR250713-421A	25-Jul-13	42.22284	-83.12737	Fighting Island: West shore - Offshore	TRL
	2013	2013-GLAP-DTR080813-411A	08-Aug-13	42.22285	-83.1257	Fighting Island: West shore - Nearshore	BEF
	2013	2013-GLAP-DTR080813-421A	08-Aug-13	42.22287	-83.12732	Fighting Island: West shore - Offshore	BEF
	2013	2013-GLAP-DTR161013-411A	16-Oct-13	42.22288	-83.12573	Fighting Island: West shore - Nearshore	TRL
	2013	2013-GLAP-DTR161013-421A	16-Oct-13	42.22284	-83.12737	Fighting Island: West shore - Offshore	TRL
	2013	2013-GLAP-DTR051113-411A	05-Nov-13	42.22288	-83.12573	Fighting Island: West shore - Nearshore	BEF
	2013	2013-GLAP-DTR051113-421A	05-Nov-13	42.22284	-83.12737	Fighting Island: West shore - Offshore	BEF
5	2013	2013-GLAP-DTR060813-511A	06-Aug-13	42.09156	-83.1134	CCG Amherstburg - Nearshore	BEF
	2013	2013-GLAP-DTR060813-521A	06-Aug-13	42.09001	-83.11346	CCG Amherstburg - Offshore	BEF
	2013	2013-GLAP-DTR051113-511A	05-Nov-13	42.0903	-83.11305	CCG Amherstburg - Nearshore	BEF

Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
5	2013	2013-GLAP-DTR051113-521A	05-Nov-13	42.09126	-83.1134	CCG Amherstburg - Offshore	BEF
6	2013	2013-GLAP-DTR240713-611A	24-Jul-13	42.32991	-82.97948	Windsor Fountain - Nearshore	TRL
	2013	2013-GLAP-DTR240713-621A	24-Jul-13	42.33001	-82.97961	Windsor Fountain - Offshore	TRL
	2013	2013-GLAP-DTR070813-611A	07-Aug-13	42.3299	-82.97944	Windsor Fountain - Nearshore	BEF
	2013	2013-GLAP-DTR070813-621A	07-Aug-13	42.32999	-82.97945	Windsor Fountain - Offshore	BEF
	2013	2013-GLAP-DTR171013-611A	17-Oct-13	42.32991	-82.97948	Windsor Fountain - Nearshore	TRL
	2013	2013-GLAP-DTR171013-621A	17-Oct-13	42.33001	-82.97961	Windsor Fountain - Offshore	TRL
	2013	2013-GLAP-DTR061113-611A	06-Nov-13	42.32991	-82.97948	Windsor Fountain - Nearshore	BEF
	2013	2013-GLAP-DTR061113-621A	06-Nov-13	42.33001	-82.97961	Windsor Fountain - Offshore	BEF

Appendix 2. Descriptions of sites sampled by DFO in the St. Clair River in 2007, 2012, and 2014 and the gear type used.

Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
1	2007	2007-GLAP-SCR-230507-011A	23-May-07	42.93189	-82.44827	Suncor	BEF
	2007	2007-GLAP-SCR-230507-012A	23-May-07	42.92777	-82.45067	Suncor	BEF
	2007	2007-GLAP-SCR-300707-011A	30-Jul-07	42.93189	-82.44827	Suncor	BEF
	2007	2007-GLAP-SCR-300707-012A	30-Jul-07	42.92777	-82.45067	Suncor	BEF
	2007	2007-GLAP-SCR-240907-011A	24-Sep-07	42.93189	-82.44827	Suncor	BEF
	2007	2007-GLAP-SCR-240907-012A	24-Sep-07	42.92777	-82.45067	Suncor	BEF
2	2007	2007-GLAP-SCR-230507-021A	23-May-07	42.90003	-82.46188	West of Stag Island	BEF
	2007	2007-GLAP-SCR-230507-022A	23-May-07	42.89626	-82.46496	West of Stag Island	BEF
	2007	2007-GLAP-SCR-010807-021A	01-Aug-07	42.90003	-82.46188	West of Stag Island	BEF
	2007	2007-GLAP-SCR-010807-022A	01-Aug-07	42.89626	-82.46496	West of Stag Island	BEF
	2007	2007-GLAP-SCR-250907-021A	25-Sep-07	42.90003	-82.46188	West of Stag Island	BEF
	2007	2007-GLAP-SCR-250907-022A	25-Sep-07	42.89626	-82.46496	West of Stag Island	BEF
3	2007	2007-GLAP-SCR-230507-031A	23-May-07	42.90495	-82.45869	Talford Creek	BEF
	2007	2007-GLAP-SCR-230507-032A	23-May-07	42.90028	-82.45877	Talford Creek	BEF
	2007	2007-GLAP-SCR-010807-031A	01-Aug-07	42.90008	-82.45877	Talford Creek	BEF
	2007	2007-GLAP-SCR-010807-031A	01-Aug-07	42.90495	-82.45869	Talford Creek	BEF
	2007	2007-GLAP-SCR-010807-032A	01-Aug-07	42.90028	-82.45877	Talford Creek	BEF
	2007	2007-GLAP-SCR-250907-031A	25-Sep-07	42.90495	-82.45869	Talford Creek	BEF
	2007	2007-GLAP-SCR-250907-032A	25-Sep-07	42.90028	-82.45877	Talford Creek	BEF
4	2007	2007-GLAP-SCR-240507-041A	24-May-07	42.79743	-82.47459	OPG Lampton	BEF
	2007	2007-GLAP-SCR-240507-042A	24-May-07	42.79319	-82.47202	OPG Lampton	BEF
	2007	2007-GLAP-SCR-310707-041A	31-Jul-07	42.79743	-82.47459	OPG Lampton	BEF
	2007	2007-GLAP-SCR-310707-042A	31-Jul-07	42.79319	-82.47202	OPG Lampton	BEF
	2007	2007-GLAP-SCR-250907-041A	25-Sep-07	42.79743	-82.47459	OPG Lampton	BEF
	2007	2007-GLAP-SCR-250907-042A	25-Sep-07	42.79319	-82.47202	OPG Lampton	BEF
5	2007	2007-GLAP-SCR-240507-051A	24-May-07	42.75138	-82.46836	Clay Creek	BEF
	2007	2007-GLAP-SCR-240507-052A	24-May-07	42.74721	-82.47127	Clay Creek	BEF
	2007	2007-GLAP-SCR-310707-051A	31-Jul-07	42.75138	-82.46836	Clay Creek	BEF
	2007	2007-GLAP-SCR-310707-052A	31-Jul-07	42.74721	-82.47127	Clay Creek	BEF

