STUDENT FINAL REPORT TO THE UNIVERSITY OF HAWAI‘I MARINE OPTION PROGRAM

Establishing an Entry Level Coral Monitoring Program for University of Hawai‘i at Hilo Marine Option Program (MOP) Students

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FINAL DATE

December 3rd, 2021

Abstract

Coral reefs are highly biodiverse ecosystems that are important due to the many environmental services they provide, including coastal protection, food supply, and income for many tourist-heavy areas. Coral reefs are a delicate ecosystem and their overall health is declining due to bleaching episodes, algal overgrowth, and coral disease. New coral observation techniques are being tested globally to ensure corals are being constantly monitored and to discover new and more effective ways in which to do it. This project aimed to create a set of entry level monitoring techniques for bleaching, algal overgrowth, and coral disease at a local Hilo beach. Corals at Leleiwi Beach Park in Hilo, Hawai‘i were monitored for bleaching, algal, and disease damage for four months. Results showed low levels of bleaching and disease damage, but high levels of algal overgrowth in the area. Baseline data from this project will aid in future observations of coral health off the coast of Hilo, Hawai‘i.

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Introduction

Coral reefs are highly biodiverse ecosystems that are important due to the many environmental services they provide. Coral reefs are globally renowned for their high levels of biodiversity and productivity partly due to their live scleractinian corals. Scleractinian corals provide a necessary biological substrate that is important for providing food and shelter, and aid in moderating competitive interactions by providing safe places and specific niche habitats (Coker et al. 2013). Coral reefs also aid coastal communities. Reef fishes and invertebrates are a fundamental source of protein for tropical coastal countries and coral heavy coasts are protected from hurricanes and wave damage (Wilson 1997). The coral tourism industry supports economic growth and alternative livelihoods for local people in developing countries (Wong et al. 2018). Areas with heavy branching coral density provide fishing grounds and fish nurseries which can be crucial for securing the sustainable use of fisheries resources along tropical coastlines (Suzuki et al. 2020).

Coral reefs of the world are in danger due to an increase in anthropogenic threats, particularly reef-based tourism and coastal development. Current threats to reefs are due to a mix of anthropogenic and climate change effects working synergistically; this includes overexploitation, chemical and oil pollution, sedimentation and eutrophication from deforestation, construction, and agricultural runoff (Shadrack et al. 2019; Wilson 1997). In the Pacific, impacts are often associated with coastal development issues like land use change, urbanization, and poor management. Overfishing and coral disease also lead to an increase in sediment, nutrients, and chemical runoff from farms, and these pollutants settle into reef beds (Shadrack et al. 2019). Coastal development, like the construction of hotels and restaurants, consequently increases sedimentation, turbidity, and sewage loading (Wong et al. 2018). The heavy usage of reef habitats by tourism companies with options like diving, snorkeling, and boating can result in the physical damage of corals which can be linked to disease and lower abundance of not only corals, but coral - associated fish. Nutrient enrichment, a common result of reef based tourism, has increased the severity of coral disease and its regularity (Wong et al. 2018). Stony corals, an important reef building species and coastal protector, have been showing an increase in viral infections and bleaching after being exposed to sunscreen. Commercial sunscreens have chemicals that are not water soluble so they rest at the surface. This can impede light penetration and affect light availability. Sunscreens are washed into the ocean and due to sunscreen's lipophilic nature, they can accumulate in aquatic animals affecting their overall health. As a result of tourism, roughly 10% of the world's coral reefs are jeopardized by sunscreen pollution (McCoshum et al. 2016).

Reefs are declining rapidly due to bleaching, meaning the mutualistic relationship between corals and their endosymbiotic dinoflagellate algae is endangered as corals expel the microorganisms in response to environmental stressors. Oxidative stress occurs when environmental stressors, like those closely associated with climate change, increase (Roth 2014). Global climate change has worsened the effects on the ocean, with increasing surface temperatures as the main source of bleaching events (Weiler et al. 2019). Patterns among rising CO_2 levels, increasing surface temperatures and the biological responses of reefs are specifically documented over time which provides a solid foundation for future research and predictions (Veron et al. 2009). Many corals bleach because of increasing seawater temperatures which results in the loss of symbiotic algae (Rowan 2004). Dinoflagellate algae live inside coral cells and provide corals with almost all the energy needed to meet metabolic needs (Muscatine 1990). Endosymbionts are forced out of the coral host due to oxidative stressors, leaving the coral unable to acquire energy through algal photosynthesis which results in high coral mortality and suppressed growth (Pandolfi et al. 2011). Reef ecosystems flourish in oligotrophic environments, meaning areas with low available nutrients and high oxygen levels, due to the relationship between corals and their endosymbiotic dinoflagellate algae *Symbiodinium*. *Symbiodinium* converts sunlight and carbon dioxide into oxygen and organic carbon to power coral growth and calcification (Roth 2014).

