Fish Abundance and Diversity with varying Coarse Woody Habitat and Time of Day

BIOS 35502: Practicum in Environmental Field Biology

Cassidy T. Hayes

Mentor: Jacob Ziegler

Abstract

Human development along lakes that reduces coarse woody habitat (CWH), limits the ability of fish to hide from predation and find food. The effects of removing CWH in lakes on fish populations have been well documented but little is known about how variation in CWH effects prey fish in undisturbed ecosystems and how this might change at different times of the day. In this study, I consider fish abundance and diversity in various amounts of CWH in two lakes, Bay and Crampton, in the Upper Pennisula of Michigan. Results showed no relationship between the density of CWH and the abundance or species diversity of fish caught in both lakes. There was also no relationship between the time of day and abundance but there was a relationship between the species diversity and time of day for both lakes. The time of day that fish were sampled had a significant influence on the species caught per hour, with more species were caught during the day than nighttime for both lakes. Collecting the fish with minnow traps which could have limited the catch rate and the sufficient amount of CWH in all sites may have influenced our results.

Introduction

Coarse Woody Habitat (CWH) – dead tree fall – is greatly reduced in lakes with human development and may represent a critical variable determining fish distribution and diversity in lake ecosystems (Everett and Ruiz 1993, Christensen et al. 1996, Francis and Schindler 2006). Food availability and safety from predators are two factors that may determine fish distribution and diversity (Lewin et al. 2004). The removal of CWH in lakes effects the refugia and resource availability for prey fish in which there was a significant decrease in fish distribution with increased lakeshore development (Scheuerell and Schindler 2004). Adult largemouth bass in CWH rich basins have smaller home range sizes and are less selective predators (Ahrenstorff 2009). Wagner investigated the selection of habitat by muskellunge juveniles in varying CWH complexities in a lake. Despite results displaying no increase in abundance of juveniles with increasing CWH complexity, selection of CWH was not random. Different complexities of the habitat types were decisive in predicting the occurence of young fish in the littoral zone of Lake

Muggelsee (Wagner 2015). This could be due to that CWH provides resources for macroinvertebrates that prey fish feed on.

The time of day is another factor that effects the preference for a habitat of prey fish in a lakes due to diel vertical migration (DVM) (Busch et. al 2012). The regular DVM of zooplankton involves some zooplankton that stay in deep dark water layers during the daytime, ascending at dusk and staying in higher water levels during the night then returning to deeper layers at dawn which might affect the distribution of prey (Busch et al. 2012). Large, grazing cladocera coexist with fish depending on the provision of daytime refuge of the claudocera and grazing was greatest in the open water at night (Timms et. al 1984).

While studies have considered CWH density and fish abundance in lakes that have been developed by people, little is known on how varying CWH and time of day effects prey fish abundance and diversity in undisturbed ecosystems. In this experiment, we will study if variation in density of CWH affects juveniles and YOY fish abundance. In this study, we will examine if variation in the density of CWH predicts fish diversity and abundance. For my hypotheses, I predict that the abundance of prey fish will increase as the density in CWH increases because the high density provides more protection from predators in an undisturbed ecosystem. The abundance will also increase during the daytime than nighttime because predators cannot see during the night which allows the prey fish to search for food in open water. The species diversity will increase as the density in CWH increases because the high density would have a higher preference among a wider range prey fish species.

Methods

Lake Selection

I sampled fish from 2 lakes: Bay and Crampton, which are known to have a wide range of coarse woody habitat (CWH) and fish abundance (Christensen et al. 1996). Using Google Earth, each lake was divided into four quadrants based on the ordinal directions (North, East, South, and West) and one site (50m of shoreline) was randomly chosen in each quadrant. One additional site was added in each lake to the quadrants that were closest to the lake's boat landing for a total of six sites per lake.

Creating transects for each site

For each site, stakes were placed every 10 meters running parallel to shore with a string stretched between them, marking the transect. All stakes were placed where the water had a depth of 0.5 meter. Pieces of wood that are at least 5cm in diameter, 150cm in length and crossed the transect line were tallied to determine the CHW density in each transect.

