Comparing 40-year sediment records of aquatic ecosystem evolution in two large lakes in the blast zone of Mount St. Helens

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Introduction

- The 1980 eruption of Mount St. Helens sterilized Spirit Lake and dammed Coldwater Creek, forming Coldwater Lake.
- Sprit Lake has a floating log mat covering 20% of the surface from trees felled during the eruption.
- Ecosystem recovery related to patterns of log mat coverage has been studied extensively at Spirit Lake.
- New work at Coldwater Lake provides an important point of comparison in a lake without woody debris.

Figure 1: Site location. Mount St. Helens, Coldwater Lake, and Spirit Lake

- The two lakes together provide a unique opportunity to study how volcanic eruptions alter freshwater environments.

Field Work

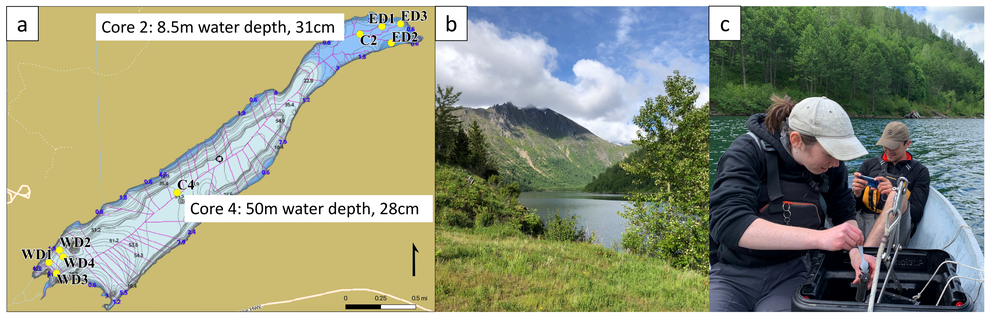
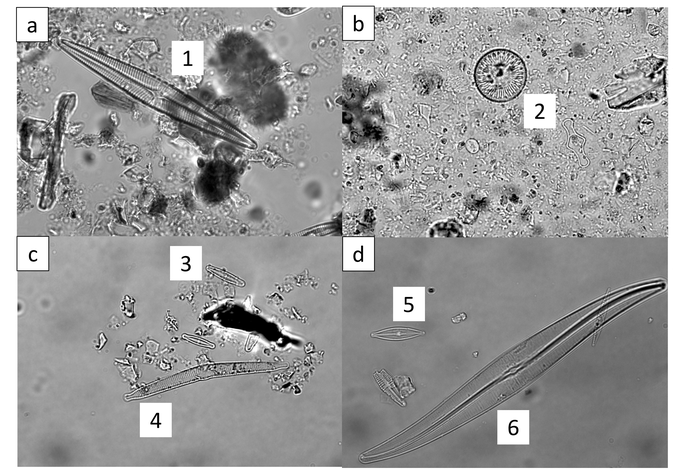


Figure 2a: Sample locations at Coldwater Lake; 2b: Coldwater Lake, Mount St. Helens National Monument; 2c: Sampling surface sediment

- Took four sediment cores using a gravity corer at various flat benches around the lake.
- Cores were taken at 9m, 30m, 48m, and 50m water depth; each core was around 30cm long.
- Took three surface sediment dredge samples between 3-8m depth.
- Took two plankton tow samples at the lake surface

Lab Work



Figures 3a-d: Common diatom taxa found in Coldwater Lake.
(1) Navicula sp.
(2) Cyclotella sp.
(3) Achnanthes minutissima
(4) Hannaea Arcus
(5) Anomoeneis vitrea
(6) Gomphonema acuminatum

- Extruded and sectioned the cores into 1cm intervals
- Dried and weighed subsamples for organic geochemical analysis
- Cleaned, prepped, and diluted subsamples to make diatom slides
- Identified and counted diatoms from 16 samples

Part One: Temporal Changes in Coldwater Lake

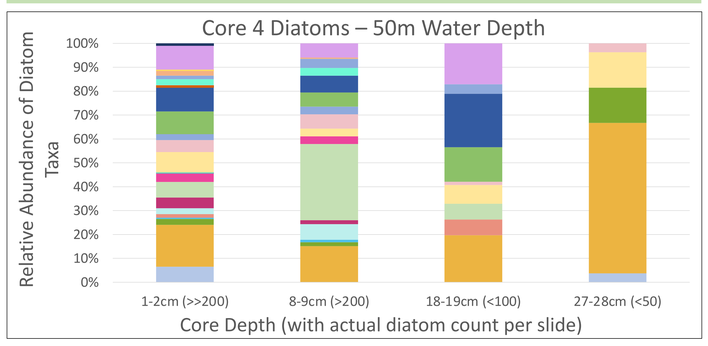


Figure 4: Changes in diatom taxa from the top to the bottom of the deepest core taken at Coldwater Lake.

- Younger sediment displays much more diversity in diatom taxa, as well as a higher abundance of diatoms overall, implying that nutrients and substrate in the lake have increased over time as the lake has developed.
- There is less change in diversity between the top few centimeters of sediment than between the bottom few centimeters, implying that the lake has become relatively stable in recent years.

