Diel Vertical Migration of Zooplankton in Bay Lake

Ashley Stiffarm
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Advisor: Matt Igleski

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Abstract

For this research we looked at diel vertical migration of zooplankton in Bay Lake. This act is a phenomenon that small living organism undergo each day for various reasons. These reasons could be predation, necessity of food, or reproduction. To study this act we sampled on Bay Lake in UNDERC property. Our hypothesis was that parameters such as DO, temperature, depth and time will effect zooplankton diel vertical migration. Our analysis of variance ran showed that time of day and time and depth together showed significance between them. On 23 June 2011 we sampled from 0.5-8 m and our p value was significant for time ($F_{1, 20}$= 19.78 P= 0.0002), time and depth together ($F_{4, 20}$= 4.362 P=0.011). Thus the evidence supports that there is significance with the abundance of zooplankton and time and time and depth together. And there is no significance with depth (F 4, 20= 0.556 P= 0.697) and abundance of zooplankton in Bay Lake.

Introduction

Zooplankton are an important link between primary production and higher trophic levels in aquatic ecosystems. Their main predator threats are normally fish, insects and insect larvae (Fernando, 1994). In order to avoid predation zooplankton may exhibit behavior such as diel vertical migration (DVM). Diel vertical migration (DVM) is a common spectacle in marine and fresh water zooplankton. DVM is a pattern movement that living organisms undergo each day. It involves moving up and down the water column often into different stratified levels of the lake. For example, zooplankton descend to the hypolimnion during day. This level of stratification is dark, cold, nutrient poor, and anoxic. Then ascend to the epilimnion, top layer of the lake, at night (Flik and Fingelberg, 1993). There are reports that when food supply is limited, zooplankton stay in the upper layer throughout the day despite the presence of predators (Huntley *et al*. 1982). When the abundance of food is low in the deeper stratified level of the lake where the zooplankton normally are during the day, then zooplankton will take the risk of the visual predators to find food. Thus zooplankton undergo DVM for the necessity of food regardless of the threat to avoid visual searching predators (Johnsen *et al*. 1987)

Several factors that can influence DVM are predation, water temperature, food abundance and concentration of dissolved oxygen in the water. Zooplankton may move to different stratified layers in water column for protection from predators. Normal migration behavior is to move to the dark hypolimnion during the daytime (Lampert, 1993). The hypolimnion is dark and deeper than the other stratified layers. Therefore, zooplankton descend because their predators can't see them as well. Another factor that influences diel vertical migration is where their food is more abundant in the stratified layers (Dodson 1974). If there is more food in one stratified layer than the other, the layer with the most abundance of food should have the most zooplankton. Thirdly, zooplankton need to be in an area with enough dissolved oxygen to survive (Laars et al. 2000) They may migrate to layers that have enough oxygen for them, but not enough for fish. Finally zooplankton can also vertically migrate for reproduction. Yet it is costly because it reduces total time feeding, diverts energy to swimming from growth and reproduction, and slows growth production by moving to deeper colder water (Dodson 1985). Therefore the advantage of vertically migrating for reproduction is the warmer water aids in more successful reproduction for the zooplankton. The warm water speeds up growth rate and allows zooplankton to easily reproduce. Overall, if there was not any threat or advantage of moving then there would not be a reason for zooplankton to undergo DVM.

This study will look at diel vertical migration of zooplankton in Bay Lake, which has not yet been researched at UNDERC. Bay Lake is one of the larger, deeper lakes at UNDERC, which provides an opportunity to acquire samples from different depths and locations. The objective will be to determine if zooplankton are selecting different depths between day and night. One hypothesis is that we will find the majority of the zooplankton in shallow water during the night rather than the day. Our second hypothesis is that zooplankton diel vertical migration will have a relationship between dissolved oxygen and temperature in Bay Lake at UNDERC.

Methods

The property where we collected our data is around 6510 acres of both terrestrial and aquatic systems. All the property is devoted to environmental research through the University of Notre Dame. The research studying diel vertical migration was done on Bay Lake. Bay Lake is in Goegbic, County Wisconsin; it has a surface area of 420 hectares (Elser 1978, unpublished). The coordinates of Bay Lake are longitude –89.48769, latitude 46.24369.

Sampling was done two times a day at noon and midnight along three different sampling sites at three different time periods throughout the summer. The depths sampled were from 0.5-8 m at 1 m increments. From each depth we sampled 12 L of the lake water to examine and count the individual zooplankton taxa from each of the different depths.