The direct link between bleaching and coral disease has become a growing concern among coral reliant communities. The link between the two is exceptionally high water temperatures. Increasing water temperatures can physiologically stress coral holobionts and coral communities, and ultimately lead to bleaching and increasing coral's susceptibility to disease (Miller et al. 2009). Increasing sea surface temperatures have been associated with bacterial proliferation which includes pathogens, leading to higher levels of coral mortality. Coral disease has shown a positive correlation with bleaching as it weakens the coral host (Weiler et al. 2019). Nutrient enrichment has increased the development of white, black, and yellow band disease, the intensity of aspergillosis in sea fans and the regularity of dark spots disease (Shaver et al. 2017). Black band disease is characterized by black microbial mats that grow over and into coral tissue. White band disease is seen as clear lesions that border newly exposed white skeleton and tissues (Ainsworth et al. 2006). Aspergillosis appears as a highly visible lesion appearing on coral tissues. Dark spot disease appears as a dark brown or purple area on coral tissue, the tissue remains intact but lesions and coral death are seen in the center of the spots. White pox appears as tissue degradation that accompanies round lesions, tissue loss progresses along a distinctive line or with small areas of remaining tissue and is sometimes present near the edge of oddly shaped patches. Yellow band disease is known for large rings or patches of bleached, yellow tissue. Tissue loss is slow but can blend in with common bleaching signs (artificifialreefs.org 2021).

The overgrowth of algae on what was once coral heavy areas is also of growing concern. Phase shifts, coral reefs shifting to extremely low levels of coral cover and constant states of high microalgae cover (McManus and Polsenberg 2004), are becoming more prevalent. Phase shifts may be caused by many things, including both periodic anthropogenic or environmental pressure in short duration and recurring pressures in long duration (Arias-Gonzalez et al. 2017). One way algae causes coral mortality is by increasing the prevalence of microbial activity by releasing dissolved compounds. Compounds released by algae enhance microbial activity causing mortality and further algal growth. This can be linked to a positive feedback loop between human impacts and algae (Smith et al. 2006). The increase of available nutrients may be driving degradation levels higher as it encourages fast growing algae that can stunt coral growth and survivorship (Shantz & Burkepile 2014). Mechanisms of overgrowth include allelopathy, smothering, shading, and abrasion (McCook 1999). The global decline of coral reefs is partially driven by algal overgrowth of live and recently dead corals, benthic algae are commonly replacing corals. Coral - algae competition is mediated through the complex interactions of numerous components of reef communities including herbivores, predators, and microbes, all of which are being impacted by coral loss (Wolf & Nugues 2013).

The point of this project was to establish a baseline data set and usable techniques for students in the University of Hawaiʻi at Hilo Marine Option Program (MOP) program to use for the continuous monitoring of a beach off the coast of Hilo. The intent was to create an entry level program with entry level techniques for students with little experience in a field research environment.

Materials and Methods

Site Description

Leleiwi Beach Park, also known as Wai'uli, is a small area that neighbors Richardon's Beach Park. Leleiwi is a popular site for shallow snorkeling and swimming because of the lava rock pools, tide-pools, fresh water springs, and abundant marine life. The area of the beach park used for this project covered roughly 918.68 m^2 (Google Earth). This site was chosen due to its shallow water habitat and moderate coral cover. Figure 1 displays where Leleiwi Beach Park is in relation to Hawai'i Island. Figure 2 displays the approximate area in which the observations were conducted.

