Ocean Acidification Exploration

(What Kinds of Water Organisms Get Affected More From Ocean Acidification? Seawater or Freshwater?)

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I. Abstract

Since humans began pumping out Co2 into the atmosphere, the world's oceans have been absorbing some of that Co2. This is good for us, but it comes at a price. The oceans are becoming more and more acidic. When Co2 gets absorbed into the ocean, it forms carbonic acid, which is acidic, which dissolves calcium carbonate. Unfortunately, some of the most important organisms in the ocean have shells out of calcium carbonate. Mussels, Clams, Coral, and most importantly, plankton. Zooplankton provide the basis of all marine ecosystems, and phytoplankton, which produces sixty percent of all oxygen on earth, and remove one third of all of the Co2 in the atmosphere. Without plankton the earth would be uninhabitable. We heard of this problem and decided to do an experiment on it. Our objectives are to test is freshwater or seawater organisms would dissolve quicker if Co2 was added to the water. This experiment is important because it provides valuable information about ocean acidification and also helps with predicting the acidification of the oceans and its consequences. Our hypothesis is that freshwater organisms would dissolve quicker because we thought that when Co2 enters seawater, it forms carbonic acid, lowering pH and dissolving calcium carbonate, which then reacts with the carbonate in seawater to form hydrogen carbonate. This takes away from the calcium carbonate in the water and makes shell building harder to do. However, freshwater is not already saturated with calcium or carbonate and already is hard for shell building. When Co2 enters freshwater, it forms carbonic acid, which lowers pH, but does not turn into hydrogen carbonate. When we finished our experiment, we found out that our hypothesis was correct. Freshwater does dissolve calcium carbonate more quickly than seawater. Freshwater mussels dissolved 11.54 percent and seawater mussels dissolved 10.14 percent. The control freshwater mussels dissolved 2.94 percent while the control seawater dissolved 3.03 percent. Freshwater mussels dissolved about 115 percent more than seawater mussels. So our hypothesis was correct, and freshwater mussels dissolve more quickly than seawater mussels.

II. Introduction

The Problem / Background Research

The world's reefs, seashells, crustaceans, and everything made out of Calcium Carbonate (CaCo3) are in trouble due to ocean acidification, which is slowly but surely dissolving them into microscopic particles.[1]

Ocean acidification is the process in which the world's oceans are becoming more acidic. This is a problem for shells, and reefs, because the complex chemistry of the oceans causes ocean acidification which causes them to dissolve. Hermit crabs, mussels and much more creatures make their homes out of pulling calcium and carbonate out of the water to make calcium carbonate (CaCO3). The newly formed calcium carbonate doesn't dissolve back into the seawater because it is already saturated with as much calcium and carbonate as it can hold. But at greater depths, calcium and carbonate is more scarce so shells dissolve more easily then they form. So there is a dissolving depth in which any calcium carbonate formed will start to dissolve. The dissolving depth depends on the concentration of calcium and carbonate already in the water. If the concentration is high, the depth will be lower. If the amount of calcium and carbonate is low, the dissolving depth is higher. But this is a system, and it checks itself. Shells that dissolve add their calcium carbonate to the water, and they increase the level of calcium

[1] "How To Make a Seashell - Just Add Water!."
YouTube Video, 3:26
Posted by "Minute Earth," December 2, 2013.
https://www.youtube.com/watch?v=kmpzDfrqliU

carbonate in the water, lowering the dissolving depth. But that's when Co2 makes everything complicated. Dissolved Co2 that enters the water combines with water to form carbonic acid (CH2O3). Carbonic acid is a acid, so it lowers the ph of water, dissolving calcium carbonate. Then carbonic acid reacts with carbonate to form hydrogen carbonate (HCO3), reducing the amount of carbonate in the water. So the seashells start dissolving. Given enough time, the dissolved seashells will return their calcium carbonate to the water and restore normal levels. But it could take centuries to do so, and in that time, the ocean could be a barren desert. In freshwater, the carbonic acid does not turn into hydrogen carbonate because there is no or very little calcium or carbonate in the water. The main cause of ocean acidification is Co2 in the air, which is caused by human emissions such as factories, deforestation, and vehicle emissions.[2] When Co2 is released into the air, the Co2 levels in the atmosphere rise, and so do the levels in the water, leading to ocean acidification.

[2] Stone, Debbi and Kevin Van Dien. "How are humans causing ocean acidification?." Climateinterpreter.org https://climateinterpreter.org/content/how-are-humans-causing-ocean-acidification (accessed November 11, 2018)

The Objectives

Our objectives are to test if freshwater coral, clams, mussels, plankton, or other freshwater organisms that have shells made out calcium carbonate, or seawater coral, clams, mussels, plankton, or other seawater organisms that have shells made out calcium carbonate are affected more by ocean acidification. We will be using tap water as freshwater and the tap water will be representing rivers and lakes. We chose to do experiments on freshwater and seawater because there is not much information or experiments related to freshwater acidification, so we wanted to do experiments on freshwater. So basically we are going to test if freshwater organisms or seawater organisms dissolve faster when Co2 is added to the respective waters. Also we are going to test how fast calcium carbonate dissolves when put under increasing amounts of Co2. Ocean acidification is a serious problem, and one that needs to be addressed.

The Hypothesis

Our hypothesis is that the freshwater mussels will dissolve faster because on one hand, saltwater organisms might dissolve faster because the Co2 that enters the water turns into carbonic acid which then reacts with the carbonate in the water to form hydrogen carbonate, which lowers the carbonate level in the water to dissolve it faster. Also the carbonic acid will also lower the pH, giving the seawater creatures a double whammy. But on the other hand, Co2 that enters freshwater turns into carbonic acid, which lowers the pH but freshwater is not already saturated with calcium and carbonate. So since it is not saturated with calcium and carbonate, we think the shells will dissolve much faster. So we think that freshwater organisms will dissolve faster and be more affected by ocean acidification.

