Devil's Kitchen Lake
Physical, Chemical, and Biological Analysis

Zoology 415 – fall semester, 2007
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Devils Kitchen Lake is an 810 acre, impoundment in Williamson County, Illinois. Its morphometry is dendritic, typical of impoundments in the region. Devil's Kitchen was created by the damming of Grassy Creek in the late 1930s. Devil's Kitchen is one of the deepest lakes in Illinois with a maximum depth of approximately 27 meters. As a result of its depth it has cooler waters than most lakes in the region and is one of the few Southern Illinois lakes that can sustain rainbow trout.

In the summer and fall of 2007, prior to any autumnal mixing, we sampled Devil's Kitchen to establish a physical, chemical and biological profile of the lake. This report is the culmination of that effort and attempts to interpret the data and the implications for Devil's Kitchen Lake. Variables are presented individually, without mention of interaction amongst them that may lead to patterns seen. These patterns and the overall picture of Devil's Kitchen Lake painted by the data are discussed in the final section of the paper. Variables measured at two sites on the lake were: depth, incident light, water clarity, pH, temperature, dissolved oxygen, and conductivity. Zooplankton and nutrient content data were taken at one site near the deepest part of the lake.

<u>Incident Light and Water Clarity</u> (note: because ambient light was only measured at one site, it is not reported, although results were similar)

Incident light was measured with a photometer on a clear, sunny, and calm day and both it and water clarity were likely higher than average. At both sampling locations, incident light dropped dramatically and steadily from the surface until approximately the 5m mark after which the change was more gradual. <u>The compensation point can be marked at approximately 10m</u> where the incident light reaches 1% (fig. 1). Water clarity was measured with a Secchi disk and was <u>6.42m at site one and 5.43m at site two</u>. Because it was a calm, clear day, the difference in Secchi readings can probably be attributed to the fact that site one was in the middle of the lake near the dam, thus having less suspended organic matter and sediment, and site two was nearer shore in a side bay of the lake. Note that the Secchi readings correspond closely with the photometer incident light readings that drop steadily to 5m.