Materials

Temperature and dissolved oxygen (DO) of the water was taken with the YSI 55 (YSI Inc. Yellow Spring, OH). Temperature and dissolved oxygen measurements was taken at 1m increments from 1-8 m. Also, to determine the turbidity of the lake we used a Secchi disk. At each sampling location a pH reading was taken using a Hanna instruments pHep probe. For sampling the zooplankton we used a Schindler-Patalas trap. A small amount of formalin was used in each sample to preserve the zooplankton.

Data collections and Statistical analysis

For each sample, I counted the number of each zooplankton taxon found. To determine that zooplankton species abundance changes at different depths between day and night a 2-way ANOVA was used for each time sampled. For our experiment we ran three 2-way ANOVA and a regressions one for each sampling period. The 2-way ANOVA was looking at the abundance of zooplankton compared to the time, depth and time and depth together. Our regressions looked at the abundance of zooplankton to see if there was a relationship any between abundance dissolved oxygen and temperature.

Results

The taxa found include *Holopedium gibberum*, *Ceriodaphnia, Daphnia spp*., *Bosmina,* Calanoid copepods*,* Cyclopoid copepods, and *Leptodora kindti*. A regression was done to see if there was a relationship between the zooplankton and DO and temperature for each day and night sampled showed no significance with an alpha value of 0.05. The data collected on 6 June 2011($F_{1, 22}$=0.113) and the (p-value=0.3028) with the (R^2=0.04816).

From the analysis of variance test we found that depth alone had no statistical significances because each analysis night and day was separate. For example 6 June 2011, The F and p values for depth ($F_{4, 20}$= 0.1145 P=0.9503) and time and depth ($F_{4, 20}$=1.538 P= 0.2431) together was not significant compared to the other days sampling because we did not sample at 0.5m on 6 June 2011. On the other hand on 23 June 2011 we sampled at 0.5 m and our p value changed to be significant for time and depth together ($F_{4, 20}$= 4.362 P=0.011) Thus the evidence supports that there is significance with the abundance of zooplankton and time and time and depth together in, and no significance with depth and abundance of zooplankton in Bay Lake.

Figures 1-6 show the majority of zooplankton at different depths during the day and night in Bay Lake. Our total abundance of zooplankton was driven by *Holopedium gibberum* because this species of zooplankton was the most accounted. Figure 7-8 is the analysis variance of the data collected on 23 June 2011. In figure 7 the abundance of zooplankton is shown to be more abundant at night time than day.

Table 1 Analysis of variance from all zooplankton sampling periods at depths of 0.5-8m. Also shown are the independent variables, (dissolve oxygen, time,and depth) used in the 2way AVOVA.

Sampling Period	**Time**	**Depth**	**Time and Depth**
1 June 2011	$F_{1, 20}$ = 10.203 P=0.0056	$F_{4, 20}$= 0.1145 P=0.9503	$F_{4, 20}$=1.538 P= 0.2431
23 June 2011	$F_{1, 20}$= 19.78 P= 0.0002	$F_{4, 20}$= 0.556 P= 0.697	$F_{4, 20}$= 4.362 P=0.011
4 July 2011	$F_{1, 20}$= 47.964 P=0.000001	$F_{4, 20}$ = 1.659 P=0.198792	$F_{4, 20}$= 8.849 P= 0.000278