Importance Of Study

Ocean Acidification is a huge problem that world leaders need to adress, and fix the problem by cutting down carbon emissions. If humans don't stop pumping Co2 into the atmosphere, then the world could be affected permanently and irreversibly. One of the most critical things about ocean acidification is that it dissolves calcium carbonate. And one of the organisms most affected by ocean acidification is plankton, as they build their tiny shells out of calcium carbonate. [3]Zooplankton provides the basis of all marine ecosystems, and phytoplankton produces sixty percent of all of the oxygen on earth, and removes one third of all of the

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[3] Nahigyan, Pierce. "Ocean Acidification Is Bad, And It Is Getting Worse." huffingtonpost.com https://www.huffingtonpost.com/pierce-nahigyan/ocean-acidification-is-ba_b_8952240.html (accessed December 9, 2018)

atmospheric Co2.[4] Without plankton, the earth would quickly become uninhabitable, as marine life would disappear, and 60 percent of the world's oxygen would be gone, as well as Co2 levels going through the roof and turning Earth into Venus.

My experiment shows just how dire the situation is, by illustrating the rate of dissolving for freshwater and seawater creatures. If in a month or two a mussel could lose 30% of its mass, imagine how fast reefs, shelled creatures, and most importantly, plankton would dissolve if the world keeps pumping out Co2 into the atmosphere! If us humans don't stop pumping greenhouse gases into the atmosphere, a whole plethora of problems would occur. Reefs would vanish. Clam and oyster catches would suffer hugely. Marine animals would vanish, and the Earth will keep absorbing Co2 until it is uninhabitable, if it already wasn't because more than half of the oxygen in the world would disappear. My study also shows whether freshwater or saltwater creatures would suffer more due to ocean acidification. This can hugely come in handy for predicting catches in freshwater or seawater environments. It can also come in handy for predicting if freshwater plankton or saltwater plankton would disappear faster, as well as estimating the oxygen produced from freshwater or saltwater bodies of water.

[4] Mahadevan, Amala. "How Plankton Blooms Absorb Co2" scienceforthepublic.org http://www.scienceforthepublic.org/earth/how-plankton-blooms-absorb-co2 (accessed December 9, 2018)

The Variables

The variables for this experiment are:

Independent Variables: Type of Water: Freshwater or Seawater, and Carbonation of Water: Control or Carbonated

Dependent Variables: Dissolution Rate and pH

Controlled Variables: Type of jar, material of jar, amount of water, species of mussel, source of mussel, lid tightness, air temperature, liquid temperature, sunshine, air pressure, air density, liquid density, liquid pressure, Co2 in air outside of jar, amount of carbonated liquid in Co2 groups.

Experimental Group	Controlled Variables for Each
Original (Control) Freshwater, samples 1 and 2	Same jars, same amount of tap water (200 ml), same sunlight, same temperature, same density, same pressure, same source
Original (Control) Seawater, samples 1 and 2	Same jars, same amount of sea water (200 ml, from Huntington Beach), same sunlight, same temperature, same density, same pressure, same source, same saltiness
Carbonated Freshwater, samples 1,2,3	Same jars, same amount of tap water (200 ml), same sunlight, same temperature, same density, same pressure, same source, same amount of carbonated water (from Sodastream)
Carbonated Seawater, samples 1,2,3	Same jars, same amount of seawater (200 ml, from Huntington Beach), same sunlight, same temperature, same density, same pressure, same source, same amount of carbonated water (from Sodastream)

III. Materials

We Used:

- 10 Glass Mason Jars: To hold the water and the mussel.
- 10 Mussels (shells): To measure the weight and the weight change
- Control Seawater: To use and compare for the experiment
- Control Freshwater: To use and compare for the experiment
- Co2 Seawater: To use and compare for the experiment
- Co2 Freshwater: To use and compare for the experiment
- Carbonated Seawater (SodaStream): To insert in the the Co2 seawater
- Carbonated Freshwater (SodaStream): To insert in the Co2 freshwater
- SodaStream: To make the Carbonated Seawater and Freshwater
- SodaStream Bottles: To hold the carbonated water
- pH Meter: To measure the pH of the water
- Scale: To measure the weight of the mussels
- Chopsticks: To fish out the seashell from the narrow rimmed jars
- Test tube: To measure the amount of carbonated water (SodaStream) to put
- Syringe: To measure the amount of carbonated water to put
- Measuring Cup: To measure the 200 ml of water to put in all of the jars

IV. Methods

At Home, making the carbonated water with the SodaStream every 2 sessions:

1. We got out the SodaStream machine, as well as the SodaStream Bottles.
2. We got out the Seawater from the fridge (seawater from Huntington Beach).
3. We filled one of the SodaStream bottles with tap water (representing freshwater).
4. We filled one of the SodaStream bottles with seawater.
5. We put one of the bottles on the SodaStream machine, and pressed the button 3 times for 3 seconds each for a total of 9 seconds, to make carbonated freshwater.
6. We put the other bottle on the SodaStream machine, and pressed the button 3 times for 3 seconds each for a total of 9 seconds, to make carbonated seawater.
7. We put the bottles in my backpack and cleaned up.
8. We repeated steps 1-7 every 2 sessions so the carbonated water would not go stale and lose all of its carbon dioxide due to evaporation.

At School (for Every Experiment Session): *All the data collected was written down.

1. We measured the mussel weights of Original Seawater mussels.
2. We measured the pH level of Original Seawater.
3. We measured the weights of Original Freshwater mussels.
4. We measured the pH level of Original Freshwater.
5. We closed the lids on the Original Jars, and then put them aside.
6. We measured the weights of Acidified Seawater mussels (samples 1, 2, 3).
7. We measured the pH level of Acidified Seawater (samples 1, 2, 3).
8. We measured the weights of Acidified Freshwater mussels (samples 1, 2, 3).
9. We measured the pH level of Acidified Freshwater (samples 1, 2, 3).
10. We poured in corresponding amounts of Acidified Seawater (SodaStream) to the jars containing Acidified Seawater (increasing amounts every time).
11. We poured in corresponding amounts of Acidified Freshwater to the jars containing Acidified Freshwater (increasing amounts every time).
12. We closed the lids on the Acidified Sea and Freshwater.
13. We put them aside and cleaned up.
14. We repeated steps 1-13 every session from November 15, 2018 to November 30, 2018.

