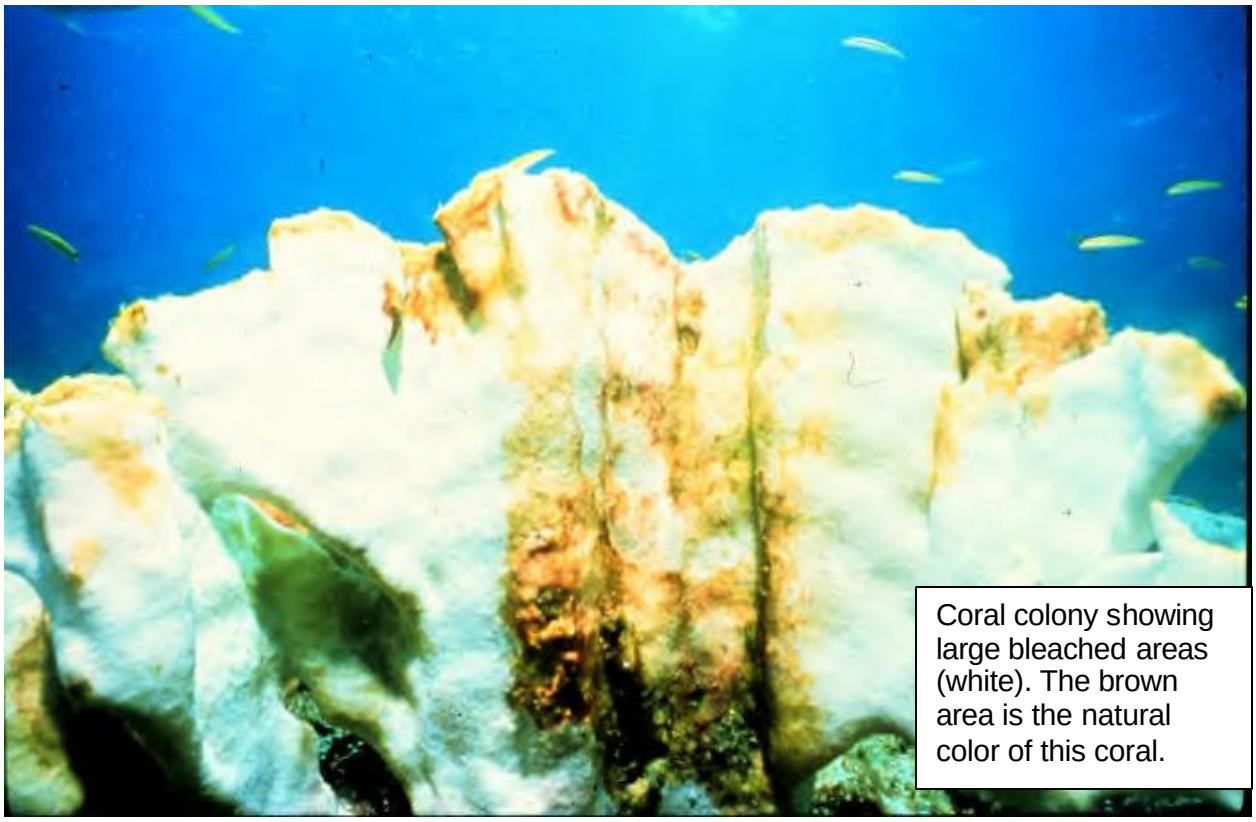
Coral Bleaching: What's the Role of Water Temperature?



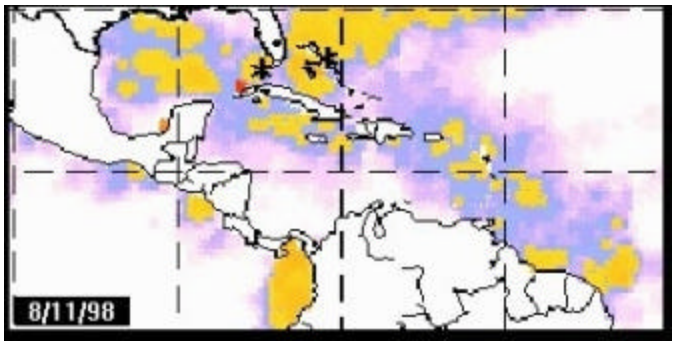
Coral colony showing large bleached areas (white). The brown area is the natural color of this coral.

Focus Question:
What is the temperature threshold for coral bleaching events?

