THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF BIOLOGY

Diet and Habitat Comparison of Two Closely Related Darters (*Percina bimaculata* and *Percina caprodes*)

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FALL 2023

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Biology
with honors in Biology

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ABSTRACT

Chesapeake Logperch, *Percina bimaculata*, is a threatened darter species native to the Susquehanna and Potomac rivers, including the Chesapeake Bay. With many stakeholders that would be affected by its elevation to being federally endangered, multiple projects are being completed to assess the Chesapeake Logperch. This study was conducted to compare the microhabitats of the Chesapeake Logperch and the Northern Logperch, *Percina caprodes semifacsciata,* and the diets of the Chesapeake Logperch and the Ohio Logperch, *Percina caprodes caprodes*, both subspecies of an abundant relative. The study aimed to determine if habitats that the Northern Logperch can be used as models for Chesapeake Logperch. Microhabitat surveys were conducted in three tributaries of Lake Erie, Chiques Creek, and West Branch Octoraro. Snorkel surveys were used to assess bottom and average flow (m/s), depth (cm), position in stream, orientation in the stream, and substrate preference. Diet was determined by dissecting collected Ohio Logperch and Chesapeake Logperch. Preference and avoidance of prey were calculated using the Strauss Liner Index. The Chesapeake Logperch showed a range that was within the Northern Logperch's habitat, but much narrower. The bottom flow and average flow were both significantly higher for the Northern Logperch, while the Chesapeake Logperch showed a preference for the middle of the stream. In a similar pattern, the Chesapeake Logperch also had a narrower composition of the Ohio Logperch diet, preferring Chironomidae. This shows that, while not the same, habitats that support Northern Logperch have similar conditions to the habitat of the Chesapeake Logperch. While effort still

needs to be made to solidify what the other life stages are doing, the microhabitat could be one of the first steps to having successful reintroductions. With invasive species increasing and suitable habitat decreasing for the Chesapeake Logperch, future reintroductions may be key for maintaining populations.

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Acknowledgments

I want to first thank my advisor Dr. Jay Stauffer who gave me the opportunity to complete a master’s degree with him and for helping me throughout the entire project. Thank you to all my committee members, Dr. Jason Keagy, Dr. Elizabeth Boyer, and Dr. Timothy Ryan, for supporting my work and dealing with every last-minute email and meeting.

I would like to thank Andrew Bucha for helping me throughout my entire project, with collection, processing, and general support. Without Andrew, I would not even be working and studying under Dr. Stauffer. I would also like to thank all my previous lab coworkers; Kyle Clark, Nathan Weyandt, Dr. Sara Mueller, Joshua Wisor, and Andrew Ross. I also wanted to extend that thank you to all of Dr. Stauffer’s previous students who collected data for him in past years, which ended up saving my project timeline when I was rained out of doing habitat surveys.

Additionally, I would like to thank Pennsylvania State University’s Biology Department for funding most of my semesters through TA assistantships. I would also like to extend that thanks to the Pennsylvania Fish and Boat Commission for indirectly funding my project by funding Dr. Stauffer’s lab with the Chesapeake Logperch Grant. Lastly, I would like to thank both my parents, Karen and Georgios Stylianides, as well as my sister, Aikaterini Stylianides, for always supporting me and helping me to reach this far in my academic career.

Introduction

Description and Biology of the Common Logperch

The Common Logperch (*Percina caprodes*) is a darter in the subgenus *Percina* and is the largest darter in Pennsylvania (PA) (Stauffer et al., 2016). There are two subspecies found in Pennsylvania that are found on the western portion in the Lake Erie drainage, the Northern Logperch (*P. c. semifasciata*) and the Ohio drainage, the Ohio Logperch (*P. c. caprodes*) (Becker, 1983; Trautman, 1981). The Ohio Logperch is still commonly found throughout the Ohio drainage in Pennsylvania. The Northern Logperch, however, has been observed to have been affected by the introduction of the invasive Round Goby to the Great Lakes. While current population abundances have not been studied, observations where the Round Goby occur found that the populations are likely decreasing (Stauffer et al., 2016). Balshine et al. (2005) used experimental data to test what effect round gobies were possibly having on Northern Logperch. They found that the Round Goby had the ability to outcompete the Northern Logperch with aggressive behaviors, potentially affecting the Northern Logperch's preferred habitat. Further work was done in French Creek that reported the presence of Round Gobies pushing darter species, including the Ohio Logperch, to deeper, slower moving water (Wisor, 2019).

Both subspecies are known for their light-yellow dorsal coloration that leads to a white stomach and sharp, conical snout. While meristics are variable, they are commonly known to have 14-16 dorsal-fin spines, 15-17 dorsal-fin rays, 2 anal-fin spines, 10-11 anal-fin rays, and 14-15 pectoral-fin rays (Jenkins &

Burkhead, 1994). There are usually three black saddles along the dorsum, as well as black and brown bands that can be vertical, slightly angled posteriorly, and can be variable among individuals (Figure 1). The main difference between the subspecies, besides the distribution, can be seen at the nape of individuals. The Northern Logperch have no scales on their nape, while Ohio Logperch do have scales on their nape (Figure 2) (Stauffer et al., 2016).

Figure 1. Ohio Logperch (*Percina. c. caprodes*) individual from The Fishes of Pennsylvania

Figure 2. Nape of Ohio Logperch (*Percina c. caprodes*) (left), Northern Logperch (*Percina c. semifasciata*) (middle), and Chesapeake Logperch (*Percina bimaculata*) (right)

The Northern Logperch has an estimated spawning occurrence of mid-April through June when the temperatures start to rise in the water. The females often have 1-2 male mates and can release 10-12 eggs per spawning event. The fertilization period generally only lasts around a week before larvae hatch. The main food source for larvae were found to be insect larvae, amphipods, and isopods (Stauffer et al., 2016). When searching for food, observations have been visually documented of individuals using snouts to flip small rocks.

Description and Biology of the Chesapeake Logperch

The Chesapeake Logperch (*Percina bimaculata*) is a darter in the same subgenus as the Common Logperch, *Percina*. Elevated to species status in 2008, the Chesapeake Logperch was commonly thought to be a subspecies of the Common Logperch (Near, 2008). The range is mainly the Chesapeake Bay watershed and the Susquehanna River, where it crosses into Pennsylvania, but was known to be in the Potomac River, now extirpated (Figure 4). The conservation status is similar federally, as well as between states. It is on the threatened list in both Pennsylvania (S1) and Maryland (S1S2) and is being considered critically imperiled over its range (G1), but it is not federally endangered (*NatureServe*, 2012; Stauffer et al., 2016). Since there has been a recording in Virginia, it has S1 status but does not show on the threatened and endangered list. It is currently being considered for assessment on whether it should be federally endangered (*Percina bimaculata*).

The coloration also starts with a light-yellow dorsal coloration that turns white around the stomach. The fin spine and ray counts are as follows: 13-15 dorsal-fin spines, 14-16 dorsal-fin rays, 2 anal-fin spines, and 9-11 anal-fin rays. Three black saddles are common on dorsum, as well as variable bars. The bars along the length of the body can vary from defined bars to blotches depending on the individual. The snout is short and conical, similar to the Common Logperch (Figure 3). The nape does not have any scales, sharing the characteristic with the Northern Logperch (Figure 2) (Stauffer et al., 2016).

Figure 3. Chesapeake Logperch (*P. bimaculata*) individual from The Fishes of Pennsylvania

The Chesapeake Logperch's spawning occurrence has been estimated to be from April-July. Little observations have been made in the wild, but individuals have been observed in lab conditions when breeding. When in captivity, fish started to spawn when the water temperature reached around 16.5°C. After multiple attempts to spawn, it was observed that one female would lay eggs with 3-4 male mates. Adults were known to predominantly eat chironomids, but the diet also consisted of various insect larvae. Similar to the

Common Logperch, Chesapeake Logperch individuals have been visually documented flipping rocks in search of food.

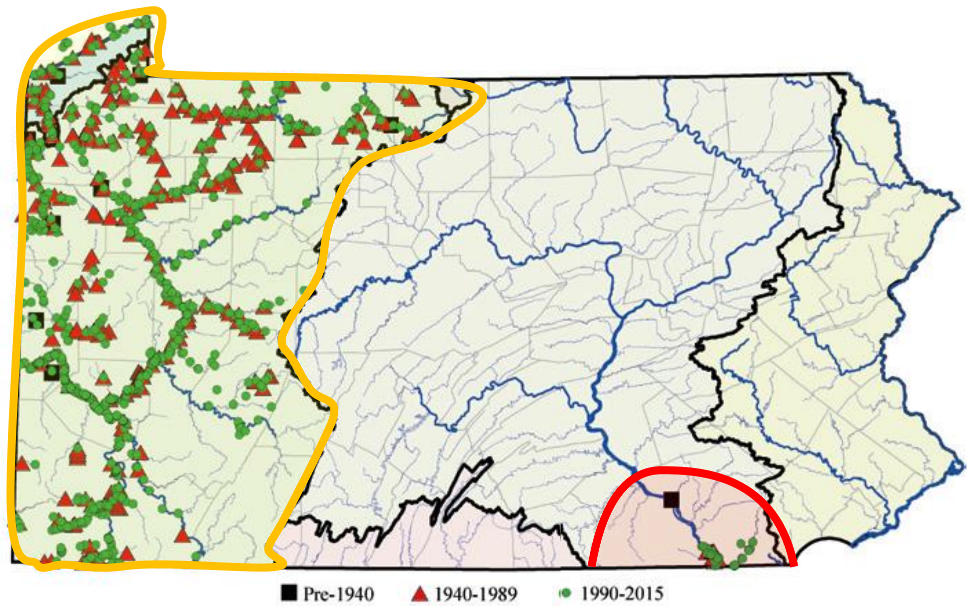

Figure 4. Range of Chesapeake Logperch, highlighted in red, and the Northern Logperch and Ohio Logperch, highlighted in orange

Known similarities between Common Logperch and Chesapeake Logperch

The Common and Chesapeake Logperch have many similarities, with coloration, patterning, and meristic counts. They have also been known in the past, through observations, to share similar habitats (Stauffer et al., 2016). Both species have been seen over general cobble and silt, but no formal research has been conducted to determine if the specifics of the habitat differ, such as depth and flow rate. The Chesapeake Logperch possibly branched from the Northern Logperch. Currently, it is speculated that sharing a scaleless nape may be a key identification for their relationship. Further work has been done with the morphological data and has been seen to have significantly different measurements than both the Northern and Ohio Logperch (Stauffer, 2023). With limited information, new work is being done on the Chesapeake Logperch with the proposal to add it to the Federally Endangered list. Once more information is recorded, better differences between the two species may be documented.

Importance of Endangered Species

Species conservation has long been a topic concerning fishery biologists, with arguments for conservating species, functional groups, or to let organisms just go extinct. While functional diversity is likely the most applicable parameter for keeping ecosystems from being lost, species conservation should still play an important role in ecosystems. Leitão et al. (2016) found that rare species can be key to ecosystems, even when it is not obvious. When looking at freshwater fishes in tropical systems, even species that were the 2% and 5% of the rarest species showed niche effects on the ecosystem that were not seen otherwise. There are difficulties in conservation when attempting to quantify a species' value. Stauffer and Morgan (2022) reviewed studies and hypotheses on valuing fish and found a lot of information about a species is required to assign a value.

The Chesapeake Logperch's conservation has major stakeholders other than ecologists trying to preserve species. While the species is not federally endangered, special precautions do not need to be followed by organizations and ships. The Chesapeake Bay has many different companies that bring ships through the bay, as well as having buildings along the bay. It is also a large area for recreation for residents and travelers. If the Chesapeake Logperch were to gain the status of being federally endangered, there would need to be policies put in place to protect them. This would cause repercussions for some stakeholders who use the bay.

Attempts to Reintroduce Native Fishes

Reintroducing native fishes has been a subject studied by many with improvements in recent years. Malone et al. (2018) looked at planning reintroductions and found that matching habitat suitability is of great importance. Since fishes prefer different habitats, matching habitats can be crucial in maximizing the number of survivors when reintroducing fish. Determining differences in the preferences of other present fishes was also found to play an important role. When trying to introduce the banded and mottled sculpin, it was found that if they colonized the same stream, they would still move to a preferred habitat. This would reduce competition for each species and make it easier to stabilize. Cochran-Biederman et al. (2014) suggests that while general habitat and potential range should be addressed, the reason why a certain fish was extirpated from a certain river or stream should be addressed. If suitable sites are not present, it was also recommended that attempts to create proper habitats should be made. Previous work has been done with reintroductions of native fishes with varying success. There was a successful attempt to make a native assemblage in the Blue River, Arizona. Spikedace (*Meda fulgida*), Loach Minnow (*Rhinichthys cobitis*), and Roundtail Chub (*Gila robusta*) were reintroduced to a section that had invasive species. After doing a removal effort for the invasive fishes, all the native fishes stabilized in the river (Hickerson et al., 2021).

Efforts by the Pennsylvania State University and the Pennsylvania Fish and Boat Commission (PFBC) have been started on the reintroduction of the Chesapeake Logperch to streams in which it was extirpated. Collected individuals are continuously being bred by laboratories in conjunction with the PFBC over many years. The raised individuals have now been used to try to reintroduce the Chesapeake Logperch to Chiques Creek in Pennsylvania. Chesapeake Logperch captured in Octoraro Creek were transplanted to Conewago Creek, where there is indication of a stabilizing population, with sampling from PFBC in Conewago Creek returning tagged individuals 1-2 years old. Chiques Creek also showed a potential population arising, with sampling finding Chesapeake Logperch after the introduction in previous years. PIT tags were used to track individuals who left, and while most fish did not get recorded on the array system, a few individuals were recorded the following year (Stauffer, 2023).