	2007	2007-GLAP-SCR-250907-051A	25-Sep-07	42.75138	-82.46836	Clay Creek	BEF
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Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
5	2007	2007-GLAP-SCR-250907-051A	25-Sep-07	42.75128	-82.46836	Clay Creek	BEF
	2007	2007-GLAP-SCR-250907-052A	25-Sep-07	42.74721	-82.47127	Clay Creek	BEF
6	2007	2007-GLAP-SCR-240507-061A	24-May-07	42.68637	-82.49632	Downstream of Fawn Island	BEF
	2007	2007-GLAP-SCR-240507-062A	24-May-07	42.68226	-82.49834	Downstream of Fawn Island	BEF
	2007	2007-GLAP-SCR-310707-061A	31-Jul-07	42.68637	-82.49632	Downstream of Fawn Island	BEF
	2007	2007-GLAP-SCR-310707-062A	31-Jul-07	42.68226	-82.49834	Downstream of Fawn Island	BEF
	2007	2007-GLAP-SCR-260907-061A	26-Sep-07	42.68637	-82.49632	Downstream of Fawn Island	BEF
	2007	2007-GLAP-SCR-260907-062A	26-Sep-07	42.68226	-82.49834	Downstream of Fawn Island	BEF
7	2007	2007-GLAP-SCR-240507-071A	24-May-07	42.69721	-82.49077	Fawn Island	BEF
	2007	2007-GLAP-SCR-240507-072A	24-May-07	42.6938	-82.49462	Fawn Island	BEF
	2007	2007-GLAP-SCR-310707-071A	31-Jul-07	42.69721	-82.49077	Fawn Island	BEF
	2007	2007-GLAP-SCR-310707-072A	31-Jul-07	42.6938	-82.49462	Fawn Island	BEF
	2007	2007-GLAP-SCR-260907-071A	26-Sep-07	42.69721	-82.49077	Fawn Island	BEF
	2007	2007-GLAP-SCR-260907-072A	26-Sep-07	42.6938	-82.49462	Fawn Island	BEF
8	2007	2007-GLAP-SCR-230507-081A	23-May-07	42.99445	-82.42232	Bluewater Bridge	BEF
	2007	2007-GLAP-SCR-230507-082A	23-May-07	42.98973	-82.42119	Bluewater Bridge	BEF
	2007	2007-GLAP-SCR-300707-081A	30-Jul-07	42.99445	-82.42232	Bluewater Bridge	BEF
	2007	2007-GLAP-SCR-010807-081A	01-Aug-07	42.99445	-82.42232	Bluewater Bridge	BEF
	2007	2007-GLAP-SCR-010807-082A	01-Aug-07	42.98973	-82.42119	Bluewater Bridge	BEF
	2007	2007-GLAP-SCR-240907-081A	24-Sep-07	42.99445	-82.42232	Bluewater Bridge	BEF
	2007	2007-GLAP-SCR-240907-082A	24-Sep-07	42.98973	-82.42119	Bluewater Bridge	BEF
1	2012	2012-GLAP-SCR-310712-111A	31-Jul-12	42.93188	-82.44828	Suncor	TRL
	2012	2012-GLAP-SCR-310712-115A	31-Jul-12	42.92867	-82.4501	Suncor	TRL
	2012	2012-GLAP-SCR-080812-111A	08-Aug-12	42.93188	-82.44828	Suncor	BEF
	2012	2012-GLAP-SCR-080812-115A	08-Aug-12	42.92867	-82.4501	Suncor	BEF
	2012	2012-GLAP-SCR-121012-111A	12-Oct-12	42.93189	-82.44827	Suncor	TRL
	2012	2012-GLAP-SCR-121012-115A	12-Oct-12	42.9286	-82.45023	Suncor	TRL
	2012	2012-GLAP-SCR-241012-111A	24-Oct-12	42.93188	-82.44828	Suncor	BEF
	2012	2012-GLAP-SCR-241012-115A	24-Oct-12	42.92846	-82.45026	Suncor	BEF

