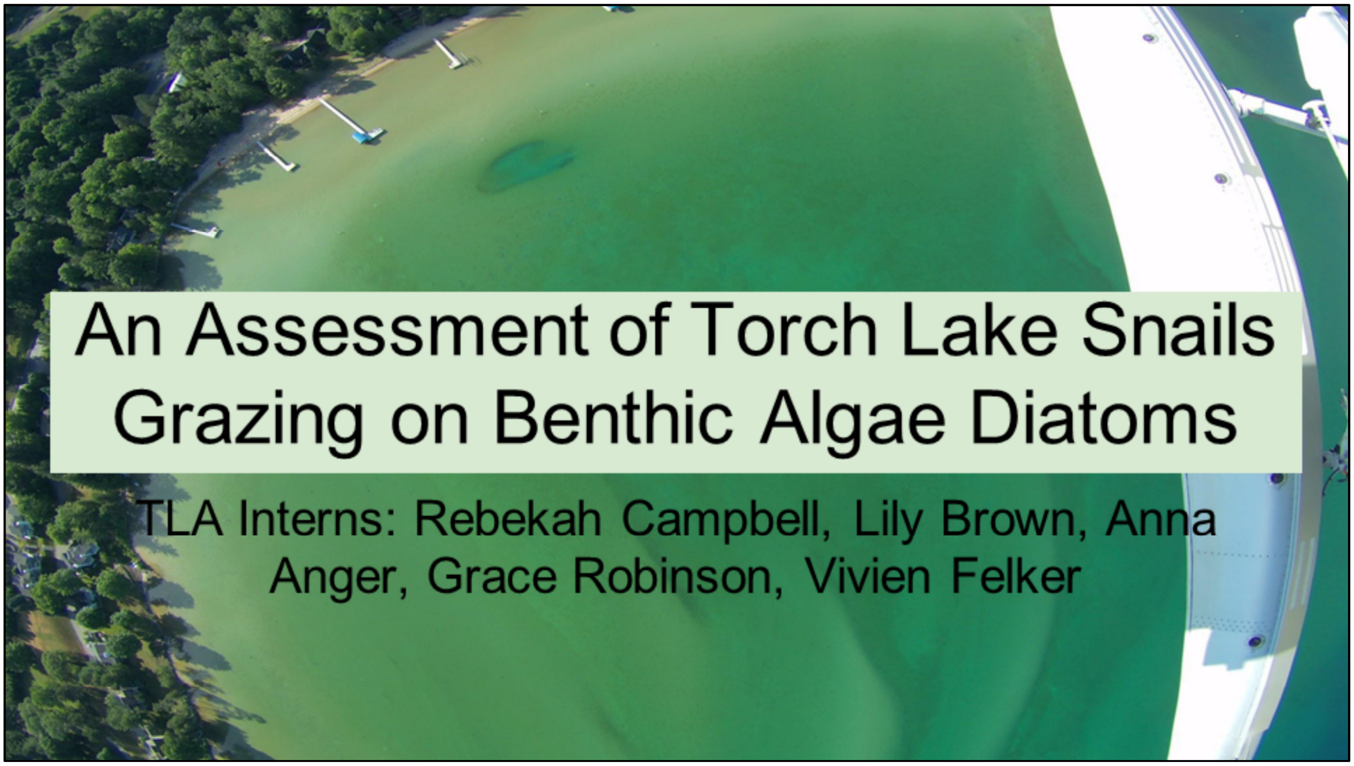


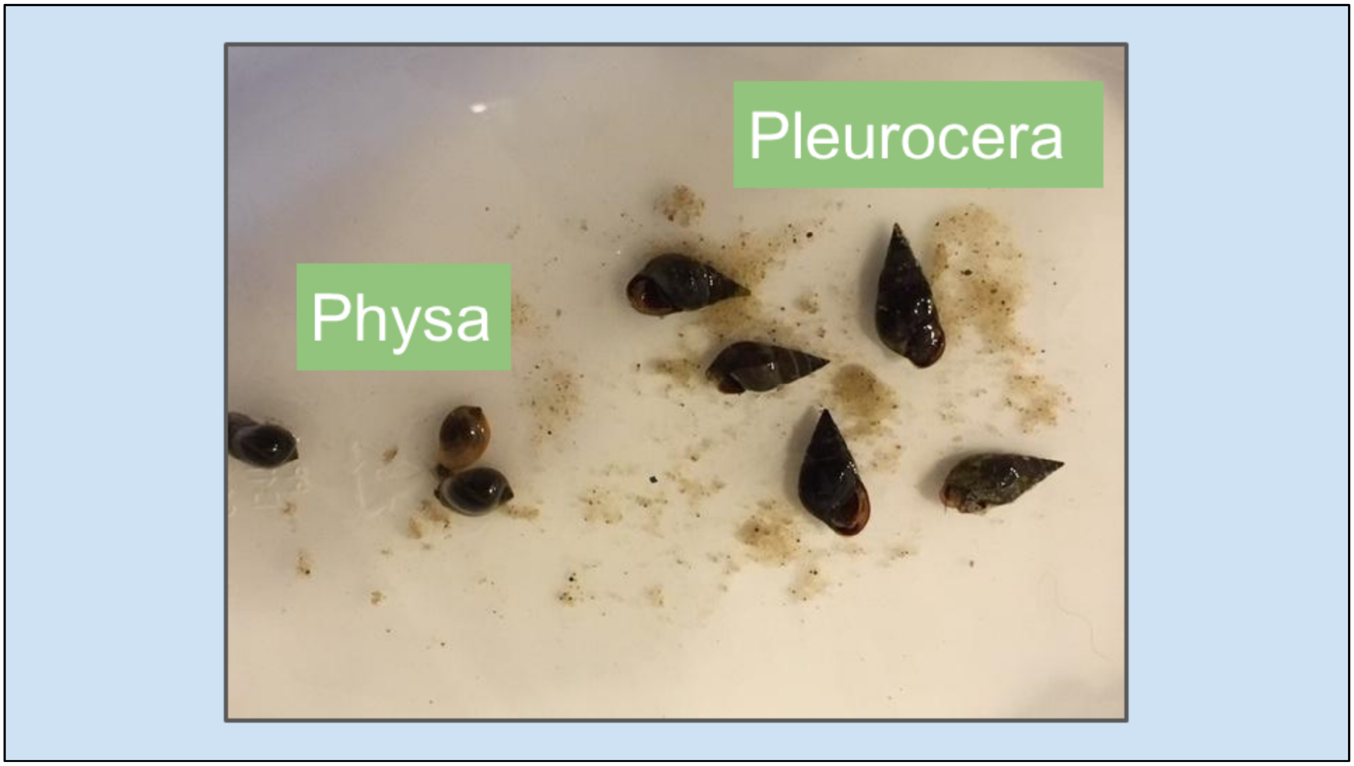
For our project we chose to investigate the relationship between snails on the bottom of torch and the benthic algae diatoms. These diatoms are what exist in the algae as seen in this aerial photo. The darker green color shows the growth of the algae and how it threatens the beautiful crystal clear legacy torch lake has always had. These matts of benthic algae can reach up to a quarter to a half inch thick, which is a part of the aesthetic issue that influenced our study. Not only did we pick this topic to research because of the unappealing color, but also because Three Lakes has been studying the root cause of Golden Brown Algae for the last few years, and we wanted to extend the research to how nature and other organisms like snails contribute to it.

