A Comparison of Community Based Citizen Science Seining and Electrofishing for Sampling Fish Assemblages in an Urban River

by

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Abstract

Community based citizen science has increased the scope of ecological data collection and monitoring. Despite its growing popularity, validation of citizen science methods especially in fisheries is rarely done. This validation is important to produce high quality data that can be used in scientific studies, monitoring, and management. For the last 10 years, Friends of the Rouge (FOTR), a non-profit in southeast Michigan working to restore, protect, and enhance the Rouge River watershed, has been seining to collect fish community data throughout the river network. The Rouge River, an Environmental Protection Agency (EPA) Area of Concern (AOC), is considered a highly degraded river, but since the Clean Water Act has benefited from numerous restoration projects. These projects have improved the abiotic components of the river, but improvements to the biotic communities are uncertain. FOTR's largely volunteer monitoring program has sampled > 120 sites in the watershed and identified over 60 fish species. Validating the seining data against data collected by electrofishing, the state and federal preferred assessment method, allows the FOTR data to be used in management decisions and possible AOC delisting. Electrofishing is considered the preferred sampling method for evaluating warmwater stream fish communities due to standardization and effectiveness. However, concerns, including costs and safety, have prohibited FOTR from electrofishing in the past. I aimed to evaluate differences between seining compared to electrofishing in the Rouge River. During the summer of 2022, I assisted FOTR community scientists in electrofishing > 50 sites in the watershed. I compared data collected using the two methods, electrofishing and seining, by examining a): the species captured by both methods or by one exclusively, b) the number of species observed with increasing sampling effort, c) diversity metrics used for standardized

evaluation and d) community similarity across areas of the watershed. FOTR is the only organization consistently monitoring in the Rouge, and I found that seining produces reliable assessments and has several advantages for their program.

Introduction

Citizen science has increased the scope of ecological data collection and monitoring, by involving community members and volunteers in scientific research (Cooper et al. 2007; Dickinson et al. 2010). Citizen science can help to fill ecological data gaps when scientists and managers are unable to collect data due to time or monetary constraints (Conrad & Hilchey, 2011). Furthermore, citizen science can increase spatial and temporal resolution of ecological data which has advanced scientific knowledge around bird, plant, insect and fish species (Cooper et al. 2007; Bonney et al. 2009, 2021; Conrad and Hilchey 2011; Buytaert et al. 2012).

Originating from astrometry and ornithology, citizen science has recently broadened to aquatic ecosystems as a cost-effective method for long term monitoring, (Dickinson et al., 2010; Metcalfe et al., 2022). In aquatic systems, citizen science has been used in large scale coral reef monitoring, water quality assessments, stock assessment, invasive species detection and restoration monitoring (Bernhardt et al., 2005; Dickinson et al., 2010; Fairclough et al., 2014; Forrester et al., 2015; Metcalfe et al., 2022). In freshwater ecosystems, however, citizen science focuses more on monitoring abiotic habitat conditions and macroinvertebrate diversity, rather than fish communities (Metcalfe et al. 2022). The limited studies that involve fish have been limited to iNaturalist data, an app that allows users to submit photos of species, or observations of single species (DiBattista et al. 2021; Metcalfe et al. 2022). Conducting routine, protocol-based fish community sampling and monitoring events is rarely done by citizen scientists due to the lack of accessibility to fish collection methods and technical expertise.

Electrofishing and seining are two commonly used sampling methods in fisheries science. Electrofishing is a common method for stream assessment, especially at state and federal agencies (Barbour et al. 1999; Michigan Department of Environmental Quality 2000). The method involves placing electrodes in the water to create an electrical field that momentarily stuns the fish, allowing researchers to net the fish for processing. Researchers can use backpack, barge, or boat electrofishers depending on the depth and width of the stream. Electrofishing is known to be biased against fishes with absent or reduced swim bladders and towards larger fish as the electrical current more easily stuns larger fish (Regis et al. 1981). One of the major considerations with electrofishing is water quality as it can affect shocking efficiency. High water conductivity and high turbidity can decrease catchability (Thompson et al. 1998; Smith Root n.d.). Sampling can always be stressful on fishes, but mortality and injury of fishes is of concern for electrofishing, especially with novice samplers who are often members of community science teams (Snyder 2003). Lastly, electrofishing can be cost prohibitive and requires safety training and precautions to protect researcher's safety.

Seining, another fisheries method, is typically used in sampling smaller, wadeable streams. A long fine mesh is strung between a lead line and buoyant line that is either pulled through the water to capture fish or rushed by researchers when it is stretched across the river, forcing fish into the net. Seining is usually limited by depth as the lead line needs to be kept on the bottom to prevent fish escapement (Portt et al., 2006). Catchability can be limited by fish size in seining, as larger fish can more easily flee outside the seine net (Bayley & Herendeen, 2000). Water quality is less of an issue than with electrofishing, but turbidity can in some cases improves catchability by limiting fishes ability to see the seine (Hahn et al. 2007). Seining is believed to be less injurious to fishes than electrofishing but this has been poorly investigated (Snyder 2003; Poos et al. 2007).

In both electrofishing and seining, regimented sampling is key for standardization and comparison (Barbour et al. 1999; Portt et al. 2006). At times, the quality and standardization of citizen science data has been called into question (Dickinson et al. 2010). To address quality concerns in citizen science data, careful planning of the project scope and methods of collection are extremely important (Dickinson et al. 2010; Metcalfe et al. 2022). In the last decade, citizen science data have become more widely accepted, but validation studies between collection methods are rarely done, especially in freshwater ecosystems (Krabbenhoft and Kashian 2020). Validation is particularly important in areas where high numbers of aquatic citizen science projects occur, such as water bodies in the Laurentian Great Lakes Basin where watershed councils and organizations host regular citizen science monitoring programs (Lottig et al. 2014; Krabbenhoft and Kashian 2020; MiCorps n.d.). For many projects in this region, the data collected have the potential to influence policy and management decisions as these are often the only data collected.

For the last 10 years, Friends of the Rouge (FOTR), a non-profit working to restore, protect, and enhance the Rouge River watershed, has been seining to collect fish community data throughout the river network. This community science program developed out of a need to monitor the recovery of fish communities from historic degradation. This program is truly a mix of citizen and community science as it rooted in collecting scientific data that directly benefits community members (Cooper et al. 2021; Lin Hunter et al. 2023). Therefore, we have decided to call the FOTR project community-based citizen science. Once one of the most polluted rivers in Michigan, the Rouge River was designated as an Area of Concern (AOC) under the Great Lakes

Water Quality Agreement of 1987 (Beam and Braunscheidel 1998; US EPA 2019). An AOC is an area of significant environmental degradation due to human actions. Beneficial Use Impairments (BUIs) must be addressed and removed before the AOC is delisted. BUIs designate significant degradation in biological, chemical, and physical conditions and in associated ecosystem services. Plagued by sediment and water contamination from industrial development, nonpoint source pollution, dredging, and combined sewer overflows, nine of fourteen possible BUIs are identified for the Rouge River AOC. These include Eutrophication or Undesirable Algae, Degradation of Benthos, Restrictions on Fish and Wildlife Consumption, Loss of Fish and Wildlife Habitat, and Degradation of Fish and Wildlife Populations. The removal of the fish related BUIs requires improvements in fish populations which can be determined through sampling and monitoring of fish communities. Therefore, it is important to understand the quality of the data which has been collected since AOC designation in 1987. FOTR approached the University of Michigan (UM) to evaluate their seining data regarding delisting status. Therefore, a partnership between FOTR and UM formed to complete this analysis. When I use, we this refers to the FOTR staff team, volunteers, and me.

I aimed to evaluate differences between seining by community scientists in the Rouge River watershed and electrofishing to assess progress towards removing BUIs related to degraded fish habitat and populations. Electrofishing is rarely accessible to community groups due to cost and safety; therefore, it is important to evaluate the difference between methods to assess the validity of seining for assessment of fish communities in the Rouge River. To validate the seining program, I compared data collected using the two methods, electrofishing and seining, by examining a): the species captured by both methods or by one exclusively, b) the number of species observed with increasing sampling effort, c) diversity metrics used for standardized evaluation (Michigan Department of Environmental Quality 2000) and d) community similarity across areas of the watershed. I expected that differences between the sampling methods in these analyses would be driven by biases in which species are captured and by differences in stream order.

Methods

Study site

The Rouge River drains 467 square miles into the Detroit River. Its four branches (Main, Upper, Middle, and Lower) flow through Wayne, Oakland, and Washtenaw counties in the Detroit Metropolitan Area. While most of the river is considered warm water, there is one transitional cold water tributary, Johnston Creek (Lyons et al. 2009).

From a geological perspective, the Rouge River watershed is rimmed by small moraines but is predominantly glacial lake plain, resulting in a river with flat topography (Wiley et al., 1998). The resulting dominant silt and clay soil composition provides poorly draining soils (Wiley et al., 1998). Additionally, eighty-four percent of land cover is considered 'developed' using the National Land Cover Dataset (2019). The combination of geologic history and human impacts results in a hydrology characterized by large and sudden fluctuations in inflows and water levels following precipitation (Beam & Braunscheidel, 1998; Wiley et al., 1998). This flashy hydrology together with combined sewage overflows (CSO) into the Rouge River has negative implications for fish community composition (Wiley et al. 1998). CSOs, stormwater discharge, and urban runoff bring increased sediments, nutrients and contamination to the Rouge River (Wiley et al. 1998; Paul and Meyer 2003). Urbanization and development can have lasting effects on aquatic ecosystems resulting in decreased fish community diversity, decreased abundance of intolerant species, and increased abundance of tolerant species (Paul and Meyer 2003; Chen and Olden 2020). Restoration and cleaning of the Rouge River has occurred since the 1980s to mitigate the problems of the urban river syndrome, but many issues remain today.

