

Lesson #6: Sea Surface Temperature and Coral Bleaching

Introduction/Rationale/Teacher Background

Coral reefs are a fragile ecosystem. Scientists monitor ocean temperature since it is linked to coral bleaching episodes. Coral bleaching is caused by environmental stresses and results in corals ejecting zooxanthellae from their polyps. Sometimes, small, localized bleaching events result from chemical spills, sedimentation, and decreases in ocean salinity from heavy rains or flooding. Large global instances of bleaching, called mass bleaching, appear to be caused primarily by an increase in water temperature and calm sunny conditions. Even small temperature increases, as little as a 1-degree Celsius above normal temperature range, over a period of a week or more, can cause corals to expel their zooxanthellae. If conditions quickly return to normal, the coral may recover. Unfortunately, in the face of other numerous threats, corals are often vulnerable and die from the bleaching process. In this lesson, students will be introduced to the bleaching phenomenon and gain experience reading satellite sea surface temperature data.

Tropical ocean temperatures have increased 1°C over the past 100 years and are currently increasing at a rate of 1-2°C per century. It is likely that this global temperature increase is due, in part, to the burning of coal, oil, and gas.

Some of the images used in this lesson are labeled "DHW," which stands for Degree Heating Weeks. One DHW is equal to one week of a sea surface temperature $\geq 1^\circ\text{C}$ above the expected summertime maximum. Two DHWs are equal to two weeks at 1°C or one week at 2°C above the expected summertime maximum temperature. A DHW of 4, indicated in green, means that coral bleaching will occur in areas where there are coral reefs.

Lesson Concepts and Skills

Coral bleaching - the process in which a coral polyp, under environmental stress, expels its symbiotic zooxanthellae from its body. The affected coral colony appears whitened.

Coral bleaching HotSpot - a region of sea surface temperature that exceeds the climatological maximum for a region by 1°C or more. These conditions may cause sufficient stress to coral reefs to result in coral bleaching.

Materials

Access to computer lab

Copies of "Coral Catastrophe Student Work" for each student, found following teacher demonstration instructions

Rubber glove (thick)

Freezer

Bowl

Whipped cream

Green, blue, or red sprinkles

Red pen or pencil

Class computer with a projector

Copies of "What Happened to the Coral?" for each student

Copies of "Predicting Peril" for each student (or read the note in "Preparation" below to conserve ink and paper)

Copies of blank US map for each group, found at

<http://dstreme.comet.ucar.edu/extras/bmap.gif>.

Preparation

At least one day before the lesson, prepare for the Coral Bleaching

Demonstration by filling a thick rubber glove with water and freezing it. *Hanging the glove upside down to freeze will create a flat base for the hand.*

Images in "Predicting Peril" student work are in color and will require a great deal of ink. Consider making color transparencies or allowing students to link to the website

<http://www.osdpd.noaa.gov/PSB/EPS/icg/wsub.7.31.1998.gif>

themselves to make their predictions.

Teaching Strategies Employed

Demonstration

Modeling

Direct instruction

Cooperative learning

Time Frame

One class period

Target Audience

Grade five

National Science Content Standards

As a result of their activities in grades 5-8, all students should develop an understanding of structure of the earth system.

As a result of their activities in grades 5-8, all students should develop understanding of structure and function in living systems.

Behavioral Objectives

Students will determine the anatomy of coral bleaching by drawing conclusions from a teacher demonstration.

Students will identify temperature increase as one cause of coral bleaching by observing a teacher demonstration.

Students will predict general areas likely to be affected by coral bleaching by interpreting sea surface temperature data over a period of months in 1998.

Engagement

Ask students how they measure the temperature outside. (Place a thermometer outside and read it.) Next, ask them how they would measure the water in a swimming pool. (Put the thermometer in the water to get a reading.) Instruct students to go to the website <http://www.ametsoc.org/amsedu/dstreme/>. They must scroll down to "Satellite" and click "Infrared Surface Temperature Determination." Tell them that as they move their mouse over different portions of the map, the temperature, latitude and longitude of that of that particular location will be displayed. Ask the students how scientists got this information. (Satellite data.)