Fish Surveys

At each transect for each lake, we estimated the prey fish abundance and diversity using the standard technique of minnow trapping (MacRae at el. 2006). A minnow trap was placed in the center of each transect for a total of 30 traps per lake. This provides us a sufficient amount of data for each site and lake without time constraints. My daytime (AM) traps were set during the morning at approximately 9:00AM then checked during the afternoon at approximately 5:00PM and collected during the following morning at 9:00AM. This allowed us to examine both abundance and diversity of prey fish with varying CWH densities and at two different periods of the day.

Statistical Analysis

The dependent variables will be the fish abundance measured in catch per unit effort (CPUE) and fish diversity measured as species caught per hour. The independent variables will be the sampling period and density of CWH. We related the total CPUE of prey fish in each lake to CWH within and among sites using ordinary least square regression and we compared the total CPUE of prey fish to sampling period (i.e. AM = 9:00AM to 5:00PM, PM = 5:00PM to 9:00AM) using a Kruskal-Wallis Rank Sum Test. We transformed the total CPUE data using a log transformation to meet the assumption of normally distributed errors for all ordinary least squares regression analyses.

Results

There was no effect of CWH on the total CPUE of fish for Bay lake (F-statistic = 0.56, DF = 58, p-value: 0.46) and for Crampton lake (F-statistic = 0.63, DF = 58, p-value: 0.43). There was also no effect of CWH on the total CPUE in each site within Bay lake (F-statistic = 1.742, DF = 48, p-value: 0.09) and within Crampton lake (F-statistic = 1.42, DF = 48, p-value: 0.20). When allowed the effect of CWH on CPUE of prey fish to vary by sampling period there was still no significant effect of CWH on CPUE of prey fish for both lakes (F-statistic = 0.618, DF = 56, p-value = 0.61; F-statistic = 1.219, DF = 56, p-value = 0.31 for Bay and Crampton respectively). We used a Kruskal-Wallis Rank Sum Test to compare mean CPUE of prey fish between sampling periods because our CPUE data did not meet assumptions of normality. There was no significant effect of time of day on mean CPUE of prey fish for both lakes (chi-squared = 0.59, DF = 1, p-value = 0.44; chi-squared = 3.53, DF = 1, p-value = 0.06 for Bay and Crampton respectively).

We related CWH and sampling period to species diversity, measured as species caught per hour, using ordinary least squares regression and, Kruskal-Wallis Rank Sum Test for Bay and Crampton lake. There was no significant effect of CWH on species caught per hour for Bay (F-statistic = 0.15, DF = 58, p-value = 0.70) and for Crampton (F-statistic = 0.01, DF = 58, p-value = 0.91). However, there was a significant effect of sampling period on species diversity for both lakes (chi-squared = 9.1, DF = 1, p-value = 0.002; chi-squared = 8.4, DF = 1, p-value = 0.004 for Bay and Crampton respectively).

Discussion

The results do not support the hypothesis that as the density in CWH increases, the abundance and diversity of fish will increase as well. Both lakes are undisturbed ecosystems in which there seems to be a sufficient amount of CWH distributed in most shoreline areas. This would not influence the preference of fish on a specific area with differing CWH because the areas with high densities are close in proximity of each other. The results also show that prey fish seem to prefer an intermittent density of CWH. This is in relation to the experiment by Wagner in Forbes lake in which the greatest abundance of fish were in the intermittent density than any other of CWH (Wagner 2015). Selection of intermittent density could be due to trade off among prey availability and predator foraging efficiency. Higher densities of CWH could cause visual impairment and decrease predator foraging success of prey fish (Wagner 2015).

There was no significant difference between the relationship of CPUE and sampling period, which does not support the hypothesis that abundance will be greater during the daytime than nighttime sampling period. My method of capturing the prey fish could have had an effect on the abundance and diversity of fish I caught. A study on the fish community abundance,

diversity and richness in 56 Danish lakes showed that the species of fish caught was greatly influenced by the method of capture. On average, electrofishing captured more species than offshore gillnets, but not more than littoral gillnets (Menezes et. Al 2016). I only used minnow traps that were small in size and consisted of two small entrances the fish could go through. This constrained my catchability rate that could have influenced the abundance and the species I caught.