V. Data Analysis and Results

From the consistent data we have collected, we can conclude that Freshwater gets affected by Ocean Acidification more than Seawater. The Original Seawater and Original Freshwater's weight stays similar over the duration that we collected data in. This was because no Co2 was added. The Acidified Seawater mussel's weight, the water's pH level decreased over time as we put in increasing amounts of acidified seawater each time we collected data. The Acidified Freshwater mussels' weight, the water's pH level decreased over time as we put in increasing amounts of acidified freshwater each time we collected data. The Acidified Seawater and the Acidified Freshwater mussel weight, and pH level decreased, but we can see that the Acidified Freshwater mussel weight decreased more than the Acidified Seawater.

We calculated the average weight of each type of sample, and then calculated Variance, Standard Deviation, and Standard Error, to figure out if our data is reliable.

* **Variance -**a quantity calculated to indicate how far a set of numbers is spread out
* **Standard Deviation** -a quantity calculated to indicate the extent of deviation for a group as a Whole.
* **Standard Error** -a measure of the statistical accuracy of an estimate, equal to the standard deviation of the theoretical distribution of a large population of such estimates.

Table 1. This table shows the raw data for our original samples. This table has the weights and the pH of each of the samples. Notice that the weight and the pH did not change much. The original samples mean controlled samples.

No.	Date	Original SW 1	Original SW 1	Original SW 2	Original SW 2	Original FW 1	Original FW 1	Original FW 2	Original FW 2
		weight (g)	pH level	weight (g)	pH level	weight (g)	pH level	weight (g)	pH level
1	11/5/2018	1.8	8.1	1.5	8.1	1.9	8	1.5	8
2	11/7/2018	1.8	7.4	1.5	7.3	1.8	7.7	1.5	7.9
3	11/9/2018	1.8	7.3	1.5	7.1	1.8	7.7	1.5	7.9
4	11/14/2018	1.8	7.3	1.4	7.5	1.8	7.9	1.5	7.8
5	11/16/2018	1.7	7.4	1.5	6.9	1.8	8.2	1.5	8.1
6	11/19/2018	1.7	7.5	1.5	7.6	1.8	8.2	1.5	8.1
7	11/26/2018	1.7	7.6	1.5	7.6	1.8	8.1	1.5	8.2
8	11/28/2018	1.7	7.6	1.5	7.7	1.8	8.2	1.5	8.1
9	11/30/2018	1.7	7.7	1.5	7.7	1.8	8.2	1.5	8.2

Table 2. This shows the average weight and the average pH of the two control samples for both seawater and freshwater. It also shows the variance, the standard deviation, and the standard error of weight for both seawater and freshwater. This is the average raw data from the experiment.

Control Seawater					**Control Freshwater**				
Average Weight (g)	Average PH of Seawater	Variance of weight	Standard deviation of weight	Standard Error of weight	Average Weight (g)	Average PH	Variance of weight	Standard deviation of weight	Standard error of weight
1.65	8.1	0.0011			1.7	8	0.001975		
1.65	7.35	0.0011			1.65	7.8	0.000031		
1.65	7.2	0.0011			1.65	7.8	0.000031		
1.6	7.4	0.0003			1.65	7.85	0.000031		
1.6	7.15	0.0003			1.65	8.15	0.000031		
1.6	7.55	0.0003			1.65	8.15	0.000031		
1.6	7.6	0.0003			1.65	8.15	0.000031		
1.6	7.65	0.0003			1.65	8.15	0.000031		
1.6	7.7	0.0003			1.65	8.2	0.000031		
1.62		0.0006	0.0236	0.00786	1.655555		0.000247	0.0157	0.0052

The Standard Deviation of control seawater is 0.0236, which indicates that our data is consistent. The Standard Error of control seawater is also low, at 0.00786, so there is little room for error. The Standard Deviation of control freshwater is 0.0157, which indicates that our data is consistent. The Standard Error of control freshwater is also low, at 0.0052, so there is little room for error. If the CV (standard deviation/mean) is less than 1, it means the standard deviation and data is consistent. Our CV of the control seawater is 0.015, and the CV of the control freshwater is 0.0095.

Table 3. This shows the weights and pH of the Co2 seawater samples. This is the raw data for the experiment. Notice how the weights and the pH dropped significantly.

No.	Date	CO2 SW 1	CO2 SW 1	CO2 SW 1	CO2 SW 2	CO2 SW 2	CO2 SW 2	CO2 SW 3	CO2 SW 3	CO2 SW 3
		weight (g)	pH level	CO2 SW (mL)	weight (g)	pH level	CO2 SW (mL)	weight (g)	pH level	CO2 SW (mL)
1	11/5/2018	1.8	8.1	2	1.8	8.1	2	2.3	8.1	2
2	11/7/2018	1.7	7	4	1.8	7	4	2.3	7	4
3	11/9/2018	1.7	7	6	1.8	7	6	2.2	7	6
4	11/14/2018	1.6	7	10	1.8	6.9	10	2.2	6.8	10
5	11/16/2018	1.4	6.6	12	1.3	6.4	12	2.1	6.5	12
6	11/18/2018	1.6	6.6	14	1.8	6.5	14	2.2	6.6	14
7	11/26/2018	1.6	6.8	18	1.8	6.8	18	2.2	6.8	18
8	11/28/2018	1.5	6.5	20	1.7	6.6	20	2.1	6.6	20
9	11/30/2018	1.5	6.5	22	1.7	6.5	22	2.1	6.5	22

Table 4. This shows the average weight and the pH across all three of the Co2 seawater samples. This also shows the variance of the weight, the standard deviation of the weight, and the standard error of the weight.

Average weight (g)	Average pH	Variance of Weight	Standard Deviation of Weight	Standard Error of Weight
1.967	8.100	0.017		
1.933	7.000	0.009		
1.900	7.000	0.004		
1.867	6.900	0.001		
1.600	6.500	0.056		
1.867	6.567	0.001		
1.867	6.800	0.001		
1.767	6.567	0.005		
1.767	6.500	0.005		
1.837		0.011	0.105	0.035

Standard Deviation: .105

Standard Error: 0.035

CV: 0.105/1.837 = 0.057

Since the CV is less than 1, the standard deviation and the data is consistent.