Exploration

Follow the directions to carry out the "Coral Bleaching" teacher demonstration. Instruct students to answer the accompanying "Coral Catastrophe" student worksheet.

Explanation

Display the map found at <http://reefgis.reefbase.org/mapper.asp> to remind students where coral reefs are found across the globe. You might want to zoom into specific regions.

Discuss the results of the "Coral Bleaching" demonstration as a class and review students' answers to the "Coral Catastrophe" questions.

Teach students that when zooxanthellae leave the coral polyp it is called "coral bleaching." The coral appears colorless and eventually dies unless new algae "move in" to complete the symbiotic relationship.

Distribute the "What Happened to the Coral?" handouts to all students. (If your students need extra help with their geography skills, distribute world atlases at this point as well.) Read and discuss the information as a class, then direct them to work with a partner to complete pages 2 and 3 of the handout. Check answers as a class.

Extension

Direct students back to the weather map at <http://www.ametsoc.org/amsedu/dstreme/> (they must follow the same navigation steps as in the Engagement). Divide the class into three groups: Gulf of Mexico, Atlantic Ocean (or East Coast), and Pacific Ocean (or West Coast). Instruct students to use the information from the AMS's Datastreme Atmosphere website to create a rough map of current sea surface temperatures in their assigned region. Stress to student that it is impossible for them to map every temperature variation in their assigned body of water, so they must just sample different areas. Write the following scale up on the board for students to use: 10.3-13.9°C = purple, 14.0-19.2°C = blue, 19.3-24.4°C = green, 24.5-27.1°C = yellow, 27.2-29.8°C = orange, 29.9-31.6°C.

Have them visit the site

<http://www.osdpd.noaa.gov/PSB/EPS/SST/contourthumb.html> and click

their assigned location in the *Colored Field* column. Students are to compare their maps with NOAA produced ones.

Evaluation

Distribute "Pinpointing Peril" handouts to students. Instruct them to work with a partner to make predictions of coral bleaching events in the Caribbean.

Assessment

Use the site <http://www.osdpd.noaa.gov/PSB/EPS/SST/data/anw98d.gif> to determine the accuracy of students' predictions in "Predicting Peril."

Bibliography

Cerullo, M.M. (1996). *Coral reef: A city that never sleeps*. New York: Cobblehill Books. pp. 47-48.

The Coral Reef Alliance. (2002). *International coral reef information network*. Retrieved <http://www.coralreef.org/factSheets/coralbleaching.html>, July 23, 2004.

Hoegh-Guldberg, O. (n.d.) *Climate change, coral bleaching, and the future of the world's coral reefs*. Retrieved <http://archive.greenpeace.org/climate/science/reports/coralbleach.pdf>, July 27, 2004.

Intergovernmental Panel on Climate Change (2001). *Summary for Policymakers: A Report of Working Group I of the Intergovernmental Panel on Climate Change*, January 2001.

NOAA/NESDIS. (2003). *NOAA/NESDIS experimental degree heating weeks*. Retrieved <http://www.osdpd.noaa.gov/PSB/EPS/icg/ehet.s51998.e71998.gif>, July 27, 2004.

Wells, S. and Hanna, N. (1992). *The Greenpeace book of coral reefs*. New York: Sterling Publishing Co., Inc. pp. 54-55.

Coral Bleaching teacher demonstration

Materials

Rubber glove (thick)

Freezer

Bowl

Whipped cream

Green sprinkles

Procedure

1. Fill the glove with water and tie the end shut. Place in freezer overnight or until completely frozen.
2. Remove the rubber glove. Place hand upright in bowl.
3. Carefully pour whipped cream over the palm and back of hand. Avoid getting any on the fingers or thumb.
4. Add sprinkles to the topping.
5. Have students observe what happens as the ice melts. (The sprinkles should fall off, leaving a white polyp behind.)

