COMPARITIVE ASSESMENT OF LAKE STURGEON (*Acipenser fulvescens)* SPAWNING HABITAT ON THE UPPER BLACK RIVER AND STURGEON RIVER

Calla Beers

University of Michigan Biological Station
EEB 321/ENVIRON 331 Biology and Ecology of Fishes
August 15, 2018
Dr. Amy Schrank

Abstract

Lake Sturgeon are key members of freshwater lake system as well as culturally significant. In the northern part of Michigan's lower peninsula efforts to encourage the growth of the sturgeon population in Burt lake have been initiated through increased environmental awareness and limited fishing quotas. This study analyzed habitat parameters vital to lake sturgeon development including substrate composition and embeddedness of particles, substrate and average velocity, and similarity of benthic macroinvertebrates at known sturgeon spawning habitats in the Black River compared to sites on the Sturgeon River. Results showed that based on habitat parameter ranges defined by past research and data collected on the Black River, spawning of lake sturgeon on the Sturgeon River is likely viable and could potentially be improved though the addition on cobble to the substrate. Further study of spawning habitats during spring spawning season are essential to determining the practicality of implementing habitat management methods.

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Introduction

Sturgeon are among the oldest living ray-fin fishes on the planet, thought to be at least 200 million years old (Tyus 2012). In the 1800s lake sturgeon were considered a bycatch fish in the United States and populations were severely diminished through mass extermination (SGM 2018). A reversal of public mindset occurred in the 1800s and commercial fishing began to target lake sturgeon as a delicacy, increasing the harvesting rate of lake sturgeon to more than 4 million pounds in 1880 in Michigan alone (SGM 2018). Currently lake sturgeon are listed as a threatened species in Michigan and fishing is highly regulated (DNR 2018). Black Lake does allow spear fishing for a three-day season in February which allows permitted anglers a quota of six fish for the entire season (DNR 2018). While they are often consumed after being caught, lake sturgeon are most valued today for the novelty of the catch, their persistence as a primeval species, and as a cultural symbol of the Great Lakes region.

While recent protective regulation has aided lake sturgeon populations, sturgeon life history makes recovery difficult. The species reaches sexual maturity two decades after they hatch and only ten to twenty percent of adult lake sturgeon spawn in a given spawning season, and spawning seasons remain less prolific than historic estimates (Hubbs and Lagler 2007; SGM 2018). The construction of dams and other human development negatively affected spawning ability of sturgeon by restricting historic migratory paths to the Great Lakes and limiting access to river systems (SGM 2018). These added constraints on movement within water systems are still a major obstacle in recruitment, as lake sturgeon adults travel upstream in rivers to spawn, where eggs settle in interstitial substrate spaces before becoming dislodged and swept downriver in their larval stage (Bruch *et al.* 2016). This limited spawning space necessitates that inflows to lakes that can support adult lake sturgeon meet sturgeon spawning requirements.

Ideal lake sturgeon spawning habitat requires a substrate composition that shelters fertilized eggs from the onslaught of water that threatens to wash eggs away, ideally between gravel and course cobble sized rock (Bruch *et al.* 2016). Within this range rocks have large enough interstitial spaces to protect eggs from river flow without obstructing larval sturgeon from drifting downstream (Bruch *et al.* 2016). Interstitial spaces are also influenced by overall embeddedness, which at low levels functions to increase these gaps and also influences the stability of the substrate to remain immobile despite fast flow rates (Bruch *et al.* 2016). While water velocity plays a critical role on larval drift, appropriate substrate velocity is a key component in preventing displacement and asphyxiation of eggs (Auer and Baker 2002). Lake sturgeon typically successfully spawn between an average water velocity of 0.5 to 2.0 m s^{-1}, which causes oxygenation through riffles on the surface but does not negatively affect placement of eggs (Bruch *et al.* 2016).

Substrate cover type and velocity also impact benthic macroinvertebrate communities that form another component of spawning parameters (Kerr *et al*. 2015). Diptera as well as Ephemoropera, Mollusca, and Decpoda are considered typical prey items necessary to support juvenile sturgeon before they return to their home lakes (Bruch *et al.* 2016). In addition to benthic macroinvertebrates functioning as a food source, Perlidae and other families function as lake sturgeon egg predators, ultimately reducing fitness where they are present (Walquist *et al*. 2015). In order to support spawning, macroinvertebrate abundance must be high enough to sustain sturgeon populations and a diverse community of macroinvertebrates must include a lesser number of predator macroinvertebrates and high levels of prey.

