An Analysis of Crayfish Populations in the Rouge River Compared with Select Water Quality Parameters

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Abstract:

The Rouge River watershed of Southeastern Michigan is encompassed within a region that has become highly urbanized during the last century. This development has led to a significant number of fragmented ecosystems that has decreased species biodiversity. The wetlands, floodplains, and tributaries of the Rouge River make up a variety of smaller sub-ecosystems, each with its set of unique characteristics. There must be attention and research into the species that inhabit these smaller regions if we hope to restore, preserve and protect the species that remain. The crayfish is one crustacean that inhabits these inland wetlands and branches of the Rouge River. Crayfish are considered a keystone species in many aquatic ecosystems. They control plant and fish populations and are a needed food source for many aquatic lifeforms. The crayfish's prominent role explains why it is necessary to study these lobster-like creatures. This research was conducted over two months using minnow traps that were designed, engineered, and deployed to monitor crayfish populations in two branches of the Rouge River - the Lower and Middle Branch. Data was also simultaneously collected on air and water temperature, dissolved oxygen, and turbidity using Vernier LabQuest 2 sensors. During this research, crayfish populations were monitored throughout the autumn of 2021. Crayfish were trapped, measured, identified, and returned to the river. As autumn progressed and temperatures dropped, the quantity of crayfish collected increased. Only one crayfish species was trapped in both areas of the Rouge River during sampling - the Virile Crayfish *(Orconectes virilis)*. For future research, we would like to expand our collecting period to include other seasons and to see what specific river environments and water quality parameters are most suited for crayfish reproduction and growth.

Key Words: crayfish, air and water temperature, dissolved Oxygen, turbidity, LabQuest 2, Rouge River

Introduction and Review of Literature:

Crayfish are aquatic crustaceans found in inland bodies of water around much of the world. They have a varied diet of small organisms including insects, tadpoles, fish, snails, plants, and even decaying material (Helfrich). This wide-ranging diet allows them to fill an important niche as energy is transferred within aquatic food webs. While they eat smaller and often inaccessible forms of food, crayfish then can be eaten by larger animals such as raccoons, herons, and otters helping to transfer energy up the food chain creating a more productive ecosystem. However, this varied diet makes some crayfish species notoriously opportunistic and invasive. Once introduced into an environment, they can survive and create significant competition with native crayfish species for food and habitat resources. Crayfish are oftentimes introduced into a nonnative environment accidentally, due to human consumption of crayfish, their use as bait when fishing, and some are even kept as aquarium pets (Faulkes). In Michigan, humans are most likely the reason for the introduction of invasive species into local aquatic ecosystems. The two invasive species that are rapidly spreading are the Rusty Crayfish (*Orconectes rusticus*) and the Red Swamp Crayfish (*Procambarus clarkii*). The Rusty Crayfish has been known to consume much more food than native species which results in aquatic environments becoming barren (Reid). The introduction of the Red Swamp Crayfish has been more recent and extensive efforts have been made in Michigan to contain their spread to other bodies of water. According to Dr. Nathan Lucas, a crayfish researcher at Michigan State University, these notorious invasive crayfish are now predominately found in urban drainage systems where artificial ponds have been created that possess higher temperatures than natural bodies of water. The Red Swamp Crayfish is the most common species used for consumption making their spread as an invasive species the most widespread around the world (Loureiro). Crayfish are considered important bioindicators as their population numbers often correlate significantly to specific environmental conditions. As a result, their populations can be used as a sign of a change in certain conditions within aquatic ecosystems. According to Dr. Nathan Lucas, crayfish are significant bioindicators of select water quality parameters such as pH, BOD, and dissolved oxygen. These important bioindicator properties and the significance of crayfish as a keystone species, makes understanding their local populations even more essential to properly assessing and managing the Rouge River watershed.

Research Questions:

The following questions were asked in this research:

1. What species of crayfish are present in select segments of two branches of the Rouge River?
2. Do crayfish population numbers vary due to fluctuating levels of dissolved oxygen?
3. Do crayfish population numbers vary in response to changing levels of turbidity?
4. Do crayfish population numbers change as a result of decreasing temperatures in the autumn?