2	2012	2012-GLAP-SCR-300712-211A	30-Jul-12	42.90048	-82.46197	West of Stag Island	TRL
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Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
2	2012	2012-GLAP-SCR-300712-215A	30-Jul-12	42.8972	-82.46423	West of Stag Island	TRL
	2012	2012-GLAP-SCR-080812-211A	08-Aug-12	42.90048	-82.46197	West of Stag Island	BEF
	2012	2012-GLAP-SCR-080812-215A	08-Aug-12	42.8972	-82.46423	West of Stag Island	BEF
	2012	2012-GLAP-SCR-121012-211A	12-Oct-12	42.90003	-82.46188	West of Stag Island	TRL
	2012	2012-GLAP-SCR-121012-215A	12-Oct-12	42.89721	-82.46444	West of Stag Island	TRL
	2012	2012-GLAP-SCR-231012-211A	23-Oct-12	42.90068	-82.46386	West of Stag Island	BEF
	2012	2012-GLAP-SCR-231012-215A	23-Oct-12	42.89741	-82.46463	West of Stag Island	BEF
3	2012	2012-GLAP-SCR-300712-311A	30-Jul-12	42.90488	-82.45974	Talford Creek	TRL
	2012	2012-GLAP-SCR-300712-315A	30-Jul-12	42.90119	-82.45892	Talford Creek	TRL
	2012	2012-GLAP-SCR-080812-311A	08-Aug-12	42.90488	-82.46874	Talford Creek	BEF
	2012	2012-GLAP-SCR-080812-315A	08-Aug-12	42.90119	-82.45892	Talford Creek	BEF
	2012	2012-GLAP-SCR-111012-311A	11-Oct-12	42.90495	-82.45869	Talford Creek	TRL
	2012	2012-GLAP-SCR-111012-315A	11-Oct-12	42.90111	-82.45892	Talford Creek	TRL
	2012	2012-GLAP-SCR-241012-311A	24-Oct-12	42.90519	-82.45863	Talford Creek	BEF
4	2012	2012-GLAP-SCR-241012-315A	24-Oct-12	42.90163	-82.45898	Talford Creek	BEF
	2012	2012-GLAP-SCR-020812-411A	02-Aug-12	42.79749	-82.47447	OPG Lampton	TRL
	2012	2012-GLAP-SCR-020812-415A	02-Aug-12	42.79417	-82.47247	OPG Lampton	TRL
	2012	2012-GLAP-SCR-080812-411A	08-Aug-12	42.79749	-82.47447	OPG Lampton	BEF
	2012	2012-GLAP-SCR-080812-415A	08-Aug-12	42.79417	-82.47247	OPG Lampton	BEF
	2012	2012-GLAP-SCR-191012-411A	19-Oct-12	42.79743	-82.47459	OPG Lampton	TRL
	2012	2012-GLAP-SCR-191012-415A	19-Oct-12	42.79406	-82.47253	OPG Lampton	TRL
	2012	2012-GLAP-SCR-231012-411A	23-Oct-12	42.79749	-82.47447	OPG Lampton	BEF
5	2012	2012-GLAP-SCR-231012-415A	23-Oct-12	42.79417	-82.47255	OPG Lampton	BEF
	2012	2012-GLAP-SCR-010812-511A	01-Aug-12	42.75139	-82.46823	Clay Creek	TRL
	2012	2012-GLAP-SCR-010812-515A	01-Aug-12	42.74797	-82.47061	Clay Creek	TRL
	2012	2012-GLAP-SCR-090812-511A	09-Aug-12	42.75139	-82.46823	Clay Creek	BEF
	2012	2012-GLAP-SCR-090812-515A	09-Aug-12	42.74797	-82.47061	Clay Creek	BEF
	2012	2012-GLAP-SCR-181012-511A	18-Oct-12	42.75138	-82.46836	Clay Creek	TRL
	2012	2012-GLAP-SCR-181012-515A	18-Oct-12	42.74797	-82.47066	Clay Creek	TRL

	2012	2012-GLAP-SCR-231012-511A	23-Oct-12	42.75133	-82.46827	Clay Creek	BEF
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Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
5	2012	2012-GLAP-SCR-231012-515A	23-Oct-12	42.74801	-82.47047	Clay Creek	BEF
6	2012	2012-GLAP-SCR-010812-611A	01-Aug-12	42.68644	-82.4963	Downstream of Fawn Island	TRL
	2012	2012-GLAP-SCR-010812-615A	01-Aug-12	42.68304	-82.49794	Downstream of Fawn Island	TRL
	2012	2012-GLAP-SCR-130812-611A	13-Aug-12	42.68644	-82.4963	Downstream of Fawn Island	BEF
	2012	2012-GLAP-SCR-130812-615A	13-Aug-12	42.68304	-82.49794	Downstream of Fawn Island	BEF
	2012	2012-GLAP-SCR-101012-611A	10-Oct-12	42.68637	-82.49632	Downstream of Fawn Island	TRL
	2012	2012-GLAP-SCR-101012-615A	10-Oct-12	42.68289	-82.49799	Downstream of Fawn Island	TRL
	2012	2012-GLAP-SCR-221012-611A	22-Oct-12	42.68655	-82.49627	Downstream of Fawn Island	BEF
	2012	2012-GLAP-SCR-221012-615A	22-Oct-12	42.68292	-82.49789	Downstream of Fawn Island	BEF
	2012	2012-GLAP-SCR-010812-711A	01-Aug-12	42.69732	-82.49079	Fawn Island	TRL
7	2012	2012-GLAP-SCR-010812-715A	01-Aug-12	42.69455	-82.49403	Fawn Island	TRL
	2012	2012-GLAP-SCR-130812-711A	13-Aug-12	42.69732	-82.49079	Fawn Island	BEF
	2012	2012-GLAP-SCR-130812-715A	13-Aug-12	42.69455	-82.49403	Fawn Island	BEF
	2012	2012-GLAP-SCR-101012-711A	10-Oct-12	42.69721	-82.49077	Fawn Island	TRL
	2012	2012-GLAP-SCR-101012-715A	10-Oct-12	42.69451	-82.494	Fawn Island	TRL
	2012	2012-GLAP-SCR-221012-711A	22-Oct-12	42.69788	-82.48983	Fawn Island	BEF
	2012	2012-GLAP-SCR-221012-715A	22-Oct-12	42.69551	-82.49306	Fawn Island	BEF
	2012	2012-GLAP-SCR-310712-811A	31-Jul-12	42.99441	-82.42233	Bluewater Bridge	TRL
8	2012	2012-GLAP-SCR-310712-815A	31-Jul-12	42.99076	-82.42158	Bluewater Bridge	TRL
	2012	2012-GLAP-SCR-130812-811A	13-Aug-12	42.99441	-82.42233	Bluewater Bridge	BEF
	2012	2012-GLAP-SCR-130812-815A	13-Aug-12	42.99076	-82.42158	Bluewater Bridge	BEF
	2012	2012-GLAP-SCR-241012-811B	24-Oct-12	42.99445	-82.42232	Bluewater Bridge	TRL
	2012	2012-GLAP-SCR-241012-811A	24-Oct-12	42.99445	-82.42232	Bluewater Bridge	BEF
	2012	2012-GLAP-SCR-241012-815A	24-Oct-12	42.99073	-82.4216	Bluewater Bridge	BEF
	2012	2012-GLAP-SCR-241012-815B	24-Oct-12	42.99073	-82.4216	Bluewater Bridge	TRL
	2012	2012-GLAP-SCR-241012-815B	24-Oct-12	42.99073	-82.4216	Bluewater Bridge	TRL
1	2014	2014-GLAP-SCR120814-111A	12-Aug-14	42.93185	-82.44833	Suncor	BEF
	2014	2014-GLAP-SCR120814-115A	12-Aug-14	42.92835	-82.45035	Suncor	BEF
	2014	2014-GLAP-SCR270814-111A	27-Aug-14	42.93185	-82.44833	Suncor	TRL
	2014	2014-GLAP-SCR270814-115A	27-Aug-14	42.92835	-82.45035	Suncor	TRL

