Measuring Ocean pH

Summary

Grade Level: 10 - 12

Teaching Time: 40 minutes

Activities:

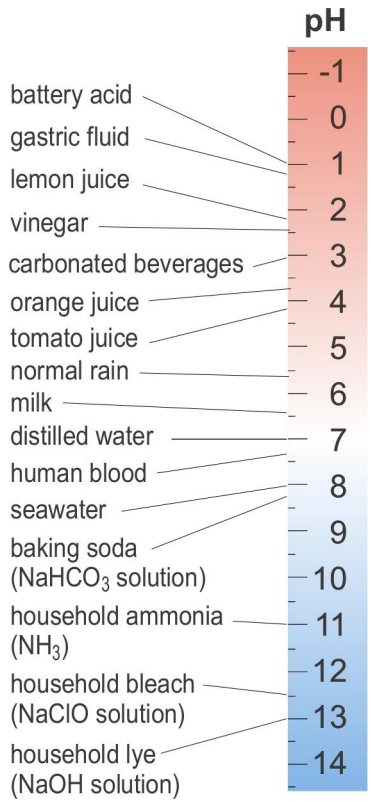
- **Examine false-color maps to examine changes in pH within the study area.**
- **Compare time-series graphs to correlate changes in pH and sea-surface temperature over time.**

Objectives

- Students will learn how to use online tools to access false-color data maps and graphs of ocean pH data.
- Students will examine data maps and graphs to look for patterns and relationships that would explain variations in ocean pH.

Background

Your students should be familiar with measuring the pH of solutions in the laboratory. pH is the measure of the hydrogen ion concentration in a solution. pH is used to express acidity or alkalinity on a scale of 0 to 14. Less than 7 represents acidity, 7 is neutral, and greater than 7 is alkaline. This illustration shows the pH values of common solutions:



pH is measured on a logarithmic scale, where small changes have increasingly greater effects. A solution with a pH of 3 is ten times more acidified than a solution with a pH of 4 and 100 times more acidified than solution with a pH of 5.

Earth's oceans are naturally slightly alkaline. The pH of surface seawater is around 8.1. Ocean acidification refers to the observed, ongoing process by which the pH in Earth's oceans is gradually decreasing, with the result that the water is becoming less alkaline. In this instance, "acidification" means that it the pH is becoming increasingly less alkaline and moving toward the acid end of the pH scale. The water in Earth's oceans will never actually become acidic.

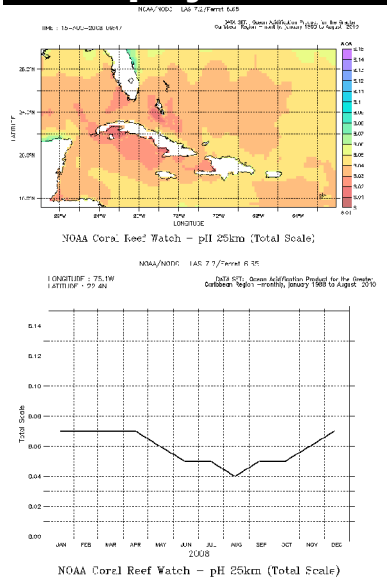
Scientists are not able to measure pH over vast expanses of ocean. Instead, they have created models based on satellite-imaging data to look at complementary data that allows them to better understand changes in pH over large areas of ocean. Results of these models are then checked

Take Note

What is a scientific model?

A scientific model is a representation of a complex phenomenon that helps us better understand the phenomenon. Models are approximations. Scientists start by proposing simple models that can be tested against actual phenomenon. The original model can then be rejected or modified. A good model becomes more accurate over time as it continues to be tested against observed data.

To Display



Generate these images at www.dataintheclassroom.org

with hands-on data collected by researchers on ships or from scientific instruments on buoys distributed within a study area. This is the type of data you will access and share with your students in this activity and which your students will access later in the Ocean Acidification module.

Preparation

If you have access to a computer and projector, you can display a color version of the pH contour maps you create online. Use the following steps:

1. Visit www.dataintheclassroom.org and click on the Ocean Acidification module link.

2. To access the data area for the Ocean Acidification module, select the "Get Data" link at the bottom of the left menu.

3. First you will create two pH maps for the entire study area in the Caribbean. In future data sets, you will be able to select a portion of the study area using the "Select a region" part of the screen. For now, leave this set for the default area.

