USING SATELLITE SEA SURFACE TEMPERATURE TO PREDICT MASS CORAL BLEACHING

Two conditions that have been linked to coral bleaching are unusually high water temperatures and low surface winds. Your assignment is to use NOAA satellite data to investigate whether these conditions occurred in the Caribbean during the early fall of 2005. You will be assigned to one of four locations:

- Bermuda, located at 32.0°N, 64.5°W
- Lee Stocking Island (Bahamas), located at 23.5°N, 76.5°W
- The west coast of Puerto Rico, located at 18.0°N, 67.5°W
- US Virgin Islands, located at 18.0°N, 65.0°W

A. WHAT WERE THE LOCAL CONDITIONS AT YOUR REEF ON SEPTEMBER 2, 2005?

Find your reef on the sea surface temperature figure (Figure 1). This map shows the temperature of the ocean waters, measured from NOAA's Polar Orbiting Environmental Satellites (POES). The data are broken up into pixels that are 0.5-degree (~ 50-km) on a side.

1. What was the temperature at your reef on that day?

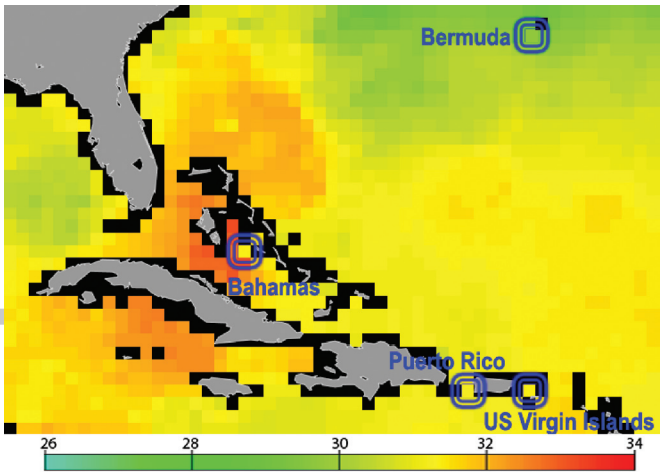

Figure 1: Sea Surface Temperature, September 2, 2005

Find your reef on the Coral Reef Hotspot figure (Figure 2). This map shows positive temperature anomalies. In this case, the anomaly is the temperature above the warmest monthly average for each location. If your area is white, temperatures are at or less than the average for the warmest month. Warm colors (yellow to red) indicate the Hotspot is above the bleaching threshold (≥ 1°C).

2. Was the temperature at your site unusually warm? If so, what was the anomaly?

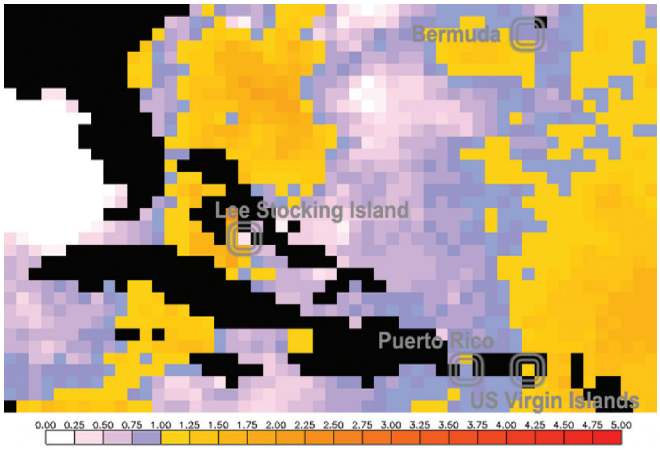

Figure 2: Coral Reef Hotspot, September 2, 2005

Look to see if the winds were low at your site on September 2. Find your reef in the Doldrums figure (Figure 3), which shows colored pixels in areas where the average wind speed over the last four days was less than five knots. The color bar tells you for how many days these low-wind (doldrums) conditions have lasted. The darker shades of grey indicate land and a land mask where there is no satellite data. A light grey pixel means that the average wind speed was above five knots, and a white pixel means that there were no data for that day.

3. Were there doldrums over your reef? If so, for how many days did the doldrums conditions persist? If not, were there doldrums regions close to your reef?