There was a significant difference between the sampling periods and number of species caught per hour for both lakes. This supported the hypothesis that species diversity will be greater during the day than nighttime sampling period. Despite no significant difference in the abundance of prey fish caught between sampling periods, there was still more prey fish during the AM than PM sampling period which could have contributed to the increase in species diversity. The greater number of individuals increases the chances for a higher number of species. This is also affected by the diel vertical migration in which most prey fish stay in CWH during the day for safety from predators and forage in open waters during the night (Busch et. al 2012). There was a greater number of prey fish during the day than nighttime which correlates to the number of species caught.

Acknowledgments

A great appreciation goes to Jake Ziegler, who taught me everything I needed for this project and who supported me every step of the way. I also greatly appreciate Elizabeth Wildenhain, Casey Moor, Renai Nez and Jennifer Lam who assisted me in collecting my data and setting/dismantling my traps. A great thank you to Dr. Michael Cramer and Gary Belovsky for helping me get here and teaching me so much I never learned before. Another great thank

you to the Bernard J. Hank Family for funding this program for us to learn and grow. Thank you to all the rest of the UNDERC students and staff who have made this summer a wonderful experience.

References

Ahrenstorff, T.D., Sass, G.G., and Helmus, M.R. (2008). The influence of littoral zone coarse woody habitat on home range size, spatial distribution, and feeding ecology of largemouth bass (Micropterus salmoides). *Hydrobiologia* 623, 223–233.

Busch, Susan, and Thomas Mehner. "Size-Dependent Patterns Of Diel Vertical Migration: Smaller Fish May Benefit From Faster Ascent." *Behavioral Ecology* 23.1 (2012): 210-217.

Christensen, D.L., Herwig, B.R., Schindler, D.E., and Carpenter, S.R. (1996). Impacts of Lakeshore Residential Development on Coarse Woody Debris in North Temperate Lakes. Ecol. Appl. 6, 1143–1149.

Everett, R.A., and Ruiz, G.M. (1993). Coarse woody debris as a refuge from predation in aquatic communities. *Oecologia 93*, 475 – 486.

Francis, T.B., and Schindler, D.E. (2006). Degradation of Littoral Habitats by Residential Development: Woody Debris in Lakes of the Pacific Northwest and Midwest, United States. AMBIO J. Hum. Environ. *35*, 274 – 280.

Lewin, W., Okun, N., & Mehner, T. (2004). Determinants of the distribution of juvenile

fish in the littoral area of a shallow lake. *Freshwater Biology*, 49(4), 410-424. doi:10.1111/j.1365-2427.2004.01193.x

MacRae, Pamela S. D., and Donald A. Jackson. "Characterizing North Temperate Lake Littoral Fish Assemblages: A Comparison Between Distance Sampling And Minnow Traps." *Canadian Journal Of Fisheries & Aquatic Sciences* 63.3 (2006): 558-568.

Menezes, Rosemberg, et al. "Variation In Fish Community Structure, Richness, And Diversity In 56 Danish Lakes With Contrasting Depth, Size, And Trophic State: Does The Method Matter?." *Hydrobiologia* 710.1 (2013): 47-59

Timms R. M. , Moss Brian , (1984), Prevention of growth of potentially dense phytoplankton populations by zooplankton grazing, in the presence of zooplanktivorous fish, in a shallow wetland ecosystem, Limnology and Oceanography, 3, doi: 10.4319/lo.1984.29.3.0472.

Wagner, C.P., Weber, M.J., and Wahl, D.H. (2015). Structural Complexity Influences Littoral Coarse Woody Habitat Selection by Juvenile Muskellunge. North Am. J. Fish. Manag. 35, 14–19.