Field Methods

I compared two field sampling techniques in the Rouge River: seining and electrofishing. FOTR has been collecting fish community data by seining in the river since 2012 at 5-10 sites yearly between April-September. At each site, and in each sampling event, they seined roughly 20 times trying to cover the variety of habitats present; and then identified, counted, and measured each fish before returning it back to the river. For most of their sites, they use a four-foot high and fourteen-foot length, 1/8th inch mesh seine and have used four-, eight-, twelve- and twenty-foot seines in the past. Seining has been led by a small team which is a mix of FOTR staff and community volunteers. Since sampling has occurred in the watershed for 10 years, a core team is well trained on fish identification and sampling protocols. The team frequently collaborates and communicates with the Michigan Department of Natural Resources (MDNR) and the Department of Environment, Great Lakes, and Energy (EGLE). They also confer with the UM Museum of Zoology on fish identification when questions arise.

From June to August 2022, we resampled 54 sites throughout the watershed by electrofishing. We chose sites based on FOTR priorities and length of time between previous sampling events while maintaining at least two sites per river valley segment (Wiley et al. 1998; Seelbach et al. 2006) to assure spatial distribution throughout the river network. Backpack, barge, and boat electrofishing were all utilized, depending on stream size. A Smith-Root backpack shocker and an ETS Electrofishing barge shocker were used depending on stream size and access. For the boat electrofishing, we partnered with MDNR to sample. We followed Procedure 51 sampling protocols for sampling as closely as possible (Michigan Department of Environmental Quality, 2000). Personnel, river conditions, and obstructions sometimes resulted in sampling shorter lengths than Procedure 51 recommendations. We always sampled at least one pool-riffle complex. As in the FOTR methods, we identified, counted, and measured all the fish collected.

Data Analysis

To compare differences in fishes captured across sampling methods, we used a variety of analysis techniques. All analysis occurred in R Studio open-source statistical software (RStudio Team 2023). Two sites that were poorly sampled due to equipment failure or poor river conditions were removed from analysis. Analysis occurred on three scales: watershed level, subwatershed level, and stream reach level (Figure 1). The Rouge River contains four subwatersheds, the Main, Upper, Middle, and Lower. Each subwatershed contains several different sampled stream reach. The Main Rouge subwatershed contains Evans Creek, Franklin Creek, Main Branch, Pebble Creek, and Quarton Branch. The Main Branch is broken up into a wadeable and non-wadeable reach with the reaches being separated by a dam. The Upper Rouge subwatershed contains Bell Creek, Seeley Creek, Tarabusi Creek, Minnow Pond, and Upper Branch. The Middle Rouge subwatershed contains Bishop Creek, Johnson Creek, Tonquish Creek, Middle Branch, and Walled Lake Branch. The Lower Rouge subwatershed contains Fowler Creek, Fellows Creek, and Lower Branch.

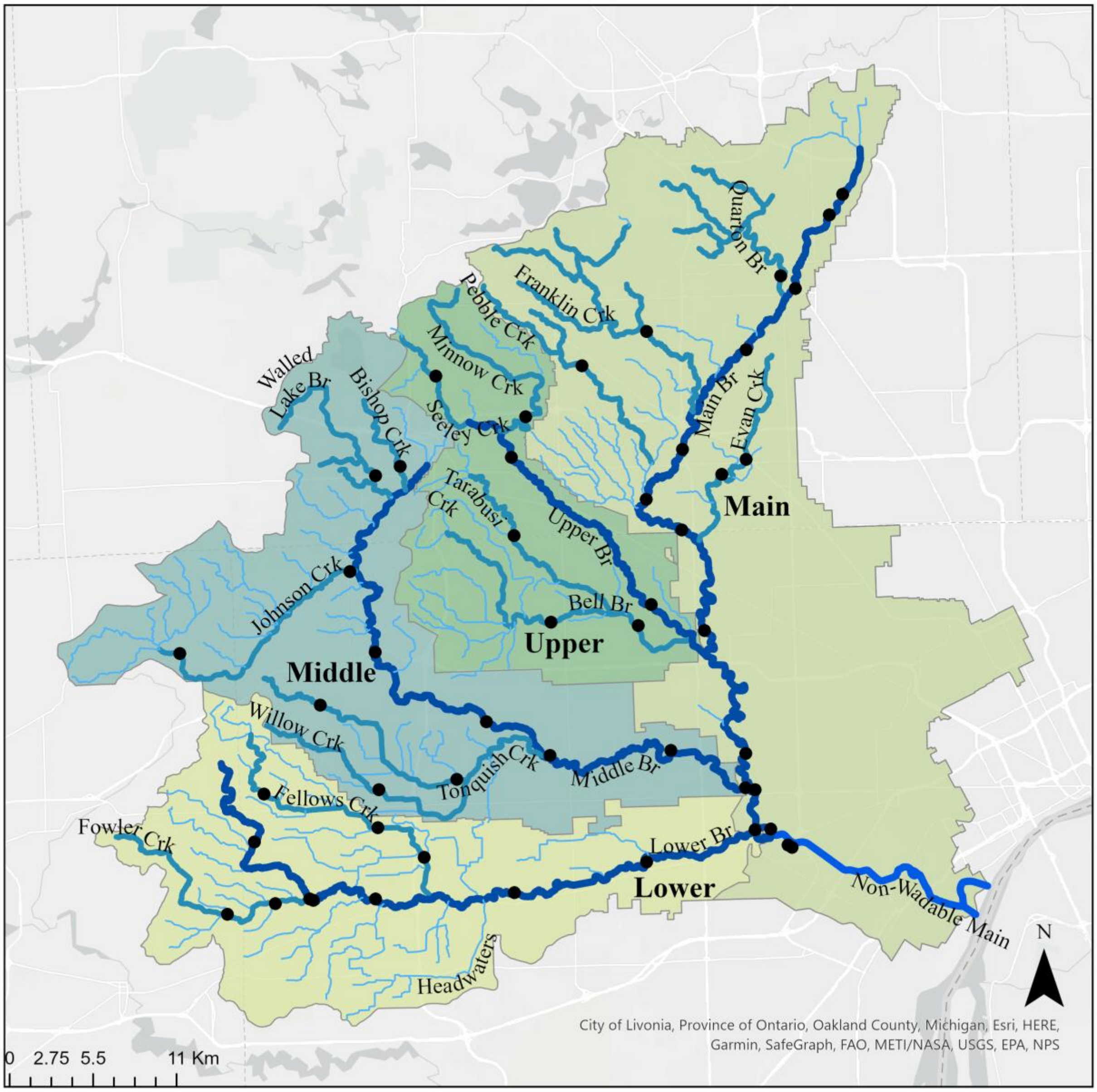

Figure 1: Rouge River Watershed broken down by subwatershed (background color), major branches and tributaries. Stream order is indicated by line thickness, and black dots are paired sampling locations. For labeled locations see appendix.

Overall Comparison of Species Caught

We began with an overall watershed-scale comparison to identify species captured by the two methods. With the aim of understanding which species could be captured by which methods, we compared all species caught over the 10 years of seining with the one summer of electrofishing data. All riverine sites from FOTR seining were included as well as all fully sampled shocking sites. We conducted a simple presence-absence species comparison between methods.

Paired Comparison: Watershed, Subwatershed, and Stream Reach Levels

For species accumulation, Procedure 51, and similarity analyses, we only considered species captured during the most recent seining event at each electrofishing location. Data were pooled within the watershed, subwatershed, or stream reach scales. Sites within a stream reach are known to have similar species composition (Seelbach et al., 1997). Therefore, I did not make site-level comparisons except for comparisons of Procedure 51 scores. At the watershed level, I analyzed data for the entire watershed (wadeable and non-wadeable) and then just the wadeable watershed. This decision was made because of differences in sampling conditions between the wadeable and non-wadeable river reaches. Originally, FOTR sampled both wadeable and non-wadeable reaches of the Rouge River, but due to safety concerns they discontinued the non-wadeable sampling. At the subwatershed and stream reach levels, only wadeable sites were compared. Stream reaches were organized by stream size to examine differences between methods.

Species Accumulation Curves

To assess the effectiveness of each method in capturing the diversity of species we compared species accumulation curves representing the cumulative number of species captured with increasing numbers of sites sampled. We used the R package 'Biodiversity R' to generate species accumulation curves (Kindt and Coe 2022). We used the 'random' method within the 'specaccum' function to calculate means and standard deviations for random permutations of subsamples from our data set without replacement (Gotelli and Colwell 2001; Oksanen et al. 2022). First, at the watershed scale, we analyzed all sites (n=48) and then only wadeable reaches (n=45 sites) of the Rouge River. The three non-wadeable sites sampled by boat shocking in the Non-Wadeable Main Rouge were excluded from the wadeable analysis (Figure 1). Second, we generated species accumulation curves for subwatersheds (wadeable reaches).