Null Hypothesis:

1. There is no difference in crayfish species and their numbers found in two (2) branches of the Rouge River.
2. There is no correlation between crayfish numbers and dissolved oxygen levels.
3. There is no correlation in crayfish numbers and turbidity.
4. There is no correlation between temperature values and crayfish numbers.

Research Methods:

In order to address the research questions of this investigation, it was necessary to carefully design the research protocols. Initially, the research was planned to take place from the beginning of September to the end of October. This two-month period was considered to be enough time to analyze overall crayfish population trends and to observe a decrease in both air and water temperature. To collect sufficient data, it was decided to sample two locations simultaneously, one at the Middle Branch and another at the Lower Branch of the Rouge River.

Figure 1-2 Middle Rouge Site. Figure 2 (right) near (42.3476499-83.2915850) shows the testing site for the Middle Branch of the Rouge. Our team cast off the minnow traps and conducted our testing near the circled area, along a

bridge. Figure 1 (left) shows a closer look into the area. There are some critical obstructions along the testing site, predominately fallen trees.

Figure 3-4 Lower Rouge Site. Figure 3 (left) is an aerial view of the Lower Rouge Site (42.298477, -83.305998). The site is indicated by the red markers shown to be located within Inkster Park. Figure 4 (right) is a photo taken at the Lower Rouge Branch Site. It is observed that there weren't many large obstructions within the river and the water flowed at a fairly fast rate.

Specialized crayfish traps are used as a reliable means to collect crayfish during scientific research. There are a variety of techniques used to enumerate the number of crayfish in a given location. Some examples could be using fishing nets, open bait traps, electro-fishing, and even one's hands (Larson). However, these required expense and expertise which our team lacked access to. Before beginning our research, we conducted a trap test to determine what homemade traps might work the best for our testing locations. We constructed a cylindrical and square shape trap design with ½ inch mesh wire, and two designs made out of plastic bottles. In the end, the cylindrical trap we designed and constructed using ½ inch mesh square wire worked best. The cylindrical trap caught 2 crayfish in the test run while the two other designs failed to catch any. The final trap design we built and used was inspired by using ideas and techniques from a variety of different crayfish traps that are used both commercially, for sport, and for research. We made the design out of sturdy square mesh wire which cost around 13 dollars. A bait was also needed in order to attract crayfish into these traps. Past studies have used commercial crayfish bait to dog food (Larson). Canned cat food was used in this study as it had been used in past studies of crayfish, and it is widely available and inexpensive, costing 50 cents a can.

Figure 5-6 Trap Mechanisms. Figure 5 (left) shows one of two traps built for this study. They had been built from mesh wire with the dimensions of .6 meters long and with a diameter of .17 meters. Figure 6 (right) is the bait used which is a can of cat food.

Figure 7-8 Equipment. Figure 7 (left) shows the LabQuest 2 where the optical DO probe and temperature probe can be attached to give the readings. Each probe is dipped into the water and the team reports the results displayed on the LabQuest 2. Figure 8 (right) shows the turbidity tube. The tube gets filled with river water and is drained until the pattern on the bottom of the tube is visible. Then the tube stops being drained and the water level is recorded to give the group the turbidity measure.

The water quality parameters we tested included air temperature, water temperature, dissolved oxygen, and turbidity. A Vernier LabQuest 2 was used with an accompanying Vernier Stainless Steel Temperature Probe and Vernier Optical DO Probe. With this equipment the temperature probe could connect to the LabQuest 2 in order to measure both surface and water temperatures. The DO Probe can also connect in order to measure the dissolved oxygen of the sites of the

