Coral Bleaching: A White-Hot Problem

Lesson Time : 60 minutes
Grade Level : 9-12
Vocabulary: cnidarian, zooxanthellae, sedimentation, bleaching, HotSpot, degree heating week

Summary
Assess coral bleaching using water temperature data from the NOAA National Data Buoy Center.

Objectives

- Describe the relationship between corals and zooxanthellae.
- Identify stresses to corals.
- Explain coral bleaching and the processes that cause coral bleaching.
- Examine water temperature data and compare to levels known to induce coral bleaching.
- Predict the effects of prolonged, increased temperatures on coral reefs.

Introduction

The magnificent beauty of a coral reef is a true masterpiece of Mother Nature. A reef is a sculpture of living organisms, varied in color, texture, shape, and size. The creation of these works of art takes many, many years (some reefs are thousands of years old), and they don't exist solely for show. Reefs are building blocks for rich communities, providing habitat for a myriad of organisms, and they are some of the most diverse ecosystems on the planet. In addition, they support fishing grounds, attract tourists, and protect shorelines from waves and storms.

Coral reefs exist in a geographical band 30 degrees north and south of the equator. Corals are cnidarians (related to jellyfish and anemones) and have symbiotic algae called zooxanthellae living in their tissues. These zooxanthellae are photosynthetic and produce food for the coral during the day. Corals live in waters with a salinity range of 30 to 40 ppt and can tolerate water temperatures between 16-35 °C, but the ideal temperature for growth is between 23-25 °C.

Sadly, coral reefs around the world are suffering the hardships of environmental stress. Corals are susceptible to several stressors, both natural and human-induced, including pollution, sedimentation, increased temperature, ocean acidification and physical damage by humans. These stresses can kill coral reefs outright or make the corals more susceptible to disease.

Average global sea temperature has been rising gradually over several decades, 0.85 °C (1.5° F) in the past 30 years alone, which is believed to be due to global warming. This thermal stress can cause coral bleaching, or the loss of zooxanthellae from the coral tissues. Since the zooxanthellae

are what give the coral tissue their color, the loss of them makes the coral appear white. With the loss of the photosynthetic algae, corals lose their primary food source and can die.

Corals which had thrived along Australia's Great Barrier Reef for hundreds of years suddenly died in 2016. It was the worst year ever recorded globally for coral bleaching up to that point, and it brought the hottest sea surface temperatures since 1998. View a NOAA map of coral bleaching hot spots:

https://mapscaping.com/coral-reef-bleaching-map

Note: Areas where the sea surface temperature exceeds the climatological expected maximum for that region by 1° C or more, colored orange to red.

In 2005, sustained high sea surface temperatures caused coral bleaching in the Caribbean. According to some scientists, the 2005 Caribbean bleaching events were bigger than all the previous 20 years combined. The effects of this are still being felt now. Recently, there was a large die off of corals off the coast of Puerto Rico and the U.S. Virgin Islands. These corals had survived the high heat of 2005 but were weakened and succumbed to white plague disease. The following data activity examines NOAA water temperature data for San Juan, Puerto Rico for 2005 through 2008. We will compare the observed water temperature with the known stressful temperature level for coral reefs and discuss the effects.

Data Activity

Corals can survive in water temperatures up to 35 °C, however the optimal growth temperature for corals is around 25 °C. Researchers have determined that, for any given area, water temperatures of 1 °C above the expected summertime maximum temperature is stressful to corals. If an area experiences this it is called a coral bleaching “Hot Spot”. If the thermal stress lasts for a week or longer, the stress accumulates. To measure this, researchers use a degree heating week (DHW) value. If the temperature is above the expected average maximum for one week, the DHW is 1. If the temperature is 2 °C higher than the expected maximum for one week then the DHW value is 2. You can also get a DHW value of 2 if the temperature is 1 °C higher for 2 weeks.

For Puerto Rico, the expected maximum temperature is 28.5 °C. This makes the DHW level 29.5 °C.

Print the graphs of observed daily water temperature for San Juan, Puerto Rico for 2005 – 2008 that are attached to this lesson. These data were collected by the NOAA National Data Buoy Center. Each year has its own graph, and the last graph shows all years (2005 – 2008) compiled.

In the graphs, the vertical lines mark one-week time periods. The yellow line marks the 1 DHW level of 29.5 °C and the red line marks the 2 DHW level of 30.5 °C.