Stream Reach Comparison of Species Richness Metrics

Procedure 51 multi-metrics were developed by the (Michigan Department of Environmental Quality 2000) to assess river quality and are considered in delisting the Degradation of Fish and Wildlife Populations BUI (Environmental Consulting & Technology 2008). Therefore, we used several Procedure 51 metrics as well as total multi-metric scores to compare seining and electrofishing and evaluate whether the seining data can be used in future AOC delisting. The Procedure 51 scores range from -10, poor, to 10, excellent, with 0 being considered neutral. If a site has less than 50 fish, the site is automatically considered poor or -10. I analyzed both scores calculated with raw data, regardless of the number of fish captured and adjusted scores in which any site with fewer than 50 fish was scored as -10. I also compared three metrics which are used to calculate the overall Procedure 51 score: total species richness, tolerant species richness, and intolerant species richness (species classification followed

Procedure 51, Michigan Department of Environmental Quality, 2000; see Appendix Table 2). Given that Procedure 51 has different scoring and sampling for wadeable and non-wadeable sites, we focused this analysis on the wadeable sites only. To compare methods, I conducted a paired t-test of both raw scores and adjusted scores.

Differences in Community Composition

To quantify differences in community composition in wadeable stream reaches, I used the Sørensen dissimilarity metric in the "vegan" package (Oksanen et al. 2022). Using presence-absence data, this metric compares the overlap between communities by the ratio of shared species to the relative number of species in both communities. The equation is:

$$Beta = (b + c)/(2a + b + c)$$

where *a* is the number of species shared between two communities, and *b* and *c* are the numbers of unique species (not shared) for each community. The metric ranges from 0 (all the same species) to1 (no species in common). Once the metric was calculated, I converted the metric to percent similarity between the methods, by subtracting from 1 and multiplying by 100%, thus making 100 (all the same species) and 0 (no species in common). I did this to easily visualize where shocking and seining produce similar results. Similarities were mapped to stream reaches using ArcGIS Pro (ESRI n.d.).

Results

Overall Comparison of Species Caught

As I predicted, seining and electrofishing captured many similar species but also each method captured unique species. When examining all sampling events in the watershed, we found more unique species were caught seining (n=368 samples in 10 years) than electrofishing (n=52 samples in 2022). 40 species were caught by both methods (Figure 2). However, seining caught 15 unique species while electrofishing caught 9 unique species (Figure 2). Of the 9 caught electrofishing, 5 were caught boat electrofishing in the non-wadeable main branch.

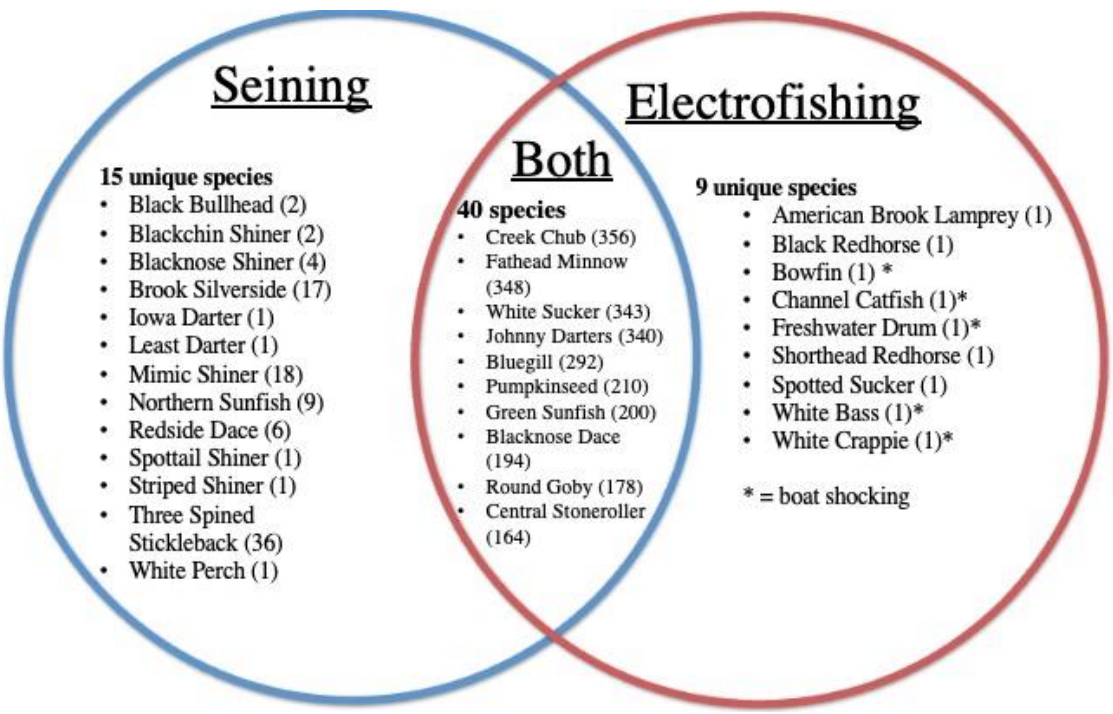

Figure 2: Venn Diagram of fish species caught by seining and electrofishing. The parentheses indicate how many times each species has been captured in the watershed. The 10 most frequent species caught in the watershed are represented in the overlapping circle. The * indicates species only found by boat shocking. For species taxonomy, see Table 1 in Appendix 1.

Paired Comparison: Watershed, Subwatershed and Stream Reach Levels

Species Accumulation Curves

For the entire watershed (wadeable and non-wadeable sites), 48 paired sites were compared. Total species richness by electrofishing was 48 species and seining was 44 species. In the entire Rouge River, the average time between electrofishing and the most recent seining event was 4.39 years with a maximum time of 10.29 years and minimum time of 361 days (Appendix, Table 2). Concentrating on only the wadeable portion of the watershed, we compared 45 samples for each method, which were paired by site; total species richness was 43 for both seining and electrofishing. For the wadeable sites, the average time between electrofishing and the most recent seining event was 4.42 years with a maximum time of 10.29 years and minimum time of 361 days.

None of the watershed scale species accumulation curves appeared to capture the total species richness; neither seining nor electrofishing curves reached an asymptote, but both curves slowly approached an asymptote. Electrofishing captured more species on average than seining for many sampling efforts (Figure 3). However, given the overlapping confidence intervals in both curves, there were almost no significant differences in cumulative species richness between seining and electrofishing across sample sizes. When including the three additional non-wadeable samples, electrofishing did capture significantly more species due to the species captured only by boat shocking in the Main Rouge which, given depth, is not sampled well by seining.

In the wadeable reaches, species richness differed depending on subwatershed, but again given the overlapping confidence intervals, there was no significant difference between sampling methods (Figure 3). In the Main Rouge, electrofishing collected more species on average than seining, while the opposite was true in the Upper Rouge (Figure 4). The Middle and Lower Rouge were similar in species accumulation by either method (Figure 4).

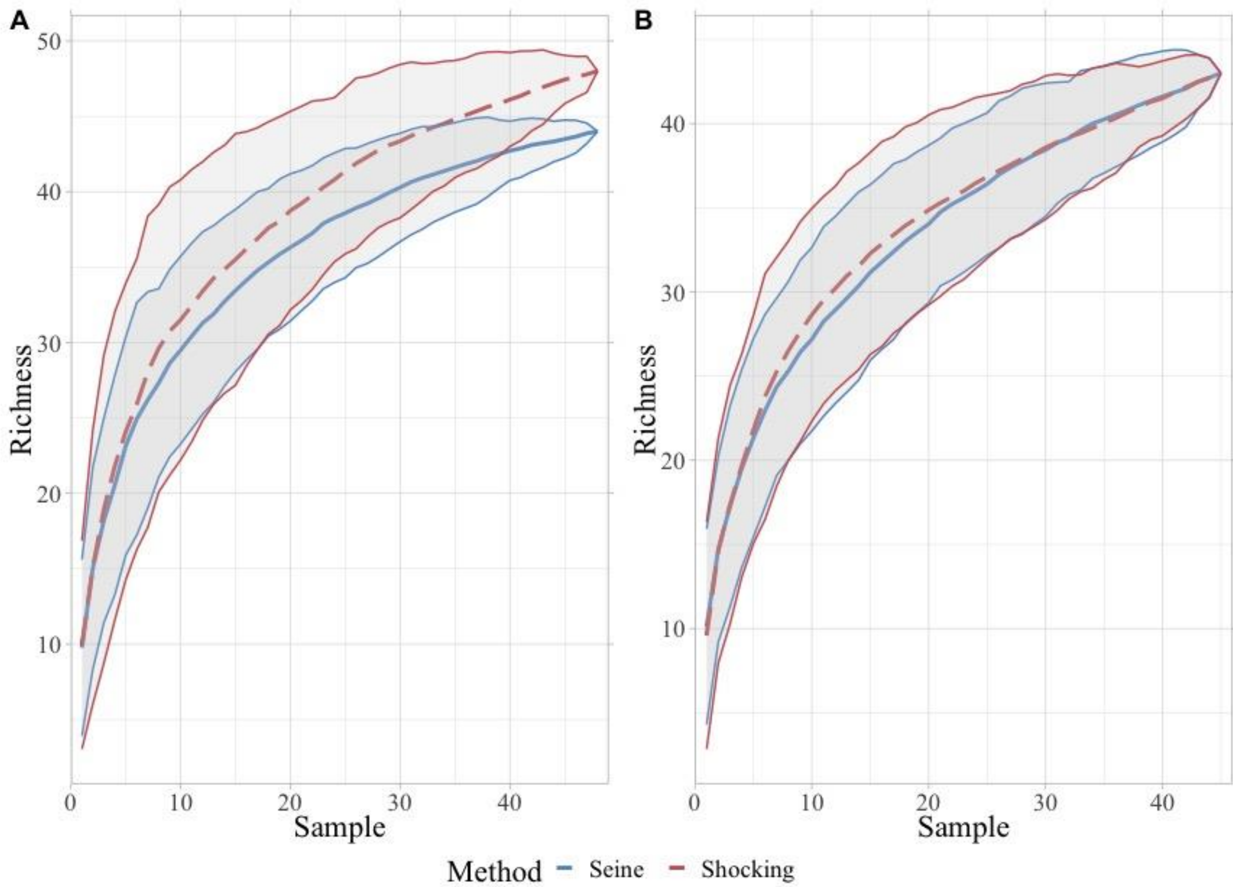

Figure 3: Species accumulation curve for Rouge River watershed. **A)** The entire watershed: wadeable and non-wadeable (n=48). **B)** The wadeable reach of the watershed (n=45). Confidence Interval represents two standard deviations.