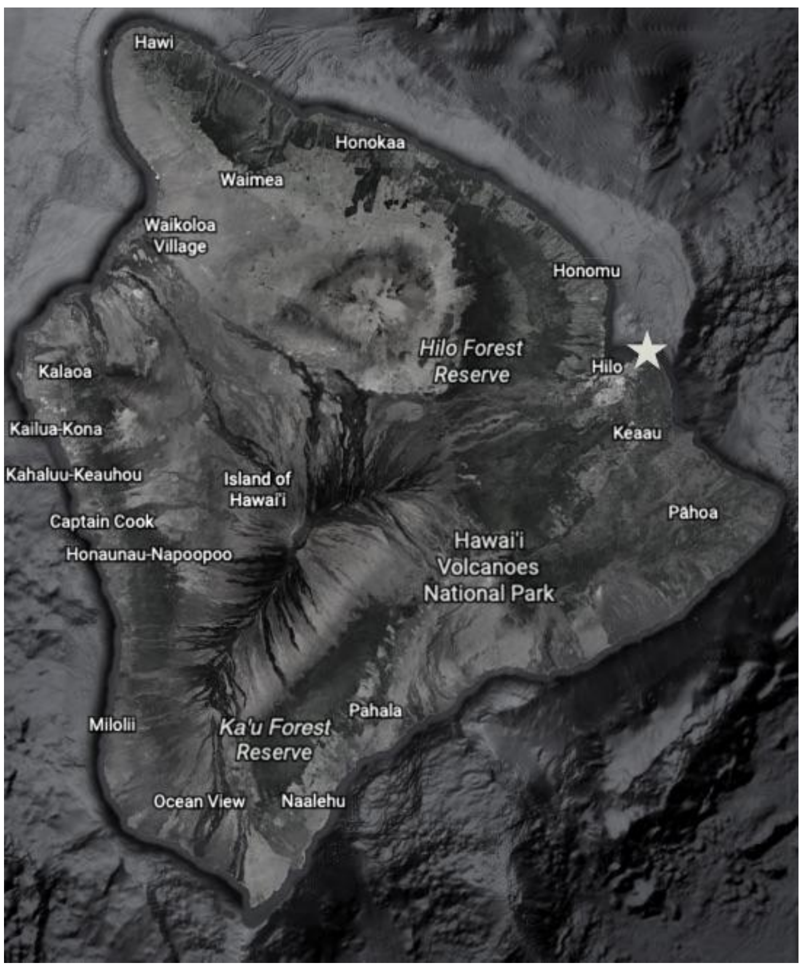

Figure 1: Google Earth image of Leleiwi Beach Park in relation to the Big Island of Hawai'i

Figure 2: Google Earth Image of Leleiwi Beach Park; circle indicates area that was observed from June 2021 to September 2021

Establish baseline data for corals within the study area

This project ran from June 2021 to September 2021. During the last weekend of each month, weather permitting, corals at Leleiwi Beach Park were observed for bleaching, disease, and algal damage. The sampled corals were chosen because they were at least 3 inches in width, height, or length. Each coral head was photographed using an Olympus Tough TG-870 underwater digital camera.

The location of each coral head was marked using a Garmen GPS 73 and a waterproof housing was made for the GPS. Coordinates taken from each day were matched with the corals that were photographed both from that day and previous sample days.

Development of a scale for measuring live coral cover

A severity scale for assessing bleach damage, algal overgrowth, and coral disease was made and modeled after the Eyes of the Reef Hawai‘i (EOR) Coral Bleaching Report form (https://eyesofthereef.wufoo.com/forms/q17t18yt1b9itat/). The scale was broken down to identify the percent of live coral cover in each coral head sampled (Figure 3). An “in the field” model was created for students to further understand the percentage of live coral cover (Figure 4).

Severity Scale	Percent Live Coral Cover
1	81% - 100%
2	61% - 80%
3	41% - 60%
4	21% - 40%
5	0% - 20%

