Water Quality and the Rusty Crayfish

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Abstract

The Rusty Crayfish (Orconectes rusticus) is an invasive species that is native to Ohio but has spread all over the continental United States. As it has spread, it has outcompeted other species of crayfish and other organisms. This has lead to a decline in the species native to the areas where the Rusty has invaded. Because of the continuous spread of the Rusty, the goal of this study was to study two different bodies of water (that have the Rusty crayfish in them) to see if there was a different in the water parameters. The bodies of water that were studied were Lake Michigan and the Pike River, which is a river that runs through Racine and Kenosha counties in Wisconsin, United States. The goal was to determine which location is closest to the ideal conditions for the Rusty crayfish to reach its realized niche. Knowing which area is better for the Rusty, I thought that it would be helpful to focus on preventing that area from getting more individuals of the Rusty and use that body of water as a place to start preventing the Rusty from spreading to other waterways near it. The data was collected on three different days in three different months. The results showed that the bodies of water were more similar than different. However, with a cautious conclusion, the Pike River had better water quality parameters than Lake Michigan. This study showed that there is more water quality conditions in common with the Pike River and Lake Michigan, than originally thought.

Literary Review

The objective is to determine which body of water will have water quality conditions that are more suitable for the Rusty Crayfish, while acknowledging that the Rusty is in both locations. The goal would be to find out which location is better so that the better one would be studied more and prevention of the individuals in that body of water from affected locations that do not currently have the Rusty Crayfish. The question was, which location will the Rusty Crayfish produce more individuals? Can one of bodies of water be supported statically in having better water quality conditions for the Rusty Crayfish, The hypothesis is The water quality will be different from the Pike River to Lake Michigan and that one location will have water quality parameters that are more similar to the ideal water quality parameters of the Rusty Crayfish.

The project's main focus was to take samples of water and thier water quality parameters. Then the results were compared to the ideal water quality parameters for the Rusty Crayfish to see which body of water was better for the Rusty Crayfish to live in. It is noted that the Rusty is found in both locations but in determining which one is better, there was hope that future projects would focus on preventing the population of Rustys from spreading to other bodies of water that were not invaded by the Rusty Crayfish.

Rusty Crayfish are found in aquatic areas and life in an aquatic system is very different from life on land. On land, the organisms can move around in their environment if they need to get to better living conditions. For example if an organism is too hot, it moves into the shade. If the organism too cold, it can move to an area where there is better shelter. However, organisms in aquatic systems cannot move away from the water when the temperature is too cold or too hot. The organisms can temporarily move to a deeper part or shallower part that is a better temperature but in general, overtime organisms need to have a certain water temperature if they are to survive and fulfill their niches. Water quality is the conditions that the water has. Some conditions of the water include: temperature, dissolved oxygen content, and pH.

Temperature affects the water quality in many ways. First, the temperature needs to be at a certain rate for organisms to be able to live. The temperature that species need to maintain a healthy population varies from species to species. Some organisms are able to regulate their internal body temperatures via adaptations such as flubber or having their body regulate its temperature (warm blooded species)(Source 6) But many fish and other organisms do not have a way to self-regulate. They rely on the temperature of the water to be able to be warm enough for the organism to fill it niche in the ecosystem. Second, the temperature affects the metabolic rate. Metabolic rate is the minimal rate of energy expenditure/unit of the time by warm-blooded animals at rest (Source 6). Organisms need to maintain a healthy metabolic rate so that they do not use more energy than what they are taking in. If they do not maintain that healthy metabolic rate, then they can starve and die. Third, the temperature of the water affects

photosynthesis,(Source 6) and if photosynthesis is not occurring then plants cannot grow. Plants need to grow because they are needed as an energy source and habitat for many species.

Oxygen is a crucial element that is needed for most basic and advanced living things. Without oxygen most species(including humans) would not be alive. In terrestrial environments, organisms obtain oxygen through cell respiration or basically takes in the atom of oxygen. However, organisms that live in aquatic ecosystem cannot take in oxygen from the atmosphere. Instead, they rely on the dissolved oxygen in the water. Oxygen gets dissolved into water by diffusion, aeration, and as the waste product of plants that are performing photosynthesis. The dissolved oxygen levels need to be at a certain percentage for organisms to breathe. The lower the dissolved oxygen content, the harder it is for the individuals to take in oxygen. In extreme cases the lack of sufficient dissolved oxygen results in the death of the individuals.

