Evaluating the Effects of Heat Stress on Coral Reflectance Signatures

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Abstract

Recently, coral bleaching has been occurring more often due to sea surface temperatures that are rising because of climate change. Coral bleaching refers to the expulsion of the symbiotic algae by corals due to environmental disturbances, and can lead to coral mortality after long periods of stress[1]. Research by Hochberg *et al.* 2004 demonstrated that remote sensing of corals is a possibility because corals have a unique spectral reflectance signature[2]. We ran an experiment on the Caribbean coral, *Porites furcata*, to observe the effects of heat on coral reflectance.

Introduction

These photos depict corals that have undergone coral bleaching over time. Photo Credit: XL Catlin Seaview Survey

Background: Coral reefs are one of the most biodiverse ecosystems in the world. Being home to 25% of all marine life, it is imperative that we protect our coral reefs[3]. However, since 2014, we are currently experiencing the third mass coral bleaching event. In the first global bleaching event in 1997/98, 16% of the world's corals bleached, and it was mainly due to elevated sea surface temperatures (NOAA's Coral Reef Watch).

Our objective: 1) To investigate the effects of heat stress on the reflectance signature of the Caribbean coral, *Porites furcata*, and 2) to evaluate the use of reflectance signatures as a diagnostic tool to determine coral's health.

We would then be able to better monitor coral health using remote sensing.

Spectral Reflectance Signature

Coral with little algae on surface:

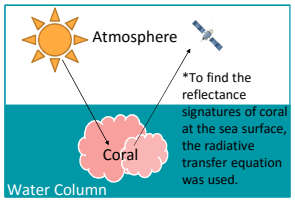
Coral covered in algae due to coral bleaching:

As coral bleach, they lose the ability to fight off the algae that grows on their surface. Algae blocks the light from reflecting off of the internal skeleton of the coral.

Radiative Transfer Equation (Mobley 1999)

Rrs = Lu/Ed

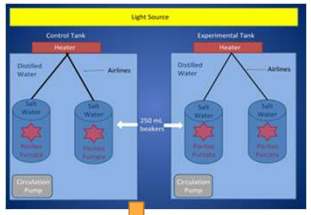
- Lu = coral's radiance
- Ed (above water) = π * Lp
- Lp = radiance of the Lambertian surface



Methods

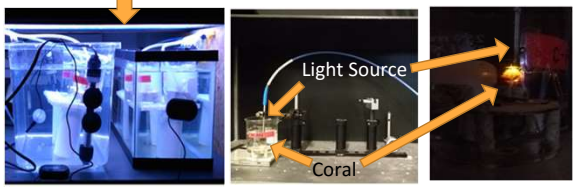
We performed an experiment to evaluate the effects of heat stress on coral's reflectance signature.

Schematic:



- The control group was kept at a normal temperature for Caribbean corals at 26°C.
- The experimental group was kept at an extreme temperature for Caribbean corals at 34°C.
- The experiment was run for five days, with temperature, salinity, and reflectance being measured daily.

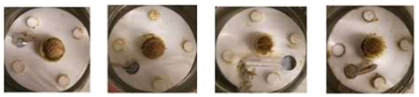
Measuring coral's reflectance signature:



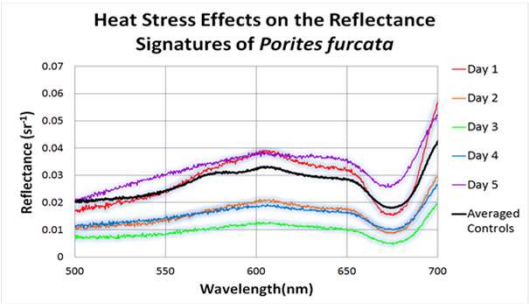
Results

After five days:

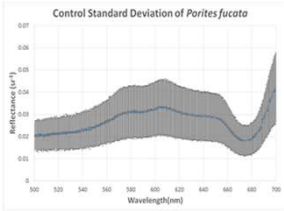
Control 1 Control 2 Heat 1 Heat 2



An Ocean Optics spectrometer was used to measure coral reflectance.



Additional Results



Standard deviation was used to show the amount of variation of the data. Data only from the control group is displayed to show the overall variation of reflectance signatures of *P. furcata*.

P-values from the Mann-Whitney U test comparing the heat stress and controls

Wavelength (nm)	Day 1	Day 5
579	0.6667	0.3333
605	0.6667	0.3333
632	0.6667	0.3333

Using the statistical program R, the Mann-Whitney U test was used to determine the p-value. The p-value indicates whether or not there is a statistically significant difference between the control and heat groups.

Discussion

- Based on the graph comparing the heat stress and control reflectance signatures, there was an overall decrease in spectral reflectancedue to increased algae growth on its surface.
- The reflectance signature of the heat stress samples taken on Day 5 shows an increase in reflectance, most likely due to measuring the reflectance on certain areas of the coral where algae was not present.
- Since *P. furcata* is known to have a dense, yet porous skeleton, it is common to see a large variation in reflectance signatures.
- The Mann-Whitney U test was used rather than the t-test because our data did not have a normal distribution because we had a small sample size. The alpha was set at 0.1 rather than 0.05 because of the small sample size.
- The p-values show that Day 5 had a more statistically significant difference than Day 1, indicating that if the experiment ran longer, the p-value could have possibly come closer to the alpha value.
- Overall, the reflectance signature is a good indicator of coral bleaching because there was a clear correlation between the reflectance signature and coral health.

Future Works

- Investigate the effects of cold stress on the reflectance signature and determine whether or not reflectance is a good indicator of coral health when cold stress is applied.
- Determine whether or not fluorescence is a good indicator of coral health.
- Perform similar experiment on a larger sample size over a longer period of time.

Resources

[1]Douglas, A. E. "Coral bleaching—how and why?." *Marine Pollution Bulletin* 46.4 (2003): 385-392.
[2]Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide and implications for coral reef remote sensing. *Remote Sensing of Environment*, *85*(2), 159-173.
[3]Cesar, Herman, Lauretta Burke, and Lida Pet-Soede. "The economics of worldwide coral reef degradation." (2003).

Acknowledgements

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