Table 5. This shows the weights and pH of the Co2 freshwater samples. This is the raw data for the experiment. Notice how the weights and the pH dropped significantly.

No.	Date	CO2 FW 1	CO2 FW 1	CO2 FW 1	CO2 FW 2	CO2 FW 2	CO2 FW 2	CO2 FW 3	CO2 FW 3	CO2 FW 3
		weight (g)	pH level	CO2 FW (mL)	weight (g)	pH level	CO2 FW (mL)	weight (g)	pH level	CO2 FW (mL)
1	11/5/2018	1.8	8	2	1.7	8	2	1.7	8	2
2	11/7/2018	1.7	7.4	4	1.7	7.3	4	1.7	7.3	4
3	11/9/2018	1.7	7.2	6	1.7	7.3	6	1.7	7.3	6
4	11/14/2018	1.6	7.2	10	1.6	7.2	10	1.6	7.2	10
5	11/16/2018	1.5	7	12	1.6	6.9	12	1.6	7	12
6	11/19/2018	1.6	7	14	1.6	6.9	14	1.6	7	14
7	11/26/2018	1.6	7	18	1.6	6.9	18	1.6	7	18
8	11/28/2018	1.6	6.9	20	1.5	6.8	20	1.6	6.8	20
9	11/30/2018	1.5	6.8	22	1.5	6.7	22	1.6	6.7	22

Table 6. This shows the average weight and the pH across all three of the Co2 freshwater samples. This also shows the variance of the weight, the standard deviation of the weight, and the standard error of the weight.

Average Weight (g)	Average pH	Variance of weight	Standard Deviation of Weight	Standard Error of Weight
1.733	8.000	0.005		
1.700	7.333	0.002		
1.700	7.267	0.002		
1.600	7.200	0.004		
1.567	6.967	0.058		
1.600	6.967	0.004		
1.600	6.967	0.004		
1.567	6.833	0.009		
1.533	6.733	0.016		
1.622		0.004	0.067	0.022

Standard Deviation: .067

Standard Error: 0.022

CV: .067/1.622= 0.041

Since the CV is less than 1, the standard deviation and the data is consistent.

Table 7. This is average weight of all of the samples. Notice that the Co2 samples' weight decreased much more than the control samples.

Date	Average Mussel Weight (g)			
	Control Seawater	Control Freshwater	Co2 Seawater	Co2 Freshwater
11/5/2018	1.65	1.70	1.97	1.73
11/7/2018	1.65	1.65	1.93	1.70
11/9/2018	1.65	1.65	1.90	1.70
11/14/2018	1.60	1.65	1.87	1.60
11/16/2018	1.60	1.65	1.60	1.57
11/19/2018	1.60	1.65	1.87	1.60
11/26/2018	1.60	1.65	1.87	1.60
11/28/2018	1.60	1.65	1.77	1.57
11/30/2018	1.60	1.65	1.77	1.53

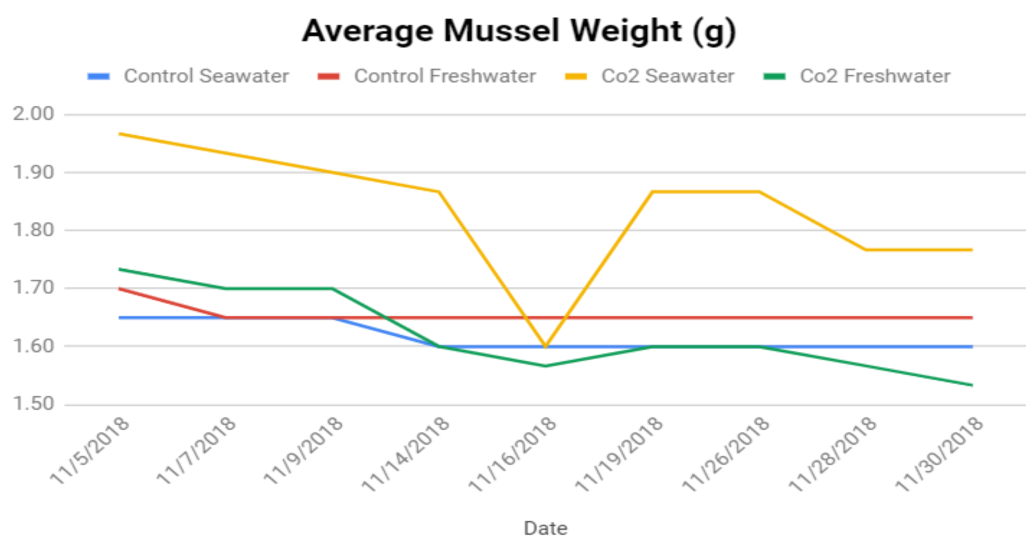

Fig 1. This is a graph that shows all of the average weights of all of the ten samples. Notice that the Co2 samples' weight decreased much more than the control samples. Also notice that the Co2 freshwater samples' weight decreased more than the Co2 seawater samples. The Co2 freshwater's weight decreased the most out of all of the samples.

Table 8. This shows the average weight of the Co2 seawater mussels, and is comparing the weight ratio change for the control seawater, and the weight ratio change for the Co2 seawater.

