Coral Reefs & Global Warming: Mapping Analysis Activity

Directions:

- Write your name, today's date, and the class period on the upper right corner of a piece of loose-leaf paper.
- Write the heading *"Coral Reefs & Global Warming"* on the top left corner.
- Read the *Background Information.*
- Complete the mapping activity.
- Answer all of the background and analysis questions on loose-leaf paper.
- You do not need to write the question. However, be sure to number each answer clearly.

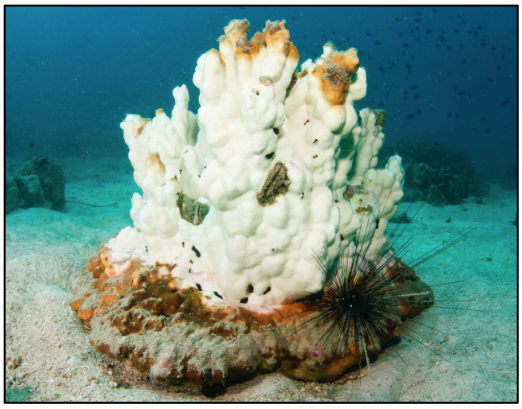
Part 1

Background Information

Coral reef ecosystems are in trouble. About 20 percent of the world's coral reefs have already been lost, and that number may climb to 50 percent in the next 20 to 40 years. The main culprits are pollution, overfishing, and climate change. In this activity, you will analyze satellite data to determine threats to coral reef ecosystems from warming ocean water.

What are corals?

Although they may look like plants or rocks at first glance, corals are animals related to jellyfish and anemones. Individual corals are called polyps and, in many species, form colonies of identical clones. Polyps secrete a hard calcium-based skeleton that creates the physical structure of coral reefs. Reef-building corals have a limited ability to acquire food and nutrients on their own, so they rely on intracellular symbiotic algae (symbiont) that supply sugars and oxygen produced via photosynthesis.



Why study corals?

Coral reefs are a critical marine habitat, accounting for 25 percent of marine biodiversity even though they only occupy 0.015 percent of the ocean. Five hundred million people depend on coral reefs for food sources, coastal protection, building materials, and income from tourism. The net value of coral reef ecosystems has been estimated to be almost $30 billion per year.

What is coral bleaching?
Elevated temperatures can damage the photosynthetic system of the symbiont, causing them to create reactive oxygen molecules that can damage the coral cells. Corals respond by ejecting the symbionts, without which the polyps are colorless and the coral reef appears white.
This is called bleaching and is a serious threat to the health of the coral reefs. Corals can survive without symbionts for short periods of time and can reacquire symbionts when heat stress subsides. However, if the bleaching is prolonged, the coral will likely die.

When does bleaching occur?
Heat stress makes corals vulnerable to bleaching. Generalizing about the amount of heat stress that corals can withstand is complicated because they are adapted to local environments and are somewhat able to acclimate to changing environments. One method to determine whether a coral is at risk of bleaching is to record when temperatures rise 1°C or more above the normal maximum for a given location; this is known as the bleaching threshold. For purposes of tracking coral health, normal temperatures are determined by averaging monthly temperatures for 1985 to 1993. The warmest normal temperature is the month with the highest average temperature, called the maximum monthly mean (MMM). The temperatures are measured by satellites using an infrared radiation sensor and represent sea surface temperature (SST). Only nighttime data are used to avoid overestimating heat due to solar heating of a thin layer at the sea surface.

Heat stress is assessed by a measure called degree-heating weeks (DHW). It is a cumulative measurement of the intensity and duration of heat stress that a coral reef experiences over a period of 12 weeks, equivalent to a season. 1-DHW is equivalent to 1 week of SST 1°C above the expected maximum monthly mean. Empirical observations suggest that bleaching occurs when four DHW accumulate within a 12-week window, and coral death occurs when DHW values are greater than 8. Because heat tolerance can vary within and between different coral species, these DHW thresholds are merely guidelines: some corals may survive in areas with high heat stress, while others may perish with relatively mild stress. Further, the temperature data is averaged over relatively large areas of 5 km^2, but actual temperatures experienced by corals may vary greatly due to local conditions. Finally, corals can recover after the stress disappears, and the 12-week window accounts for this.

<u>Mapping Activity- Procedure</u>
Use the following procedure to complete the 2002, 2010, & 2014 degree heating week maps. Using the latitude and longitude coordinates in the data table on page 3, plot the locations of each coral reef on the map by coloring in the circle at each location according to the degree heating week (DHW) key on the right.

DHW key	
0	Green
1 - 4	Blue
5 - 8	Yellow
> 8	Red

Location	Latitude	Longitude	MMM	2002	2010	2014
Asuncion Island	19.5 N	145.0 E	29.3	3.3	4	18
Abul Thama, Bahrain	27.0 N	51.0 E	31.9	6	18	9
Barbados	13.0 N	60.0 W	28.5	2	22	4
Fernando de Noronha, Brazil	4.0 S	33.0 W	28.6	0.4	8	1
Cayman Islands	19.5 N	80.5 W	29.2	5	11	5
Chagos Archipelago, U.K.	6.0 S	72.0 E	29.2	3	6	4
Clipperton Island, France	10.5 N	109.0 W	28.7	9	4	8
Hurghada, Egypt	27.0 N	34.5 E	28.9	1	8	5
Fiji	18.5 S	178.5 E	28.1	21	2	16
Florida Inshore Shelf	25.5 N	81.5 W	29.3	6	15	16
Galápagos	1.0 N	90.0 W	26.5	8	3	2
Santa Rosa Reef, Guam	13.0 N	145.0 E	29.5	1	2	8
Lizard Island, Great Barrier Reef	14.5 S	145.5 E	28.9	8	5	1
Martin, Florida	27.0 N	79.5 W	29.1	4	9	8
Midway Atoll North, US	28.5 N	177.5 W	26.9	9	7	11
Oahu, Hawaii	21.0 N	158.0 W	27	2	0	9
Okinawa, Japan	27.0 N	128.0 E	28.8	0.1	3	5
Muscat, Oman	24.0 N	58.0 E	30.3	18	12	14
Palmyra Atoll	6.0 N	162.0 W	28.7	19	19	13
Paracel Islands, China	16.5 N	112.5 E	29.3	3	15	17
El Nido, Philippines	12.0 N	119.0 E	29.7	3	24	13
Pulu Keeling, Australia	12.0 S	96.5 E	28.5	3	6	14
Réunion Island, France	21.5 S	55.0 E	27.5	1	5	9
Arnavon, Solomon Islands	8.0 S	158.0 E	29.5	13	15	20
Spratly Islands, Philippines	11.0 N	115.0 E	29.6	3	22	12
Bar Reef, Sri Lanka	8.5 N	79.5 E	29.5	6	5	1
Tarawa, Kiribati	1.5 N	172.5 E	29.1	40	31	38

Analysis Questions

1) Identify the main threats to coral reef ecosystems.
2) Describe the coral building process and the symbiotic relationship on which corals rely.
3) Why are coral reefs considered critical marine habitat?
4) Describe the economic services provided by coral reefs ecosystems.
5) How do corals respond to elevated temperatures and what does this cause?
6) What is the maximum monthly mean (MMM) and why is it useful?
7) What are degree heating weeks (DHW) and why are they useful?
8) At what DHW level is it more likely that coral bleaching will occur?
9) After analyzing the world maps, what patterns, differences, or similarities do you notice between the different years represented?
10) What geographic patterns do you notice? Are there regions of the globe that are more prone to bleaching than others?
11) Is there a global trend from 2002 to 2014? Explain.