The Upper Black River in the norther lower peninsula of Michigan is a current lake sturgeon spawning habitat where adults can survive, grow, and produce viable gametes (Smith and King 2004). Spawning commences in early spring when lake sturgeon move from the benthos of Black Lake about 11 kilometers into the fast flowing Upper Black River where movement upstream is interrupted by Kleber Dam (Smith and King 2004). Spawning is abundant in areas accessible to sturgeon below Kleber Dam, where a steep gradient (7 meters per kilometer) ensures oxygenated water and unobstructed cobble for spawning and the mean water temperature remains between the ideal 13 and 16°C during the spring (Smith and King 2004).

The objective of this study was to compare the parameters of the Upper Black River spawning habitat to habitats on the Sturgeon River and determine potential management methods that might induce natural spawning within the Sturgeon River. Three sites were chosen on each river that were selected due to their accessibility by car, were shallow enough to stand in, and visually appeared to meet some of the habitat parameters that support lake sturgeon spawning. At the main branch of the Sturgeon River sites were selected between Wolverine and the confluence at Burt Lake and sites on the Upper Black River were selected between Kleber Dam and the confluence at Black Lake (Figure 1). Descriptions of river vegetation, human manipulated factors, and other characteristics are given elsewhere (TMWS 2017). The congruity of the habitats of the two rivers was examined through analysis of discharge, substrate and average velocity, substrate composition and embeddedness of particles, and similarity of benthic macroinvertebrates.

Materials and Methods

Substrate

To characterize substrate size composition and embeddedness, a 1 m^2 quadrat was placed at the bottom of the river. Each team member stood downstream of the quadrat and simultaneously estimated percent cover of each classification size (Wentworth 1922) and percent embeddedness, or the percent of rock submerged compared to percent exposed to water (USGS 1989). This procedure was repeated five times per transect resulting in fifteen defined quadrats on each site (Figure 2).

Abiotic Variables

Air and water temperature were taken once at each site with a water thermometer. At ten points along the transect a flow meter was used to measure velocity at sixty percent depth. The width of the stream, depth at each point on the transect, average velocity, and the location of the measurement on the transect were recorded (Figure 2). This procedure was repeated once at each site.

Substrate velocity was recorded using similar methods. At five points along the transect velocity was recorded with a flow meter at the substrate and the location of the measurement along the transect. This process was repeated three times at each site resulting in 15 substrate velocity measurements per site for six sites.

Macroinvertebrates

Macroinvertebrates were collected from river substrates in the Upper Black River and the Sturgeon River. 30 cm^2 quadrat surber samplers were placed on the substrate and the sediment to a depth of 5 cm was disturbed using our feet for two minutes into the ground when applicable. This procedure was repeated twice along each transect at edges of transect at which team members could stand, resulting in a total of six samples per site.

Contents of each sample were placed in enamel pans and sorted for thirty person minutes on site. Macroinvertebrates were preserved in eighty-five percent isopropyl and stored separated by sample. Organisms were identified under a microscope using keys from Stroud Water Research Center and the University of Wisconsin and classified to their order.

Abundance of bugs was found from the number of macroinvertebrates found in each site sample divided by meters squared of total surber area samples (54 m^2).

Statistics

The assumptions of all ANOVA tests were assessed using a Q-Q plot and a test of homogeneity of variances and a Tukey post hoc test was used to identify significant differences. A p-value of 0.05 was used in all tests. Mean substrate size, mean percent embeddedness, mean velocity, substrate velocity, mean macroinvertebrate abundance, and mean Shannon diversity indices for each site were evaluated using ANOVA tests. A cluster analysis was used to compare the total number of macroinvertebrates found in each of the six sites.

Results

Mean discharge was greater at the Sturgeon River and was colder, shallower and narrower than the Black River (Table 1). Mean substrate on the Sturgeon River had less cobble and boulder than the Black River but a greater amount of pebble (Figure 3). Fisher Woods on the Sturgeon had a mean cobble cover of 5.8%, significantly less than the 21.6% cover found on Waveland (p=.03) and much less than the 31% at Fireline (p=.004). Mean pebble cover at Wolverine 46.3%, significantly lower than at the Haakwood site also on the Sturgeon River which had 66.6% cover (p=.046). Haakwood also had greater cover than Waveland which had 41.7% cover (p=.034) as well as Fireline which had 33.6% cover (p=.004). Fisher Wood had significantly higher pebble cover at 64.6% than Fireline (p=.014). Other cover types were similar among all sites (Figure 3).

Mean substrate embeddedness was similar among all sites expect for Wolverine Park, which was significantly more embedded with 33.6% embeddedness compares to the two other

Sturgeon River sites, Haakwood with only 12.3% embeddedness (p=.002) and Fisher Wood with 7% (p=<.001) (Figure 4).