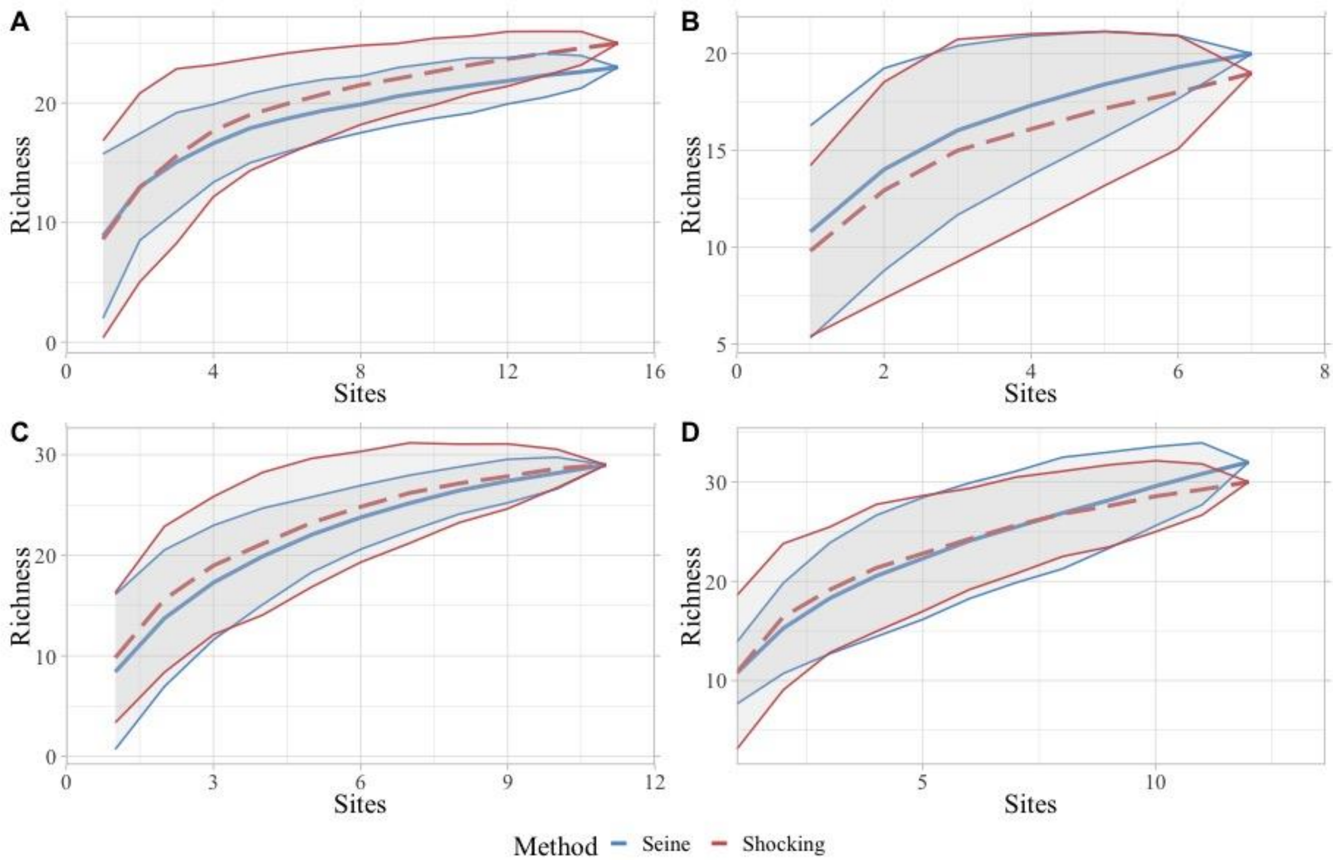

Figure 4*: Species accumulation curves by wadeable subwatershed,* ***A)*** *Main Rouge (n=15, Shocking=25, Seine=23)* ***B)*** *Upper Rouge (n=7, Shocking=19, Seine=20)* ***C)*** *Middle Rouge(n=11, Shocking=29, Seine=29)* ***D)*** Lower Rouge (n=12, Shocking=30, Seine=32). *Confidence interval represents two SDs.*

<u>Stream Reach Comparison of Species Richness Metrics</u>

In many of the individual reaches, seining collected more species than electrofishing (Figure 5A), especially in smaller creeks and streams. The largest difference in species richness, however, was in the Middle Rouge stream reach where shocking captured 21 species and seining only 17. A similar pattern emerged for both tolerant and intolerant species (Figure 5B). In the larger branches, shocking captured a higher richness of tolerant and intolerant species, compared to the seining. In the smaller branches and creeks, the opposite occurred.

Although Procedure 51 scores varied between sites and methods, overall, there was no significant difference between methods. There was not a significant difference for raw Procedure 51 scores between seining (mean=-1.39, SD=±2.89) and electrofishing (mean= -0.568, SD±2.64;

alpha=0.05, p=0.891) (Figure 6). There was also not a significant difference between the adjusted Procedure 51 scores between seining (mean=-1.91, SD= ±3.76) and electrofishing (mean= -1.91, SD= ±4.43; alpha=0.05, p=1) (Figure 6). There does not appear to be a clear pattern as to which method produced higher scores. For example, overall, in Main Branch (sites Main1-9), shocking produced higher scores, but the Upper, Middle, and Lower Branches did not show a similar pattern. For the smaller tributaries, no clear pattern emerged either. In Upper Rouge tributaries, seining produced higher scores but then electrofishing produced higher scores in Middle Rouge tributaries.

Finally, the Sørensen dissimilarity index indicated that most members of the fish community were sampled well using either method, similar to what I found in other analyses (visually represented in Figure 7). The range of similarity is between 50-90% with most of the Rouge River branches showing >76% similarity. Many of the smaller tributaries, Evans Creek, Quarton Branch and Bishop Creek are the least similar. The Lower and Upper branches had the highest similarity.

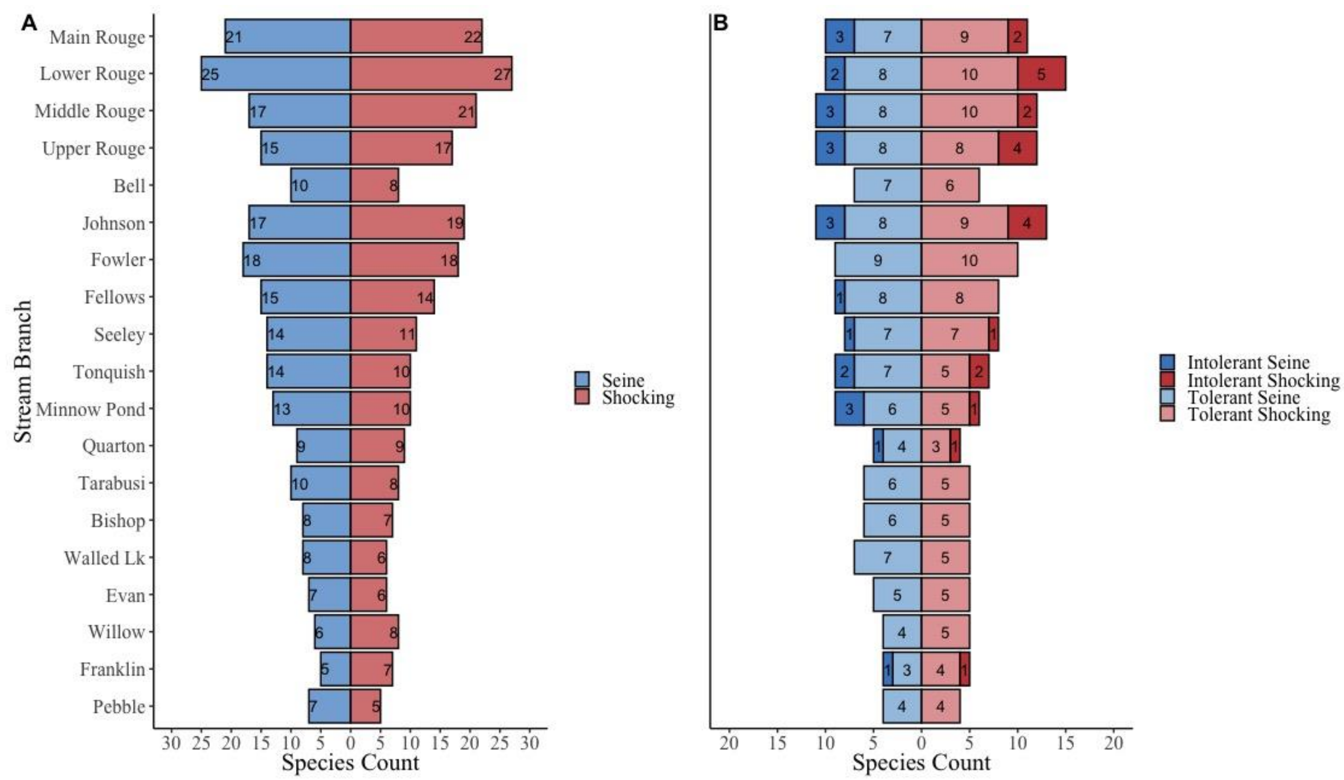

Figure 5: ***A)*** *Total species richness,* ***B)*** *intolerant and tolerant species count by sampling gear. Blue hues are for seining and red hues for shocking. Sites are ordered by branch length, largest (top) to smallest (bottom). Counts increase to the left with seining and to the right with shocking. Symmetry between the left and right sides of these figures indicates similarity between sampling methods.*

