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Environmental Science 102
Professors Art, Dethier, Thoman
Experiment Performed: March 6- May 15, 2006
Experiment Submitted: May 18, 2006

The Vernal Pools: Analyses of Weather and Water Chemistry in the Migration of Spotted Salamanders

Abstract: In this project we analyzed the effects of weather on the inward and outward migration of the spotted salamanders in two vernal pools in Williamstown. We also analyzed the effect of the salamanders on the chemistry of the water in the pools. We found that weather, especially precipitation and temperature had effects on the migration of the salamanders. There was little evidence that the salamanders had particular effects on the chemistry of the water.

Introduction

During the spring, thousands of amphibians flock to vernal pools, pools that form during the spring months. We spent the April and May, 2006, tracking the movement of spotted salamanders visiting the two vernal pools in Hopkins Forest for the purpose of breeding. By taking various measurements related to the physical and chemical properties of the water and the environment surrounding the pools, we worked to discover patterns related to the migration of the amphibians to and from the pools. We used the results to gain understanding about the interrelationship between weather, water chemistry and amphibian migration.

Methods

From April 8 until May 8 we took readings almost every day from the upper and lower vernal pools in Hopkins Forest. At the pools we used the DO meter to read DO and temperature. Each pool also had a measuring stick at its estimated deepest part, and we recorded height using these sticks. Finally, we took two water samples from each pool. In the lab, we measured pH with a pH meter, and then the water samples were diluted by a factor of 10. We found the cations (Sodium and Calcium) for our diluted solutions by using an atomic absorption spectrophotometer.

The other data we obtained was collected from March 27 until early May by the vernal pool team and Hopkins Forest Weather Station. The measurements taken were extensive, and for our purposes only a selection of the data was used. We used measurements of air temperature, Hopkins Forest weather charts, and in-and-out charts for salamanders. The data for salamanders provided the total number of incoming and outgoing salamanders instead of numbers for individual pools. The pools were fenced off, and surrounded by buckets inserted into the soil; there were buckets on the outside of the fence, and corresponding buckets on the inside. Furthermore, all of our data was taken during the morning, so there is no data on night conditions.

Results

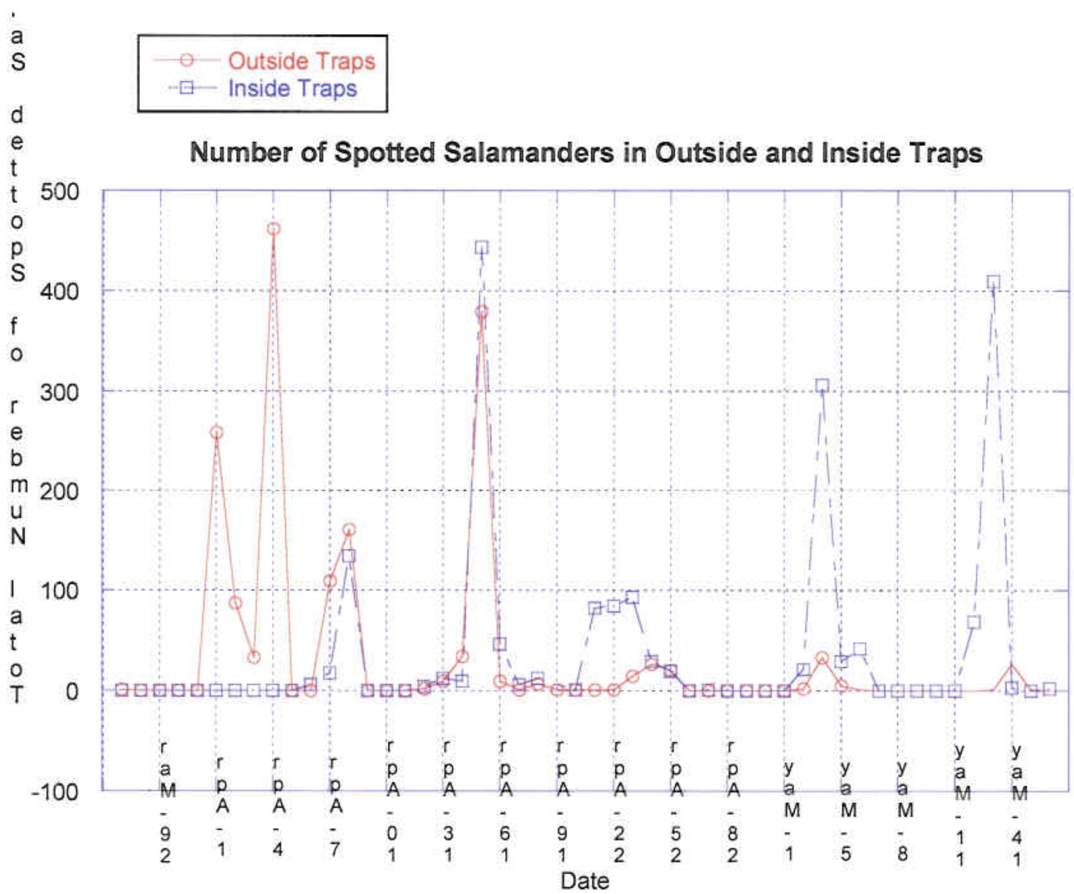

Figure 1: The number of spotted salamander found in the outside traps, the salamanders entering the pool, mirrors the number of spotted salamanders exiting the pools through the inside traps.