Figures

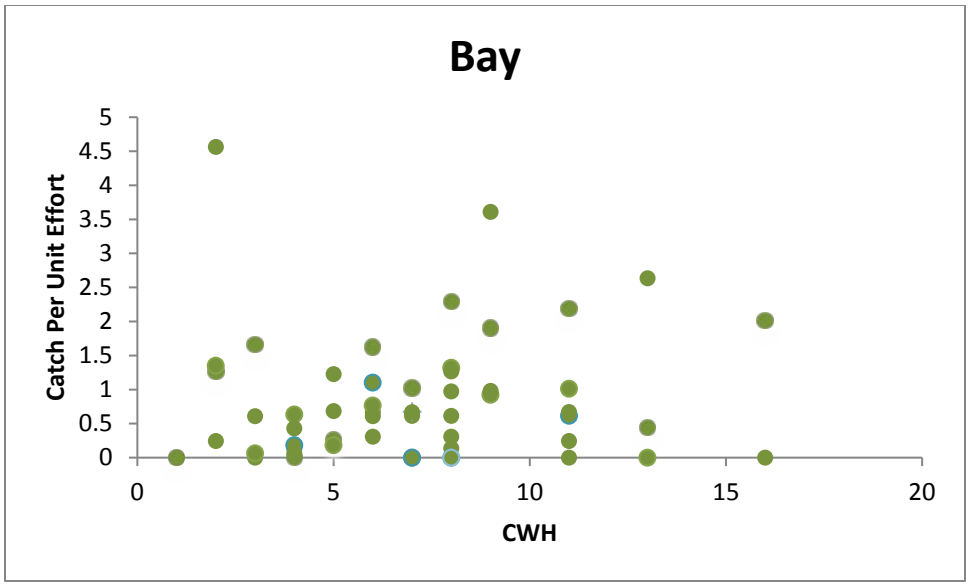

Figure 1: Catch Per Unit Effort of fish in different density of Coarse Woody Habitat in Bay lake. Using ordinary least square regression test, we compared the density in CWH to the CPUE of fish in which there was no significant effect yielding F-statistic = 0.56 and a p-value = 0.46.

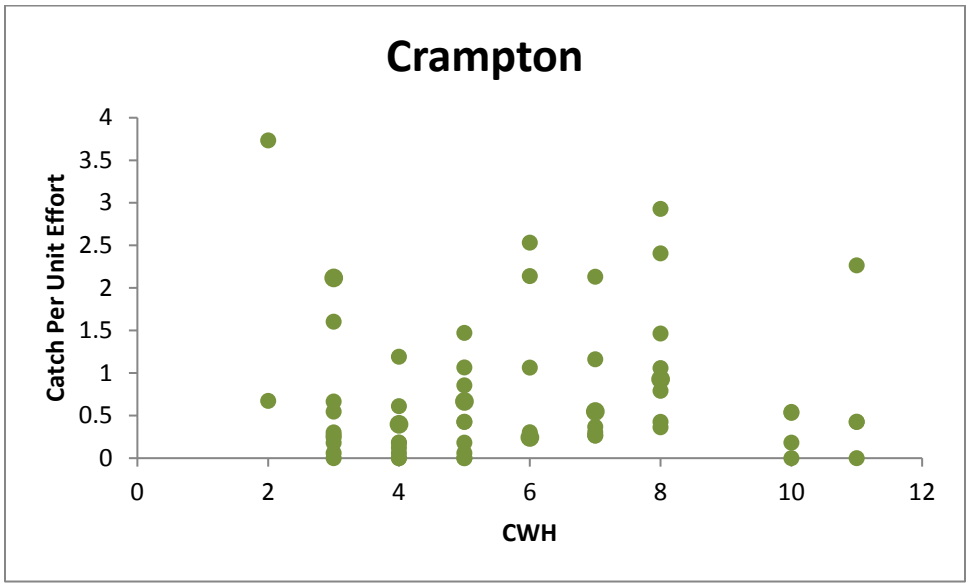

Figure 2: Catch Per Unit Effort of fish in different densities of Coarse Woody Habitat in Crampton lake. Using ordinary least square regression test, we compared the density of CWH to CPUE of fish in which there was also no significant effect yielding F-statistic = 1.42, DF = 48, p-value: 0.20.

