# Links Between Climate Change and the Abundance of *Cyclotella stelligera* in Alpine Lakes

Audra De Vault

Faculty Sponsor: Jasmine Saros, Department of Biology

## ABSTRACT

Alpine lake ecosystems are sensitive to changes in precipitation and temperature, which have significant effects on nutrient loading and the delivery of dissolved organic material (DOM). Previous research has shown that the diatom *Cyclotella stelligera* experienced rapid fluctuations in abundance in sediment cores, with these fluctuations correlating with a period of drier than average summers. Decreases in precipitation may lower the availability of nutrients to phytoplankton, and increase ultraviolet radiation (UVR) exposure by causing a decline in DOM. Based on patterns in the sediment records, we hypothesized that *C. stelligera* would thrive under high UVR levels and a low Si:P ratio, which are conditions that would result from decreased precipitation. The study was conducted on Emerald Lake, which is located on the border of Montana and Wyoming in the Beartooth Mountains, to determine the effects of nutrients and UVR on *C. stelligera*. A factorial experiment was established, in which UVR exposure, phosphorus, and silica were varied, and the effects of these treatments on the abundance of *C. stelligera* were measured. We found that *C. stelligera* grew equally well under all conditions tested, indicating that, unlike most other alpine phytoplankton, this species can do well when UVR levels are high. This tolerance to UVR may partially explain the patterns observed in the sediment records.

## INTRODUCTION

Alpine lake ecosystems are sensitive to changes in precipitation and temperature, which have significant effects on nutrient loading and the delivery of dissolved organic material (DOM). Because the surrounding watersheds consist primarily of bedrock, they are generally characterized by low nutrient and DOM levels. This results in an increased exposure to ultraviolet radiation (UVR).

Diatoms are a type of phytoplankton that are often used to study the effects of climate change on alpine lakes. They have a cell wall that is composed of silica, which allows them to remain well preserved in the fossil record. This project focuses on *Cyclotella stelligera*, which is a small diatom commonly found in alpine regions.

Previous research has shown that *C. stelligera* experienced rapid fluctuations in abundance in sediment cores. When compared with climate data, it was found that these fluctuations correlated with periods of drier than average summers. It was also observed that UVR did not appear to affect *C. stelligera*, which contrasts the effects seen in other phytoplankton species (Saros, unpublished). Decreases in precipitation may lead to decreases in erosion and weathering of bedrock. Therefore, this may lower the availability of nutrients to phytoplankton and increase UVR exposure by causing a decline in DOM. Based on patterns in the sediment core, we hypothesized that *C. stelligera* would thrive under high UVR levels and a low Si:P ratio, which are conditions that would result from decreased precipitation.

To test the effects of nutrients and UVR on phytoplankton, a study was conducted on Emerald Lake, WY in which silica, phosphorus, and UVR exposure were varied, and the effects of these treatments on *C. stelligera* abundance were determined.

## METHODS

*Description of Study Site*

The study was conducted on Emerald Lake, which is located on the border of Montana and Wyoming in the Beartooth Mountains. The bedrock in the surrounding watershed is comprised primarily of silica, but also contains some phosphorus. Because nutrient inputs in this area generally originate from weathering bedrock, both silica and phosphorous levels in the lakes are low (Saros et al., 2003).

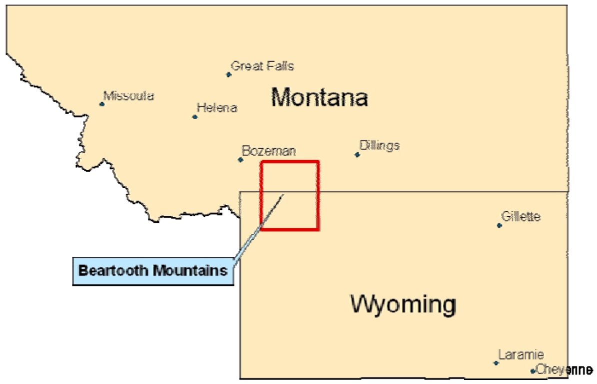


**Figure 1.** Location of Beartooth Mountains. Emerald Lake is part of the Bearthooth-Absaroka Wilderness Area, which is located northeast of Yellowstone National Park.