A study conducted by researchers from the University of Puerto Rico found that 54 days of 29.5 °C water temperatures or 10 days of 30.5 °C water temperatures correlated with severe coral bleaching.

Print out the Student Worksheet and fill in the answers to the following questions.

- For each year, approximately what date did the water temperatures of San Juan, PR hit 1 °C above expected summertime maximum?
- For each year, approximately what date did the water temperatures hit 2 °C above expected summertime maximum?
- What date did the water temperature drop and remain below the 2 °C above expected maximum for the remainder of the year?
- What date did the water temperature drop and remain below the 1 °C above expected maximum for the remainder of the year?
- Approximately how many weeks over the year were temperatures 1 °C above expected maximum?
- Approximately how many weeks over the year were temperatures 2 °C above expected maximum?
- How many Degree Heating Weeks (DHW) were there for the year? (*Remember: 1 week at 1 °C above expected maximum = 1 DHW and 1 week at 2 °C above expected maximum = 2 DHW*

Discussion

- As you know, 2005 was a year of high water temperatures. How do the years 2006-2008 compare to 2005?
- What trend, if any, do you see in the number of DHWs over the 2005-2008 period? Is this a long enough period to determine a trend? If not, how long a period would you suggest?
- Based on the 2005-2008 data, what would you expect to see for water temperatures in San Juan, PR for 2009? What about 2019 and 2025? (*Hint: Access the San Juan, PR NOAA buoy data to see the current water temperature.*)
- Over the next few decades, if water temperatures continue to remain high for long periods of time at a stretch (resulting in significant DHWs per year), how do you think this will affect coral reefs? What impact would this have on the ecosystem? On the local economy?