Seawater Comparison		
Weight Ratio Change, % (Control)	Average weight, (g) (Co2)	Weight Ratio Change, % (Co2)
	1.97	
0.00	1.93	-0.02
0.00	1.90	-0.02
-0.03	1.87	-0.02
0.00	1.60	-0.14
0.00	1.87	0.17
0.00	1.87	0.00
0.00	1.77	-0.05
0.00	1.77	0.00

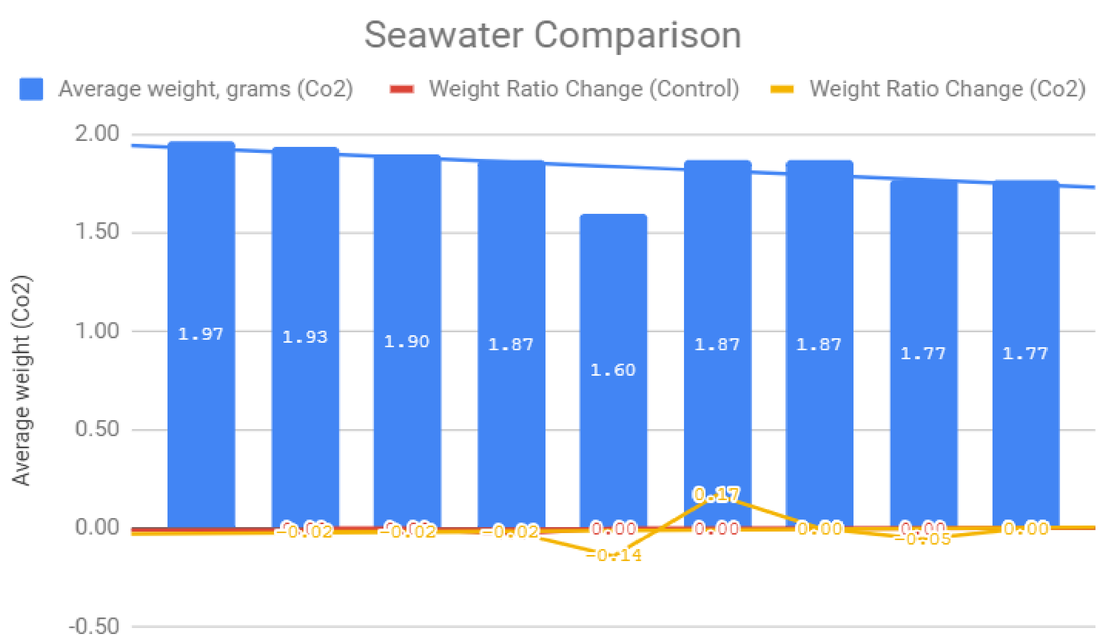

Fig 2. This is a graph for the table above, and it show the average weight of the Co2 seawater mussels, and compares the weight ratio change for the control seawater, and the Weight ratio change for the Co2 seawater. Notice that the control mussels weight ratio did not change but the Co2 mussel weight ratio changed much more.

Table 9. This shows the average weight of the Co2 freshwater mussels, and is comparing the weight ratio change for the control freshwater, and the weight ratio change for the Co2 freshwater.

Freshwater Comparison		
Weight Ratio Change, % (Control)	Average Weight, (g) (Co2)	Weight Ratio Change, % (Co2)
	1.73	
-0.03	1.70	-0.02
0.00	1.70	0.00
0.00	1.60	-0.06
0.00	1.57	0.19
0.00	1.60	-0.16
0.00	1.60	0.00
0.00	1.57	-0.02
0.00	1.53	-0.02

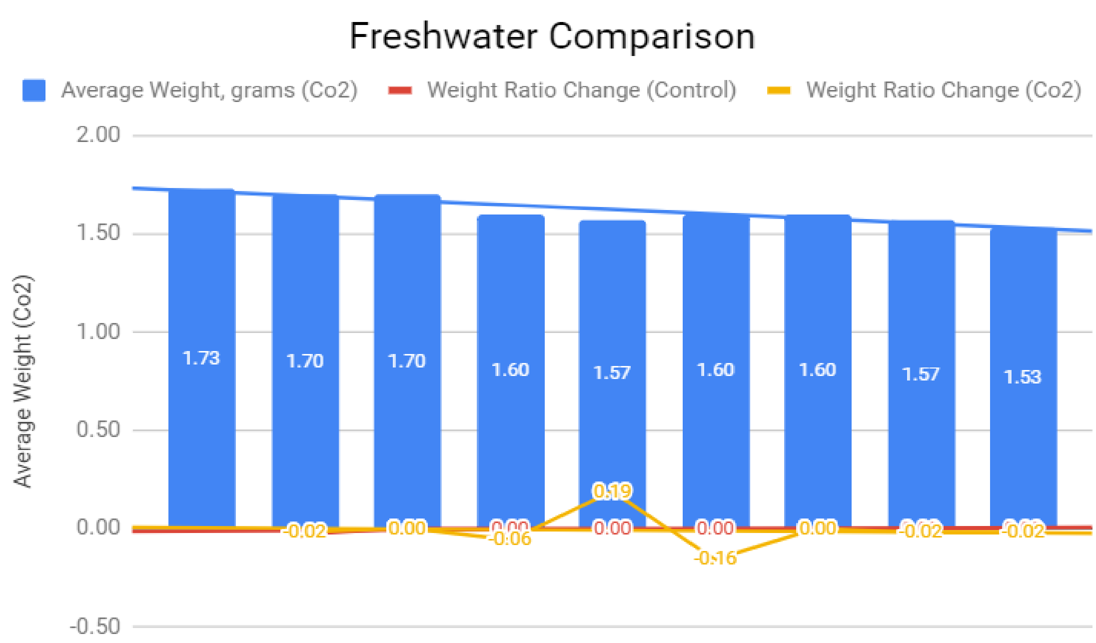

Fig 3. This is a graph for the table above, and it show the average weight of the CO_2 freshwater mussels, and compares the weight ratio change for the control freshwater, and the Weight ratio change for the CO_2 freshwater. Notice that the control mussels weight ratio did not change but the CO_2 mussel weight ratio changed much more.

Table 10. This table shows the average weight and the average pH of the seawater CO_2 samples.

