REPORT FOR THE UNIVERSITY OF HAWAIʻI AT HILO MARINE OPTION PROGRAM

The monitoring of two corals in Onekahakaha Beach Park for coral bleaching

Laura Ibbotson

Marine Science Department
University of Hawaiʻi at Hilo

MOP ADVISOR

Julia Stewart

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Abstract:

Coral reefs are the most diverse marine ecosystem; however, they are under several threats, including coral bleaching. Caused by the loss of symbiotic algae, coral bleaching is a stress response brought on by changes in ocean conditions. Two rice corals (*Montipora capitata)* were monitored at Onekahakaha Beach Park in Hilo, Hawaii for bleaching. Top and side-view pictures were taken, as well as water temperature, salinity, and pH measurements. Over the course of the study, both corals initially recovered but began to bleach again toward the end of the study. It was determined that there was no significant difference between the three water quality measurements at both corals. There was a significant difference in coral bleaching at both corals for the top views. Neither coral became diseased or had algal growth. During this study, I learned valuable monitoring skills, including Eyes of the Reef protocol for taking and analyzing photographs of corals, how to measure salinity and pH using a refractometer and pH meter, and how to identify and monitor bleaching over a long period of time. Outreach was conducted to educate the general public on causes and issues surrounding coral bleaching and disease.

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Introduction:

Coral reefs in the Pacific are currently being impacted by bleaching events. Monitoring coral reefs is important due to their impact on not only the marine environment but also land environments as well. Reefs provide shelter to at least 25% of marine species, protect the coastlines, support fish industries, and provide raw materials for medicines (Moberg & Folke 1999). They also support tourism revenues and hold cultural significance (Bellwood et al. 2004). Due to their importance, coral bleaching and coral diseases need to be monitored in order to develop ways to prevent such events from occurring.

Coral bleaching is a stress response that occurs when the environmental conditions are not at optimum levels, causing the coral to expel symbiotic algae called *Symbiodinium.* Because *Symbiodinium* cause the corals to have such bright colors, this expulsion results in the coral becoming white, or bleached (Baker et al. 2004). Many environmental factors can cause coral bleaching to occur; however, the main cause of bleaching is increased water temperatures (Hughes et al. 2003). Bleaching occurs when sea temperatures surpass the temperature tolerance of both the coral and the symbiotic algae (Hoegh-Guldberg 1999).

Due to how influential water temperatures can be, it is believed by some scientists that global climate change is the root cause of bleaching (Ban et al. 2014). Other factors include low salinity due to freshwater input, changes in pH, and poor water quality due to pollution and sedimentation. Additionally, large bleaching events can be linked to El Niño events (Douglas 2003). If environmental conditions continue to be unfavorable, the coral will eventually die. However, bleaching does not automatically cause death; if the stress was not severe and environmental conditions return to normal, the coral can become healthy again by reabsorbing *Symbiodinium* (Baker et al. 2004).

Whether a coral reef recovers from bleaching depends on many factors. In one study, coral recovery was found to be dependent on water depth, abundance of juvenile coral, and amount of nutrients after analyzing the data collected (Graham et al. 2015). Another study found that shallow reefs near shore were more likely to bleach and less likely to recover (Furby et al. 2013). Another study found that the likelihood of coral recovery was impacted by the bioavailability of iron, as iron is required for the *Symbiodinium* to function correctly (Song et al. 2015). Other studies have shown that the type of symbiont also determines the likelihood of recovery; some symbionts have become more accustomed to the warmer water temperatures than others (Baker et al. 2004; Donner et al. 2005; Rowan 2004).

Unfortunately, because of bleaching, the coral will be more susceptible to coral diseases in the future (Baker et al. 2004). Coral diseases are caused by abiotic and biotic factors. Environmental stressors include changes in temperature and salinity, as well as exposure to pollution, toxic chemicals, and sedimentation. Biotic stressors include several pathogens (Brown 1997). The frequency of coral diseases has increased significantly over the past decade with increased pollution and sea temperatures. Coral diseases are another reason why coral bleaching should be closely monitored.