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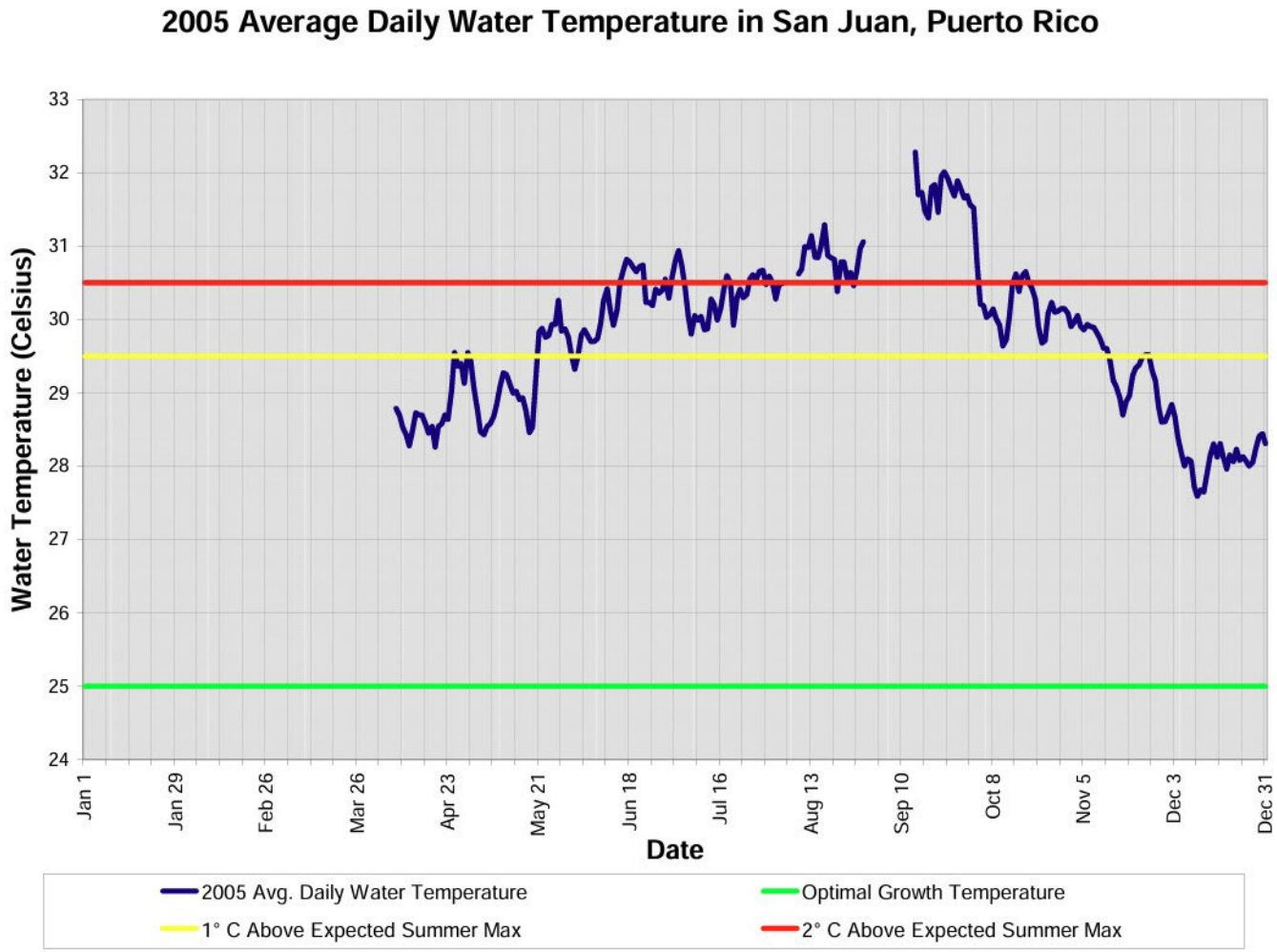
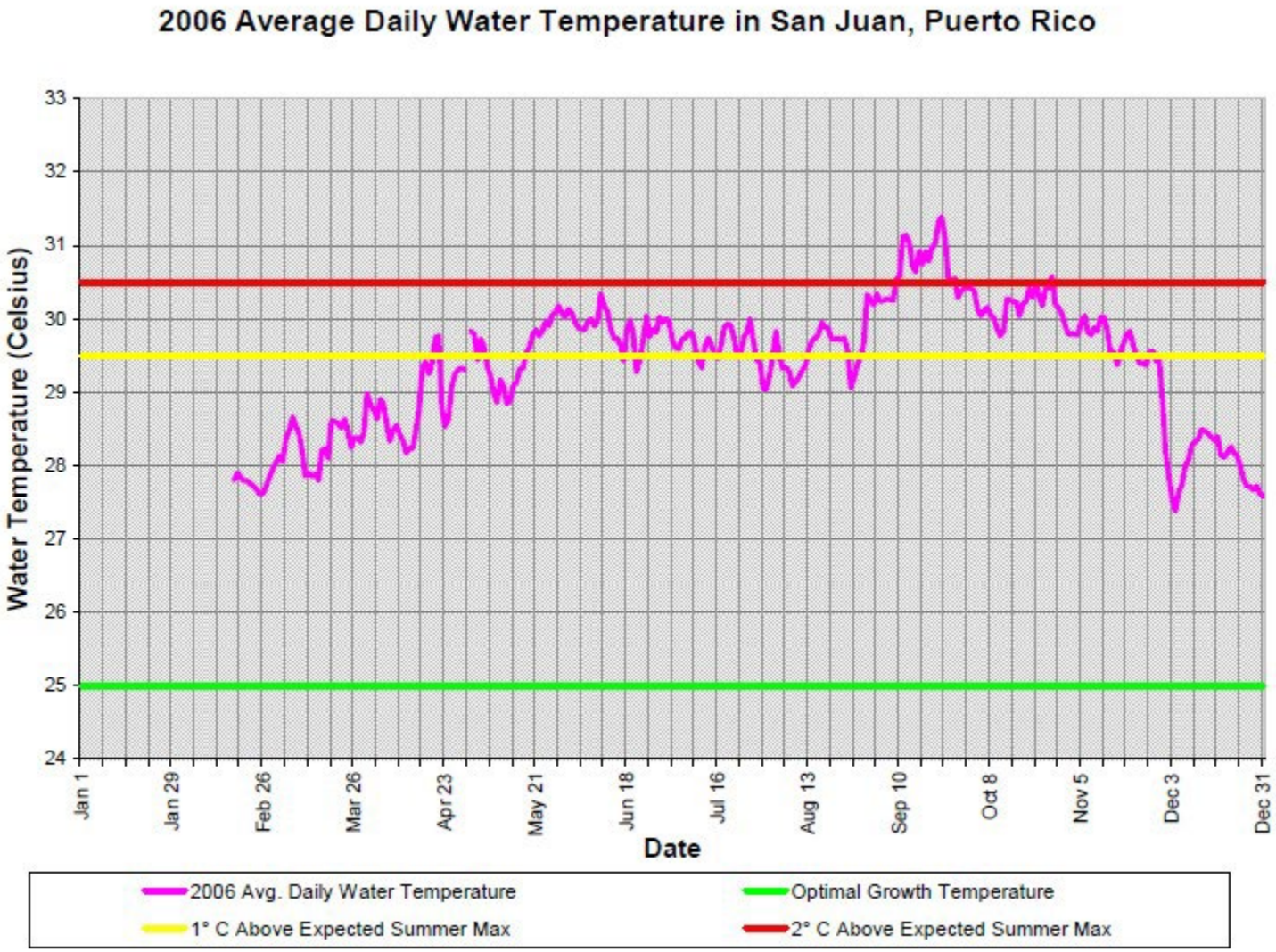
DATA Series

