Coral Bleaching Hot Spots

Introduction

Coral bleaching is a major concern for reefs all over the world. Under certain environmental stresses zooxanthellae algae will vacate their coral hosts. Without the zooxanthellae, corals lose their colors and appear pale or white, hence the name coral bleaching. Zooxanthellae are also coral's primary source of food and play a key role in helping coral polyps build skeletal reef material. Bleaching can be caused by a number of different stresses including changes in ocean chemistry (particularly salinity or acidification), increased sedimentation in the water, high levels of solar irradiance, or pathogen infections. However, the primary cause of bleaching events is believed to be higher than normal sea surface temperatures. During this lab, you will explore some of the tools used by scientists to identify areas around the world where corals are at risk for bleaching. You will also learn about what bleaching means for the long-term health of coral reefs.

After completing this investigation, you should be able to:

- explain how maps of bleaching hot spots and degree-heating weeks help identify reefs at risk for bleaching; and
- describe the consequences of coral reef bleaching

Part A: Understanding Coral Bleaching

Under normal conditions, the zooxanthellae algae living in coral tissue absorb energy from the sun and use it for photosynthesis. However, when the water gets too warm, zooxanthellae can produce toxins, which are harmful to both the algae and their coral hosts. For self-preservation, the coral polyps must expel the zooxanthellae, even though they rely on these algae for key life processes such as eating and calcification. Because coral tissue is transparent, coral reefs appear white (the color of their aragonite skeletons) without the zooxanthellae algae. This is why we call this process coral "bleaching."

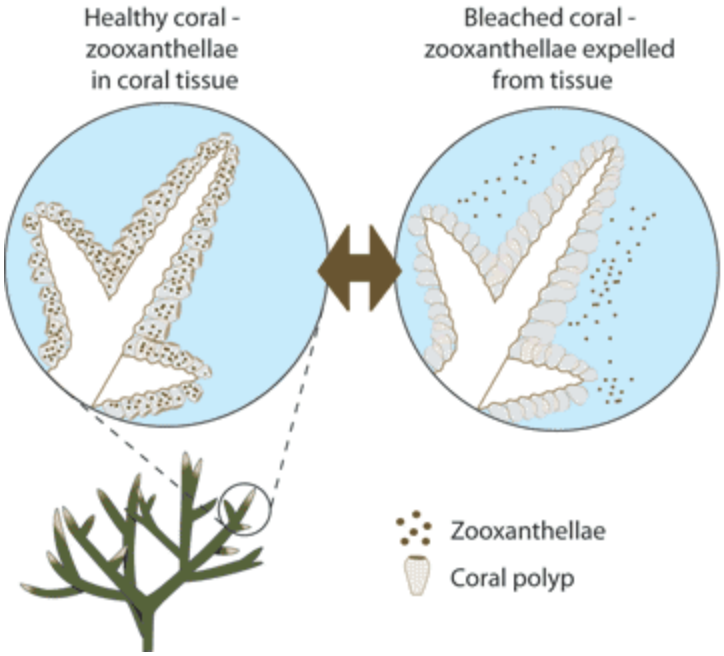


Diagram of coral bleaching process. *Image source: Great Barrier Reef Marine Park Authority*.

What Coral Bleaching Looks Like:

1. **Do a Google image search for "Healthy Coral Reef" to see what healthy coral should look like.**
2. **Now do an image search for "coral bleaching" to view pictures of coral bleaching.**

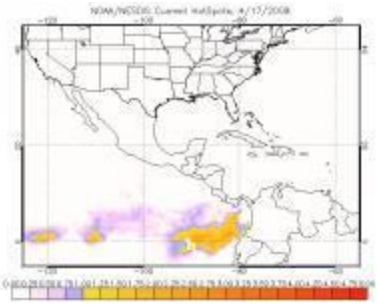
Questions:

1. **How do the colors of bleached corals compare to those of healthy corals?**
2. **In addition to color change, what other irregularities did you see in the bleached corals? Explain.**
3. Approximately 1 million species worldwide depend on coral reefs for survival. Based on what you observed in the photographs of bleached corals, what impact do you think coral bleaching has on biodiversity and the overall health of coral reef ecosystems? Explain your answer.

Without the zooxanthellae, corals are without their main source of energy, and are left in a weakened state. Just like a stressed person is more likely to get sick, stressed coral is more likely to become infected with coral diseases. To learn more about diseases that affect corals, read

NOAA's descriptions of common coral diseases.

Part 1: Bleaching Hot Spots



Bleaching hot spot map for North America on April 17, 2008. *Image source: NOAA*.

Scientists have found that corals begin to get stressed when the sea surface temperature (SST) gets just 1 °C warmer than the highest expected temperature for the warmest month of the year. This temperature is called the **bleaching threshold**. SST can be monitored using Earth-orbiting satellites, which are able to keep a continuous watch on the state of the oceans around the globe. Data from these satellites are vital for predicting and fighting coral bleaching.

1. To identify areas at risk for bleaching, start by looking for places where SSTs are warmer than normal. Go to NOAA's Coral Reef Watch home page. Click on the **Hot Spots** icon in the left-hand navigation bar to access the most up-to-date bleaching hot spot data. The Coral Reef Watch HotSpot maps highlight those areas around the world where sea surface temperatures are above the maximum monthly mean (MMM).

2. Click on the **Global** link below the image to open up a global map of current hot spot data.

3. Examine the map to familiarize yourself with how the data are reported.
   - How to interpret the scale:
     - white areas are at or below the MMM temperature
     - light purple areas are above the MMM, but still below the bleaching threshold
     - yellow to red areas are above the bleaching threshold (HotSpot: SST = 1 °C greater than the maximum expected summer time temperature), meaning that corals in those areas are experiencing thermal stress
     - numeric values show the number of °C the temperature is above the MMM

Questions

4. Using the dotted line grid as a way of dividing the map into smaller regions, how many of these regions were experiencing thermal stress?