Coral bleaching in Hilo, Hawaii is currently being monitored by Eyes of the Reef. Eyes of the Reef is a network that was created to increase public awareness and engage communities in the monitoring and reporting of coral bleaching and disease. The organization trains community members to identify coral bleaching and disease and these reports are used to help reef managers respond to harmful changes to the reefs (Eyes of the Reef 2016). However, few current studies are being conducted on the relationship between water quality and coral bleaching within Hilo, Hawaii.

For this project, I monitored two corals over a period of four months, noting the general health of the corals and the conditions of the environment around them. I applied monitoring methods used by Eyes of the Reef as well as methods from previous courses, which allowed me to find correlations between the environmental conditions and the affected corals. By monitoring two corals, I determined whether or not the environmental conditions affected other reefs in the vicinity. This study benefited people living on the coast, fisheries, and the tourism industries.

Objectives:

The goals of this research project were to monitor multiple corals over an extended period of time, differentiate coral bleaching from other similar coral diseases, and use protocols from Eyes of the Reef to take photographs and analyze them. Another purpose of this project was to experience conducting a research experiment and to write a formal report and presentation, as well as educate the general public on the subject of bleaching.

Methods:

a.) Study Site:

This study was conducted at Onekahakaha Beach Park in Hilo, Hawaii (Figure 1). This location was chosen for this study due to the frequently calm and shallow waters, which allowed easy access to the corals. It was also chosen because few people are monitoring Hilo beaches for coral bleaching. Onekahakaha is well-known for its coral and fish by residents that live in Hilo, and so it was important that monitoring of bleaching take place there. Onekahakaha consists of several tide pool-like areas, many of them too shallow to contain coral. The area where the chosen corals were located in was the larger tide pool; both corals were close to the rock edge (Figure 2).

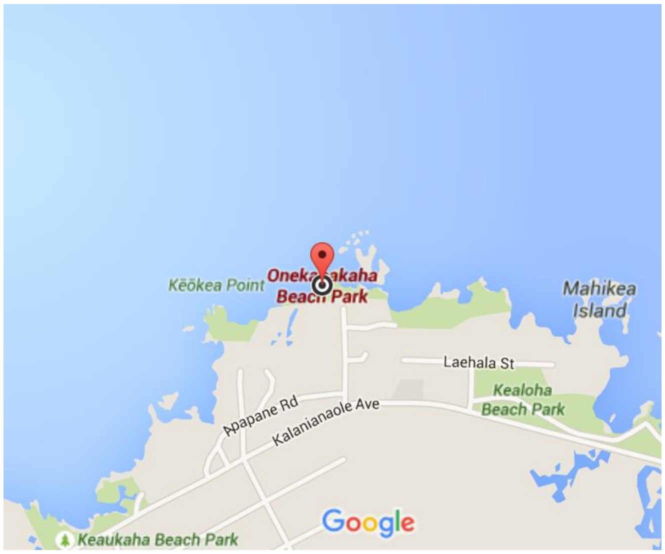

Figure 1: Onekahakaha Beach Park located in Hilo, HI

Figure 2: The location of both corals at Onekahakaha Beach Park, marked with an “X”.

b.) Choosing the two corals

Both corals were chosen because they were of the same species (rice corals or *Montipora capitata)* and were in an area that could easily be remembered, which allowed for the corals to be easily found. The corals specifically chosen were selected because they were in different stages of the bleaching process; one was almost completely bleached while the other was only partially bleached. The corals were approximately five meters away from each other.

c.) Taking photographs

Following the methods of Eyes of the Reef, two types of photographs were taken during every data collection. One picture was a top-view, while the other was a side-view. Normally, four side-view photographs would be taken (from the north, south, east, and west) but because my corals only faced one direction, this did not have to be done. Every photograph was taken perpendicular to the coral, about three feet away, and approximately in the same orientation each time. Included in the photographs was a plastic ruler tied with fishing weights. This was used as a measurement reference. The ruler was placed in approximately the same location each time, next to the coral.

d.) Taking measurements of abiotic factors

Three abiotic factors were measured during this study: water temperature, salinity, and pH. Water temperature was taken *in situ* using a glass thermometer. The thermometer was held close to the coral in approximately the same location each time and after waiting a few seconds, the temperature was recorded. Samples of the water close to each coral were taken so that the salinity and pH of the water could be measured off-site. The measurements were done using a pH meter and a refractometer.