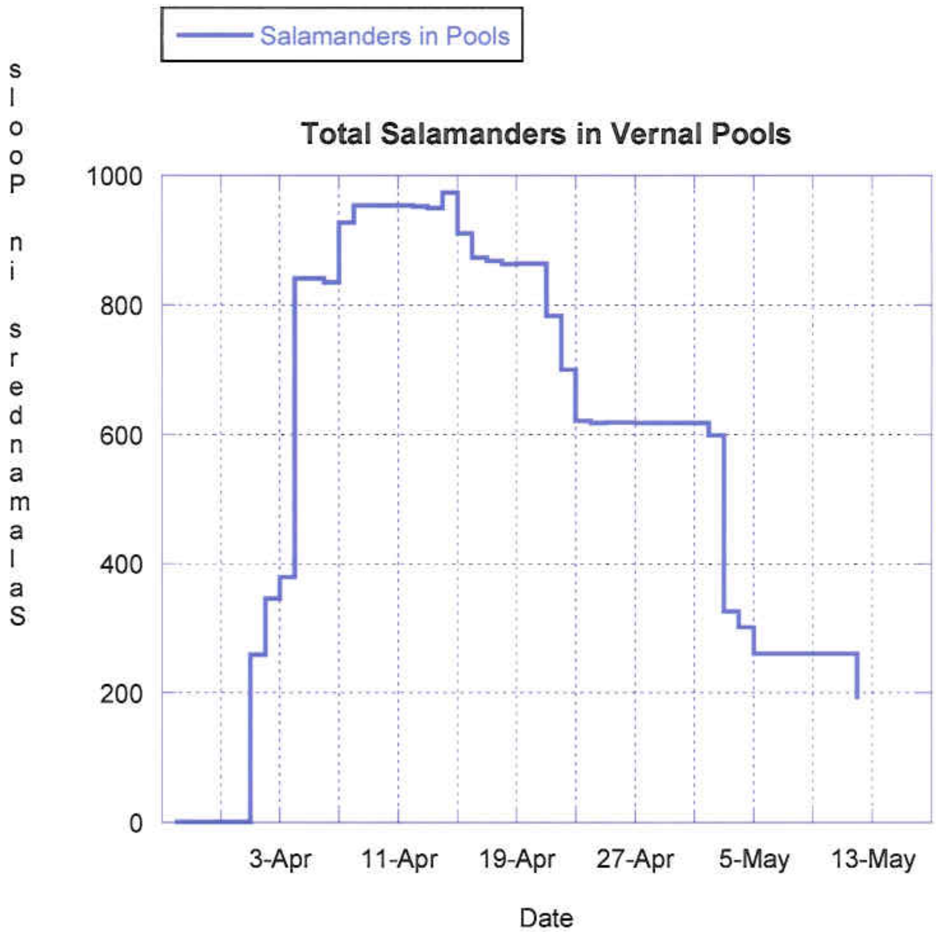

Figure 2: The estimate number of salamanders in the pools increased steeply before decreasing steadily from April 15th till mid May.

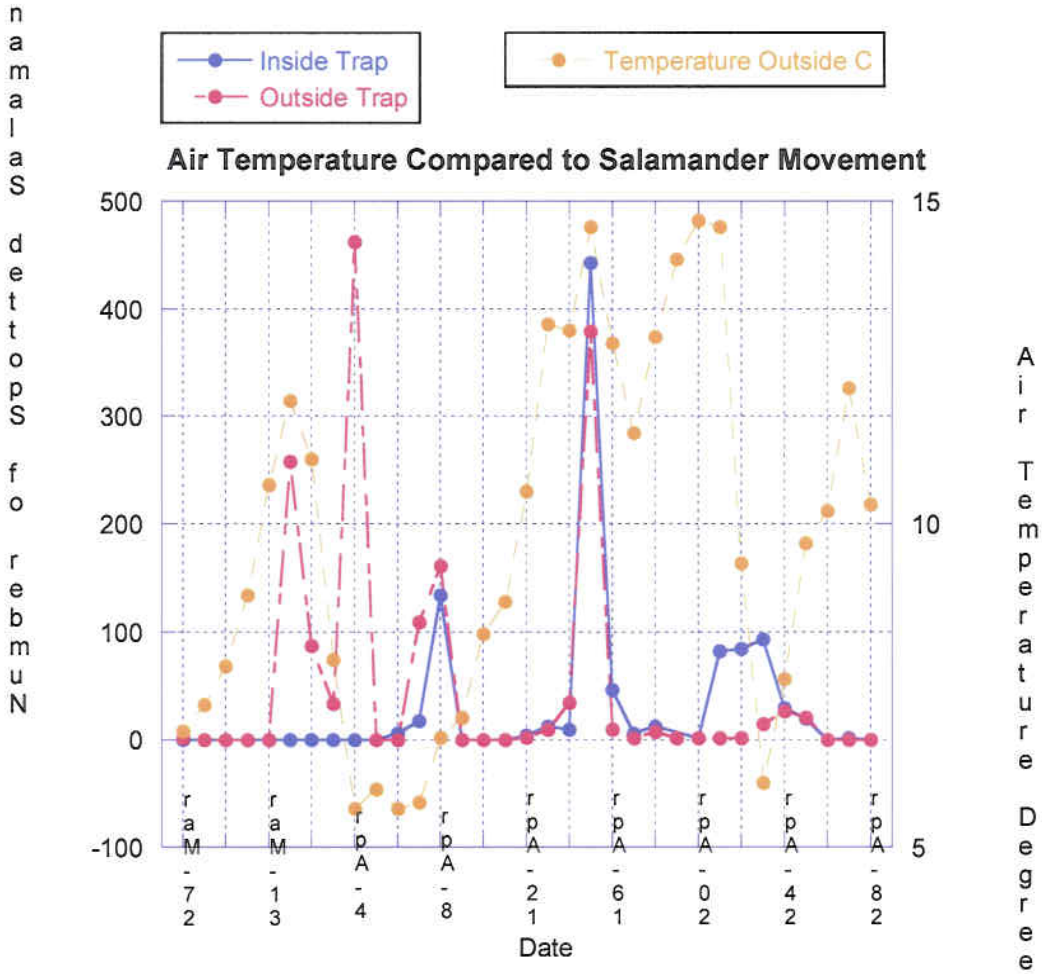

Figure 3: The air temperature modestly correlates to peaks in salamander movement.