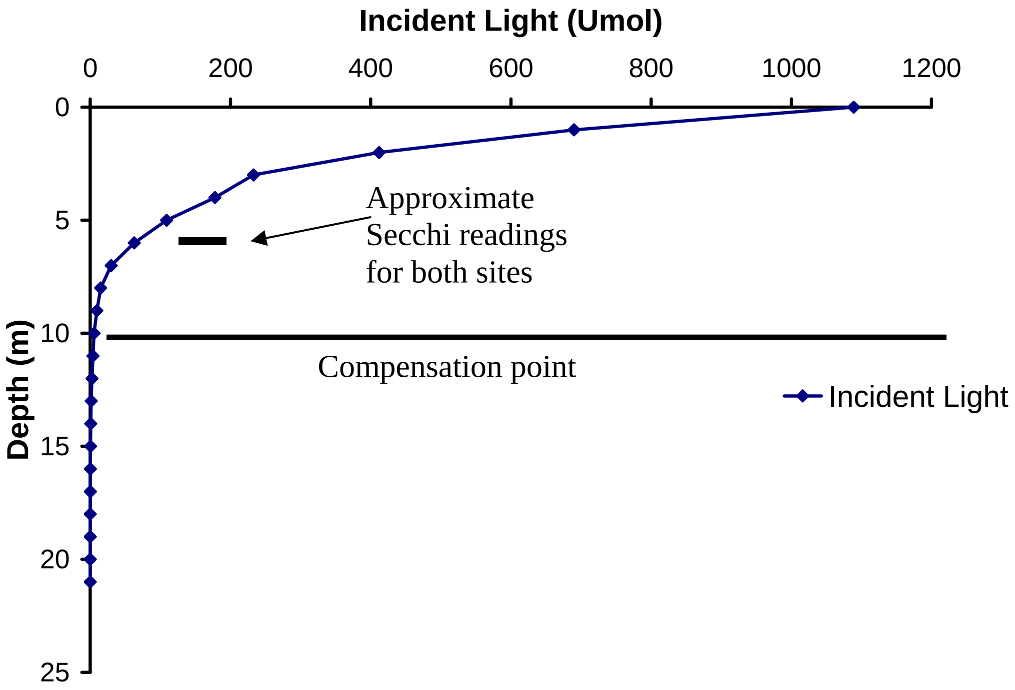

fig. 1: Incident light and Secchi depth reading at site one on Devil's Kitchen Lake as measured with a photometer. Site two had a similar incident light profile and thus is not presented.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen (D.O.) were measured using a Quanta™ brand handheld meter. D.O. at both site one and site two showed a positive heterograde profile with a metalimnetic bulge at approximately a 5m depth. Temperature also begins to dramatically change at this depth. This temperature and D.O. profile marks the Epilimnion / Metalimnion transition point at approximately 5m. The temperature and D.O. stabilizes again at approximately 10m, marking the Metalimnion / Hypolimnion transition (fig. 2, fig. 3).

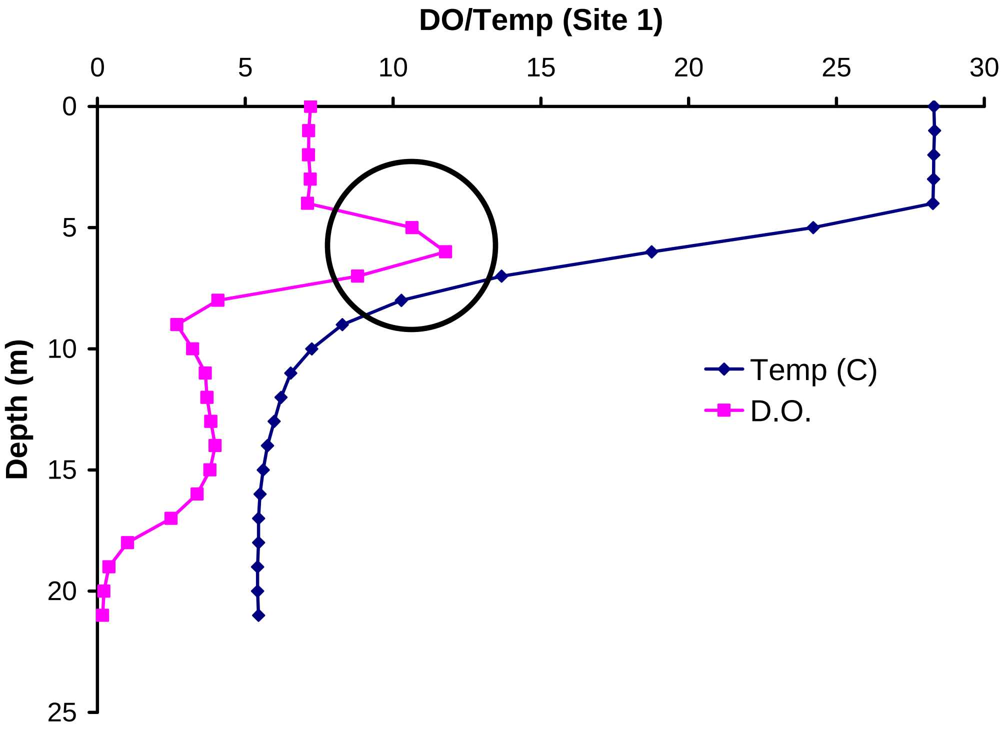

fig. 2: Temperature and D.O. profile for site one on Devil's Kitchen Lake. Note the metalimnetic bulge near the 5m depth (circled).