2	2014	2014-GLAP-SCR230714-211A	23-Jul-14	42.89969	-82.46222	West of Stag Island	TRL
Site	Year	Field number	Date	Start latitude	Start longitude	Narrative locality description	Gear type
2	2014	2014-GLAP-SCR230714-215A	23-Jul-14	42.89624	-82.46458	West of Stag Island	TRL
	2014	2014-GLAP-SCR140814-211A	14-Aug-14	42.89969	-82.4622	West of Stag Island	BEF
	2014	2014-GLAP-SCR140814-215A	14-Aug-14	42.89624	-82.46458	West of Stag Island	BEF
3	2014	2014-GLAP-SCR230714-311A	23-Jul-14	42.90484	-82.45869	Talford Creek	TRL
	2014	2014-GLAP-SCR230714-315A	23-Jul-14	42.90113	-82.4589	Talford Creek	TRL
	2014	2014-GLAP-SCR120814-311A	12-Aug-14	42.90484	-82.45869	Talford Creek	BEF
	2014	2014-GLAP-SCR120814-315A	12-Aug-14	42.90113	-82.4589	Talford Creek	BEF
4	2014	2014-GLAP-SCR210714-411A	21-Jul-14	42.7975	-82.47455	OPG Lampton	TRL
	2014	2014-GLAP-SCR210714-415A	21-Jul-14	42.79394	-82.47248	OPG Lampton	TRL
	2014	2014-GLAP-SCR140814-411A	14-Aug-14	42.79831	-82.47507	OPG Lampton	BEF
	2014	2014-GLAP-SCR140814-415A	14-Aug-14	42.79479	-82.47291	OPG Lampton	BEF
5	2014	2014-GLAP-SCR220714-511A	22-Jul-14	42.75142	-82.46822	Clay Creek	TRL
	2014	2014-GLAP-SCR220714-515A	22-Jul-14	42.74791	-82.47061	Clay Creek	TRL
	2014	2014-GLAP-SCR140814-511A	14-Aug-14	42.75142	-82.46822	Clay Creek	BEF
	2014	2014-GLAP-SCR140814-515A	14-Aug-14	42.74791	-82.47061	Clay Creek	BEF
6	2014	2014-GLAP-SCR220714-611A	22-Jul-14	42.68644	-82.49625	Downstream of Fawn Island	TRL
	2014	2014-GLAP-SCR220714-615A	22-Jul-14	42.68289	-82.49795	Downstream of Fawn Island	TRL
	2014	2014-GLAP-SCR130814-611A	13-Aug-14	42.68644	-82.49625	Downstream of Fawn Island	BEF
	2014	2014-GLAP-SCR130814-615A	13-Aug-14	42.68289	-82.49795	Downstream of Fawn Island	BEF
7	2014	2014-GLAP-SCR220714-711A	22-Jul-14	42.69742	-82.49072	Fawn Island	TRL
	2014	2014-GLAP-SCR220714-715A	22-Jul-14	42.69447	-82.49409	Fawn Island	TRL
	2014	2014-GLAP-SCR130814-711A	13-Aug-14	42.69742	-82.49072	Fawn Island	BEF
	2014	2014-GLAP-SCR130814-715A	13-Aug-14	42.69447	-82.49409	Fawn Island	BEF
8	2014	2014-GLAP-SCR130814-811A	13-Aug-14	42.99387	-82.42223	Bluewater Bridge	BEF
	2014	2014-GLAP-SCR130814-815A	13-Aug-14	42.99027	-82.42142	Bluewater Bridge	BEF
	2014	2014-GLAP-SCR270814-811A	27-Aug-14	42.99387	-82.42223	Bluewater Bridge	TRL
	2014	2014-GLAP-SCR270814-815A	27-Aug-14	42.99027	-82.42142	Bluewater Bridge	TRL

Appendix 3. Hamilton IBI classification scheme.