e. Analyzing the photographs

All pictures taken of the corals were analyzed using a free, Windows-based software called Coral Point Count with Excel Extensions (CPCe). This program was used in the determination of coral cover to analytically determine areas of bleaching and recovery. In the program, the entire coral was first outlined and the program then calculated the total area of the outlined coral. The total area was recorded and then the outline was erased. The bleached areas were then outlined. This part of the procedure was difficult because the term “bleached” had to be defined in terms of what could be outlined. A protocol was created to determine what bleached spots would be outlined. If the bleached spot was missing 75% or more of the polyps, then the spot was outlined.

f. Statistical Analysis

Various 2-sample *t*-tests were run to determine if there was a significant difference in salinity, water temperature, and pH between the two corals ($\alpha = 0.05$). Additionally, 2-sample *t*-tests were run to determine if there were differences in percent coral bleaching in top and side views of both corals. Correlation tests were run to determine any relationship between the three water quality measurements and percent bleaching. Simple linear regressions were also run to determine how well each variable could be used to predict coral bleaching.

g. Outreach

At the end of the study, two other people and I set up and operated a booth at the annual Earth Day Fair that occurred on campus. This booth was designed to educate both young students and adults on what is currently happening to coral reefs, especially local reefs. At the booth, we educated anyone interested in why corals were important, what was currently affecting them, and what the process of coral bleaching involved. We also talked about a few different coral diseases and what scientists are currently doing to learn more about them. We always ended our little “Coral 101” information session with a few things that the public can do to help both directly and indirectly, such as never stepping on the coral or carpooling to reduce climate change.

For the younger students, we also had a game for them to play. This game involved a box, four cups, and a bunch of small bouncy balls. The whole setup represented the coral colony, the cups represented the polyps and the balls represented the *Symbiodinium*. We started every game with a healthy coral (the cups were full of the colorful balls) and then announced that warming waters were causing the “coral” to bleach. The balls were emptied from the cups, showing the white insides of the cups. We then told the students that it was now their responsibility to save the coral by answering a series of questions. For every correct question, they could put one ball/*Symbiodinium* into the cups. A question wrong resulted in the emptying of one polyp. Challenge questions were also given and correct answers were rewarded with two balls/*Symbiodinium*. This game was meant to encourage students to remember their new knowledge and work collaboratively.

At our booth, we had a few posters showing healthy corals, bleached corals, and diseased corals, as well as other natural processes that affect corals, such as predation. We often used these posters during our explanations to give the audience a visual on what we were describing. We also had a MOP poster and a few flyers and brochures from Eyes of the Reef on how to identify the different diseases while snorkeling or diving. This booth helped raise awareness on the environmental issue of coral bleaching and disease, as well what community members can do to help.

Results:

Over the span of four months, two corals were monitored at Onekahakaha Beach Park. At the beginning of this study, both corals were already bleaching, although the second coral was more bleached (Figure 5). At the end of the study, both corals were healthier than on the first day of monitoring. There was also no sign of coral diseases or other biological factors, such as obvious predation or algal growth.

