Coral Reefs and Global Warming

hhmi | BioInteractive

Activity
Educator Materials

OVERVIEW

In this computer-based activity, students download, graph, and analyze authentic satellite temperature data for coral reef sites around the world. After observing global trends in the data, students evaluate the threat to coral reefs from heat stress, which has been occurring with increased intensity and frequency in recent years. The activity requires that students have access to computers with spreadsheet software. If computers are unavailable or students are unfamiliar with using spreadsheet software, students can be provided with handouts of prepared graphs for analysis and evaluation.

Additional information related to pedagogy and implementation can be found on this resource's webpage, including suggested audience, estimated time, and curriculum connections.

KEY CONCEPTS

- Coral bleaching is an observable consequence of global warming caused by human activities.
- The symbiotic relationship between a coral polyp and its symbiotic algae is threatened by higher water temperature.
- The increased mortality of coral polyps and the bleaching of coral reefs are consequences of sustained periods of elevated water temperature.
- Recent global sea surface temperature data is widely available and useful for studying environmental change.

STUDENT LEARNING TARGETS

- Make evidence-based claims about the threat of rising ocean temperatures to coral reefs.
- Identify global patterns by comparing data from three world maps.
- Graph data using spreadsheet software and estimate the area under a curve.

PRIOR KNOWLEDGE

Students should be familiar with:

- basic computer skills, including the use of a spreadsheet program (Microsoft Excel, OpenOffice, etc.)
- the use of scientific modeling to make predictions
- some basics about symbiotic species interactions

MATERIALS

For each student/pair of students:

- a copy of the "Student Handout"
- one "Location Card"
- access to a spreadsheet program

For the entire class:

- copies of the "World Maps"
- colored pencils or stickers with four different colors (e.g., green, blue, yellow, and red)

TEACHING TIPS

- You can download all the files for this activity from the "Materials" box on this resource's webpage. Note that most of the PDF files are in the **"Other Materials"** ZIP file.
- If you want to skip the graphing part of the activity, you can provide students with the prepared graphs from the **"Temperature Graphs"** PDF.
- Consider these options for saving paper:
  - Have students use digital versions of the files instead of printing them out.
  - Print out and laminate copies of the "Student Handout" for the class. Instruct students to write on them with erasable markers so that they can be reused.
  - Print out copies of the "Student Handout" for the class, but instruct students not to write on them so that they can be reused. To this end, you could:
    - Have students copy and complete the data table for Step 3 of "Student Handout" on the back of their "Location Card," then turn in their card at the end of the activity.
    - Use the "Questions" at the end for a class discussion or have students submit responses separately.
- As an extension, students can access the NOAA Coral Reef Watch site for more information, references, and downloads of near real-time data (updated twice weekly).

PROCEDURE

Before the Activity

1. Prior to doing the activity with students, try doing it yourself for troubleshooting and to help to ensure that the activity is successful.
   a. If students will be doing the activity in class, try doing it in the computer lab or on one of the devices that students will be using. Use a student login if applicable.
   b. Confirm that students will be able to access the files they need. If necessary, upload the files to your school website or cloud storage service (e.g., Google Drive, Box, Microsoft OneDrive).
2. The day before the activity, consider doing the following:
   a. Ask students to read through the **"Student Handout"** as homework.
   b. Have students view the *Coral Bleaching* animation or its accompanying interactive exploration, either in class or as homework.
   c. Print and cut out cards from the **"Location Cards"** PDF in preparation for the activity.

During the Activity

3. Assign each student/pair of students a specific "Location Card."
4. Ask students to download the data file for their assigned location from the Coral Temperature Data page (**Step 1** in the "Student Handout"). The names of the data files match the location names and are indicated on the "Location Cards."
5. Have students graph the data for their location using a spreadsheet program of your choice (**Step 2** in the "Student Handout").
   a. Instructions for making the graphs in Microsoft Excel and OpenOffice are provided at the end of the "Student Handout." You may want to walk through an example in class.
   b. Note that students should make three graphs, each covering two years of data.
6. Have students calculate DHW values for their location just in the years 2002, 2010, and 2014 (**Step 3** in the "Student Handout").

a. There are several examples of how to calculate DHW in the "Student Handout." If students struggle with these calculations, consider walking through an example in class.

b. Students should use the DHW for each year to determine a risk level (**Step 3a** in the "Student Handout"). There are four possible risk levels: "No Bleaching" (DHW = 0), "Bleaching Possible" (0 < DHW < 4), "Bleaching Likely" (4 ≤ DHW < 8), and "Mortality Likely" (DHW ≥ 8).

7. Provide students with copies of the 2002, 2010, and 2014 maps from the "**World Map"** PDF. For each year, have students indicate the risk level at their location on the map (**Step 3b** in the "Student Handout").

   a. Make sure all students use the same system to indicate risk level. For example, they could use stickers or colored pencils of certain colors for certain risk levels.

   b. To make this activity accessible to colorblind students, do *not* rely on color alone to indicate risk level. Instead, have students use different symbols, numbers, patterns, etc., for each risk level.