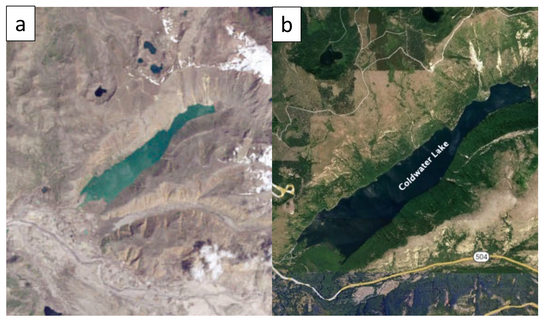


Figure 5a: Coldwater Lake, 1984
Figure 5b: Coldwater Lake, 2021

- The morphology of Coldwater Lake has not changed since 4 years after its formation.
- Coldwater Lake in 1984 appears slightly soupier than it is today, meaning it had higher nutrient availability in the past

Part Two: Spatial Variability in Coldwater Lake Diatom Assemblages and Biogeochemistry

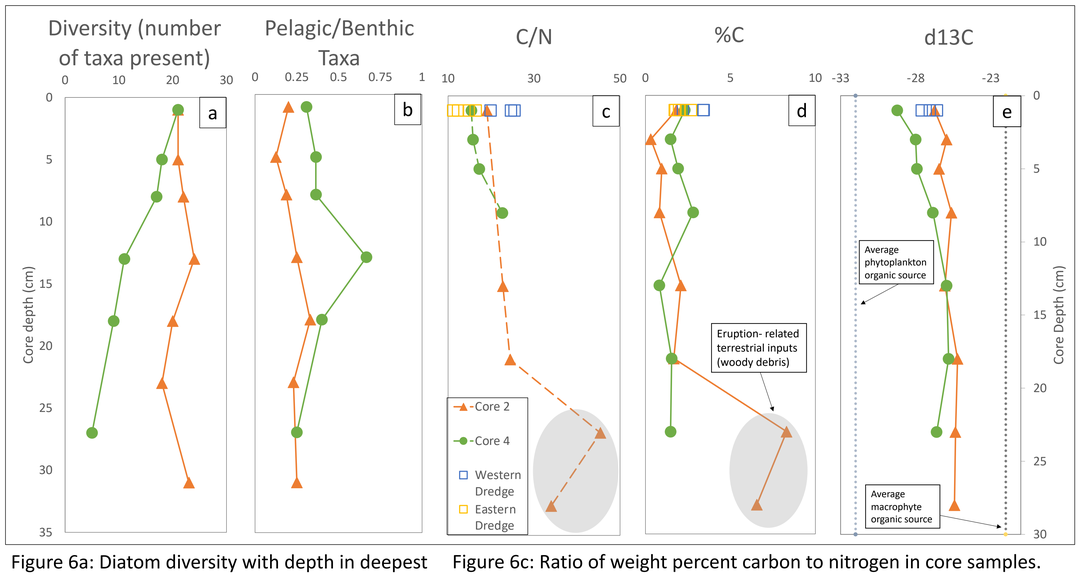


Figure 6a: Diatom diversity with depth in deepest and shallowest cores taken at Coldwater Lake.
Figure 6b: Ratio of pelagic to benthic taxa at Coldwater Lake.
Figure 6c: Ratio of weight percent carbon to nitrogen in core samples.
Figure 6d: Weight percent carbon in core samples.
Figure 6e: Carbon isotope data in core samples.

- The diversity of diatom taxa in C4 has increased over time, while taxa diversity in C2 has remained similar to the top 10cm of C4 (Figure 6a).
- While C4 has had a slightly higher ratio of pelagic to benthic diatom taxa over time, both cores are consistently dominated by benthic taxa. (Figure 6b).
- C4 and Eastern dredge samples have slightly lower C/N values, meaning their organic source is more planktonic (aquatic). C2 and Western dredge samples have higher C/N ratios and have a more terrestrial organic input of macrophytes (Figure 6c).
- Both Cores 2 and 4 have stable, similar, and relatively low %C values through time. Dredge samples on average have slightly higher %C values. High values in low C2 samples could be due to eruption-related terrestrial woody input (Figure 6d).
- Cores 2 and 4 had similar carbon isotope ratios until about 10cm where they start to diverge. Currently, d13C values suggest more organic input from planktonic sources in the deep lake (C4) and more macrophyte sources in the shallow lake (C2) (Figure 6e).

Coldwater Lake Conclusions

- Most organic productivity in the deep lake (C4) is coming from the water column, while most of the productivity in the shallow lake (C2) is coming from macrophytes (Figures 6b, 6c, 6e).
- Diatoms and biogeochemistry support a conclusion that Coldwater Lake has been a stable, oligotrophic lake in the recent past with no significant changes in nutrient availability. Google Earth imagery suggests that the lake may have had more nutrients early in its formation, so our data may not have reached that far in the past (Figures 5, 6b, 6d).

Comparison to Spirit Lake

- Spirit Lake has more pelagic diatoms than Coldwater Lake, implying that Coldwater has lower nutrient availability.
- Spirit Lake had a eutrophic period marked by a spike in planktonic diatoms. Coldwater lake is lacking this spike, meaning it either never went eutrophic or our cores don't reach far enough back in the sediment record to see this.
- Differences between the two lakes are mostly explained by their geologic formations. Spirit Lake was directly in the path of the debris flow, causing an influx of nutrients, while Coldwater Lake was formed as a brand-new lake on top of a stream bed.
- Both lakes have stabilized and reached ecological equilibrium after the eruption of Mount St. Helens.

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