Rouge River. Turbidity was measured using a “Transparency Tube” or “Turbidity Tube” that was filled with the water from the sites and emptied until the bottom of the tube was clearly visible. This would output a value giving the maximum depth of water that the bottom could be seen clearly. This investigation took place from September 3, 2021 to October 17, 2021. At each location air temperatures, water temperatures, turbidity, and dissolved oxygen were measured. Each parameter was measured three times with the equipment. The values of the three trials were then averaged. The constructed minnow traps were tied to a nearby branch and dropped to the floor of the river at the two sites. 24 hours later, the researchers would return and recover the traps. The data for each crayfish trapped was then recorded along with their length from their rostrum to tail fan, sex, and species. Before releasing the crayfish, we marked them with a non-washable marker to see population trends. Recapturing marked crayfish would have given us an insight of the population density of crayfish in the area. Unfortunately, we did not recapture any. One interesting thing to note, however, is that there was some bycatch. There were two small minnows that were caught in along with the crayfish. We were unable to identify the species and they were promptly released. At the end of data collection, all crayfish were placed back into the water and were left undisturbed until the trap was placed again the following week. Finally, the data was entered into the GLOBE database.

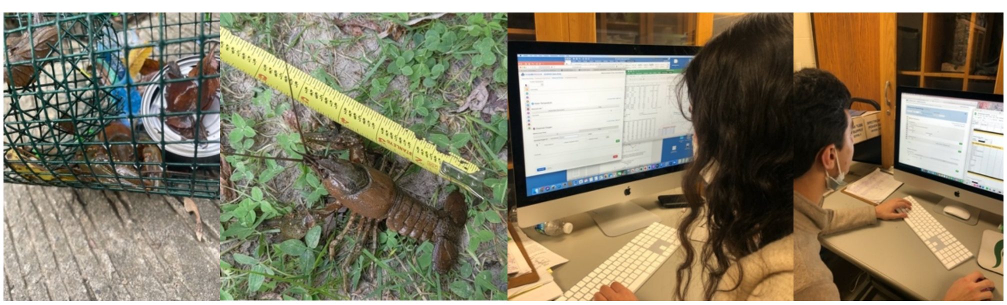

Figure 9-12 Crayfish Data Collection. As shown in Figure 9 (left), the traps would be retrieved the following day. Crayfish would be extracted from the traps and they would be measured from rostrum to tail fan in Figure 10 (middle left). Once the data had been recorded, it would then be entered into the GLOBE database in Figure 11-12 (middle right and right).

Results: Middle Branch Site

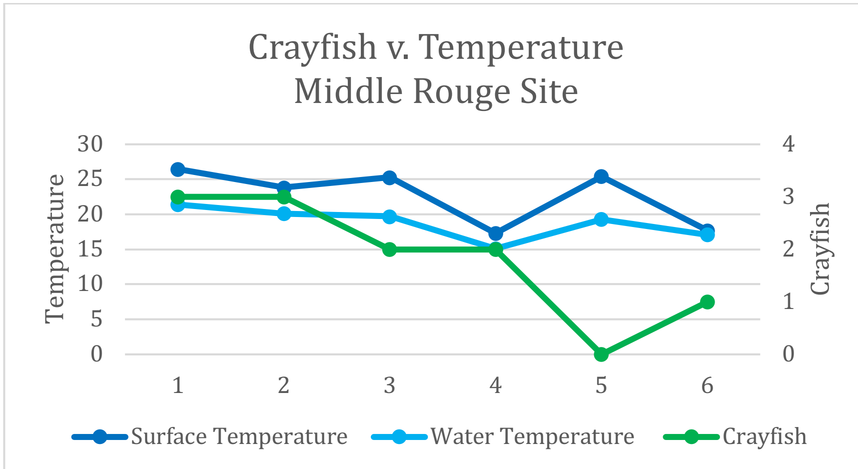

Figure 13 - Crayfish Temperature Results. The graph shows a negative correlation between air temperature (dark blue line) and crayfish populations (green line). There is also a less clear negative correlation between water temperature (light blue line) and crayfish populations (green line). These correlations are most clear in data points 4-6.