Seawater Co2	
Average weight (g)	Average pH
1.967	8.100
1.933	7.000
1.900	7.000
1.867	6.900
1.600	6.500
1.867	6.567
1.867	6.800
1.767	6.567
1.767	6.500

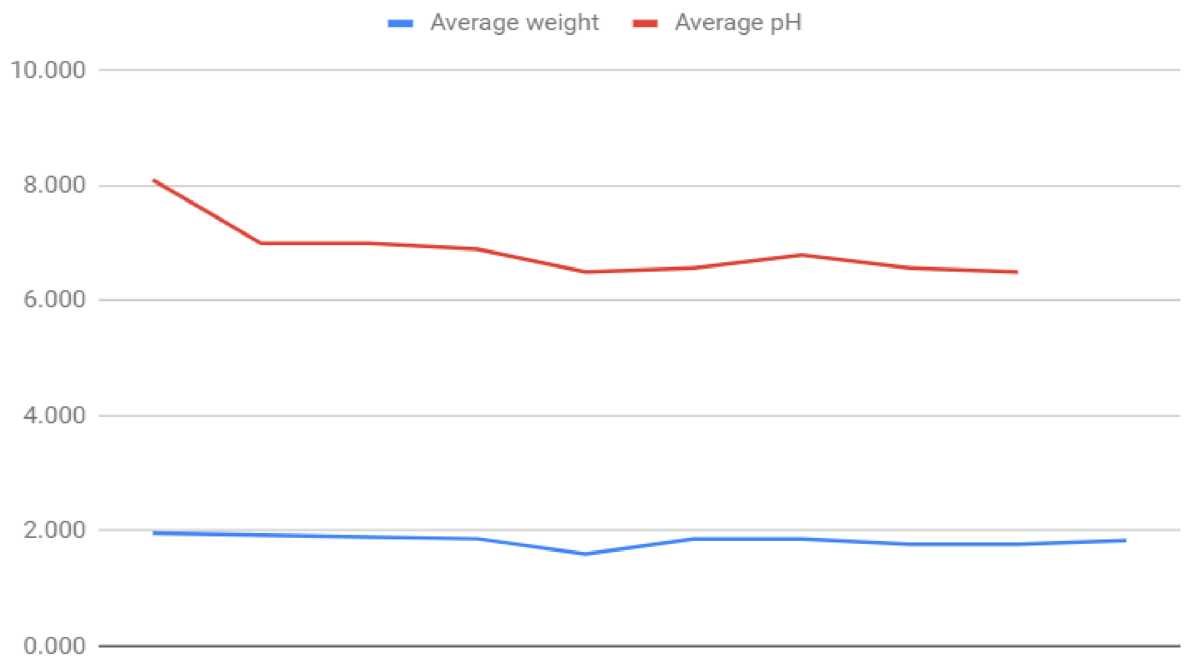

Fig 4. This graph shows the average weight and the average pH of the seawater Co2 samples over time. Notice that the decreased pH level correlated to the decreased mussels' weight in the Co2 seawater.

Table 11. This table shows the average weight and pH of the freshwater Co2 samples.

Freshwater Co2	
Average Weight (g)	Average pH
1.733	8.000
1.700	7.333
1.700	7.267
1.600	7.200
1.567	6.967
1.600	6.967
1.600	6.967
1.567	6.833
1.533	6.733

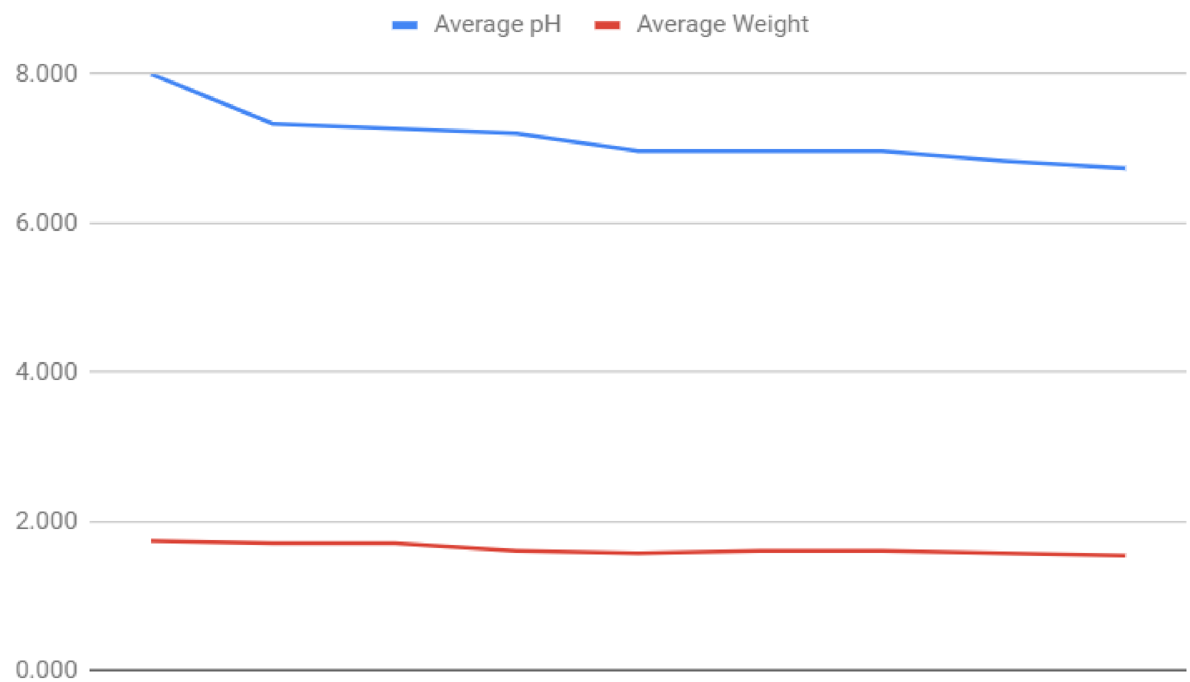

Fig 5. This graph shows the average weight and the average pH of the seawater Co2 samples over time. Notice that the decreased pH level correlated to the decreased mussels' weight in the Co2 freshwater.

Table 12. This shows all of the different types of samples' weight change (percent) and the pH change (percent). This allows easy comparison of all of the different types of sample. We took the difference of the first date weight and the last date weight. We did the same with pH.