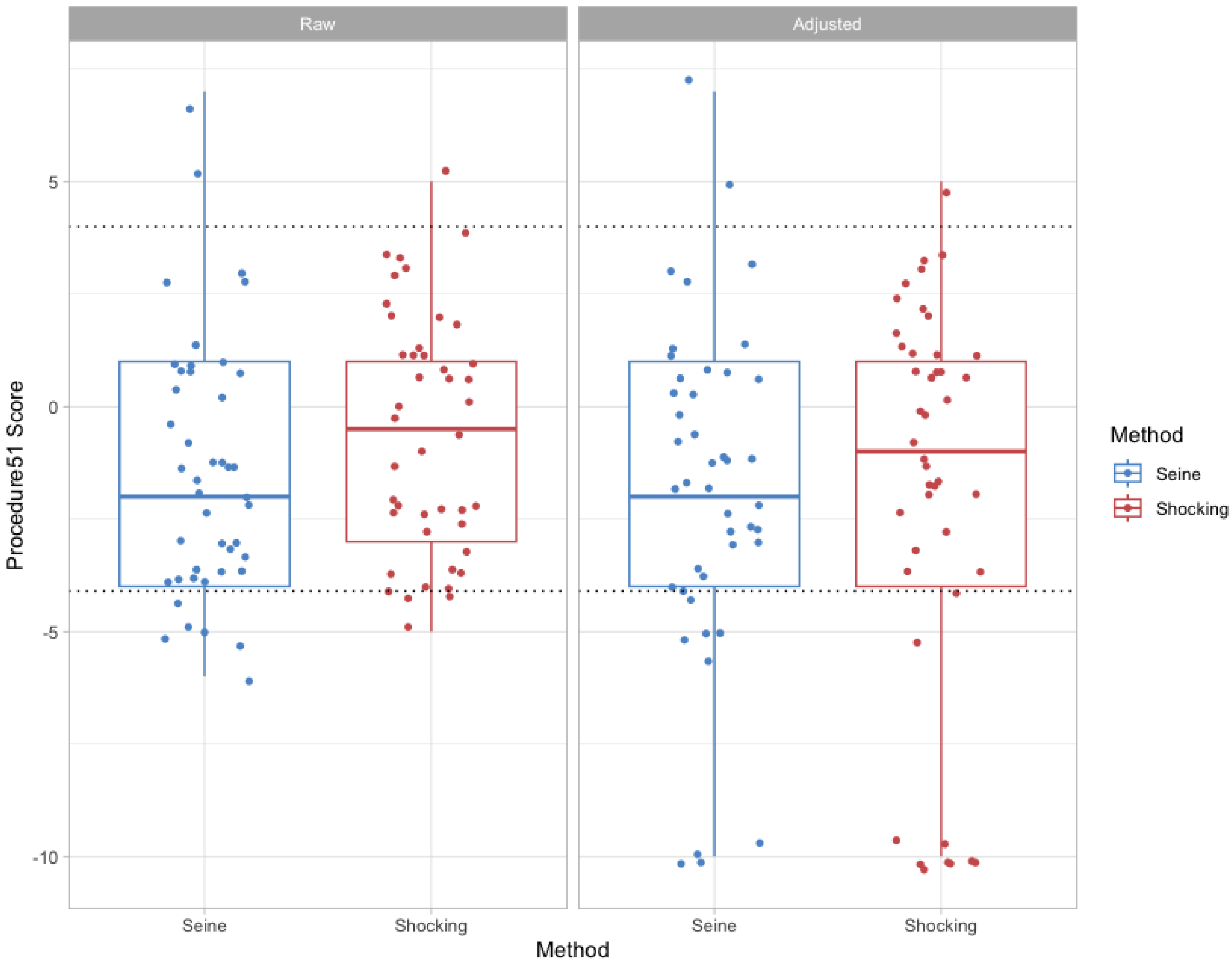

Figure 6: Box plots of raw and adjusted Procedure 51 scores for each sampling method. Each data point represented jittered individual sites scores. Lower and upper limits of boxes are 25th and 75th percentiles, and the median is in the line in the center of box. For Procedure 51 scores, -10 to -5 is 'poor', -4 to +4 is 'acceptable' (between black dotted lines) with 0 neutral, 5 to 10 is 'excellent'.

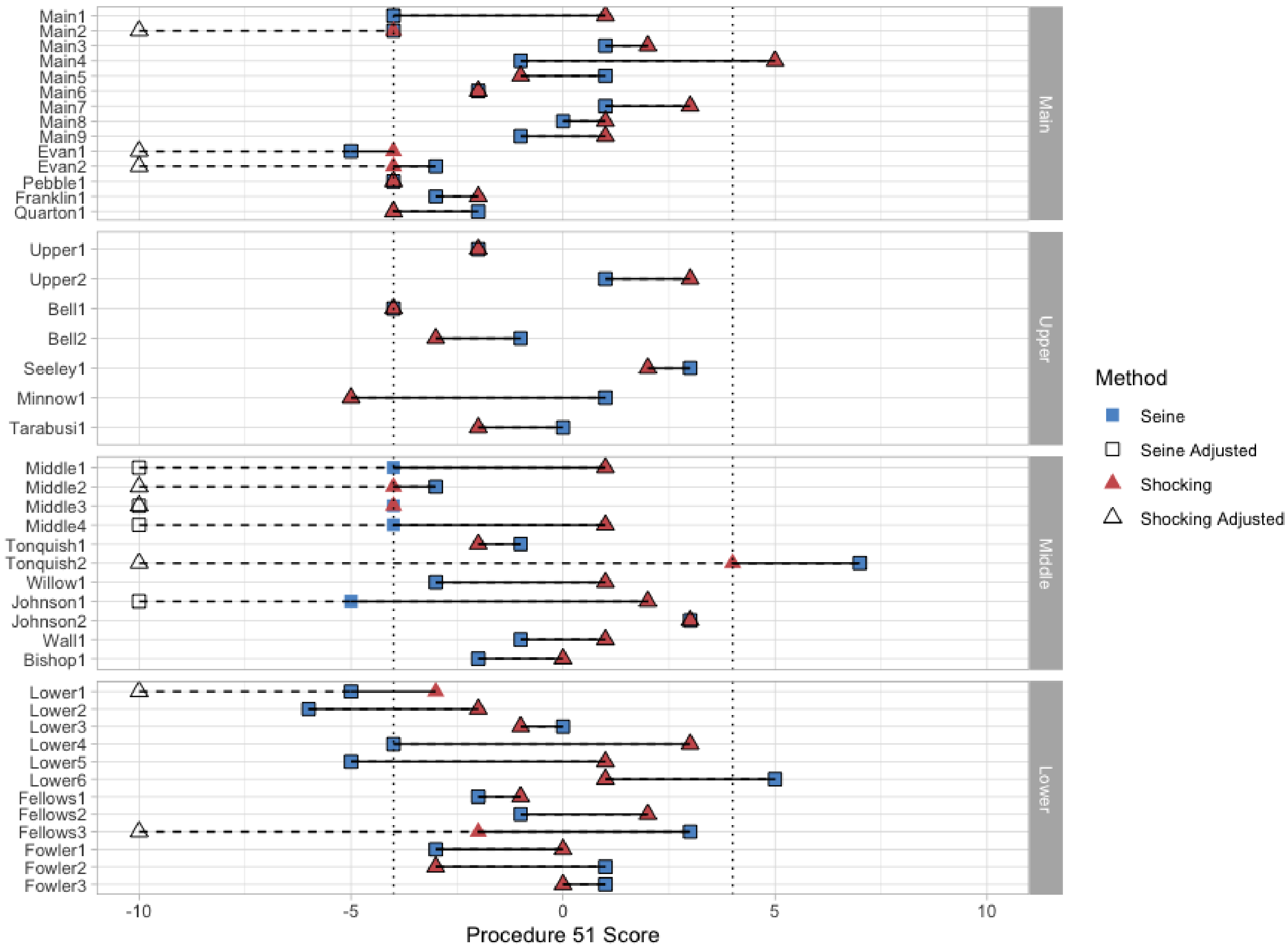

Figure 7: Differences between Procedure 51 scores at each sampling site, by method. The open squares (Seine) and open triangles (Shocking) indicate the adjusted score for sites that contained less than 50 fish. The scores are broken up by subwatershed with each subwatershed order from the most downstream (top) to upstream (bottom) site. Dashed vertical lines indicate the range where scores are considered 'acceptable'.