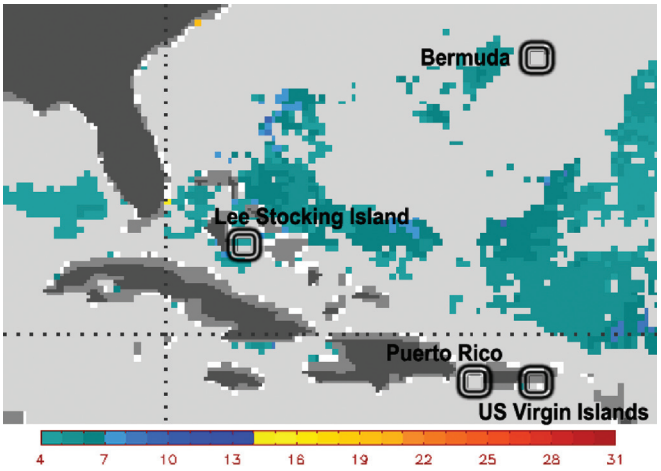

Figure 3: Doldrums (days), September 2, 2005

Find your reef on the Ocean Surface Winds figure (Figure 4). This data set is collected by several satellites and processed by NOAA each day. Keep in mind that a white area on this map means "no data," not "no wind." If your area is white, look at the surrounding area to get an idea of what the wind speed was probably like.

4. What was the approximate range of wind speeds in the region around your reef on that day?

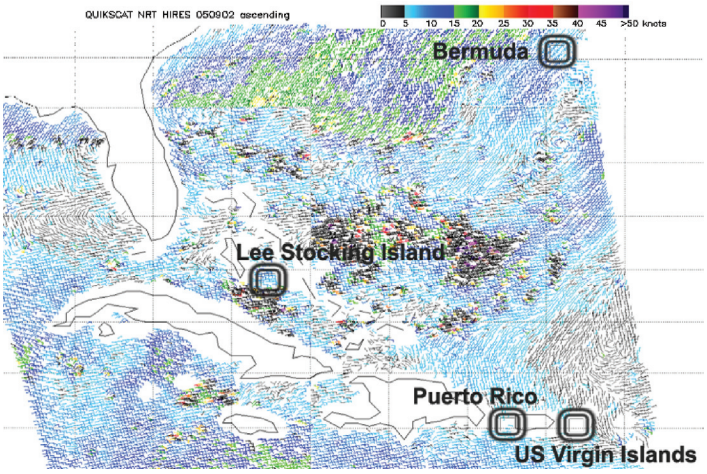

Figure 4: Ocean Surface Winds, September 2, 2005

B. HOW HOT WAS THE WHOLE LATE SUMMER/EARLY FALL SEASON?

Find the sea surface temperature (SST) time series for your reef (Figure 5). These graphs give the yearly temperature record for each of the four reef sites, measured by NOAA satellites. Note that both 2004 and 2005 are plotted on the same graph.

The SST for the site is shown in purple. The dashed blue line shows the average temperature for the warmest month. One degree above that is considered to be the threshold temperature for coral bleaching, shown as the solid blue line. When ocean temperatures over the reef exceed this threshold, the corals are thermally stressed.

5. Based on the 2005 temperature graph for your reef site, answer the following questions:

a. What was the maximum temperature during the 2005 summer?

b. When did the temperature first reach the bleaching threshold?

c. How long did the temperature stay at or above the threshold?

The solid red line at the bottom of the graph shows the Degree Heating Weeks (DHW) for that site throughout the year. The DHWs show the accumulation of bleaching-level thermal stress the corals have seen in the last 12 weeks. Remember the DHWs combine intensity of the temperature anomaly (how hot) and duration (for how long). This is a good measure of how stressed the corals are.

6. Based on the 2005 temperature graph for your reef site, answer the following questions:

a. When did DHWs start to accumulate at your reef site?

b. How high did the DHWs get?