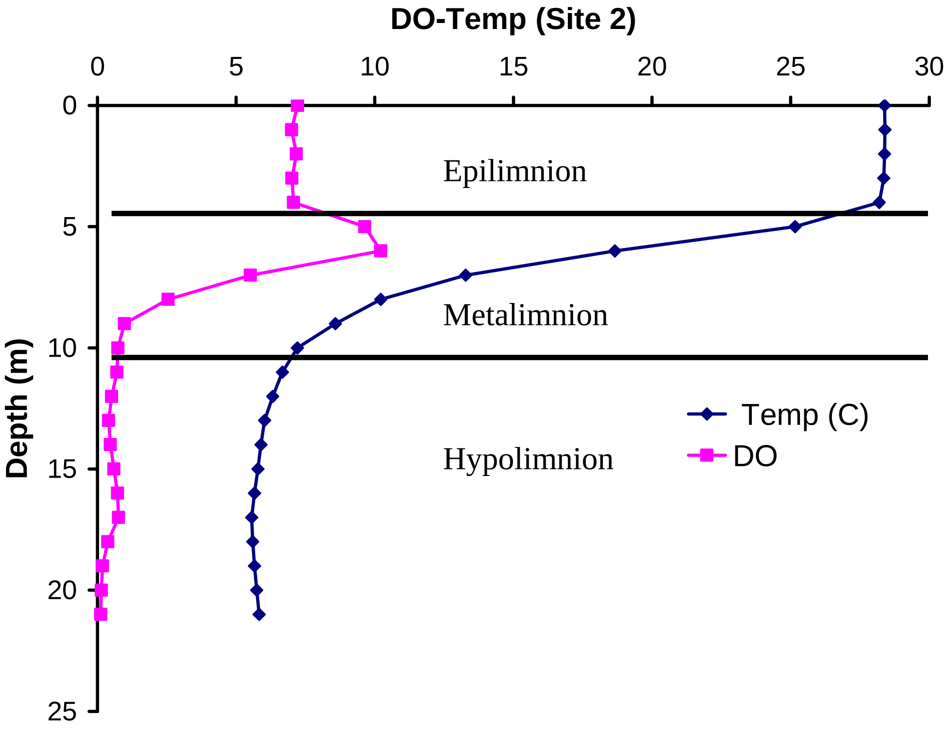

fig. 3: Temperature and D.O. profile for site 2 on Devil's Kitchen Lake. Note the stratification.

pH

pH was measured using a Quanta™ brand handheld meter. pH was more basic at the surface at site one than at site two (7.38 and 6.73 respectively). Both sites showed a rapid increase in pH (increasingly basic) near 5m in depth. The pH at site two gradually increased from the surface to this depth. At site one, pH held steady near 7.5 until 4m, when it rapidly increased. The maximum pH was recorded at both sites between the 6m and 7m depth (8.15 at site one, and 7.68 at site 2). After this point, pH steadily decreased at both sites to near 6.5 before rising again near the bottom of the lake (fig. 4, fig. 5).