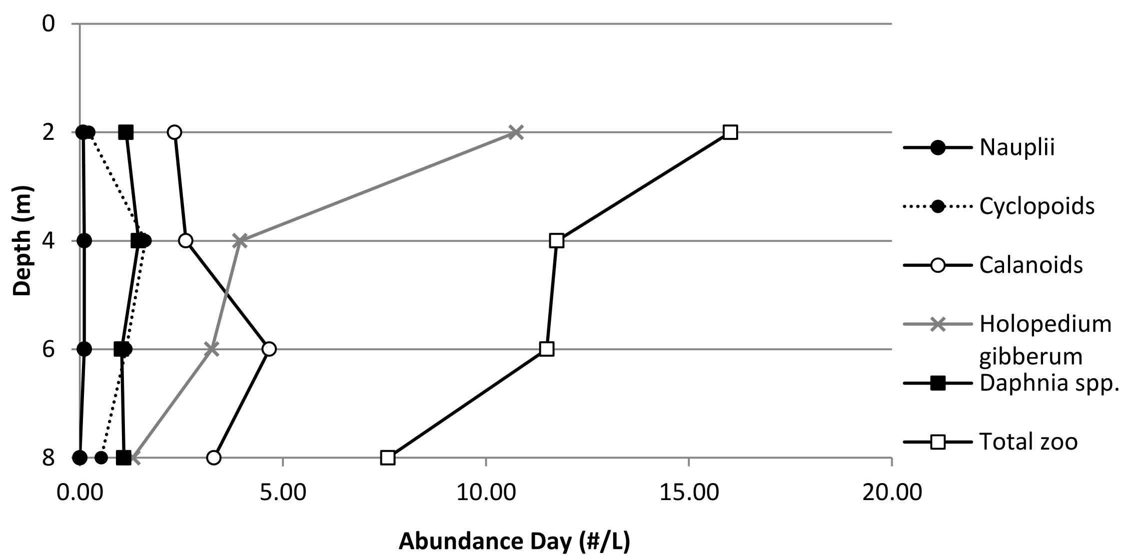

Figure 1 Zooplankton species abundance collected on 6 June 2011 during the daytime at in Bay Lake.

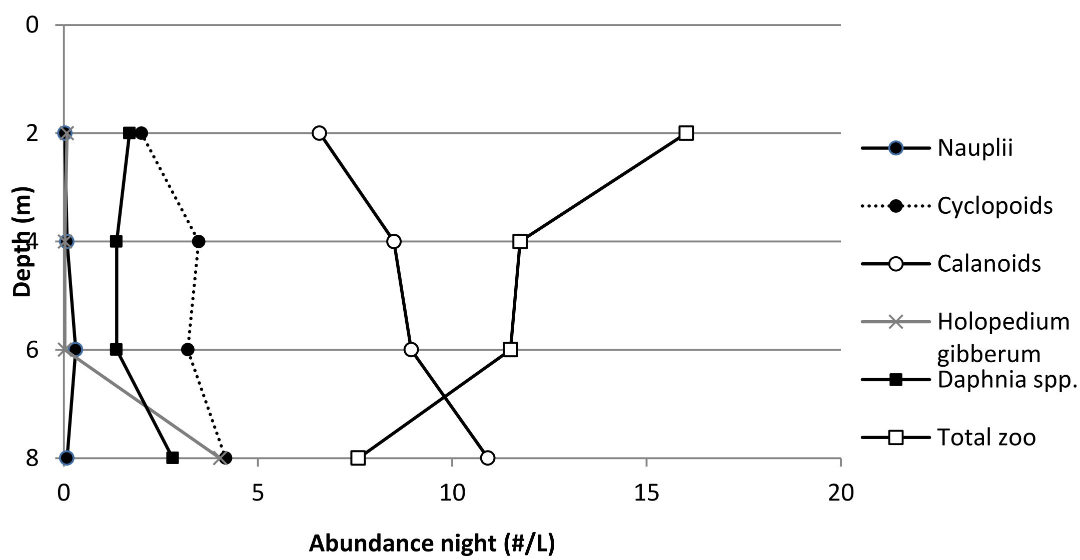

Figure 2 Zooplankton species abundance collected on 6 June 2011 during the nighttime in Bay Lake.