Graphs for Coral Bleaching: A White-Hot Problem



Graphs created using data from the NOAA National Buoy Data Center. Additional data-based lessons can be found at bridgeoceaneducation.org/data-series.



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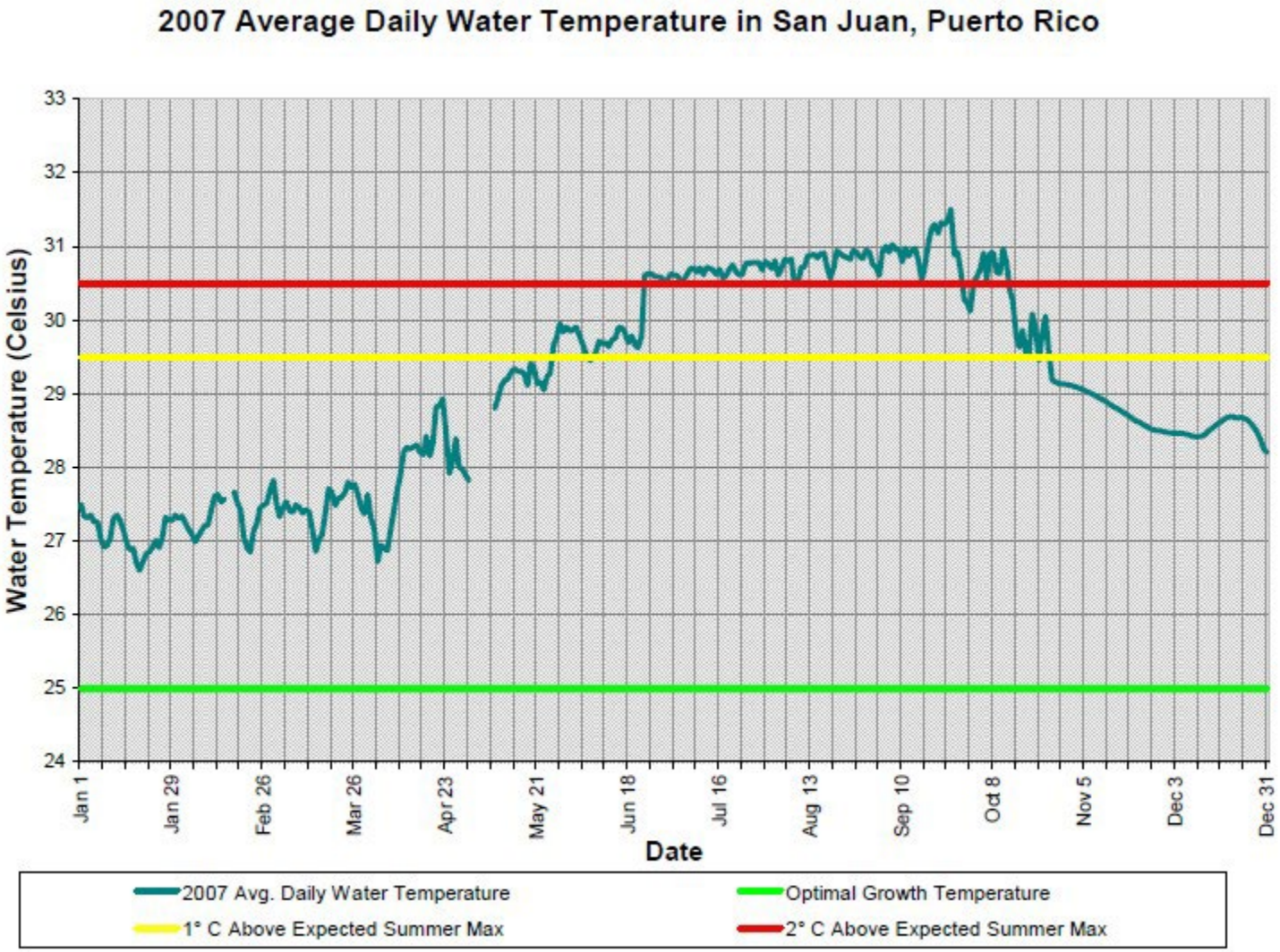