Section	Description	Scoring criteria			
		0	1	3	5
<i>Species richness and composition</i>	Number of species collected in each sample (as a % of total collected in the entire AOC)	0	0-25%	26-50%	> 50%
	Number of percid species present in each sample area	0	1	2	≥ 3
	Number of naturally-spawned salmonid and coregonid species present in each sample area	0	1	2	≥ 3
<i>Subtotal:</i>					
<i>Trophic composition</i>	Proportion of individuals considered specialist/insectivores/planktivores	0	< 20%	20-40%	> 40%
	Proportion of individuals considered generalists	0	> 40%	20-40%	< 20%
	Proportion of individuals considered top piscivores	0	< 2%	2-5%	> 5%
<i>Subtotal:</i>					
<i>Fish abundance and health</i>	Ratio of CPUE in the sample area to mean AOC CPUE (as %)	-	< 80%	80-120%	> 120%
	Occurrence of individuals which are hybrids, diseased, have lamprey scars or are invading species	-	> 5%	1-5%	0
<i>Subtotal:</i>					
<i>Total:</i>					

Rating System:

- < 15 = very poor
- 18-23 = poor
- 25-29 = fair
- 31-34 = good
- 37-40 = excellent

Appendix 4. Edwards adaptation of the Hamilton (1987) IBI classification scheme.

Section	Description	Scoring criteria			
		0	1	3	5
<i>Species richness and composition</i>	Number of species collected in each sample (as a % of total collected in the entire AOC)	0	0-25%	26-50%	> 50%
	Number of percid species present in each sample area	0	1	2	≥ 3
	Number of native naturally-spawned salmonid and coregonine species present in each sample area	0	1	2	≥ 3
<i>Subtotal:</i>					
<i>Trophic composition</i>	Proportion of individuals considered specialist/insectivores/planktivores	0	< 20%	20-40%	> 40%
	Proportion of individuals considered generalists	0	> 40%	20-40%	< 20%
	Proportion of individuals considered top piscivores	0	< 2%	2-5%	> 5%
<i>Subtotal:</i>					
<i>Fish abundance and health</i>	Ratio of CPUE in the sample area to mean AOC CPUE (as %)	-	< 80%	80-120%	> 120%
	Occurrence of individuals which are hybrids, diseased, have lamprey scars or are invading species	-	> 5%	1-5%	0
<i>Subtotal:</i>					
<i>Total:</i>					

Rating System:

- < 15 = very poor
- 18-23 = poor
- 25-29 = fair
- 31-34 = good
- 37-40 = excellent

Appendix 5. Minns IBI for the Great Lakes littoral fish assemblage with the coefficient intercept (A) and slope (B) in equations 1 standardizing the metrics and values for each raw metric. * Coefficient dependent on best professional judgement reference condition.
 ** Coefficients calculated using the 95th percentile, dependent on the scale of analysis.

Section	Metric Descriptions	Metric Coefficients	
		A	B
Species richness	Natives	0	*
	Centrarchids	0	*
	Intolerants	0	*
	Nonindigenous	10	*
	Native cyprinids	0	*
Trophic structure	% piscivore biomass	0	0.3
	% generalist biomass	15	-0.15
	% specialist biomass	0	0.3
Abundance and condition	Number of native individuals	0	**
	Biomass of natives (kg)	0	**
	% nonindigenous numbers	10	**
	% nonindigenous biomass	10	**

Rating System: 0 = No fish
 >0-20 =very poor
 >20-40 = poor
 >40-60 = fair
 >60-80 = good
 >80 = excellent

Appendix 6. Best professional judgement selections from Granados (2010) for 2, 3, and 5 respondent agreements of species in the HEC reference condition. A value of 1 indicates inclusion on the species list of respondents. * species omitted from analysis