The pattern of the benthic algae mats changes with the wind patterns. Please hold questions until the end.

The Questions

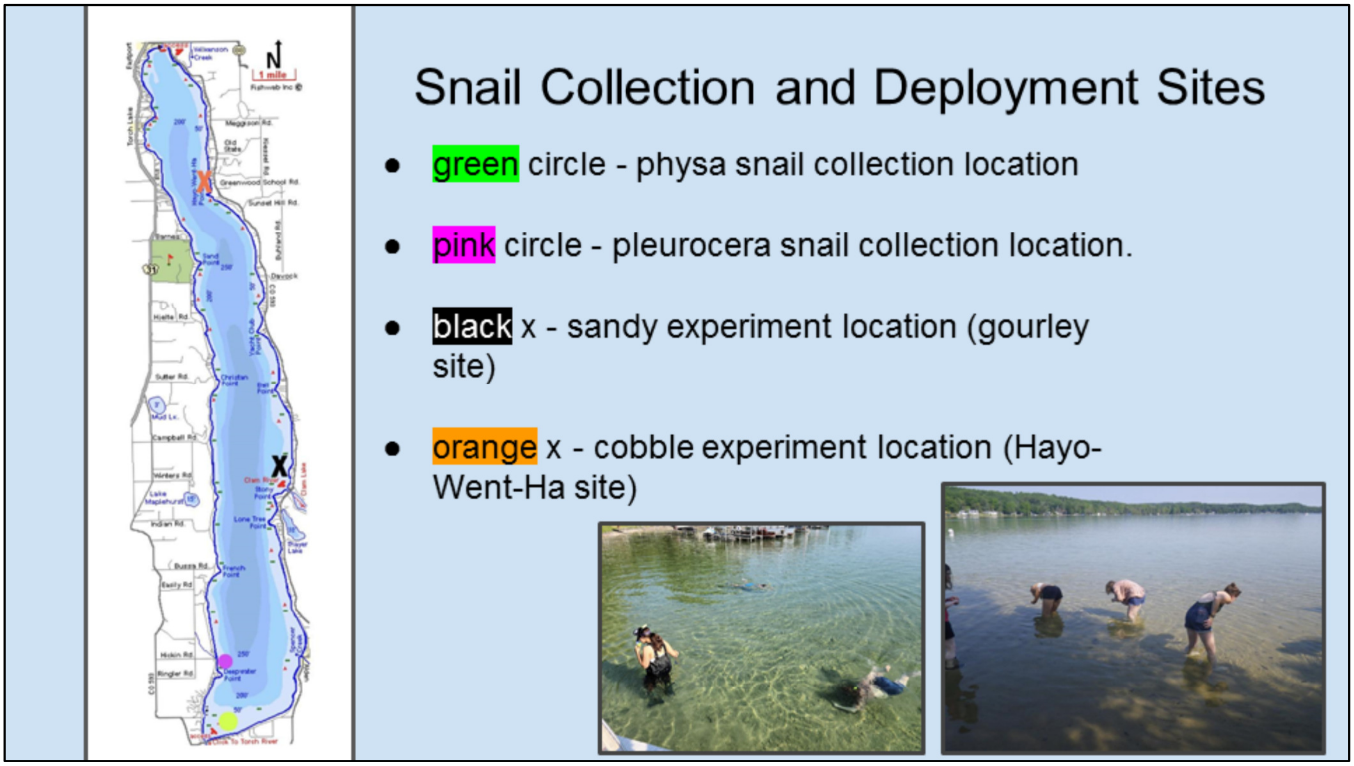
1. What was available for the snails to eat?
2. What did they end up eating?
3. What did they actually digest?

To guide our project we made a list of 3 main questions we wanted answers to. The first question was what was available for the snails to eat? This would help us to gain a better understanding of what types of diatoms the snails were exposed to. We planned to find this out by looking at the benthic sediment at each of our sites and identifying what kinds of diatoms were there. The 2nd question was what they ate. This would tell us whether or not the snails were selective eaters or if they were simply eating what was available to them in the benthos. Now this we found out by comparing the benthic sediment diatoms to what we found in their feces. The last question we wanted answers to was what the snails actually digested. It's one thing to look at their feces and see what was eaten, but whether or not it provided nutritional sources and was broken down is another. This could be found out by comparing which diatoms were alive and which were dead in their feces. The dead ones would most likely be digested whereas the alive ones could just be the result of bycatch. The picture on the right is of us reflecting on our day at the Gourley site thinking of how we could improve on our process for next time. Now as far what we ate and digested during the experiment, as pictured on the left we all fueled up on some muffins after a hard day of looking at snail feces.