Mean velocity ranged from .66 to .85 m/s at our Sturgeon River sites and .32 to .37 m/s on Black River sites. Wolverine had significantly higher velocity compared to Fireline (p=.022). Haakwood also had significantly higher velocity than Waveland (p=.001) and Fireline (p=.003) leaving Waveland and Fireline the only sites not within the suitable range during sampling (Figure 5).

Mean substrate velocities ranged from 0.28 to 0.37 m/s at our Sturgeon River sites and 0.18 to 0.30 m/s at our Black River sites though values were statistically different among sites. Waveland has significantly lower substrate velocity compared to Haakwood on the Sturgeon River (p=.025). Other sites did not differ in a statistically significant way (Figure 6).

A comparison of macroinvertebrate abundance between sites was determined through an Kruskal-Wallis test which showed no statistically significant differences between sites (df=5, Sig.=.456). Species richness was calculated using an ANOVA to compare Shannon diversity index for each site. Diversity ranged from .58 to .75 on the Sturgeon River and .57 to .71 on the Black River, and no site was statistically different from others (p=.285). A cluster analysis was used to compare the total number of macroinvertebrates found in each of the six sites (Figure 7). Mean number of bugs at Kleber was the mist dissimilar from other sites while Haakwood and Waveland on different rivers were the most similar.

Discussion

Substrate cover and embeddedness indicate that both rivers have interstitial spaces within the suitable range of lake sturgeon spawning. However, cobble on the Sturgeon River differs from the amount found on Black River Spawning sites. Since velocity at 60% depth was lower than the suitable range on two of the Black River spawning sites it is possible that as a result of the measurements being taken in July and August instead of May when lake sturgeon are spawning, flow for both rivers is lower due to a lack of snowmelt. If this is true it is possible that all three of the Sturgeon River sites experience increased velocity during spawning season that results in a velocity that exceeds the range in which fertilization of eggs may occur. Further testing, ideally in the spring, would be required to better understand the implication of snowmelt and increased velocity. Substrate velocity could also be impacted by increased velocity during spawning season due to a higher mean velocity on Sturgeon River site than Black River sites. However, since only Haakwood, the fastest flowing site, and Waveland, the slowest, are significantly different potential increases in flow might not impact the ability of eggs to remain in interstitial spaces.

Similarly, mean temperature on the Black River was above the suitable range and was too warm on the Sturgeon River by half a degree. All measurements were taken during the summer, where temperature is expected to be warmer than when lake sturgeon spawning occurs,

Though counts of macroinvertebrate communities could have the same complication of data that show differing communities in the spring compared to summer, analyzing abundance and diversity in both rivers during summer enabled us to make comparisons between community similarity rather than relating them to previous abundances of spawning habitats in the spring. Both abundance and diversity were not significantly different among any site, suggesting that food availability at all sites would be similar when sturgeon spawn. It also suggests that though predator stonefly larva were present and reduce sturgeon fitness, the similar measurements of diversity implies that this would not prevent recruitment from occurring in the Sturgeon River since it is possible in the Black River.

An observable distinction between sites on the Sturgeon River compared to the Black River was that human disturbances in the form of kayakers and rafters were a constant occurrence on the Sturgeon River while the Black River's inaccessibility caused a noticeable lack of human disturbance while sampling was occurring. While Kleber Dam does alter the natural course of the Black River and greatly limits the amount of habitat available for lake sturgeon to spawn on, human development lines the banks of the Sturgeon River from the confluence at Indian river through Wolverine (Figure 8). Though it could be presumed that some of these disturbances would be less frequent in the spring, lake sturgeon living in the stream in their larval and juvenile stages could still be impacted by this activity.

Management action that could both improve lake sturgeon spawning habitat in the Sturgeon river that is also feasible includes implementing an artificial cobble substrate to increase interstitial spaces. In 1972, similar action was taken on the Black River that has since lost its effectiveness due to new sediment dispersal covering much of this material, but a similar project on the St. Clair river that introduced 4 to 8 in limestone fragments did demonstrate improved spawning success (Smith and King 2004; Kerr *et al*. 2010). This study investigated the similarity of parameters of the Upper Black River spawning habitat to habitats on the Sturgeon River by focusing on the congruity of discharge, substrate and average velocity, substrate composition and embeddedness of particles, and similarity of benthic macroinvertebrates. Further study is required in order to better understand the life history of lake sturgeon early development and to begin creating viable spawning habitats that enable population growth.

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Figures and Tables

Site	Discharge (m^3/s)	Water Temperature (°C)	Mean Depth (cm)	Mean Width (m)
Wolverine	5.7	14.0	54.4	13.5
Haakwood	6.0	17.0	38.4	17.5
Fisherwood	6.9	18.5	47.6	19.5
Sturgeon River	6.2	16.5	46.8	16.8
Waveland	4.3	25.0	48.0	22.0
Kleber	4.6	22.0	36.8	18.0
Fireline	4.6	23.0	63.5	20.0
Black River	4.5	23.3	49.4	20.0

Table 1. Comparisons of Sturgeon River and Black River average discharge, water temperature, depth, and width with site averages.