Project

The objective of this project was to compare the habitat and diet of both the Northern Logperch and Chesapeake Logperch. Habitat data were collected by completing snorkel surveys for benthic fishes. The Chesapeake Logperch were found in West Branch Octoraro and Chiques Creek, while the Common Logperch were found in 12-Mile Creek, 20-Mile Creek, and Elk Creek. Diet was collected through stomach dissections of both the Chesapeake Logperch and Ohio Logperch. Chesapeake Logperch were collected from Peter’s Creek, West Branch Octoraro, and Fishing Creek, while Common Logperch were collected from the

Shenango River. A comparison of the Common and Chesapeake Logperch will contribute to future reintroductions of the Chesapeake Logperch. The comparison will further the understanding of the Common and Chesapeake Logperch, and create the groundwork for future work to find suitable streams for reintroduction.

Methods

Survey Sites

Survey sites included: 12 Mile Creek, 20 Mile Creek, Elk Creek, West Branch Octoraro, Chiques Creek, the Shenango River, Peter's Creek, and Fishing Creek. 12 Mile Creek, 20 Mile Creek, and Elk Creek were all sites that were used for the microhabitat collection for the Common Logperch. The West Branch Octoraro and Chiques Creek were sampled for microhabitat of the Chesapeake Logperch. Diet for the Common Logperch was at the Shenango River, and diet for the Chesapeake Logperch was collected at the West Branch Octoraro, Peter's Creek, and Fishing Creek.

12 Mile Creek, 20 Mile Creek, Elk Creek

Tributaries of Lake Erie included 12-Mile, 20-Mile, and Elk Creek near Erie, Pennsylvania. The substrate was similar among all the creeks, bedrock is the main substrate with patches of silt and gravel throughout the streams. Species composition is also similar among the streams, with both invasive and native fishes. The benthic fishes compositions include several species of darters, including the Banded Darter (*Etheostoma zonale*), Greenside Darter (*Etheostoma blennioides*), Fantail Darter (*Etheostoma flabellare*), and Rainbow Darter (*Etheostoma caeruleum*). The remaining species of benthic fishes include various sucker species, the Mottled Sculpin (*Cottus bairdii*), and the highly invasive Round Goby (*Neogobius melanostomus*). They all have Steelhead (*Oncorhynchus mykiss*) and Brown Trout (*Salmo trutta*) present. 12-Mile Creek was sampled above Route 5 bridge (42.20716; -79.91493) and close to the mouth (42.21154; -79.91508), 20-Mile Creek was sampled above the route 5 bridge (42.257963; -79.77769) and near the Route 5 bridge (42.26074; -79.78024), and Elk Creek was sampled 100m below the Route 5 bridge (42.007161; -80.354423) and at the first boat launch (42.018760; -80.370763).

West Branch Octoraro

The West Branch Octoraro is a tributary of the Susquehanna River in Pennsylvania. The substrate varies along the stream, with long stretches of silt and long stretches of gravel. The benthic fishes community consisted mainly of Tessellated Darter (*Ethostoma olmstedi*) and various species of suckers. The Chesapeake Logperch has long been in high numbers, but recent years have shown a large decrease in abundance when sampling. Microhabitat and diet were collected upstream of the White Rock Forge Covered Bridge (39.8258027, -76.090526).

Peter's Creek and Fishing Creek

Both Peter's Creek and Fishing Creek are tributaries of Conowingo Pond in Pennsylvania. Both have mainly gravel bottoms with some larger boulders and silt present. The benthic fishes community is similar to the West Branch Octoraro with mainly Tessellated Darters and various suckers present. Many sunfishes and some bass have also been seen in the creeks. Recent work has shown that the invasive Northern Snakehead (*Channa argus*) has made its way into Conowingo Pond and are reproducing. While there has not been documentation of them entering the creeks, it is possible in the future. Collections at Peter's Creek were made at Stubbs Mill Road (39.761534, -76.227332). Fishing Creek collections were made near the closest bridge to the mouth of the creek (39.792642, -76.261579)

Chiques Creek

Chiques Creek, also spelled Chickies Creek, is a tributary of the Susquehanna River close to Lancaster, Pennsylvania. The substrate is mainly a gravel bottom with occasional stretches of boulders. There are also sections of boulders that form some of the riffles present. The benthic community of darters includes the Tessellated Darter, Greenside Darter, and Banded Darter. Additional species present are catfishes, Smallmouth Bass (*Micropterus dolomieu*), and various suckers and minnows. The microhabitats were sampled at the East Donegal Township Chiques Creek Day Use Area (40.0554753; -76.5184977).

Shenango River

The Shenango River is a tributary of the Beaver River that eventually leads to the Ohio River. The site sampled for Ohio Logperch for diet studies occurred near Halfway Road Bridge (41.488190, -80.425205) and the Riverside Park (41.409570, -80.393932) in Mercer County Pennsylvania. Both sites had similar substrate, mainly a gravel bottom, but had the occasional silt and larger cobble. The benthic fishes consisted of Banded Darter, Greenside Darter, and Johnny Darter (*Etheostoma nigrum*), as well as Yellow Bullhead (*Ameiurus natalis*) and several sucker species. Other species present included Pumpkinseed Sunfish (*Lepomis gibbosus*), White Crappie (*Pomoxis annularis*), and several minnow species.

Snorkel Surveys

All habitat surveys were collected by members of Dr. Jay Stauffer's lab from the years 2010-2011 and 2019-2021, following methods slightly altered from microhabitat partitioning (Stauffer et al., 1996; van Snik Gray & Stauffer, 1999). More recent surveys for the Common Logperch were originally planned but were not able to be collected because of high water and due to turbid conditions at the Shenango River at the Riverside Park. The Shenango River site near the Halfway Road Bridge was too deep to successfully complete surveys without scaring the present fishes.

Microhabitat data were collected by completing snorkel surveys at sites with either the Chesapeake Logperch (2019-2021) or the Northern Logperch (2010-2011). For each collection effort, four transect lines were made perpendicular to the stream to create three sections 10m long (Figure 5). Yellow kite lines were used to create the transect lines, tied to either a tent stake in the bank or a bordering piece of vegetation, if stable enough. Snorkelers were equipped with a PVC wrist slate, a pencil, and a set of flags with numbers on them. Starting at the most downstream transect line, they worked their way upstream trying to cover all of one section before moving to the next. For every benthic fish observed, the snorkeler put down a numbered flag and marked down; the species, if it was above or below an object, the direction it was facing (upstream, downstream, left or right bank), and the unique flag number (Figure 6).

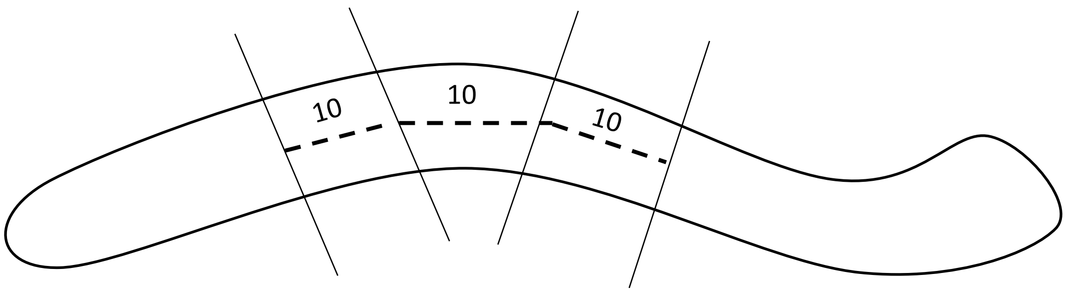

Figure 5. Diagram of microhabitat transect layout for 30m

Figure 6. Photo of Snorkel Survey being completed by Kyle Clark and Joshua Wisor

Once all sections were completed by snorkeling, data at each flag was collected using a substrate board, flowmeter, and measuring tapes. Each flag was measured using metric measuring tapes from the first transect line in its section as well as the right bank of the stream, when facing downstream. Using the flowmeter rod, depth was recorded to the nearest centimeter at the flag. The flow rate was then recorded using a Marsh-McBirney Flo-Mate 2000 flowmeter at the bottom of the stream, to represent the flow rate where benthic fishes reside, as well as the rate at 0.6 * depth to represent the average flow. The final step for each flag was using a 25cm x 25cm clear piece of Plexiglas to measure the substrate. The square was marked by cells 5cm x 5cm with black sharpie marker. The board was then placed at the surface of the water to allow for clear viewing of the substrate below. Each object that was larger than one cell was recorded by how many cells were taken up. Any rock not larger than one cell was counted as one cell. If only one cobble was seen in three cells and the rest were pebbles, it would be marked as 1x3 and 22x1 rocks.

The substrate was later indexed using methods from van Snik & Stauffer (1999) to quantify the size of the substrate present using the equation:

$$\sum_{1}^{25} (N_x * x^2)$$

N_x representing the number of rocks found of the size and x representing the number of cells occupied by a rock. A recording of 1x3 and 22x1 for a flag would result in a score of 31; $(22 * 1^2) + (1 * 3^2)$ (Figure 7). Indexing the substrate was used to quantify the types of substrate each fish was spending time at.

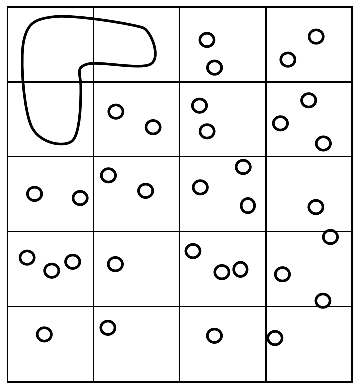

Figure 7. Example of a 1x3, 22x1 substrate on substrate board

To collect general environmental data for each site, each transect was sampled for the bottom flow (m/s), average flow (m/s), depth (m), and substrate, following the same methods as above. Five points along each transect line were sampled for the previous variables, as well as the distance from the first transect (m) and left ascending bank (m). The transect lines were broken into five equal sections and records were taken at a random spot in each section.

Fish Collection

Since fish collected were used for diet or morphological work and were planned to be euthanized, backpack electrofishing was used to collect fish at sites (Figure 8). Each electrofishing backpack was run at a constant 12V, but wattage was chosen based on current water conditions. To allow for low mortality of fishes not kept, the total amperage was kept from 7-10amp. Once netted by either the person running the backpack or the helpers, the fishes were placed in a bucket with water to avoid the chance of shocking them twice. The Chesapeake Logperch and the Ohio Logperch were kept in a separate bucket to avoid keeping other fishes. The Chesapeake Logperch sampling occurred over multiple days for a total of 33 fish. The Ohio Logperch were collected in one day until 40 fish were collected. Once sampling was completed, all fishes were euthanized with clove oil following a protocol accepted by the IACUC board at the Pennsylvania State University.

Once euthanized, they were placed in a 10% formaldehyde (formalin) solution for at least two weeks to stiffen the muscles and stop further digestion. After a minimum of two weeks, they were washed with water for three days to remove any formalin to allow for the fish to be worked on safely in a lab. The formalin waste was put into a waste container for further disposal, then replaced with water. Over the three days, the containers with the fish were filled with new water twice a day, while disposing of the old water in a waste container. After the third day, the fish were placed in specimen jars that were filled with a 70% ethanol solution for preservation and catalogued into the Penn State Fish Museum.

Figure 8. Backpack electrofishing collecting of fishes at the Shenango River near Halfway Road Bridge

Stomach dissections

The diet of the Chesapeake Logperch and the Ohio Logperch were studied by doing stomach dissections of each fish. After being preserved in a 70% ethanol solution, fish at each site were given a unique number, labeled by a small tag tied around the caudal peduncle. For each fish, small scissors were used to cut along the ventral side starting from the anus and finishing at the gills. Tweezers were then used to remove the stomach, esophagus, and intestine. After removal, the organs were then stored in 70% ethanol for later dissection. After all fish were dissected, the organs were cut open in 70% ethanol using small scissors and tweezers to allow for any contents to be collected. Contents were removed by making sure nothing was obstructing their removal to reduce any pulling and damages to the macroinvertebrates. Every macroinvertebrate found was placed in a vial of 70% ethanol specific to the fish it was collected from.

Macroinvertebrate collection

While at each site for the Ohio Logperch, kick net samples were taken using a D-frame kick net. Over the two sites samples, nine total 20-second kicks were completed at a riffle, run, and pool. A grouping of nine 20-second kicks has been found to be effective at sampling macroinvertebrate diversity for darters (Figure 9) (Tzilkowski and Stauffer, 2004; Bradshaw, 2015). Kick-net sampling for macroinvertebrates has also been an effective quick method for sampling riffles, runs, and pools (Frost et al., 1970). After collection, all debris, besides large pieces of wood or large rocks, were put in 1gal jugs with 70% ethanol. All discarded objects were checked for any macroinvertebrates before being placed back in the water. Once brought back into the lab, the jugs were emptied into white trays to be picked through. After being picked through, all macroinvertebrates for each site were placed in their own separate jars of 70% ethanol for identification.

Figure 9. D frame kick net sampling for macroinvertebrates in the Shenango River at the Halfway Road Bridge

Macroinvertebrate identification

Identification of the macroinvertebrates was conducted using a dissection scope with magnification of 10x to 45x (Leica ModelEZ4). All macroinvertebrates from the stomachs of the darters were identified down to family level, to allow for little error for partially digested macroinvertebrates. Macroinvertebrates from the kick net samples were identified to genus level using *An Introduction of Aquatic Insects of North America* (2019) as the key.