Background / Rationale:
By now you have learned about the process of coral bleaching, and why it is such a concern to scientists. Scientists are working to understand the different factors, both natural and human, that cause bleaching and how we may be able to prevent further bleaching events.

One factor that scientists study is the effects of warm water on corals. Scientists have already observed that when the water around coral reefs becomes warmer than the typical or average temperature, coral bleaching occurs. While there are many other factors that can also cause bleaching, such as ultra violet radiation, elevated temperature is the one factor that seems to set the stage for other factors to have an effect. Scientists use temperature monitoring techniques to determine exactly how much of a temperature increase is required in order for bleaching to begin. This temperature at which bleaching begins, or *temperature threshold,* is different for coral reefs all over the world but is usually the same for most corals in a particular region, such as the Caribbean. The temperature threshold might have to be maintained for a certain number of days for bleaching to occur. By watching the water temperatures at coral reefs, scientists can predict when they think coral bleaching might begin and make plans to collect information and learn as much as they can while bleaching happens.

In this exercise, you will compare temperature data from two different years on the same reef to see if you can determine the temperature threshold required to start a bleaching event. You will be using actual data from the Coral Reef Early Warning System (CREWS) buoys.



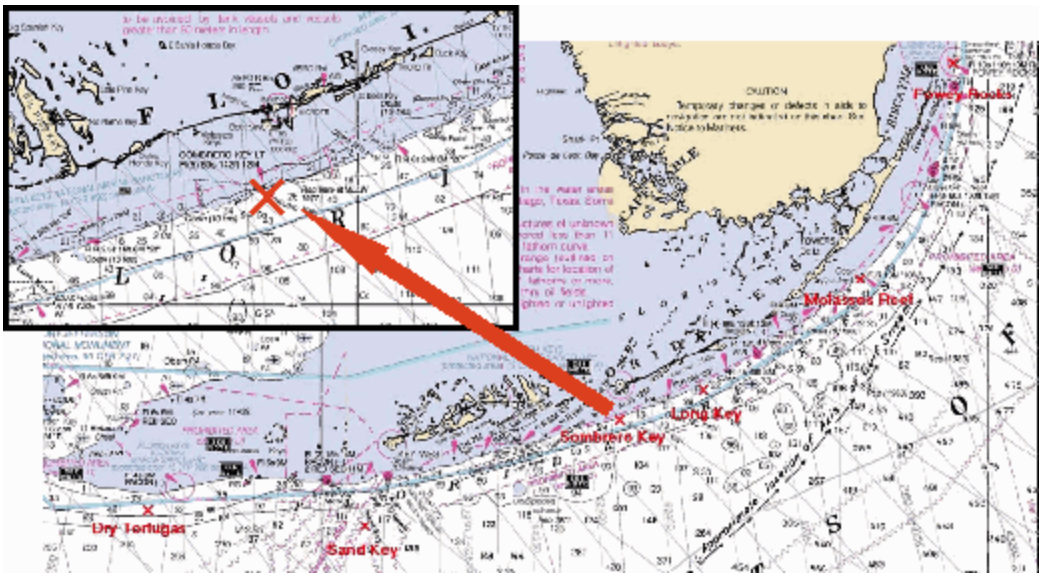
Map of Sea surface temperature from a NOAA website. The yellow areas show higher than normal sea surface temperatures. Black crosses show areas where coral bleaching occurred. Taken from: http://www.photolib.noaa.gov/noaa_products/noaa1558.htm

Student Activity:

In this activity you will be asked to graph and analyze sets of temperature data, looking for patterns that correlate with a known bleaching event. This may sound like an easy task, but it isn't just a single day of high water temperature that affects bleaching, rather how long the water temperature stays above a certain level. Scientists are still unsure of these temperature thresholds and time limits, so large amounts of temperature data must be compared from sites where bleaching occurred, and from where bleaching did not occur to try to determine the critical temperature threshold. Bleaching may also be affected by other environmental factors, such as pollution, changes in salinity, and even bacteria. However, in this exercise, we will only be looking at temperature over time.

Part 1:

Construct four graphs of the temperature data according to the instructions provided by your teacher. You may be using pencil and paper, or you may have access to computer graphing software. The temperature data is from parts of August and September (the warmest time of the year) on Sombrero Reef in the Florida Keys National Marine Sanctuary.



Location of Sombrero Reef and monitoring station, noted with a red X.