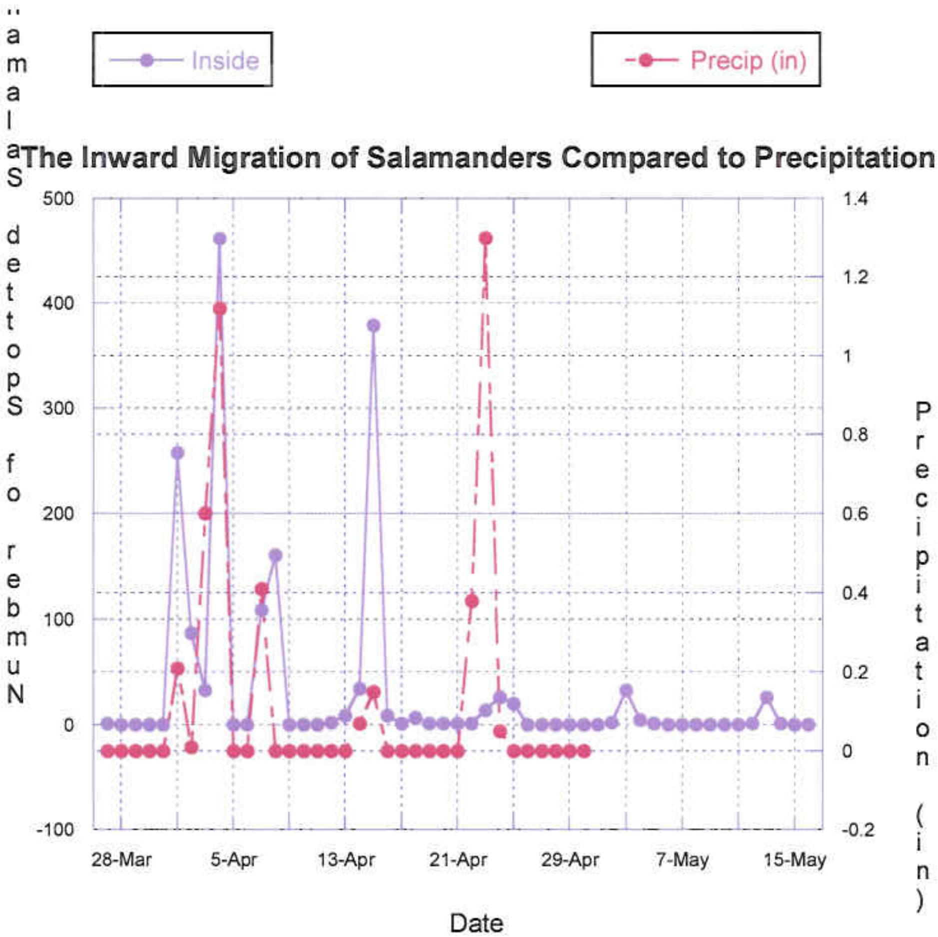

Figure 4: Precipitation significantly affects salamander movement.

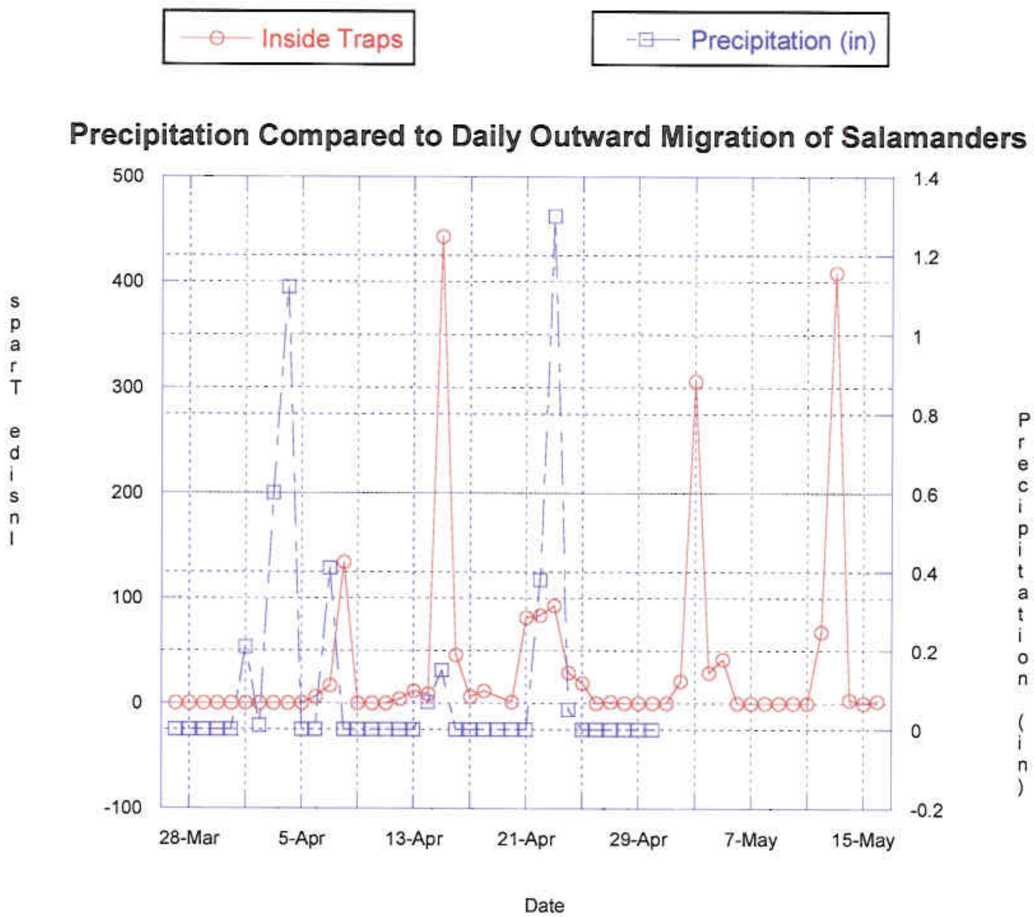

Figure 5: Precipitation significantly affects salamander migrating outward.

The data (figures 1-5) on spotted salamander migration suggests a direct correlation between the migration in and out of the vernal pools and precipitation. To a lesser degree, temperature also affects salamander movement. On April 4th, there was 1.12" of rain. The same day the greatest number of salamanders moved into the vernal pools. Another spike in salamander movement occurred around April 15th and 16th. Again, this movement was related to precipitation; the site received .15" of rain on the 15th.

The temperature was 12.36 ˚C on March 31st and is correlated with increased inward spotted salamander movement (Figure 3). The temperature reaches a high again at 14.01 ˚C on April 15th and there is an increase again in salamander numbers. Though the salamanders are more inert on colder days, the temperature does not have the great affect on salamander movement that precipitation does; this is illustrated by the data on the number of spotted salamanders in the buckets compared to the HMF precipitation in Figure 1, 4, and 5. The affect temperature has can be negated by the amount of precipitation. For example, the greatest number of salamanders, over 400, moved in and out of the pool on April 4th. The precipitation was high, but the temperature was at a low of 1.28 ˚C.

On occasion, rain fall and warm temperatures correspond. On the 15th of April there was 0.15" of rain; this corresponded to the highest number of salamanders leaving. The 15th was also a comparatively warm day. The air temperature was 14.01 ˚C. The combination of rain and warmth clearly affected the timing of the salamander migration from the pools. Similarly, the rainfall on the 23rd of April signals a peak in salamander outward migration. It should be noted that two other peaks in outward migration, on the 5th and the 14th of May were recorded, but the Hopkins Weather Station data on precipitation for these days is unavailable.