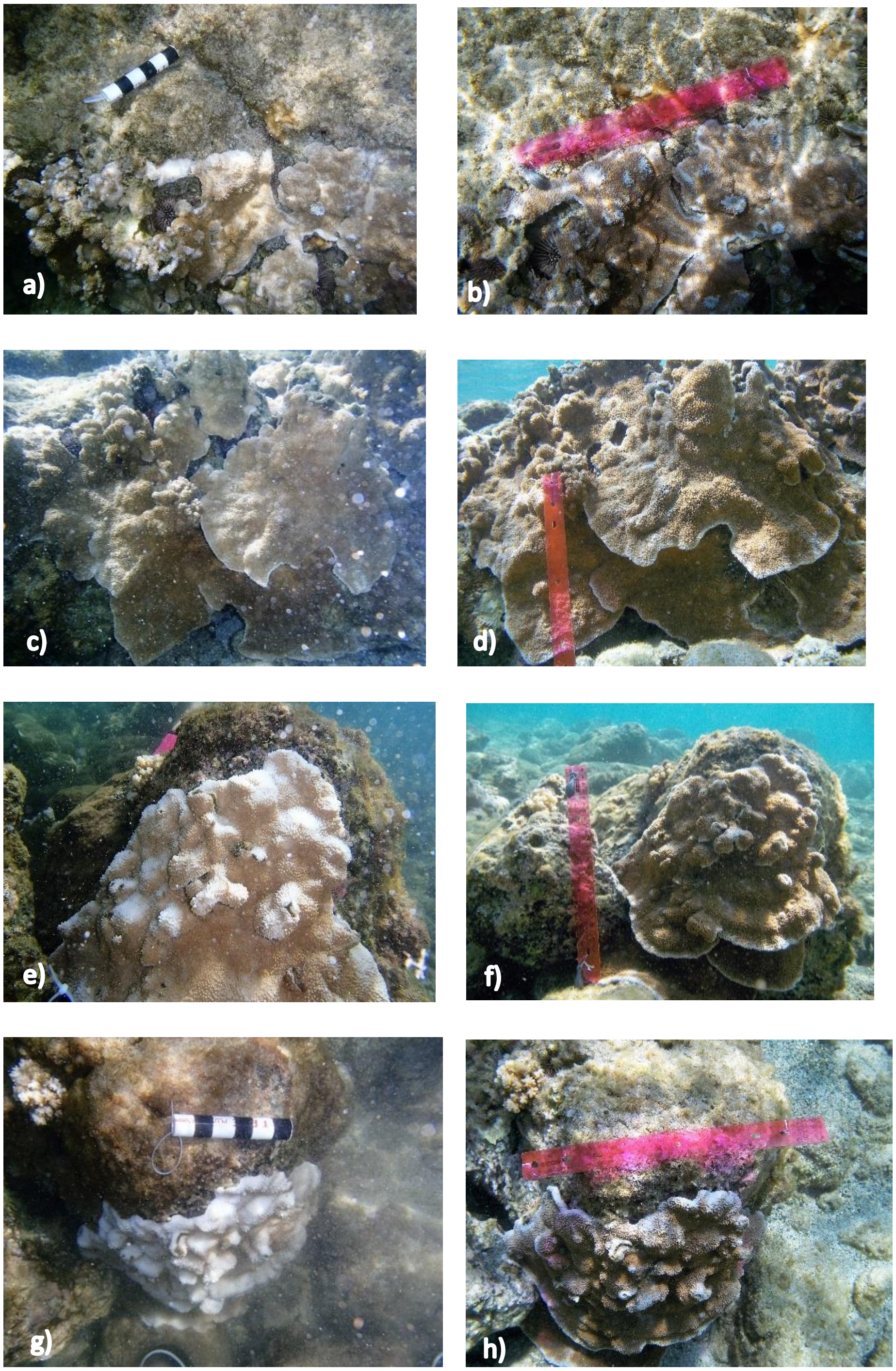

Figure 5: Photographs taken of both corals from both positions on the first and last day of the study. Column 1 represents the first day. Column 2 represents the last day. 5a and 5b represent top views of coral 1. 5c and 5d represent side views of coral 1. 5e and 5f represent side views of coral 2. 5g and 5h represent top views of coral 2.

Throughout the first few months, both corals were recovering as shown by the percentage of bleached coral decreasing; however, in mid-January of 2016, both corals began to bleach once again and continued to do so throughout the remainder of the study (Figure 6). Both trends were observed for the top and side views of each coral. There was not a significant difference between percent bleaching of the side views of both corals ($p = 0.312$). However, there was a significant difference in percent bleaching of the top views of both corals ($p = 0.006$). A comparison of the top and side views of both corals can be seen in Figure 7 and Figure 8.