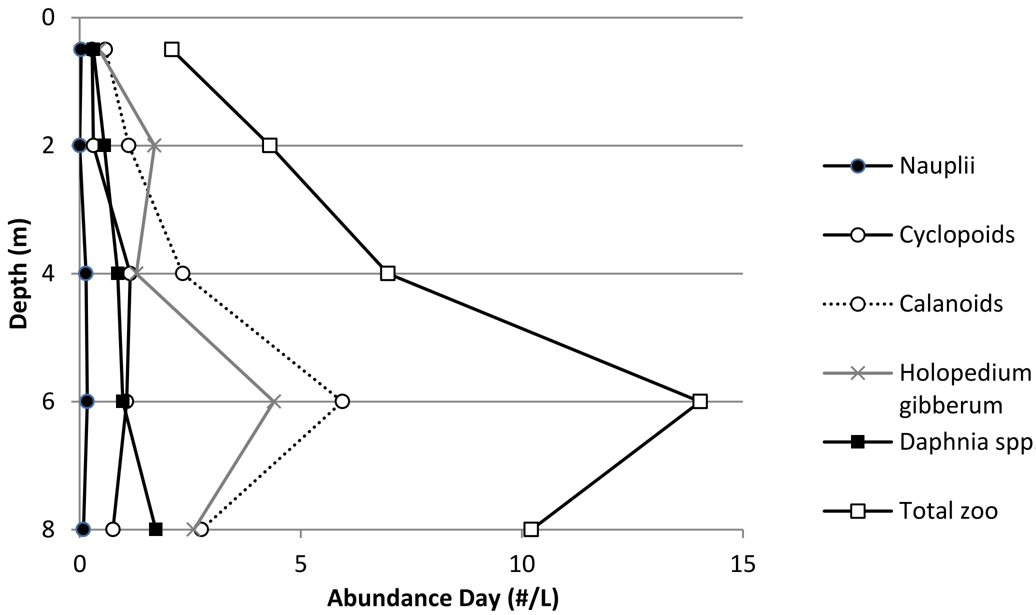

Figure 3 Zooplankton species abundance collected on 23 June 2011 during the daytime in Bay Lake.

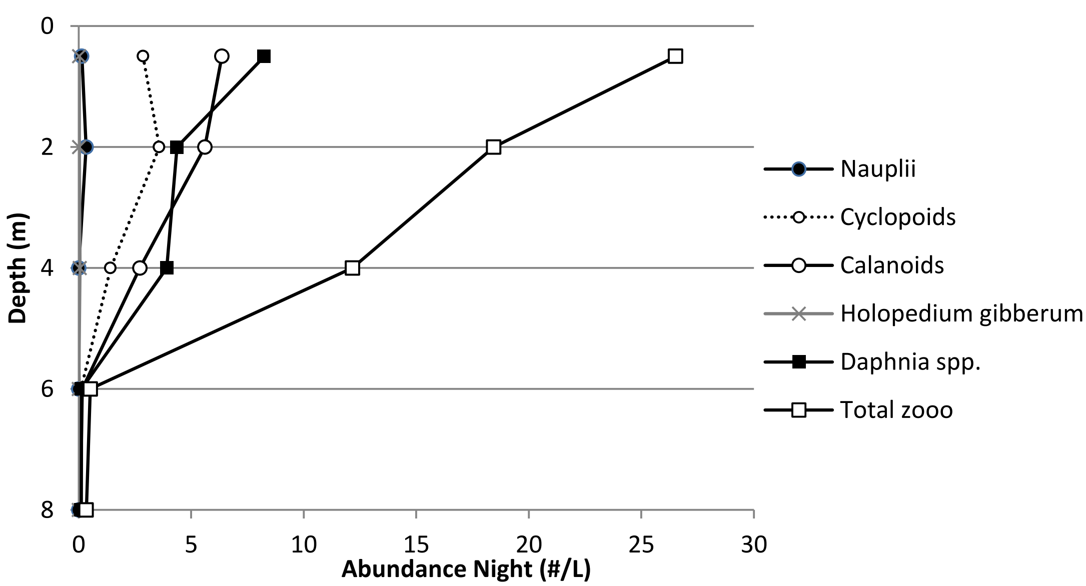

Figure 4 Zooplankton specie abundance collected on 23 June 2011 during the nighttime in Bay Lake.