Key

Frozen hand = coral polyp

Fingers = tentacles

Bowl = limestone cup

Whipped cream = limestone skeleton

Sprinkles = zooxanthellae

Name _____
Date _____

Coral Bleaching Student Work

1. Use what you have learned about corals to identify the parts of the model.

Limestone cup = _____

Zooxanthellae = _____

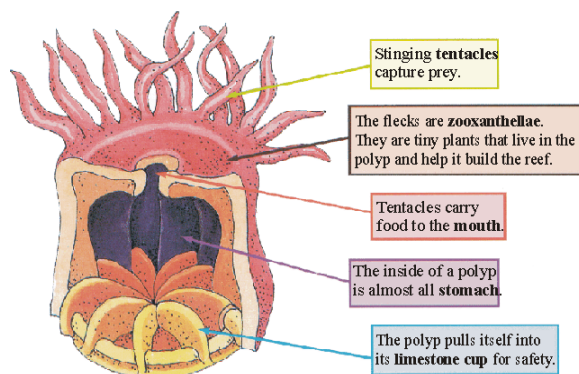
Coral polyp = _____

Tentacles = _____

2. Describe how the “polyp” changed throughout the class period.

3. What caused these changes to occur?

4. How do you think a real polyp’s appearance would change after the zooxanthellae left? Why?