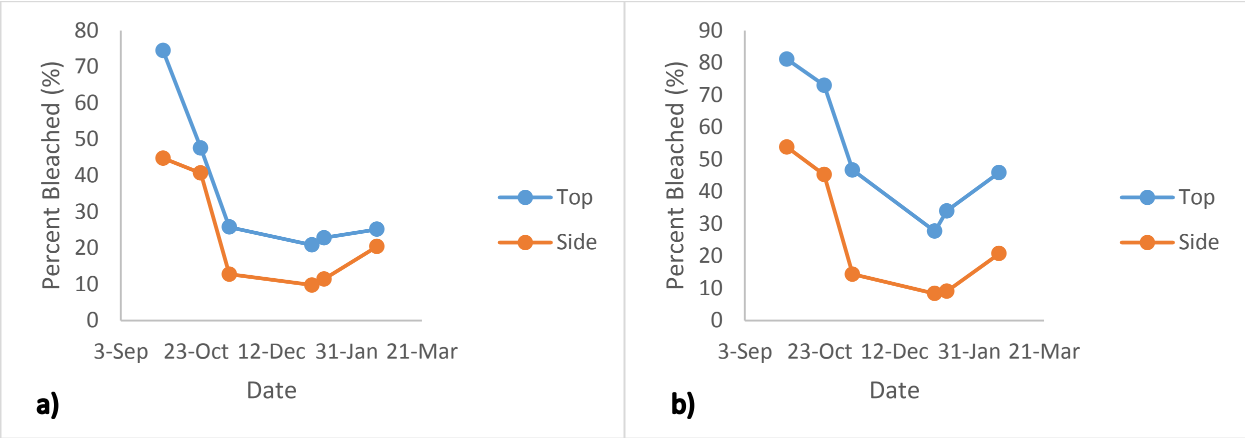

Figure 6: Coral bleaching over a time span of four months for both the first (6a) and second coral (6b).

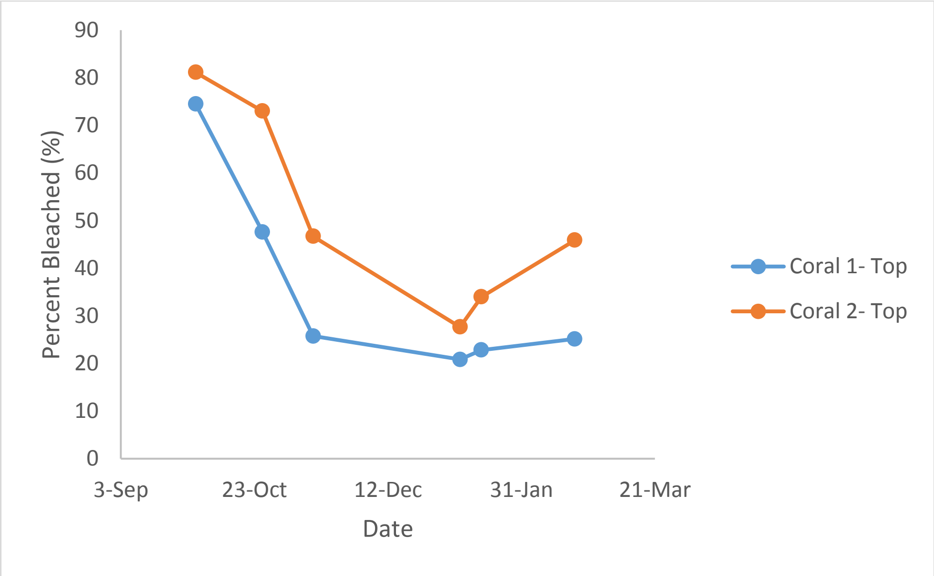

Figure 7: Coral bleaching of the top of both corals.