8. Display the completed world maps on a screen using a projector, smart board, etc., for students to use when answering the questions in the "Student Handout."

9. Check students' work using the following options:

   a. The **"World Maps (Key)"** PDF shows the completed maps.

   b. The **"Temperature Graphs with DHW"** PDF shows the completed graphs for each location and time period, along with the DHW calculations.

   c. An **answer key** for the questions in the "Student Handout" is provided below.

   d. A **summary table** for all the locations and time periods in this activity — including the MMMs, DHWs, and risk levels — is provided at the end of this document.

ANSWER KEY

1. After analyzing the world maps, what patterns, differences, or similarities do you notice between the different years represented?
   Answers will vary but may include observations such as:
   - ***In 2002, the worst heat stress appeared to be focused on the South Pacific Ocean.***
   - ***In 2010, heat stress was slightly lower in the Pacific but higher in the Indian and Atlantic oceans.***
   - ***In 2014, heat stress was widespread.***
2. What geographic patterns do you notice? Are there regions of the globe that are more prone to bleaching than others?
   The equatorial region of the Pacific Ocean (except for the Galápagos Islands) shows significant heat stress in all three years.
3. Is there a global trend from 2002 to 2014? Explain.
   From 2002 to 2014, the heat stress increased for 14 locations, stayed the same for 9 locations, and decreased for 5 locations. Not all places are experiencing the same trends, but overall, the evidence suggests the globe is warming.

CREDITS

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Data from NOAA Coral Reef Watch, used under public domain
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Summary Table

Refer to the "Temperature Graphs with DHW" PDF for illustrations showing how DHW values were calculated. Note that students will probably get less precise DHW values since they are eyeballing the graphs.

				DHW		
LOCATION	LATITUDE	LONGITUDE	MMM	2002	2010	2014
Asuncion Island	19.5 N	145.0 E	29.3	3.3	4.4	17.9
Abul Thama, Bahrain	27.0 N	51.0 E	31.9	6.4	18.1	9.2
Barbados	13.0 N	60.0 W	28.5	1.6	22.3	4.2
Fernando de Noronha, Brazil	4.0 S	33.0 W	28.6	0.4	7.6	0.9
Cayman Islands	19.5 N	80.5 W	29.2	4.9	10.6	5.4
Chagos Archipelago, UK	6.0 S	72.0 E	29.2	2.6	5.6	3.6
Clipperton Island, France	10.5 N	109.0 W	28.7	8.6	4.3	7.9
Hurghada, Egypt	27.0 N	34.5 E	28.9	0.9	8.3	4.5
Fiji	18.5 S	178.5 E	28.1	20.7	1.5	16.3
Florida Inshore Shelf	25.5 N	81.5 W	29.3	6.3	15.2	15.9
Galápagos	1.0 N	90.0 W	26.5	7.9	3.1	2.4
Santa Rosa Reef, Guam	13.0 N	145.0 E	29.5	0.5	2.1	7.6
Lizard Island, Great Barrier Reef	14.5 S	145.5 E	28.9	8.4	4.5	1.4
Martin, Florida	27.0 N	79.5 W	29.1	3.7	9.4	7.7
Midway Atoll North, US	28.5 N	177.5 W	26.9	8.5	7.0	10.6
Oahu, Hawaii	21.0 N	158.0 W	27.0	1.5	0.0	8.9
Ofu, Samoa	14.0 S	170.0 W	29.3	9.5	7.8	6.9
Okinawa, Japan	27.0 N	128.0 E	28.8	0.1	2.9	5.2
Muscat, Oman	24.0 N	58.0 E	30.3	18.1	11.9	14.3
Palmyra Atoll	6.0 N	162.0 W	28.7	19.1	19.0	13.4
Paracel Islands, China	16.5 N	112.5 E	29.3	2.9	14.8	16.5
El Nido, Philippines	12.0 N	119.0 E	29.7	3.4	24.3	12.5
Pulu Keeling, Australia	12.0 S	96.5 E	28.5	3.4	6.2	13.8
Réunion Island, France	21.5 S	55.0 E	27.5	0.6	5.2	9.2
Arnavon, Solomon Islands	8.0 S	158.0 E	29.5	13.1	14.8	19.5
Spratly Islands, Philippines	11.0 N	115.0 E	29.6	2.5	21.5	12.0
Bar Reef, Sri Lanka	8.5 N	79.5 E	29.5	6.2	4.6	0.7
Tarawa, Kiribati	1.5 N	172.5 E	29.1	40.2	31.3	38.0

Legend

DHW = 0 (no bleaching)	
0 < DHW < 4 (bleaching possible)	
4 ≤ DHW < 8 (bleaching likely)	
DHW ≥ 8 (mortality likely)	