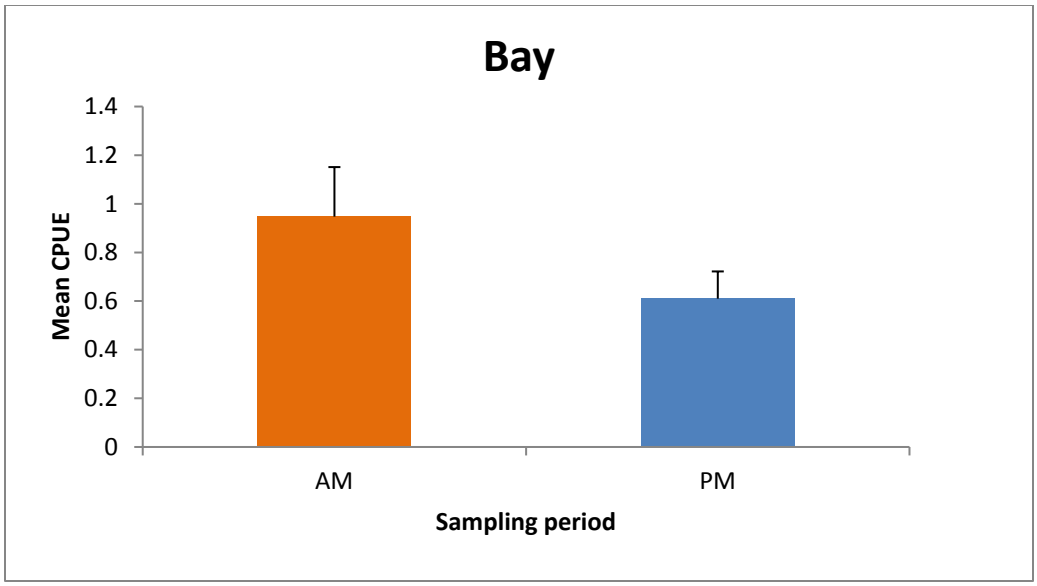

Figure 3: The mean Catch Per Unit Effort between different sampling periods in Bay lake. Using a Kruskal-Wallis Rank Sum Test, we compared the mean CPUE between sampling periods which showed no significant difference yielding chi-squared = 0.59, DF = 1 and p-value = 0.44.

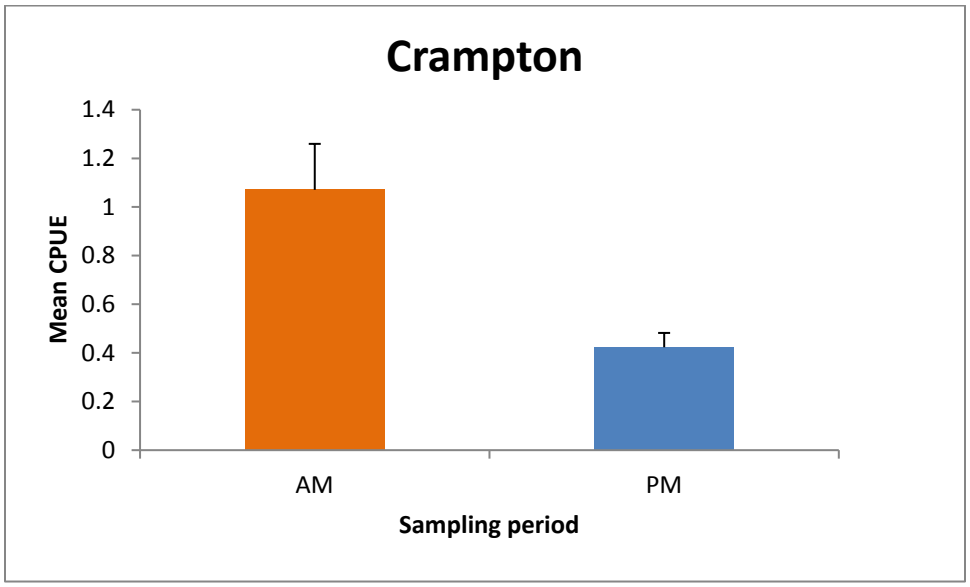

Figure 4: The mean Catch Per Unit Effort between different sampling periods in Crampton lake. Using a Kruskal-Wallis Rank Sum Test, we compared the mean CPUE between the AM and PM periods which showed no significant difference yielding chi-squared = 3.53, DF = 1, p-value = 0.06.

