NOAA CREST

Evaluating Coral's Reflectance Signatures in Response to the Chemical Oxybenzone, and Classification of Coral Reefs using Landsat 8 Imagery

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Abstract

The purpose of this project is to further study the viability of satellites as an assessment tool in the monitoring and classification of coral reefs and coral bleaching by evaluating the relationship between coral health and coral's reflectance signature. A controlled laboratory based experiment was performed using the Caribbean coral species, *Porites furcata*. The experimental group was subjected to stress from a 200 ppm solution containing the chemical oxybenzone. The experiment was conducted for 5 days, and the reflectance measurements of the corals were taken each day around 1:30 p.m. We hypothesize that the reflectance signature of the experimental group will increase as it bleaches due to stress from the chemical oxybenzone. In addition to the experiment, data from the satellite Landsat 8 was downloaded from the USGS Earth Explorer, and processed using the GRASS GIS application. A k-means unsupervised classification was performed on the coral reefs surrounding Heron Island, Australia, with the corals being classified by information pertaining to their reflectance. This research can eventually help to establish whether or not satellite monitoring can be an appropriate monitoring tool to asses coral bleaching.

Introduction

Coral reefs play a great role in the equilibrium of the ocean. Unfortunately, they are currently undergoing a period of decline due to various factors, most notably global warming due to climate change. According to NOAA Coral Reef Watch, coral reefs are currently experiencing the third mass Global Coral Bleaching Event, which greatly endangers coral reef environments all over the world. However, corals are also endangered by small scale human activity, such as the everyday products they use. Recent research by Downs *et al.* 2015 demonstrated that the chemical oxybenzone, which is commonly found in sunscreens, can actually lead to increased rates of coral bleaching in planulae. Every year, between 6,000 and 14,000 tons of sunscreen lotion are deposited into areas containing coral reefs by swimmers, boats and other human activity (Downs *et al.* 2015). As coral reefs continue to bleach and decrease in numbers around the world, it is important to find cost effective ways of monitoring the reefs at a large scale, in order to better assess the issue of coral bleaching. Remote sensing using satellite data is a method that can one day be a viable method of monitoring coral reefs.

Photo Credit: XL Catlin Seaview Survey

Methods

- A 5 day controlled lab experiment was conducted in which an experimental group was exposed to a 200 ppm solution of the chemical oxybenzone. The substance was created using Neutrogena Ultra Sheer Dry-Touch Sunscreen Broad Spectrum SPF 45, which has a 9% Oxybenzone concentration. Please refer to figure 1 for the experiment schematic.
- Reflectance measurements were taken around 1:30pm each day of the experiment, for both the experimental and control group using the computer program OceanView, and the Ocean Optics USB2000+ spectrometer.
- The Radiative Transfer Equation was used to convert reflectance measurements to remote sensing reflectance.

  Rrs = Lu/Ed Lp = radiance of the Lambertian Lu = coral's radiance Ed (above water) = π * Lp (Mobley 1999))
- At the end of the experiment, the statistical program R was used to run a Mann-Whitney U Test with an alpha value set to 0.1 to compare the control and experimental group, due to the data not having a normal distribution.
- The classification of Heron Island was done by using the GRASS GIS computer program. Landsat 8 data from July 06, 2016 was downloaded from the USGS website and uploaded to the GRASS GIS program. Using the program, the digital numbers were converted to reflectance values, and atmospheric correction was also conducted. The image was then classified with 15 classes and the results were determined by comparing the resulting image with that of the same classification done in Leipers *et al.* study in 2014.

Control and Sunscreen Experimental Tank

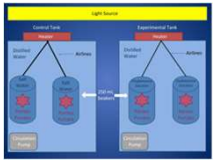


Figure 1: Experiment Schematics

Coral fragment in beaker for sunscreen experiment

Conclusion/Discussion

- The reflectance signature of the experiment group was lower than that of the control group's. This is likely due to the fact that as the coral's health deteriorated, it was unable to fight off algal growth, which in turn caused the reflectance signatures to decrease as the opportunistic algae grew on top of the coral.
- Results from the Mann-Whitney U test didn't show statistically significant differences between the control and experimental group , likely due to a small sample size, and short duration of the experiment.
  - The test showed that the reflectance peak found at 579 nm wavelength on Day 5, may possibly have a better correlation as it was closer to the set alpha.
- The high standard deviation can be attributed to the skeleton of *Porites furcata* being relatively dense and porous, which leads to more variation in the control measurements.
- Ultimately, reflectance signature is a good indicator of health in *Porites furcata* as there are observable changes in the reflectance as the coral bleaches.

Results

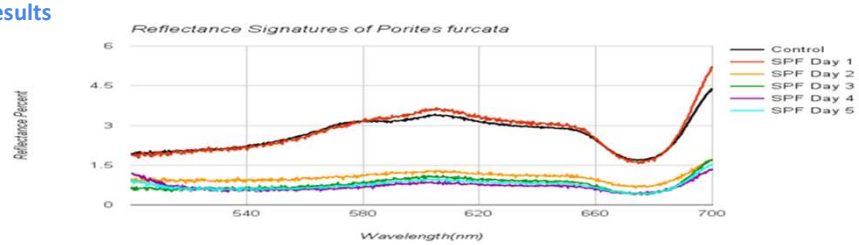
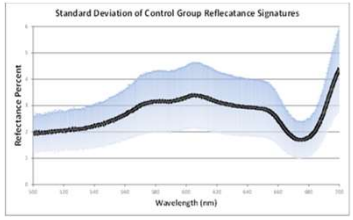


Figure 2: The reflectance signatures of the averaged control, and sunscreen experimental groups from days 1 through 5.

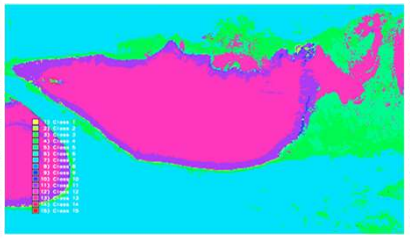
Man-Whitney U Test Results

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

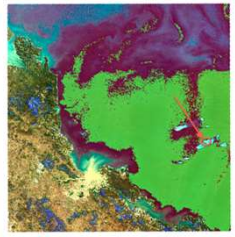
Table 1: P-values from the Mann-Whitney U-Test Comparing the Control and Sunscreen Experiment Groups.



Landsat 8 Image



Class 1: Coral
Class 2-5: Algae



Class 6-10: Water
Class 11-15: Sediment

Future Work

- Use satellite imagery with a higher resolution and more bands to be able to classify coral reefs more effectively.
- Continue conducting experiments exposing corals to oxybenzone, with different coral species, longer duration, and larger sample size.

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