ENGPROJ102
Sensing Systems for Sustainability
Seagrass & pH

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Abstract: Seagrass is currently being looked at as a possible solution in combating the effects of ocean acidification on calcifying aquatic organisms. This is a fairly new field of research and is still being debated in the scientific community. The objective of our research project is to determine the difference in pH fluctuations in locations with abundance of seagrass and locations without. This will be done in the closest location with seagrass in the vicinity of Middelburg and Vlissingen. We will be measuring our data with light, pH, temperature and current sensors to further compare the data patterns between locations and the relationship between each variable. We will check our measurements every week to compile our ultimate data set. We will gather our data over a total of approximately 3 weeks, considering that one week will be needed per area.

1. Introduction

Climate change, Ocean acidification, biodiversity loss and many more are some of the most debated and researched topics in the scientific world today. A major part of scientific research is to make data collection more and more easy and at a reasonable price. This proposal focuses on a very specific topic in relation to Ocean acidification as well as biodiversity loss. Indeed, the sensor that will be developed will focus on the possible difference in pH fluctuations between locations with Seagrass and without. This is done because pH fluctuation with Seagrass meadows is nowadays seen as a possible solution to for instance coral bleaching. Indeed, seagrass capacity of changing their chemical environment could be used as a buffer against ocean acidification for calcifying organisms. This will be further explained in the first part of this proposal, starting with a short summary on what pH is, what ocean acidification is, what are its impacts on calcifying species, and finally what are the effects of seagrass on the surrounding water pH. If time allows for all of them, the following variables will be assessed: pH, light, current and temperature. The second part of this proposal will focus more on the actual project description. But first we will introduce important topics in our research in order to understand the project as a whole.

1.1. pH

The pH of water is measured by the concentration of H+ hydrogen ions. Specifically, pH is represented as the following formula: -log [H+]. (Water Science School, 2019 ; Huber & Blaha-Robinson, n.d.) pH is a logarithmic function; that is, one unit change in pH indicates a ten times difference in H+ concentration. However, in actuality, the hydrogen ion activity is measured and not the concentration of hydrogen. Acids have many H+ ions, while bases have many OH- ions. pH ranges on a scale of 0 to 14, with seven being neutral. Furthermore, values below seven are considered acidic and above seven bases. Although basic solutions are alkaline, “basicity” and “alkalinity” are not the same thing. Basicity is the ratio of hydrogen ions in solution and is directly related to pH, whereas alkalinity is referred to the acid-neutralising capacity. (Suter et al., n.d.)

1.2. Ocean Acidification

Ocean Acidification is directly linked to CO_2 emissions. Our ocean’s act as a sink for CO_2 (Doney et al, 2009; Fabry et al, 2008). These CO_2 sinks enable CO_2 to diffuse into a variety of ions as well as an aqueous form of CO_2 itself. The adding of these ions leads to a decrease in the concentration of CO3 2- , and thus a decrease in pH. This process is known as Ocean Acidification. It can be further described as the chemical shift in acid-base ratio within seawater where these shifts are brought about by means of thermodynamics and air to sea gas transfer processes (Doney et al, 2009). It is evident to say that Ocean Acidification has been rapidly rising in the past few hundred years (Doney et al, 2009; Rérolle et al, 2012) This is due to the human produced CO_2 levels within our atmosphere. A significant portion of CO_2 is absorbed by our oceans, and without it, serious adverse effects on a variety of terrestrial and aquatic ecosystems will occur (Fabry et al, 2008).There are also a variety of specific methods that can be used to measure ocean acidification (Rérolle et al, 2012), but functionally they all accomplish the main method of measuring the hydrogen-ion concentration in solution. In addition to adverse biological impacts there are also more obscure physical impacts of ocean acidification such as sound and light propagation (Doney et al, 2009). There may even be compromises to our infrastructure at more severe levels of Ocean Acidification. Electrolysis and other chemical processes could also be affected (Doney et al, 2009). In conclusion, Ocean Acidification is on the rise, and it will affect a plethora of organisms and ecosystems.