What Happened to the Coral?

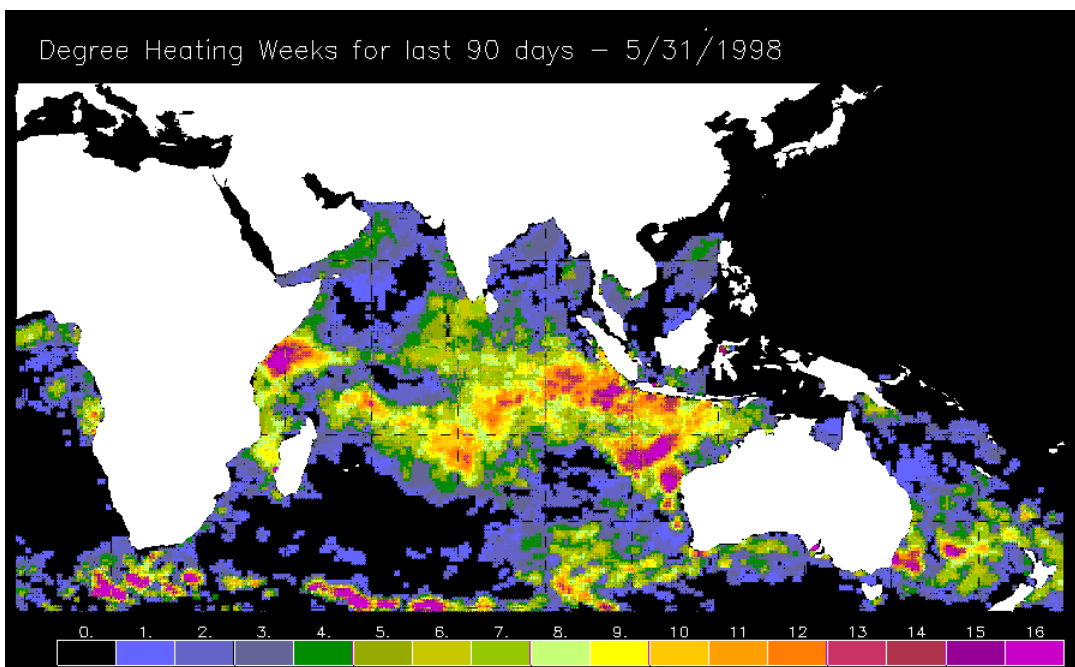
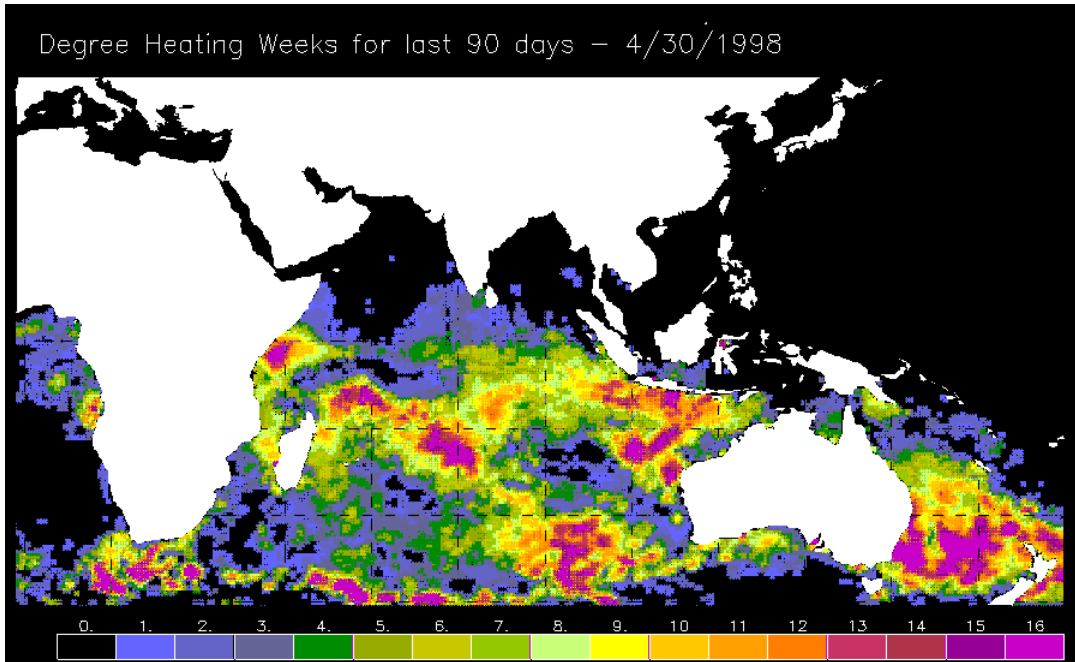
Coral bleaching is a natural disaster in which most or all of corals' plant partners (zooxanthellae) leave their host polyp. The polyp itself is colorless, so when the algae leave, it appears to have been bleached. "Bleaching" is triggered by environmental stress and very often has been linked to increases in the temperature of the ocean water. Once the zooxanthellae are gone, the polyps lose their ability to build a reef.

