Combating Ocean Acidification via Chemical Manipulation and Photosynthetic Aquatic Plants

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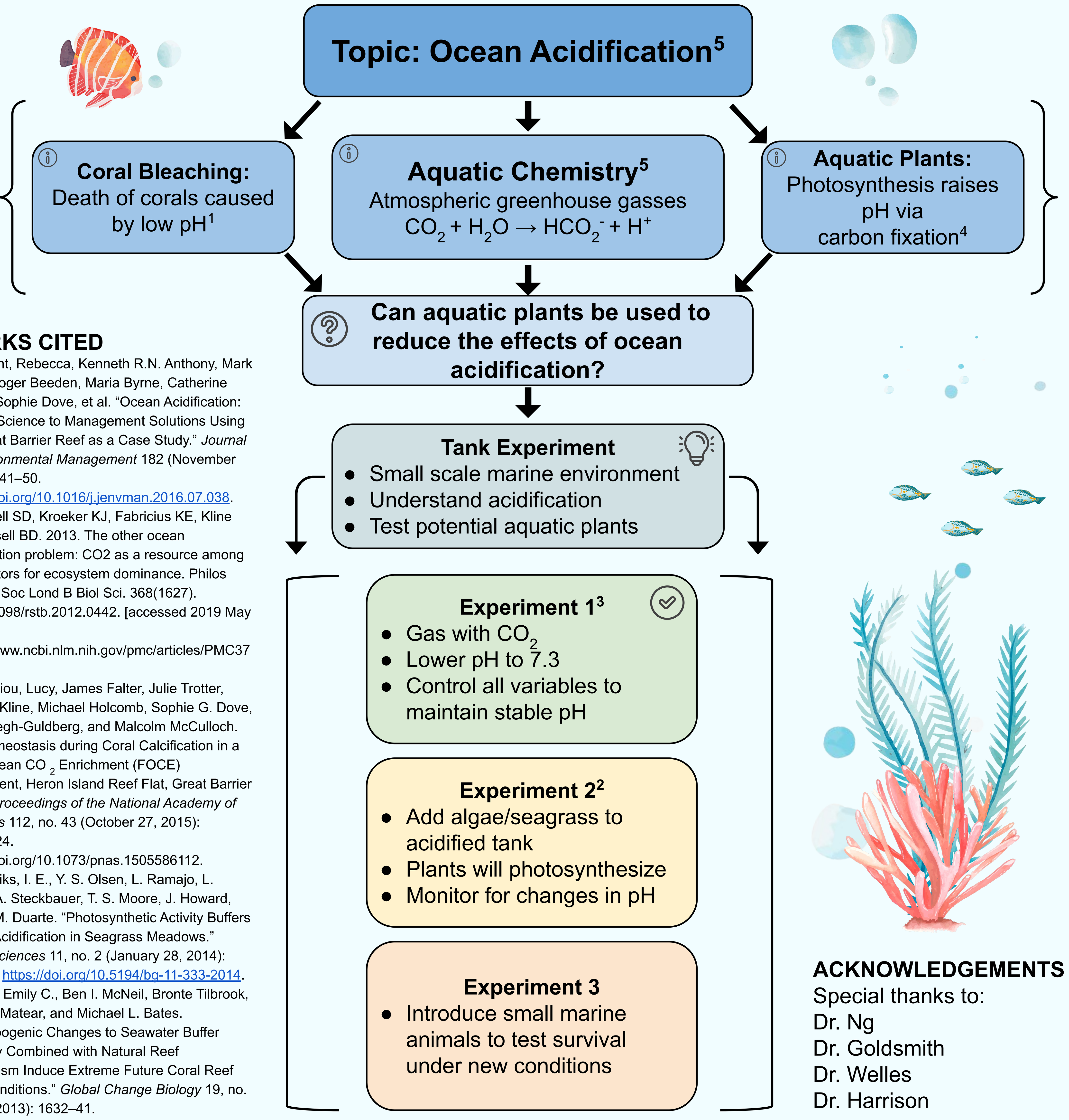
ABSTRACT

Ocean acidification is currently a major issue because of the damages it causes on the ocean's ecosystem beginning with coral bleaching. In some past research, aquatic plants have demonstrated the ability to increase pH of surrounding water through carbon fixation and photosynthesis. With these ideas in mind, a series of tank experiments were created for an acidic ocean environment with the intention of finding an aquatic plant that could raise the pH and form a symbiotic relationship with coral reefs to protect them from ocean acidification. The first single tank experiment explored some of the nuances of creating a small scale marine environment with pH adjustments which led to important discoveries in variables that must be controlled in the future prior to the addition of aquatic plants and algae. The next two tank experiments would include an aquatic plant that could potentially increase the pH via photosynthesis and carbon fixation, reversing the effects of ocean acidification. If a promising aquatic plant was found, it could be paired with coral to protect the reefs from acidic waters and allow the reefs to continue thriving.