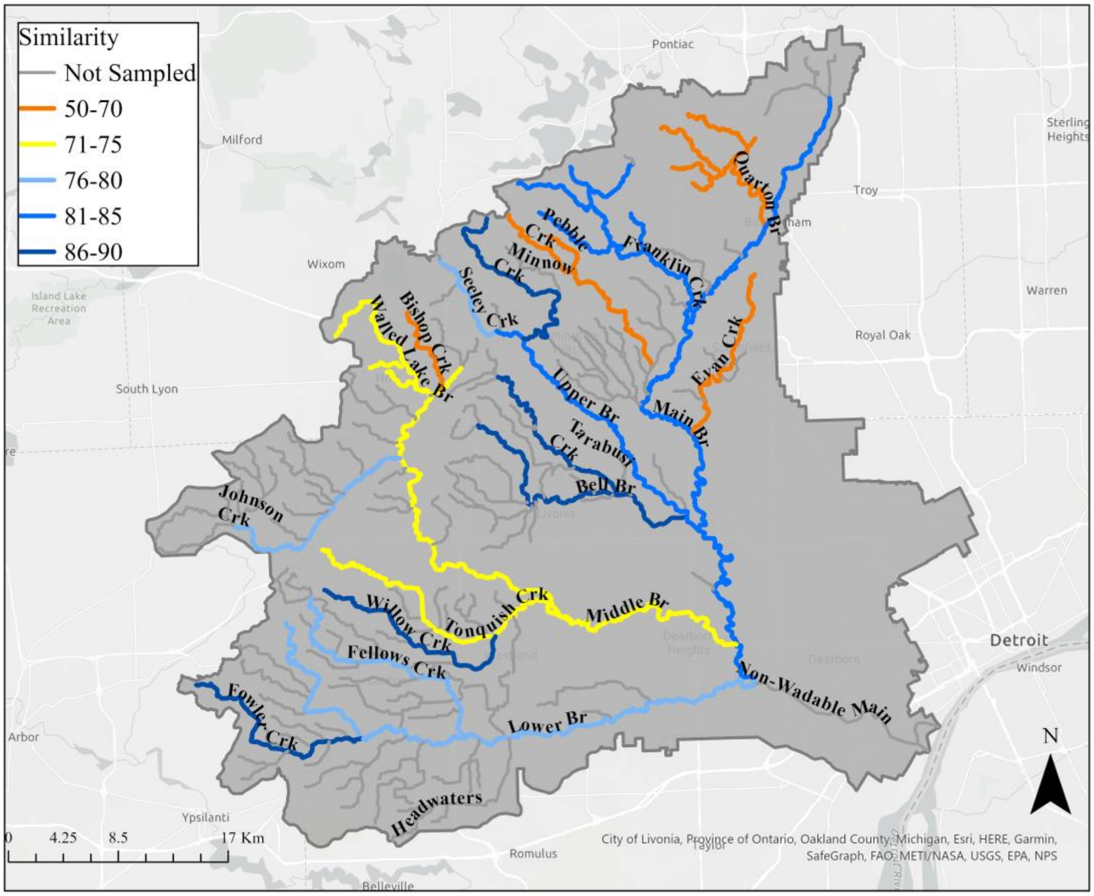

Figure 8: Map of Rouge River with Sørensen similarity. Missing reaches are lakes which were not captured in the analysis. Stream order is indicated by line thickness.

Discussion

The validation of community-based citizen science data is important to support its inclusion into monitoring and research datasets. Our study aimed to evaluate differences between seining by citizen scientists in the Rouge River watershed and the electrofishing method recommended in state assessments (Michigan Department of Environmental Quality 2000). Our results show that in the wadeable reaches, electrofishing and seining appear to be comparable.

We opted to exclude the non-wadeable main branch from most comparisons due to clear differences in habitat, safety concerns, and sampling effectiveness. Habitat in the non-wadeable Main Branch is unlike habitat in the rest of the river network (Figure 1). The non-wadeable Main Branch runs from the Fair Lane Estate Dam to the confluence with the Detroit River, a major industrial connecting channel of the Laurentian Great Lakes. The non-wadeable Main Branch has experienced extreme amounts of industrialization due to the Ford Motor Company Rouge Plant and continues to experience flashy flows due to high urbanization in the watershed (Beam and Braunscheidel 1998). Due to the extreme flashiness and resulting local flooding, 6 kilometers of concrete river channel with no floodplain was created (U.S. Army Corps of Engineers 2011). This reach of river has habitat considered unfavorable due to both poor water quality and low habitat heterogeneity leading to limits on aquatic organisms in this reach (Roseman et al. 2020). Given this reach's depth, between 2- 4 meters, seining is not an effective method for capturing the fish community as a seine cannot sample at that depth. Water depth and velocity pose a safety risk for community scientists. Four species were caught in this reach, but nowhere else in the watershed, Bowfin (*Amia calva*), Freshwater Drum (*Aplodinotus grunniens*), White Bass (*Morone chrysops*) and Channel Catfish (*Ictalurus punctatus*). Bowfin and Channel

Catfish are listed as possible target species for delisting of the AOC (Wiley et al. 1998). Given safety concerns and lack of effective sampling by seine, we decided to focus our comparisons on wadeable reaches of the Rouge River. Given the unique species sampled, I recommend that the non-wadeable reach of the Rouge River should continue to be sampled with a boat shocker in partnership with MDNR or other agencies.

Overall differences between the two methods appeared to be driven by rare and benthic fish. Benthic fish such as darters are more easily captured by seining. Seining caught unique benthic species such as Iowa Darter (*Etheostoma exile*) and Least Darter (*Etheostoma microperca*). Shocking is less effective on benthic fish that have reduced or no swim bladders, as once shocked they remain at the bottom of the stream and are difficult to net (Cowx 1983; Beaumont 2016). Additionally, benthic fish tend to be smaller, and therefore are less attracted to the anode of the electrofisher making them harder to capture (Beaumont 2016). These results are consistent with other studies, where electrofishing caught larger, predatory fish and seining caught more darter species (Onorato et al. 1998; Neebling and Quist 2011). In examining a comprehensive list of species captured by each method, it should be noted that we considered many more seining than electrofishing events; in seven times more seining events only one and a half times more unique species were captured (Figure 2). Further analysis of data from comparable sampling effort, however, produced similar differences in the types of fishes captured by each method.

Both seining and shocking caught rare species in the Rouge River system. Our results, therefore, differ from some previous work, in other systems, which suggest electrofishing may be more efficient at capturing rare fishes (Poos et al. 2007). Shocking in the Rouge captured redhorse species, while seining captured the state-endangered Redside Dace (*Clinostomus* *elongatus*). Because of their rarity, captured only 2-5 times in the watershed, it is unclear whether either method is more efficient at capturing these species. Given its history of industrialization and urbanization, landscape factors affecting species distribution should be considered when sampling for rarer species. Therefore, areas of the watershed with rare species should be sampled with a greater effort in order to understand their likely patchy distributions (Smith and Jones 2005).

At the watershed and subwatershed scales, seining was comparable to electrofishing but neither method captured the full richness of Rouge River fishes within 45 samples. Overall species richness in wadeable reaches at the watershed level for both methods was identical. Species accumulation curves, however, did not reach a full asymptote indicating that several more sites need to be sampled to capture the total species richness of the watershed. We know that at least 8 additional species have been observed in the system by anglers, and other non-standardized sampling efforts. These species were: American Brook Lamprey (*Lethenteron appendix*), Black Bullhead (*Ameiurus melas*), Blacknose Shiner (*Notropis heterolepis*), Freshwater Drum (*Aplodinotus grunniens*), Northern Sunfish (*Lepomis peltastes*), Spotail Shiner (*Notropis hudsonius*), White Perch (*Morone americana*), and Walleye (*Sander vitreus;* caught by USGS, Roseman et al. 2020). Some differences in richness occurred at the subwatershed level and branch level. At the subwatershed levels, both shocking and seining resulted in two species differences in every branch. A consistent pattern emerged in the species captured: electrofishing caught larger, predatory fishes while seining caught smaller benthic fishes. For example, in the Lower Rouge, Rainbow Trout (*Oncorhynchus mykiss*) and Northern Pike (*Esox lucius)* were captured with electrofishing, while seining captured Striped Shiner (*Luxilus chrysocephalus*) and Spotfin Shiner (*Cyprinella spiloptera).*

The analysis of community similarity conveys a similar pattern of shocking capturing larger, predatory fish and seining capturing more small benthic fish. The fish communities that were most similar in composition when sampled by seining and electrofishing occur in the Bell Branch, Minnow Pond, Tarabusi Creek, Willow Creek, and Fowler Creek. All of these creeks are relatively small and support fewer fish species than the larger main branches of the Rouge River (Zorn et al. 2002). Even in the larger reaches of the Rouge River, community similarity was over 70%. The least similar reaches of the Rouge River were Evans Creek, Quarton Branch, and Pebble Creek. Besides Redside Dace, all other species in these three reaches are found abundantly throughout the watershed. Additionally, these reaches have only one or two sites sampled meaning more seining might be needed in these reaches to fully capture all species present.

Similarities between seining and electrofishing were further illustrated by the Procedure 51 scores. Procedure 51 scores can be considered in assessing the removal for the Degradation of Fish and Wildlife Populations BUI (Environmental Consulting & Technology 2008; Michigan Department of Environmental Quality 2015). Other AOCs have used various fish sampling methods for BUI delisting including electrofishing, seining, and fyke nets (Michigan Department of Environmental Quality 2015; Michigan Department of Environment, Great Lakes, and Energy (EGLE) 2019; Fond du Lac Indian Reservation et al. 2022). Given the lack of significant differences between the methods and other AOCs using a variety of methods, the citizen science seining data should be considered a valid approach to assessing the fish community when considering BUI delisting in the Rouge River.