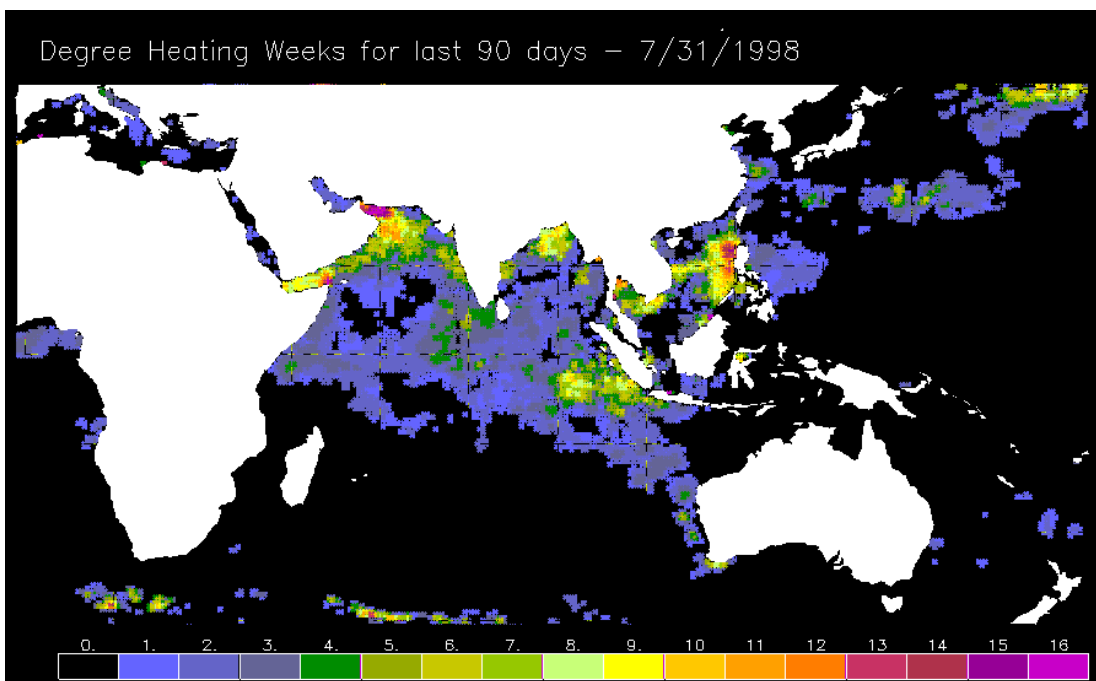
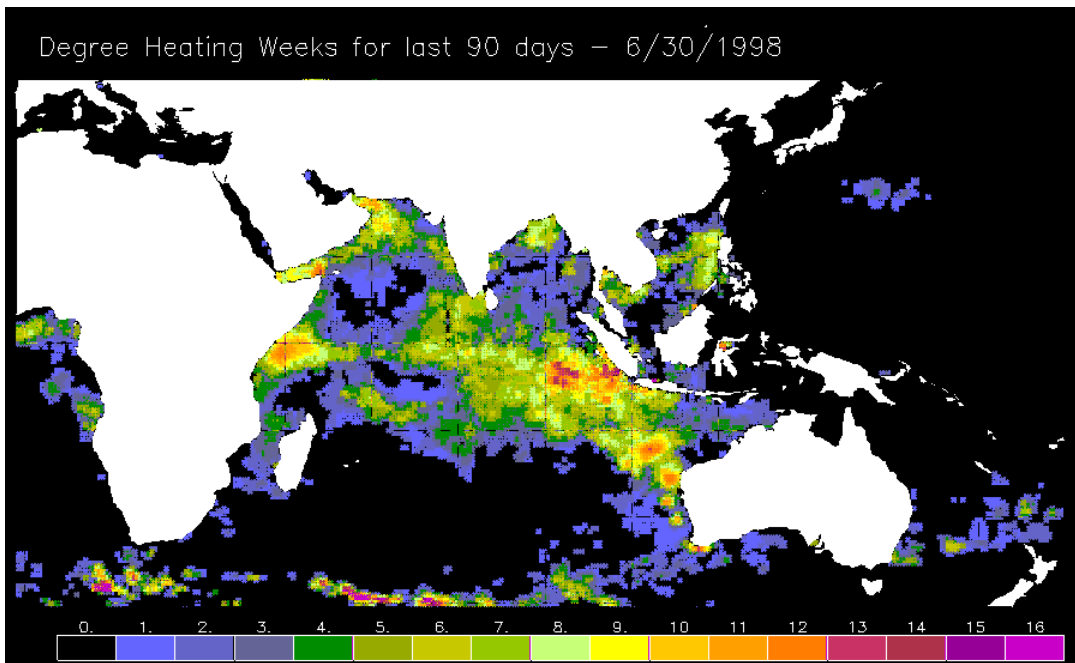
Sea Surface Temperature