Figure 1 shows the different oxygen requirements of some species

Specific Conductivity

Specific Conductivity is the "measurement of how the substance can conduct electricity Specific Conductance (SC) is a measure of how well water can conduct an electrical current. Conductivity increases with increasing amount and mobility of ions. These ions, which come from the breakdown of compounds, conduct electricity because they are negatively or positively charged when dissolved in water.(Source 6)". The measurement of specific conductivity is important because the measure is highly dependent on the amount of dissolved solids in the water(Source 7). One of the main solids that affect a water's conductivity is salt. The higher the specific conductivity is the higher the amount of salt that is found in the body of water. Geology of the water and surrounding environment and the soil composition also affect how much conductivity that the water has. The measurements of this parameter can be as low as below one and higher than 100. Conductivity is affected by various elements. Some of the elements are: chloride, sulfur, sodium, calcium, iron, magnesium, sulfate, and phosphate.(Source 7) Pure water is said to have low specific conductivity (around 0-10 s/m) while salt water is said to have a specific conductivity that is very higher (>1000 s/m). High specific conductance indicates high dissolved-solids concentration; dissolved solids can affect the suitability of water for domestic, industrial, and agricultural use.Both bodies of water are freshwater and therefore need to have a lower amount of salt and thus a lower amount of specific conductivity.

pH

pH is the measure of how much hydrogen ions are found in an aqueous solution. The scale is 1 to 12. Acidic is zero to seven and basic is seven to fourteen. The pH of pure water is 7 and pH between 6.5 and 9 is what water pH needs to be for most aquatic organisms to survive. If a pH is too basic then the organisms can be burned and if the pH is too acidic then shells of organisms will be eroded away. This will cause the organism to lose their protection and that makes them more vulnerable to predators. To prevent such situations from occurring, the pH has to be in balance in the water system. "pH affect the solubility and toxicity of chemicals and heavy metals in the water, (Source 6), and then relate it back to organisms' ability to live in water.This shows how important that pH is to water quality.

The Rusty started to move away from their native habitat in Ohio in the 1930s. The Environmental Protection Agency (EPA) states that people are involved in the movement of invasive species (Source 5). It is presumed that fisherman took the Rusty to areas outside of its natural range to use as bait. The Rusty was used in other areas to help fishermen catch large fish. The thought is that some individuals escaped from the fishing line and because they are fast reproducers, they quickly took over the new locations.

The Rusty Crayfish can survive in many ecosystems that vary in temperature, dissolved oxygen content, and other things that relate to water quality. There are ideal conditions that would allow them to fulfil the niche. The Rusty prefers clear and well oxygenated water. The can live in temperatures of 0-39 degrees Celsius but prefer the water temperature to be 20-25 degrees Celsius. The Rusty likes good water quality but it also adds to the bad water quality of places that it lives There are many factors that affect the water quality Source 1).

The ideal location for the Rusty is having the best kind of sediment for the Rusty is where the sediment is cobblestone like. The Rusty can be found in locations with moving water and locations where the water stands still. The Rusty is mostly found in depths less than one meter but can be found in areas as deep as 15 meters. The water quality is best clear because the Rusty uses it eye site to catch prey. Also, the juveniles the depth of the water shallower than the adults do. The Rusty prefers well oxygenated water.

The Rusty does not need to have all of the conditions to be ideal for them to survive. THe Rusty Crayfish is known as a generalist.A generalist is a category used to describe how a species adapts to a new environment (Source 8).The generalists reproduce at a fast rate and have many offspring at a time. The Rusty l 80-575 eggs at one time (Source 1). The eggs hatch a few weeks later and are considered adults after one year. The Rusty will live up to four years in the wild. The shorter lifespan is the reason why the Rustys produce many offspring so quickly. The fact

that the Rusty reaches adulthood relatively quickly and only lives for a couple of years, these are characteristics of a generalist.

In Summary, four types of water parameters were tested to see if the hypothesis was accurate. The hypothesis that was being test was, the water quality is different between both bodies of water and that the difference would show that one body of water has better conditions for the Rusty Crayfish. This hypothesis is thought because the dynamics of a lake (size, current) is different from the dynamics of a river (low depth, narrow area), and because of this difference, there can be different results of the water quality parameters in the bodies of water. The testing was done using a Hydro Lab system, which allows a person to put the sensor in the water and the device automatically shows the water parameters on the monitor. After the data from the device was collected, it was averaged and t-tests were performed to see if there was any water parameters that were different enough to be considered statistically significant.

Methods

The bodies of water were the Pike River and Lake Michigan. It was assumed that the river and lake were to have different water quality conditions. This was because a lake is different from a river by some but not exclusively the following: surface area, depth, length, human use, and energy stored in the water.