Figure 3: Score chart from the google sheets key

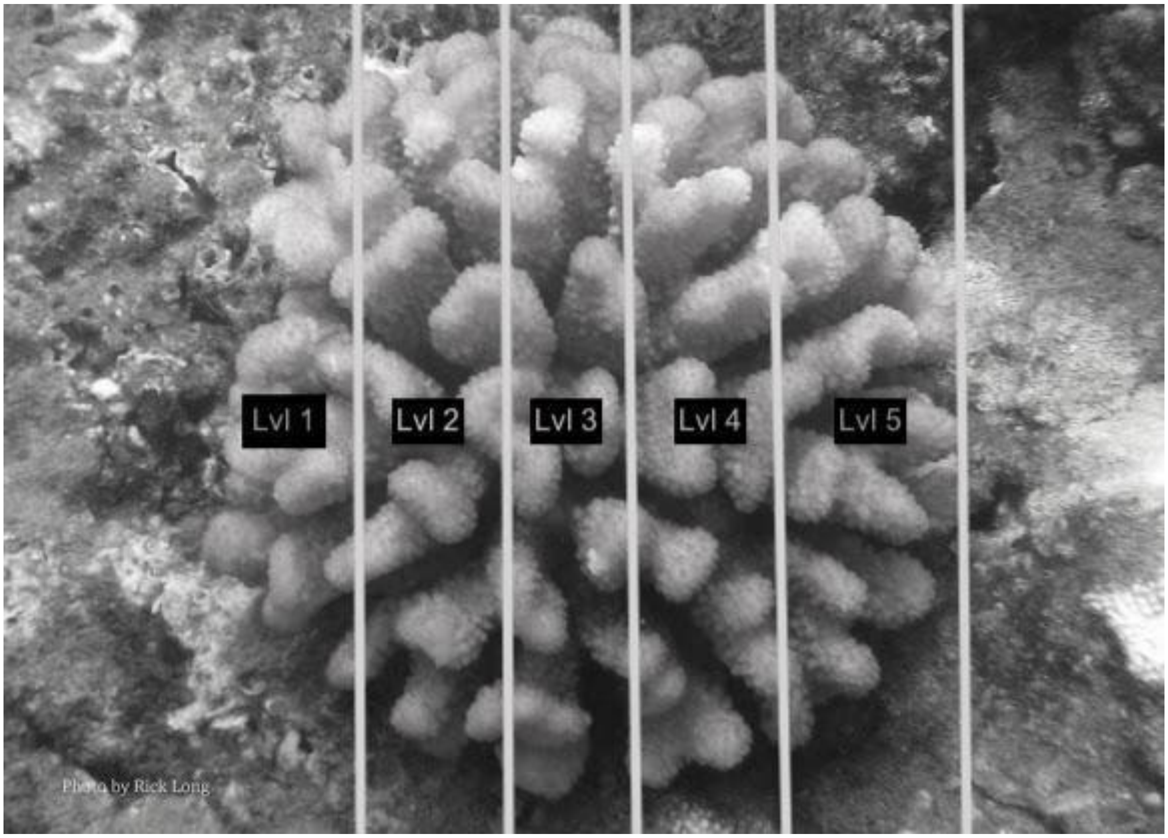

Figure 4: Coral head with percent live coral cover scale (photo credit: Rick Long)

Building the spreadsheet

A spreadsheet was created to match coordinates and compare data from different sample days (https://docs.google.com/spreadsheets/d/1kcojkkSD3do-aJ1LqZ6U-QtWJnAABAbp0GjahA1m05I/edit?usp=sharing). The spreadsheet was split into 3 tabs; one for the severity scale and coordinates, another showing the breakdown of the key and a few examples of how to identify corals with different rankings, and a third where field steps and equipment were listed. The spreadsheet also included the Google Photos folder link that contains the photographs from previous sample days. Students will be able to follow the steps listed on the spreadsheet and sample data exactly as I did using the information provided.

All equipment used was on loan from the University of Hawaiʻi at Hilo Marine Science Department. This baseline data sheet can be used for comparisons of past and future coral data sampling through the University of Hawai‘i at Hilo's Marine Option Program (MOP).

Results

Approximately 14 coral heads were studied throughout this project. After comparing the photos for the 4 months, there were no noticeable changes among any of the coral heads observed. There were approximately 4 coral heads that showed potential for future bleaching and 3 coral heads that showed evidence of algal overgrowth. The evidence of bleaching severity was lower than predicted, but the evidence of algal overgrowth was higher than expected. There was no evidence of coral disease at any point during this observation period. Figure 5 displays a breakdown of the observations recorded on June 30th, 2021 with coral scores. After all data was collected, 64.3% of the corals observed scored a level one severity, 14.3% scored a level three, and 21.4% scored a level five. None of the corals observed scored levels two or four (Figure 6).

