Sea Surface Temperature and Coral Bleaching

Region: Caribbean

Grade Level(s): 5-8

Time Required: One 45-minute class period

Focus Question:

- Where are coral reefs located and what conditions are required to maintain healthy coral?

Learning 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.

Materials:

- Access to computer lab
- Copies of “Coral Bleaching Student Worksheet” for each student
- 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.

Prerequisite Knowledge:

- Students should have a basic understanding of ecosystems.
- Students should understand the role of polyps and zooxanthellae and the formation and existence of coral reefs.

Background:

- Coral reefs are a fragile ecosystem. Scientists who monitor ocean temperature have noted a link between temperature and 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 numerous other threats, corals are often vulnerable and can die after extended periods of bleaching.

- 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 (1.8°F) over the past 100 years and are currently increasing at a rate of 1-2°C (1.8 – 3.6°F) 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 ≥ 1ºC (1.8°F) above the expected summertime maximum. Two DHWs are equal to two weeks at 1ºC (1.8°F) or one week at 2ºC (3.6°F) above the expected summertime maximum temperature. A DHW of 4 or higher, indicated in green, means that coral bleaching will occur in areas where there are coral reefs.

Procedures/Instructional Strategies:

1. **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 worksheet 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.

2. **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)

3. **Exploration:** Follow the directions to carry out the "Coral Bleaching" teacher demonstration. Instruct students to answer the accompanying "Coral Bleaching" student worksheet.

4. **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 Bleaching" questions. Teach students that when zooxanthellae leave the coral polyp it is called "coral bleaching." The coral appears colorless and eventually dies unless zooxanthelle "move in" to resume 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 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 (50.5–57.0 °F) = purple, 14.0-19.2°C (57.2–66.6 °F) = blue, 19.3-24.4°C (66.7–75.9 °F) = green, 24.5-27.1°C (76.1–80.8°F) = yellow, 27.2-29.8°C (81.0-85.6 °F) = orange, 29.9-31.6°C (85.8-88.9 °F).
- 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 "Predicting 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."

National Science Education Standards:

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science

- Populations and ecosystems
- Interdependence of organisms

Life & Climate are Linked

- Life on Earth has been shaped by, depends on, and affects climate.
- The evolution of organisms can be driven by specific climatological conditions, including but not limited to temperature, humidity, precipitation, and sunlight.
- Changes in one or more of these climate conditions can produce damaging changes in ecosystems.
- Changes in environmental conditions can affect the survival of individual organisms as well as entire species.

The Nature of Science

- We increase our understanding of the climate system through observation and modeling.
- We gain understanding of climate and how it has changed over time from observational data from weather stations, buoys, satellites, radars, ice and ocean sediment cores, tree rings, cave deposits, native knowledge, and other sources.

Natural Variability & Change

- Earth's weather and climate vary over time and space.
- Climate is understood as the atmospheric conditions (i.e., weather variables) averaged over a long period of time (season, year, or longer) and over a large area (region, continent, or larger).
- The temperature of a specific place on Earth's surface tends to rise and fall in a somewhat predictable pattern every day and over the course of a year.
- Differences in the intensity of sunlight warm Earth's surface and produce daily, seasonal and long-term variations in temperature.

Additional Resources:

- The Coral Reef Alliance. (2002). International coral reef information network. http://www.coral.org/
- Hoegh-Guldberg, O. (n.d.) Climate change, coral bleaching, and the future of the world's coral reefs. http://archive.greenpeace.org/climate/science/reports/coralbleach.pdf
- NOAA Coral Reef Conservation Program. http://coralreef.noaa.gov/

- NOAA/NESDIS. (2003). NOAA/NESDIS experimental degree heating weeks. http://www.osdpd.noaa.gov/PSB/EPS/icg/ehet.s51998.e71998.gif
- NOAA's National Ocean Service Corals Roadmap to Resources http://oceanservice.noaa.gov/education/kits/corals/supp_coral_roadmap.html

References

This activity was adapted from Sea Surface Temperature and Coral Reefs found at http://coralreefwatch.noaa.gov/satellite/education/docs/6_Sea_Surface_temp.pdf

The complete curriculum for middle school students about remote sensing and coral reefs can be found at http://coralreefwatch.noaa.gov/satellite/education/reef_remote_sensing.html

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 place 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 Worksheet

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.