One of the sites that water quality will be tested is the Pike River. The Pike River is located throughout Racine and Kenosha Counties in Wisconsin. The river is about sixteen miles. The temperature of the river can vary greatly. In the summer months the river can be as warm as 80 degrees Fahrenheit, while as cold as zero degrees fahrenheit. The river can freeze over in the winter. The Pike runs through many parts of Wisconsin. The Pike can be as shallow as one foot during times of little precipitation. When the river is flooded, the depth can be more than six feet. Because the Pike is long, one site was picked to be studied over many months. The location on the Pike is in a park called Petrifying Springs. This park is located in Kenosha, WI and is in an area where reaching the river is easy to do. There are spots where the land is not steep so a

person can have access without being in a dangerous situation. In the park, the location selected runs parallel to a large dog park. There is a trail that goes near the river and a specific spot where accessing the water is easy. This particular location was selected because of the ease of accessibility.

The habitat that surrounds the Pike River is a wetland.This wetland creates the river flood during the spring. The overflowing and receding of the waters along the banks bring many nutrients and sediments into the river. There is knowledge of the Rusty being in the Pike. The sizes of them were on the smaller end (about 7,5cm). The individuals were caught during time that I was sampling other parts of the river for other classes. The crayfish were seen and caught mainly because they were easy to catch in those areas. Rusty have been found in the pike for a long time. Over this time, the river has had periods of abundant precipitation and times where at some locations, the water depth was a foot or less. The Rustys have been able to survive these times. This has to do with the fact that they are able to move within the waterways to areas where more water was present.

The other location that was tested was on the shores of Lake Michigan, specifically the shore in Kenosha, Wisconsin. Lake Michigan is the second largest great lake. It is approximately 118 miles wide and 307 miles long. The lake has 44,600 miles of a drainage basin (Source 14). A drainage basin is an area where all the precipitation in the basin drains into a larger body of water, in this case, Lake Michigan.The lake has over 1,100 cubic miles of water(Source 14). The lake often freezes in the these species. Many invasive species have overtaken the lakes. Some examples of invasive species are zebra mussels, reticulated pythons, goldenrod, and termites.There are some species that were purposely introduced such as the salmon. The salmon are sport fish that many people enjoy with other species such as the Asian carp are not enjoyed (the asian carp outcompetes other fish, affecting the populations of other species, including Rustys).

The specific area that was chosen to be studied along Lake Michigan is a sandy beach on a shoreline. The shore along a sandy beach was chosen because of its ease of accessibility. A person can go directly into the water and not have to worry about tripping over large rocks (on a lot of the shoreline in Kenosha, there are a lot of big rocks placed to prevent erosion of the land).

The testing was done in the fall of 2014 (October), in the winter of 2015 (January), and in early spring (April). The testing was done in these particular times of year because of the restraints of time. In the article "Lakes Alive", the effect of the winter (mainly low temperatures) is discussed. The article spoke about where the temperatures of the water were different. It was found that the warm water was not at the surface but rather at the bottom of the water ecosystem. This is an important find because it explains how species like the Rusty crayfish can survive the winter. The Rusty is known to live three to four years and that means that it has to survive the winter. However, the Oxygen content in the water is highest near the surface so any species needs to be able to adapt to either colder water or lowered oxygen content.

The Hydro Lab is a testing device that is able to take accurate and fast water perimeters.. It is a water tester that is made by the Hach company. This device was made in February 2006 and is edition three. It is a water tester that is made by the Hach company. This device was made in February 2006 and is edition three (Source 9).The Hydro is fairly easy to use and it was available for use in the project at a low cost. The device has a variety of testing parts that can be added and this makes the Hydro lab versatile and lets a person gather many times (types?) of measurements.The thermometer has the range of temperatures that it can measure is: -5 to 50 C. The accuracy of the device is +-.10 C and the resolution is .001C. The Specific Conductance Sensor measures the conductance of a water sample and it has a range that it can measure from 0-100mS/cm. The accuracy is about +- 1% of reading and .001mS/cm. Specific conductivity is measured by how well the water can resist passing electricity through it (Source 6). The resolution is .001 units. The pH sensor can measure the entire scale of acid and base numbers. The sensor is as accurate as +-.2 units and the resolution is .01 units.

To collect the data,one person entered the water, another person stayed on land. The person on land held the data collecting device and turned the device on. The device automatically gave water quality measurements without the need for the person holding the device to touch any buttons.Then, the person in the water placed the sensor at the desired depth.Once placed at the desired depth, the person in the water told the person on land. Then the person on land recorded the water quality measurements that were displayed on the device. The the person in the water removed the sensor from the water for a minute. Then the sensor was placed back at the same depth and the person on land recorded the water quality measurements. This step was done so that there were three replicates at each depth. After three replicates were done at the first depth (.04m), the steps were repeated with the depth being at .17 meters and .25 meters. Once all the data was collected in the field, it was brought back to the lab to analyze. The data analyzed water parameters of) water temperature, pH, dissolved oxygen, and specific conductivity. The data was first analyzed to find the average numbers at each location. Then all the averages were put into graphs to compare what the results mean. Many graphs were made in order to show all the variables and how they compare to each other.