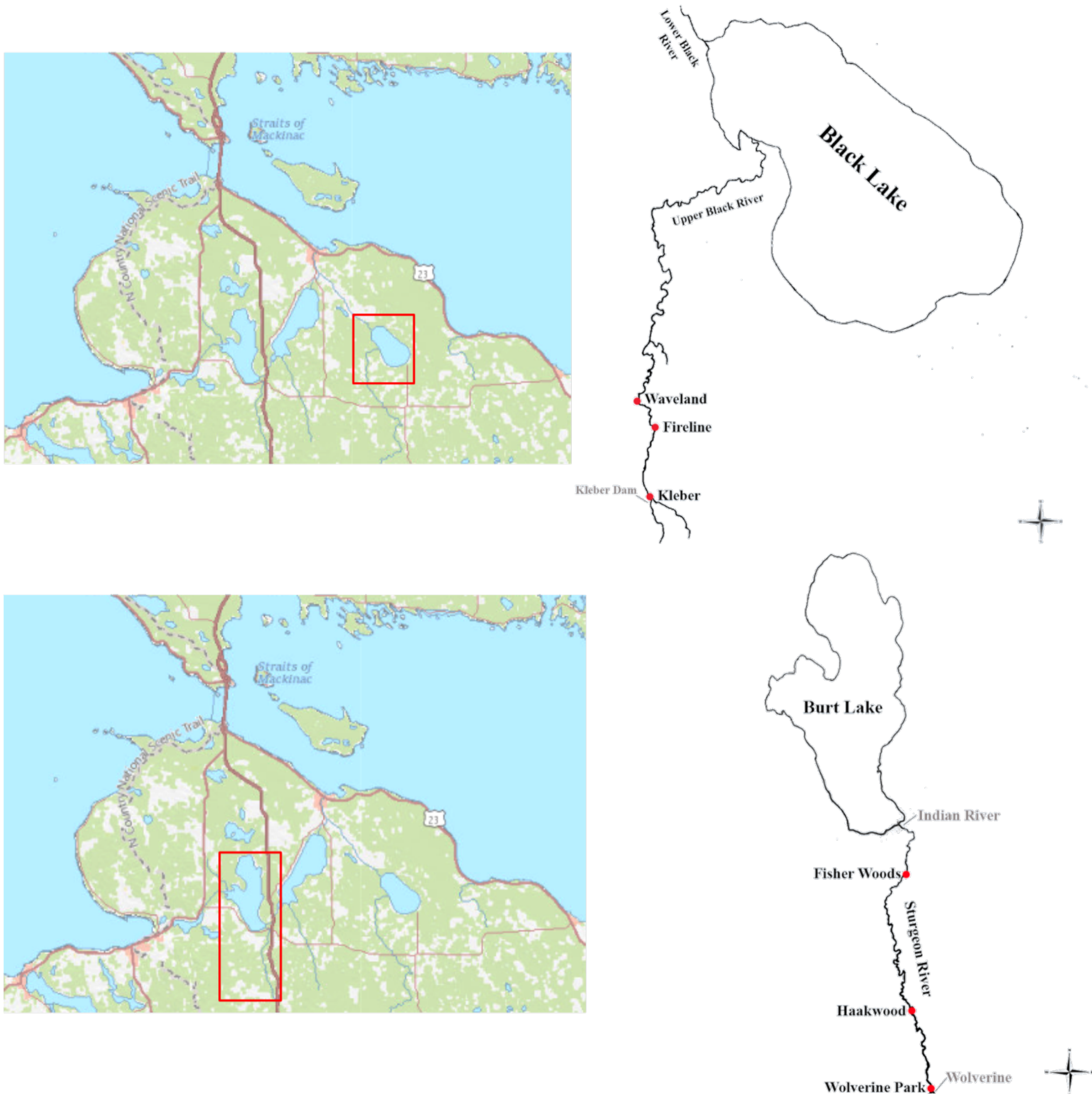

Figure 1. Maps on the left show northern Michigan with each river area shown on them (red rectangles). The Upper Black River map indicates site locations (red circles) of Waveland, Fireline, and Kleber. The Sturgeon River map indicates site locations (red circles) of Fisher Woods, Haakwood, and Wolverine Park.