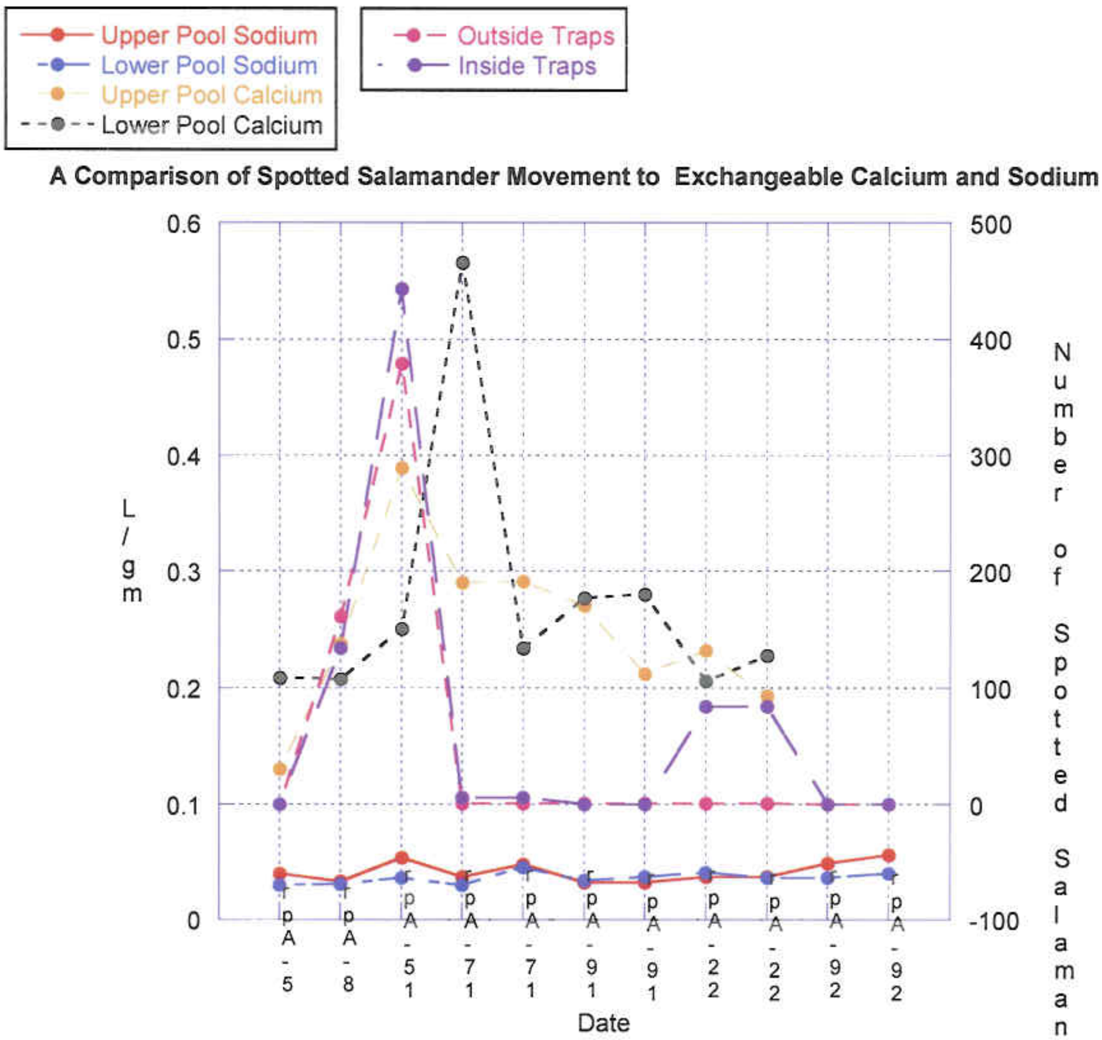

Figure 6: There is a clear correlation in salamander movement on the 15th of April and the amount of exchangeable calcium in the upper and lower pools.

The cation data on calcium and sodium is inconsistent. During the beginning of April the number of cations and salamander movement increase concurrently, this is particularly evident between April 5th and April 17th. The greatest overall migration also signals peaks in exchangeable calcium and sodium in both pools on the 15th and also a few days past the 17th. However, peaks in migration after the 17th have no visible affect on the amount of calcium or sodium in the water.

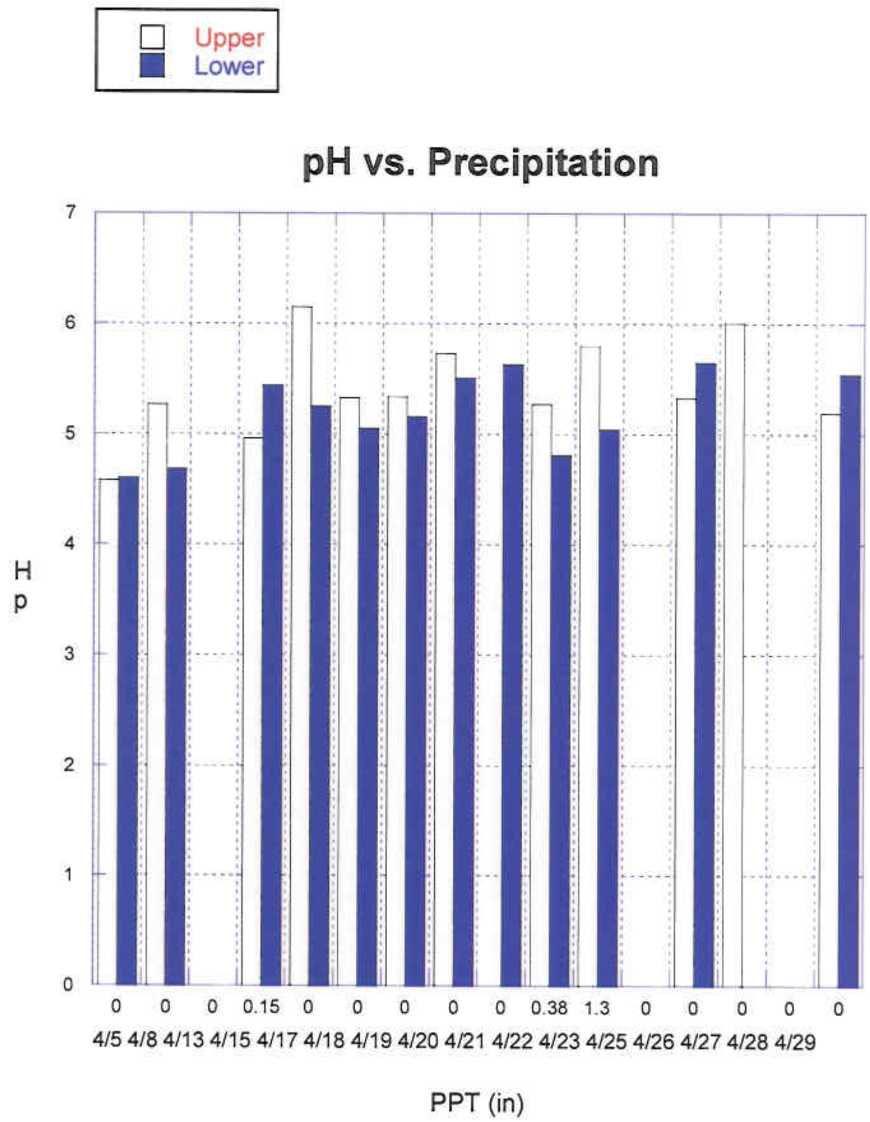

Figure 7: There is no direct correlation between precipitation and pH.