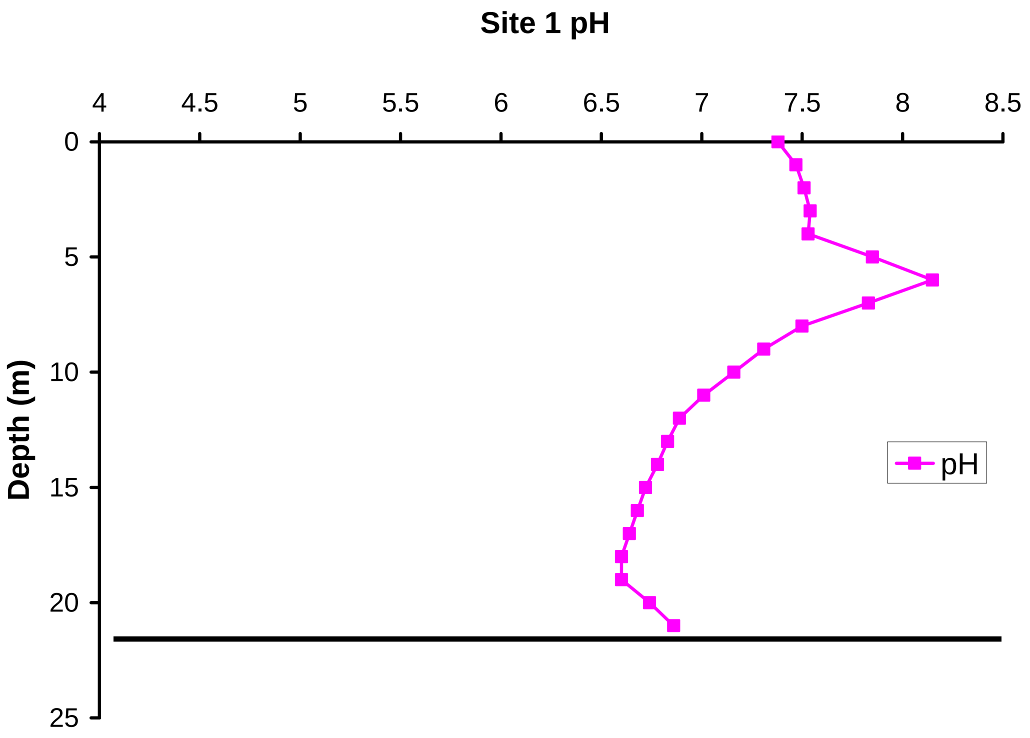

fig. 4: pH profile at site one on Devil's Kitchen Lake. Note the line indicating the bottom.

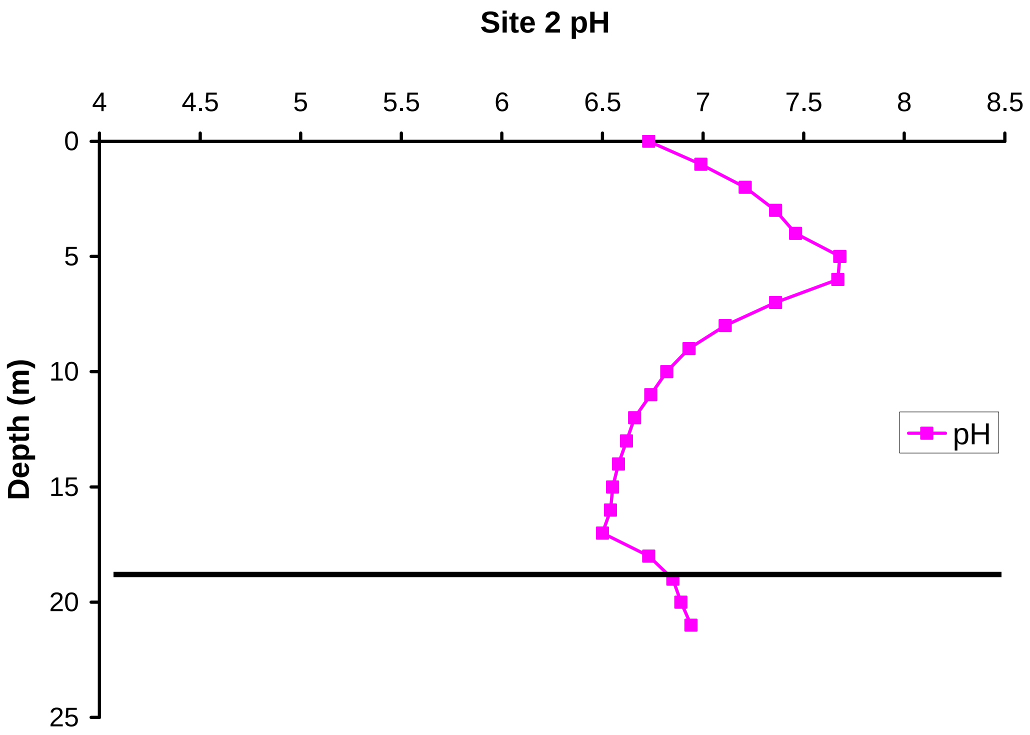

fig. 5: pH profile at site two on Devil’s Kitchen Lake. Note the line indication the bottom.

Conductivity

Conductivity was measured using a Quanta™ brand handheld meter. Conductivity was just above 0.08 mS/cm from the surface to near the bottom of the lake, with one notable exception. Near the 5m depth mark, there was a noticeable reduction in conductivity at both sites. This reduction rebounded quickly and was back to 0.08 mS/cm by the 8m mark. Because both sites were almost exactly alike in conductivity, only one profile is shown (fig. 6).