1.3. Ocean Acidification Impact on Calcifying Species

As carbon dioxide dissolves into the ocean, seawater becomes undersaturated with carbonate ions reducing the total amount of calcium carbonate available, a substance essential for calcifying organisms such as coral reefs. Coral reefs depend on calcium carbonate to build their exoskeleton, and a change in pH levels, due to acidification, can harm the structural integrity and growth of these organisms (Hoegh-Guldburg et al, 2007). When the pH lowers, it takes more energy for the calcification process, and corals have not properly adapted to this new change in environment. (Kleypas et al, 2009). Coral reefs bleach, which is a loss in their colour due to the changing environment, or die because of the low pH levels. According to Joan A. Kleypas et al, a doubling of pre industrial atmospheric CO_2 concentration results in about a 10–50% decrease in the calcification rate of reef-building corals and coralline algae. A data collection of corals from the Great Barrier Reef, which extends these records through 2005, indicates a 14% decline in calcification rates between 1990 and 2005 because of acidification and rising temperatures(Hoegh-Guldberg et al., 2009). Other sources, such as Hoegh-Guldberg et al suggest that an increase in carbon dioxide to 560 ppm decreases coral calcification and growth by as much as 40 percent due to the inability to form aragonite (an important component of a coral skeleton). Oceanic acidification affects other organisms as well such as echinoderms, mollusks, corals and a variety of calcifying algae (Hoffman, 2014). The effects on these organisms are different depending on the species, stage of growth and rate of calcification. Although ocean acidification has been shown to harm the structural integrity of most organisms, it might actually promote photosynthesis in others. For instance, in seagrass and several types of microalgae, growth has been shown to increase and carbon dioxide levels have decreased (Kleypas et al, 2009). Although, ultimately as pH levels continue to lower and temperatures rise important ecosystems will perish resulting in a loss of biodiversity and coastal protection.

1.4. Seagrass effect on pH & possible applications

Seagrass are angiosperm species present in shallow coastal areas; these are some of the most productive ecosystems in the world. According to Chou et al. (2018) if seagrass meadows cover only about 0.1% of the sea floor, they could be contributing to up to 10% of the organic carbon sequestration in the ocean. Adding that seagrass meadows about 27% of the overall sequestered carbon by the plant, is then stored in what is called matte and this for millennia (Barruffo et al, 2021). Over the past years, seagrass has been looked at as a possible chemical buffer for Coral reefs or other calcifying organisms against the effects of Ocean Acidification (Koweek et al, 2018). This can be explained by the fact that seagrasses are known for modifying seawater carbon chemistry through high levels of primary productivity or also called photosynthesis (Chou et al, 2018). Considering the important diurnal variability in the seawater levels of carbon, it has been found that seagrass could either mitigate or enhance Ocean Acidification depending on the time of the day (Chou et al, 2018). Indeed, during the day, seagrass will be photosynthesizing, taking the CO_2 out of the water, but during the night, it will release some of the CO_2 during respiration. If respiration and photosynthesis are two of the main impacts on surrounding pH and CO_2 fluctuations, other species present within the meadow, such as epiphytes, calcifying organisms and benthic invertebrates, all might also have an important effect on pH fluctuations (Chou et al, 2018). If this subject is still widely debated, it is of great interest to the scientific community to search more into it.

2. Project Description

We will be developing a sustainable device to measure the pH, light intensity, current, and temperature in areas with seagrass and areas without. As explained above, in places with Seagrass, the pH fluctuates quite a lot over the day and the night, which could in turn create a favourable environment for endangered coral species. Due to the complexity of field experiment and data gathering, we will be assessing 4 different variables: pH, light, current and temperature. pH being the centre of our research, it must be assessed no matter the time constraint. But if time allows, light will be very useful since it is one of the main factors in seagrass photosynthesis and could be impacted by clouds, sediments or dirt in the water, etc. Current could also be quite important since it can create mistakes in data gathering considering that the water within the seagrass could be impacted by changes in water flows. Finally, temperature is important as a whole since it is needed in pH measurements. Since our sensors will be immersed in water and at a certain depth (that still needs to be determined), we aim to develop a water-proof and submersible device. Indeed, in previous studies and experiments taking individual samples at a regular rate has been found to be highly time-consuming and we aim to remedy this inefficiency by creating an easy to use device. We seek to create a unit that can remain in the water and collect sufficient data for our experiment and especially over, if possible, a number of days and no matter the weather constraints. The project will be fully completed once we have developed the final device and, with said device, gathered and organized enough data from areas with and without seagrass. We estimate that this may take about a week per area. Furthermore, in our literature review, there is a significant part on how pH is affected by CO_2output, but we will not be measuring CO_2levels directly but instead pH that is partially impacted by CO_2. The literature review will mostly be used as background information. We will be looking into the impact of seagrass on the surrounding pH of the water, but we will not be looking into the impact on calcifying organisms, since we do not have the time, neither the resources and it is not directly answering our research question: "How does the pH fluctuations differ between locations with Seagrass and without?". Nevertheless, our sensing device could be used as the first step towards using seagrass as a buffer against ocean acidification for calcifying organisms.

3. First draft of the project agenda

Week (Date)	Project Objective/Goal
March 1st	We will continue to work on improving our skills with Arduino boards.
March 7th	Focus our Arduino work on building sensors + delegate who will work on which sensor, Begin working on the pH sensor and design a prototype
March 14th	Continue working on the pH sensor and begin prototyping the water proof structure for the sensor
March 21st	Finish the pH sensor
March 28th	Finish prototype for water proof structure + begin working on light sensor and temperature sensor and current sensor
April 15th	Finish light/temperature/current sensor (depending on the amount of time available)
May 1st	Set up time slots for experiment and determine location of experiment + finish the sensors and entire physical project
May 5th to May 26 (Subject to change)	Set up experiment and log measurements
June 1st	Finish entire project

4. References

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