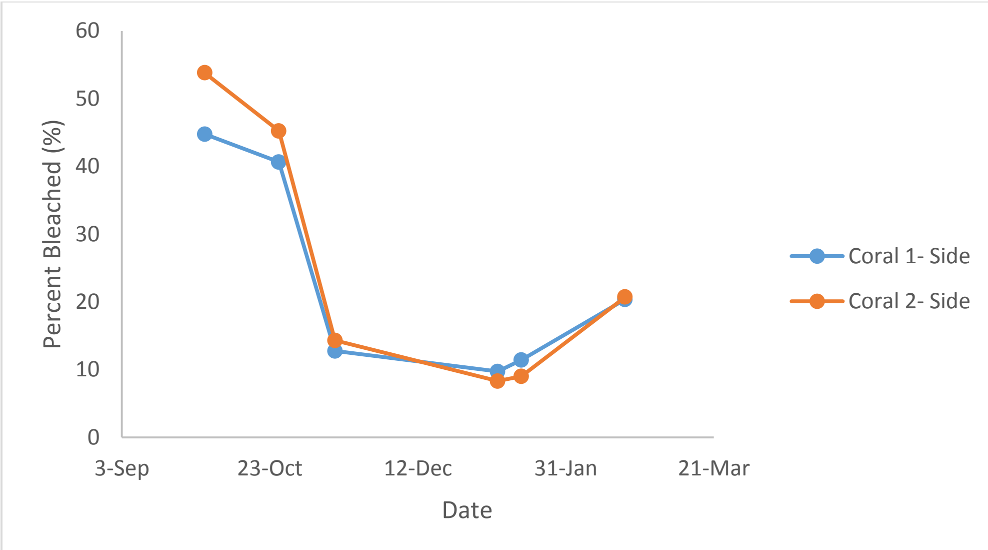

Figure 8: Coral bleaching of the side of both corals

The water conditions were constantly changing throughout the study. Salinity was high at the beginning of the study, decreased for a month, and then fluctuated for the remainder of the study (Figure 9). There was not a significant difference in salinity between the two corals ($p = 1.000$). Water temperature greatly decreased for a month and then continued to decrease at a slower pace for a few more months before increasing mid-January (Figure 10). Water temperature was not significantly different between the two corals ($p = 0.9169$). The pH of the water varied greatly throughout the study (Figure 11). There was no significant difference in pH between the two corals ($p = 0.8325$).

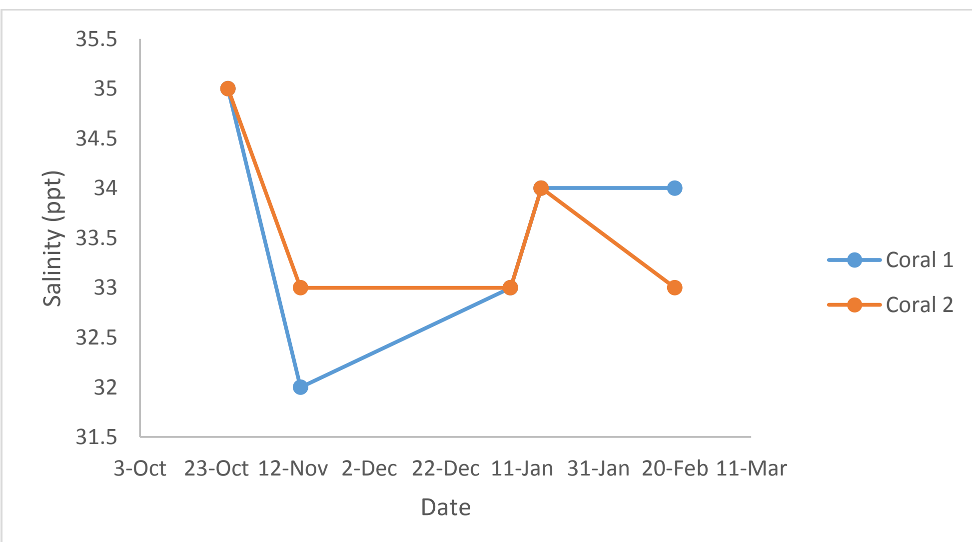

Figure 9: The salinity of the water as measured throughout the study.