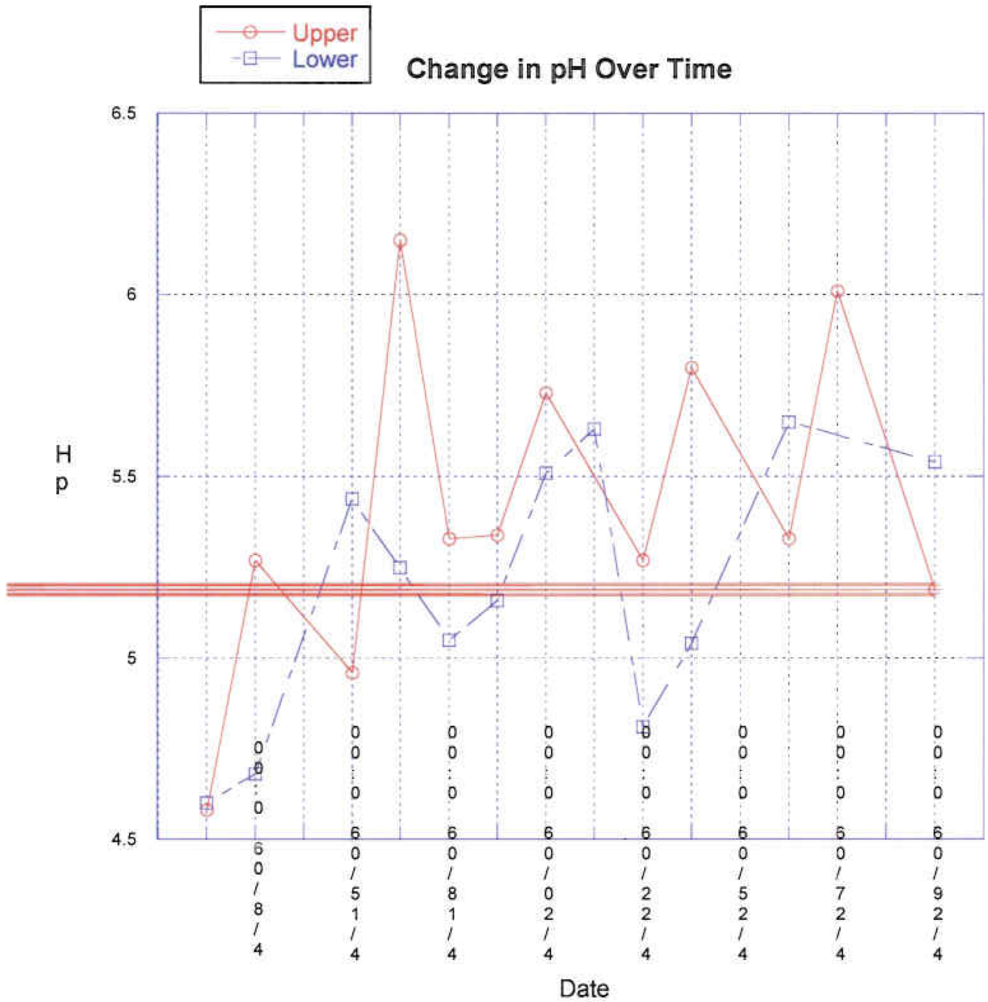

Figure 8: The lower pool is more acidic than the upper pool. There seems to be a slight increase in pH in both of the pools over time, but there is no strong correlation between any of the variables.

There is no clear relationship between pH, precipitation, and time. PH is lower on the three days that received rain, the 15th, 22nd, and 23rd, than on many of the days without precipitation, but not on all. For example, the pH readings from the days with rain are quite close to those taken from April 17th to the 21st, when there is no rain. Over time, the pH in both pools increases, however there is too much variation from day to day to accurately fit a curve to the data. In general, the lower pool was more acidic than the upper pool.

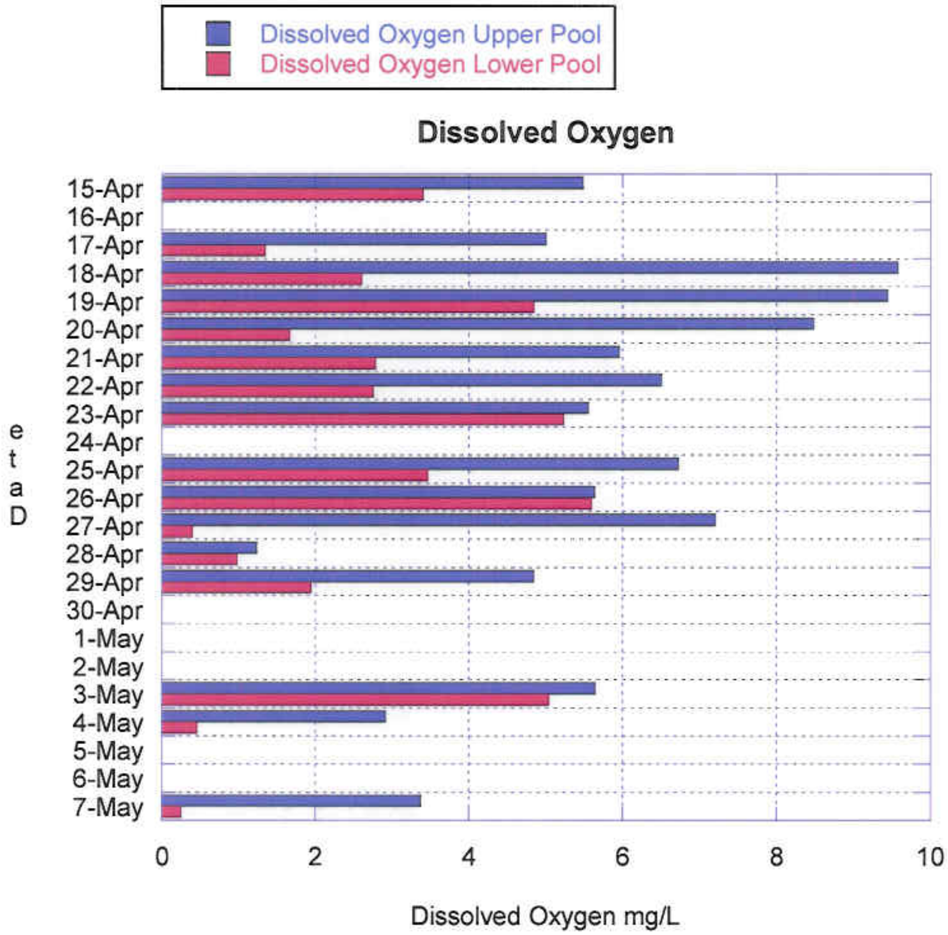

Figure 9: The Dissolved Oxygen in the Upper Pool does not correspond in any obvious way to the Dissolved Oxygen in the Lower Pool.