Scientific name	Common name	≥ 2	≥ 3	≥ 4
<i>Acipenser fulvescens</i>	Lake Sturgeon	1	1	1
<i>Ambloplites rupestris</i>	Rock Bass	1	1	1
<i>Ameiurus melas</i>	Black Bullhead	1	1	1
<i>Ameiurus natalis</i>	Yellow Bullhead	1	1	1
<i>Ameiurus nebulosus</i>	Brown Bullhead	1	1	1
<i>Amia calva</i>	Bowfin	1	1	1
<i>Aplodinotus grunniens</i>	Freshwater Drum	1	1	1
<i>Camptostoma anomalum</i>	Central Stoneroller	1	1	0
<i>Carassius auratus</i>	Goldfish	1	1	0
<i>Carpoides cyprinus</i>	Quillback	1	1	1
<i>Catostomus</i>	Longnose Sucker	1	1	0
<i>Catostomus commersonii</i>	White Sucker	1	1	1
<i>Clinostomus elongates</i>	Redside Dace	1	0	0
<i>Coregonus artedii</i>	Lake Herring	1	1	1
<i>Coregonus clupeaformis</i>	Lake Whitefish	1	1	1
<i>Cottus bairdi</i>	Mottled Sculpin	1	0	0
<i>Couesius plumbeus</i>	Lake Chub	1	1	1
<i>Cyprinella spiloptera</i>	Spotfin Shiner	1	1	1
<i>Cyprinus carpio</i>	Common Carp	1	1	1
<i>Dorosoma cepedianum</i>	Gizzard Shad	1	1	1
<i>Erimyzon oblongus</i>	Creek Chubsucker	1	0	0
<i>Esox americanus vermiculatus</i>	Grass Pickerel	1	0	0
<i>Esox lucius</i>	Northern Pike	1	1	1
<i>Esox masquinongy</i>	Muskellunge	1	1	1
<i>Esox niger</i>	Chain Pickerel	1	1	0
<i>Etheostoma nigrum</i>	Johnny Darter	1	1	0
<i>Fundulus diaphanus</i>	Banded Killifish	1	1	1
<i>Fundulus notatus</i>	Blackstripe Topminnow	1	0	0
<i>Gasterosteus aculeatus</i>	Threespine Stickleback	1	0	0
<i>Hybognathus hankinsoni</i>	Brassy Minnow	1	0	0
<i>Hypentelium nigricans</i>	Northern Hogsucker	1	1	1
<i>Ichthyomyzon fossor</i>	Northern Brook Lamprey	1	0	0
<i>Ichthyomyzon unicuspis</i>	Silver Lamprey	1	0	0
<i>Ictalurus punctatus</i>	Channel Catfish	1	1	1
<i>Ictiobus bubalus</i>	Smallmouth Buffalo	1	0	0
<i>Ictiobus cyprinellus</i>	Bigmouth Buffalo	1	1	0
<i>Ictiobus niger</i>	Black Buffalo	1	1	0
<i>Labidesthes sicculus</i>	Brook Silverside	1	1	1
<i>Lepisosteus oculatus</i>	Spotted Gar	1	0	0
<i>Lepisosteus osseus</i>	Longnose Gar	1	1	1
<i>Lepomis cyanellus</i>	Green Sunfish	1	1	0
<i>Lepomis gibbosus</i>	Pumpkinseed	1	1	1
<i>Lepomis gulosus</i>	Warmouth	1	0	0
<i>Lepomis humilis</i>	Orangespotted Sunfish	1	0	0

Scientific name	Common name	≥ 2	≥ 3	≥ 4
<i>Lepomis macrochirus</i>	Bluegill	1	1	1
<i>Lepomis megalotis</i>	Longear Sunfish	1	1	1
<i>Lota lota</i>	Burbot	1	1	0
<i>Luxilis chrysocephalus</i>	Striped Shiner	1	1	0
<i>Luxilis cornutus</i>	Common Shiner	1	1	1
<i>Lythrurus umbratilis</i>	Redfin Shiner	1	0	0
<i>Macrhybopsis storeriana</i>	Silver Chub	1	1	0
<i>Margariscus margarita</i>	Pearl Dace	1	0	0
<i>Micropterus dolomieu</i>	Smallmouth Bass	1	1	1
<i>Micropterus salmoides</i>	Largemouth Bass	1	1	1
<i>Minytrema melanops</i>	Spotted Sucker	1	1	1
<i>Morone americana</i>	White Perch	1	1	1
<i>Morone chrysops</i>	White Bass	1	1	1
<i>Moxostoma anisurum</i>	Silver Redhorse	1	1	1
<i>Moxostoma carinatum</i>	River Redhorse	1	1	1
<i>Moxostoma duquesnei</i>	Black Redhorse	1	1	1
<i>Moxostoma erythrurum</i>	Golden Redhorse	1	1	1
<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	1	1	1
<i>Moxostoma valenciennesi</i>	Greater Redhorse	1	1	0
<i>Neogobius melanostomus</i>	Round Goby	1	0	0
<i>Nocomis biguttatus</i>	Hornyhead Chub	1	1	1
<i>Nocomis micropogon</i>	River Chub	1	0	0
<i>Notemigonus crysoleucas</i>	Golden Shiner	1	1	1
<i>Notropis anogenus</i>	Pugnose Shiner	1	1	0
<i>Notropis ariommus</i>	Popeye Shiner	1	0	0
<i>Notropis atherinoides</i>	Emerald Shiner	1	1	1
<i>Notropis buchanani</i>	Ghost Shiner	1	0	0
<i>Notropis heterodon</i>	Blackchin Shiner	1	1	0
<i>Notropis heterolepis</i>	Blacknose Shiner	1	1	0
<i>Notropis hudsonius</i>	Spottail Shiner	1	1	1
<i>Notropis rubellus</i>	Rosyface Shiner	1	1	0
<i>Notropis stramineus</i>	Sand Shiner	1	1	1
<i>Notropis volucellus</i>	Mimic Shiner	1	1	1
<i>Noturus flavus</i>	Stonecat	1	1	1
<i>Noturus gyrinus</i>	Tadpole Madtom	1	1	0
<i>Noturus insignis</i>	Margined Madtom	1	0	0
<i>Noturus miurus</i>	Brindled Madtom	1	0	0
<i>Noturus stigmosus</i>	Northern Madtom	1	1	1
<i>Opsopoeodus emiliae</i>	Pugnose Minnow	1	1	0
<i>Perca flavescens</i>	Yellow Perch	1	1	1
<i>Percina caprodes</i>	Logperch	1	1	1
<i>Percina maculata</i>	Blackside Darter	1	0	0
<i>Percopsis omiscomaycus</i>	Trout-perch	1	1	0
<i>Phoxinus eos</i>	Northern Redbelly Dace	1	0	0
<i>Pimephales notatus</i>	Bluntnose Minnow	1	1	1
<i>Pimephales promelas</i>	Fathead Minnow	1	0	0