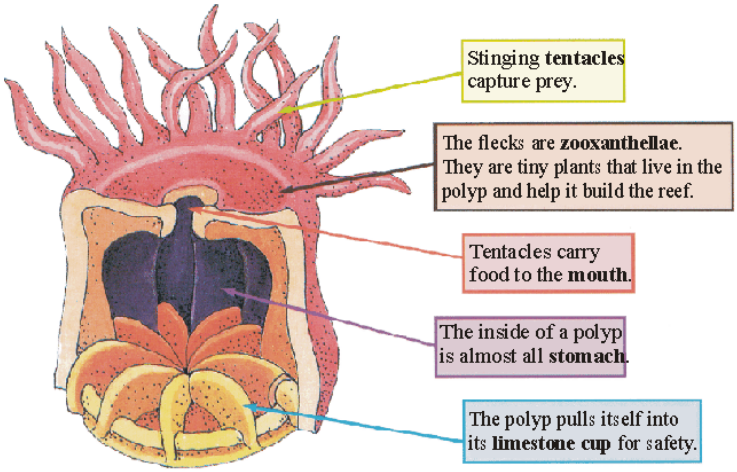
_____
_____

3. What caused these changes to occur?

_____
_____

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

_____
_____



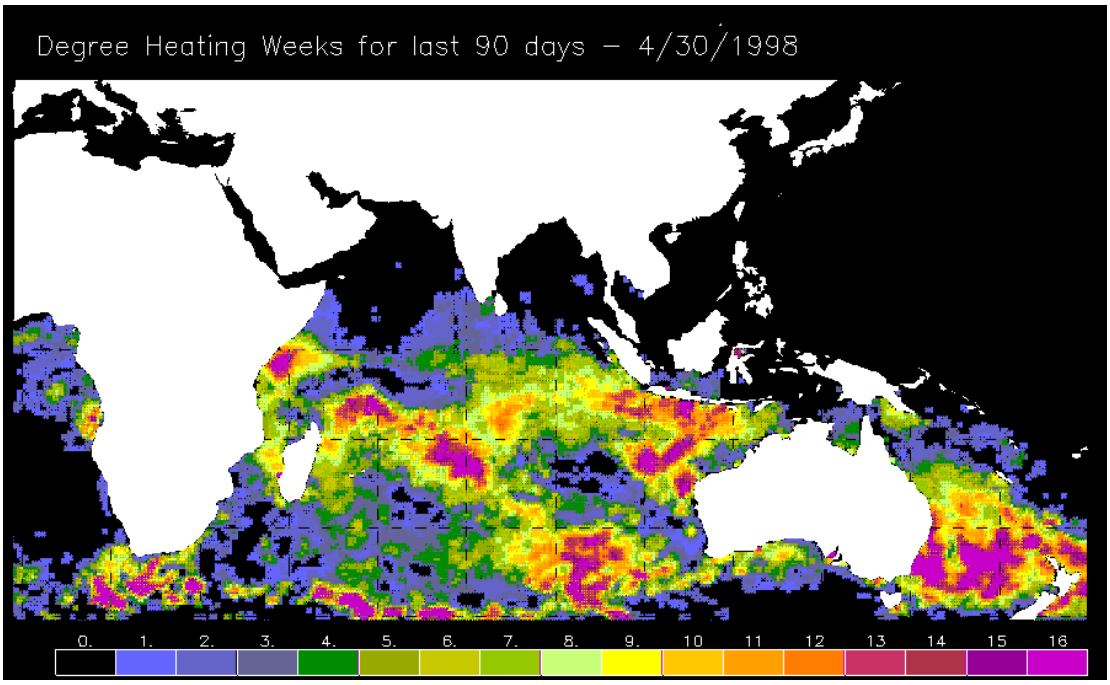
What Happened to the Coral?