Diet Preference

Diet was analyzed with the Strauss selectivity index. Since sample sizes of diet for both fish are not equal, Ivlev's Electivity Index and the Forage Ratio were not used to analyze the diet preference. Using the Strauss selectivity index also has the advantage of showing items that were not found in the habitat and the macroinvertebrates not found in the stomachs as the extreme values, +1 or -1 respectively (Strauss, 1979). The Strauss selectivity index using the prey found in stomachs and the macroinvertebrates found in the habitat to calculate the Strauss' Linear Index, following the equation below:

$$L = r_i - p_i$$

Each prey item, i, has an index value using the abundance found in the stomach and the habitat, r_i and p_i respectively. Significance was identified by $L > 0.3$ and $L < -0.3$ for preference and avoidance, respectively.

Data analyses

RStudio packages

All data analyses were made using RStudio version 4.2.1 (2022-06-23). The specific packages utilized were: tidyverse (1.3.2), ggplot2 (3.4.2), dplyr (1.1.2), factoextra (1.0.7), rstatix (0.7.2), and tabula (3.0.0).

Principal Component Analysis

All Principal Component Analyses (PCA) were completed using base RStudio to prepare the data for visualization of the habitat and microhabitat differences among streams and between species. All contributions were specified using factoextra to define each dimension and the variables' contributions to each. PCA's were also graphed using factoextra and the fviz_pca_biplot() function to specify the including of ellipses, vectors, and to group by species.

Multivariate Analysis of Variance

All observations were assumed to be independent, with each benthic fish observation being random and independent of the other observations. Independence was assumed for transect data since each spot on the transect was chosen at random. Statistical assumptions for the multivariate analysis of variances (MANOVA) were tested using rstatix. The assumptions for multivariate normality were violated for both the microhabitat and stream habitat ($W = 0.906$, $W = 0.698$, $p < 0.05$). However, the central limit theorem was followed since all degrees of freedom were greater than 20, allowing for more robustness of MANOVA results for nonnormal data (Tabachnick & Fidell, 2012). Multicollinearity was not found through pairwise Pearson correlation tests for all MANOVA tested variables ($0.2 > r < -0.2$, $p < 0.0001$). Homogeneity of covariances were also violated tested by Levene's test of equality of variances ($p < 0.05$). Due to violations of assumptions, Pillai's Trace was used as the MANOVA test and Games-Howell post-hoc test was completed to be more robust.

Base RStudio code was used to calculate the MANOVA using the manova() function and summary() to see the summarization of habitat differences between streams and the microhabitat differences between species. Post-hoc testing for the MANOVA's were completed using rstatix and the games_howell_test() function. To check for the differences in biodiversity of kicks, tabula was used to calculate the Brillouin diversity, using heterogeneity().

Multivariate outliers were removed from the microhabitat data by calculating the Mahalanobis distance for all rows, using rstatix mahalanobis_distance(). Mahalanobis distances (d_M) were used because they consider the covariance of the data. While significant outliers were found ($p > 0.001$), only outliers with $d_M > 100$ were removed. Most substrate data had individuals under large rocks, that greatly skewed the distance. Removal of all true outliers would have taken some of the expected microhabitat out of the dataset. Tests were completed with outliers and the removal of all outliers. Removal of outliers with $d_M > 100$ did not show a large effect on the PCA and MANOVA.

Results

Stream Habitats

12-Mile Creek, 20-Mile Creek, and Elk Creek (Northern Logperch) had wider ranges of habitats, while Chiques Creek and the West Branch Octoraro (Chesapeake Logperch) showed narrowed conditions inside of the previous creeks' habitats. Dimension 1 (Dim1) was contributed to the most by the average flow (47.2%) and bottom flow (46.1%). The greatest contributions to Dimension 2 (Dim2) were depth (55.3%) and substrate index (43.8%). The streams that contained Chesapeake Logperch were more correlated to depth and inversely smaller substrate, while the streams with Northern Logperch all had wider ranges of flow rates, both bottom and average (Figure 10). The MANOVA did show significance for at least one mean among the streams ($V = 0.21$, $p < 0.05$). However, most of the habitats did not show significant differences among the bottom flow, average flow, depth, and substrate index. The only significant differences occurred between the Northern Logperch and Chesapeake Logperch. Chiques Creek had significantly different values for all variables ($t^* > 3.64$, $p < 0.05$), besides average flow ($t^* < 2.44$, $p > 0.05$). The West Branch Octoraro showed similar results being significantly different in all aspects from streams ($t^* > 2.89$, $p < 0.05$), besides average flow ($t^* < 0.68$, $p > 0.05$) and depth ($t^* < 1.94$, $p > 0.05$), with the Northern Logperch ($p < 0.05$). The only stream that differed significantly from all other streams was that 12-Mile Creek had larger substrate ($p < 0.05$).

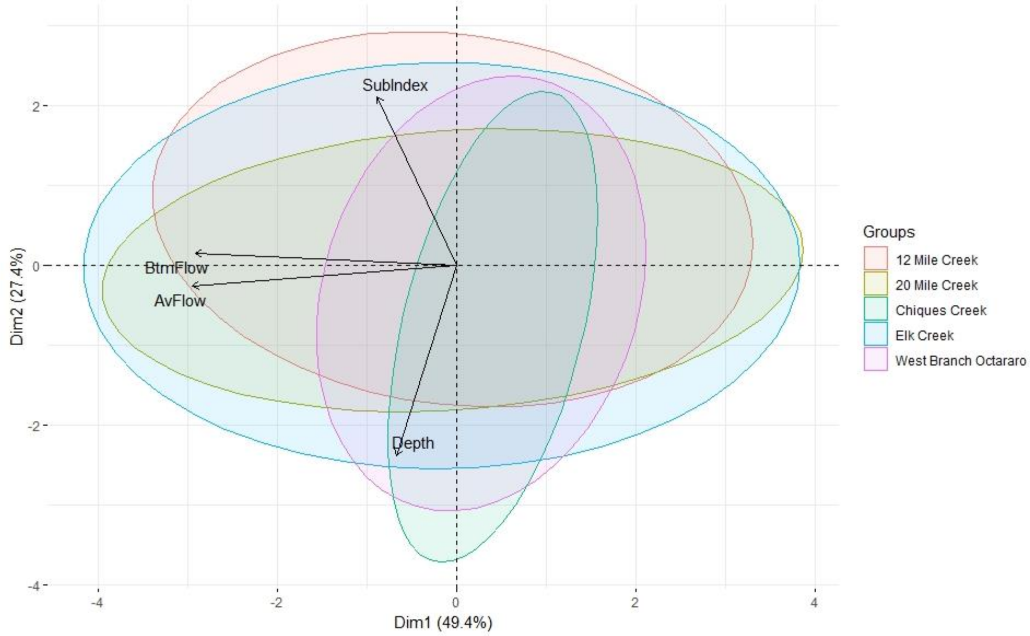

Figure 10. PCA of habitat for the streams with the Chesapeake Logperch, Chiques Creek (n=100) and West Branch Octoraro (n=49), and streams with the Northern Logperch, 12-Mile Creek (n=183), 20-Mile Creek (n=199), and Elk Creek (n=220) for Bottom Flow (m/s) (BtmFlow), Average Flow (m/s) (AvFlow), Depth (cm), and Substrate Index (SubIndex)

Microhabitats

The microhabitats of the Chesapeake Logperch and Northern Logperch showed some overlap of similar conditions but had different ranges. While overlap of habitats occurred, the Chesapeake Logperch showed a smaller range of conditions, shown by the overall smaller ellipse (Figure 11). The greatest contributions to Dimension 1 (Dim1) were bottom flow (33.7%), average flow (32.2%) and orientation in the stream (12.4%). Dimension 2 (Dim2) was contributed to the most by the depth (28.2%), position (25.9%), distance from the start of the transects (17.3%), and orientation in the stream (13.8%). The Northern Logperch showed a much wider range of conditions, while the Chesapeake

Logperch mainly covered only a portion of the former's range. The only condition the Chesapeake Logperch showed a difference in overlap was depth (Figure 11). Bottom and average flow had the greatest contributions to Northern Logperch microhabitats. The MANOVA showed a significant difference between the Chesapeake Logperch and Northern Logperch for at least one of the conditions ($V = 0.49$, $p < 0.05$). Bottom flow ($t^* = 4 .37$, $p < 0.05$), average flow rate ($t^* = 2.38$, $p < 0.05$), and the distance from the start of the transects ($t^* = 8.68$, $p < 0.05$) for the Common Logperch were higher than the Chesapeake Logperch. Inversely, the Chesapeake Logperch had significantly higher depth ($t^* = 7.18$, $p < 0.05$) and distance from the bank ($t^* = 6.77$, $p < 0.05$) (Figure 12). Substrate index was shown to not be significantly different between the two species ($t^* = 1.09$, $p < 0.05$). While not significant, the substrate index showed the Northern Logperch preferred slightly larger substrate. Most of the Northern Logperch had wider upper and lower quartile groups than the Chesapeake Logperch, with the widest occurring in bottom flow (0.62 m/s), average flow (0.98 m/s), and depth (58 m).

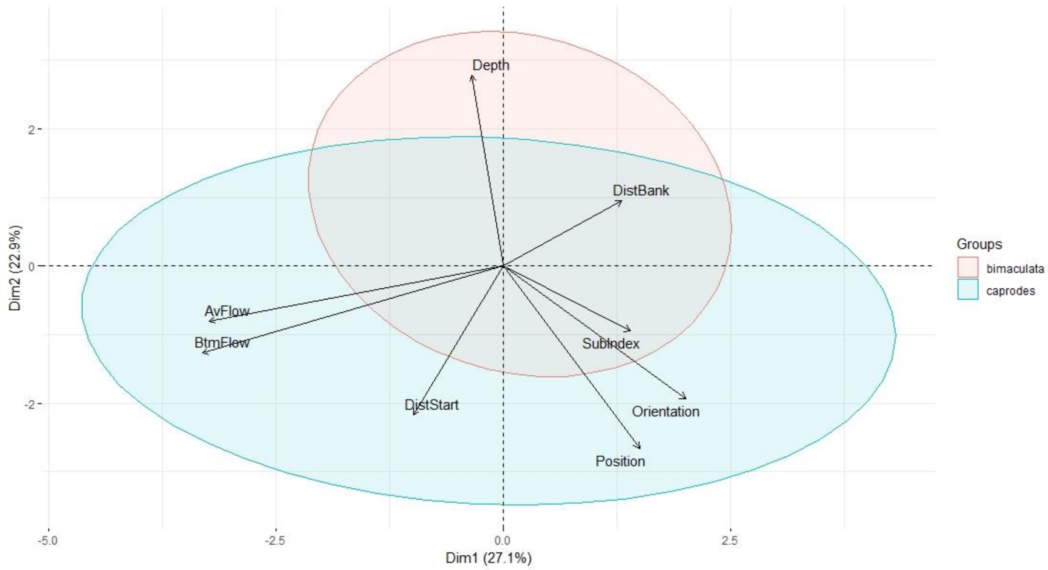

Figure 11. PCA of habitat for the Chesapeake Logperch (n=124) and Common Logperch (n=140) for Bottom Flow (m/s) (BtmFlow), Average Flow (m/s) (AvFlow), Depth (cm), Orientation in stream (upstream, downstream, bank), Position in stream (above or below). Distance from Bank (cm) (DistBank), Distance from Start of Transects (cm) (DistStart), and Substrate Index (SubIndex)

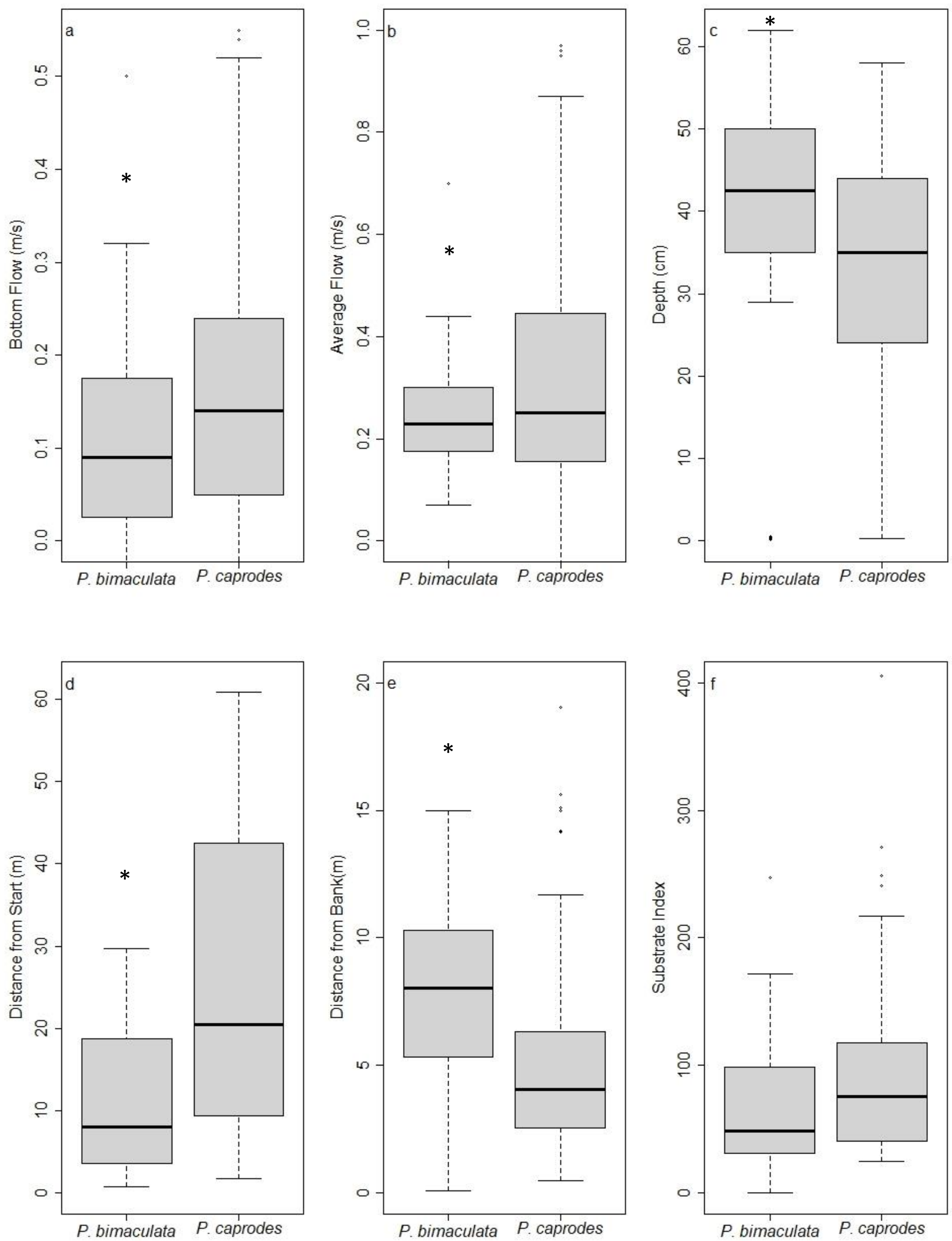

Figure 12. Boxplots of habitat data for the Chesapeake Logperch (*Percina bimaculata*) (n=124) and the Northern Logperch (*Percina c. semifasciata*) (n=140) for a) Bottom Flow (m/s) b) Average Flow (m/s) c) Depth (cm) d) Distance from Start of Transects (m) e) Distance from Right Bank (m) f) Substrate Index with '*' showing significance ($p<0.05$)