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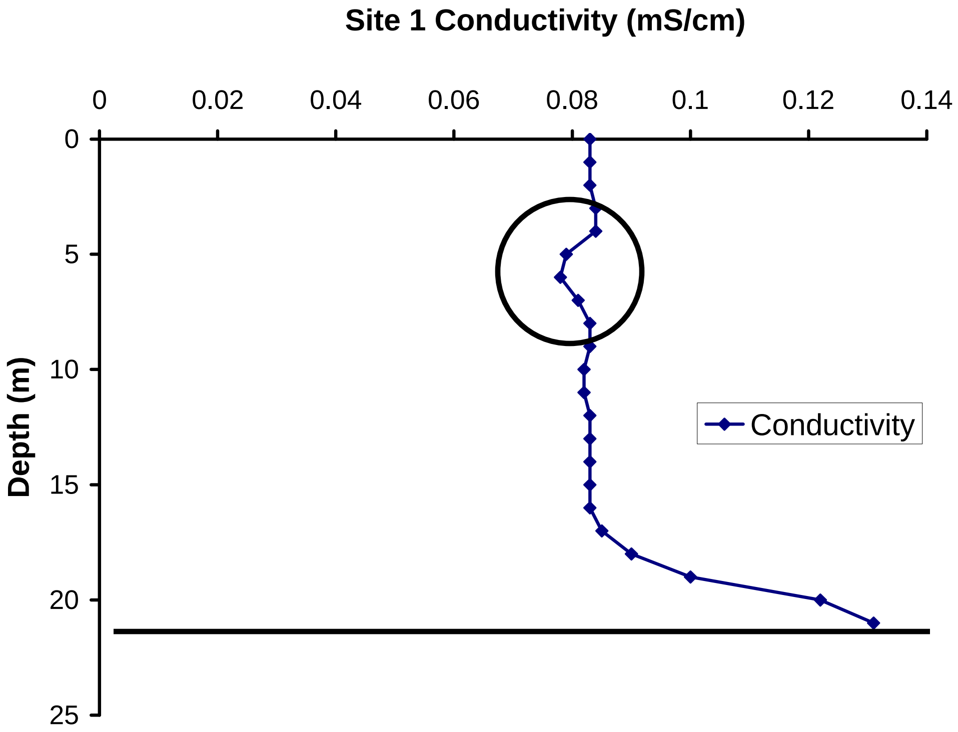

fig. 6: Conductivity at site one on Devil's Kitchen Lake. Site two was nearly identical and is not shown. Note the lower conductivity "bulge" (circled) near the 5m depth, and the line indicating the bottom.

Nutrient Content

Water quality was assessed from water samples taken at site one. Orthophosphate (PO4), ammonia, nitrate and nitrite were measured at 1m, 6m, and 10m depths. Unexpected results call into question the validity of the data. Devil's Kitchen is considered at least meso-eutrophic, and possibly eutrophic. However, the phosphorus measurements we took put the water in the hypereutrophic range. PO4 was measured at extremely high levels at the surface, and at a 10m depth, but went to zero at the 6m depth. PO4 levels this high do not correspond with the patterns observed in other variables. Similarly, there are conflicting images brought to light by looking at the nitrogen levels. Ammonia (NH3-N) was measured at levels toxic to fish and invertebrates at 1m, but this level is where the largest number of invertebrates were collected (fig. 7). This will be discussed in the discussion section.