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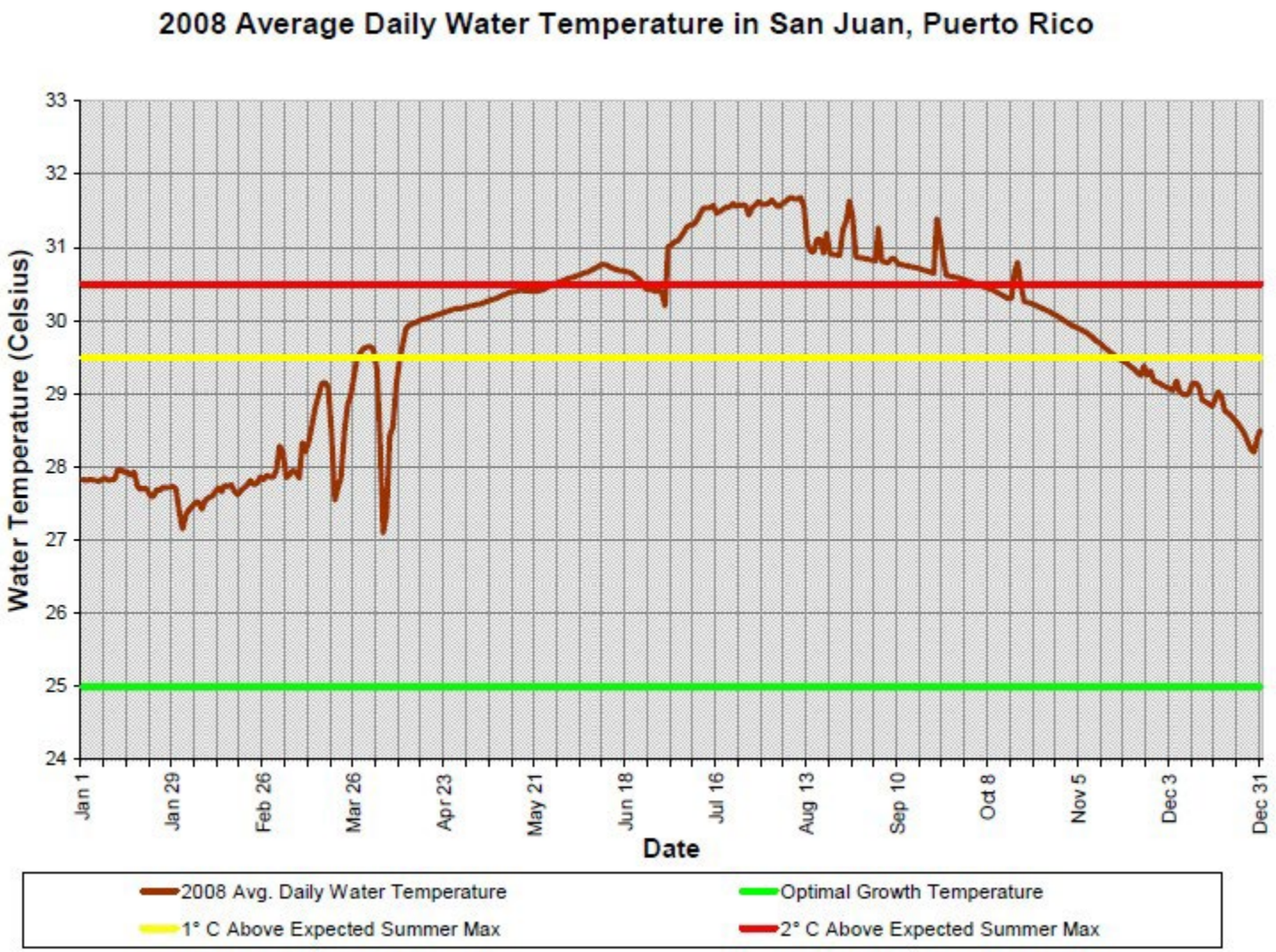