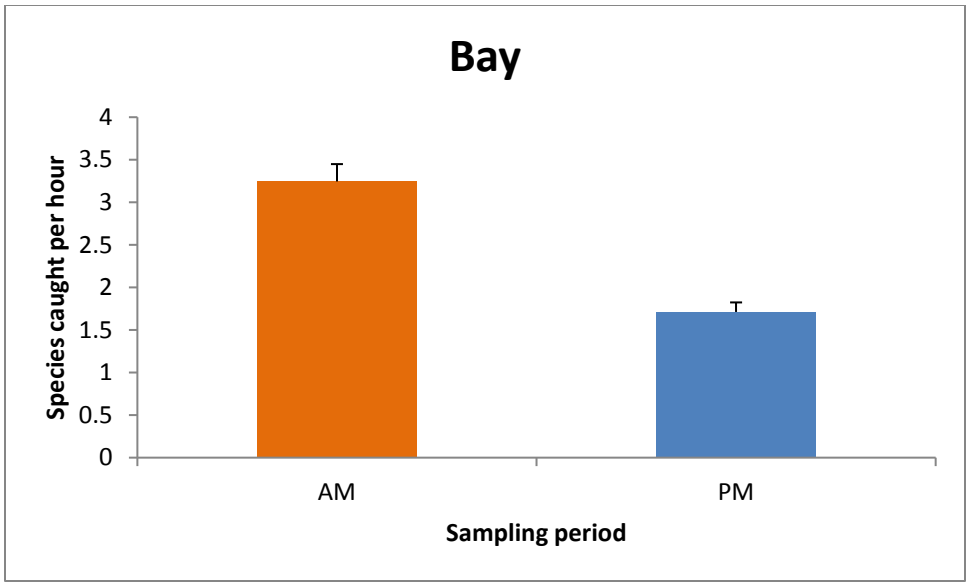

Figure 5: Species caught per hour during the different sampling periods in Bay lake. Using a Kruskal-Wallis Rank Sum Test, we compared the total number of species caught per hour during the AM and PM periods which showed a significant difference yielding chi-squared = 9.1, DF = 1 and p-value = 0.002.

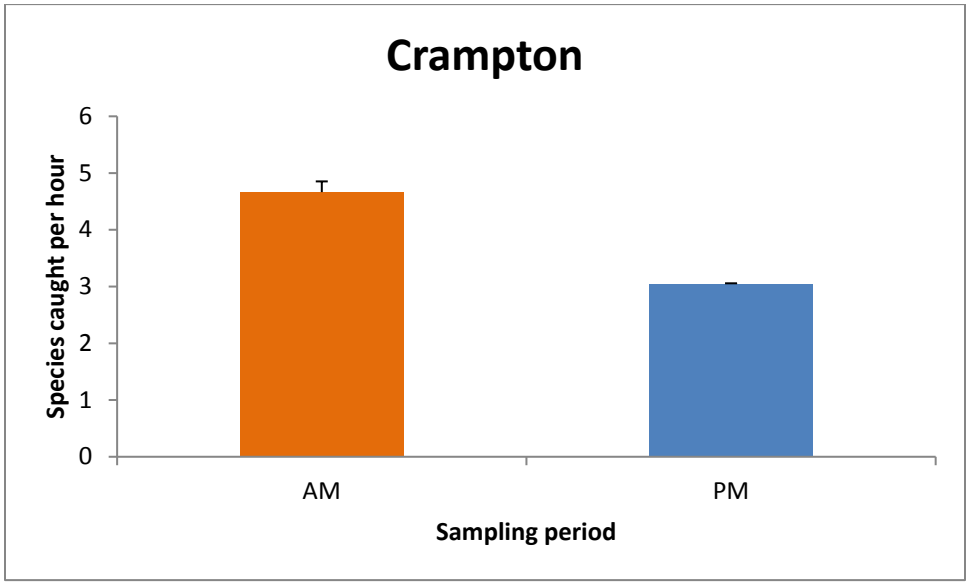

Figure 6: Species caught per hour during the different sampling periods in Crampton lake. Using a Kruskal-Wallis Rank Sum Test, we compared the total number of species caught per hour during the AM and PM periods which showed a significant difference yielding chi-squared = 8.4, DF = 1 and p-value = 0.004.