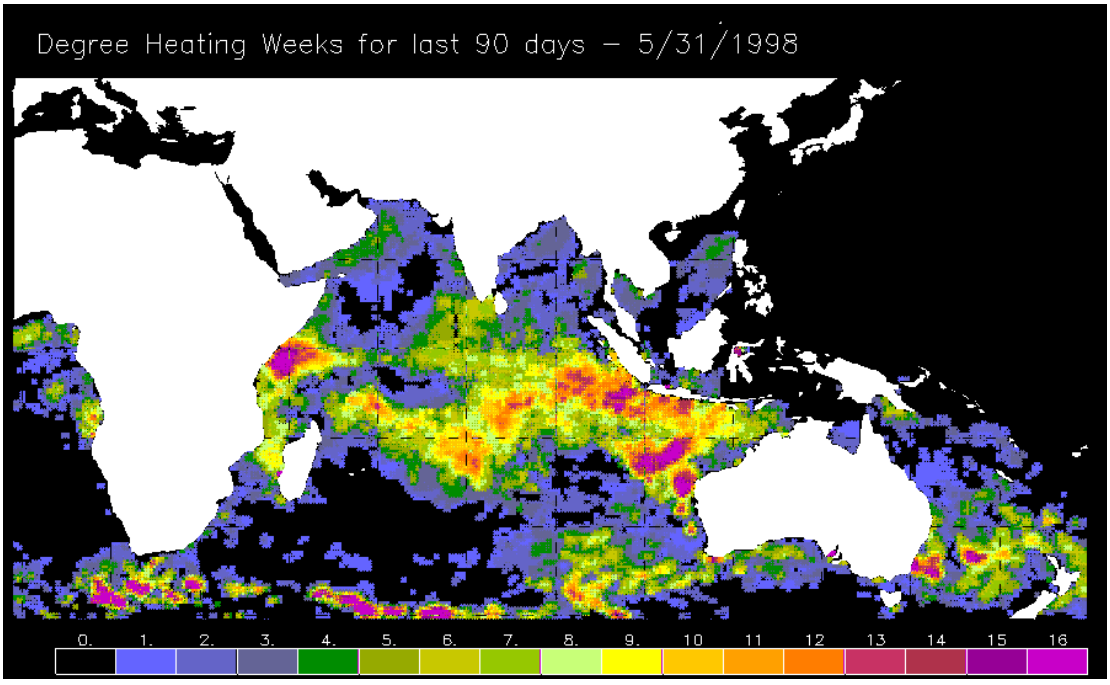
Coral bleaching is a reaction to stress in which most or all of corals' plant partners (zooxanthellae) leave their host polyp. The polyp itself is colorless, so when the algae leave, it appears to have been bleached. "Bleaching" is triggered by environmental stress and very often has been linked to increases in the temperature of the ocean water. Once the zooxanthellae are gone, the polyps lose their food source and do not have the necessary energy to build a reef.

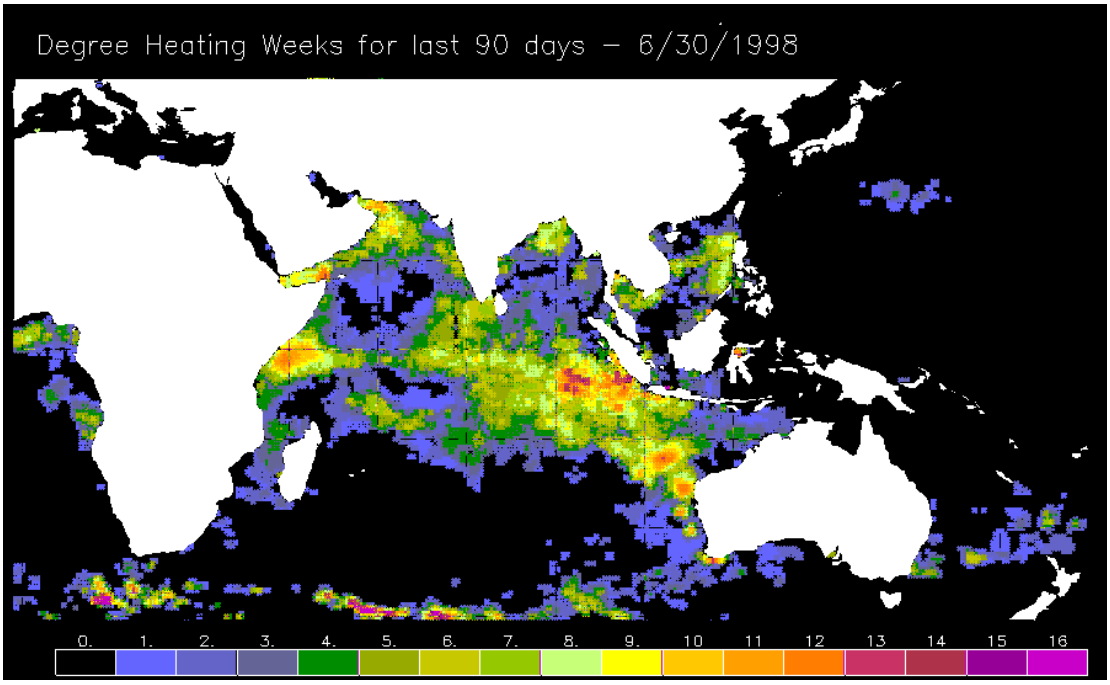
Sea Surface Temperature
The temperature of the ocean changes as you dive deeper and deeper. Scientists measure sea surface temperature because it gives clues about the water below the surface. If surface water is warm, then the deeper water below it usually is warm. If surface water is cool, then the 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 (1.8°F) higher than the warmest summertime temperatures typical for that reef.