Results

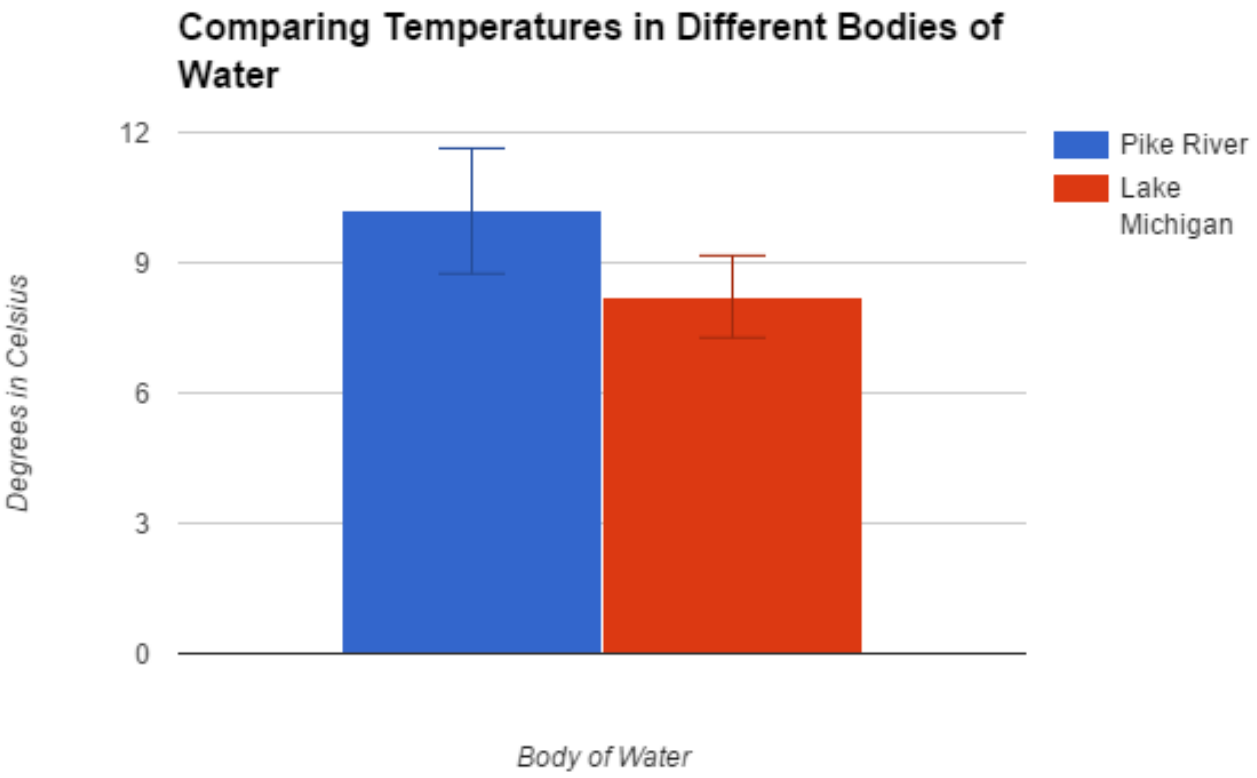

Figure 2 shows the comparison of water temperature in the Pike River and Lake Michigan. This figure shows that there is a different in the temperatures and the p-value for the temperatures is about .06, which means that the there is 94% confidence that the temperatures are statistically different.