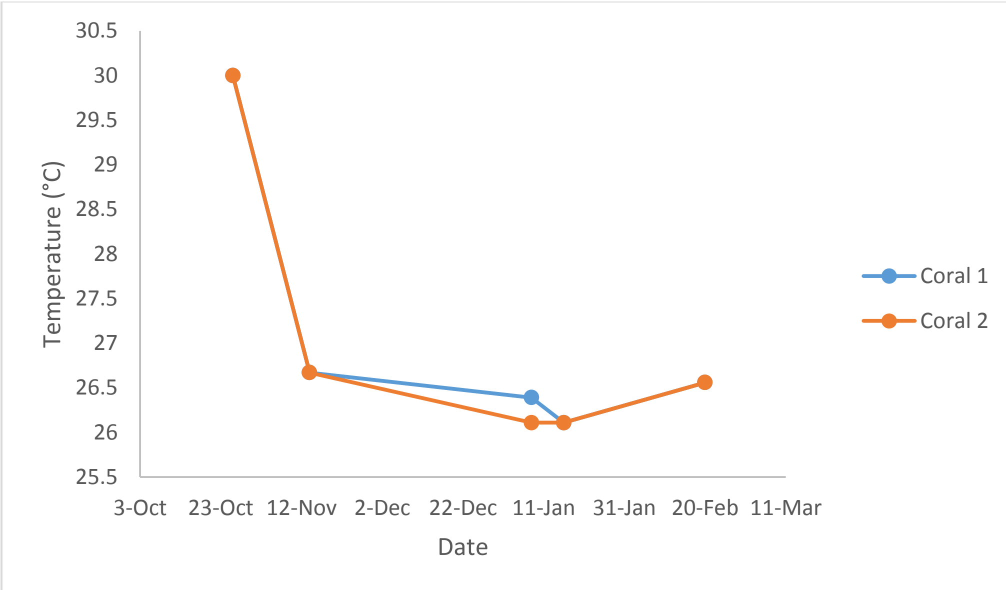

Figure 10: Water temperature as measured throughout the study.

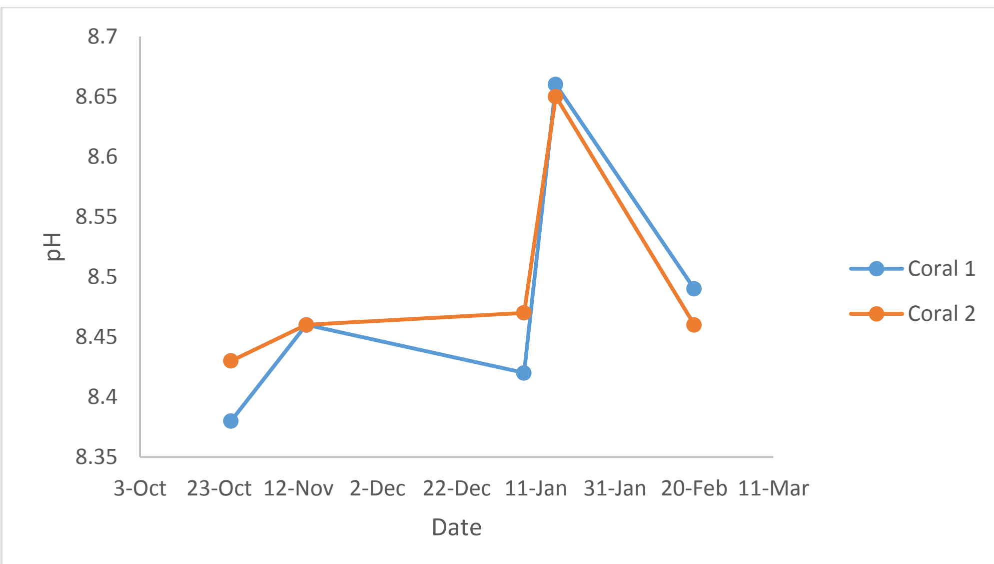

Figure 11: The pH as measured throughout the study

A correlation test was run to determine the relationship between temperature, salinity, and pH and percentage of coral bleaching. It was determined that there was no correlation between salinity and pH and percentage of coral bleaching; however, there was a strong, positive correlation between temperature and the amount of coral bleaching ($r = 0.725$). A simple linear regression was also run and it was determined that water temperature could be a predictor for coral bleaching ($R^2 = 49.86\%$). A comparison of percent bleached and temperature can be seen in Figure 12.

