



## Coral Reefs and Global Warming

### CORAL REEFS IN HOT WATER



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 use 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. For purposes of tracking coral health, normal temperatures are determined by averaging monthly temperatures over previous decades. 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. 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<sup>2</sup>, 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.

### **PROCEDURE**

You will be assigned to examine one of four coral reef regions:

- Bermuda
- U.S. Virgin Islands
- Puerto Rico
- Lee Stocking Island, Bahamas

View NOAA's Coral Reef Watch and monitoring stations here:

<http://coralreefwatch.noaa.gov/satellite/vs/>

<https://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php>

Explore the different metrics of temperature stress to corals

- 1) Access the data for your location from:

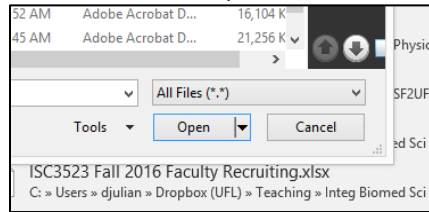
<http://coralreefwatch.noaa.gov/satellite/vs/caribbean.php>

<https://coralreefwatch.noaa.gov/satellite/vs/atlanticocean.php#Bermuda>

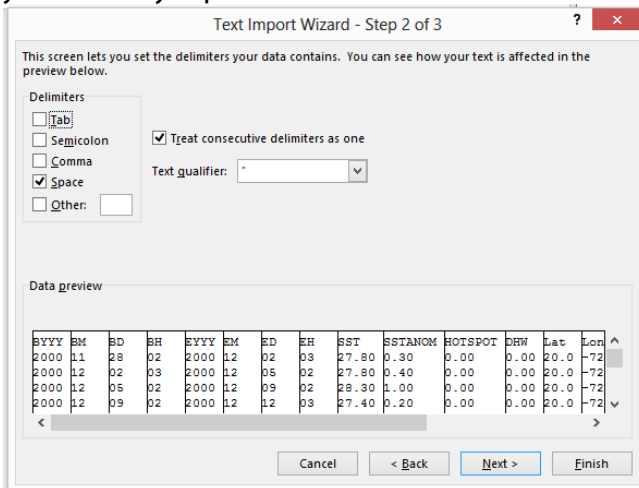
Find your location and right click on "time series data" and select "Save Link As...."

2) Import your data to Excel:

- a. Browse for the file to open. **\*\*Important\*\*** you must browse for all files, not just Excel files (since your data is currently a text file)

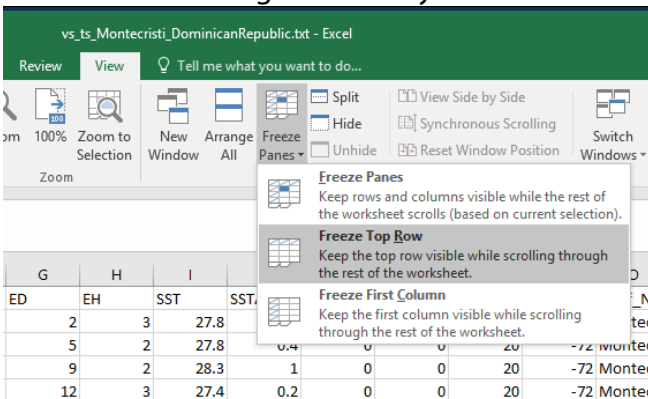


- 3) After clicking "Open" you should see the Text Import Wizard. This allows you to import the into columns in a spreadsheet. Note that the data in each row of the text file are separated (delimited) by spaces. Select "Delimited" on the Import Wizard and separate your data by "Space" and click "Finish". You now have your NOAA data in Excel!



4) Save the resulting file as an Excel Workbook (xls or.xlsx)

- 5) Open the View menu, click on Freeze Panes and then Freeze Top Row. This will keep the column headings visible as you scroll down through the spreadsheet.



- 6) What do my column labels mean? The time series data are extracted in four-day composites from the monitoring stations. The beginning and end times for each measurement are represented in the first eight columns:
  - a. BYYY, BM, BD, BH = year, month, day, and hour of the beginning time point
  - b. EYYY, EM, ED, EH = year, month, day, and hour of the ending time point
  - c. SST: Twice-weekly sea surface temperature composite value
  - d. SSTANOM: The difference between the SST and the daily climatological SST
  - e. HOTSPOT: HotSpots values are greater than zero when bleaching thermal stress is present
  - f. DHW: Bleaching Degree Heating Weeks (DHW) value in the units of degree Celsius-weeks. The DHW is a measure of thermal stress accumulated over a 12-week period.
  - g. Lat and Lon: Latitude and longitude of the center of the pixel with the monitoring station Reef\_Name: The name of the reef site to which the virtual station is associated.
- 7) To plot the data conveniently, you will need to combine the beginning date data into a single column that can be the X-axis.
  - a. Insert a new column and give it the column title of "B-Date"
  - b. Enter "=Date(A2, B2, C2)", where BYYY is located in cell A2, BM is located in cell B2, and BD is located in cell C2 (remember that starting a cell entry with "=" tells Excel to read it as a formula).
  - c. Copy the formula down to the last data row.
- 8) Plot the data for your site by selecting the SST column and insert a line chart
  - a. Use the formatting options to enhance the ability of the chart to convey the desired information. For example, you may want to alter the Y-axis range.
  - b. Add B-Date as your X-axis by adding this column to the horizontal axis labels under "Select Data"
  - c. Examine the resulting chart. What trends are immediately obvious?
- 9) Add a solid line to indicate the Threshold Temperature for bleaching concern (Max Monthly Mean or MMM SST). A Hot Spot is defined as  $MMM + 1^{\circ}\text{C}$  and use the temperatures that register as Hot Spots to calculate the MMM value for your location.
  - a. Enter this value in a new column and copy it down the entire length of the dataset. Add a second series to your graph to visualize this line in relation to the variation in SST. Are there any years in which the risk was especially high?
- 10) Add a third series to your graph for DHW. This line should appear as another color. You may need to readjust your Y-axis range.
- 11) Find the maximum Degree Heating Weeks experienced in 2004 and in 2005 for your location for comparison to the other sites. How much bleaching risk do you expect for your site?