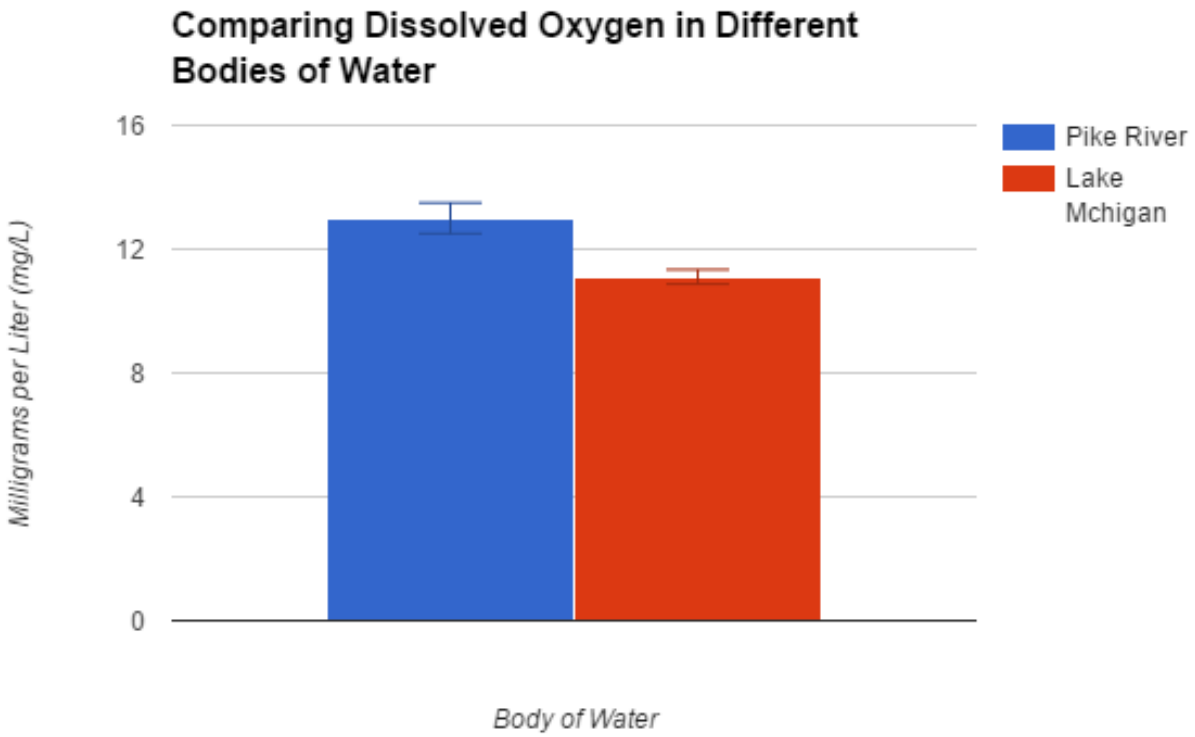

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Figure 3 shows the comparison of dissolved oxygen in the Pike River and Lake Michigan. This figure shows that the amounts of dissolved oxygen in both bodies of water are similar enough to state that there is not enough evidence that there is a statistically different from one body of water to another.