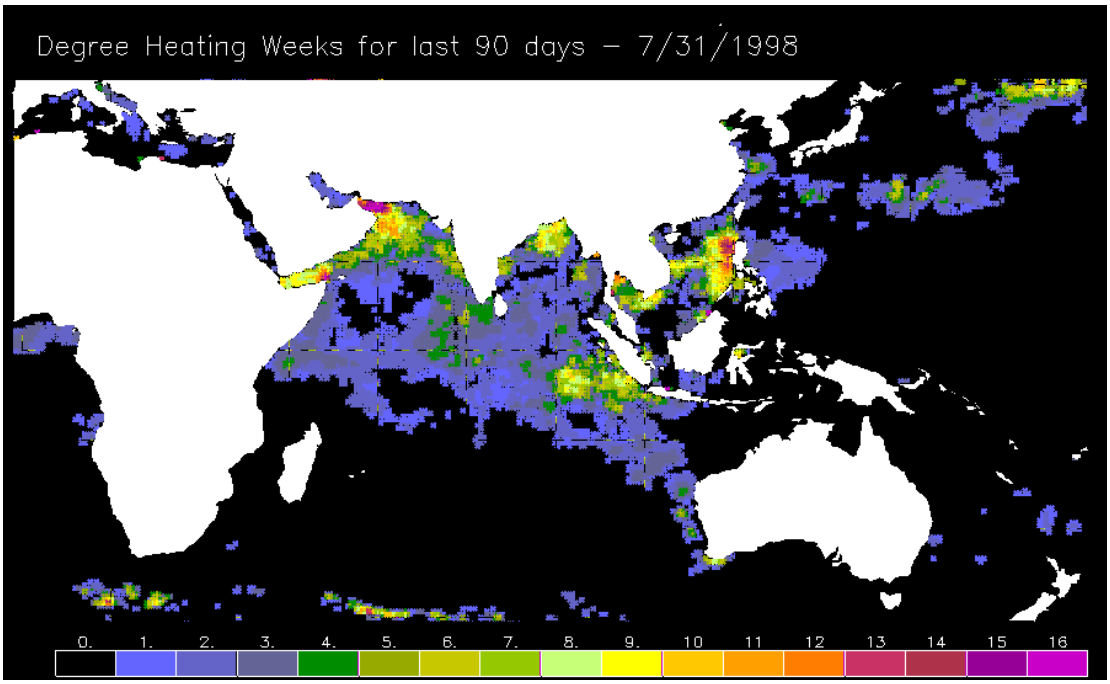
Warmer water is not the only cause of bleaching events. Other factors may make the stress worse for the corals. A variety of other environmental stresses—such as disease, increased levels of ultraviolet radiation, sedimentation, pollution, and salinity changes (how salty the water is)—and human stresses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

Look at the following DHW images, based on sea surface temperature data and displayed in chronological 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.