INTRODUCTION

Figure 1. *Using the main topic of ocean acidification and literature research into coral bleaching, aquatic chemistry, and aquatic plants, the series of tank experiments were designed to find a photosynthetic aquatic plant that could increase pH of its surrounding water to protect coral reefs. In past studies, some types of aquatic plants, like seagrasses and algae, have demonstrated the ability to increase pH levels via carbon fixation[4], which set a basis for the experiments we planned on conducting.*



WORKS CITED

1.Albright, Rebecca, Kenneth R.N. Anthony, Mark Baird, Roger Beeden, Maria Byrne, Catherine Collier, Sophie Dove, et al. "Ocean Acidification: Linking Science to Management Solutions Using the Great Barrier Reef as a Case Study." *Journal of Environmental Management* 182 (November 2016): 641–50. https://doi.org/10.1016/j.jenvman.2016.07.038.

2.Connell SD, Kroeker KJ, Fabricius KE, Kline DI, Russell BD. 2013. The other ocean acidification problem: CO2 as a resource among competitors for ecosystem dominance. Philos Trans R Soc Lond B Biol Sci. 368(1627). doi:10.1098/rstb.2012.0442. [accessed 2019 May 10]. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3758175/.

3.Georgiou, Lucy, James Falter, Julie Trotter, David I. Kline, Michael Holcomb, Sophie G. Dove, Ove Hoegh-Guldberg, and Malcolm McCulloch. "PH Homeostasis during Coral Calcification in a Free Ocean CO_2 Enrichment (FOCE) Experiment, Heron Island Reef Flat, Great Barrier Reef." *Proceedings of the National Academy of Sciences* 112, no. 43 (October 27, 2015): 13219–24. https://doi.org/10.1073/pnas.1505586112.

4.Hendriks, I. E., Y. S. Olsen, L. Ramajo, L. Basso, A. Steckbauer, T. S. Moore, J. Howard, and C. M. Duarte. "Photosynthetic Activity Buffers Ocean Acidification in Seagrass Meadows." *Biogeosciences* 11, no. 2 (January 28, 2014): 333–46. https://doi.org/10.5194/bg-11-333-2014.

5.Shaw, Emily C., Ben I. McNeil, Bronte Tilbrook, Richard Matear, and Michael L. Bates. "Anthropogenic Changes to Seawater Buffer Capacity Combined with Natural Reef Metabolism Induce Extreme Future Coral Reef CO_2 Conditions." *Global Change Biology* 19, no. 5 (May 2013): 1632–41. https://doi.org/10.1111/gcb.12154.

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METHODS

Due to unforeseen circumstances, only the first experiment of the three outlined in Figure 1 was actually performed. The main components of that experiment were a 10 gallon tank, 30 liters of salt water, and substrate. The salt water solution was created by combining 102 grams of Instant Ocean with 30 liters of distilled water. Once this salt water solution was created it was gassed with a CO2 tank until the solution reached the desired pH of 7.3. The substrate utilized was a mixture of sand and gravel and while not officially weighed out, enough was utilized to ensure that the entire bottom of the tank was covered in substrate. Once the salt water solution was gassed the experiment was run for 24 hours. During the first 10 hours of the experiment the tank was monitored for an hour and then a period of 14 hours passed before the final measurement was taken. The measurements being taken consisted of pH, salinity, water level, and temperature. The pH was measured using Vernier pH probes and the salinity was measured using a digital TDS meter. When measurements were not being taken, bubble wrap was placed directly on top of water to prevent evaporation and contamination from air particles.

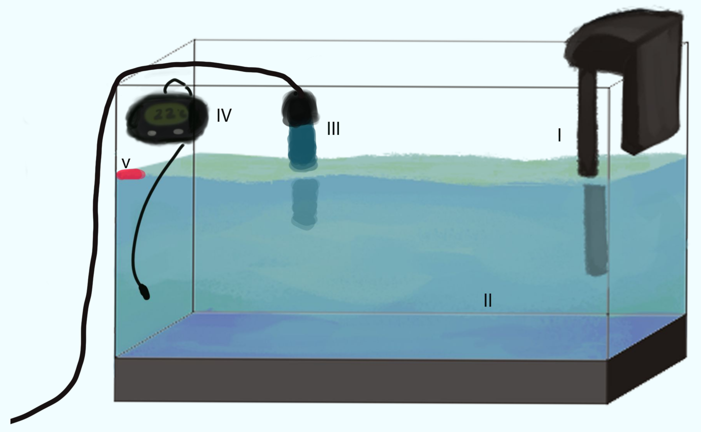

Figure 2. *Diagram of the experimental set up.*
I : Filter
II : 10 gallon tank
III : Vernier pH probe
IV : Thermometer
V : Water line mark used to keep track of evaporation