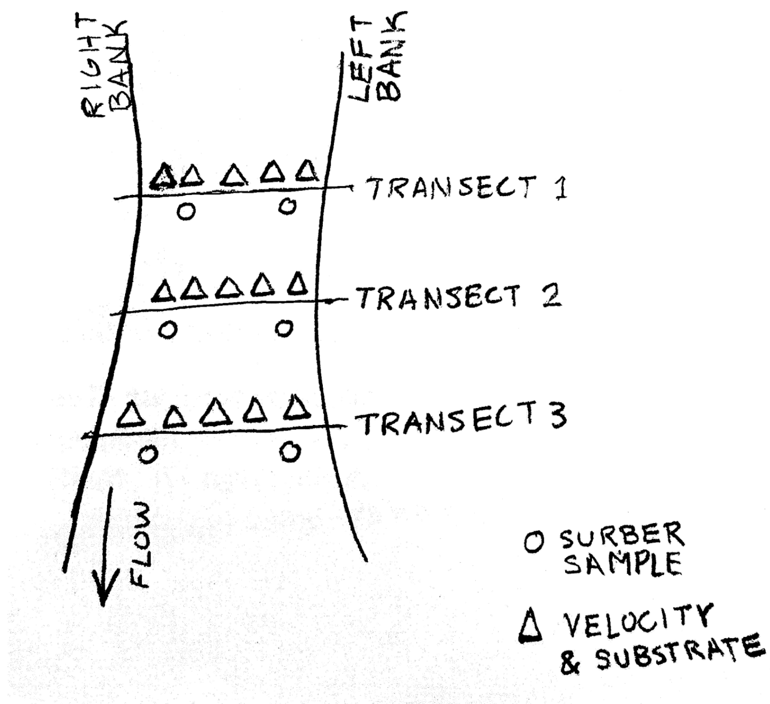

Figure 2. Diagram of a hypothetical site setup. Three transects cross river, where two surber samples (circles) are taken and velocity and substrate measurement locations (triangles) were taken five times across transects starting from the left bank to the right bank. This was repeated on each river.