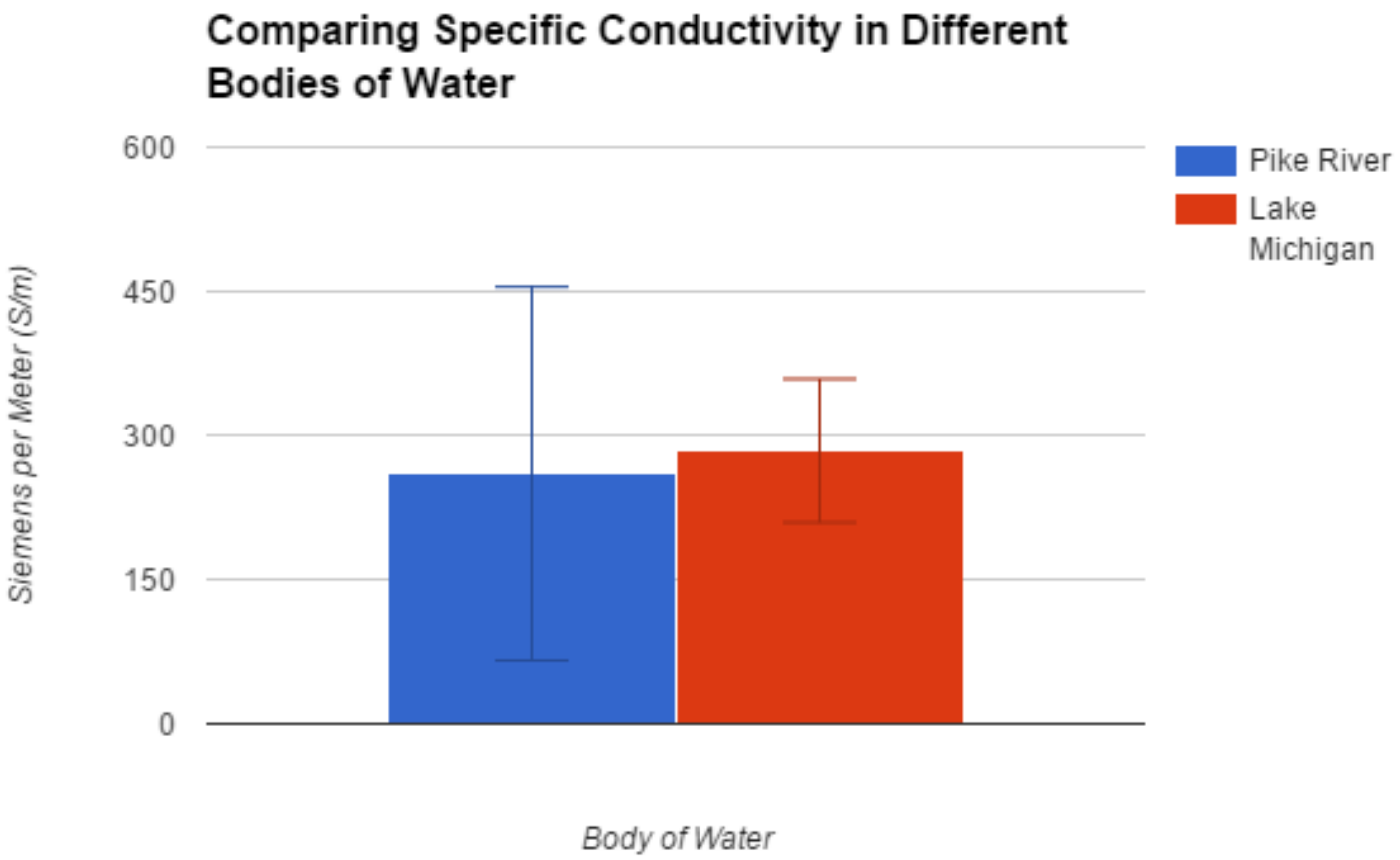

Figure 4 shows the comparison of the amount of specific conductivity that each body of water has. The amount of electricity that each body of water can conduct is similar in both bodies of waters and the measurements are not too high but not too low. This means that the water has some amount of salt and other minerals dissolved in it but not a lot compared to other bodies of water that can have amounts over 1.000s/,.Statistically speaking, there is not a lot of different in specific conductivity in the bodies of water.