Diet

The diet of the Chesapeake and Ohio Logperch had different variation in preference (Figure 13). Dipteran pupae, Isonychiidae, Philopotamidae, and Perlidae were all more associated with the Chesapeake Logperch. The Ohio Logperch ate more Potomanthidae, Hydropsychidae, Leptoseridae, and Molannidae. Chironmidae were found at all sites, but contributed more to the Chesapeake Logperch's diet, while still contributing to a portion of the Common Logperch diet (Figure 13). Both axes did not explain most of the variation, explaining only 12.5% and 8.3% respectively.

The Strauss Linear Indices (L) for all macroinvertebrate families showed no biologically meaningful results ($L > 0.3$, $L < -0.3$). The highest L value was 0.095 for Daphniidae, where prey was found in stomachs but not in the habitat kick nets (Table 1, Appendix A). Multiple avoidance values were found with Elmidae (-0.07) and Unknown Worms (-0.076) represented by the lowest L values of all Common Logperch (Table 1). While two sites were sampled along the Shenango River, both sites showed similar biodiversity values of 2.049 and 2.097.

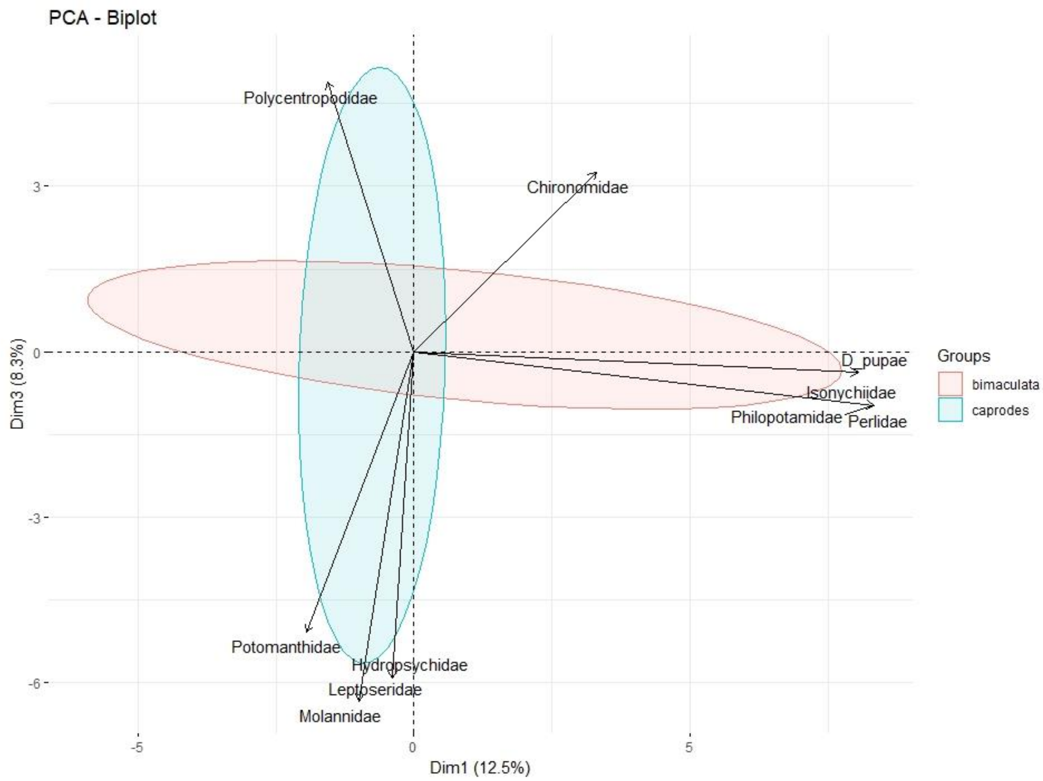

Figure 13. PCA of diet of the Chesapeake Logperch (n=33) and the Ohio Logperch (n=40) of the 10 highest contributing macroinvertebrate families (in order): Perlidae, Philopotamidae, Isonychiidae, Diptera Pupae (D_pupae), Molannidae, Leptoseridae, Hydropsychidae, Potomanthidae, Polycentropodidae, Chironomidae

Table 1. L values for diet of the Ohio Logperch (n=40) in the Shenango River for L > 0.01 and L< - 0.01, L > 0 shows preference and L < 0 shows avoidance or inaccessibility

Macroinvertebrate	L	Macroinvertebrate	L
Daphniidae	0.095	Hydropsychidae	0.036
Gammaridae	0.068	Emerging Insect	0.019
Unsegmented Worm	0.062	Uenoidae	-0.013
Asellidae	0.048	Chironomidae	-0.020
Tipulidae	-0.028	Potomanthidae	-0.042
Unknown Worm	-0.076	Elmidae	-0.070

Discussion

The use of microhabitats was able to show some of the main differences between the Chesapeake and Northern Logperch. The narrowed habitat conditions of the Chesapeake Logperch show that they may require much stricter habitats. This could be one of the reasons their numbers have decreased in the past years. Among freshwater fishes, habitat degradation has been found to be a large factor in endangerment and extinction (Ricciardi & Rasmussen, 1999). Studies have also been done on more restricted animals, finding that disturbances or habitat loss can greatly affect more specialized animals (Pratchett et al., 2012).

While some of the restrictions can be accounted for by the streams, not all of the differences can be accounted by the specific stream (Figure 10). With the overlap of most of the depth and substrate, it showed potential in all the streams to be similar, with the deepest records from Chiques Creek. Even with the overlap, the most notable was that the depth of Chiques Creek was shown to be deeper than the West Branch Octoraro, which was a known current habitat for the Chesapeake Logperch before reintroductions. Chiques Creek did not have a population of Chesapeake Logperch, at least one that was detectable through any snorkel surveys or electrofishing, before their reintroduction. This could have been one of the reasons the Chesapeake Logperch had a significantly higher depth, since depth accounted for over half of the variation in Dim2, which is where the overlap of Chesapeake and Common Logperch streams was the lowest (Figure 11, Figure 12). The implication is important because Chesapeake

Logperch are known to generally be in shallower waters than the Northern Logperch, often collected in about a 0.3 m of water.

The microhabitats of the Chesapeake and Northern Logperch shows that more consideration might need to be given to the depth and width of the stream. Figure 11 shows that there is the chance for streams that have similar habitat to the Northern Logperch to be used as a general layout for possible introduction streams. However, as previously noted, the Chesapeake Logperch did show a more restricted habitat. To better understand the range that the Chesapeake Logperch can live in, more research might be needed to see if fishes would directly compete with them for habitat or food. The most common benthic fish found in the same habitat, the Tessellated Darter, has been shown to not be aggressive to other benthic darters (van Snik & Stauffer, 2001). While there are more Tessellated Darters than Chesapeake Logperch, with their non-aggressive behavior, there is the chance of them not limiting Chesapeake Logperch.

The last detail for each species' microhabitat is that while most conditions are significantly different, the difference is not a large difference. Both flow rates had a median that is <0.1 m/s of a difference and the median depth difference is only 5cm (Figure 12). Including the ranges of the Common Logperch's conditions, the results may be skewed by the large ranges. The visualization by the PCA helps to see how those small differences affect the preferences.

The diet study of the Ohio Logperch shows that they are generalists in the Shenango River. None of the families found in the stomachs and environment showed a significant electivity ($0.3 < L < -0.3$) (Table 1). There were individuals that showed high preference for certain macroinvertebrates, the highest being Daphniidae, Gammaridae, and Hydropsychidae. All having individuals with $L > 0.6$ and multiple individuals with $L > 0.3$. However, all families did have some individuals with a negative L index. This caused all three of the families to still result with a non-significant L index ($L < 0.3$) (Appendix B). This shows that diet can depend greatly on the individual and is not common among even a population, since all diet was from the Shenango River. Bradshaw (2015) also found that Ohio Logperch are generalists when it comes to diet in French Creek. Chesapeake Logperch diet have found that they significantly prefer Chironomidae ($L=0.589$), compared to other families with the second highest being Hydropsychidae (Stauffer, 2023). There were some Chironomidae found in Ohio Logperch's stomachs, but there were enough that avoided them to leave the overall index negative. The trend is comparable to that of microhabitats, where the Chesapeake Logperch diet showed a smaller range of the Ohio Logperch diet. This shows that the macroinvertebrate composition is not as similar between the species as the microhabitats.

Several considerations should be made when interpreting the relevance of the results. First, when using the comparisons, it should be noted that the microhabitat data was compared with the Northern Logperch, while the diet was compared to the Ohio Logperch. While both are subspecies of the Common Logperch, it has been noted that the taxonomy of the Northern Logperch needs to be reviewed (Stauffer, 2023). This would show the potential that the Northern and Ohio Logperch have differences in habitat use and diet. Caution should also be taken when interpreting the diet for the Ohio Logperch. This study only found the diet for Ohio Logperch in the Shenango River. While Bradshaw (2015) found similar results to support being generalists, more streams and locations on streams would need to be sampled to claim Ohio Logperch as a species and not subpopulations. The most likely confounding factor for this study was that the microhabitat for the Northern Logperch was collected in 2010-11, over a decade old. With a large difference in the timeline, 9-11 years, the differences in streams for the Northern Logperch and Chesapeake Logperch could be due to just changes of the streams over time. This would need to be analyzed in the future by comparing the conditions of the streams over time to see if there are significant changes.

The future of this work would need to look more into the life history of the Chesapeake Logperch. While there is a consensus on how they reproduce in the wild, possibly going up tributaries of larger rivers to reproduce, there have been sighting of juveniles in the Susquehanna River Flats in the Chesapeake Bay, where tributaries would not be accessible by adults. More observations also need to be made in the larger rivers. Currently, most studies have looked at the Chesapeake Logperch's presence in the streams, but not as many observations have been made for when they are in the larger bodies of water, partially due to visibility decreasing in many larger bodies of water. To successfully complete reintroductions in the future, more factors, not just one portion of their life, would need to be addressed.

With the potential for invasive species to become bigger threats in the Susquehanna River, reintroductions into the smaller tributaries may be crucial for their survival. Using the microhabitat data, the potential for mapping out habitable streams for the Chesapeake Logperch can be increased. With overlapping conditions with the Northern Logperch, more Common Logperch habitat studies may possibly be used to define Chesapeake Logperch habitats. Similar macroinvertebrate communities might not be as helpful with deciding streams, as the Chesapeake Logperch showed a much narrower diet than the Ohio Logperch.

Conclusion

With the potential for the Chesapeake Logperch to be added to the federally endangered list, there needs to be an effort to describe and preserve the species. This study looked at the microhabitats and diet of the Chesapeake Logperch and the Northern and Ohio Logperch, respectively, to compare them. The Chesapeake Logperch were shown to have a narrower range of habitat than the Northern Logperch. While the confounding timeline needs to be addressed in the future, the initial results can help to look at similar habitats as the Northern Logperch to identify potentially viable habitat for the Chesapeake Logperch. The diet was not as comparable, with the Chesapeake Logperch previously found to prefer Chironomids, while the Ohio Logperch in the Shenango River were generalists. Future efforts should focus on the rest of the Chesapeake Logperch's life history, for example to find out what habitats juveniles are using and their diet. This will help to identify sites that will not support just adults, but also the reproduction and survival of future generations.

References

Balshine, S., Verma, A., Chant, V., & Theÿsmeÿer, T. (2005). Competitive Interactions between Round Gobies and Logperch. *Journal of Great Lakes Research*, *31*(1), 68–77. https://doi.org/10.1016/s0380-1330(05)70238-0

Becker, G. C. (1983). *Fishes of Wisconsin*. University of Wisconsin Press.

Bradshaw, C. R. (2015). *Analysis of Historical and Contemporary Consumption of Aquatic Macroinvertebrates in Darter Species of a Highly Diverse Stream* [Doctoral dissertation, Pennsylvania State University]. PennState University Libraries Electronic Theses and Dissertations for Graduate School.