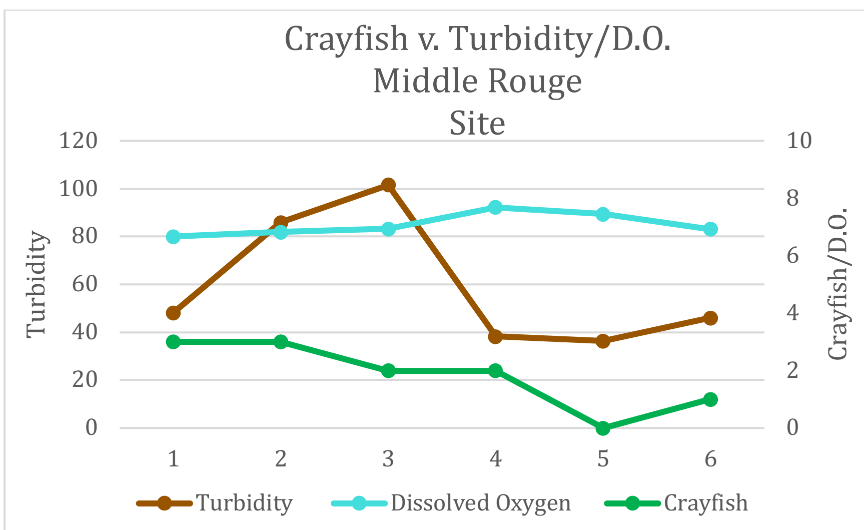

Figure 14 - Water Quality Results. The graph shows little to no correlation between turbidity (brown line) and crayfish populations (green line). The graph also shows little to no correlation between dissolved oxygen (cyan line) and crayfish populations (green line). However, this is inconclusive and more data and research would be needed to determine the correlation.

The trends illustrated in the graphs display that in the Middle Branch of the Rouge during the 7-week testing period:

1. Crayfish numbers were higher when air temperature was lower
2. Crayfish numbers were lower when air temperature was higher.
3. Crayfish numbers had little to no correlation with water temperature.
4. Crayfish numbers had no correlation with turbidity.
5. Crayfish numbers had no correlation with dissolved oxygen.

A total of **11** crayfish were caught at the Middle Rouge capture site during the study period. 7 of the captured crayfish were female while 4 were male. All the crayfish captured have been identified to be Virile Crayfish *(Orconectes virilis)* using the Field Guide to Michigan Crayfish by the Department of Fisheries and Wildlife at Michigan State University. The Virile Crayfish, also known as northern crayfish, are highly adaptable burrower crayfish. This species prefers rocky substrates and is found in small streams, large rivers, inland lakes, and the great lakes within Michigan, according to the Michigan Crayfish Field Guide from the Michigan Department of Nature Resources (DNR). The lengths of the 11 crayfish caught varied from 8.5725-12.7 cm. Let’s see how this site differs from the Lower Rouge.

Results: Lower Rouge Site

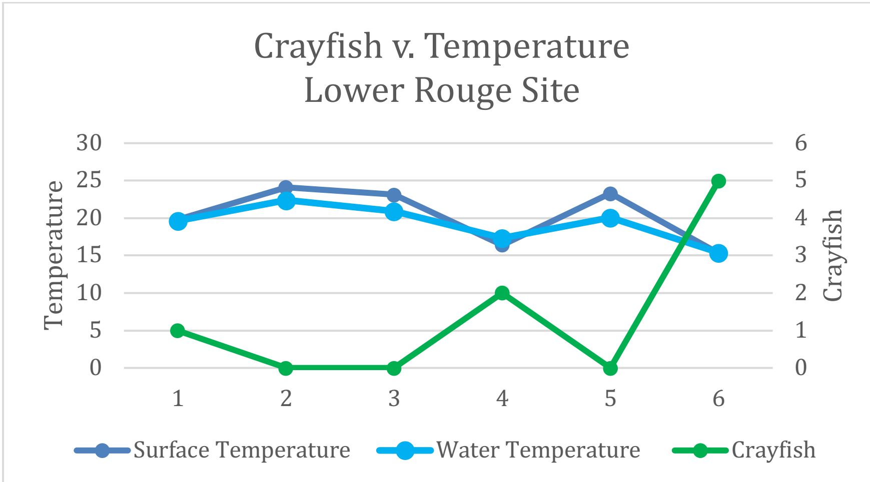

Figure 15 - Temperature Results. The graph shows a strong negative correlation between air temperature (dark blue line) and crayfish populations (green line). The graph shows a strong negative correlation between water temperature (light blue line) and crayfish populations (green line).