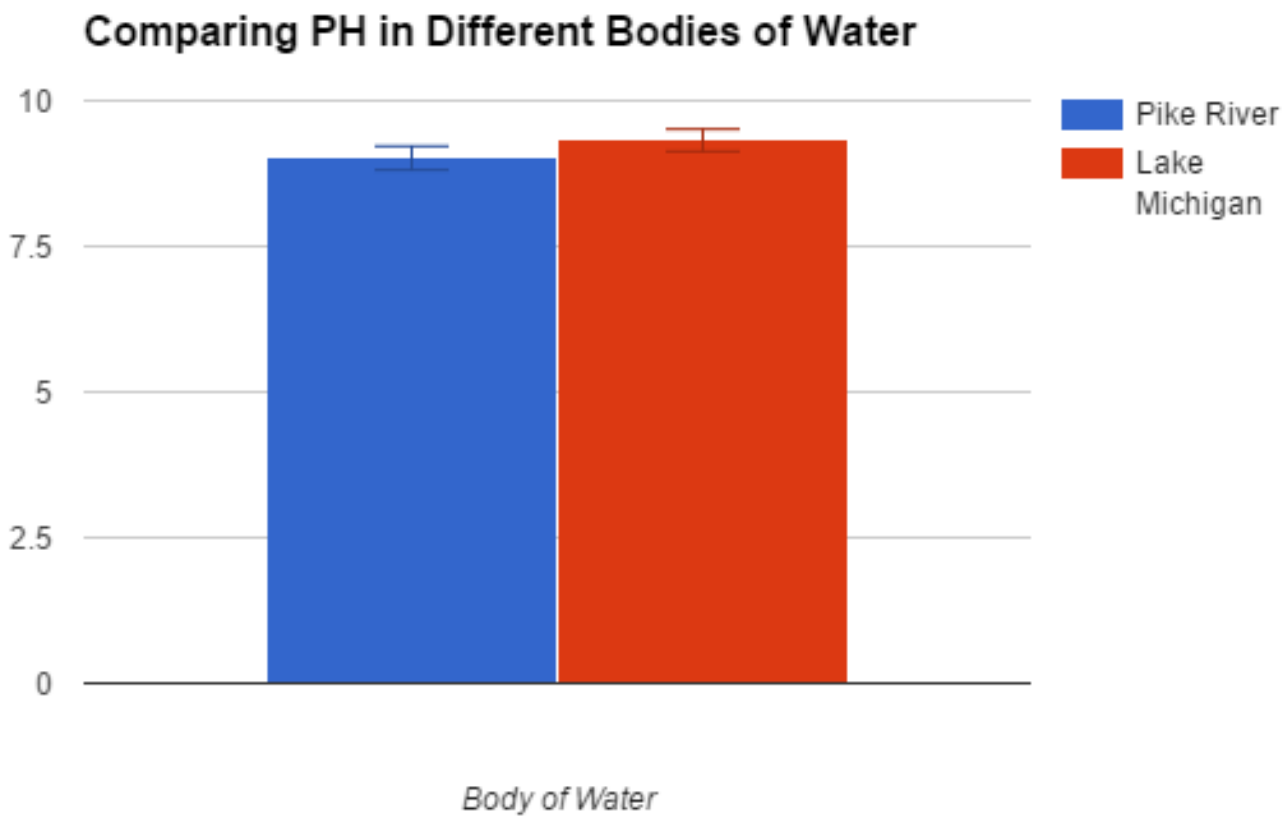

Figure 5 shows the comparison of the pH in the Pike River and Lake Michigan. At first glance, the pH of each body of water looks similar but the pHs are slightly statistically different. The p-value for the pH values was .1137 which means that there is an 89% chance that the pHs are the same but chance is too low to be considered significant, so the pH are considered similar.

Water Parameters	**Ideal Water Conditions for Rusty Crayfish**	**Pike River Water Conditions and Standard Deviation**	**Lake Michigan Conditions and Standard Deviation**	**T-tests and P values**	**Location that is Near the Ideal Water Conditions**
Temperature	20-25C 0-39 extreme	10.191 (SD 1.443)	8.2185 (SD .945)	T=2.1141 P=.0606	Pike River
Dissolved Oxygen	High	13.001 (SD .496)	11.1045 (SD .234)	T=9.799 P=.3528	Pike River
Specific Conductivity	unknown	260.319 (SD 194.498)	284.179 (SD 75.065)	T=.2277 P=.825	Lake Michigan had a higher amount
pH	7	9.015 (SD .205)	9.3205 (SD .1902)	T=1.7519 P=.1137	Both

This table shows how the water parameters of the two bodies of water compare to the ideal water parameters for the Rusty Crayfish. After a glance at this graph it seems that the Pike River has the better water conditions for the Rusty Crayfish but this observation will be discussed more in the conclusion section.

The water parameters were compared by averaging a particular water parameter using the averages that were found at each location in the body of water and in the same location over a period of time . This means that the averages of each body of water were calculated separately and then compared to each other.Then, the averages at one location along each body of water were analyzed. The average water parameter result from each day of the testing (each day in the months that were studied) were averaged to find the average water parameters of that body of water over a period of time.Lastly, all the averages were put into graphs and a table and were analyzed to find which body of water had the best water parameters of the ideal parameters for the Rusty Crayfish.

A t-test was performed in order to get a p-value. The p value showed how similar that the averages from each water parameter was to the other body of water. The temperature's p value 2 was .0606. This means that there is about a 94% chance that the temperatures were not the same. The usual cut off for examining what is considered a high probability of the numbers not to be the same is 95% but because the temperature p-value is so close to the 95% cut off, it is considered as representing data that is most likely not the same.The p-value for pH is .1137 and this meant that there is about 89% chance that the pH is not the same is both locations.The p-value for dissolved oxygen is .3528 and this meant that there is about 65% chance that the dissolved oxygen contents in both bodies of water were the same. The p-value for specific conductivity was .825 and this meant that there is only a 17.5% chance of the specific conductivity not being the same.

Because the p-values were low for both the water temperature and the pH, a cautious conclusion that there was a big enough difference to each location, these are the water parameters that were analyzed in determining which location might be a better place for the Rusty. The temperature and pH of the Pike River were closer to the ideal water parameters for the Rusty Crayfish. It is important to note that the variation is not by enough to be considered statistically significant but the difference was enough to use to predict which location that the Rusty will reach its full

potential(meaning that there should be more Rusty in the Pike because they are able to be more productive because of the better water parameters).

Because the p-values for specific conductivity and dissolved oxygen were found to be high(meaning the two different values are very similar), it was decided that these parameters would not be involved in concluding which body of water has the better water parameters for the Rusty Crayfish. The quantitative measurements did show that both locations had similar amounts of dissolved oxygen in them and a fairly low amount of dissolved particles in them This means that both the measurements show that they have reasonable amounts of each water parameter and therefore are good water parameters that can sustain species including the Rusty Crayfish.

Discussion

The data from the water parameters that were collected did not support the thesis statement. Both bodies of water were found to be more similar than different. The thesis statement suggested that the bodies of water were different. It was thought that way because the Pike River is narrower, smaller, generally shallower, subjected to seasonal flooding, easier affected by human activities (fishing, dumping of waste products) than the Lake. The Lake is larger, has more surface area, and the it has more human activity (but that activity is in general doesn't affect the Lake because of the Lake's size).