Cochran-Biederman, J. L., Wyman, K. E., French, W. E., & Loppnow, G. L. (2014). Identifying correlates of success and failure of native freshwater fish reintroductions. *Conservation Biology*, *29*(1), 175–186. https://doi.org/10.1111/cobi.12374

Frost, S., Huni, A., & Kershaw, W. E. (1970). Evaluation of a kicking technique for sampling stream bottom fauna. *Canadian Journal of Zoology*, *49*(2), 167-173. https://doi.org/10.1139/z71-026

Hickerson, B. T., Grube, E. R., Mosher, K. R., & Robinson, A. (2021). Successful restoration of a native fish assemblage in the Blue River, Arizona. *North American Journal of Fisheries Management*, *41*(3), 746–756. https://doi.org/10.1002/nafm.10584

Leitão, R. P., Zuanon, J., Villéger, S., Williams, S. E., Baraloto, C., Fortunel, C., De Mendonça, F. P., & Mouillot, D. (2016). Rare species contribute disproportionately to the functional structure of species assemblages. *Proceedings of the Royal Society B: Biological Sciences*, *283*, https://doi.org/10.1098/rspb.2016.0084

Malone, E., Perkin, J. S., Leckie, B., Kulp, M. A., Hurt, C., & Walker, D. M. (2018). Which species, how many, and from where: Integrating habitat suitability, population genomics, and abundance estimates into species reintroduction planning. *Global Change Biology*, *24*(8), 3729–3748. https://doi.org/10.1111/gcb.14126

Merrit, R. W., Cummins, K. W., & Berg, M. B. (2019). *An Introduction of Aquatic Insects of North America* (5th ed.). Kendall Hunt Publishing Company.

NatureServe Explorer 2.0. (2012, April 10). https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.844068/Percina_bimaculata

Near, T. J. (2008). Rescued from Synonymy: A Redescription of Percina bimaculata Haldeman and a Molecular Phylogenetic Analysis of Logperch Darters (Percidae: Etheostomatinae). *Bulletin of the Peabody Museum of Natural History*, *49*(1), 3–18. https://doi.org/10.3374/0079-032x(2008)49

Percina bimaculata | U.S. Fish & Wildlife Service. (n.d.). FWS.gov. https://www.fws.gov/species/chesapeake-logperch-percina-bimaculata

Pratchett, M. S., Coker, D. J., Jones, G. P., & Munday, P. L. (2012). Specialization in habitat use by coral reef damselfishes and their susceptibility to habitat loss. *Ecology and Evolution*, *2*(9), 2168–2180. https://doi.org/10.1002/ece3.321

Ricciardi, A., & Rasmussen, J. B. (1999). Extinction rates of North American freshwater fauna. *Conservation Biology*, *13*(5), 1220–1222. https://doi.org/10.1046/j.1523-1739.1999.98380.x

Stauffer, J. R. (2023). *Recovery of Chesapeake Logperch* (Final Report).

Stauffer, J. R., Boltz, J. M., Kellog, K. A. & van Snik, E. S. (1996). Microhabitat partitioning in a diverse assemblage of darter sin the Allegheny River system. *Environmental Biology of Fishes*, *46*, 37-44. https://doi.org/10.1007/BF00001696

Stauffer, J. R., Criswell, R. W., and Fischer, D. P. (2016). *The Fishes of Pennsylvania*. Cichlid Press.

Stauffer, J. R., & Morgan, R. P. (2022). Determination of endangered freshwater fishes: Can value be estimated? *Water*, *14*(16), 2524. https://doi.org/10.3390/w14162524

Tabachnick, B. G., & Fidell, L. S. (2012). Using Multivariate Statistics (6th Edition). In *Allyn & Bacon, Inc. eBooks* (6th ed.). Pearson.

Trautman, M. B. (1981). *The fishes of Ohio* (2nd ed.). Ohio State University Press.

Tzilkowski, C. J. & Stauffer, J. R. (2004). Biology and Diet of the Northern Madtom (*Noturus stigmosus*) and Stonecat (*Noturus flavus*) in French Creek, Pennsylvania. *Journal of the Pennsylvania Academy of Science, 78*(1), 3-11.

van Snik Gray, E., & Stauffer, J. R. (1999). Comparative microhabitat use of ecologically similar benthic fishes. *Environmental Biology of Fishes*, *56*(4), 443–453. https://doi.org/10.1023/a:1007536019444

van Snik Gray, E., & Stauffer, J. R. (2001). Substrate choice by three species of darters (Teleostei: percidae) in an artificial stream: Effects of a nonnative species. *Copeia*, *2001*(1), 254–261. https://doi.org/10.1643/0045-8511(2001)001

Wisor, J. M. (2019). *The Invasion of the Round Goby (Neogobius melanostomus) and Its Effect on the Habitat Partitioning of Benthic Fishes in French Creek* [Master's thesis, Pennsylvania State University]. PennState University Libraries Electronic Theses and Dissertations for Graduate School.

APPENDIX A

STRAUSS' LINEAR INDEX (L) FAMILY AVERAGES

Taxon Family	Average
Ancylidae	0.004
Asellidae	0.048
Baetidae	0.005
Bivalvia	-0.055
Caenidae	-0.001
Cambaridae	-0.003
Chironomidae	-0.024
Coleoptera	0.000
Corydalus	-0.001
Daphniidae	0.095
Elmidae	-0.071
Emerging Insect	0.019
Ephemerillidae	0.003
Gammaridae	0.070
Gastropoda	-0.026
Glossosomatidae	-0.001
Goeridae	-0.005
Gyrinidae	0.001
Helicopsychidae	-0.001
Heptageniidae	-0.006
Heptaginiidae	0.001
Hydropsychidae	0.038
Leptohyphidae	-0.005
Leptophlebiidae	0.002
Leptoseridae	-0.004
Molannidae	0.001
Polycentropodidae	0.006
Potomanthidae	-0.042
Psephenus	-0.001
Psychomyiidae	0.001
Simuliidae	0.007
Tipulidae	-0.028
Uenoidae	-0.012
Unknown Worm	-0.077
Unsegmented Worm	0.062

APPENDIX B

STRAUSS' LINEAR INDEX (L) VALUES FOR INDIVIDUALS SORTED LARGEST TO SMALLEST FOR L ≠ 0

Site	Fish ID	Taxon Family	L
Halfway Road Bridge	11	Daphniidae	1.000
Halfway Road Bridge	4	Daphniidae	0.998
Halfway Road Bridge	10	Daphniidae	0.990
Halfway Road Bridge	5	Daphniidae	0.776
Riverside Park	10	Hydropsychidae	0.724
Halfway Road Bridge	3	Gammaridae	0.695
Halfway Road Bridge	18	Elmidae	0.612
Riverside Park	15	Chironomidae	0.540
Riverside Park	4	Chironomidae	0.516
Riverside Park	5	Chironomidae	0.512
Riverside Park	1	Simuliidae	0.488
Halfway Road Bridge	8	Heptageniidae	0.478
Halfway Road Bridge	2	Gammaridae	0.475
Riverside Park	16	Gammaridae	0.462
Riverside Park	14	Hydropsychidae	0.455
Halfway Road Bridge	17	Chironomidae	0.449
Riverside Park	6	Unsegmented Worm	0.448
Halfway Road Bridge	7	Unsegmented Worm	0.429
Riverside Park	17	Chironomidae	0.419
Halfway Road Bridge	19	Asellidae	0.417
Riverside Park	12	Chironomidae	0.400
Riverside Park	11	Hydropsychidae	0.387
Halfway Road Bridge	1	Gammaridae	0.387
Halfway Road Bridge	22	Elmidae	0.352

Riverside Park	2	Chironomidae	0.352
Halfway Road Bridge	1	Heptageniidae	0.342
Riverside Park	8	Chironomidae	0.341
Halfway Road Bridge	20	Gammaridae	0.339
Riverside Park	3	Chironomidae	0.337
Halfway Road Bridge	13	Chironomidae	0.335
Riverside Park	9	Chironomidae	0.335
Halfway Road Bridge	9	Chironomidae	0.285
Halfway Road Bridge	23	Gammaridae	0.279
Halfway Road Bridge	6	Unsegmented Worm	0.278
Halfway Road Bridge	16	Asellidae	0.270
Halfway Road Bridge	15	Elmidae	0.263
Halfway Road Bridge	12	Asellidae	0.260
Halfway Road Bridge	20	Asellidae	0.257
Riverside Park	1	Hydropsychidae	0.247
Riverside Park	3	Unsegmented Worm	0.237
Halfway Road Bridge	15	Emerging Insect	0.222
Halfway Road Bridge	19	Gammaridae	0.214
Halfway Road Bridge	14	Chironomidae	0.198
Riverside Park	6	Hydropsychidae	0.196
Halfway Road Bridge	2	Heptageniidae	0.195
Riverside Park	13	Chironomidae	0.193
Riverside Park	16	Hydropsychidae	0.177
Halfway Road Bridge	8	Asellidae	0.169
Halfway Road Bridge	6	Baetidae	0.167
Riverside Park	2	Unsegmented Worm	0.167
Riverside Park	7	Hydropsychidae	0.163

Halfway Road Bridge	16	Hydropsychidae	0.161
Riverside Park	7	Chironomidae	0.157
Halfway Road Bridge	21	Gammaridae	0.152
Riverside Park	13	Gammaridae	0.152
Halfway Road Bridge	6	Asellidae	0.151
Halfway Road Bridge	8	Gammaridae	0.131
Halfway Road Bridge	12	Chironomidae	0.123
Halfway Road Bridge	20	Elmidae	0.122
Halfway Road Bridge	22	Asellidae	0.117
Halfway Road Bridge	3	Cambaridae	0.116
Riverside Park	14	Leptoseridae	0.115
Halfway Road Bridge	15	Unsegmented Worm	0.111
Riverside Park	8	Polycentropodidae	0.111
Riverside Park	16	Unsegmented Worm	0.111
Halfway Road Bridge	7	Elmidae	0.104
Halfway Road Bridge	21	Unsegmented Worm	0.103
Halfway Road Bridge	9	Gammaridae	0.096
Halfway Road Bridge	15	Asellidae	0.095
Halfway Road Bridge	23	Asellidae	0.095
Riverside Park	17	Bivalvia	0.093
Halfway Road Bridge	21	Chironomidae	0.088
Halfway Road Bridge	16	Gammaridae	0.088
Halfway Road Bridge	21	Asellidae	0.088
Halfway Road Bridge	3	Heptageniidae	0.085
Halfway Road Bridge	12	Gammaridae	0.083

Riverside Park	9	Polycentropodidae	0.083
Halfway Road Bridge	22	Hydropsychidae	0.081
Halfway Road Bridge	5	Unsegmented Worm	0.079
Halfway Road Bridge	14	Unsegmented Worm	0.074
Halfway Road Bridge	14	Emerging Insect	0.074
Halfway Road Bridge	2	Asellidae	0.072
Halfway Road Bridge	16	Emerging Insect	0.071
Halfway Road Bridge	8	Potomanthidae	0.071
Riverside Park	6	Emerging Insect	0.069
Halfway Road Bridge	13	Asellidae	0.067
Halfway Road Bridge	21	Potomanthidae	0.065
Halfway Road Bridge	13	Emerging Insect	0.063
Halfway Road Bridge	2	Unsegmented Worm	0.059
Riverside Park	14	Molannidae	0.059
Halfway Road Bridge	14	Asellidae	0.058
Halfway Road Bridge	15	Gammaridae	0.057
Riverside Park	16	Heptaginiidae	0.056
Riverside Park	11	Ancylidae	0.054
Riverside Park	9	Psychomyiidae	0.052
Riverside Park	11	Ephemerillidae	0.052
Riverside Park	16	Cambaridae	0.051
Riverside Park	13	Unsegmented Worm	0.048
Halfway Road Bridge	17	Unsegmented Worm	0.047
Riverside Park	1	Ephemerillidae	0.046
Riverside Park	8	Unsegmented Worm	0.044
Riverside Park	12	Polycentropodidae	0.043
Halfway Road Bridge	1	Asellidae	0.043
Riverside Park	11	Gammaridae	0.043

Riverside Park	7	Unsegmented Worm	0.042
Riverside Park	7	Simuliidae	0.042
Halfway Road Bridge	23	Elmidae	0.041
Halfway Road Bridge	9	Daphniidae	0.038
Halfway Road Bridge	14	Ancylidae	0.037
Halfway Road Bridge	12	Unsegmented Worm	0.034
Halfway Road Bridge	12	Emerging Insect	0.034
Halfway Road Bridge	18	Unsegmented Worm	0.034
Halfway Road Bridge	21	Emerging Insect	0.034
Riverside Park	8	Emerging Insect	0.033
Riverside Park	9	Simuliidae	0.031
Riverside Park	17	Unsegmented Worm	0.031
Halfway Road Bridge	18	Potomanthidae	0.031
Halfway Road Bridge	16	Heptageniidae	0.031
Halfway Road Bridge	19	Emerging Insect	0.030
Halfway Road Bridge	1	Unsegmented Worm	0.029
Riverside Park	14	Emerging Insect	0.029
Riverside Park	14	Baetidae	0.029
Riverside Park	4	Leptophlebiidae	0.029
Riverside Park	9	Ephemerillidae	0.029
Halfway Road Bridge	13	Gammaridae	0.029
Riverside Park	11	Gyrinidae	0.027
Riverside Park	14	Ephemerillidae	0.027
Riverside Park	13	Hydropsychidae	0.026
Halfway Road Bridge	1	Potomanthidae	0.026
Riverside Park	5	Emerging Insect	0.025
Riverside Park	1	Leptophlebiidae	0.024
Riverside Park	13	Emerging Insect	0.024
Riverside Park	13	Ancylidae	0.024