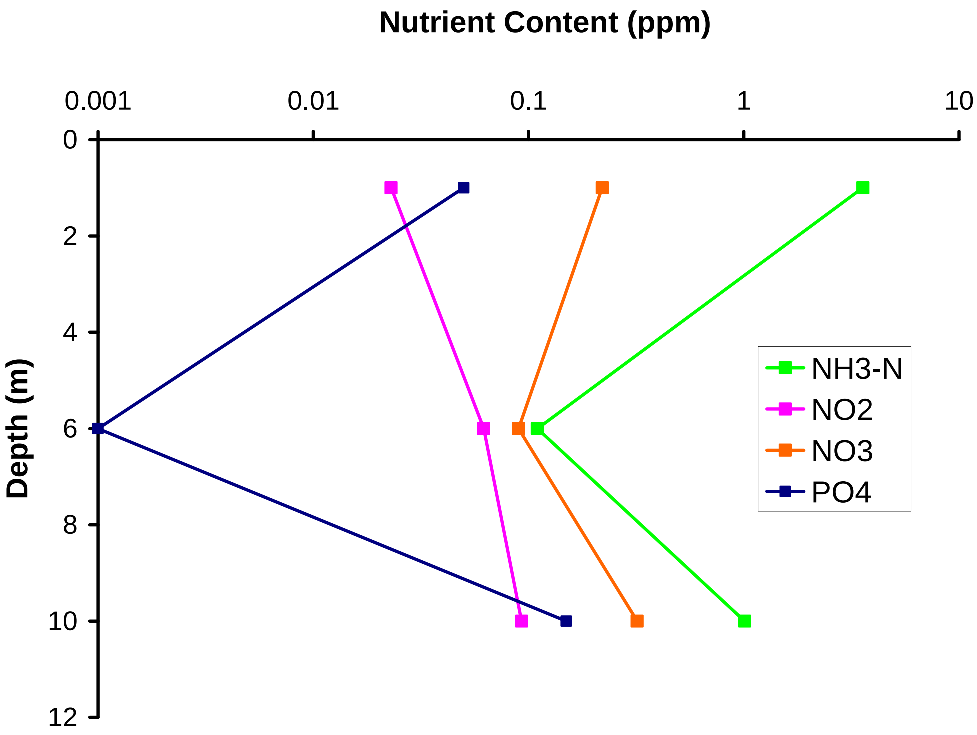

fig. 7: Nutrient measurements at three depths in Devil's Kitchen Lake. Note that NH3-N levels are above the toxic range (<1 ppm) at 1m. Also note that PO4 levels are in the range normally considered hypereutrophic. This calls in to question the accuracy of this data.

Zooplankton

Zooplankton was collected at depths of 1m, 3m, and 6m at site one using a Schindler-Patalas (S-P) zooplankton trap. Integrated samples of zooplankton were also taken from a 6m depth with a 0.5m diameter and a 0.12m diameter zooplankton net. Because densities were almost the same for the 2 methods (S-P and net), I have chosen to focus on the S-P data because of its standardized collection method (known quantity of water at a known depth). Total zooplankton / L were highest at the 1m depth (~45). Total zooplankton dropped sharply at 3m (~22) and rebounded slightly at 6m (~30) (fig. 8). Interestingly, cladocerans are the most common zooplankton at 1m, but copepods dominate at 3 and 6m. (fig. 9).