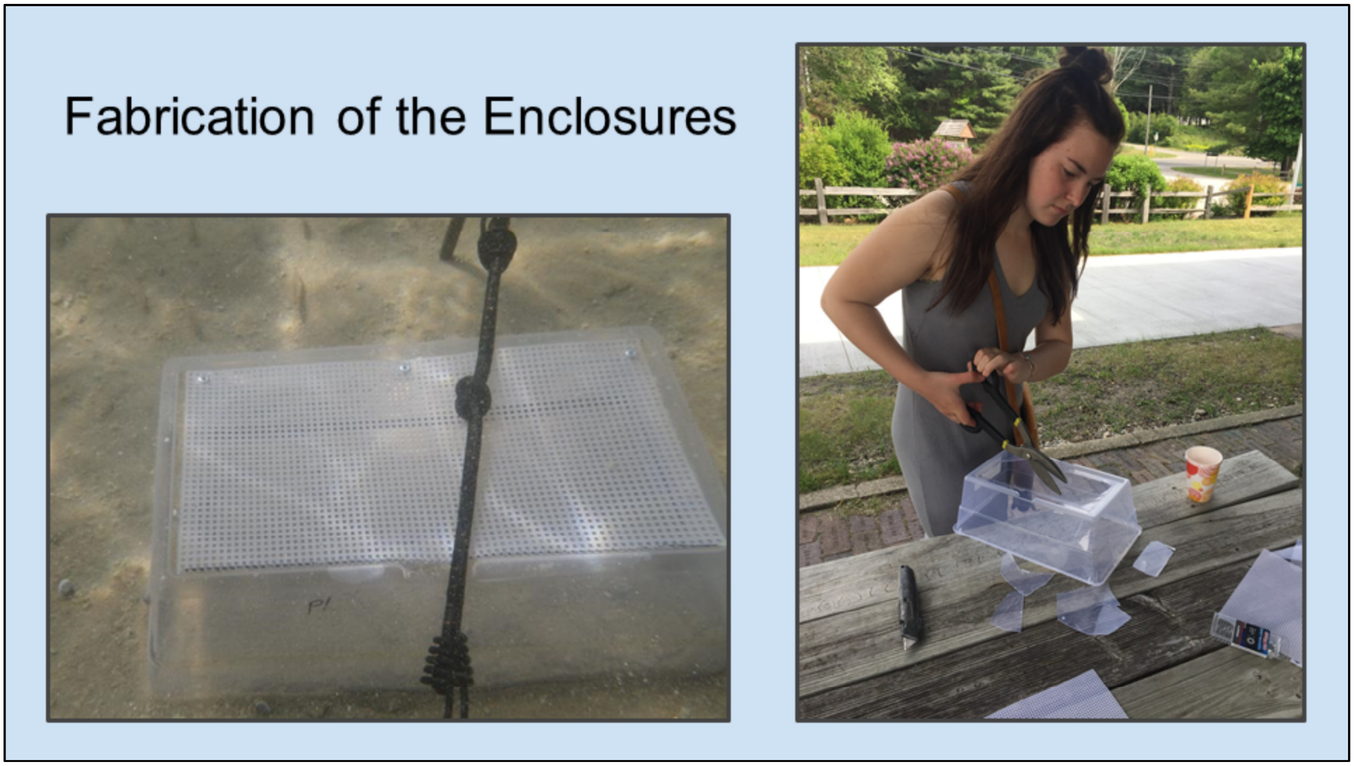


These are the two types of snails we used in our study. On the left are the Physa snails, which we extracted from the Torch Lake Sandbar, and on the right are the Pleurocera snails from the Robson-Morse property on Deepwater point. We picked these 2 species mostly because they were what was most abundant st the sites and gave us a good comparison of what is most present at those areas. An interesting side note to our study that we found out from the help of Becky was that the Physa snails carry swimmers itch while the Pleurocera snails did not. Of course these are only a few of the 216 snails collected. We ended up placing 12 snails in each enclosure at the Gourley site, and 6 in each at the Hay-o-Wenta site. And now Lily will describe the methodology including how we went about collecting these snails and how we built the enclosures.

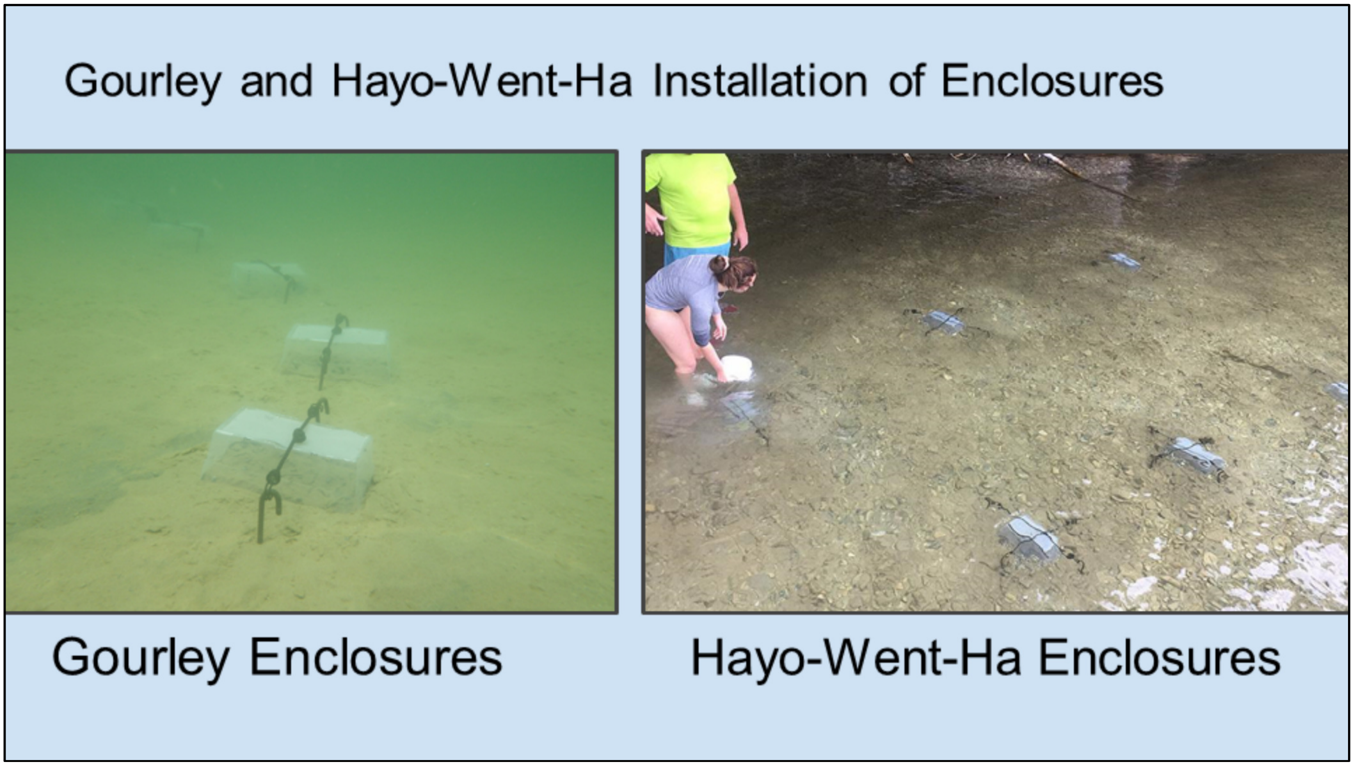
We collected 216 snails
And 18 benthic algae sample



This slide shows the locations we collected snails and The pink location had only pleurocera snails and the green location had only physa snails



To make the enclosures, we cut off the bottom of a small storage box and attached a piece of cross stitch mesh using rivets. This allowed us to lift up the top and place the snails in without lifting the whole box up.



We chose to use enclosures because we wanted to make sure the snails would have lots of benthic algae to eat.