The first two graphs will contain data from 1994, when bleaching occurred. First, make a line graph of the **lowest** temperature recorded on each of the days for which data is provided. Your line graph represents the minimum temperature during the warmest time of the year. Next, make a graph of the **highest** temperature recorded on each of the days for which data is provided. Be sure your graphs are labeled with the year to avoid confusion. Together, you have graphs of daily highs and lows the time of highest sea temperatures. Now construct two more graphs in the same way, but use the data from 1998, a year in which bleaching did not occur.

Part 2:
Compare the temperatures in the two sets of data. Fill in the blanks below to help focus on important data.

*** Data:**	**Graph 1 1994 lows**	**Graph 2 1994 highs**	**Graph 3 1998 lows**	**Graph 4 1998 highs**
Highest minimum temperature				
Highest maximum temperature				
Number of days above 30 C.				
Number of days above 31 C.				
Number of days above 32 C.				
Number of days above 33 C.				

* For "Number of days" data above, count the number of days the temperature continuously stayed at or above the numbers listed. Temperatures are in degrees Celsius.

Data Analysis (You may need a separate sheet of paper for your answers):

1. The data selected for the table above indicate only the maximum temperatures, and how many days the temperature stayed above certain points, instead of the temperature range for each day. How is this unrealistic?

2. Suppose that the temperature only needed to reach 33 degrees for bleaching to occur, even if only for a short time. If this were true, would bleaching have occurred in 1998?

3. Can the threshold temperature and time for bleaching be determined solely on the basis of these graphs? Explain why or why not.

4. After careful study, the scientists who analyzed the data proposed a hypothesis, that bleaching would occur if the temperature remained above 31.5 degrees C. for at least 72 hours straight. What would have to be done to test this hypothesis?

5. Do you suppose that other scientists studying bleaching would agree with this hypothesis? Explain why or why not.

6. How many sets of data do you think a scientist would have to examine to be certain that he or she knew the threshold temperature for coral bleaching?

7. After examining all that data you suggest, could a scientist be certain that they had identified the exact correct temperature threshold?

8. From your reading, what are some sources of uncertainty in the data? In other words, could a bleaching event be caused at least in part by something besides temperature? If so, what might cause bleaching?

9. Could a combination of high temperatures and other factors make bleaching more likely?

10. In a laboratory experiment, scientists try very hard to have good control groups, and eliminate variables except the ones they are testing. Is this possible in field work such the project depicted here? How can we minimize the confusion created by these uncontrollable factors?

Conclusions:

What general conclusions can you draw about the study of bleaching on a real reef?

<u>For Teachers:</u>

Educational Objectives / National Science Standards:

Strand A (Science as Inquiry), Strand B, (Physical Science), C (Life Science), Strand E (Science and Technology), Strand G (The Nature of Science)

Teaching time / Setting:

A pre-lab discussion about corals and bleaching may be helpful. It is suggested that students read the introduction on coral bleaching from the website. This can be done immediately before the lab, or on the previous day. Depending on students' graphing skills and the tools they have available, one to two hours may be needed to complete the exercise, including follow-up questions.

Suggestions:

If interdisciplinary work is possible, you may want to enlist the help of a math teacher to help students with the graphing. You may wish to provide graph paper which already has number scales on it so that student graphs can be easily compared. This is a good time to review graphing skills.

Analysis and Assessment:

The questions provided should provide a good basis for assessing students' understanding. In addition, you may wish to discuss concepts such as variability or repeatability of scientific data, and uncontrollable variables which create problems in field work (such as a school of fish which swims by, eating all the gametes they can hold).

Follow-up / Extension Activities:

This exercise can be used to introduce many discussion topics on the environment, preservation of habitats, and even human impacts on global warming and climate. The use of statistics and remote sensing in experimental design can also be introduced using this lesson.

References and Internet Resources:

www.coralreef.noaa.gov This is NOAA's Coral Reef Home page, with access to photos and a variety of sites related to coral reefs.

www.coral.noaa.gov/crews/index.shtml This is NOAA's Coral Reef Early Warning System homepage, with access to coral reef related data and from CREWS stations.

www.coralreef.noaa.gov/ NOAA's Coral Reef Conservation Program, a website that supports NOAA's mission to provide effective management and sound science to preserve, sustain and restore valuable coral reef ecosystems

http://coralreefwatch.noaa.gov/satellite/ NOAA's on-line program using near-real time data from satellites for monitor coral reefs world wide.