Halfway Road Bridge	17	Gammaridae	0.024
Halfway Road Bridge	13	Gyrinidae	0.021
Riverside Park	9	Emerging Insect	0.021
Halfway Road Bridge	9	Unsegmented Worm	0.019
Halfway Road Bridge	18	Hydropsychidae	0.016
Halfway Road Bridge	17	Emerging Insect	0.016
Riverside Park	4	Unsegmented Worm	0.014
Riverside Park	4	Ancylidae	0.014
Halfway Road Bridge	5	Emerging Insect	0.013
Halfway Road Bridge	5	Coleoptera	0.013
Riverside Park	5	Unsegmented Worm	0.013
Riverside Park	5	Ancylidae	0.013
Riverside Park	5	Leptophlebiidae	0.013
Halfway Road Bridge	17	Potomanthidae	0.012
Halfway Road Bridge	22	Gammaridae	0.012
Riverside Park	8	Baetidae	0.011
Riverside Park	9	Unsegmented Worm	0.010
Riverside Park	9	Ancylidae	0.010
Riverside Park	2	Hydropsychidae	0.010
Riverside Park	8	Ephemerillidae	0.009
Riverside Park	15	Emerging Insect	0.009
Riverside Park	15	Ancylidae	0.009
Riverside Park	17	Leptophlebiidae	0.008
Halfway Road Bridge	2	Hydropsychidae	0.006
Halfway Road Bridge	10	Ephemerillidae	0.003
Halfway Road Bridge	6	Hydropsychidae	0.003
Halfway Road Bridge	1	Glossosomatidae	-0.002
Halfway Road Bridge	1	Caenidae	-0.002

Halfway Road Bridge	1	Corydalus	-0.002
Halfway Road Bridge	1	Psephenus	-0.002
Halfway Road Bridge	2	Glossosomatidae	-0.002
Halfway Road Bridge	2	Caenidae	-0.002
Halfway Road Bridge	2	Corydalus	-0.002
Halfway Road Bridge	2	Psephenus	-0.002
Halfway Road Bridge	3	Glossosomatidae	-0.002
Halfway Road Bridge	3	Caenidae	-0.002
Halfway Road Bridge	3	Corydalus	-0.002
Halfway Road Bridge	3	Psephenus	-0.002
Halfway Road Bridge	4	Glossosomatidae	-0.002
Halfway Road Bridge	4	Caenidae	-0.002
Halfway Road Bridge	4	Corydalus	-0.002
Halfway Road Bridge	4	Psephenus	-0.002
Halfway Road Bridge	5	Glossosomatidae	-0.002
Halfway Road Bridge	5	Caenidae	-0.002
Halfway Road Bridge	5	Corydalus	-0.002
Halfway Road Bridge	5	Psephenus	-0.002
Halfway Road Bridge	6	Glossosomatidae	-0.002
Halfway Road Bridge	6	Caenidae	-0.002
Halfway Road Bridge	6	Corydalus	-0.002
Halfway Road Bridge	6	Psephenus	-0.002
Halfway Road Bridge	7	Glossosomatidae	-0.002

Halfway Road Bridge	7	Caenidae	-0.002
Halfway Road Bridge	7	Corydalus	-0.002
Halfway Road Bridge	7	Psephenus	-0.002
Halfway Road Bridge	8	Glossosomatidae	-0.002
Halfway Road Bridge	8	Caenidae	-0.002
Halfway Road Bridge	8	Corydalus	-0.002
Halfway Road Bridge	8	Psephenus	-0.002
Halfway Road Bridge	9	Glossosomatidae	-0.002
Halfway Road Bridge	9	Caenidae	-0.002
Halfway Road Bridge	9	Corydalus	-0.002
Halfway Road Bridge	9	Psephenus	-0.002
Halfway Road Bridge	10	Glossosomatidae	-0.002
Halfway Road Bridge	10	Caenidae	-0.002
Halfway Road Bridge	10	Corydalus	-0.002
Halfway Road Bridge	10	Psephenus	-0.002
Halfway Road Bridge	11	Glossosomatidae	-0.002
Halfway Road Bridge	11	Caenidae	-0.002
Halfway Road Bridge	11	Corydalus	-0.002
Halfway Road Bridge	11	Psephenus	-0.002
Halfway Road Bridge	12	Glossosomatidae	-0.002
Halfway Road Bridge	12	Caenidae	-0.002
Halfway Road Bridge	12	Corydalus	-0.002
Halfway Road Bridge	12	Psephenus	-0.002

Halfway Road Bridge	13	Glossosomatidae	-0.002
Halfway Road Bridge	13	Caenidae	-0.002
Halfway Road Bridge	13	Corydalus	-0.002
Halfway Road Bridge	13	Psephenus	-0.002
Halfway Road Bridge	14	Glossosomatidae	-0.002
Halfway Road Bridge	14	Caenidae	-0.002
Halfway Road Bridge	14	Corydalus	-0.002
Halfway Road Bridge	14	Psephenus	-0.002
Halfway Road Bridge	15	Glossosomatidae	-0.002
Halfway Road Bridge	15	Caenidae	-0.002
Halfway Road Bridge	15	Corydalus	-0.002
Halfway Road Bridge	15	Psephenus	-0.002
Halfway Road Bridge	16	Glossosomatidae	-0.002
Halfway Road Bridge	16	Caenidae	-0.002
Halfway Road Bridge	16	Corydalus	-0.002
Halfway Road Bridge	16	Psephenus	-0.002
Halfway Road Bridge	17	Glossosomatidae	-0.002
Halfway Road Bridge	17	Caenidae	-0.002
Halfway Road Bridge	17	Corydalus	-0.002
Halfway Road Bridge	17	Psephenus	-0.002
Halfway Road Bridge	18	Glossosomatidae	-0.002
Halfway Road Bridge	18	Caenidae	-0.002
Halfway Road Bridge	18	Corydalus	-0.002

Halfway Road Bridge	18	Psephenus	-0.002
Halfway Road Bridge	19	Glossosomatidae	-0.002
Halfway Road Bridge	19	Caenidae	-0.002
Halfway Road Bridge	19	Corydalus	-0.002
Halfway Road Bridge	19	Psephenus	-0.002
Halfway Road Bridge	20	Glossosomatidae	-0.002
Halfway Road Bridge	20	Caenidae	-0.002
Halfway Road Bridge	20	Corydalus	-0.002
Halfway Road Bridge	20	Psephenus	-0.002
Halfway Road Bridge	21	Glossosomatidae	-0.002
Halfway Road Bridge	21	Caenidae	-0.002
Halfway Road Bridge	21	Corydalus	-0.002
Halfway Road Bridge	21	Psephenus	-0.002
Halfway Road Bridge	22	Glossosomatidae	-0.002
Halfway Road Bridge	22	Caenidae	-0.002
Halfway Road Bridge	22	Corydalus	-0.002
Halfway Road Bridge	22	Psephenus	-0.002
Halfway Road Bridge	23	Glossosomatidae	-0.002
Halfway Road Bridge	23	Caenidae	-0.002
Halfway Road Bridge	23	Corydalus	-0.002
Halfway Road Bridge	23	Psephenus	-0.002
Riverside Park	1	Leptoseridae	-0.002
Riverside Park	1	Leptohyphidae	-0.002
Riverside Park	1	Helicopsychidae	-0.002

Riverside Park	2	Ephemerillidae	-0.002
Riverside Park	2	Leptoseridae	-0.002
Riverside Park	2	Leptohyphidae	-0.002
Riverside Park	2	Helicopsychidae	-0.002
Riverside Park	3	Ephemerillidae	-0.002
Riverside Park	3	Leptoseridae	-0.002
Riverside Park	3	Leptohyphidae	-0.002
Riverside Park	3	Helicopsychidae	-0.002
Riverside Park	4	Ephemerillidae	-0.002
Riverside Park	4	Leptoseridae	-0.002
Riverside Park	4	Leptohyphidae	-0.002
Riverside Park	4	Helicopsychidae	-0.002
Riverside Park	5	Ephemerillidae	-0.002
Riverside Park	5	Leptoseridae	-0.002
Riverside Park	5	Leptohyphidae	-0.002
Riverside Park	5	Helicopsychidae	-0.002
Riverside Park	6	Ephemerillidae	-0.002
Riverside Park	6	Leptoseridae	-0.002
Riverside Park	6	Leptohyphidae	-0.002
Riverside Park	6	Helicopsychidae	-0.002
Riverside Park	7	Ephemerillidae	-0.002
Riverside Park	7	Leptoseridae	-0.002
Riverside Park	7	Leptohyphidae	-0.002
Riverside Park	7	Helicopsychidae	-0.002
Riverside Park	8	Leptoseridae	-0.002
Riverside Park	8	Leptohyphidae	-0.002
Riverside Park	8	Helicopsychidae	-0.002
Riverside Park	9	Leptoseridae	-0.002
Riverside Park	9	Leptohyphidae	-0.002
Riverside Park	9	Helicopsychidae	-0.002
Riverside Park	10	Ephemerillidae	-0.002
Riverside Park	10	Leptoseridae	-0.002
Riverside Park	10	Leptohyphidae	-0.002
Riverside Park	10	Helicopsychidae	-0.002
Riverside Park	11	Leptoseridae	-0.002
Riverside Park	11	Leptohyphidae	-0.002
Riverside Park	11	Helicopsychidae	-0.002
Riverside Park	12	Ephemerillidae	-0.002
Riverside Park	12	Leptoseridae	-0.002
Riverside Park	12	Leptohyphidae	-0.002
Riverside Park	12	Helicopsychidae	-0.002
Riverside Park	13	Ephemerillidae	-0.002
Riverside Park	13	Leptoseridae	-0.002

Riverside Park	13	Leptohyphidae	-0.002
Riverside Park	13	Helicopsychidae	-0.002
Riverside Park	14	Leptohyphidae	-0.002
Riverside Park	14	Helicopsychidae	-0.002
Riverside Park	15	Ephemerillidae	-0.002
Riverside Park	15	Leptoseridae	-0.002
Riverside Park	15	Leptohyphidae	-0.002
Riverside Park	15	Helicopsychidae	-0.002
Riverside Park	16	Ephemerillidae	-0.002
Riverside Park	16	Leptoseridae	-0.002
Riverside Park	16	Leptohyphidae	-0.002
Riverside Park	16	Helicopsychidae	-0.002
Riverside Park	17	Ephemerillidae	-0.002
Riverside Park	17	Leptoseridae	-0.002
Riverside Park	17	Leptohyphidae	-0.002
Riverside Park	17	Helicopsychidae	-0.002
Halfway Road Bridge	5	Asellidae	-0.003
Halfway Road Bridge	1	Goeridae	-0.004
Halfway Road Bridge	2	Potomanthidae	-0.004
Halfway Road Bridge	2	Goeridae	-0.004
Halfway Road Bridge	3	Potomanthidae	-0.004
Halfway Road Bridge	3	Goeridae	-0.004
Halfway Road Bridge	4	Potomanthidae	-0.004
Halfway Road Bridge	4	Goeridae	-0.004
Halfway Road Bridge	5	Potomanthidae	-0.004
Halfway Road Bridge	5	Goeridae	-0.004
Halfway Road Bridge	6	Potomanthidae	-0.004
Halfway Road Bridge	6	Goeridae	-0.004
Halfway Road Bridge	7	Potomanthidae	-0.004
Halfway Road Bridge	7	Goeridae	-0.004

Halfway Road Bridge	8	Goeridae	-0.004
Halfway Road Bridge	9	Potomanthidae	-0.004
Halfway Road Bridge	9	Goeridae	-0.004
Halfway Road Bridge	10	Potomanthidae	-0.004
Halfway Road Bridge	10	Goeridae	-0.004
Halfway Road Bridge	11	Potomanthidae	-0.004
Halfway Road Bridge	11	Goeridae	-0.004
Halfway Road Bridge	12	Potomanthidae	-0.004
Halfway Road Bridge	12	Goeridae	-0.004
Halfway Road Bridge	13	Potomanthidae	-0.004
Halfway Road Bridge	13	Goeridae	-0.004
Halfway Road Bridge	14	Potomanthidae	-0.004
Halfway Road Bridge	14	Goeridae	-0.004
Halfway Road Bridge	15	Potomanthidae	-0.004
Halfway Road Bridge	15	Goeridae	-0.004
Halfway Road Bridge	16	Potomanthidae	-0.004
Halfway Road Bridge	16	Goeridae	-0.004
Halfway Road Bridge	17	Goeridae	-0.004
Halfway Road Bridge	18	Goeridae	-0.004
Halfway Road Bridge	19	Potomanthidae	-0.004
Halfway Road Bridge	19	Goeridae	-0.004
Halfway Road Bridge	20	Potomanthidae	-0.004
Halfway Road Bridge	20	Goeridae	-0.004

Halfway Road Bridge	21	Goeridae	-0.004
Halfway Road Bridge	22	Potomanthidae	-0.004
Halfway Road Bridge	22	Goeridae	-0.004
Halfway Road Bridge	23	Potomanthidae	-0.004
Halfway Road Bridge	23	Goeridae	-0.004
Riverside Park	1	Cambaridae	-0.005
Riverside Park	1	Uenoidae	-0.005
Riverside Park	2	Cambaridae	-0.005
Riverside Park	2	Uenoidae	-0.005
Riverside Park	3	Cambaridae	-0.005
Riverside Park	3	Uenoidae	-0.005
Riverside Park	4	Cambaridae	-0.005
Riverside Park	4	Uenoidae	-0.005
Riverside Park	5	Cambaridae	-0.005
Riverside Park	5	Uenoidae	-0.005
Riverside Park	6	Cambaridae	-0.005
Riverside Park	6	Uenoidae	-0.005
Riverside Park	7	Cambaridae	-0.005
Riverside Park	7	Uenoidae	-0.005
Riverside Park	8	Cambaridae	-0.005
Riverside Park	8	Uenoidae	-0.005
Riverside Park	9	Cambaridae	-0.005
Riverside Park	9	Uenoidae	-0.005
Riverside Park	10	Cambaridae	-0.005
Riverside Park	10	Uenoidae	-0.005
Riverside Park	11	Cambaridae	-0.005
Riverside Park	11	Uenoidae	-0.005
Riverside Park	12	Cambaridae	-0.005
Riverside Park	12	Uenoidae	-0.005
Riverside Park	13	Cambaridae	-0.005
Riverside Park	13	Uenoidae	-0.005
Riverside Park	14	Cambaridae	-0.005
Riverside Park	14	Uenoidae	-0.005
Riverside Park	15	Cambaridae	-0.005
Riverside Park	15	Uenoidae	-0.005
Riverside Park	16	Uenoidae	-0.005
Riverside Park	17	Cambaridae	-0.005
Riverside Park	17	Uenoidae	-0.005