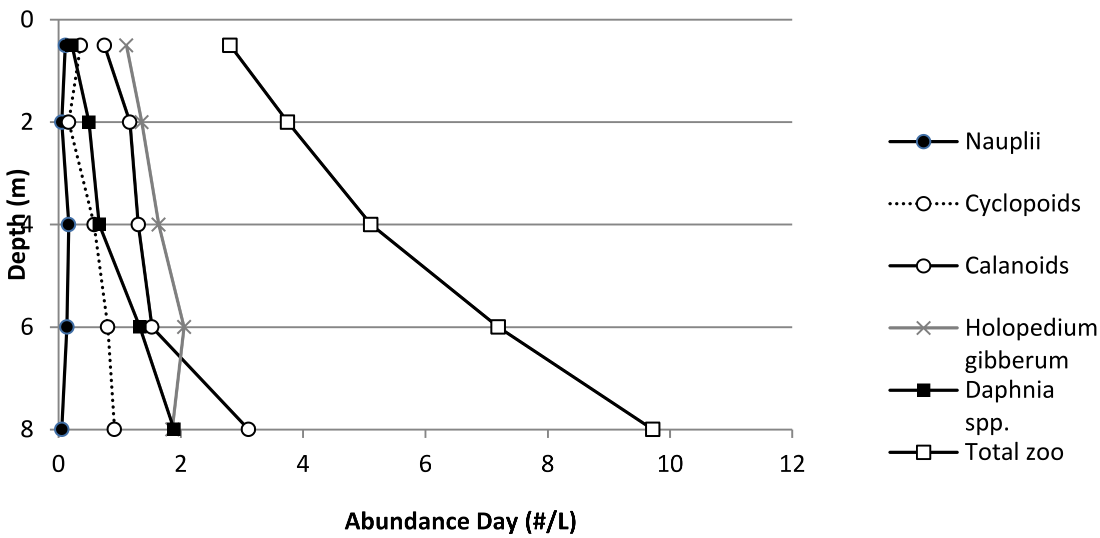

Figure 5 Zooplankton species abundance collected on 4 July 2011 during the daytime in Bay Lake.

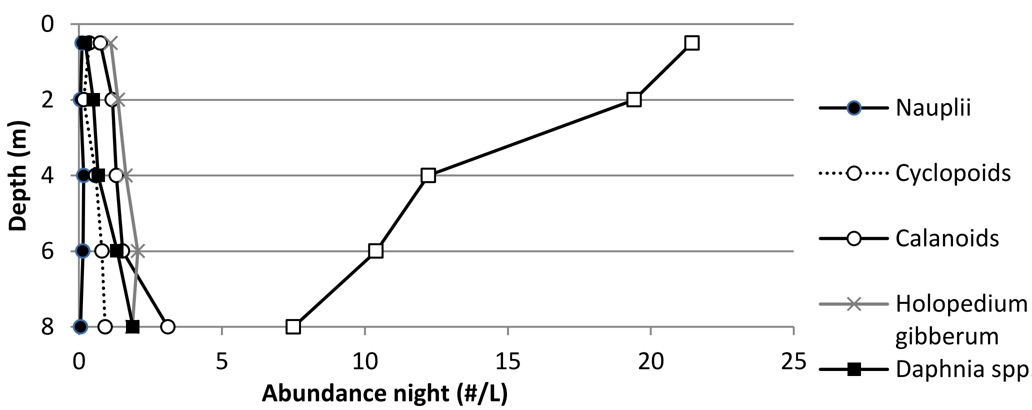

Figure 6 Zooplankton species abundance collected on 4 July 2011 during the nighttime in Bay Lake.

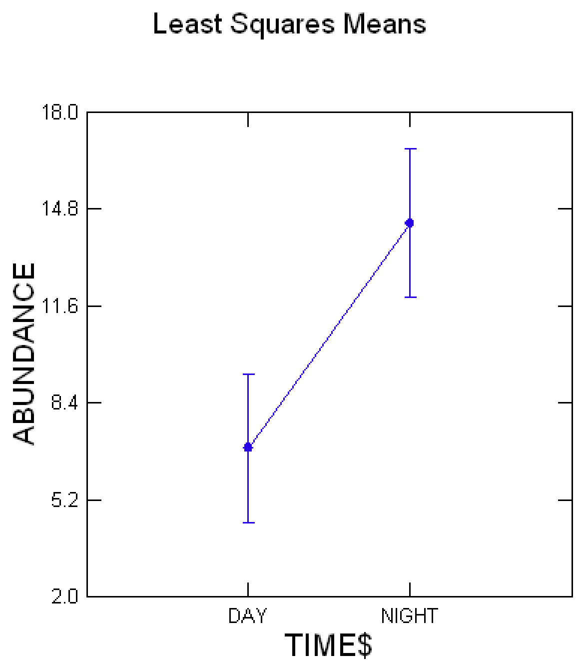

Figure 7 Analysis of variance on data collected 23 June 2011 in Bay Lake. Analysis shows significance for time and abundance (F1=19.78, p=0.0002).