Scientific name	Common name	≥ 2	≥ 3	≥ 4
<i>Pomoxis annularis</i>	White Crappie	1	1	1
<i>Pomoxis nigromaculatus</i>	Black Crappie	1	1	1
<i>Prosopium cylindraceum</i>	Round Whitefish	1	0	0
<i>Pungitius</i>	Ninespine Stickleback	1	0	0
<i>Pylodictis olivaris</i>	Flathead Catfish	1	0	0
<i>Rhinichthys atratulus</i>	Blacknose Dace	1	1	0
<i>Rhinichthys cataractae</i>	Longnose Dace	1	1	0
<i>Salvelinus fontinalis</i>	Brook Trout	1	0	0
<i>Salvelinus namaycush</i>	Lake Trout	1	1	0
<i>Sander canadensis</i>	Sauger	1	1	0
<i>Sander vireus glaucus</i>	Blue Pike*	1	0	0
<i>Sander vitreus</i>	Walleye	1	1	1
<i>Semotilus atromaculatus</i>	Creek Chub	1	1	0
<i>Umbra limi</i>	Central Mudminnow	1	1	1

Appendix 7. Species transformation coefficients for length to biomass equations. See Appendix 6 for scientific names of all species.

Common name	a	b	Transformation	Source	Related fish species
Alewife	-3.77	2.51	log	Coker et al. 2001	
Banded Killifish	-5.09	3.041	log	Coker et al. 2001	
Bigmouth Buffalo	-5.069	3.118	log	Coker et al. 2001	
Black Crappie	-5.618	3.345	log	Coker et al. 2001	
Bluegill	-5.374	3.316	log	Coker et al. 2001	
Bluntnose Minnow	-5.22	3.32	log	Coker et al. 2001	
Bowfin	-4.961	2.992	log	Coker et al. 2001	
Brook Silverside	-4.92	2.78	log	Coker et al. 2001	
Brook Stickleback	0.01102	3	log	FishBase	Ninespine Stickleback
Brown Bullhead	-5.076	3.105	log	Coker et al. 2001	
Channel Catfish	-5.8	3.294	log	Coker et al. 2001	
Channel Darter	-13.364	3.4414	ln	Coker et al. 2001	River Darter
Cisco	-4.6399	2.8906	log	Coker et al. 2001	
Common Carp	-4.639	2.92	log	Coker et al. 2001	
Common Shiner	-4.82	3.05	log	Coker et al. 2001	
Creek Chub	-4.41	2.88	log	Coker et al. 2001	
Eastern Sand Darter	-12.517	3.0949	ln	Coker et al. 2001	
Emerald Shiner	-4.71	2.73	log	Coker et al. 2001	
Freshwater Drum	-5.419	3.204	log	Coker et al. 2001	
Gizzard Shad	-5.376	3.17	log	Coker et al. 2001	
Golden Redhorse	-4.85	3.07	log	Coker et al. 2001	
Golden Shiner	-5.593	3.302	log	Coker et al. 2001	
Goldfish	-4.53	2.9	log	Coker et al. 2001	
Goldfish X Common Carp	-4.5845	2.91	log	Coker et al. 2001	Geometric mean of Goldfish and Common Carp

Common name	a	b	Transformation	Source	Related fish species
Green Sunfish	-4.915	3.101	log	Coker et al. 2001	
Hornyhead Chub	-5.2702	3.17	log	Coker et al. 2001	
Iowa Darter	-12.569	3.1799	ln	Coker et al. 2001	
Johnny Darter	-4.82	3.05	log	Coker et al. 2001	
Largemouth Bass	-5.316	3.191	log	Coker et al. 2001	
Least Darter	-4.42	2.81	log	Coker et al. 2001	
Logperch	-11.897	3.0532	ln	Coker et al. 2001	
Longnose Gar	-6.811	3.449	log	Coker et al. 2001	
Mimic Shiner	-5.22	3.32	log	Coker et al. 2001	Spottail Shiner
Mottled Sculpin	-5.29903	3.25202	log	Coker et al. 2001	
Muskellunge	-6.066	3.325	log	Coker et al. 2001	
Northern Hogsucker	-4.697	2.902	log	Coker et al. 2001	
Northern Pike	-5.437	3.096	log	Coker et al. 2001	
Nothern Madtom	-4.88	3.07	log	Coker et al. 2001	Brindled Madtom
Orangespotted Sunfish	-5.547	3.271	log	Coker et al. 2001	
Pugnose Shiner	-4.75	3.53	log	Coker et al. 2001	
Pumpkinseed	-5.17	3.237	log	Coker et al. 2001	
Rainbow Darter	-3.59	2.53	log	Coker et al. 2001	
Rainbow Smelt	-5.276	2.952	log	Coker et al. 2001	
Rainbow Trout	-5.023	3.024	log	Coker et al. 2001	
Rock Bass	-4.827	3.074	log	Coker et al. 2001	
Round Goby	-5.0582	3.0748	log	Coker et al. 2001	
Sand Shiner	-5.22	3.32	log	Coker et al. 2001	Spottail Shiner
Shorthead Redhorse	-4.841	2.962	log	Coker et al. 2001	
Silver Lamprey	0.00124	3.08	log	FishBase	
Silver Redhorse	-4.263	3.124	log	Coker et al. 2001	