Halfway Road Bridge	1	Leptohyphidae	-0.007
Halfway Road Bridge	2	Leptohyphidae	-0.007
Halfway Road Bridge	3	Leptohyphidae	-0.007
Halfway Road Bridge	4	Leptohyphidae	-0.007
Halfway Road Bridge	5	Leptohyphidae	-0.007
Halfway Road Bridge	6	Leptohyphidae	-0.007
Halfway Road Bridge	7	Leptohyphidae	-0.007
Halfway Road Bridge	8	Leptohyphidae	-0.007
Halfway Road Bridge	9	Leptohyphidae	-0.007
Halfway Road Bridge	10	Leptohyphidae	-0.007
Halfway Road Bridge	11	Leptohyphidae	-0.007
Halfway Road Bridge	12	Leptohyphidae	-0.007
Halfway Road Bridge	13	Leptohyphidae	-0.007
Halfway Road Bridge	14	Leptohyphidae	-0.007
Halfway Road Bridge	15	Leptohyphidae	-0.007
Halfway Road Bridge	16	Leptohyphidae	-0.007
Halfway Road Bridge	17	Leptohyphidae	-0.007
Halfway Road Bridge	18	Leptohyphidae	-0.007
Halfway Road Bridge	19	Leptohyphidae	-0.007
Halfway Road Bridge	20	Leptohyphidae	-0.007
Halfway Road Bridge	21	Leptohyphidae	-0.007
Halfway Road Bridge	22	Leptohyphidae	-0.007
Halfway Road Bridge	23	Leptohyphidae	-0.007

Riverside Park	1	Asellidae	-0.007
Riverside Park	1	Goeridae	-0.007
Riverside Park	2	Asellidae	-0.007
Riverside Park	2	Goeridae	-0.007
Riverside Park	3	Asellidae	-0.007
Riverside Park	3	Goeridae	-0.007
Riverside Park	4	Asellidae	-0.007
Riverside Park	4	Goeridae	-0.007
Riverside Park	5	Asellidae	-0.007
Riverside Park	5	Goeridae	-0.007
Riverside Park	6	Asellidae	-0.007
Riverside Park	6	Goeridae	-0.007
Riverside Park	7	Asellidae	-0.007
Riverside Park	7	Goeridae	-0.007
Riverside Park	8	Asellidae	-0.007
Riverside Park	8	Goeridae	-0.007
Riverside Park	9	Asellidae	-0.007
Riverside Park	9	Goeridae	-0.007
Riverside Park	10	Asellidae	-0.007
Riverside Park	10	Goeridae	-0.007
Riverside Park	11	Asellidae	-0.007
Riverside Park	11	Goeridae	-0.007
Riverside Park	12	Asellidae	-0.007
Riverside Park	12	Goeridae	-0.007
Riverside Park	13	Asellidae	-0.007
Riverside Park	13	Goeridae	-0.007
Riverside Park	14	Asellidae	-0.007
Riverside Park	14	Goeridae	-0.007
Riverside Park	15	Asellidae	-0.007
Riverside Park	15	Goeridae	-0.007
Riverside Park	16	Asellidae	-0.007
Riverside Park	16	Goeridae	-0.007
Riverside Park	17	Asellidae	-0.007
Riverside Park	17	Goeridae	-0.007
Halfway Road Bridge	1	Cambaridae	-0.009
Halfway Road Bridge	2	Cambaridae	-0.009
Halfway Road Bridge	4	Cambaridae	-0.009
Halfway Road Bridge	5	Cambaridae	-0.009

Halfway Road Bridge	6	Cambaridae	-0.009
Halfway Road Bridge	7	Cambaridae	-0.009
Halfway Road Bridge	8	Cambaridae	-0.009
Halfway Road Bridge	9	Cambaridae	-0.009
Halfway Road Bridge	10	Cambaridae	-0.009
Halfway Road Bridge	11	Cambaridae	-0.009
Halfway Road Bridge	12	Cambaridae	-0.009
Halfway Road Bridge	13	Cambaridae	-0.009
Halfway Road Bridge	14	Cambaridae	-0.009
Halfway Road Bridge	15	Cambaridae	-0.009
Halfway Road Bridge	16	Cambaridae	-0.009
Halfway Road Bridge	17	Cambaridae	-0.009
Halfway Road Bridge	18	Cambaridae	-0.009
Halfway Road Bridge	19	Cambaridae	-0.009
Halfway Road Bridge	20	Cambaridae	-0.009
Halfway Road Bridge	21	Cambaridae	-0.009
Halfway Road Bridge	22	Cambaridae	-0.009
Halfway Road Bridge	23	Cambaridae	-0.009
Halfway Road Bridge	1	Leptoseridae	-0.011
Halfway Road Bridge	2	Leptoseridae	-0.011
Halfway Road Bridge	3	Leptoseridae	-0.011
Halfway Road Bridge	4	Leptoseridae	-0.011
Halfway Road Bridge	5	Leptoseridae	-0.011

Halfway Road Bridge	6	Leptoseridae	-0.011
Halfway Road Bridge	7	Leptoseridae	-0.011
Halfway Road Bridge	8	Leptoseridae	-0.011
Halfway Road Bridge	9	Leptoseridae	-0.011
Halfway Road Bridge	10	Leptoseridae	-0.011
Halfway Road Bridge	11	Leptoseridae	-0.011
Halfway Road Bridge	12	Leptoseridae	-0.011
Halfway Road Bridge	13	Leptoseridae	-0.011
Halfway Road Bridge	14	Leptoseridae	-0.011
Halfway Road Bridge	15	Leptoseridae	-0.011
Halfway Road Bridge	16	Leptoseridae	-0.011
Halfway Road Bridge	17	Leptoseridae	-0.011
Halfway Road Bridge	18	Leptoseridae	-0.011
Halfway Road Bridge	19	Leptoseridae	-0.011
Halfway Road Bridge	20	Leptoseridae	-0.011
Halfway Road Bridge	21	Leptoseridae	-0.011
Halfway Road Bridge	22	Leptoseridae	-0.011
Halfway Road Bridge	23	Leptoseridae	-0.011
Riverside Park	7	Potomanthidae	-0.011
Halfway Road Bridge	1	Simuliidae	-0.012
Halfway Road Bridge	2	Simuliidae	-0.012
Halfway Road Bridge	3	Simuliidae	-0.012
Halfway Road Bridge	4	Simuliidae	-0.012

Halfway Road Bridge	5	Simuliidae	-0.012
Halfway Road Bridge	6	Simuliidae	-0.012
Halfway Road Bridge	7	Simuliidae	-0.012
Halfway Road Bridge	8	Simuliidae	-0.012
Halfway Road Bridge	9	Simuliidae	-0.012
Halfway Road Bridge	10	Simuliidae	-0.012
Halfway Road Bridge	11	Simuliidae	-0.012
Halfway Road Bridge	12	Simuliidae	-0.012
Halfway Road Bridge	13	Simuliidae	-0.012
Halfway Road Bridge	14	Simuliidae	-0.012
Halfway Road Bridge	15	Simuliidae	-0.012
Halfway Road Bridge	16	Simuliidae	-0.012
Halfway Road Bridge	17	Simuliidae	-0.012
Halfway Road Bridge	18	Simuliidae	-0.012
Halfway Road Bridge	19	Simuliidae	-0.012
Halfway Road Bridge	20	Simuliidae	-0.012
Halfway Road Bridge	21	Simuliidae	-0.012
Halfway Road Bridge	22	Simuliidae	-0.012
Halfway Road Bridge	23	Simuliidae	-0.012
Halfway Road Bridge	8	Hydropsychidae	-0.016
Halfway Road Bridge	1	Gastropoda	-0.016
Halfway Road Bridge	2	Gastropoda	-0.016
Halfway Road Bridge	3	Asellidae	-0.016

Halfway Road Bridge	3	Gastropoda	-0.016
Halfway Road Bridge	4	Asellidae	-0.016
Halfway Road Bridge	4	Gastropoda	-0.016
Halfway Road Bridge	5	Gastropoda	-0.016
Halfway Road Bridge	6	Gastropoda	-0.016
Halfway Road Bridge	7	Asellidae	-0.016
Halfway Road Bridge	7	Gastropoda	-0.016
Halfway Road Bridge	8	Gastropoda	-0.016
Halfway Road Bridge	9	Asellidae	-0.016
Halfway Road Bridge	9	Gastropoda	-0.016
Halfway Road Bridge	10	Asellidae	-0.016
Halfway Road Bridge	10	Gastropoda	-0.016
Halfway Road Bridge	11	Asellidae	-0.016
Halfway Road Bridge	11	Gastropoda	-0.016
Halfway Road Bridge	12	Gastropoda	-0.016
Halfway Road Bridge	13	Gastropoda	-0.016
Halfway Road Bridge	14	Gastropoda	-0.016
Halfway Road Bridge	15	Gastropoda	-0.016
Halfway Road Bridge	16	Gastropoda	-0.016
Halfway Road Bridge	17	Asellidae	-0.016
Halfway Road Bridge	17	Gastropoda	-0.016
Halfway Road Bridge	18	Asellidae	-0.016
Halfway Road Bridge	18	Gastropoda	-0.016

Halfway Road Bridge	19	Gastropoda	-0.016
Halfway Road Bridge	20	Gastropoda	-0.016
Halfway Road Bridge	21	Gastropoda	-0.016
Halfway Road Bridge	22	Gastropoda	-0.016
Halfway Road Bridge	23	Gastropoda	-0.016
Halfway Road Bridge	14	Gammaridae	-0.018
Halfway Road Bridge	1	Uenoidae	-0.018
Halfway Road Bridge	2	Uenoidae	-0.018
Halfway Road Bridge	3	Uenoidae	-0.018
Halfway Road Bridge	4	Uenoidae	-0.018
Halfway Road Bridge	5	Uenoidae	-0.018
Halfway Road Bridge	6	Uenoidae	-0.018
Halfway Road Bridge	7	Uenoidae	-0.018
Halfway Road Bridge	8	Uenoidae	-0.018
Halfway Road Bridge	9	Uenoidae	-0.018
Halfway Road Bridge	10	Uenoidae	-0.018
Halfway Road Bridge	11	Uenoidae	-0.018
Halfway Road Bridge	12	Uenoidae	-0.018
Halfway Road Bridge	13	Uenoidae	-0.018
Halfway Road Bridge	14	Uenoidae	-0.018
Halfway Road Bridge	15	Uenoidae	-0.018
Halfway Road Bridge	16	Uenoidae	-0.018
Halfway Road Bridge	17	Uenoidae	-0.018

Halfway Road Bridge	18	Uenoidae	-0.018
Halfway Road Bridge	19	Uenoidae	-0.018
Halfway Road Bridge	20	Uenoidae	-0.018
Halfway Road Bridge	21	Uenoidae	-0.018
Halfway Road Bridge	22	Uenoidae	-0.018
Halfway Road Bridge	23	Uenoidae	-0.018
Halfway Road Bridge	20	Hydropsychidae	-0.023
Halfway Road Bridge	1	Tipulidae	-0.023
Halfway Road Bridge	2	Tipulidae	-0.023
Halfway Road Bridge	3	Tipulidae	-0.023
Halfway Road Bridge	4	Tipulidae	-0.023
Halfway Road Bridge	5	Tipulidae	-0.023
Halfway Road Bridge	6	Tipulidae	-0.023
Halfway Road Bridge	7	Tipulidae	-0.023
Halfway Road Bridge	8	Tipulidae	-0.023
Halfway Road Bridge	9	Tipulidae	-0.023
Halfway Road Bridge	10	Tipulidae	-0.023
Halfway Road Bridge	11	Tipulidae	-0.023
Halfway Road Bridge	12	Tipulidae	-0.023
Halfway Road Bridge	13	Tipulidae	-0.023
Halfway Road Bridge	14	Tipulidae	-0.023
Halfway Road Bridge	15	Tipulidae	-0.023
Halfway Road Bridge	16	Tipulidae	-0.023

Halfway Road Bridge	17	Tipulidae	-0.023
Halfway Road Bridge	18	Tipulidae	-0.023
Halfway Road Bridge	19	Tipulidae	-0.023
Halfway Road Bridge	20	Tipulidae	-0.023
Halfway Road Bridge	21	Tipulidae	-0.023
Halfway Road Bridge	22	Tipulidae	-0.023
Halfway Road Bridge	23	Tipulidae	-0.023
Halfway Road Bridge	1	Hydropsychidae	-0.023
Riverside Park	8	Tipulidae	-0.025
Halfway Road Bridge	13	Hydropsychidae	-0.032
Halfway Road Bridge	9	Hydropsychidae	-0.034
Riverside Park	8	Hydropsychidae	-0.034
Riverside Park	1	Tipulidae	-0.036
Riverside Park	2	Tipulidae	-0.036
Riverside Park	3	Tipulidae	-0.036
Riverside Park	4	Tipulidae	-0.036
Riverside Park	5	Tipulidae	-0.036
Riverside Park	6	Tipulidae	-0.036
Riverside Park	7	Tipulidae	-0.036
Riverside Park	9	Tipulidae	-0.036
Riverside Park	10	Tipulidae	-0.036
Riverside Park	11	Tipulidae	-0.036
Riverside Park	12	Tipulidae	-0.036
Riverside Park	13	Tipulidae	-0.036
Riverside Park	14	Tipulidae	-0.036
Riverside Park	15	Tipulidae	-0.036
Riverside Park	16	Tipulidae	-0.036
Riverside Park	17	Tipulidae	-0.036
Riverside Park	15	Hydropsychidae	-0.037
Riverside Park	17	Hydropsychidae	-0.038
Halfway Road Bridge	19	Hydropsychidae	-0.038
Riverside Park	1	Gammaridae	-0.038
Riverside Park	1	Heptageniidae	-0.038