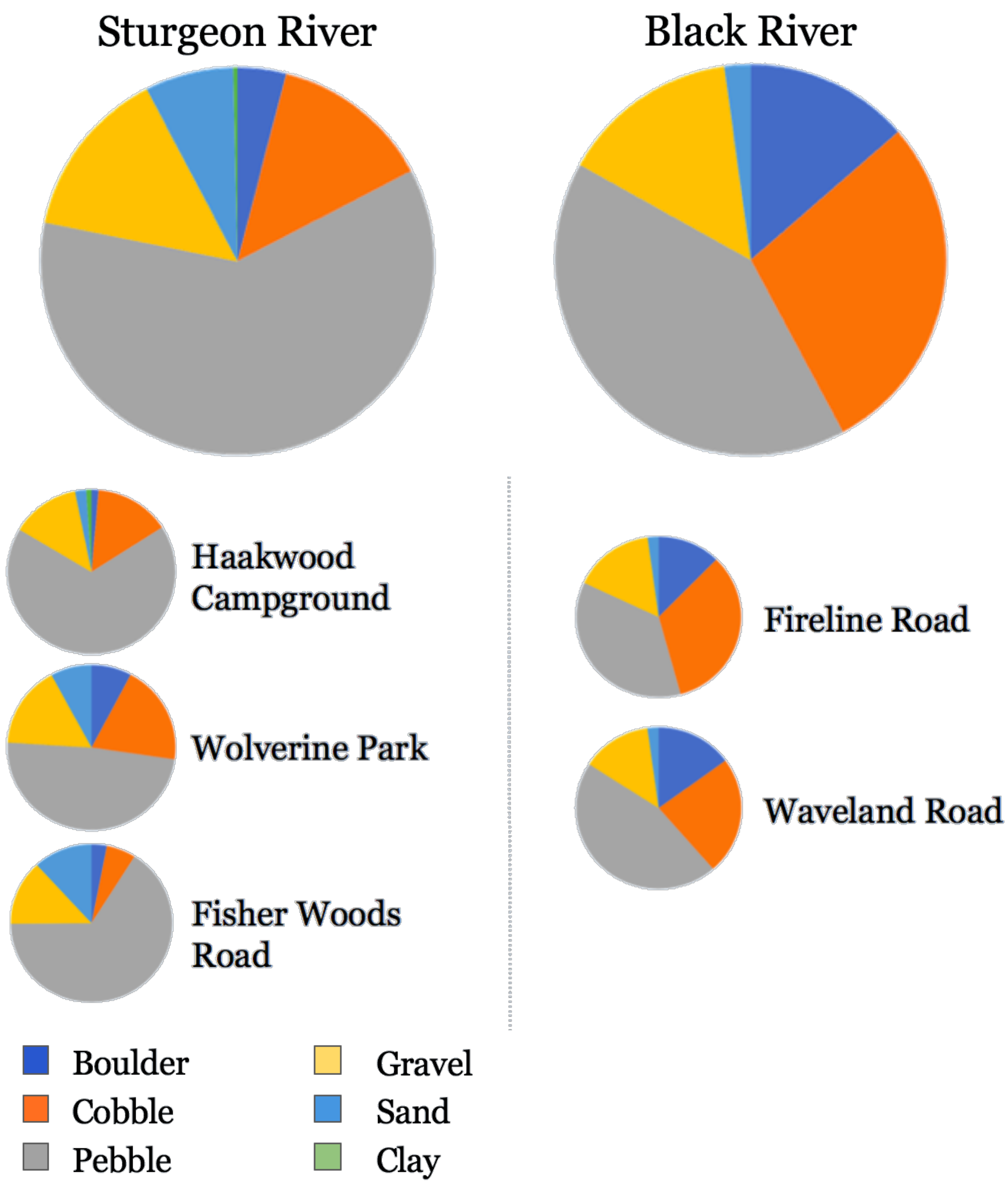

Figure 3. Substrate cover composition percentage as defined by the Wentworth scale (1922). Comparison of Sturgeon River sites (left) compared to Black River sites (right). Mean substrate composition by river is shown by the two larger graphs, with each site on the river labels beneath. (Gravel: df=74, F=.446, p-vlaue=.775) (Pebble: df=74, F=6.637, p-vlaue<0.001) (Cobble: df=74, F=5.906, p-vlaue<0.001)

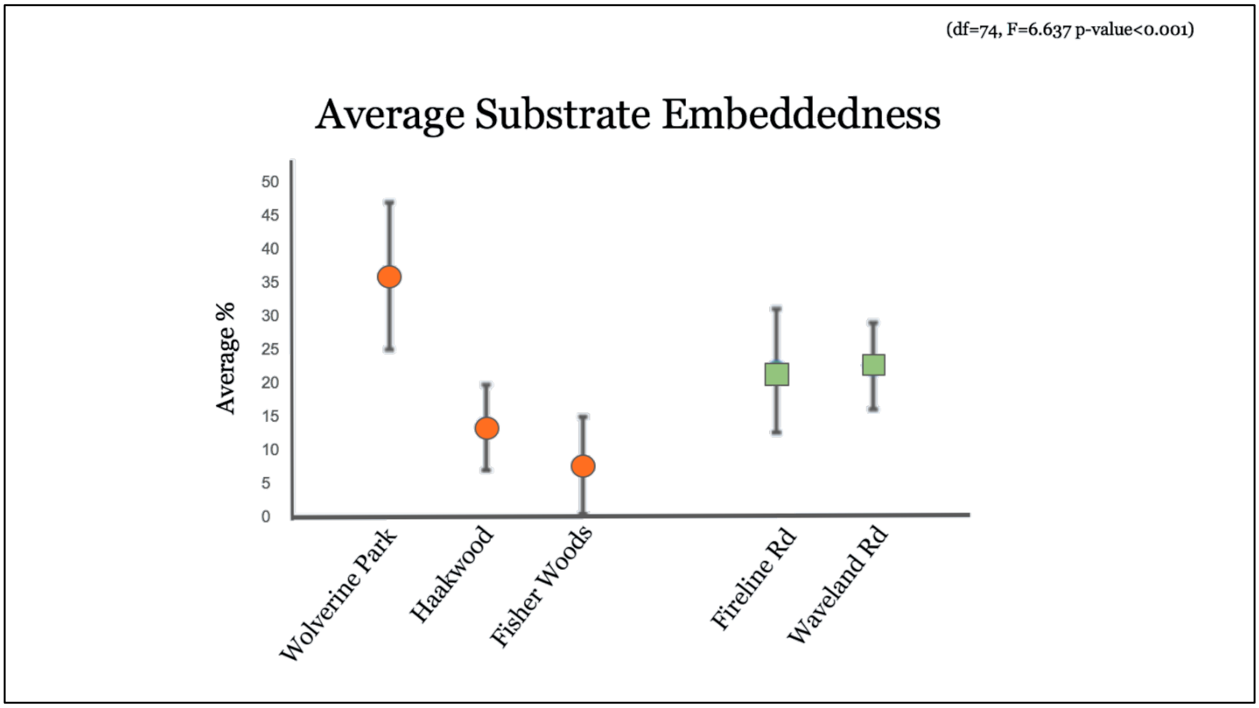

Figure 4. Percent embeddedness of embedded particles as defined by the U.S. Geological Survey. Comparison of Sturgeon River sites (orange circles) compared to Black River sites (green squares).