The temperature of the ocean changes as you dive deeper and deeper. Scientists measure sea surface temperature because it gives clues about the water below the surface. If surface water is warm, then the deeper water below it usually is warm. If surface water is cool, then the water below it usually is too. Sea surface temperature monitoring is done by satellites and buoys, which gather the data twice a week. Scientists identify an area as a coral bleaching "HotSpot" if the SST is 1°C higher than a typical hot temperature for that reef.

It is important to note that warmer water alone may not cause bleaching events. Other factors may make the stress worse for the corals. A variety of other environmental stresses—such as disease, too much shade, increased levels of ultraviolet radiation, sedimentation, pollution, and salinity changes (how salty the water is)—and human stresses – such as pollution, oil spills, breaking coral, littering, overfishing, and sewage - may also play a role.

Look at the following SST data, displayed in order. They show the areas that had higher than normal temperatures. The worst hit spots are in purple and the least affected are blue. On the last map, from 7/31/98, use a red pen or pencil to mark your prediction of a coral bleaching area around India and Australia.

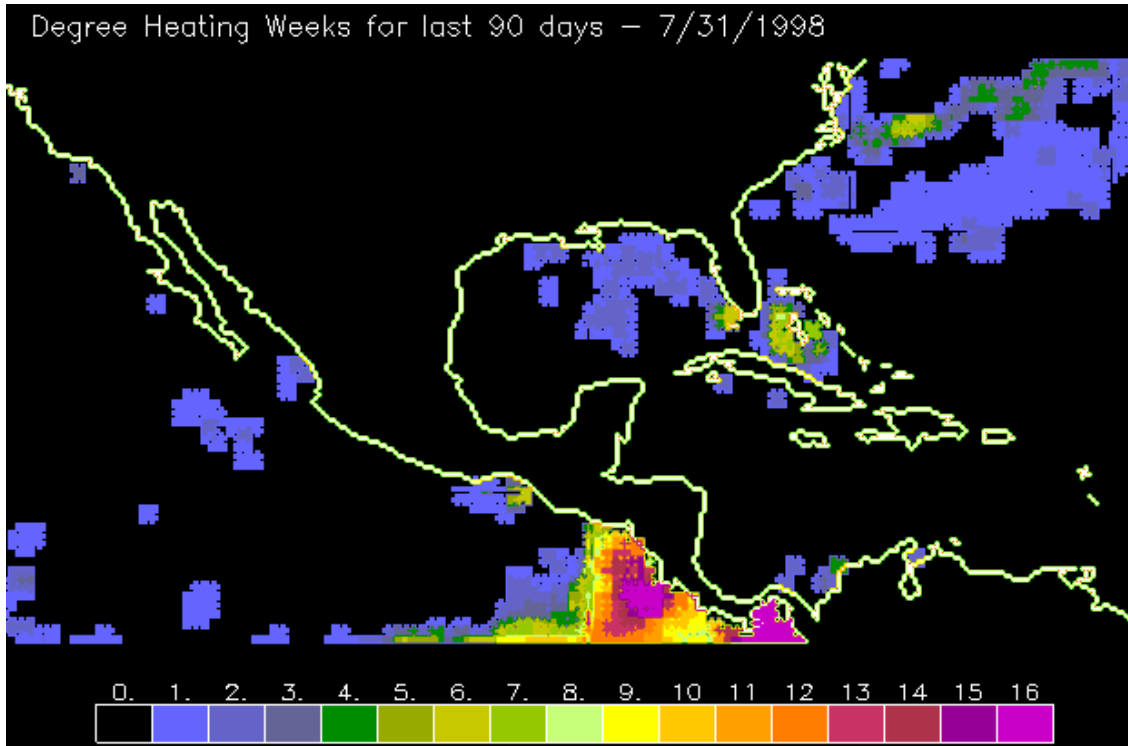


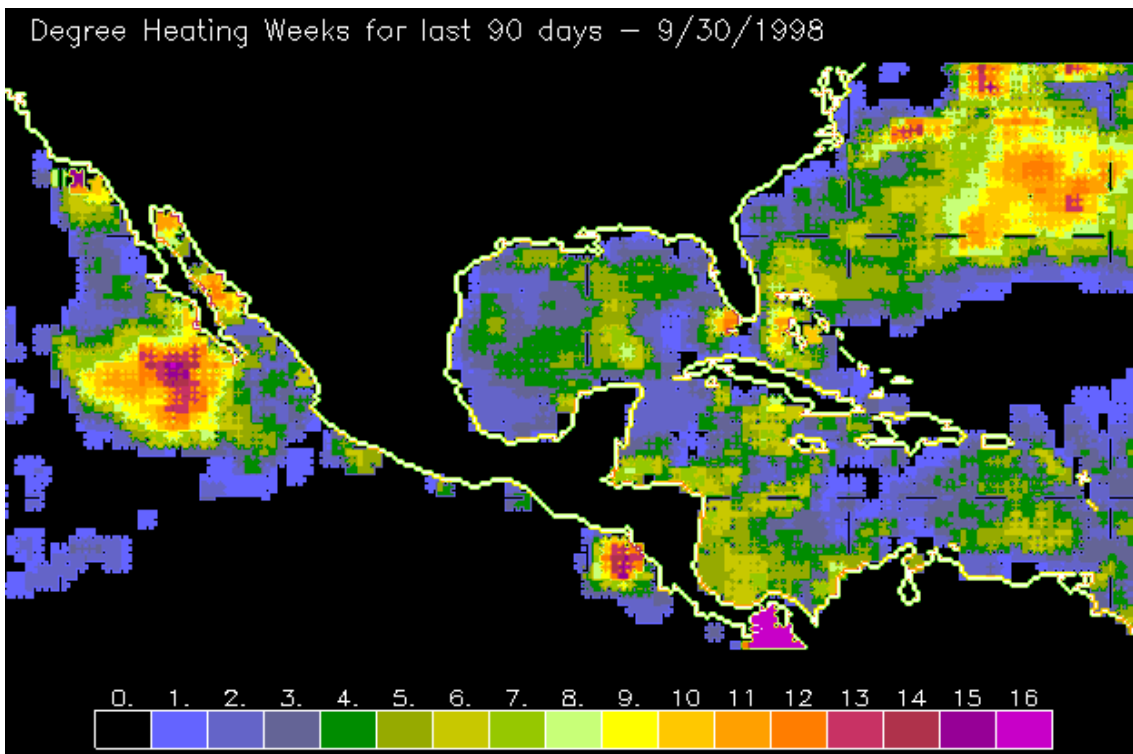
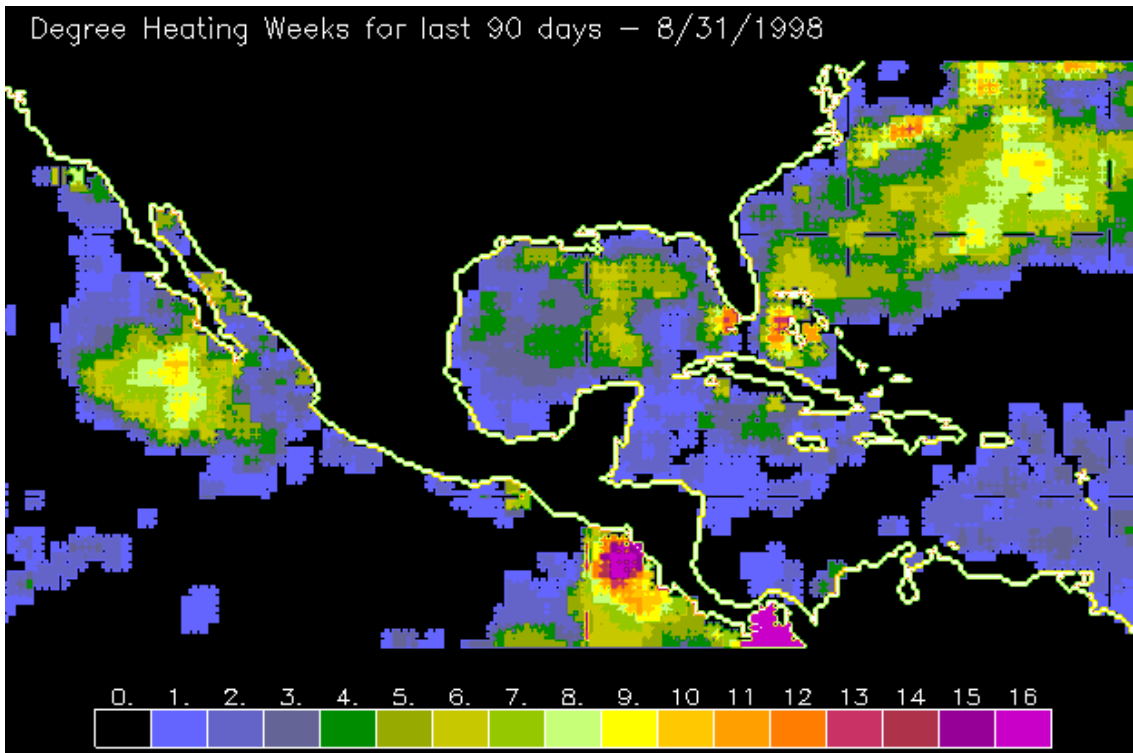