Riverside Park	2	Gammaridae	-0.038
Riverside Park	2	Heptageniidae	-0.038
Riverside Park	3	Gammaridae	-0.038
Riverside Park	3	Heptageniidae	-0.038
Riverside Park	4	Gammaridae	-0.038
Riverside Park	4	Heptageniidae	-0.038
Riverside Park	5	Gammaridae	-0.038
Riverside Park	5	Heptageniidae	-0.038
Riverside Park	6	Gammaridae	-0.038
Riverside Park	6	Heptageniidae	-0.038
Riverside Park	7	Gammaridae	-0.038
Riverside Park	7	Heptageniidae	-0.038
Riverside Park	8	Gammaridae	-0.038
Riverside Park	8	Heptageniidae	-0.038
Riverside Park	9	Gammaridae	-0.038
Riverside Park	9	Heptageniidae	-0.038
Riverside Park	10	Gammaridae	-0.038
Riverside Park	10	Heptageniidae	-0.038
Riverside Park	11	Heptageniidae	-0.038
Riverside Park	12	Gammaridae	-0.038
Riverside Park	12	Heptageniidae	-0.038
Riverside Park	13	Heptageniidae	-0.038
Riverside Park	14	Gammaridae	-0.038
Riverside Park	14	Heptageniidae	-0.038
Riverside Park	15	Gammaridae	-0.038
Riverside Park	15	Heptageniidae	-0.038
Riverside Park	16	Heptageniidae	-0.038
Riverside Park	17	Gammaridae	-0.038
Riverside Park	17	Heptageniidae	-0.038
Riverside Park	11	Elmidae	-0.039
Halfway Road Bridge	4	Heptageniidae	-0.040
Halfway Road Bridge	5	Heptageniidae	-0.040
Halfway Road Bridge	6	Heptageniidae	-0.040
Halfway Road Bridge	7	Heptageniidae	-0.040
Halfway Road Bridge	9	Heptageniidae	-0.040
Halfway Road Bridge	10	Heptageniidae	-0.040
Halfway Road Bridge	11	Heptageniidae	-0.040

Halfway Road Bridge	12	Heptageniidae	-0.040
Halfway Road Bridge	13	Heptageniidae	-0.040
Halfway Road Bridge	14	Heptageniidae	-0.040
Halfway Road Bridge	15	Heptageniidae	-0.040
Halfway Road Bridge	17	Heptageniidae	-0.040
Halfway Road Bridge	18	Heptageniidae	-0.040
Halfway Road Bridge	19	Heptageniidae	-0.040
Halfway Road Bridge	20	Heptageniidae	-0.040
Halfway Road Bridge	21	Heptageniidae	-0.040
Halfway Road Bridge	22	Heptageniidae	-0.040
Halfway Road Bridge	23	Heptageniidae	-0.040
Riverside Park	1	Gastropoda	-0.041
Riverside Park	2	Gastropoda	-0.041
Riverside Park	3	Gastropoda	-0.041
Riverside Park	4	Gastropoda	-0.041
Riverside Park	5	Gastropoda	-0.041
Riverside Park	6	Gastropoda	-0.041
Riverside Park	7	Gastropoda	-0.041
Riverside Park	8	Gastropoda	-0.041
Riverside Park	9	Gastropoda	-0.041
Riverside Park	10	Gastropoda	-0.041
Riverside Park	11	Gastropoda	-0.041
Riverside Park	12	Gastropoda	-0.041
Riverside Park	13	Gastropoda	-0.041
Riverside Park	14	Gastropoda	-0.041
Riverside Park	15	Gastropoda	-0.041
Riverside Park	16	Gastropoda	-0.041
Riverside Park	17	Gastropoda	-0.041
Halfway Road Bridge	5	Gammaridae	-0.041
Riverside Park	3	Hydropsychidae	-0.045
Riverside Park	4	Hydropsychidae	-0.045
Riverside Park	5	Hydropsychidae	-0.045

Riverside Park	9	Hydropsychidae	-0.045
Riverside Park	12	Hydropsychidae	-0.045
Riverside Park	12	Potomanthidae	-0.049
Riverside Park	12	Elmidae	-0.050
Halfway Road Bridge	1	Unknown Worm	-0.051
Halfway Road Bridge	2	Unknown Worm	-0.051
Halfway Road Bridge	3	Unknown Worm	-0.051
Halfway Road Bridge	4	Unknown Worm	-0.051
Halfway Road Bridge	5	Unknown Worm	-0.051
Halfway Road Bridge	6	Unknown Worm	-0.051
Halfway Road Bridge	7	Unknown Worm	-0.051
Halfway Road Bridge	8	Unknown Worm	-0.051
Halfway Road Bridge	9	Unknown Worm	-0.051
Halfway Road Bridge	10	Unknown Worm	-0.051
Halfway Road Bridge	11	Unknown Worm	-0.051
Halfway Road Bridge	12	Unknown Worm	-0.051
Halfway Road Bridge	13	Unknown Worm	-0.051
Halfway Road Bridge	14	Unknown Worm	-0.051
Halfway Road Bridge	15	Unknown Worm	-0.051
Halfway Road Bridge	16	Unknown Worm	-0.051
Halfway Road Bridge	17	Unknown Worm	-0.051
Halfway Road Bridge	18	Unknown Worm	-0.051
Halfway Road Bridge	19	Unknown Worm	-0.051
Halfway Road Bridge	20	Unknown Worm	-0.051

Halfway Road Bridge	21	Unknown Worm	-0.051
Halfway Road Bridge	22	Unknown Worm	-0.051
Halfway Road Bridge	23	Unknown Worm	-0.051
Halfway Road Bridge	10	Gammaridae	-0.051
Halfway Road Bridge	3	Hydropsychidae	-0.053
Halfway Road Bridge	4	Hydropsychidae	-0.053
Halfway Road Bridge	5	Hydropsychidae	-0.053
Halfway Road Bridge	7	Hydropsychidae	-0.053
Halfway Road Bridge	10	Hydropsychidae	-0.053
Halfway Road Bridge	11	Hydropsychidae	-0.053
Halfway Road Bridge	12	Hydropsychidae	-0.053
Halfway Road Bridge	14	Hydropsychidae	-0.053
Halfway Road Bridge	15	Hydropsychidae	-0.053
Halfway Road Bridge	17	Hydropsychidae	-0.053
Halfway Road Bridge	21	Hydropsychidae	-0.053
Halfway Road Bridge	23	Hydropsychidae	-0.053
Halfway Road Bridge	4	Gammaridae	-0.055
Halfway Road Bridge	6	Gammaridae	-0.055
Halfway Road Bridge	7	Gammaridae	-0.055
Halfway Road Bridge	11	Gammaridae	-0.055
Halfway Road Bridge	18	Gammaridae	-0.055
Riverside Park	11	Potomanthidae	-0.055
Halfway Road Bridge	6	Chironomidae	-0.061

Halfway Road Bridge	23	Chironomidae	-0.061
Halfway Road Bridge	14	Elmidae	-0.070
Riverside Park	14	Potomanthidae	-0.078
Riverside Park	16	Potomanthidae	-0.081
Halfway Road Bridge	9	Elmidae	-0.087
Riverside Park	1	Elmidae	-0.093
Riverside Park	2	Elmidae	-0.093
Riverside Park	3	Elmidae	-0.093
Riverside Park	4	Elmidae	-0.093
Riverside Park	5	Elmidae	-0.093
Riverside Park	6	Elmidae	-0.093
Riverside Park	7	Elmidae	-0.093
Riverside Park	8	Elmidae	-0.093
Riverside Park	9	Elmidae	-0.093
Riverside Park	10	Elmidae	-0.093
Riverside Park	13	Elmidae	-0.093
Riverside Park	14	Elmidae	-0.093
Riverside Park	15	Elmidae	-0.093
Riverside Park	16	Elmidae	-0.093
Riverside Park	17	Elmidae	-0.093
Riverside Park	10	Potomanthidae	-0.098
Halfway Road Bridge	1	Bivalvia	-0.100
Halfway Road Bridge	2	Bivalvia	-0.100
Halfway Road Bridge	3	Bivalvia	-0.100
Halfway Road Bridge	4	Bivalvia	-0.100
Halfway Road Bridge	5	Bivalvia	-0.100
Halfway Road Bridge	6	Bivalvia	-0.100
Halfway Road Bridge	7	Bivalvia	-0.100
Halfway Road Bridge	8	Bivalvia	-0.100
Halfway Road Bridge	9	Bivalvia	-0.100
Halfway Road Bridge	10	Bivalvia	-0.100

Halfway Road Bridge	11	Bivalvia	-0.100
Halfway Road Bridge	12	Bivalvia	-0.100
Halfway Road Bridge	13	Bivalvia	-0.100
Halfway Road Bridge	14	Bivalvia	-0.100
Halfway Road Bridge	15	Bivalvia	-0.100
Halfway Road Bridge	16	Bivalvia	-0.100
Halfway Road Bridge	17	Bivalvia	-0.100
Halfway Road Bridge	18	Bivalvia	-0.100
Halfway Road Bridge	19	Bivalvia	-0.100
Halfway Road Bridge	20	Bivalvia	-0.100
Halfway Road Bridge	21	Bivalvia	-0.100
Halfway Road Bridge	22	Bivalvia	-0.100
Halfway Road Bridge	23	Bivalvia	-0.100
Halfway Road Bridge	7	Chironomidae	-0.109
Riverside Park	1	Unknown Worm	-0.112
Riverside Park	2	Unknown Worm	-0.112
Riverside Park	3	Unknown Worm	-0.112
Riverside Park	4	Unknown Worm	-0.112
Riverside Park	5	Unknown Worm	-0.112
Riverside Park	6	Unknown Worm	-0.112
Riverside Park	7	Unknown Worm	-0.112
Riverside Park	8	Unknown Worm	-0.112
Riverside Park	9	Unknown Worm	-0.112
Riverside Park	10	Unknown Worm	-0.112
Riverside Park	11	Unknown Worm	-0.112
Riverside Park	12	Unknown Worm	-0.112
Riverside Park	13	Unknown Worm	-0.112
Riverside Park	14	Unknown Worm	-0.112
Riverside Park	15	Unknown Worm	-0.112
Riverside Park	16	Unknown Worm	-0.112

Riverside Park	17	Unknown Worm	-0.112
Riverside Park	13	Potomanthidae	-0.113
Riverside Park	17	Potomanthidae	-0.121
Riverside Park	15	Potomanthidae	-0.128
Riverside Park	1	Potomanthidae	-0.136
Riverside Park	2	Potomanthidae	-0.136
Riverside Park	3	Potomanthidae	-0.136
Riverside Park	4	Potomanthidae	-0.136
Riverside Park	5	Potomanthidae	-0.136
Riverside Park	6	Potomanthidae	-0.136
Riverside Park	8	Potomanthidae	-0.136
Riverside Park	9	Potomanthidae	-0.136
Halfway Road Bridge	19	Chironomidae	-0.156
Halfway Road Bridge	19	Elmidae	-0.166
Halfway Road Bridge	5	Elmidae	-0.168
Halfway Road Bridge	16	Chironomidae	-0.180
Halfway Road Bridge	1	Elmidae	-0.181
Halfway Road Bridge	2	Elmidae	-0.181
Halfway Road Bridge	3	Elmidae	-0.181
Halfway Road Bridge	4	Elmidae	-0.181
Halfway Road Bridge	6	Elmidae	-0.181
Halfway Road Bridge	8	Elmidae	-0.181
Halfway Road Bridge	10	Elmidae	-0.181
Halfway Road Bridge	11	Elmidae	-0.181
Halfway Road Bridge	12	Elmidae	-0.181
Halfway Road Bridge	13	Elmidae	-0.181
Halfway Road Bridge	16	Elmidae	-0.181
Halfway Road Bridge	17	Elmidae	-0.181

Halfway Road Bridge	21	Elmidae	-0.181
Riverside Park	6	Chironomidae	-0.184
Riverside Park	11	Chironomidae	-0.210
Riverside Park	10	Chironomidae	-0.234
Riverside Park	14	Chironomidae	-0.249
Halfway Road Bridge	22	Chironomidae	-0.261
Riverside Park	1	Chironomidae	-0.279
Halfway Road Bridge	5	Chironomidae	-0.315
Halfway Road Bridge	18	Chironomidae	-0.325
Halfway Road Bridge	1	Chironomidae	-0.365
Halfway Road Bridge	2	Chironomidae	-0.365
Halfway Road Bridge	10	Chironomidae	-0.391
Halfway Road Bridge	4	Chironomidae	-0.392
Halfway Road Bridge	3	Chironomidae	-0.394
Halfway Road Bridge	8	Chironomidae	-0.394
Halfway Road Bridge	11	Chironomidae	-0.394
Halfway Road Bridge	15	Chironomidae	-0.394
Halfway Road Bridge	20	Chironomidae	-0.394
Riverside Park	16	Chironomidae	-0.426