The dissolved oxygen in the upper pool seems unrelated to the DO in the lower pool (Figure 9). For instance, the upper pool had the greatest amount of dissolved oxygen on April 18th, 9.57 mg/L, but the lower pool had relatively little dissolved oxygen, 2.6 mg/L. The lack of correlation between the dissolved oxygen in the two pools makes it virtually impossible to analyze the relationship between DO and other biological and physical variables.

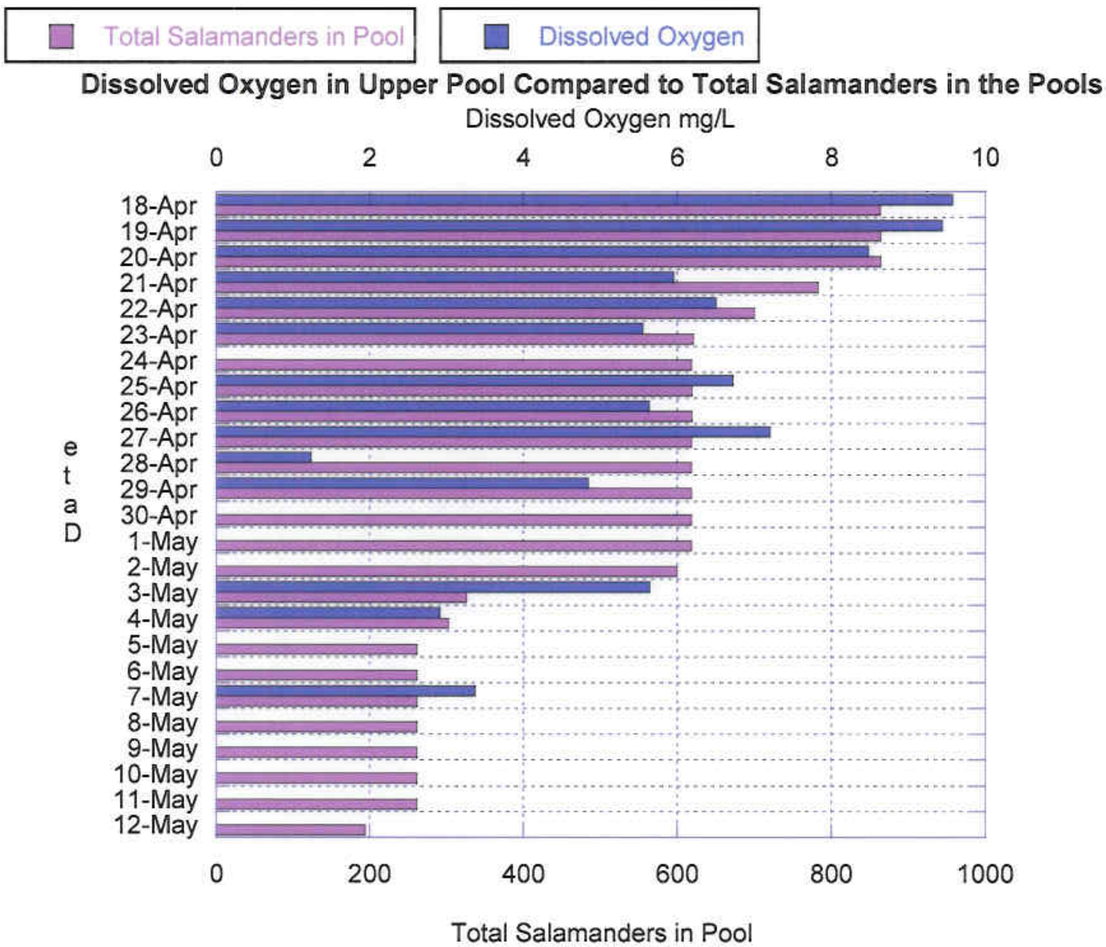

Figure 10: The Dissolved Oxygen in the Upper Pool seems to correspond to the decreased number of Spotted Salamanders as they leave the pools.

The dissolved oxygen data collected for the upper pool seems more reliable and corresponds with our hypothesis, which was that the DO would decrease over time as the temperature generally increased and the pools were made to hold an increasing number of creatures absorbing DO.

The DO for the upper pool decreases at about the same rate as the salamanders left the pool (Figure 10). To calculate the total number of salamanders in the pool we added the successive number of salamanders in the outside buckets subtracting the number of salamanders released from the inside buckets each day.