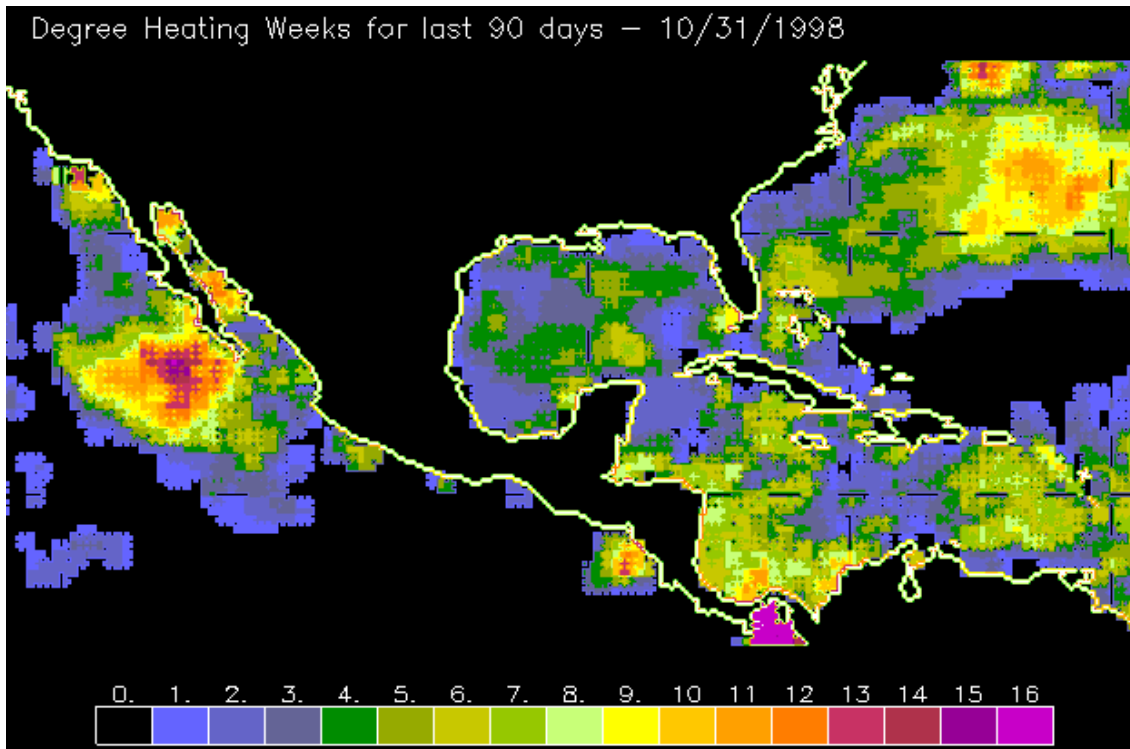
Now go to <http://www.osdpd.noaa.gov/PSB/EPS/SST/data/ane98c.gif> to view the animated version of the Indian Ocean's hotspots in 1998. Check your predictions by looking for the small black asterisks that show where there was bleaching.

Pinpointing Peril

Study the following SST data. They show the areas that had above normal temperatures. The worst hit spots are in purple and the least affected are blue. On the last map, from 10/31/98, use a red pen or pencil to mark your prediction of a coral bleaching area around the Gulf of Mexico and Atlantic Ocean.







Why do you think scientists use only SST data taken during nighttime?