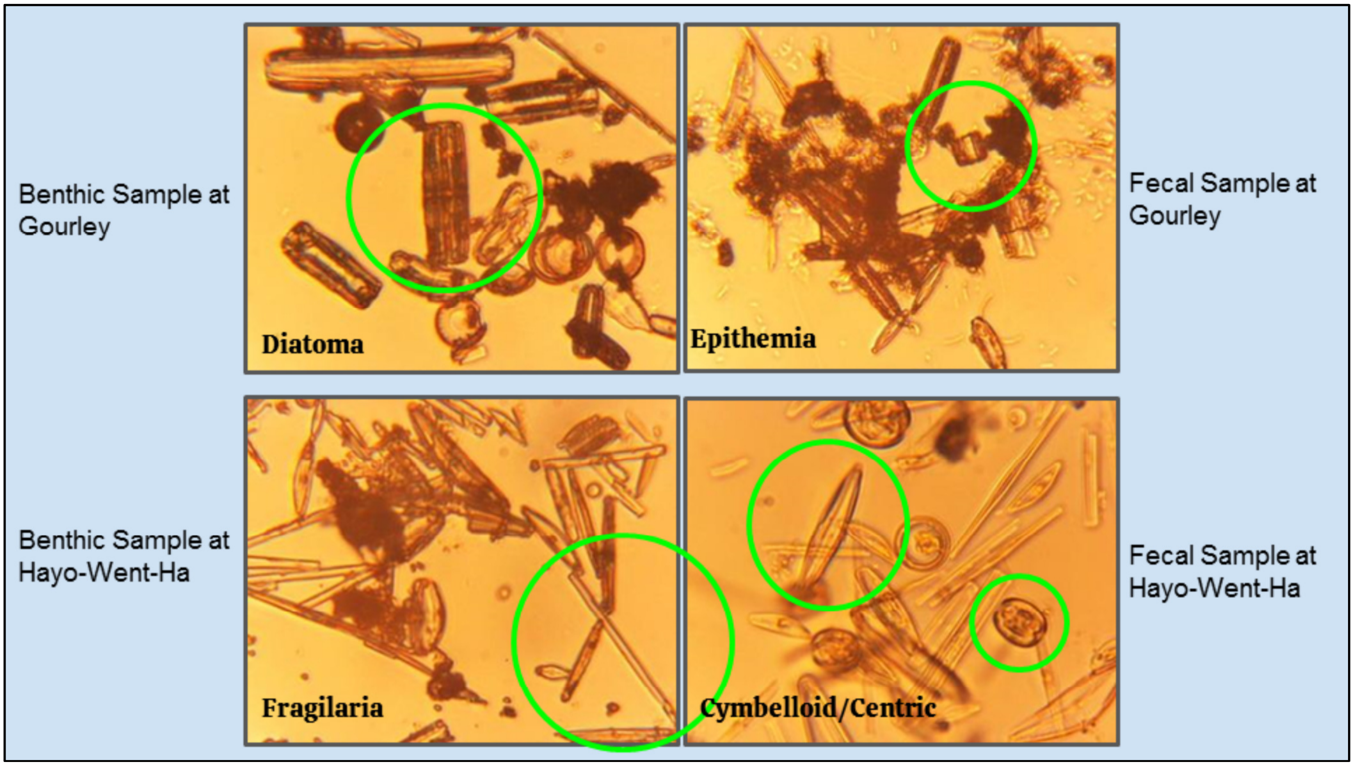
At the gourley site, we used a sledgehammer to pound two steel rods into the benthos.
Once those were in, we set the enclosure horizontally between them and poured in twelve of one species of snail.
We stretched a bungee cord across enclosure to secure it.
When it was time to collect the snails, 6 of the 12 enclosures had drifted away.
They were able to slip out from under the bungee cord because of the current in the water.

The enclosures that stayed in place had very few snails still in them.
We think they were able to crawl through the flap and/or burrow in the sand to escape.

The hayowentha site had a cobble floor which made it harder to pound the steel rebar in.
We had to get more weight behind it to get it through the rocks.
We learned from the gourley site and pounded four rods instead of two.

The crisscross of bungee cords kept the enclosures in place much more effectively.
We only lost one and that was because of a storm.
The storm also caused excess sediment to enter the enclosure through the mesh and bury the snails.
This also made it harder to find the snails.
At both sites, once we found as many snails as we could, we put them back into individual cups so we could collect their feces later.

Now anna it going to explain the diatoms and what we learned from their presence



Firstly, to understand this study, we need everyone to better understand diatoms. All of these labeled and featured diatoms are specific to diatoms founds only in the Golden Brown Algae, making them significant in our findings on whether or not they are selectively eating and controlling the GBA.

Quadrant 1 and 2 are microscopic images from Gourley, left being a benthic sample, and right being a fecal sample, same follows for Hayo-Went-Ha.

We were extremely grateful during this study to have an expert of diatoms, Dr. Jan Stevenson, give us a crash course on what we need to know about them. We learned they are one of the largest oygen producers in Torch Lake, using materials other than chlorophyll to make them brown, making them the star of this study.

Looking at our own samples, here are the diatom genuses we saw:

In quadrant 1, a Diatoma. in this image, the faint vertical lines on this diatom indicate what it is.