Control Seawater		Control Freshwater		Co2 Seawater		Co2 Freshwater	
Weight Change	pH change	Weight Change	pH change	Weight Change	pH change	Weight Change	pH change
-3.03%	-4.94%	-2.94%	2.50%	-10.17%	-19.75%	-11.54%	-15.83%

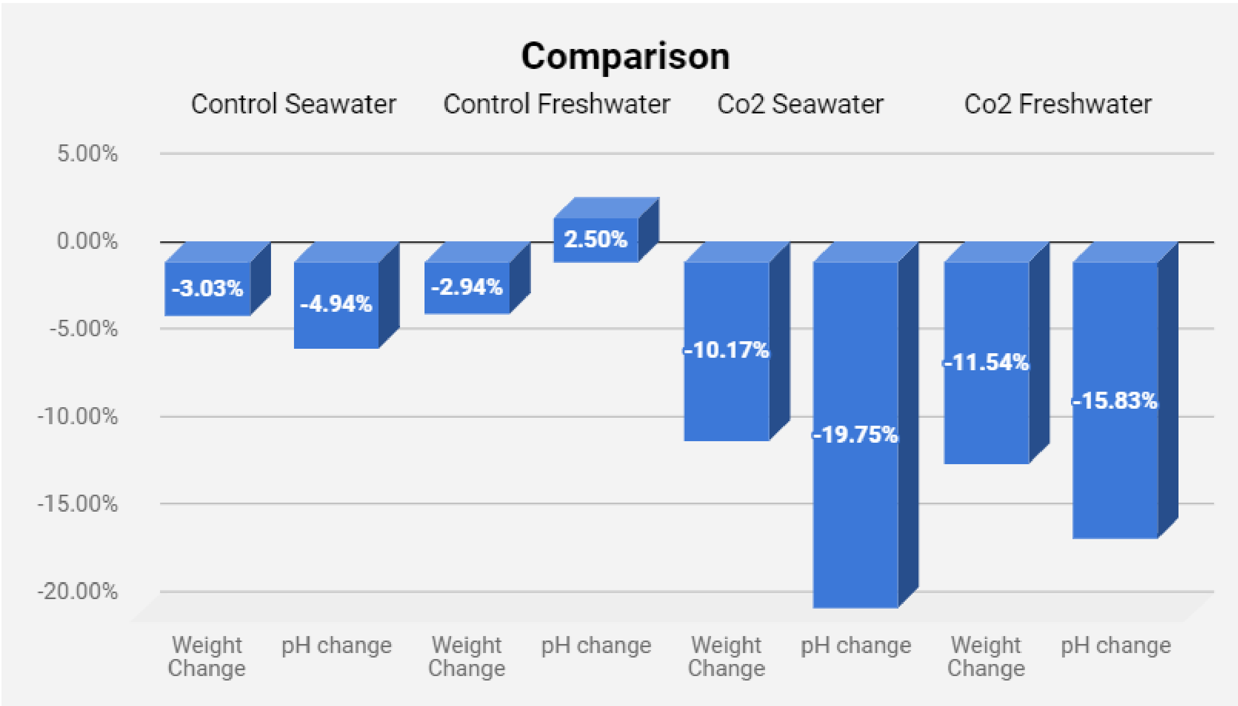

Fig 6. This shows all of the mussels' weight changes and the water's pH change of all of the different types of water. This allows easy comparison of all of the different types of samples. Notice that the Co2 freshwater samples' weight decreased 1.37 percent more than Co2 seawater. This is about a 115 percent more decrease than seawater. So Co2 freshwater decreased the most.

VI. Discussion

1. Comparing The Weight of the Seawater Mussels

The mussels in the jars with carbon dioxide added to them dissolved much quicker and lost much more weight over the ones that were in jars that were not added carbon dioxide. This is because of the chemical reaction when carbon dioxide meets water. The carbon reacts with the water to form carbonic acid, which lowers the pH. In seawater, the the carbonic acid reacts with carbonate in the water to form hydrogen carbonate. This means less carbonate in the water. So when Co2 is added, it means less calcium carbonate, and the lack of calcium carbonate dissolves mussel shells faster. The mussels with Co2 added to them lost 7.14% more weight then the ones without Co2 added.

2. Comparing The Weight of the Freshwater Mussels

The mussels in the jars with carbon dioxide added to them dissolved much quicker and lost much more weight over the ones that were in jars that were not added carbon dioxide. This is because of the chemical reaction when carbon dioxide meets water. The carbon reacts with the water to form carbonic acid, which lowers the pH. So when Co2 is added, it means lower pH, which dissolves mussel shells faster. The mussels with Co2 added to them lost 8.6% more weight then the ones without Co2 added.

3. Summary on the Weight of Freshwater and Seawater

The data shows that on both cases, freshwater and seawater, the mussels with carbon dioxide added to them dissolved faster. They dissolved the mussels 7.14 percent and 8.6 percent more than the control for seawater and freshwater respectively. The data shows that freshwater dissolves mussels faster than seawater, by 1.4 percent. This is because seawater is saturated with calcium and carbonate, the ingredients to make calcium carbonate. However, freshwater does not have or has very little of calcium and carbonate, making calcium carbonate easier to dissolve and harder to form. When Co2 is added to freshwater, it lowers pH, dissolving seashells. So that is why freshwater mussels dissolved faster. However, the reason why the freshwater did not beat seawater by a large margin is that seawater also has properties that makes the mussels dissolve faster. When Co2 is added to seawater, it forms carbonic acid, which lowers the pH of the seawater. The lower pH makes mussels dissolve faster. Then the carbonic acid reacts with carbonate to form hydrogen carbonate. When this happens, the hydrogen carbonate is unusable to mussels to build their shells, and the forming of hydrogen carbonate takes away carbonate from the seawater. So that is why freshwater did not beat seawater by a large margin.

4. Comparing pH levels of Seawater

The mussels in the jars with carbon dioxide had a lower pH, and were more acidic. The pH of the carbonated jars were 1 to 2 pH lower than the ones without carbon dioxide added to them. This is because of the chemical reaction that occurs when carbon dioxide meets water. The carbon dioxide turned into carbonic acid when it meets water, which lowered the pH of the seawater, by mixing with the seawater. The mussels in the jars with carbon dioxide dissolved faster as a consequence of the lower pH of the freshwater.

5. Comparing pH levels of Freshwater

The mussels in the jars with carbon dioxide had a lower pH, and were more acidic. The pH of the carbonated jars were 1 to 2 pH lower than the ones without carbon dioxide added to them. This is because of the chemical reaction that occurs when carbon dioxide meets water. The carbon dioxide turned into carbonic acid when it meet water, which lowered the pH of the freshwater, by mixing with the freshwater. The mussels in the jars dissolved as a consequence of the lower pH of the freshwater.