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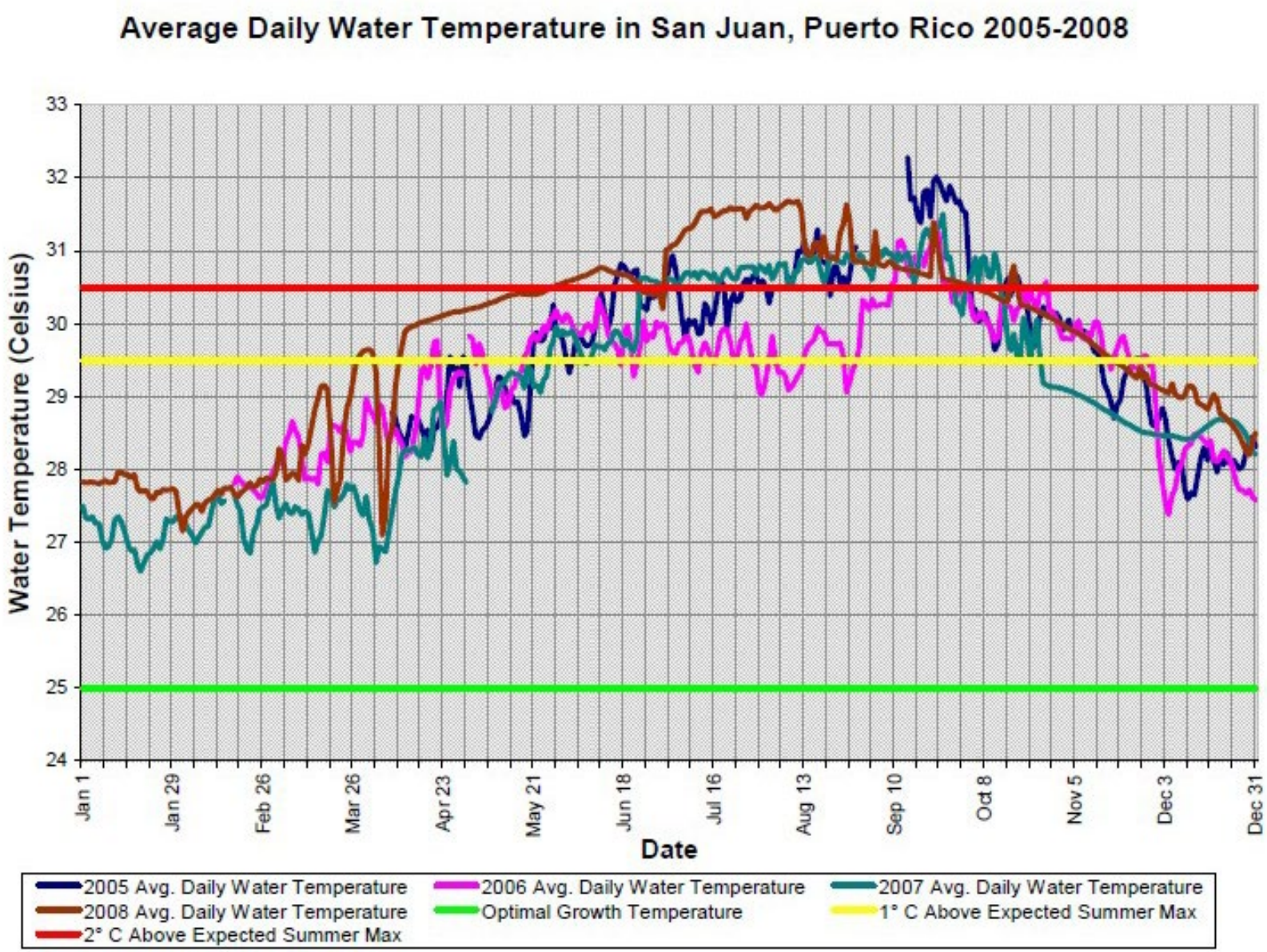

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QUESTION	2005	2006	2007	2008
What date did the water temperature first hit the 1°C above expected maximum?				
What date did the water temperature first hit the 2°C above expected maximum?				
What date did the water temperature drop and remain below the 2°C above expected maximum for the remainder of the year?				
What date did the water temperature drop and remain below the 1°C above expected maximum for the remainder of the year?				
Approximately how many weeks over the year were temperatures 1°C above expected maximum?				
Approximately how many weeks over the year were temperatures 2°C above expected maximum?				
How many Degree Heating Weeks (DHW) were there for the year? *1 week @ 1°C above expected maximum = 1 DHW* *1 week @ 2°C above expected maximum = 2 DHW*				