5. How many regions were at least 2 times above the bleaching threshold? How high of a temperature increase would this be?

4. Use your browser's back button to return to the main HotSpot map page. Scroll down to the links below the main image to find the **Animation** links and look at the 90 day animation for the globe.

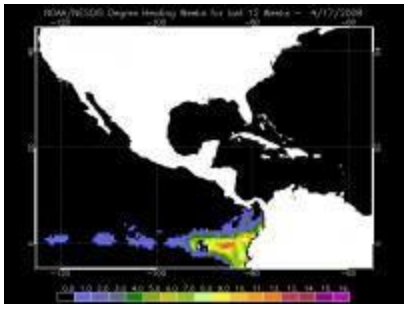
5. Watch the animation a couple of times all the way through, noting which months appear to have more or less thermal stress than is seen in the most current data.

Questions

6. How do the current levels of thermal stress compare to those over the last three months?

7. Do certain regions appear to experience thermal stress more often than others? Where are the areas that appear to be under constant thermal stress for the past 6 months?

Part 2: Degree Heating Weeks



Degree heating week map for North America on April 17, 2008. *Image source: NOAA*.

Heat stress on corals will accumulate if the SST stays above the bleaching threshold for an extended period of time. So, in addition to measuring how far above the bleaching threshold the SST is, scientists also measure how long the SST stays above the threshold. These measurements are known as degree heating weeks (DHWs). DHWs tell us how much thermal stress has built up in a given area over the last 12 weeks.

1. Use your browser's back button to the main Coral Bleaching Hotspots page. Click on the **Degree Heating Weeks** icon in the left-hand navigation bar to access the most up-to-date DHW data. The Coral Reef Watch DHW maps highlight those areas around the world where corals have been under thermal stress for extended periods of time.
2. Click on the **Global** link to open up a global map of current DHW data.

3. Examine the map to familiarize yourself with how the data are reported.
   ▶ How to interpret the scale:
   - black areas have not accumulated thermal stress over the previous 12 weeks (the temperature did not crossed the local bleaching threshold)
   - colored regions indicate thermal stress to corals in those areas
   - the units for DHW are "degree C-weeks", which combine the intensity and duration of thermal stress into one single number
   - when the thermal stress reaches 4 degree C-weeks, you can expect to see significant coral bleaching, especially in more sensitive species
   - when thermal stress is 8 degree C-weeks or higher, you would likely see widespread bleaching and mortality from the thermal stress

Questions

8. Using the dotted line grid as a way of dividing the map into smaller regions, how many regions were experiencing thermal stress?
9. Where are the areas located that you would expect to see significant or widespread bleaching? Explain.

4. Use your browser's back button to return to the main DHW map page. Scroll down to the bottom of the page and click on the **Animations** link.

5. Watch the animation a few times all the way through, noting which months appear to have more or less accumulated thermal stress than is seen in the most current data.

Questions

Answer the following question about accumulated thermal stress over the last 6 months.

10. How do the current levels of accumulated thermal stress compare to those over the last 6 months?
11. Do certain regions appear to experience prolonged thermal stress more often than others? (i.e., Do certain regions appear more at risk than others?) Where are these regions?

Part 3: Sombrero Reef

The barrier reef in the Florida Keys is the third largest living coral reef system in the world behind the Great Barrier Reef in Australia and the Belizian barrier reef. It is also the only extensive reef system in the continental United States. Sombrero Reef is located off the coast of Marathon, which is the midpoint of the Florida Keys island chain. This beautiful section of reef supports both tourism and commercial fishing, which are major contributors to the economy of the Florida Keys. Since 1990, Sombrero Reef has been under strict regulations as a Sanctuary Preservation Area in the Florida Keys National Marine Sanctuary. In this part of the lab, you will examine data from Sombrero Reef to determine if and how bleaching has affected this reef.

1. Go to NOAA's Coral Reef Watch home page. Scroll about halfway down to click on **Virtual Stations** in the left-hand navigation bar. Select Atlantic from the **Region** dropdown button in the map..

2. Find the icon for the **Florida Keys**. Click on the location name to see a map of this location. Then, click on the **Time Series Graphs and Data** link.

   This page shows time series graphs for the SST at the Florida Keys virtual station, from January through December in 2 year increments. Select the years 2015-2016

   How to interpret the data:

These graphs show the time series data at a particular station. This particular example shows data from the Florida Keys station. The left axis of each graph shows temperature in °C. SST is plotted with a dark blue solid line. The mean SST (Sea Surface Temp.)for each month is plotted as a light-blue cross, and the maximum monthly mean (MMM) is indicated by a light-blue dashed line. There is a bleaching hot spot any time the SST goes above the MMM (dashed light-blue line). The bleaching threshold temperature, equal to 1 °C higher than the MMM, is a solid light-blue line. Whenever the temperature goes above the bleaching threshold, corals experience thermal stress.

Degree Heating Weeks (DHWs) are shown at the bottom of each graph as a separate trace. , and the right axis shows the DHW scale.

3. Select the 2016-2017 graph, and compare the summer seasons of 2015, 2016 and 2017.

Questions

Use the Florida Keys graphs to answer the following questions.

12. Which month is the warmest on average?

13. What is the maximum monthly mean?
14. What is the bleaching threshold temperature?
15. What was the highest alert level for the Virtual Station Florida Keys from 2015-2017?
16. Over what time period, if any, do you think significant bleaching occurred? Explain.