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Millrace Project: A study of the physical habitat and the suitability of the water chemistry to sustain aquatic communities

Abstract:

The Eugene Millrace was construction was completed in 1851 as a part of Hilyard Shaw's industrial vision of Eugene. Over the next several decades the Millrace was at the heart of Eugene's growing agriculture industry. Hydropower generated from the Millrace supported flourmills and grain houses. During the late 19th century the Eugene Millrace was economically vital to Eugene, however it was also very fashionable. During the early 20th century, however, the Millrace began a significant transformation as the hydropower generated from its waterwheels became evermore obsolete in the presence electricity and other technological innovations. At this time the Millrace became a tremendous recreational draw. The Millrace was the place to be. Today, the Millrace is thought of as merely a run-down and polluted waterway. But is it really polluted? To take a closer look, I have measured and analyzed characterized aspects of the physical habitat and water chemistry in order to truly understand the capacity of the ecosystem to support nonhuman life.

Introduction

The correspondence in distribution of Pacific salmon, steelhead and aquatic macroinvertebrates is not without coincidence. Their distributions are indicative of particular characteristics that allow species to grow, reproduce, and otherwise sustain their populations. Each species possesses distinct preferences and evolutions that organize their prevalence and distribution. For example, the distribution of Pacific salmon is inevitably impacted by the biological availability and chemical solubility in a given stream, but their distribution is also correlated to streams with a large wood volume, riparian slope, water depth, and temperature. While the biological availability and chemical solubility could eliminate a species outright, so too, could unmatched habitat preferences.

Pacific salmon have garnered much attention as their populations have spiraled at the grips of overfishing and large-scale damming across their western breeding grounds. Salmon offer irreplaceable benefits to humans, nonhumans and entire watersheds. Their presence is a sign of incredible strength and endurance. However, as their future is as unforeseeable as ever, the time is now or never to make a difference. After all is said and done, a healthy habitat for a salmon is a healthy habitat for everything.

Unhealthy salmon habitats cause avoidance, heighten disease, and mortality. Pacific salmon demand dissolved oxygen levels greater than 8 for healthy development, a pH between 6.5 and 8.5 and water temperature between 4.5 and 19 degrees Celsius. However, extremes on either end of the scale are detrimental to fish growth and development and survival and have been shown to completely eliminate the distribution of salmonids in a given location. It has been shown that juvenile salmon exposed to low dissolved oxygen levels suffer from “oxygen distress,” which among other things, can lead to avoidance, decreased fitness, stunted development, and starvation. In addition, water temperature affects adult and juvenile salmon. Optimal growth of juveniles occurs between 10-15 degrees Celsius. Temperatures exceeding 20 degrees Celsius induce thermal stress which halts migration, causes avoidance and elevates the risk of disease.

Research question: Aside from food availability, do aspects of physical habitat and water chemistry such as temperature and pH contribute to suitable habitat for Pacific salmon and sensitive macroinvertebrates in the Eugene Millrace?

Methods

To analyze the suitability of habitat along the Eugene Millrace I measured water temperature, pH, dissolved oxygen, and photosynthetically active radiation (PAR) across ten sampling sites. Seven sampling sites were located between the Mill Pond and the Riverfront Research Park and the other three sampling locations were along the Willamette River. Originally there were just two sampling sites on the Willamette River; however, due to dramatic changes in the river level, a tenth sampling was added along the River in order to satisfy a measurement of rapidly flowing water. Furthermore, the seven sites along the Millrace were chosen at random in order to create a mix of site characteristics. For example, site 6 and 7 were particularly shady whereas sites 3 and 5 were notably more exposed. Sampling was conducted twice before the pump began to run, and five times (three times in the afternoon and twice in the morning) after the pump was activated.

PAR

A PAR sensor was utilized to measure and record the density and distribution of canopy cover by measuring the Photosynthetically Active Radiation. More specifically the PAR sensor measures the amount of light available for photosynthesis, which on the light spectrum, falls between the wavelengths of 400-700 nanometers. PAR units are quantified by the Photosynthetic Photon Flux Density (PPFD), which is recorded as micromoles per square meter per second. Essentially, PPFD quantifies the amount of available light that falls on a particularly spot of the Earth's surface at any given second. PPFD varies tremendously diurnally and seasonally due to, but not limited to, plant phenology, cloud cover, latitude, and the position of the sun overhead.

Temperature

Other simple, but important measurements were recorded using a temperature probe. Temperature probing conducted routinely at depths between 10-15 centimeters.