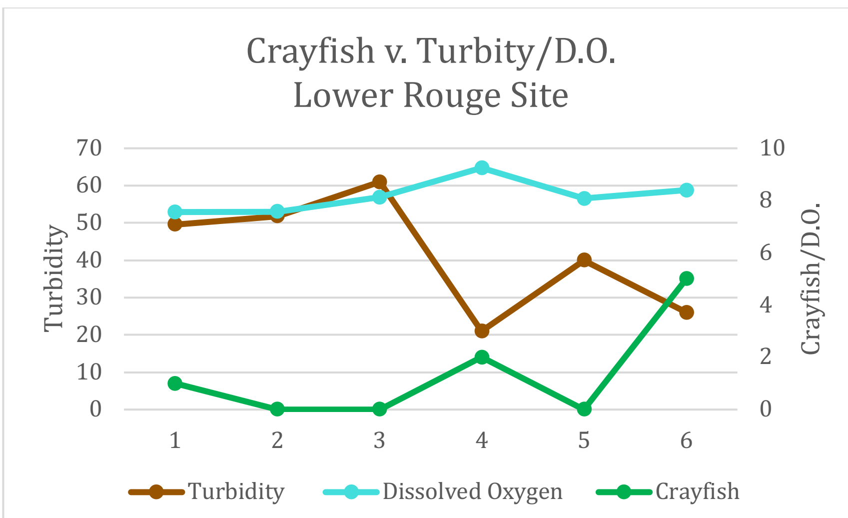

Figure 16 - Water Quality Results. The graph illustrates a slight negative correlation between crayfish populations (green line) and turbidity (brown line). The graph shows a slight positive correlation between crayfish populations (green line) and dissolved oxygen (cyan line).

The trends illustrated in the graphs display that in the Lower Branch of the Rouge River during the seven (7) week study period:

1. Crayfish numbers were higher when surface and water temperatures were lower.
2. Crayfish numbers were lower when air and water temperatures were higher.

3. Crayfish numbers were higher when turbidity was low.
4. Crayfish numbers were lower when turbidity was high.
5. Crayfish numbers were higher when dissolved oxygen was higher.
6. Crayfish numbers were lower when dissolved oxygen was lower.

A total of **8** crayfish were caught in the lower rouge testing site. 5 of the 8 crayfish were female while 3 were male. All of the crayfish captured were identified as Virile crayfish *(Orconectes virilis)*. The lengths of the 8 crayfish caught varied from 6-10 cm.

Figure (17 -19) – Virile Crayfish. One of the crayfish species caught during our research, the Virile Crayfish *(Orconectes virilis)* is shown above. One of the noteworthy features that help identify this species is their large tubercles on their claws as shown in Figure 19 (Right).

Discussion:

As noted in our results, the data varied somewhat at each study site. The Middle Rouge Branch seemed to not correlate with air temperature as closely as the Lower Branch had. The Middle Branch's crayfish population appeared to decrease as fall progressed, rather than correlating to measured air and water temperature. On the other hand, crayfish of the Lower Branch seemed to significantly correlate to changes in air and water temperature. The Middle Branch testing site had less correlation with crayfish numbers, turbidity, and dissolved oxygen as compared with the Lower Rouge testing site. This possibly demonstrates that other factors in the Middle Branch of the Rouge have more of an effect on crayfish populations than turbidity and dissolved oxygen. The Lower Rouge may not have these other factors; therefore, crayfish populations are more dependent on dissolved oxygen, turbidity, air temperature, and water temperature. The next difference was the size of the crayfish caught in the Middle Rouge was much larger than the Lower Branch. This could be due to the smaller crayfish being caught as juveniles since it was during September and October that finding juvenile crayfish would be more common. Also, the Middle Rouge could have factors that would support greater growth rates within crayfish populations. The ecosystem could offer more protection or have more resources available for their growth. The third key difference between the two sites is the number of crayfish caught and the distribution in which they were caught. The Middle Branch site caught 3 more crayfish than the Lower Rouge and the capture rate was distributed much more evenly along the seven-week testing period, where each week saw a capture between 0-3 crayfish. The Lower Rouge, on the other hand, had caught three less crayfish and the capture rate was much more varied. From week 1-6 the site captured only 3 crayfish. In the final week the site caught 5 crayfish. This very random distribution compared to the even distribution of the Middle Branch is both surprising and remarkable in how two sites containing the same species only separated by approximately 4 kilometers would behave so differently. It was also expected during preliminary research that crayfish populations would decrease as air and water temperatures dropped, as crayfish would lower activity and go dormant. However, by examining the results primarily from the Lower Rouge Site, this was not the case. Crayfish numbers and activity actually increased as air and water temperatures decreased. This drop-in activity may still occur as crayfish activity begins to drop at lower temperatures which was not observed during the period of research This may be of interest if research continues for a longer duration and during a different time of the year. Looking back at our Null Hypothesizes we can conclude that the same species was found in both rivers while their number varied therefore, we can accept the first part of this hypothesis and reject the second part. The D.O. and Turbidity correlated with crayfish populations in the Lower Branch meaning we must reject these two-null hypothesis for this site. However, D.O. and turbidity had no correlation to crayfish populations of the Middle Branch meaning we must also accept these two null hypotheses for this site. If further research was conducted, we could definitively accept or reject these two null hypothesizes. Crayfish populations correlated with air and water temperature meaning we can reject our fourth null hypothesis. A final note we would like to make is the role weather patterns had on this research. During the seven-week period our team noticed changes in the river corresponding with rainfall. Water depth, speed, and turbidity all shifted with the rain. River velocity and depth appear to warrant future research.

Conclusion:

As our society continues to develop, citizen scientists need to do our part in monitoring and keeping track of how various parameters affect our local ecosystems. Crayfish are a great indicator species for water quality assessment. This experiment was designed for the purpose of predicting the health of our local Rouge River watershed through the capture and analysis of these keystone species that are present in abundant numbers in our local waterways. Results have found trends that varied from the sites tested in both the Lower and Middle Branches. The aspects that were shared by the two sites was that populations of crayfish increased as air temperature decreased, the two sites contained the same species, the Virile Crayfish *(Orconectes virilis)*, and they both had a majority of females caught. The trend for global temperatures in the world is expected to increase because of the immense amount of greenhouse gasses entering our atmosphere annually. Since our data shows that crayfish populations fair better in cooler temperatures, this climate change trend is not optimal for the stability of many aquatic ecosystems. Crayfish most likely aren't the only species in danger of a growing industrialized society. If crayfish are disturbed by higher temperatures, whole food chains can collapse.

Research Limitations:

Although we stand by the results we obtained in this research, there were several hindrances we ran into that prevented our team from going more in depth. The first limitation was the unfortunate timing of our testing period. We began setting traps in the beginning of September as school began (the most stressful time for students). It was hard to juggle new rigorous courses, fall sports, and multiple clubs along with our project. Perhaps if we planned out the testing period more efficiently, we could have tested for longer and more thoroughly. Another issue with the timing was the fact that typically crayfish tend to thrive and have greater activity during the Summer according to Dr. Nathan Lucas. Meaning if we wanted to have better data and higher captures, it would have been ideal to do research during the summer. Another limitation was the access to only two turbidity tubes. We originally planned on having each student researcher have a testing site, three in total. However, since we only had a full set of equipment for two students, we limited our research to only two sites. It would have been interesting to see the results of a third site, possibly different to the data that we have. Finally, we had intended to approximate the populations of the two sites through the process of capture and recapture. This is where previously caught crayfish would be marked, and this data can be used to estimate a given population. However, we had not recovered any marked crayfish. This could be due to the fact that the crayfish could have molted resulting in any markings being removed. How we baited the crayfish in the traps was another limitation. Since once our canned cat food bait was dropped into the river, much of the bait would dissolve in the water which would decrease the amount of bait over time. As a result, if a better bait was chosen such as solid dog food within a secure container, we could have had higher captures of crayfish. This would have improved the data we obtained.