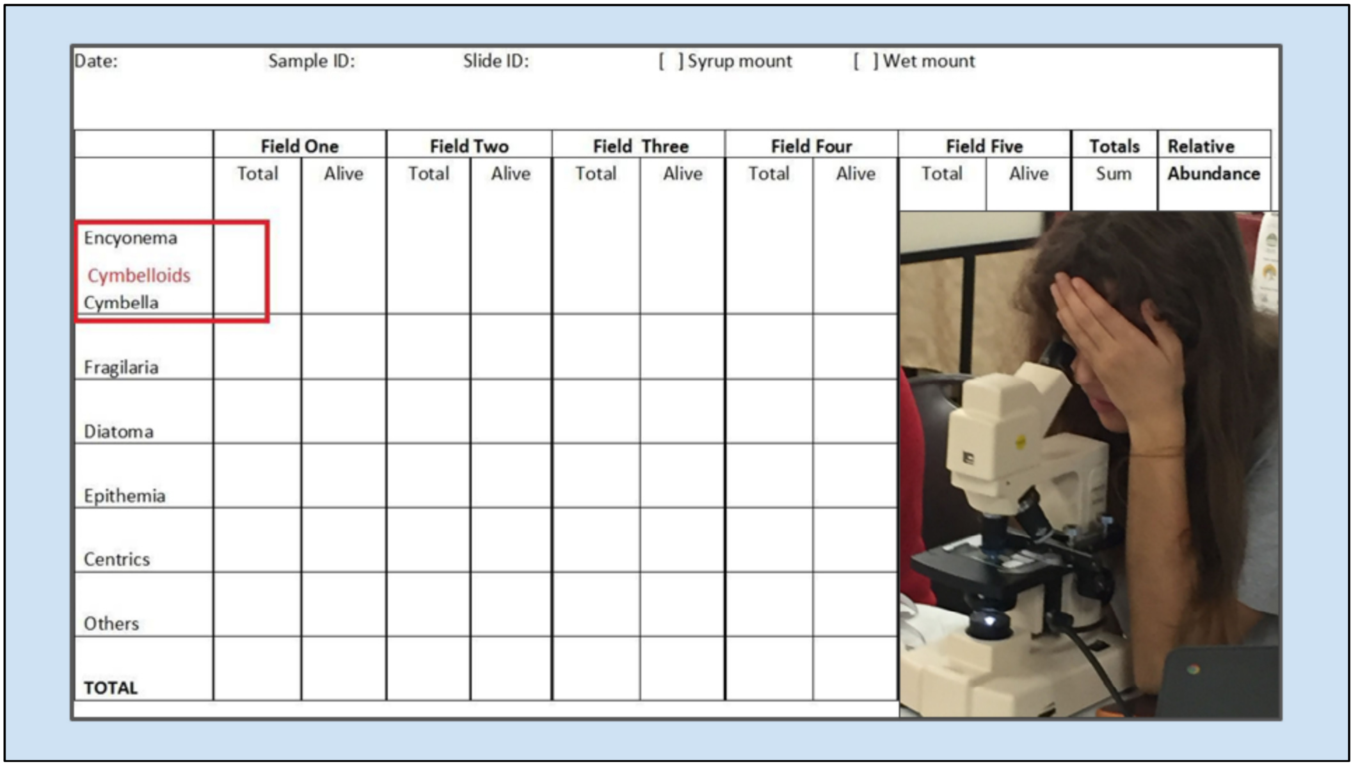
In quadrant 2, we see an ity bity epithema, characterized by its “pocket” in the center.

In quadrant 3, we have a fragilaria, a much longer, skinnier diatom.

Finally in quadrant 4, we have a cymbelloid and a centric.

A cymbelloid is more of a lemon shape, while a centic is always a perfect circle.

Looking at 5 fields per slide, we surely saw, differences between how the slides appeared, Gourley seeming to be abundant in diatoma and epithemia, while Hayo-Went-Ha had far more fragilaria.



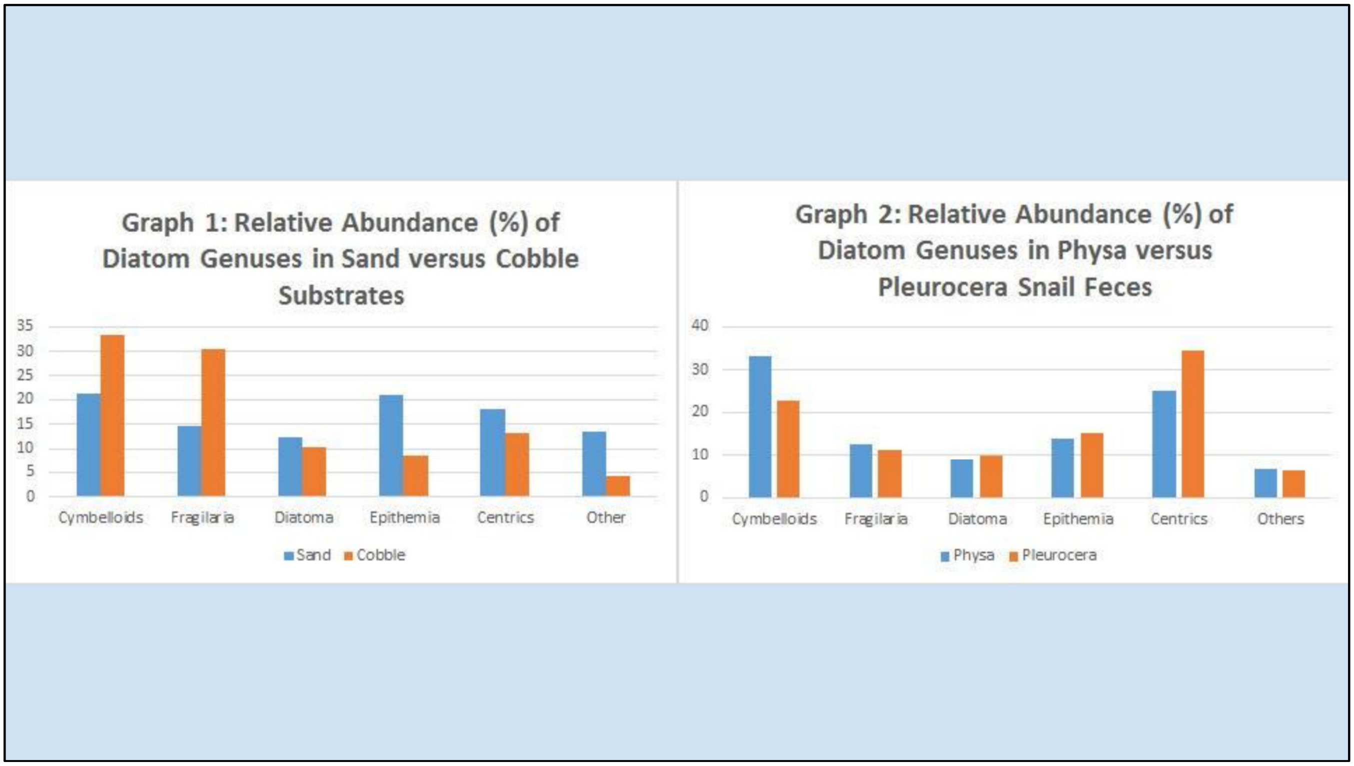
Date: Sample ID: Slide ID: [ ] Syrup mount [ ] Wet mount

	Field One		Field Two		Field Three		Field Four		Field Five		Totals	Relative
	Total	Alive	Total	Alive	Total	Alive	Total	Alive	Total	Alive	Sum	**Abundance**
Encyonema Cymbelloids Cymbella												
Fragilaria												
Diatoma												
Epithemia												
Centrics												
Others												
TOTAL												

Although we could see the fields, and much better directly under the microscope than in images, it was challenging to do with only 1 eye.. Here is our innovative intern Lily.

Behind it, is a tally sheet, you can see two diatoms named in the upper left hand corner-cymbella and encyonema-which we categorized as cymbelloids. At the magnification available in the study, we could not confidently distinguish between them were therefore couldn't be accurately observed. Furthermore, our consultant, Professor Stevenson, told us that diatoms that resemble one another tend to behave similarly and agreed with our naming of the two as “cymbelloid”.