RESULTS

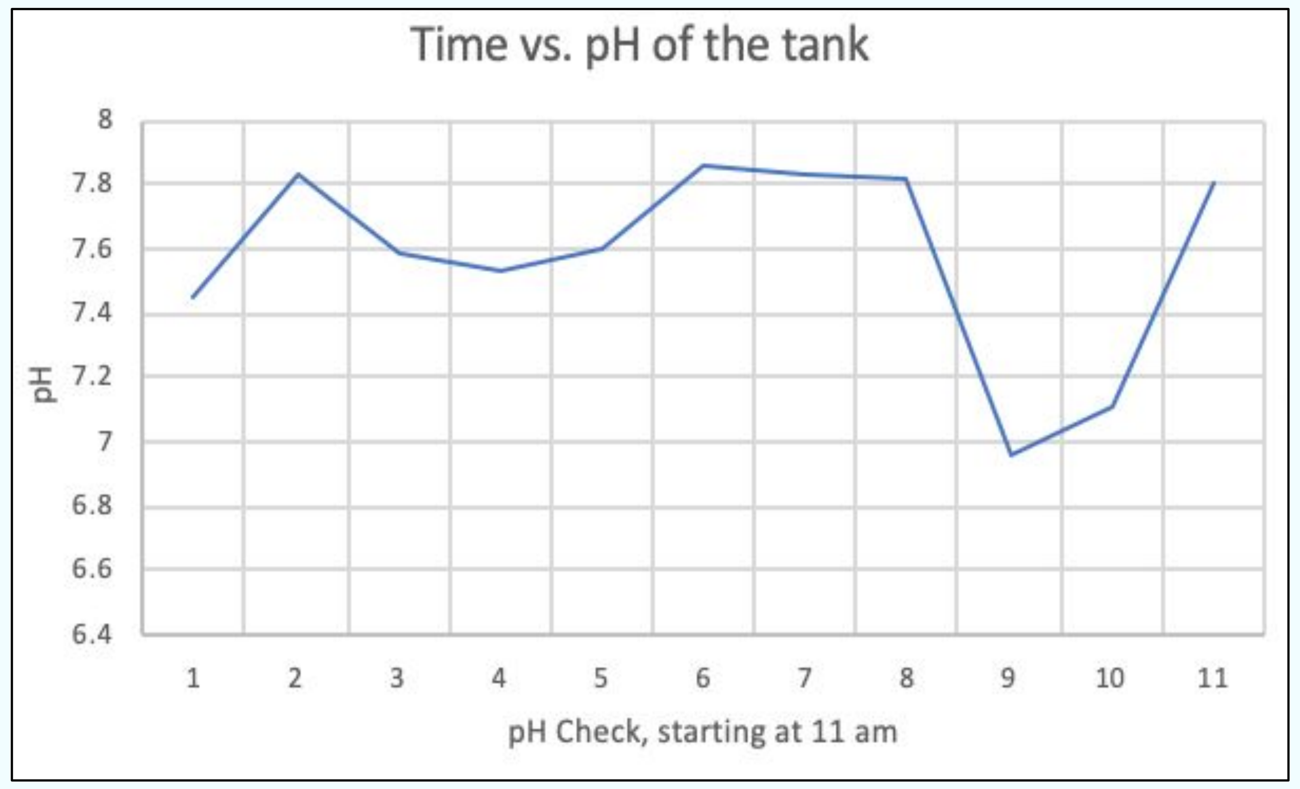

Figure 3. The changes in pH taken using two probes over the course of approximately 10 hours.

The graph on the left depicts a graph experimental data obtained when after gassing carbon dioxide into the tank and observing the pH hourly. Inconsistent pH results may be attributed to the lack of a sterile environment including microorganisms decomposing and/or photosynthesizing to lower and raise the pH respectively. Future experiments should use a sterile tank/sand in order to maintain a controlled environment.