Previous studies have seen differences in species caught between electrofishing and seining, but usually concluded that electrofishing was preferred as it produced higher species richness, biomass, and abundance estimates, and larger fish (Wiley and Tsai 1983; Mercado-Silva and Escandón-Sandoval 2008; Neebling and Quist 2011; Deacon et al. 2017, 2017). These studies were conducted by professionals and in tropical rivers or larger non-wadeable rivers making the comparison to wadeable urban rivers difficult (Mercado-Silva and Escandón-Sandoval 2008; Neebling and Quist 2011; Deacon et al. 2017). Conditions and team membership can be very different in the Rouge River system and in citizen science efforts. For example, highly variable river flows occur due to urbanization, resulting in high turbidity that makes capturing small fish with electrofishing extremely difficult due to visibility constraints (Wiley et al. 1998).

Watershed organizations should use the FOTR fish sampling program as an example of the possibilities of community-based citizen science. What began as citizen science fish sampling has become a hybrid between citizen science and community science. As one of the only non-profits in the region sampling fish, FOTR staff and a core group of volunteers have created partnerships with county and state agencies and university researchers to improve data quality and techniques while also using the data for community scientific priorities and projects. The 10 years of FOTR fish data offer a unique case study for organizations like MiCorps to begin fish sampling monitoring programs in the region. On the west coast, several watershed councils and government agencies have partnered to utilize citizen and community science to monitor restoration and life history of salmonids (Johnson Creek Watershed Council 2017; Eitzel et al. 2023). When properly planned and implemented, citizen and community science fish sampling offers an incredible opportunity to monitor fish communities (Bonney et al. 2009).

Conclusion

This study provides detailed information on how citizen science seining data compares to electrofishing data. The differences that did occur were expected given the systematic biases of the methods. The broader question is the potential use and impact of the data collected. We provide evidence that FOTR community-based citizen science seining data is comparable to electrofishing data and can be used confidently for river fish community assessment and for assessment of AOC BUI status. Community and citizen science forms of data collection is increasingly common as they fill a gap where state and federal agencies may be unable to sample thus increasing the temporal and spatial data coverage. Additionally, community and citizen science gives participants a local connection to the river, expands ecological knowledge, and often leads to environmental advocacy (Metcalfe et al. 2022; Lin Hunter et al. 2023). The validation of these types of data, in local systems, is important as they can improve knowledge around monitoring ecosystems and assist in management and conservation decisions.

Appendix

Table 1: All species caught in the Rouge River from 2011-2022. Species names and families are from the Ontario Freshwater Fish Life History Database and Fishbase (Eakins 2023; "FishBase" 2023). Tolerance is defined by Procedure 51 (Michigan Department of Environmental Quality 2000).

Common Name	Scientific Name	Family	Common Family	Tolerance	Seine	Shocking
Bowfin	*Amia calva*	Amiidae	Bowfin	Tolerant		x
Brook Silverside	*Labidesthes sicculus*	Atherinopsidae	Silversides		x	
White Sucker	*Catostomus commersonii*	Catostomidae	Sucker	Tolerant	x	x
Northern Hog Sucker	*Hypentelium nigricans*	Catostomidae	Sucker		x	x
Spotted Sucker	*Minytrema melanops*	Catostomidae	Sucker	Intolerant		x
Black Redhorse	*Moxostoma duquesnei*	Catostomidae	Suckers	Intolerant		x
Golden Redhorse	*Moxostoma erythrurum*	Catostomidae	Suckers	Intolerant	x	x
Shorthead Redhorse	*Moxostoma macrolepidotum*	Catostomidae	Suckers	Intolerant		x
Rock Bass	*Ambloplites rupestris*	Centrarchidae	Sunfishes and basses		x	x
Green Sunfish	*Lepomis cyanellus*	Centrarchidae	Sunfishes and basses		x	x
Pumpkinseed	*Lepomis gibbosus*	Centrarchidae	Sunfishes and basses		x	x
Bluegill	*Lepomis macrochirus*	Centrarchidae	Sunfishes and basses	Tolerant	x	x
Northern Sunfish	*Lepomis peltastes*	Centrarchidae	Sunfishes and basses		x	
Smallmouth Bass	*Micropterus dolomieu*	Centrarchidae	Sunfishes and basses	Intolerant	x	x
Largemouth Bass	*Micropterus salmoides*	Centrarchidae	Sunfishes and basses		x	x
White Crappie	*Pomoxis annularis*	Centrarchidae	Sunfishes	Intolerant		x
Black Crappie	*Pomoxis nigromaculatus*	Centrarchidae	Sunfishes and basses		x	x
Sunfish Hybrid		Centrarchidae	Sunfishes and basses	Intolerant	x	x
Mottled Sculpin	*Cottus bairdii*	Cottidae	Sculpins	Tolerant	x	x
Goldfish	*Carassius auratus*	Cyprinidae	Carps	Tolerant	x	x
Common Carp	*Cyprinus carpio*	Cyprinidae	Carps		x	x
Gizzard Shad	*Dorosoma cepedianum*	Dorosomatidae	Herring		x	x
Northern Pike	*Esox lucius*	Esocidae	Pikes		x	x
Mummichog	*Fundulus heteroclitus*	Fundulidae			x	
Brook Stickleback	*Culaea inconstans*	Gasterosteidae	Sticklebacks		x	x
Threespine Stickleback	*Gasterosteus aculeatus*	Gasterosteidae	Sticklebacks		x	
Round Goby	*Neogobius melanostomus*	Gobiidae	Gobies		x	x
Black Bullhead	*Ameiurus melas*	Ictaluridae	North American catfishes	Tolerant	x	
Yellow Bullhead	*Ameiurus talis*	Ictaluridae	North American catfishes	Intolerant	x	x
Brown Bullhead	*Ameiurus nebulosus*	Ictaluridae	North American catfishes		x	x
Channel Catfish	*Ictalurus punctatus*	Ictaluridae	North American catfishes			x
Stonecat	*Noturus flavus*	Ictaluridae	North American catfishes		x	x
Central Stoneroller	*Campostoma anomalum*	Leuciscidae	Minnows		x	x
Northern Redbelly Dace	*Chrosomus eos*	Leuciscidae	Carps & minnows	Tolerant	x	x
Redside Dace	*Clinostomus elongatus*	Leuciscidae	Minnows	Tolerant	x	
Spotfin Shiner	*Cyprinella spiloptera*	Leuciscidae	Minnows	Tolerant	x	x
Striped Shiner	*Luxilus chrysocephalus*	Leuciscidae	Minnows	Tolerant	x	
Common shiner	*Luxilus cornutus*	Leuciscidae	Minnows	Tolerant	x	x
Hornyhead Chub	*Nocomis biguttatus*	Leuciscidae	Minnows		x	x
Golden Shiner	*Notemigonus crysoleucas*	Leuciscidae	Minnows		x	x
Emerald Shiner	*Notropis atherinoides*	Leuciscidae	Minnows	Intolerant	x	x
Blackchin Shiner	*Notropis heterodon*	Leuciscidae	Minnows		x	
Blacknose Shiner	*Notropis heterolepis*	Leuciscidae	Minnows		x	
Spottail Shiner	*Notropis hudsonius*	Leuciscidae	Minnows	Intolerant	x	
Mimic Shiner	*Notropis volucellus*	Leuciscidae	Minnows	Intolerant	x	
Bluntnose Minnow	*Pimephales notatus*	Leuciscidae	Minnows		x	x
Fathead Minnow	*Pimephales promelas*	Leuciscidae	Minnows		x	x
Blacknose Dace	*Rhinichthys atratulus*	Leuciscidae	Minnows	Intolerant	x	x
Creek Chub	*Semotilus atromaculatus*	Leuciscidae	Minnows		x	x
White Perch	*Morone america*	Moronidae	Temperate Basses		x	
White Bass	*Morone chrysops*	Moronidae	Temperate Basses			x
Rainbow Darter	*Etheostoma caeruleum*	Percidae	Perches and Darters	Tolerant	x	x
Iowa Darter	*Etheostoma exile*	Percidae	Perches and Darters		x	
Least Darter	*Etheostoma microperca*	Percidae	Perches and Darters		x	
Johnny Darter	*Etheostoma nigrum*	Percidae	Perches and Darters	Intolerant	x	x
Yellow Perch	*Perca flavescens*	Percidae	Perches and Darters		x	x
Logperch	*Perci caprodes*	Percidae	Perches and Darters	Intolerant	x	x
Blackside Darter	*Perci maculata*	Percidae	Perches and Darters	Intolerant	x	x
American Brook Lamprey	*Lethenteron appendix*	Petromyzontidae	Lamprey	Intolerant		x
Mosquitofish	*Gambusia affinis*	Poeciliidae			x	
Rainbow Trout	*Oncorhynchus mykiss*	Salmonidae	Trouts and salmons		x	x
Brown Trout	*Salmo trutta*	Salmonidae	Trouts and salmons	Intolerant	x	x
Freshwater Drum	*Aplodinotus grunniens*	Sciaenidae	Drums	Tolerant		x
Central Mudminnow	*Umbra limi*	Umbridae	Mudminnows	Tolerant	x	x

Appendix 2:

Table 2: All Rouge River sites sampled in 2022.