We analyzed the data from the slides in a spreadsheet, and now we are going to show the most meaningful results.



The loss of some of our study enclosures and snails, made our sample size smaller than we had hoped for. This could have prevented us from finding what may have been true differences because our numbers were small and the ranges of our observations were large; however, after examining the remaining data, we had a handful of sure conclusions.

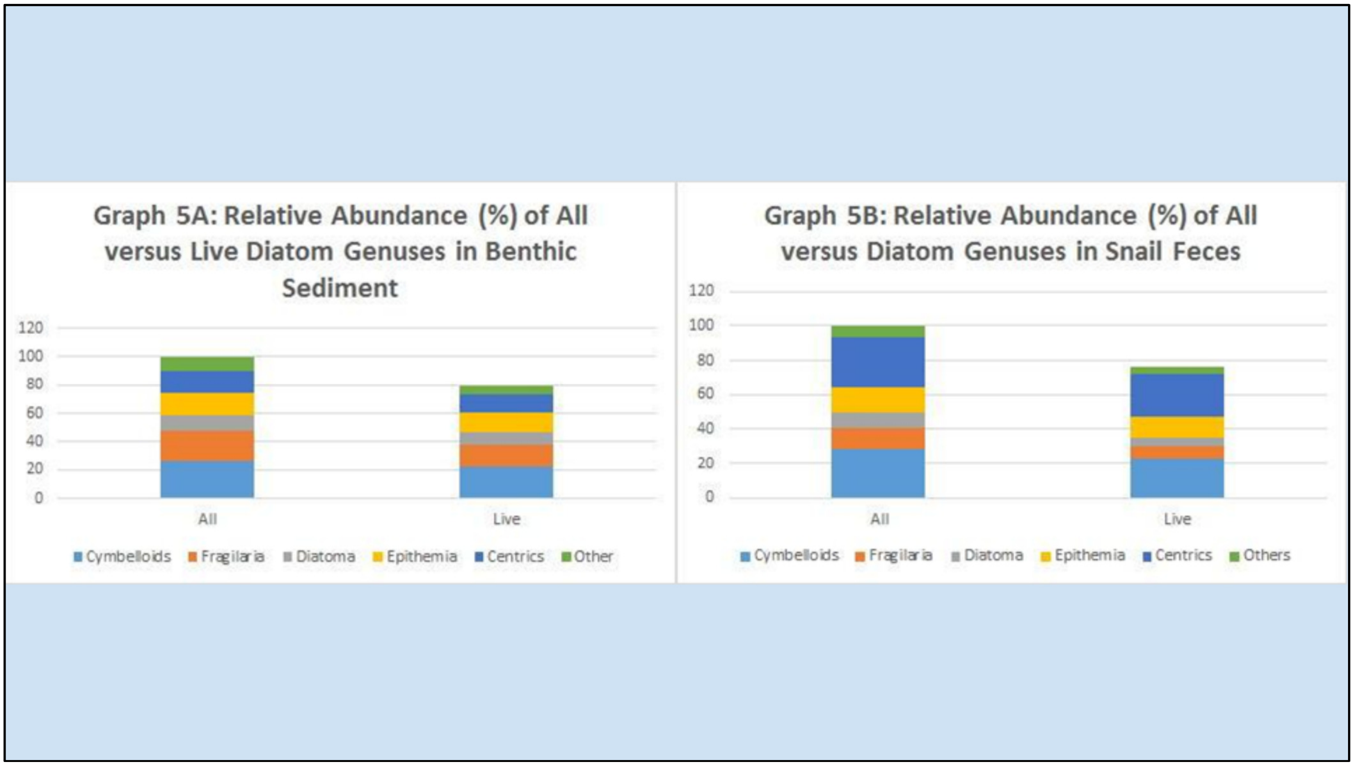
On the left, Graph 1 is the relative abundance of the different benthic diatom genus types according to our two locations-a sandy lake bottom at Gourley and cobble lake bottom at Hayo-Went-Ha.

Looking at the graph, we can see what we saw under the microscope and in the previous slides, a greater abundance of cymbelloids and fragilaria in the cobble, again, Hayo-Went-Ha, and more Diatomas, Epithemias, and Centrics at a sandy substrate, Gourley.

Although bar heights and slides appear to present major differences, most notably for Cymbelloids, Fragilaria, and Epithemia, with the minimal samples and wide range of results, no statistically significant differences could be shown between these substrates, and a student T Test was performed on the datasets and concluded likewise. To better assess the data from Graph 1, information was pooled for comparison in all following slides.

This data provides us with the answer to our first question, what is the benthic diatom composition.

Graph 2 shows the relative abundance of diatoms in both Physa and Pleurocera fecal matter. As with the substrates, no statistically significant results prevailed from a Student T test, meaning that an average of both snail types from both locations would provide us with a large, more accurate representation of the collected data. This data was also pooled for comparison.