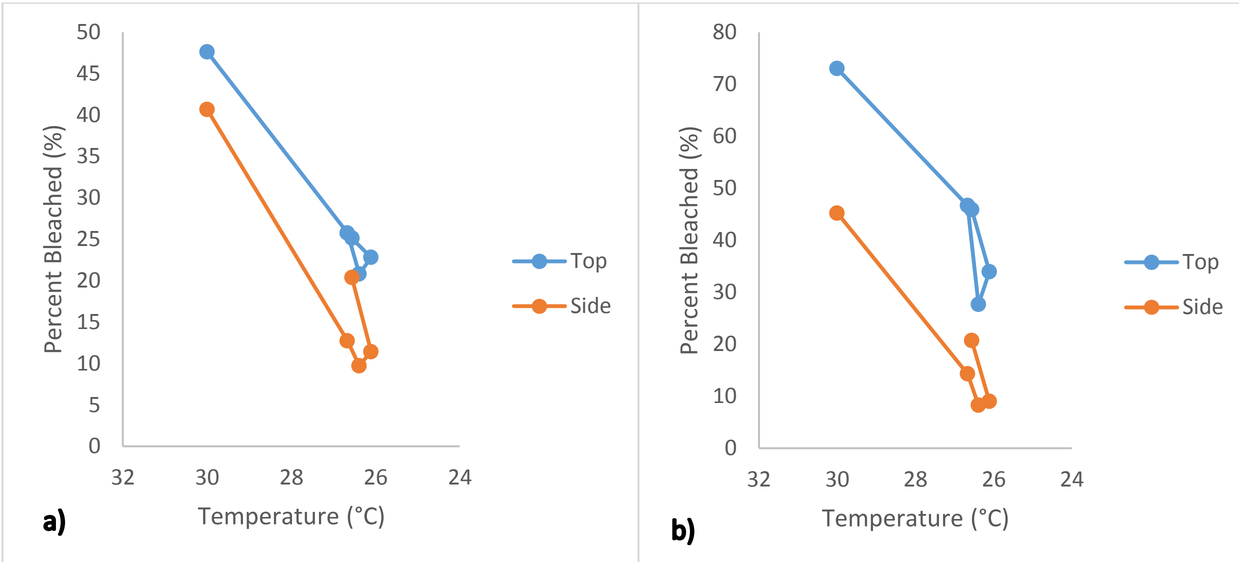

Figure 12: A comparison of percent bleached and temperature for coral 1 (12a) and coral 2 (12b).

Discussion:

The fact that temperature, salinity, and pH were not significantly different is not a surprising result because the two corals were close to one another; they were only approximately five meters apart. However, the fact that the percentage of bleaching for the top view of both corals *were* significantly different is surprising. It was determined through a regression test that temperature is a good predictor for percent bleaching, but because temperature was not significantly different between the two corals, temperature was not responsible for the differences in bleaching for the top views. The differences in bleaching could be due to other variables, or it could be due to differences in water quality prior to the study. The second option is likely because it was observed that the second coral was more bleached than the first when the corals were initially observed in early October.

It was surprising that the corals did not become diseased. As described in the scientific literature, after the coral becomes bleached, it is much more likely that the coral will become diseased (Brown 1997). Another prediction that the article described was that once the coral becomes bleached, it is much easier for the coral to bleach again. This prediction is similar to what occurred during the study; the corals began to bleach again after a few months of recovery, despite the fact that the water quality conditions had not changed.

There were many complications that occurred during this project. The largest limitation was weather conditions. Throughout the first few months of the project, several hurricanes and tropical storms had passed nearby Hawaii, making ocean conditions rough and dangerous; high surf warnings and advisories had been common. Although Onekahakaha is an enclosed area, my corals were located close to the rock edge, making it difficult to reach the corals during rough conditions. Additionally, the water was often cloudy due to the white wash occurring from the waves, making it very difficult to take clear enough pictures to analyze.

Conclusion:

Although coral bleaching is frequently monitored, it is still an important study. Coral bleaching highly affects corals and the surrounding marine environment, and with climate change and increased frequency of mass bleaching events, it is more important than ever to monitor coral reefs for bleaching. This data can be used both by Eyes of the Reef and anyone interested in the bleaching of corals located at beaches in Hilo.

During this study, I gained a vast knowledge of the techniques required for monitoring coral bleaching. I am now able to recognize and distinguish coral bleaching from similar coral diseases. I can also recognize rice corals from other species of coral. I have learned the methods used by Eyes of the Reef to both take photographs of the coral and to analyze the photographs using CPCe. I have also learned how to use a pH meter and a refractometer in determining the pH and salinity of ocean water. Additionally, I have applied previous knowledge of statistics on a research study that I have completed myself.

For future studies, corals of a different species could be monitored in order to determine any differences in bleaching or recovery between species. The monitoring process could also occur over a longer period of time, such as a full year. Additional locations could also be chosen in order to compare bleaching at different locations.

Acknowledgements:

I want to thank Eyes of the Reef, my project advisor (Julia Stewart), and Dr. Steven Colbert for their support and willingness to teach me these new skills. I also want to thank all of my fellow classmates in the Marine Option Program for supporting me in this project.

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