Dissolved Oxygen

Perhaps the most important measurement, dissolved oxygen, was measured and recorded using a dissolved oxygen probe. Again, like temperature, dissolved oxygen was measured at depths between 10-15 centimeters at the edge of the water body. Dissolved oxygen is a measurement of the molecules of oxygen that are actually dissolved in the water body. Dissolved oxygen enters the water body mainly through diffusion between the atmosphere and the waters surface, aeration as water flows over rocks and debris, and photosynthesis of aquatic plants. Dissolved oxygen fluctuates dramatically diurnally and seasonally. Typically, dissolved oxygen levels are lowest at dawn because, as plants photosynthesize in the presence of sunlight throughout the day the amount of dissolved oxygen increases to a daily peak mid afternoon, then after the sun has gone down plants continue to respire causing dissolved oxygen levels to decrease. Among other things fertilizers, decomposing waste, and algae blooms have the potential to reduce dissolved oxygen levels to the point where aquatic life cannot be sustained.

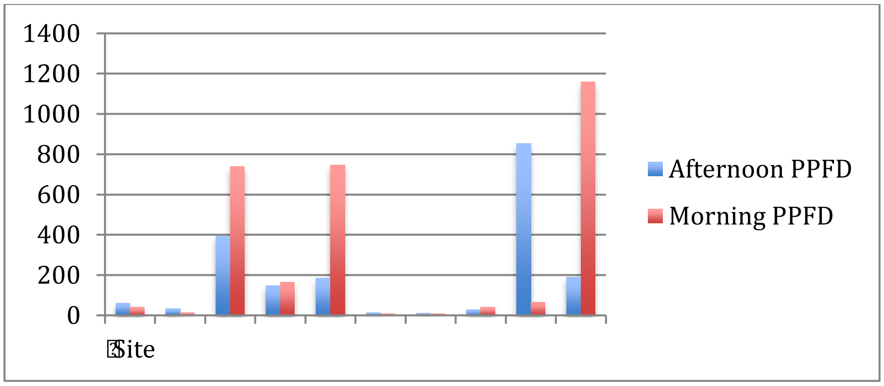
pH

Last but not least, pH was measured and recorded using a pH probe. The pH of water is an indicator of the biological availability and solubility of the chemical constituents including nutrients (such as phosphorous, nitrogen and carbon) and heavy metals (lead, and copper). It is an important measurement because pH can identify a chemically changing water body, potentially indicating the influx of pollutants and contaminants that might affect the life in the water. The pH units range from 0-14 with 7 being considered neutral. Units below 7 are considered acidic while units above 7 are deemed basic, or alkaline. Moreover, pH is measured on a logarithmic scale, where 6 is ten times more acidic than 7.

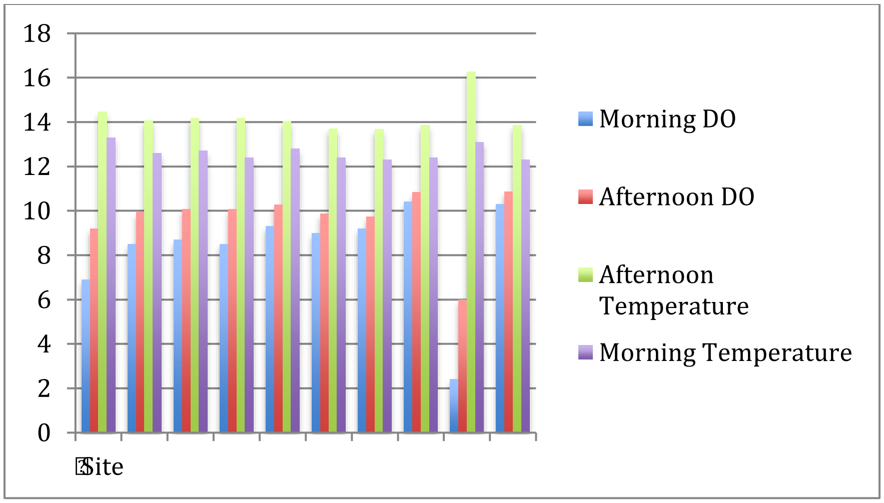
Results

I have found that, in many regards, the Eugene Millrace is capable of harboring and supporting sensitive species of Pacific salmon, steelhead, and aquatic macroinvertebrates including mayflies, stoneflies and caddisflies based on the average pH, temperature, and dissolved oxygen levels.