Even though it was thought that the water parameters would be different in both locations, there are many reasons why the water parameters showed to be similar in both locations. First, both bodies of water are located near each other and the river even flows in the Lake. The closeness to each other means that the bodies of water are receiving about the same weather, and weather is known to affect many water parameters including dissolved oxygen content and specific conductivity of the water. Second, the amounts of waste and runoff water that go into the Pike

will most likely flow downstream into the Lake. The locations that were tested were near where the Pike flows into the Lake and that means that the water is similar in the both bodies of water.

The location that has the water parameters that are closer to the ideal ones that the Rusty Crayfish has is the Pike River. Two of the water parameters were found to be not statistically different, and therefore unable to be used in the comparison of which location was better for the Rusty Crayfish, were dissolved oxygen and specific conductivity. Two of the water parameters that were statistically significant but noted that they were only somewhat different, where the temperature and pH. The average temperature. The ideal water temperature for the Rusty Crayfish is between 20-25 degrees Celsius but the extreme (meaning that they can survive but not the best for the Rusty fulfilling their niche) is between 0 and 39 degrees Celsius. The Pike River's average temperature was found to be 10.191 degrees Celsius with a standard deviations of 1.443. This means that the Pike River's temperature is in the extreme temperature range but the Rusty can still survive at that temperature. The other water parameter that was found to be statistically significant, was the pH. The pH was lower in the Pike River than Lake Michigan. THe pH for the Pike was 9.015 with a standard deviation of .205. This is close to the suggested pH for bodies of water which is between 7 and 9. Because of the data showing that the water parameters that were found to be statistically different were both water parameters for the Rusty Crayfish, the Pike River is said to be the better location for the Rusty to fulfill its niche. However, Lake Michigan has good enough water parameters for the Rusty as well.

The data may have shown that the Pike River is a slightly better location but the Rusty is found in Lake Michigan as well. Because of this both locations need to be studied more in order to gain a better picture on where the Rusty will mostly emigrate from these bodies of water into areas that they do not currently exist.

The temperature was one parameter that was shown to be statistically significant and there are a couple reasons that temperature of the water varied. The variation can be some of many things. Depth is a big factor in temperature in water. The sun heats the water at the surface first, and

then the heat is dispersed farther and farther from the surface. In general, the deep a person goes in a body of water, the colder it gets. The sun's rays cannot reach the bottom of waterways that are very deep. Also, the time of year that the water was tested affected the results. The testing occurred in late fall, winter, and early spring. In general, the temperatures in these seasons are lower than the temperatures in the summer. In the summer, there is more sunlight and the energy of the sunlight warms the water better because there is more energy to do so. This is important to note because the Rusty does not hibernate or go into torpor in the colder months, so the water temperature has to be at a certain level for the individuals to survive winter and reproduce in the spring.

The goal of the data was to try and show that the Pike River and Lake Michigan are different and therefore, the Rusty crayfish thrives in one better than the other. Also, it was hoped that the identification of the better area that the Rusty will grow the fastest could be used to study and try and protect other bodies of water that did not have the Rusty crayfish. However, the data did not show that all the water parameters are different so that an identification of a better area could be made but the data failed to show this.

This project was not perfect and is in need of improvements if it is to be recreated at a later date.The data collection method was not done in an ideal fashion. First, the length between different collections was not calculated but instead, out of convenience. If the lengths were made more consistent, then there would have been stronger data to support or oppose the hypothesis. Also, there would have been clearer conclusions. Second, the sampling was done in a manner that did not show repetitions but instead showed how accurate the machine used for the testing was. Third, the actual collection of individual Rusty Crayfish could have helped strengthen the argument on what location that the Rusty is thriving more in. Lastly, the data was averaged and the averaging does not show the exact measurements so some of the data had different measurements than the actual average. I believe that because there was so much of the data averaged to find the averages that were used to make conclusions, that some of the data may have shown the individual measurements were lost.

In the future, studying the water quality in locations where invasive species live will be important. Knowing which places that the invasive species is already thriving in will help environmentalists protect bodies of water that currently do not have the specific invasive species (in this case, the Rusty Crayfish). If one location is found to have water conditions that the Rusty would not thrive in or be able to live in long term, then environmentalists will be able to save time and spend that time protecting areas where the water conditions are suitable for the Rusty Crayfish to live.

Some of the water quality parameters that were studied had results that were not close to one another. The specific conductivity in some locations was less than one, while in other locations, in the hundreds. If there was more time, there could have been a larger focus on why there is so much variation in that parameter.

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