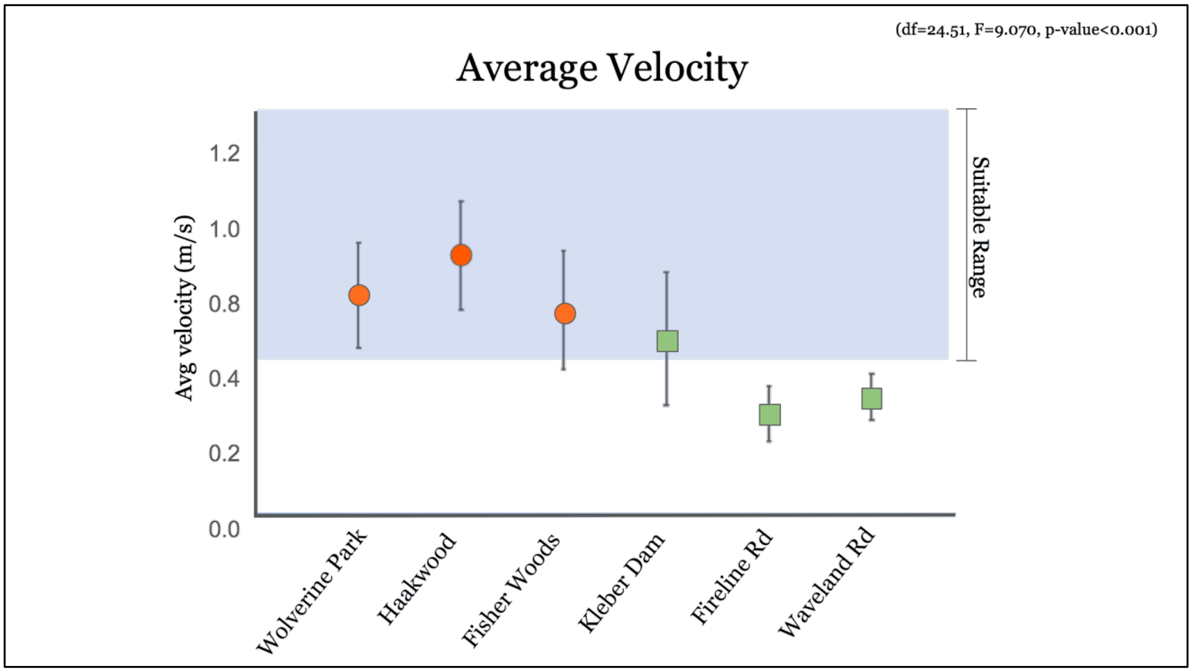

Figure 5. Average velocity taken at 60% depth at Sturgeon River sites (orange circles) and Black River sites (green squares). The suitable average velocity range of 0.5 to 2.0 m/ s^2 is represented by the shaded area.

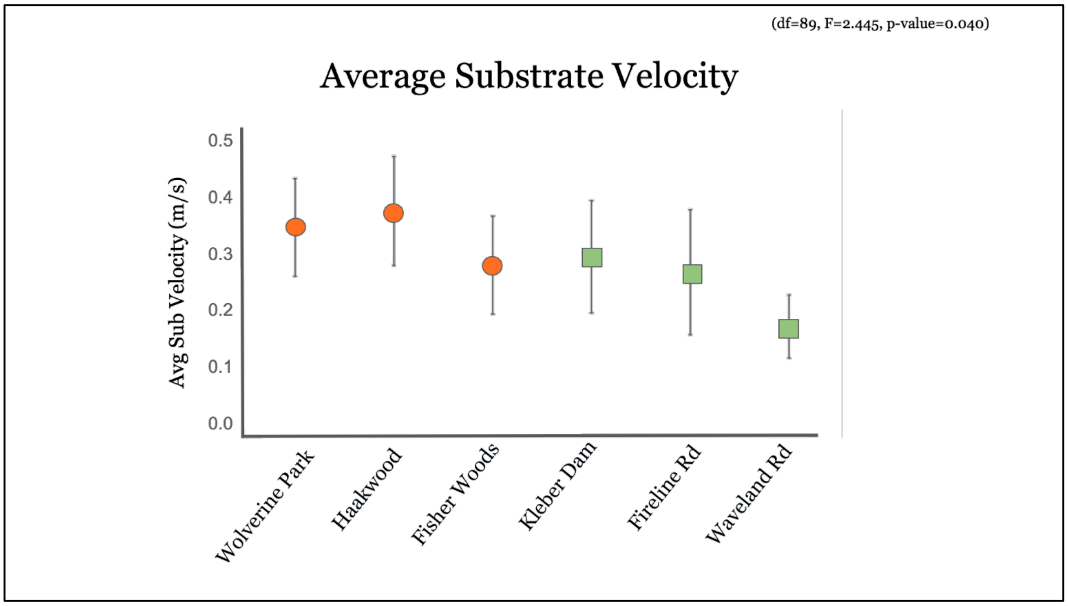

Figure 6. Average velocity taken at the substrate at Sturgeon River sites (orange circles) and Black River sites (green squares).