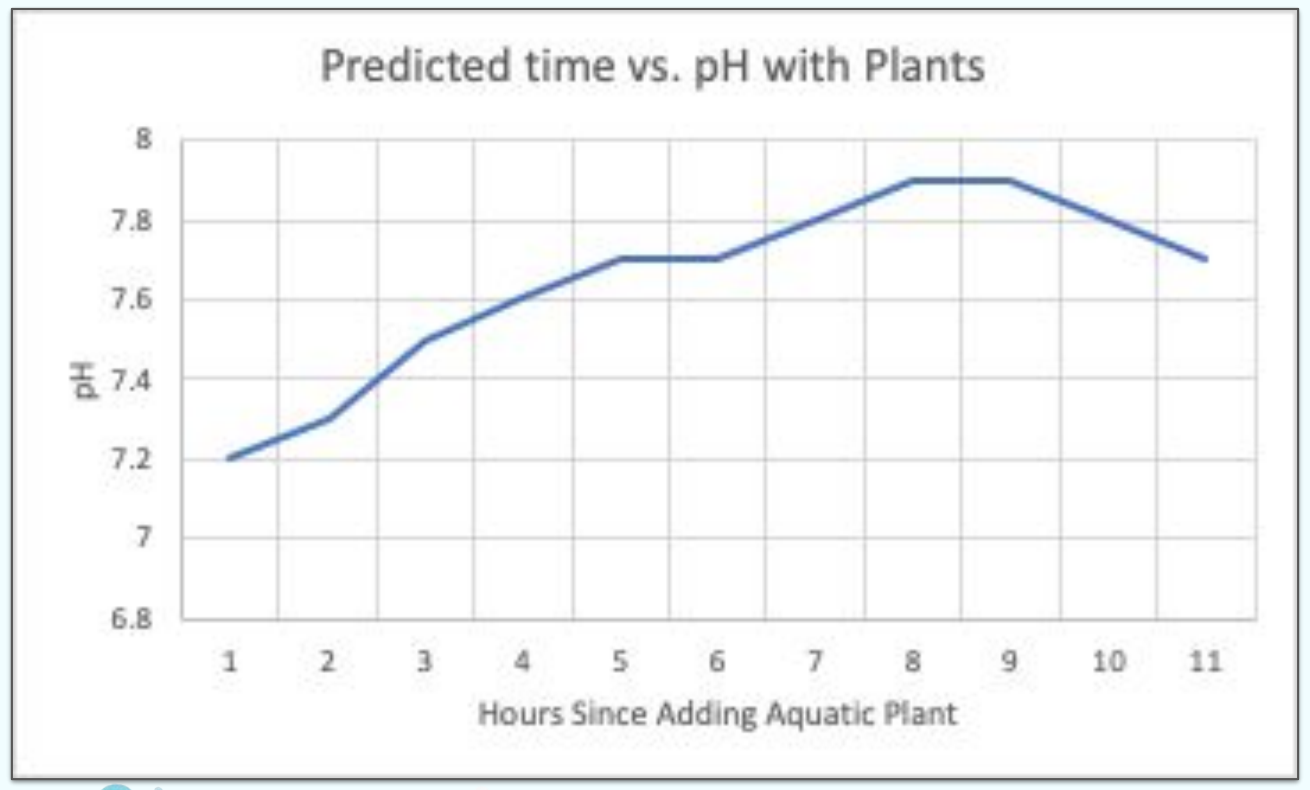

Figure 4. The predicted trend of changes in pH in the presence of carbon fixing aquatic plants. This data would be collected in experiments 2 and 3.

The graph on the left shows a predicted trend of pH values after gassing, with the addition of photosynthesizing organisms in a sterile environment. As the aquatic plants photosynthesize in the tank, the pH would increase due to the removal of carbon dioxide from the surrounding water. The equation for photosynthesis is shown below, using up carbon dioxide and thereby increasing the pH.

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Once the light source is removed, the pH should remain constant because the process of photosynthesis can no longer occur.

CONCLUSION

As reflected in the above data, the goal of maintaining an ocean environment in a tank posed many challenges. While the increase of pH due to the decomposition of unknown organisms in the sand was unexpected, the procedures and results of the experiment laid a solid foundation for future experiments. In these future experiments, once the environment can be reliably maintained at the desired pH of 7.3, marine plants such as seagrass and algae will be added to measure the effect of the plants on the pH. Further, all sand will be excluded from the future experiments to prevent the abundance of CO2 from the decomposing organisms in the sand. If the results support the hypothesis, the plants would decrease the pH in the tank. The results of these experiments could lead to helping solve the much bigger issue of ocean acidification. This can be applied to coral reef beds to see if plants and coral could form a symbiotic relationship where plants decrease the pH in the water surrounding the coral beds, allowing the corals to grow and flourish over time[5]. With this, many of the world's dying coral beds could be revived, saving the thousands of species' who need the coral beds to survive.