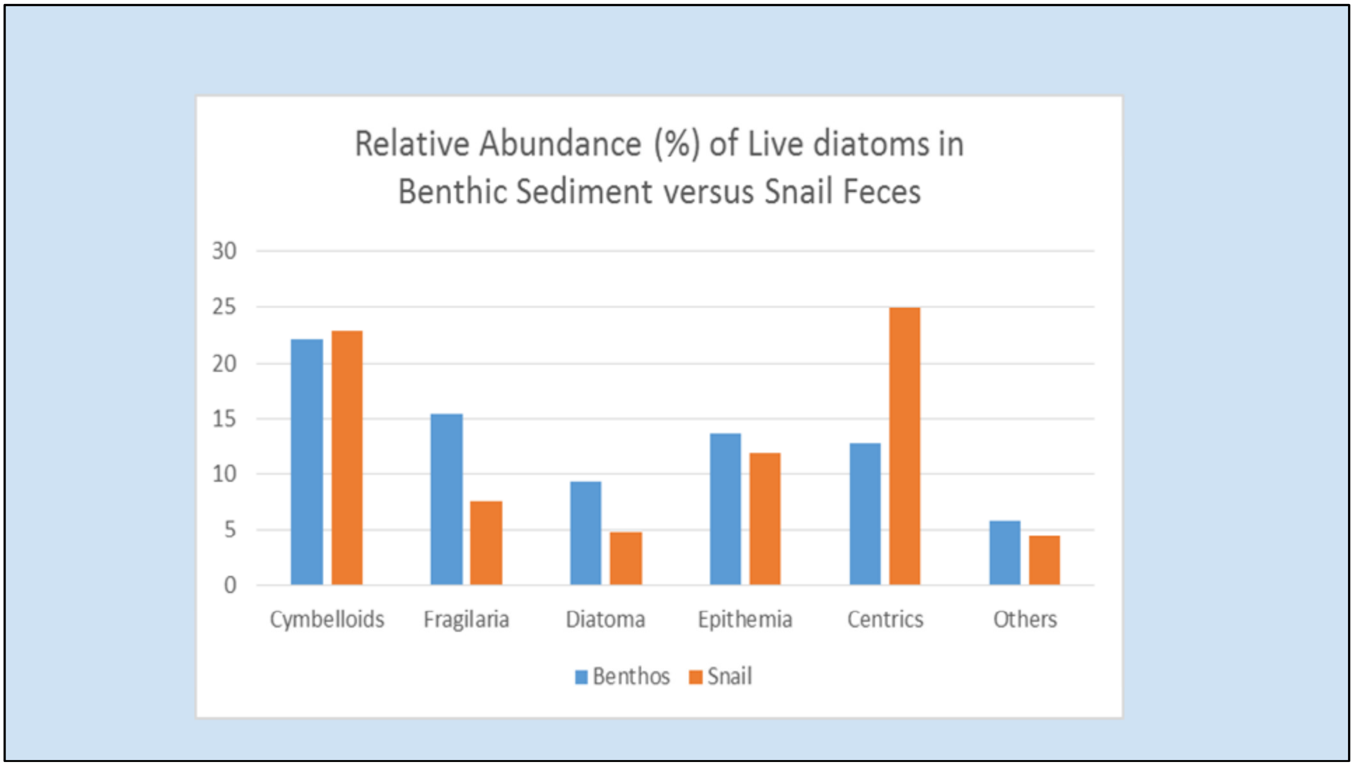


One of our remarkable findings in the project was how many diatoms actually lived. Looking at Graph 5A, we see that out of all of the diatoms in the benthic sediment available to the snails, most, 80% were alive. In Graph 5B, in the snail feces, after consumption, just under 80%, 79% still remained alive. This really tells us what the snails digested, or lack thereof, given that the snails excreted a high percentage of live diatoms which passed straight through them. It could be said that the snails aren't controlling the algae, pretty much because they're still coming out undigested.

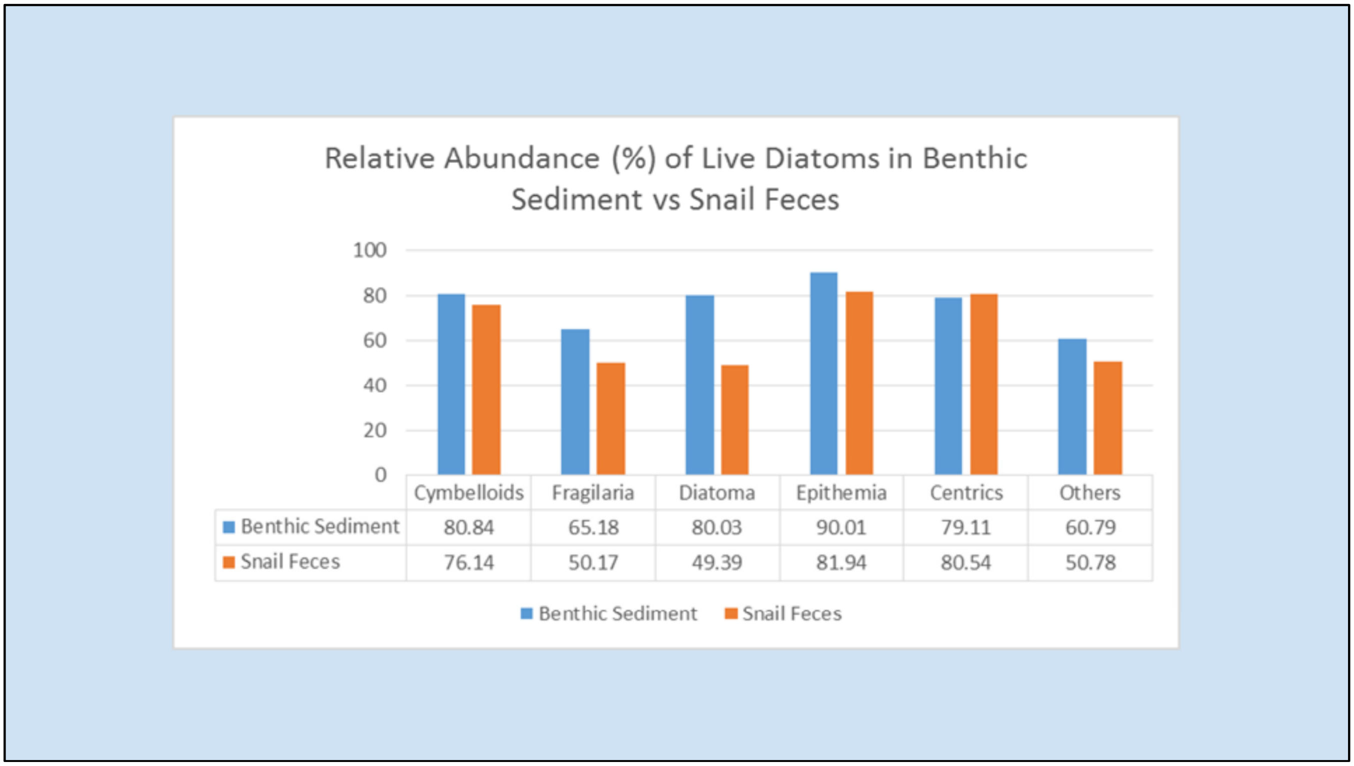
However, what was digested, may have left no trace or may not even be diatoms- bacteria and musaleges coating the diatoms also eaten by the snails-but the most common indicators that a diatom was digested was the reminisce of their broken glass shell or colorless appearance, which was hard to miss.

The abundance of alive diatoms in the benthic sediment was originally thought to decrease in the snail feces, but, this was proven inaccurate and provides us with insight as to what else the snails could be eating, if most of it was not observable in this study.