6. Summary

When the original seawater and freshwater samples were compared to the samples with carbon dioxide added to them, a clear trend emerged. The samples with carbon dioxide added to them dissolved much quicker, and lost more weight than the samples without carbon dioxide added to them. This was true for both the seawater samples and the freshwater samples. This is because of the chemical reaction when carbon dioxide meets water. The carbon dioxide turns into carbonic acid, which lowers the ph of the water. In seawater, the carbonic acid bonds with carbonate to form hydrogen carbonate. This takes away from the carbonate in the water, making it easier for mussels to dissolve. So this is the reason that the samples with Co2 added to them dissolved much faster then the samples without carbon dioxide.

The reason why the freshwater samples dissolved more quickly then the seawater samples is the complex chemistry of the oceans. When carbonic acid meets seawater, it forms carbonic acid which lowers the pH of the seawater, and then bonds with carbonate to form hydrogen carbonate. This takes away from the carbonate in the seawater, dissolving seashells. However, freshwater is not saturated with calcium carbonate, making it easier for seashells to dissolve. Since the water isn't saturated with carbonate, the mussels dissolve more quickly than seawater.

VII. Conclusion

From our data in our experiment, we concluded that our data supported the hypothesis. Our hypothesis was that freshwater mussels would dissolve faster than seawater mussels due to the complex chemistry when carbon dioxide is added to fresh and sea waters. When carbon dioxide enters freshwater, it reacts with water to form carbonic acid. This carbonic acid lowers the pH of freshwater, which dissolves the mussels. When carbon dioxide enters seawater, it reacts with water to form carbonic acid, lowering pH, dissolving mussels. But then the carbonic acid reacts with carbonate in the seawater to form hydrogen carbonate. This takes away from the carbonate in the water, making dissolving easier. The reason why freshwater dissolved more quickly than seawater is that freshwater is already not saturated with calcium and carbonate, making dissolution more easy. So our hypothesis was correct. Freshwater dissolved more quickly than seawater, supporting our hypothesis.

At the end of 9 trials, seawater dissolved 10.14 percent while freshwater dissolved 11.54 percent. Everything was the same for the seawater and the freshwater, except the type of water. There is very little room for error, and there is very few or no variables that could have affected the experiment. So our data is most likely correct. To summarize, our hypothesis was correct and valid, because freshwater dissolved more quickly than the seawater. We think there is very little room for error, and very little variables that could alter the data we got.

Table 13. Mussel Weight change ratio and difference. Notice that the difference is greater in control freshwater vs Co2 freshwater than in control seawater vs Co2 seawater by 1.46 percent. Also, the difference between the Co2 seawater and the Co2 freshwater is 1.4 percent.

Mussel Weight Change Ratio (percent)		
Control Seawater Weight	Co2 Seawater Weight	Differance
-3.03	-10.17	7.14
Control Freshwater Weight	Co2 Freshwater Weight	Differance
-2.94	-11.54	8.6
Co2 Seawater Weight	Co2 Freshwater Weight	Differance
-10.17	-11.54	1.4

VIII. Practical Application

Co2 in the atmosphere is affecting freshwater as well as seawater. In fact, Co2 is affecting freshwater more than seawater! This is a problem. The acidification of freshwater would cause a whole plethora of problems. To name a few, water fleas, a major part of the freshwater food chain, are more slow and their senses are dulled significantly.[5] Also the drinking water we drink comes mainly from lakes and rivers, so acidified drinking water would occur. Acidified freshwater can cause health problems. We can try to solve this problem by switching to renewable energy to cut down Co2 emissions. Also, factories near freshwater lakes and rivers pump out lots of Co2 every day, as well as acidifying the water with runoff. Regulations should be set on how close factories can be to freshwater sources. Also, roads should not be built near rivers or lakes because cars go on roads and cars emit Co2. If we work together to solve this problem, the consequences would lessen.

[5] Gies, Erica. Like Oceans, Freshwater is Also Acidifying. Scientificamerican.org https://www.scientificamerican.com/article/like-oceans-freshwater-is-also-acidifying/ (accessed Jan 14, 2019)

IX. Future Expansion

Trial and Error

When we first got the idea for this project, we decided to use vinegar and baking soda to create Co2 gas. However, this was not successful. Firstly, the amount of gas created was too small, so the mussels did not dissolve much at all. Also, the data was very inconsistent. The control group lost more weight than the Co2 group. Also, when we mixed baking soda and vinegar, a foam would erupt out and sometimes spill into the water. So then we decided to use the sodastream to carbonate the water.

When we completed our experiment, we reflected on our experiment and thought of some things we could do differently. First of all, the reason why the weight of the seashells in fresh and seawater increased is because we used a broken scale and that scale read the weight lower than it really was, and then next session we used a working scale and it read the weight correctly. So next time, we could pay more attention to the equipment we used. On the other hand, we might have used a working scale, but maybe it was some sort of error in our experimental procedure or another variable, but after thinking it through, a broken scale was the only explanation that made sense and was logical.

Also there were some large gaps in our session dates, mainly due to holidays or other reasons. Maybe next time we can try to minimize or reduce the number of gaps by going and doing a session on the holidays, or do a missed session the next day. If we do those things, there will be a smaller margin for error.

Further and Future Experiments

Next time we do an experiment about ocean acidification, we could do experiment on plankton and the effects of ocean acidification of plankton.

Also when we do the experiment in the future, we can make the freshwater more specific and do river water, lake water, tap water and so forth.

Maybe next time we can get more samples and be more vigilant about our equipment and out procedure and make a linear equation with the weight of the mussels and the pH.

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- She judged our work and gave comments on what we could work on

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- She gave us the dates of the science fair
- She allowed us to work in recess and in class time

Science Mentor at the Ask a Scientist Night at October 10, 2018

- She provided us with general tips about the science fair

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- They helped us prepare the materials
- They helped us find science fair resources from Orange County Science Fair website (https://ocsef.cloudaccess.host/links/science-fair-resources#2-ocsef-resources)
- They organized the meetings places for our team
- They provided us the study materials to do the data analysis