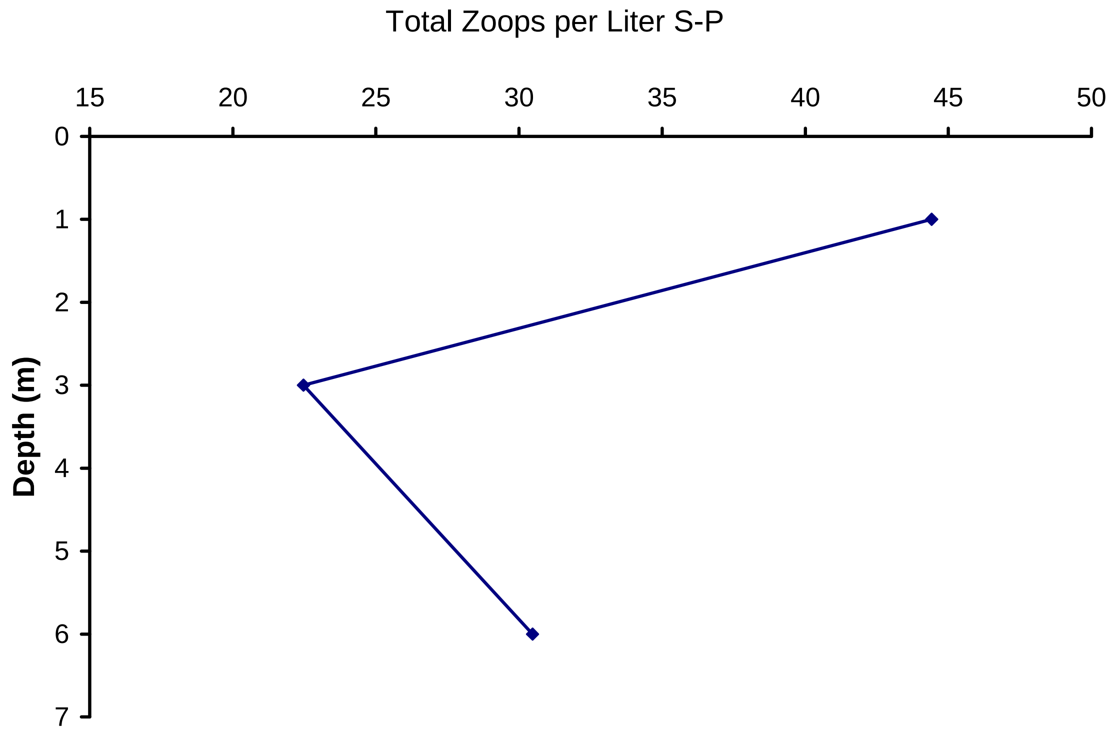

fig. 8: Total zooplankton per liter as measured with a Schindler-Patalas trap at three depths. Note the sharp drop on zooplankton numbers at 3m.

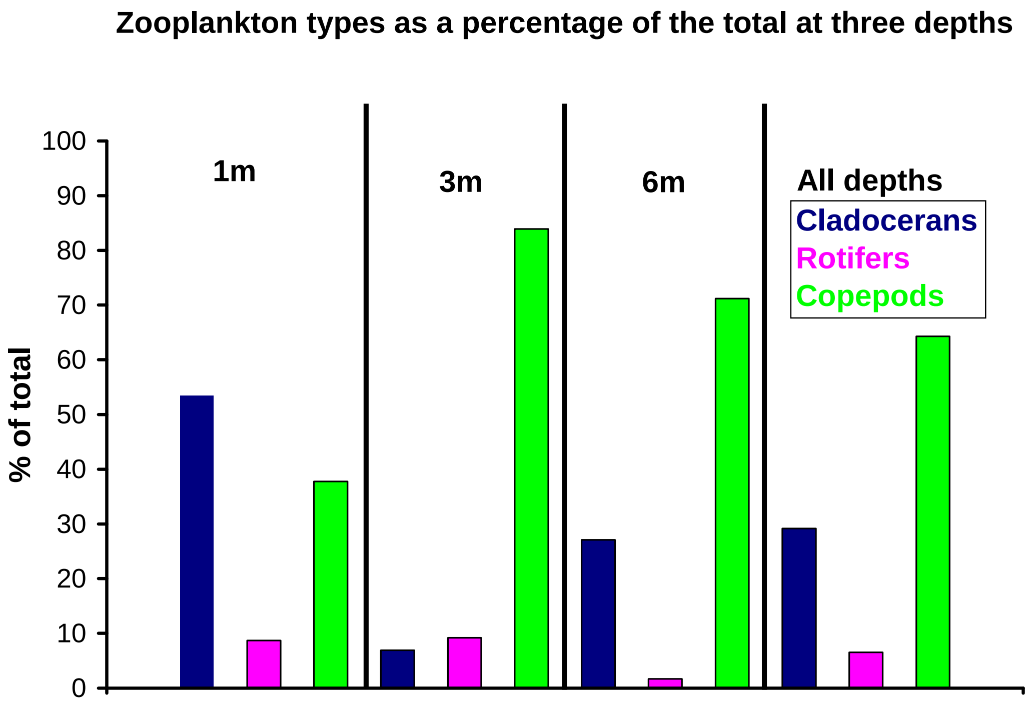

fig. 9: Cladocerans, Rotifers and Copepods as a percentage of the total zooplankton collected at three depths and at all depths combined.

Discussion

The Data we collected at Devil's Kitchen Lake are consistent with a meso-eutrophic, warm monomictic lake. Because the temperature does not stay cold enough at this latitude to promote whole-lake ice cover in the winter, Devil's Kitchen Lake stays mixed throughout the winter and stratifies only during the summer.