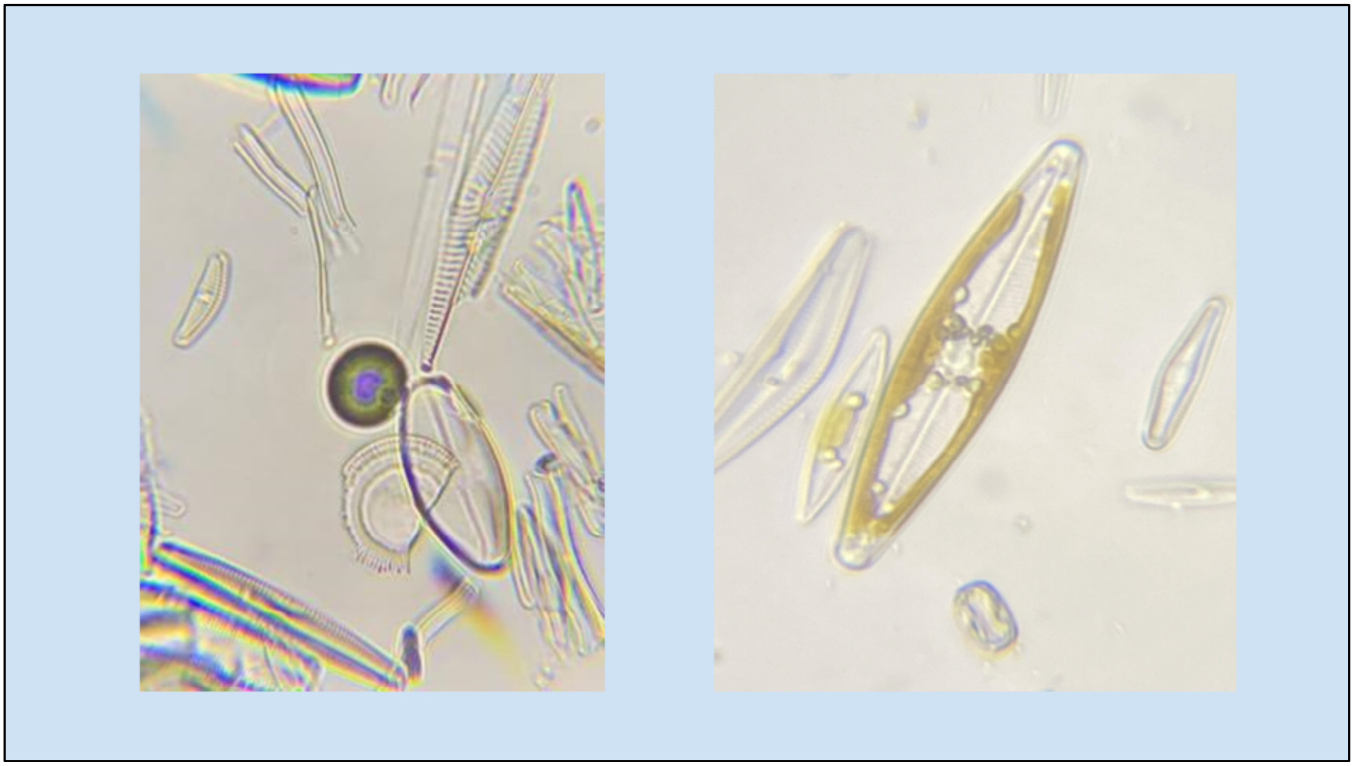
Grace will now elaborate on other project results.



The graph shows the relative abundance % of live diatoms in benthic samples versus snail feces samples. One significant finding that we found was that there was a higher percentage of centrics in the snail feces than other diatoms. We found more centrics than previously thought, as most previous studies of Torch did not consider Centrics to be abundant in the lake.Dr Stevenson gave us the theory that Centrics may be more abundant in snail feces than benthic sediment because Centrics live on top of the benthic mats instead of living in the benthic sediment. Centrics also may contribute to the color of golden brown algae since almost all of them were still alive even after being eaten by the snails..



This graph shows the relative abundance % of each type of live diatoms in the all the benthic sediment vs all the snail feces. A significant finding that we found was that Diatoma was the only diatom that had a significant number digested by the snails. Almost all of the diatoms were not digested. This was shown by the broken and colorless glass shells left over in the snail feces. (they were still alive after being eaten) This helps us conclude that that they are not digesting most of the diatoms that they eat and that they do not get much nutritional value fom diatoms.



The slide on the left shows a broken centric shell compared to an alive centric. The slide on the right shows an alive cymbella that is filled with color that is next the a colorless shell of a cymbella.

Conclusion

- The Diatoma and Centrics have proven to point to separate conclusions
- The sand and cobble benthic substrates appeared to have similar diatom composition
- The snails showed no evidence of selective grazing, with the possible exception of centric diatoms
- Snail grazing appeared to have very little impact on the amount or composition of the benthic algae

Upon analysis of the data, it was discovered that there was no clearly discernible difference between the two species of snail and/or the type of substrate they grazed upon. Therefore, we combined all corresponding data sets together from the variables that are the snail and substrate types, respectively. As noted in figures 1 and 2, however, there is a statistically significant difference of $p < .003$ by the student's T-test between the number of live Diatoma diatoms found in the benthic sample and those found alive in the snail feces, thus making them highly available to the snails. This trend was followed less obviously through all species of diatom, with the exception being that of the Centrics, where more live diatoms were found in the snail feces than the benthos. One possible explanation for this bizzare finding is that the snails were directly or indirectly grazing for the Centrics, covering a larger expanse than the relatively small benthic sample collected by the team, and that all other consumed diatoms were merely bycatch. It was hypothesized by Dr. Stevenson that the Centrics may be the photosynthesizing power producing the golden brown color that rests in large quantities on top of the algae mats. This is supported by the fact that a large percentage of all consumed diatoms were found alive, especially the Centrics, which led us to infer that they did not break down to provide nutritional value to the snails, thus solidifying that the snails could not have been pointedly aiming to consume the Centrics as they provided little to no nutritional benefit.

Proposition Moving Forward

- Proposition of a study examining the bacterial and mucilage content of the feces.
- A deeper look into the centric and its possible role in the GBA mats
- Other organisms could be eating the benthic diatoms such as clams, minnows, crayfish, and insect larvae.

We actually found a crayfish right next to the enclosure at the Hay-O-Wenta site when we collected our snails after the experiment.

We would propose a future study examining the snail feces further for bacteria that may be indicative of what they truly are grazing for and its connection to the Golden Brown Algae. As an extension of the aforementioned, we hypothesize at this time that the bonding mucilages and other byproducts of the GBA are what nutritionally fuel the snails rather than the diatoms that are the algae themselves. Through the analysis of these two statistically differentiated diatoms (Diatoma, Centric) that pointed to separate conclusions about the eating patterns of the snails, as opposed to the other diatoms (Cybelloids, Fragilaria, Epithemia, and other) that consistently followed similar patterns when analyzed relatively, our team concluded that there is no true trend in the eating habits of the snails that would point to their intentional consumption of the diatoms that make up the Golden-Brown algae.

Acknowledgements

- Experiential Link staff: David Yuhaus ,Katie Kraft, Grace Muma
- The Gourley and Robson/Morse families for use of their respective properties
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- Grass River Natural Area Education Center faculty
- MSU Professor Dr. Jan Stevenson
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- Dole family foundation

Questions?