As expected, data analysis revealed significant variability in the PAR measurements. However an important trend, which I expected to emerge, did not. As the project proceeded, I anticipated average PPFD measurements would decrease as plant phenology transformed from late winter to spring deciduous trees, shrubs, and herbivorous plants leafed out. However, the change in PPFD at sites 3, 4, and 9 revealed just the opposite, PPFD actually increased throughout the testing period. This is likely because, measurements of PPFD are oriented to represent a particular second in time, thus the PPFD measurements, on their own, did not provide any obvious indices.



Through the data collection it was demonstrated that average temperature decreased after the activation of the pump. Pre pump activation measurements averaged 15.5 to 17.0 degrees Celsius. Whereas post pump activation measurements averaged between 13.6 and 14.6 degrees Celsius. The decrease in average temperature may be attributed to daily or seasonal variability. However, due to the consistency of lower temperatures post pump activation it is more likely that the decreased temperature was produced by an increased flow, in addition to the leaf-out of deciduous trees, shrubs and other streamside vegetation. Acting alongside one another the pump cooled the water by replacing the stagnant water with an increased the rate of flow and greater water depth, while leafed-out streamside vegetation obstructed direct shortwave radiation from the sun.



Little effect was illustrated on the dissolved oxygen content pre and post pump activation. The dissolved oxygen levels along the Millrace were consistently between 9.2 and 10.2 mg/l in the afternoon and between 7 and 9 mg/l in the morning. It was illustrated that diurnal fluctuations were significant as a result of photosynthesis. Due to the low velocity of the Millrace, much of the dissolved oxygen is produced by the photosynthesis of streamside vegetation rather than the aeration of water. Sampling conducted on the Willamette River, for example, show less variability in the diurnal levels of dissolved oxygen because of the dissolved oxygen is largely derived from aeration of fast moving water over rocks and debris rather than photosynthesis along the banks.

Analyses of the pH measurements uncovered an average pH in the Millrace between 6.2 and 6.5 after the mill pump was activated. Prior to the Millrace pumps activation average pH was recorded between 5.9 and 6.2. The correlation of the pumps activation and the pH is non-inconsequential. The activation of the pump increased the discharge in the Millrace prompting a relatively significant increase in water depth (on the order of several inches) and an increase in directional flow. Albeit seemingly insignificant, the pump altered the Millrace from stagnant to moving water, which had a measurable effect on the chemical composition of the water.

Limitations

Further data collection and analysis is necessary to determine and develop a long term, annual conditions report. In no way, do I feel like the data collected is comprehensive. I believe more testing, at different times of day, and during different times of the year are required to understand the true habitat. Due to the fact, for example, the data collection phase coincided with numerous cool, cloudy days—impacting PAR, temperature, and dissolved oxygen measurements—and the most leaf-out, and flowering of streamside vegetation which may have biased the dissolved oxygen levels. I do believe my data is representative of conditions between early spring and late spring of the year 2017, however, how the water body will react to the onset of summer, or fall (when the pump is turned off) is left undiscovered. Although, I expect the Millrace would be dealt significantly higher water temperatures (a product of increased and more direct solar radiation) and decreased dissolved oxygen loads (due to decreased photosynthetic activity due and deteriorating algae blooms).

But also I believe there were many limitations to this research that came about because of my own limited experience. This project demanded me to build new skills and this created issues throughout the process. In many cases the learning curve was abrupt. For example, you should not attempt to record pH and dissolved oxygen simultaneously. Although intuitive now, to the inexperienced and somewhat inattentive beginner, it will be hugely disappointing when the realization is made that pH measurements have been compromised. In other cases, where technology is enabling, it is also inhibiting. Data transfers are anything but intuitive and also have the potential to compromise data. It is important to keep a paper trail.

Conclusion

My research has found that the Eugene Millrace has the potential to provide useful and significant habitat for Pacific salmon (should the connection to the Willamette River be reconceived) and sensitive aquatic macroinvertebrates. From a physical habitat and water chemistry perspective my research sheds a positive light on the Millrace. To the extent that my sampling is relevant, the Millrace should not be so easily considered polluted. However, the Millrace demands long term analysis to fully grasp its seasonality. The Millrace has tremendous potential as an intriguing hybrid landscape. However, the disconnection and discontinuity with the Willamette River inhibits the distribution of sensitive native fishes and macroinvertebrates. Which, in turn, favors non-native species and pollutant tolerant species that adapted to slow moving warm-water.