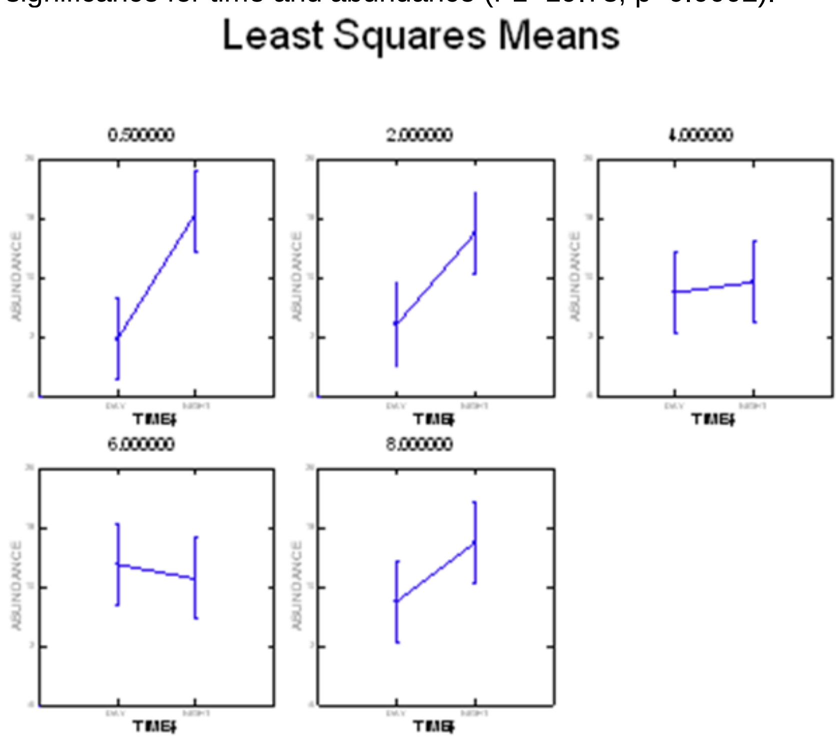

Figure 8 Analysis of variance on data collected on 23 June 2011 in Bay Lake. Analysis shows significance for abundance when both time and depth are independent variable together (F1=4.36, p=0.011)

Discussion

In this experiment we learned from our analysis that there is significance between time and time and depth together with the abundance of zooplankton in Bay Lake. Our analysis of variance shows the change in p values when looking at the independent variable depth alone; verses using the independent variables of time and time and depth together. The explanation is that each analysis is done separately pertaining to day and night. This is because the zooplankton are diurnally migrating. During the day the zooplankton are deeper and at night they are in shallow water towards the surface. If both day and night were pooled together it would graph as a straight vertical line, because during the day zooplankton are deep and dwindle towards the surface and the opposite at night. Our evidence supports that the zooplanktons are diely migrating vertically in the stratified layers of Bay Lake.

Our regressions we ran showed no significance with the abundance of zooplankton and the variables of DO and temperature. This could be because one, we didn't sample deep enough during the day. And secondly temperature and DO did not change drastically between the three different sites in Bay Lake. To better study the effects of DO and temperature on zooplankton abundance in Bay Lake with these two variables, it would be advantageous to sample during different season; each season would show a difference in temperature and DO based on the mixing in the stratified layers.

The most abundant species of zooplankton found was *Holopedium gibberum*. The possible explanation for this is that Bay Lake has high abundance of fish. The planktivore fish eat the zooplankton, as in *Daphnia spp.,* Calanoids, *and* Bosmina. The reason why they aren't eating the *Holopedium gibberum* could be the jelly sack surrounding the *Holopedium gibberum.* There could be some unknown toxin that is inside the jelly sack that is not desired by planktivorous fish. Undesired jelly sack could be an explanation for the total abundance of zooplankton to be driven by *Holopedium gibberum* because this species of zooplankton was the most counted.

Our purpose for this research was to prove that zooplankton are diel vertically migrating in Bay Lake. Other research has shown the same conclusions. That DVM is a plastic adaption of zooplankton whereby time and depth appear to control DVM (Dodson 1990). Also I would focus more on reproduction as an agent for the movement of *Daphnia spp*. and *Holopedium gibberum*, because in my sampling I found the majority of reproduction in the zooplankton were with these two groups. Also, the time of sampling started in late spring early to mid-summer where the temperature of the lake started out at around 23.0˚C, (warm). The warmer water aids in more successful reproduction for the zooplankton. The warm water speeds up growth rate and allows zooplankton to easily reproduce.

Acknowledgment

I would like to think my mentor Matt Igleski for navigating and teaching me throughout this whole research project and all the UNDERC team for guiding me with my research. Also I would like to think the Hank family for making it possible to undergo this research project

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