Common name	a	b	Transformation	Source	Related fish species
Slimy Sculpin	-5.4947	3.3207	log	Coker et al. 2001	
Smallmouth Bass	-5.329	3.2	log	Coker et al. 2001	
Spotfin Shiner	-4.82	3.05	log	Coker et al. 2001	Common Shiner
Spottail Shiner	-5.22	3.32	log	Coker et al. 2001	
Spotted Sucker	-5.753	3.341	log	Coker et al. 2001	
Striped Shiner	-4.82	3.05	log	Coker et al. 2001	Common Shiner
Threespine Stickleback	-4.67	2.795	log	Coker et al. 2001	
Trout-perch	-5.0321	3.08	log	Coker et al. 2001	
Tubenose Goby	-5.71	3.4821	log	Coker et al. 2001	
Walleye	-5.453	3.18	log	Coker et al. 2001	
White Bass	-5.066	3.081	log	Coker et al. 2001	
White Perch	-5.122	3.136	log	Coker et al. 2001	
White Sucker	-4.755	2.94	log	Coker et al. 2001	
Yellow Bullhead	-5.374	3.232	log	Coker et al. 2001	
Yellow Perch	-5.386	3.23	log	Coker et al. 2001	

Appendix 8. Species transformation coefficients for standard length to total length.

Common name	a	b	Source
Alewife	0	1.282	FishBase
Cisco	0	1.16	FishBase
Golden redhorse	0	1.198	FishBase
Pugnose shiner	0	0.853	FishBase
Common shiner	0	1.192	FishBase
Bluntnose minnow	0	1.147	FishBase
Creek chub	0	1.161	FishBase
Trout-perch	0	1.264	FishBase
Rainbow Darter	0	1.166	FishBase
Least Darter	0	1.183	FishBase
Johnny Darter	0	1.196	FishBase
Spotfin Shiner	0	1.2	FishBase
Striped shiner	0	1.169	FishBase
Nothern madtom	0	0.858	FishBase
Brook Stickleback	0	0.872	FishBase

Appendix 9. CPUE values (catch/min) for Detroit and St. Clair sampling by DFO.

Detroit River	2007				2011			2013		
Site	Spring	Summer	Fall	All	Summer	Fall	All	Summer	Fall	All
1	2.74	4.78	5.61	4.69	4.97	9.69	7.42	0.79	1.03	0.90
2	3.94	3.89	7.51	5.11	14.48	16.59	15.61	5.80	12.99	8.95
3	2.58	2.35	4.25	2.94	4.21	12.81	8.53	7.46	13.56	10.67
4	0.21	0.40	3.34	1.17	1.68	3.39	2.54	8.75	9.99	9.33
5	1.75	3.64	10.41	5.30	5.94	34.29	19.01	5.52	1.42	3.54
6	7.56	2.08	6.13	4.72	20.38	23.70	22.17	16.42	8.77	12.78
St. Clair River	2007				2012			2014		
Site	Spring	Summer	Fall	All	Summer	Fall	All	Summer		
1	3.84	0.50	1.02	1.78	1.32	2.18	2.15	2.03	2.03	2.03
2	0.63	0.94	1.06	0.88	0.45	0.36	0.56	0.39	0.39	0.39
3	7.31	6.24	2.05	5.30	2.89	15.85	9.34	6.87	6.87	6.87
4	7.28	3.64	2.25	4.53	2.20	15.57	8.63	2.19	2.19	2.19
5	0.38	1.54	2.64	1.67	2.66	1.60	3.26	0.45	0.45	0.45
6	1.68	1.04	1.10	1.27	1.04	4.52	2.84	0.14	0.14	0.14
7	0.71	2.26	2.63	1.87	3.59	9.85	7.47	2.91	2.91	2.91
8	6.42	0.53	0.42	2.51	0.70	1.72	1.55	1.97	1.97	1.97

Appendix 10. Summary of total boat electrofishing sampling effort (minutes) by site in the Detroit River. Sites were sampled using a 20ft, 7.5 GPP, dual boom electrofishing boat.

Year	Season	1	2	3	4	5	6
2007	All	234.08	119.58	150.22	140.57	103.83	93.63
2007	Spring	37.23	37.78	36.40	33.63	34.27	16.93
2007	Summer	129.60	42.13	71.93	67.73	34.60	38.533
2007	Fall	67.25	39.67	41.88	39.20	34.97	38.17
2011	All	64.12	62.27	66.38	66.60	72.27	62.03
2011	Summer	30.78	28.93	33.05	33.27	38.92	28.70
2011	Fall	33.33	33.33	33.33	33.33	33.33	33.33
2013	All	43.50	47.35	41.88	41.47	40.97	44.90
2013	Summer	24.17	26.57	19.83	21.95	21.20	23.57
2013	Fall	19.33	20.78	22.05	19.52	19.77	21.33

Appendix 11. Summary of total boat electrofishing sampling effort (minutes) by site in the St. Clair River. Sites were sampled using a 20ft, 7.5 GPP, dual boom electrofishing boat.

Year	Season	1	2	3	4	5	6	7	8
2007	All	105.52	102.73	126.25	102.83	117.93	103.53	105.33	101.93
2007	Spring	35.20	34.83	35.58	38.05	33.92	33.42	35.20	34.88
2007	Summer	36.13	32.95	53.17	31.02	34.45	35.63	33.67	33.88
2007	Fall	34.18	34.95	37.50	33.77	49.57	34.48	36.47	33.17
2012	All	51.10	48.57	52.77	55.98	52.75	56.78	51.15	41.30
2012	Summer	50.17	47.18	54.28	60.48	52.28	55.77	49.25	40.10
2012	Fall	20.18	16.73	21.20	22.48	20.68	22.78	20.82	20.97
2014	All	19.25	15.35	22.72	26.98	20.22	21.77	18.92	19.77
2014	Summer	19.25	15.35	22.712	26.98	20.22	21.77	18.92	19.77