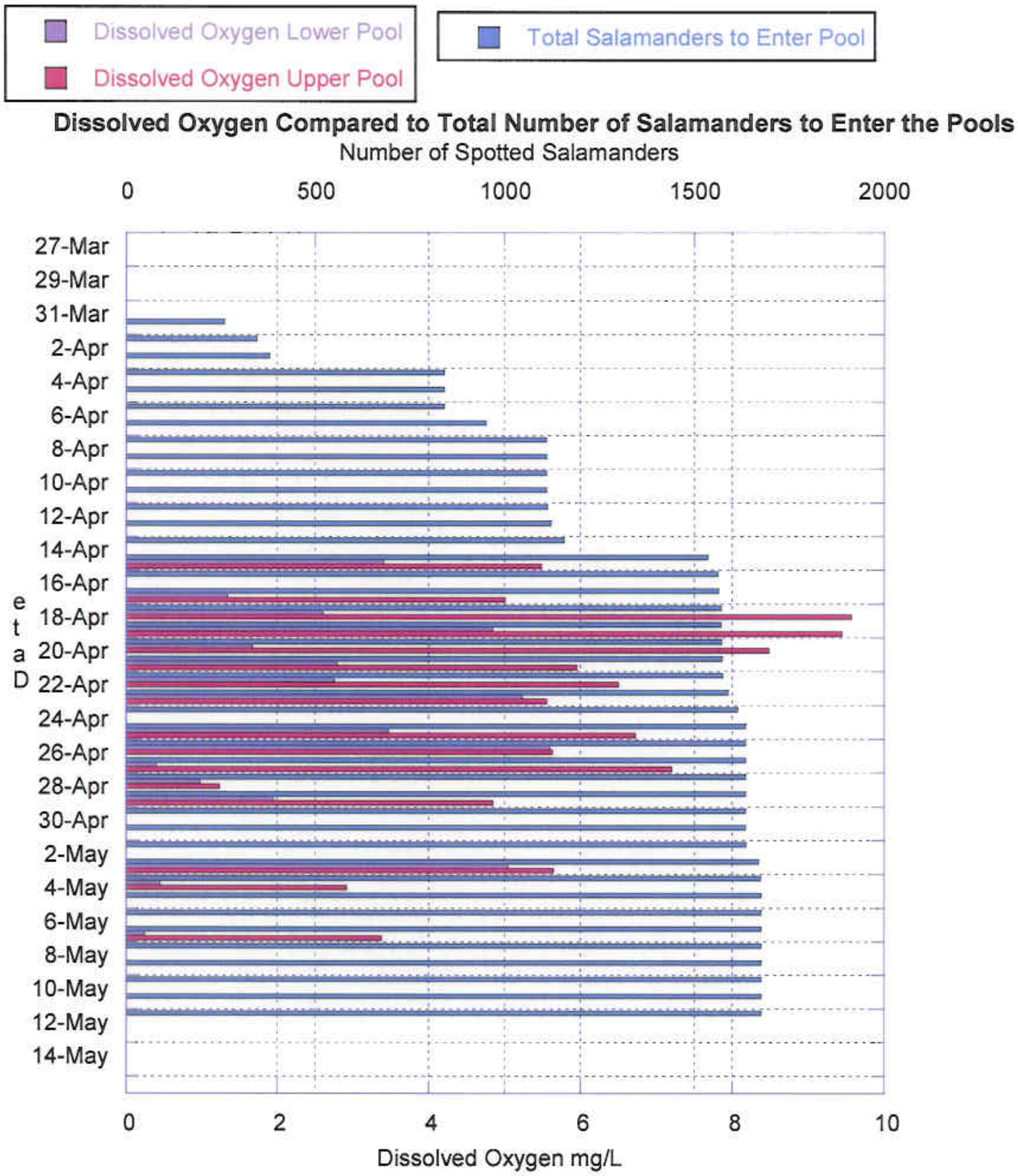

Figure 11: The Dissolved Oxygen for the two pools seems to decrease at a greater rate than the rate of total salamanders entering the pool.

The total number of salamanders to have entered the pool for any given day was calculated simply by adding together all of the salamanders found in the outside buckets previous to, and including, that day. This number increases sharply April 1st to April 15th before leveling off (Figure 11). The DO data we have decreases sharply from April 18th to the 8th of May.

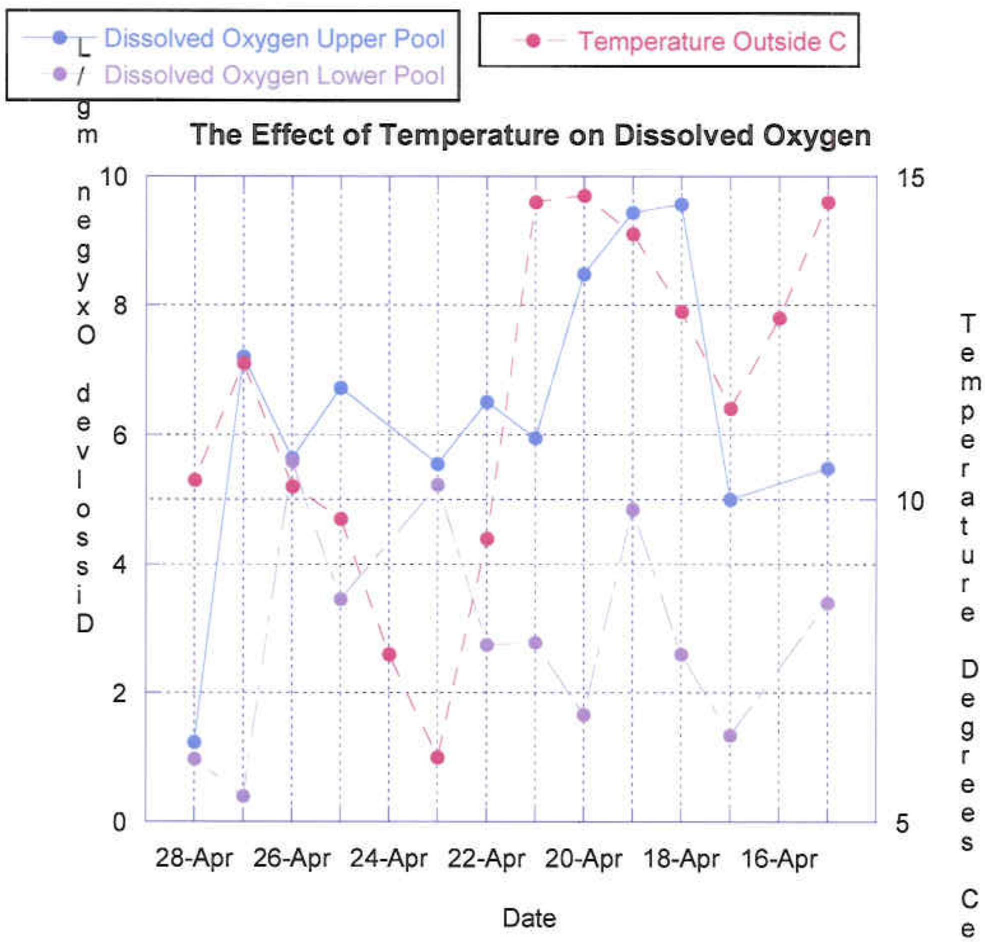

Figure 12: The air temperature does not correspond in a predictable way to the dissolved oxygen in either pool.