Figure 7. Cluster analysis depicting constellation plot of similarity of macroinvertebrates communities at on the Black River (green squares) and Sturgeon River (orange circles).

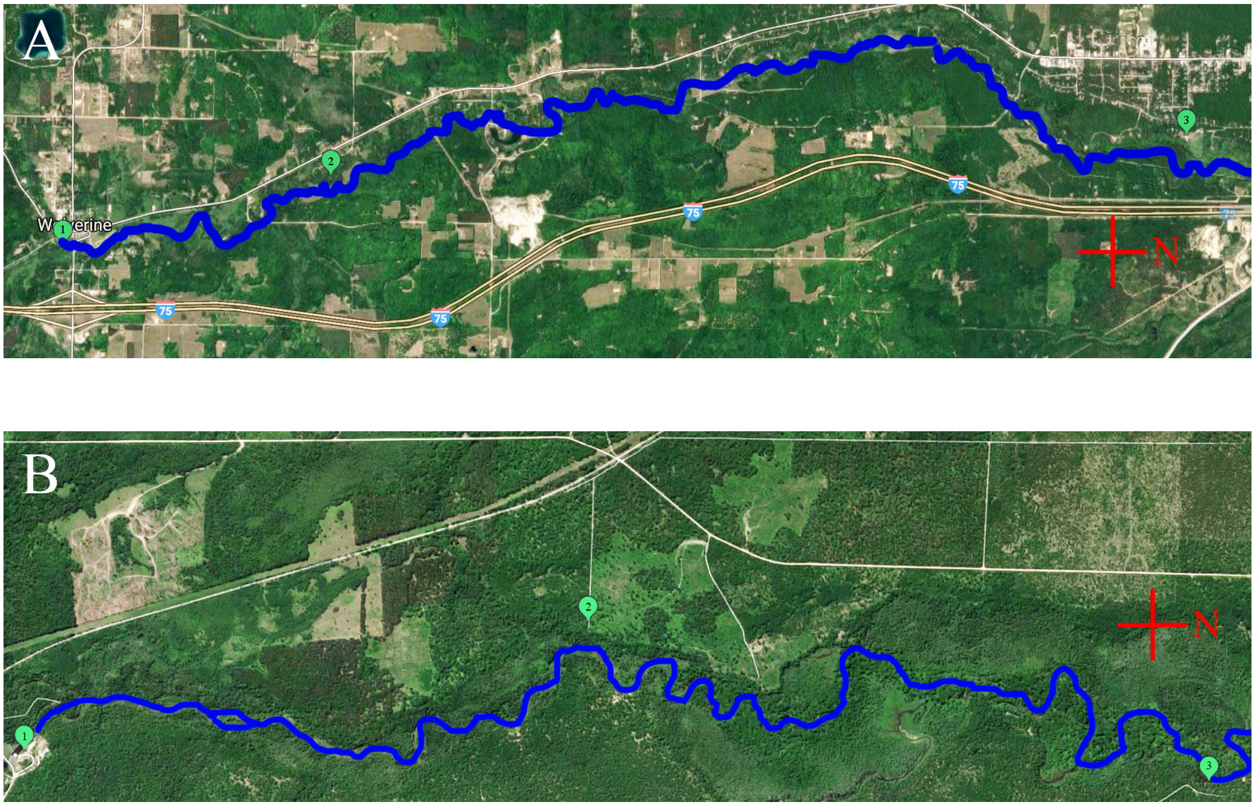

Figure 8. Map A shows the Sturgeon River (blue line) while map B shows the Upper Black River (blue line) both flowing from South to North. Wolverine Park (A-1), Haakwood Campground (A-2), Fisherwood Road (A-3), Kleber Dam (B-1), Waveland Road (B-2), and Fireline Road (B-3) sampling sites are represented by green circles.

Work Log Summary

Group Member	Primary Responsibilities	Percent Total Effort
Calla Beers	Data recorder in field Finding field locations Finding research Surber samples, bug count in field and at lab, substrate estimations, setting up transects Statistics Presentation slides	1/3 of total work load
Group Member	Primary Responsibilities	Percent Total Effort
Ellie Olds	Finding research Surber samples, bug count in field and at lab, substrate estimates, quadrat operator, flow meter operator Statistics Presentation Slides	1/3 of total work load
Group Member	Primary Responsibilities	Percent Total Effort
Rob Perrone	Finding research Surber samples, bug count in field and at lab, substrate estimations, setting up transects, flow meter operator, embeddedness sampler Statistics	1/3 of total work load