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Badges:

I Make An Impact: The researchers hope to earn the "I Make An Impact" badge with their investigation into the recent issue of invasive crayfish species within nearby ecosystems. Specifically, during their research, they monitored for the Red Swamp Crayfish (*Procambarus clarkia)* and the Rusty Crayfish (*Orconectes rusticus*). With the use of identification guides provided by the Michigan Department of Natural Resources, they were able to identify species caught within their traps during their research. Thankfully, the researchers had not identified any invasive species and all crayfish identified were native Michigan species within the Rouge River. Investigations such as these by researchers and by ordinary citizens allow a quick response to detected invasive species which gives a chance to stop invasive species from gaining a foothold within an environment preventing these invasive crayfish species competing against native species. By continuing to monitor crayfish species found within the Rouge River, native species can be protected allowing the Rouge to have a stable ecosystem and food web.

I Am A Stem Professional: The researchers hope to earn the "I Am A Stem Professional" badge upon their collaboration with Dr. Nathan Lucas, a Crayfish Specialist Researcher at MSU. Whilst writing their research report, the research team encountered questions regarding implications of their research, which compelled them to email Dr. Nathan Lucas. Via Zoom meeting, the Dr. Nathan Lucas answered the team's questions regarding crayfish as a use of bioindicators, crayfish species prevalence within regions, how exactly does environmental and ecological damage from invasive crayfish species look like, and other water parameters that should be recorded. Overall, the meeting between Dr. Nathan Lucas and the research team enhanced the team's understanding of their research and research paper.

Figure 20- Meeting with Dr. Nathan Lucas. The researchers were able to plan a meeting on a video call on ZOOM. He was able to provide us with his background expertise and research on the invasive crayfish species of Michigan.

I Am An Engineer: The researchers hope to earn the "I Am An Engineer" badge for their own design of crayfish traps. Professional grade crayfish traps were too costly and extreme for the extent of their work. The researchers would research designs that were most efficient for catching river crayfish. After researching designs, two traps, a cylindrical and rectangular designed trap were chosen for testing. The researchers decided to use metal mesh wire to structure the trap designs, hook system for easy access inside, and a rope for the trap to attach to a tree branch. The team would use the malleable wire mesh with metal scissors to create each trap design. During the research teams preliminary testing weeks, these two trap designs would be tested for the most efficiency in capturing crayfish. The researchers would choose the cylindrical design after it was concluded to capture more crayfish and would be used for the main research project.

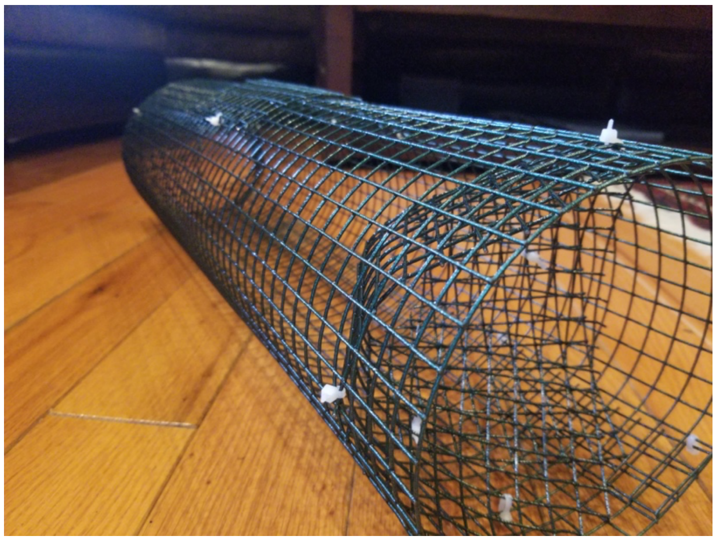

Figure 21 – Trap Building. The cylindrical trap was made using mesh wire and held together using zip ties. The trap had two openings on its sides with a latch on the top to allow one to insert bait within the trap.