Degree Heating Weeks for last 90 days – 4/30/1998
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10 11 12 13 14 15 16


Degree Heating Weeks for last 90 days – 5/31/1998
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10 11 12 13 14 15 16

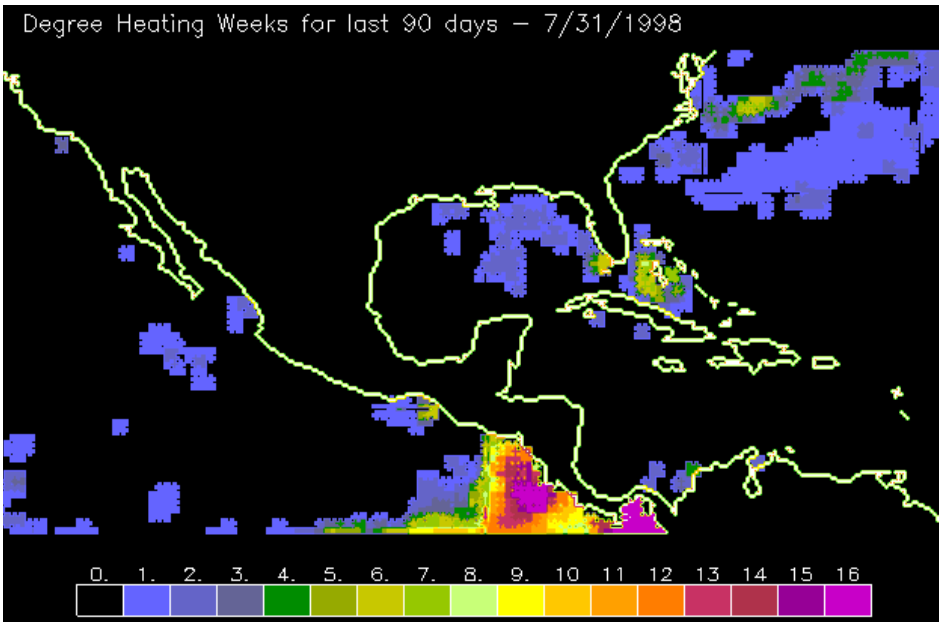


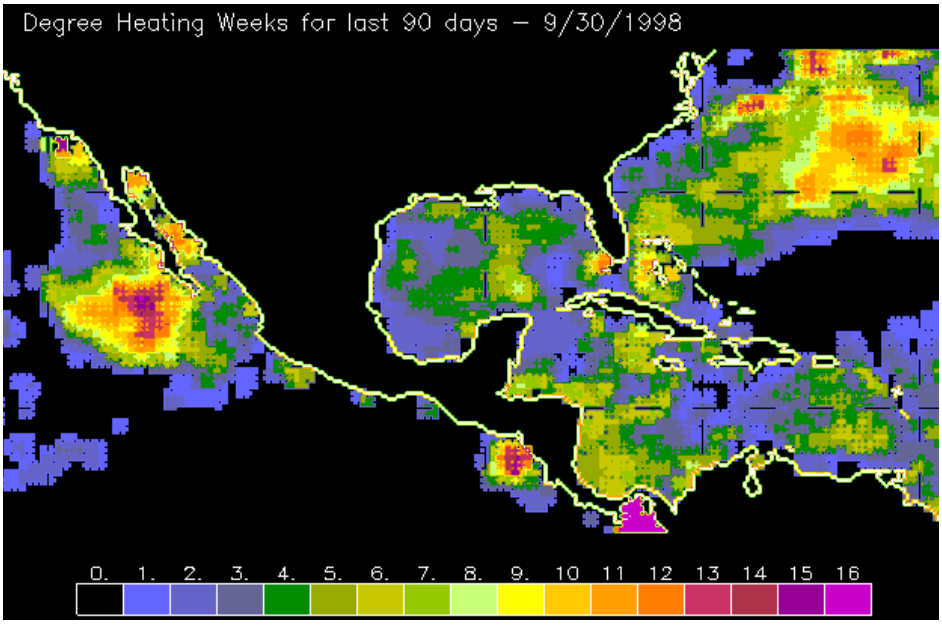


Now go to http://www.osdpd.noaa.gov/PSB/EPS/SST/data/ane98c.gif to view the animated version of the Indian Ocean's hotspots in 1998. Check your predictions by looking for the small black asterisks that show where bleaching occurred.

Predicting Peril

Study the following DHW images that are based on sea surface temperature data. They show the areas that had above normal temperatures. The higher the DHW number, the higher the temperatures are compared to normal in the region. Areas in black are normal, areas in blue to green are higher than normal, and areas with yellow to purple are much higher than normal. On the last map, from 9/30/98, 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?

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