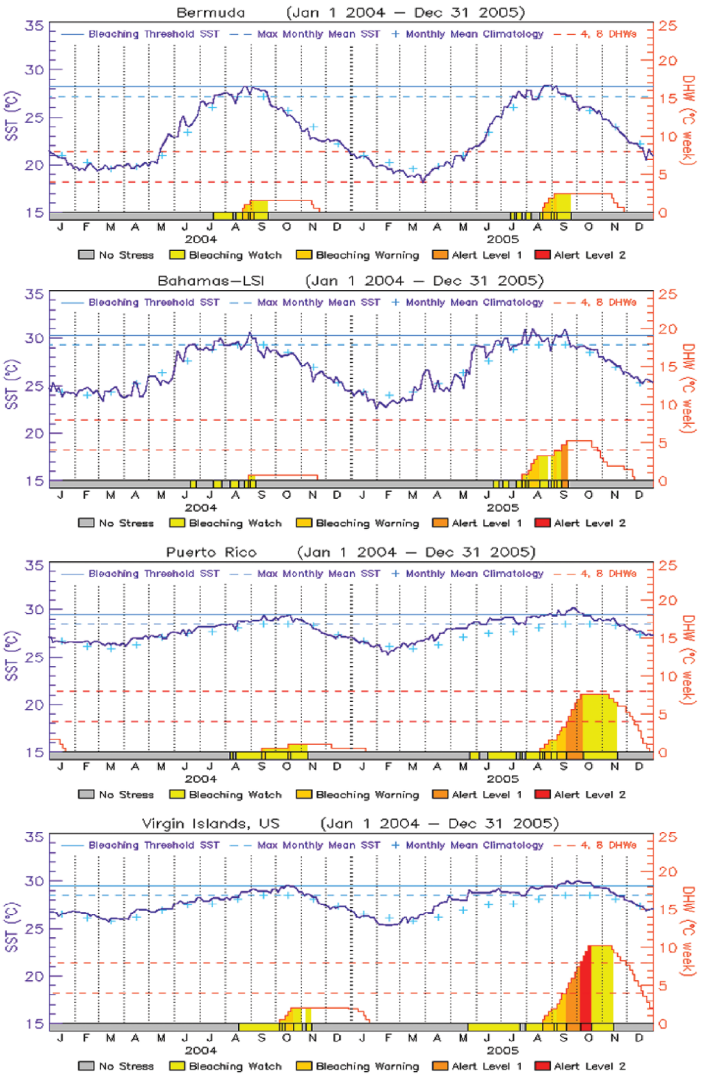

Figure 5: Sea Surface Temperature Time Series

Any level of DHW indicates accumulated thermal stress. The higher the DHW value, the more likely this stress will lead to coral bleaching. The dashed red lines show two DHW bleaching thresholds. When the value gets above 4°C-weeks, we expect to see significant coral bleaching. Values above 8°C-weeks indicate that we expect severe coral bleaching and some coral mortality as a result.

7. Based on the 2005 temperature graph for your reef site, answer the following questions:

a. Do you expect that there was coral bleaching at your reef site in 2005?

b. If so, how severe do you think the bleaching was?

C. HOW STRESSED WAS YOUR REEF SITE COMPARED WITH OTHER REEFS IN THE CARIBBEAN REGION?

Find your reef on the Maximum Degree Heating Weeks figure (Figure 6). DHWs measure the accumulated thermal stress on the reef, and this figure shows the maximum stress experienced during 2005.

8. Was the DHW value at your site in the lower third, middle third, or upper third of the range of values experienced in the Caribbean in 2005?

9. How did the thermal stress at your site compare to the stress experienced by the other three reefs highlighted in this exercise?

10. How severe do you predict the bleaching was at your site compared to the other three reefs?

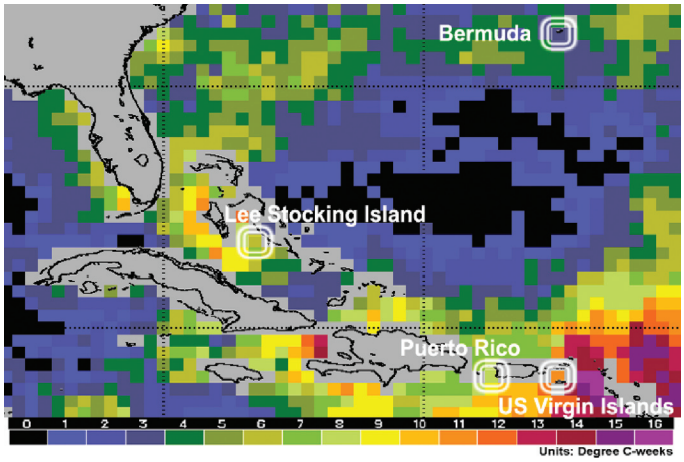

Figure 6. 2005 Maximum Degree Heating Weeks

SATELLITE IMAGERY RESOURCES ONLINE

- QuikScat Winds images from the NOAA Marine Observing Systems Team
  http://manati.orbit.nesdis.noaa.gov/hires/
- Current and past Sea Surface Temperatures, Coral Bleaching Hotspots, Degree Heating Weeks and time series
  http://coralreefwatch.noaa.gov/
- Sea Surface Temperature images (NOAA Coral Reef Watch)
  http://www.osdpd.noaa.gov/PSB/EPS/SST/sst_50km.html
- Experimental doldrums charts and data from Coral Reef Watch
  http://coralreefwatch.noaa.gov/satellite/doldrums_v2/index.html
- Sea Surface Temperature time series
  http://coralreefwatch.noaa.gov/satellite/current/sst_series_24reefs.html
- Maximum DHW image, plus more on the 2005 Caribbean bleaching event
  http://coralreefwatch.noaa.gov/caribbean2005/