Date Observed	Species	Longitude	Latitude	Severity of Damage (1-5)	Reason for Score
08.30.2021	*P. meandrina*	19* 44.094' N	155* 00.890' W	3	Left side of coral appears dead due to algal overgrowth
08.30.2021	*P. meandrina*	19* 44.098' N	155* 00.889' W	5	More than half of coral appears dead due to algal overgrowth - about
08.30.2021	*P. meandrina*	19* 44.107' N	155* 00.889' W	1	Very little bleaching
08.30.2021	*P. meandrina*	19* 44.103' N	155* 00.890' W	1	Blurry - very little bleaching
08.30.2021	*P. meandrina*	19* 44.103' N	155* 00.887' W	1	No damage/appears very healthy
08.30.2021	*P. meandrina*	19* 44.104' N	155* 00.886' W	1	No damage/appears very healthy (coral on the left side of the photo)
08.30.2021	*P. meandrina*	19* 44.104' N	155* 00.884' W	1	Slight bleaching on right side - about 20% bleached
08.30.2021	*P. lobata*	19* 44.108' N	155* 00.883' W	5	Yellow spots are dead and being colonized by algae
08.30.2021	*P. meandrina*	19* 44.102' N	155* 00.884' W	1	Very little bleaching

Figure 5: Corals observed on August 30th, 2021 and their scores.

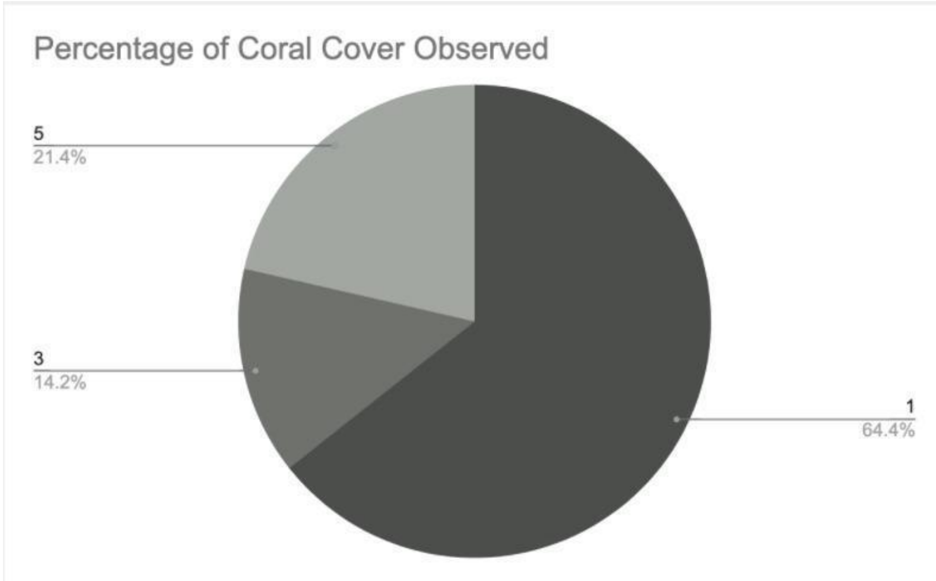

Figure 6: Graph displaying severity levels scored

Discussion

The evidence of bleaching damage was much lower than expected while the evidence of algal damage was higher. There was no evidence of coral disease seen on any of the observation days. It is safe to say that, at least for now, the levels of bleaching in the area are low and do not seem to be changing quickly. This might mean that if changes do occur, they will happen rather slowly and it does not appear that there is currently a bleaching event underway. A larger concern is the increase of algal overgrowth in the area. Throughout this project, I noticed more evidence of algal overgrowth than I did bleaching. There was also more evidence of future overgrowth amongst coral heads nearest those that had already been suffocated by algae. This project will provide UH Hilo MOP students baseline data for Leleiwi Beach Park corals and easy techniques to continue coral monitoring over time. This project can also aid in community outreach and education about the state of local corals.

Conclusion

Bleaching, algal overgrowth, and coral disease are constant threats that are becoming more common. From sunscreen poison, to chemical run off, to a rise in CO_2, corals are dying at an increased rate. It is important to establish education programs for the public by creating citizen science programs and monitoring techniques for inexperienced people. This project aimed to create a baseline data set that can be used in the future studies of corals off the coast of Hilo, Hawaiʻi.

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