*Experimental Design*

The Si:P ratio was altered in order to simulate varying environmental conditions (Table 1). The current ratio, with no alterations in nutrient levels, was used as the control. Because silica is present in higher levels than phosphorus, it would increase with increasing erosion, caused by increases in precipitation. Therefore, in order to reconstruct wetter conditions, silica was added to samples to raise the ratio. In contrast, phosphorus was added to lower the ratio, simulating drier conditions.

The effects of UVR on phytoplankton abundance were also tested. Samples from each treatment were placed in the presence of UVR, or were protected from UVR. All treatments were performed in 4 replicates.

**Table 1.** Summary of treatments

| Ratio | Condition | Treatment | UVR |
|---|---|---|---|
| 50 | Dry | +P | + |
| 50 | Dry | +P | - |
| 100 | Ambient | none | + |
| 100 | Ambient | none | - |
| 200 | Wet | +Si | + |
| 200 | Wet | +Si | - |

*Experimental Procedure*

The experiment was conducted in early July. Emerald Lake was first profiled to determine current conditions and the depth at which phytoplankton were present. Samples were collected at 12m and nutrients were added according to the previously described treatments. These samples were then placed in racks and anchored in the lake for one week. Samples that were not receiving the UVR treatment were covered with courtguard to block UVR. After a week, the samples were collected and Lugol's solution was added to stain and preserve phytoplankton for analysis. Each sample was analyzed and the abundances of *C. stelligera* and other phytoplankton species were determined.

## RESULTS

No significant trends in *C. stelligera* abundance were observed among nutrient and UVR treatments (Table 2). All other phytoplankton species, with the exception of *C. stelligera* experienced a significant decline in abundance when exposed to UVR. *Asterionella* abundance increased with the addition of phosphorus, but no other species showed significant differences with phosphorus treatments. Silica treatments resulted in a significant decrease in *Dinobryon*, but no differences in other species.

**Table 2.** Summary of the average number of phytoplankton cells observed per milliliter.

| Genus | Nutrient Treatment | UVR | Average Cell/ml +/- Standard Deviation |
|---|---|---|---|
| *Asterionella* | Control | + | 127 +/- 24 |
| | Control | - | 304 +/- 57 |
| | Phosphorus | + | 161 +/- 69 |
| | Phosphorus | - | 638 +/- 113 |
| | Silica | + | 167 +/- 20 |
| | Silica | - | 347 +/- 49 |
| *Gymnodinium* | Control | + | 5 +/- 1 |
| | Control | - | 53 +/- 11 |
| | Phosphorus | + | 8 +/- 3 |
| | Phosphorus | - | 42 +/- 16 |
| | Silica | + | 6 +/- 2 |
| | Silica | - | 47 +/- 8 |
| *Dinobryon* | Control | + | 0 +/- 0 |
| | Control | - | 567 +/- 91 |
| | Phosphorus | + | 0 +/- 0 |
| | Phosphorus | - | 441 +/- 130 |
| | Silica | + | 0 +/- 0 |
| | Silica | - | 20 +/- 10 |
| *Cyclotella* | Control | + | 162 +/- 36 |
| | Control | - | 156 +/- 33 |
| | Phosphorus | + | 196 +/- 16 |
| | Phosphorus | - | 144 +/- 48 |
| | Silica | + | 139 +/- 29 |
| | Silica | - | 100 +/- 9 |

## CONCLUSION

Nutrient treatments did not have significant effects on *C. stelligera* abundance. While UVR exposure had a detrimental effect on other phytoplankton species present in the samples, it did not affect *C. stelligera* abundance. This is consistent with results from previous studies on *C. stelligera*. Further research is required to determine the factor causing *C. stelligera* to increase.

## ACKNOWLEDGEMENTS

This research was funded by the Dean's Distinguished Undergraduate Research Fellowship of the University of Wisconsin-La Crosse. I would like to thank Dr. Craig Williamson, Kevin Rose, Erin Wilcox, Carmen Daggett, and Ben Koski for their assistance with field work.

## REFERENCES

Saros, J.E., S.J. Interlandi, A.P. Wolfe and D.R. Engstrom. 2003. Recent changes in the diatom community structure of lakes in the Beartooth Mountain Range, U.S.A. Arctic, Antarctic, and Alpine Research 35: 18-23.