Map Labeled Numbers	Site Name	FOTR Site Name	Subwatershed	Reach Stream Name	Latitude	Longitude	Wading Status	Method	Last Seine Sampled
1	NonWadeable 1	Main10	Main	Main Rouge	42.293	-83.148	Non-Wadeable	Both	2014
2	NonWadeable 2	Main12	Main	Main Rouge	42.305	-83.220	Non-Wadeable	Both	2020
3	NonWadeable 3	Main12n	Main	Main Rouge	42.306	-83.222	Non-Wadeable	Both	2020
4	NonWadeable 4	Main21	Main	Main Rouge	42.308	-83.220	Non-Wadeable	Shocking	-
5	Main 1	MN-7a	Main	Main Rouge	42.346	-83.247	Wadeable	Both	2021
6	Main 2	MN-2	Main	Main Rouge	42.400	-83.271	Wadeable	Both	2020
7	Main 3	MN-5	Main	Main Rouge	42.444	-83.285	Wadeable	Both	2017
8	Main 4	Main6	Main	Main Rouge	42.479	-83.285	Wadeable	Both	2015
9	Main 5	Main5	Main	Main Rouge	42.522	-83.247	Wadeable	Both	2018
10	Main 6	Main3	Main	Main Rouge	42.549	-83.218	Wadeable	Both	2016
11	Main 7	Main19	Main	Main Rouge	42.457	-83.306	Wadeable	Both	2018
12	Main 8	Main18	Main	Main Rouge	42.581	-83.198	Wadeable	Both	2018
13	Main 9	Main13	Main	Main Rouge	42.590	-83.190	Wadeable	Both	2018
14	Main 10*	Main20	Main	Main Rouge	42.330	-83.242	Wadeable	Both	2021
15	Pebble 1	Peb2	Main	Pebble Creek	42.515	-83.344	Wadeable	Both	2017
16	Franklin 1	Frank1	Main	Franklin Creek	42.530	-83.306	Wadeable	Both	2015
17	Quarton 1	Main11	Main	Quarton Branch	42.554	-83.226	Wadeable	Both	2016
18	Upper 1	UR-1	Upper	Upper Rouge	42.411	-83.303	Wadeable	Both	2019
19	Upper 2	Up1	Upper	Upper Rouge	42.475	-83.386	Wadeable	Both	2021
20	Bell 1	UR-2	Upper	Bell Branch	42.402	-83.311	Wadeable	Both	2021
21	Bell 2	Bell4	Upper	Bell Branch	42.403	-83.362	Wadeable	Both	2016
22	Seeley 1	See3	Upper	Seeley Creek	42.511	-83.430	Wadeable	Both	2016
23	Minnow 1	Min2	Upper	Minnow Pond	42.493	-83.377	Wadeable	Both	2012
24	Tarabusi 1	Tar2	Upper	Tarabusi Creek	42.441	-83.384	Wadeable	Both	2016
25	Middle 1	MR-9	Middle	Middle Rouge	42.347	-83.291	Wadeable	Both	2016
26	Middle 2	MR-11	Middle	Middle Rouge	42.345	-83.363	Wadeable	Both	2016
27	Middle 3	MR-4	Middle	Middle Rouge	42.364	-83.404	Wadeable	Both	2021
28	Middle 4	MR-18	Middle	Middle Rouge	42.390	-83.466	Wadeable	Both	2021
29	Middle 5*	MR-15	Middle	Middle Rouge	42.331	-83.248	Wadeable	Both	2016
30	Tonquish 1	Ton3	Middle	Tonquish Creek	42.335	-83.418	Wadeable	Both	2015
31	Tonquish 2	Ton1	Middle	Tonquish Creek	42.367	-83.499	Wadeable	Both	2015
32	Willow 1	Will1	Middle	Willow Creek	42.330	-83.464	Wadeable	Both	2015
33	Johnson 1	John6	Middle	Johnson Creek	42.425	-83.481	Wadeable	Both	2021
34	Johnson 2	John1	Middle	Johnson Creek	42.390	-83.582	Wadeable	Both	2012
35	Johnson 3*	John10	Middle	Johnson Creek	42.398	-83.528	Wadeable	Shocking	-
36	Bishop 1	Bish2	Middle	Bishop Creek	42.471	-83.452	Wadeable	Both	2017
37	Wall 1	Wall2	Middle	Walled Lk Drainage	42.467	-83.466	Wadeable	Both	2015
38	Lower 1	LR-11a	Lower	Lower Rouge	42.313	-83.242	Wadeable	Both	2021
39	Lower 2	LR-10	Lower	Lower Rouge	42.299	-83.306	Wadeable	Both	2021
40	Lower 3	LR-6	Lower	Lower Rouge	42.285	-83.384	Wadeable	Both	2014
41	Lower 4	LR-12	Lower	Lower Rouge	42.282	-83.466	Wadeable	Both	2021
42	Lower 5	LR-2	Lower	Lower Rouge	42.282	-83.503	Wadeable	Both	2021
43	Lower 6	Low2	Lower	Lower Rouge	42.307	-83.538	Wadeable	Both	2014
44	Lower 7*	Low14	Lower	Lower Rouge	42.302	-83.280	Wadeable	Shocking	-
45	Fellows 1	LR-5	Lower	Fellows Creek	42.301	-83.438	Wadeable	Both	2016
46	Fellows 2	Fel4	Lower	Fellows Creek	42.313	-83.465	Wadeable	Both	2014
47	Fellows 3	Fel6	Lower	Fellows Creek	42.328	-83.532	Wadeable	Both	2016
48	Fellows 4*	L-5	Lower	Fellows Creek	42.323	-83.488	Wadeable	Both	-
49	Fowler 1	Fowl2	Lower	Fowler Creek	42.282	-83.505	Wadeable	Both	2021
50	Fowler 2	Fowl5	Lower	Fowler Creek	42.280	-83.525	Wadeable	Both	2021
51	Fowler 3	Fowl4	Lower	Fowler Creek	42.276	-83.554	Wadeable	Both	2021
52	Evan 1	Evan5	Main	Evans Creek	42.468	-83.261	Wadeable	Both	2021
53	Evan 2	Evan2	Main	Evans Creek	42.474	-83.247	Wadeable	Both	2016

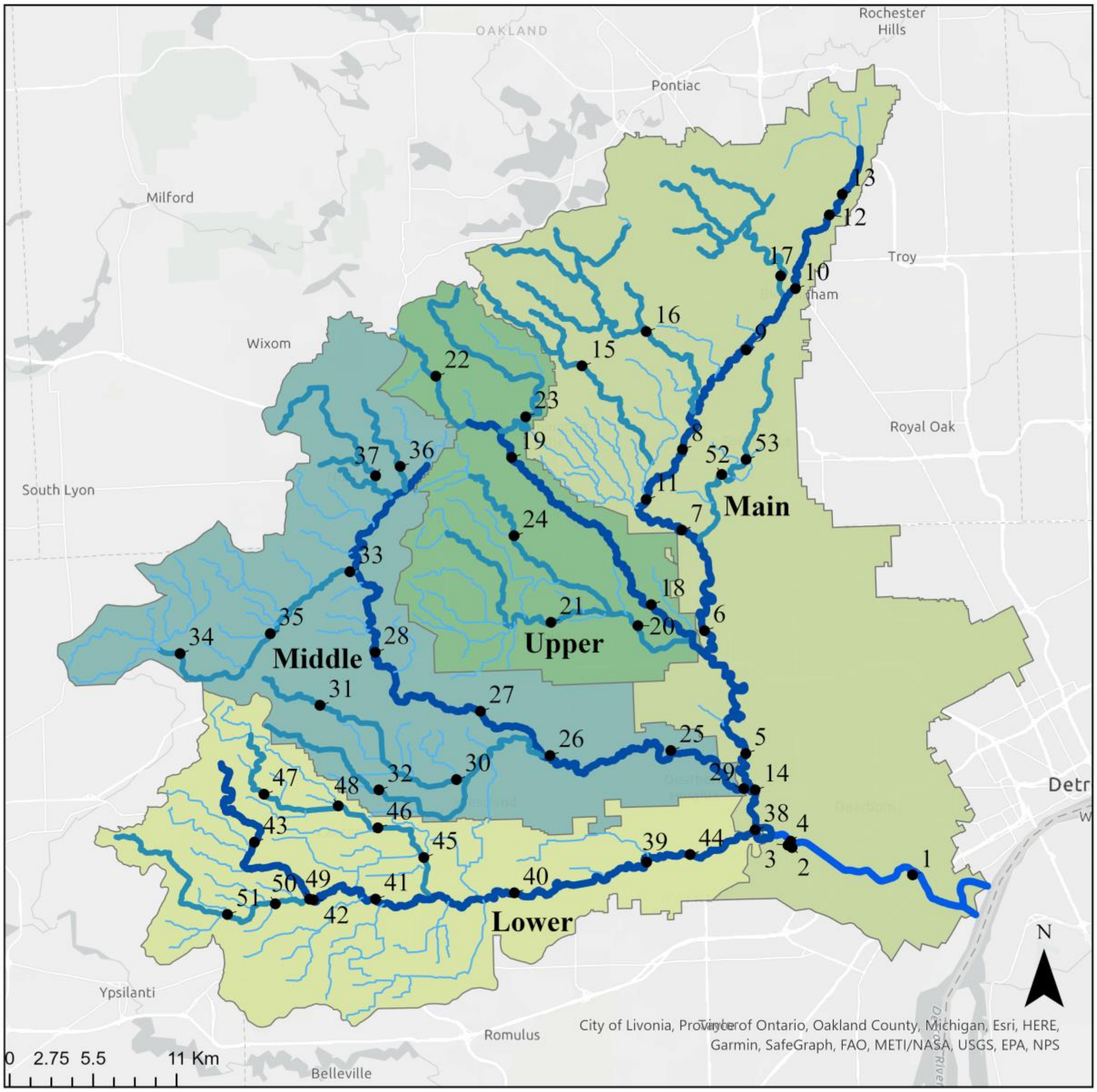

Figure 9: Rouge River Sampling locations. Numbers correspond to Table 2 above.

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