Temperature and dissolved oxygen (D.O.) measurements displayed a positive heterograde profile, with a metalimnetic bulge in the D.O. at a depth of approximately 5m. Because we did not measure primary productivity, the explanation for the D.O. pattern can be found in the nutrient data we collected. It is a common pattern in stratified lakes to have a phytoplankton "cloud" form in the metalimnion just above the compensation point. This is due to the tendency of phosphorus to quickly bond with oxygen and settle out of high oxygen environments. Phosphorus in its bio-available form (PO4) is dissolved in the low oxygen environment of the hypolimnion and some of it diffuses through osmosis into the metalimnion where it is used by phytoplankton. I expect that there is a phytoplankton "cloud" like this in Devil's Kitchen Lake. This would explain many of our observations.

The metalimnetic bulge that shows increased oxygen concentrations at 5m is a product of the photosynthesis taking place in the metalimnion. The excess oxygen of the photosynthetic process drives oxygen levels up (fig. 2). It would be expected that at night, as the phytoplankton continue to respire, but are not performing photosynthesis, the metalimnetic bulge would shift to the negative direction, as oxygen is used up. There are similar "bulges" seen in both the pH and the conductivity profiles.

Carbon dioxide (CO2) dissolved in water drives the pH down, making the water more acidic. As phytoplankton use up the CO2, this pushes pH up, making the water more basic. This explains the bulge in the pH profile seen near the 5m depth (fig. 4). There is a noticeable difference between the pH at site one and site two. I think this can be explained by the physical factors at each site. Because site two is more shaded than site one, it was likely that photosynthesis had not been going on that day as long at site two. Therefore, pH had not been increased by phytoplankton activity as much at site two (fig. 5).

Conductivity can be similarly influenced by phytoplankton activity. In order to grow, the phytoplanktons take up nutrient ions. This would include the ammonium ion (NH4+). It would be expected that as these ions are taken up, conductivity would be locally lowered in the zones of high biological activity. This is the observed pattern in the data, as evidenced by the negative bulge in the conductivity profile near the 5m depth (fig. 6).

Observed nutrient levels muddy the clear picture painted by all of the other data. This calls in to question the accuracy of the nutrient data. However, a close look at some of the data can help make some of the observations clearer. Ammonia levels were observed to be at toxic levels for most aquatic organisms at the 1m depth. However, this depth is also where the highest density of zooplankton was observed (44/L). The 1m depth was also the only depth where cladocerans (Daphnia, etc) were the dominant zooplankton type. The percentage of nitrogen as ammonia can follow a pattern similar to the one observed, with pH and temperature driving toxicity up. However, the zooplankton numbers tell a different story. Since cladocerans are not known to be any more tolerant of ammonia than other invertebrates (Arthur et al. 1987), my suspicion is this data may be faulty, and if this data were for official reporting, water samples should have been retaken (fig.7).

Nutrient levels at the 3m and 6m depth make much more sense when compared with our other observations. For instance, Orthophosphate (PO4) levels are observed close to zero at the 3m depth, and this is consistent with a typical meso-eutrophic or eutrophic lake. PO4 levels should be low at the surface and should not increase until the lower part of the metalimnion, this leads to the high primary productivity in this zone (discussed above). Similarly, ammonia in eutrophic systems has been shown to be low at the surface and increasing in the metalimnion and hypolimnion.

Possibly related to the observed patterns of zooplankton densities, was the freshwater jellyfish emergence that occurred during our study. Freshwater jellyfish (*Craspedacusta sowerbyi*) are predators that eat zooplankton, and could be related to the relative densities of cladocerans and copepods. Copepods are better at avoiding predation than cladocerans, and this could explain the overwhelming dominance of copepods if *C. sowerbyi* are having an effect. Another possible effect of jellyfish predation could explain the higher densities of cladocerans at the 1m depth. It could be hypothesized that the jellyfish emergence induced a reverse diel vertical migration in the cladocerans in order to avoid predation. Since *Craspedacusta* density was not measured, it is unknown if it was high enough to have this type of effect, but it would be an interesting future study.

Works Cited

Arthur, J.W., C.W. West, K.N. Allen and S.F. Hedtke, 1987. Seasonal toxicity of ammonia to five fish and nine invertebrate species. Bulletin of Environmental Contamination and Toxicology. 38: 324-331.

U.S. Fish and Wildlife Service, accessed 2007. Crab Orchard National Wildlife Refuge History. http://www.fws.gov/midwest/craborchard/history.html.