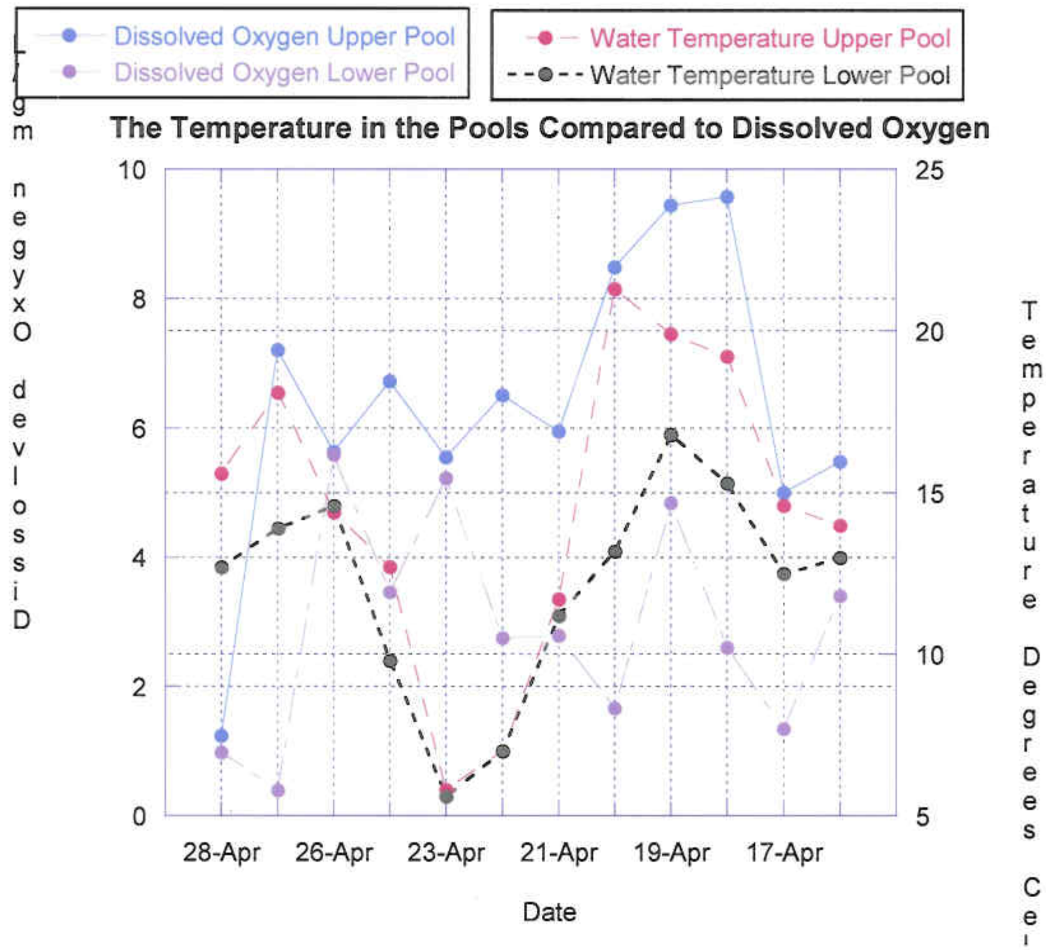

Figure 13: The relationship between the dissolved oxygen and the pool temperature is, if anything, opposite the expected relationship. The dissolved oxygen seems to peak as the temperature increases.

We expected the dissolved oxygen to increase when the water temperature decreased. Our data shows, however, the opposite occurring on certain days. For example, on April 17th the temperature and the DO for both pools decreased.

Discussion

We divided our analysis into three sections that correspond to the migration of the spotted salamanders; we did this because there are different factors influencing each of these stages. The first of these three so-called stages focuses on the migration of spotted salamanders and other amphibians into the two vernal pools. The second stage of our analysis centers on the change in water chemistry due to the presence of amphibians. Furthermore, we examined other factors, such as weather, to try to understand what variables, in addition to amphibians, might be influencing the water chemistry. Lastly, we looked at the environmental factors, both inside and outside the pools, which influenced the outward migration of the salamanders and the condition of the pools they left behind. We have taken into account the thousands of remaining embryos and larva as well as other organic matter that was excreted or released into the water.

We found that only environmental factors outside of the pools affected the migration of spotted salamanders, and by probable extension the other amphibian migration. Precipitation was the most important determinant in when salamanders migrated. During each of the several rains there was significant salamander movement, sometimes even when the air temperature was comparatively low. However, other migrations coincided with warmer temperatures. None of the physical or chemical properties of the water in the pools seemed to affect the inward migration. It is hard to conceive that the salamanders, as they are not yet exposed to the water in the pools, could be affected by the conditions therein.

While we hypothesized that water temperature might affect outward salamander migration, we found that, again, the condition of the environment outside the pools was more important than the condition inside the pools. Precipitation was the most important weather variable, with significant outward migrations occurring around rainfalls for as long as there were still salamanders in the pools. Higher air temperatures also correlated with greater outward movements of salamanders. However, the most salamanders left the pools when the air temperature was comparatively low. Water temperature did not seem to affect migration to a great degree. Two of the four major migrations occurred when the water temperatures for the two pools were not very high.

The salamanders, and presumably other amphibians, had some affect on the water quality, though it is hard to discern what that affect was. We found a loose correlation between the number of salamanders that had passed through or were still inside the pools and a decrease in the dissolved oxygen content of the two pools.

The data collected on dissolved oxygen, however, is difficult to analyze. The correlation between dissolved oxygen and temperature and the correlations between dissolved oxygen and salamander migration are unclear at best. In part, this is because DO data was only collected for a month, as opposed to the data on salamander migration, which spans nearly two months. Furthermore, the DO meters, of which there were two, are notoriously unreliable. The DO data was collected in two different forms, the percentage of dissolved oxygen for parts per million, and a DO measurement in mg/L. To analyze the data we converted the percentage DO to mg/L. Unable to find a reliable conversion factor, our conversion is an estimate based on the instances in which we collected both a percentage and mg/L form simultaneously. The relationship between the data was always approximately 0.1mg/L of DO to 1%. The percent error for this calculation ranges from 0% error to 13.9%.

While we did not find definitive trends on the chemical properties of the pools and the salamander migration, we think it is possible that this could be a result of the migration and presence of several other kinds of amphibians that were using the pools in time intervals that could overlap but not necessarily completely coincide with the migration of the salamanders. If, in fact, the amphibians do have distinct and regular effects on the quality of the water then our data could have been skewed by the different temporal distribution of the other amphibians.

We also think that we could have had more definitive water quality data if we had started collecting it earlier, during the peak of the salamander migration. Instead, we collected most of our data after the majority of the salamanders had entered, and many of them had already left, the pools. We further think that it would be enlightening to continue taking measurements of the chemistry of the pool as the number of mature amphibians in the pool continue to decrease and the embryos and larvae continue to mature.

Conclusion

The data we collected and studied on the migration of spotted salamanders into the Hopkins Forest vernal pools offers an integrated view of the pools and amphibians in relation to the chemical and physical properties of the environment. The most conclusive relationship was between salamander migration and weather conditions, specifically temperature and precipitation. Rain signaled increased amphibian movement. The salamanders also seem to prefer warmer weather when they travel, but the affect of precipitation outweighed the affect of temperature on migration.

While our comparisons of the chemical properties of the water to migration indicate some possible correlations, our data from the end of March until the beginning of May, is not substantive enough to draw any definite conclusions. For example, pH seems to be more often acidic during rainfall, but days without rain are may be equally acidic. Also, while the migration peak in the beginning of April corresponds to increases in cations, on later occasions cations increase and decrease without relating to spotted salamander migration. Based on our data, we can conclude that physical properties like rainfall and air temperature have a greater impact on spotted salamander migration to and from the vernal pools than do the chemical properties of water like pH, Calcium, and Sodium.

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