4. Select "pH" in the "Which parameter?" pulldown.

5. Next select "Map" on the menu labeled "Which view?"

6. Specify the date by changing the date input to "January 2008."

7. Select "Image" on the menu labeled "Select an output format."

8. Finally, click the "Get Data" button. A new browser window will open that contains the pH map image you requested.

9. You may now save the pH map image to your local computer for later use. On a PC, right-click on the map with your mouse, select "Save Image as…" and provide a file name and local save destination. On a Mac, hold down the Ctrl key and click with the

Vocabulary

pH – measure of the hydrogen ion concentration in a solution. pH is used to express acidity or alkalinity on a logarithmic scale of 0 to 14. Less than 7 represents acidity, 7 is neutral, and greater than 7 is alkaline.

acidic – a solution is acidic if it has an excess of hydrogen ions. Acidic solutions have a pH of less than 7.

alkaline – a solution is alkaline if it has a low concentration of hydrogen ions. Alkaline solutions have a pH greater than 7.

ion – an electrically charged atom or group of atoms formed when one or more electrons are gained or lost

sea surface temperature – the average water temperature of the uppermost layer of the ocean, measured from the air-water contact to only a few millimeters deep

false-color map – a map that uses colors to represent differences in measured values. The color is "false" in that the land, water, or other surface being shown is not really that color.

mouse. When you have finished saving the map image, you may close that browser window.

10. Now create the second pH map. Change the date input to "August 2008" and click the "Get Data" button. Save the second pH map image to your local computer. When you have finished saving the map image, you may close that browser window.

11. Next you will create two time-series graphs. These will show changes in pH over time for a point location in the middle of the default study area. You do not need to change the parameter or output format selections.

12. First, change from "Map" to "Time series graph" on the menu labeled "Which view?"

13. Change the first date input to "January 2008." A second date input will appear. Change it to "December 2008."

14. Click the "Get Data" button. A new browser window will open that contains the pH time-series graph image you requested. This graph shows changes in pH during 2008 for a location at the center of default geographic area. When you have finished saving the graph image, you may close that browser window.

15. Finally, change the date inputs to "January 1995" and "August 2010." Click the "Get Data" button. A new browser window will open that contains the pH time-series graph image you requested.

16. When you have finished saving the second graph image, you may close that browser window.

17. The last image to create is a time-series graph of sea-surface temperature (SST) for the year 2008. Select "Sea surface temperature" in the "Which parameter?" pulldown.

18. Change the date inputs to "January 2008" and "December 2008."

19. Leave the view set to "Time series graph."

20. Click the "Get Data" button. Save your new graph.

Materials

- **Computer or overhead projector**
- **Map and graph image(s) saved to your computer**
- **Copies of Student Master**

Procedure

Now that you have the images, you can either show them from your computer if it is connected to a projector, or make transparencies of the images for display using an overhead projector.

1. Show your students the map that displays monthly average pH for January 2008. Explain the key features of the map:
   - The map shows an area of the Caribbean Sea centered just northeast of Cuba and southeast of southern Florida.
   - X axis = longitude, degrees west of the Prime Meridian.
   - Y axis = latitude, degrees north of the Equator.
   - The map is a false-color map representing ocean surface water pH using colors. The key on the right correlates pH values to map colors. Have students look at the numbers at the top and bottom of the color key. These show the highest and lowest data points on the map. Therefore, while the color key goes up to pH 8.15, there are not data points above pH of 8.12. That is why there are no purple areas on the map. Similarly, while the color key goes down to a pH of 8.00, the lowest pH on the map is 8.06. That is why there are no orange or red areas on this map.
   - Map colors represent areas on the map with the same pH data readings. The light blue color on the map shows an area of ocean where the pH is 8.10. The blue-green color adjacent to the light blue area shows an area where the pH is 8.09.

2. The pH of ocean water is around 8.1. Students should know that, since pH 7 is considered neutral, a pH of 8.1 means that ocean water is slightly alkaline or basic. Discuss these questions: *Where on this map is the water more acidic? Where is the water more alkaline?* Students should know that lower pH values represent less alkaline conditions.

3. Now show students the pH data map for August 2008. Place the January 2008 and August 2008 pH maps side-by-side so that students can compare the two maps. Discuss these questions: *Is the water more basic or more acidic in August than in January? What evidence is there on the maps for this conclusion?* Students may give either colors or the data extremes at the top and bottom of the two map scales as evidence that the water in the study area was more acidic in August 2008 than it was in January 2008.

4. Next show students the time-series graph that displays pH change in the area over the entire year 2008. Explain the key features of the graph:
   - X axis = time, months of the year 2008.
   - Y axis = pH.
   - Students should notice that the graph contains only one data point per month which is plotted as occurring in the middle (15th day) of the month.

5. Students should also notice that the graph is for a single latitude/longitude location (top left above graph). This location is in the center of the geographic area specified when creating the false-color map.

6. Discuss the following questions: *Does the change in pH reflect what you observed on the two false-color maps for January and August 2008? In what months is the water the most basic (highest pH)? In what months is the water the most acidic (lowest pH)?* Students should suggest a seasonal explanation for the observed changes in pH.

7. Now show students the sea-surface temperature time-series graph for 2008. Place this graph side-by-side with the pH time-series graph for 2008 so that students can compare the two graphs. Discuss this question: *Does the temperature data support the idea that lower pH is linked to warmer surface water temperatures?* Students

should observe that the warmest water temperatures correlate to the lowest pH (most acidic water).

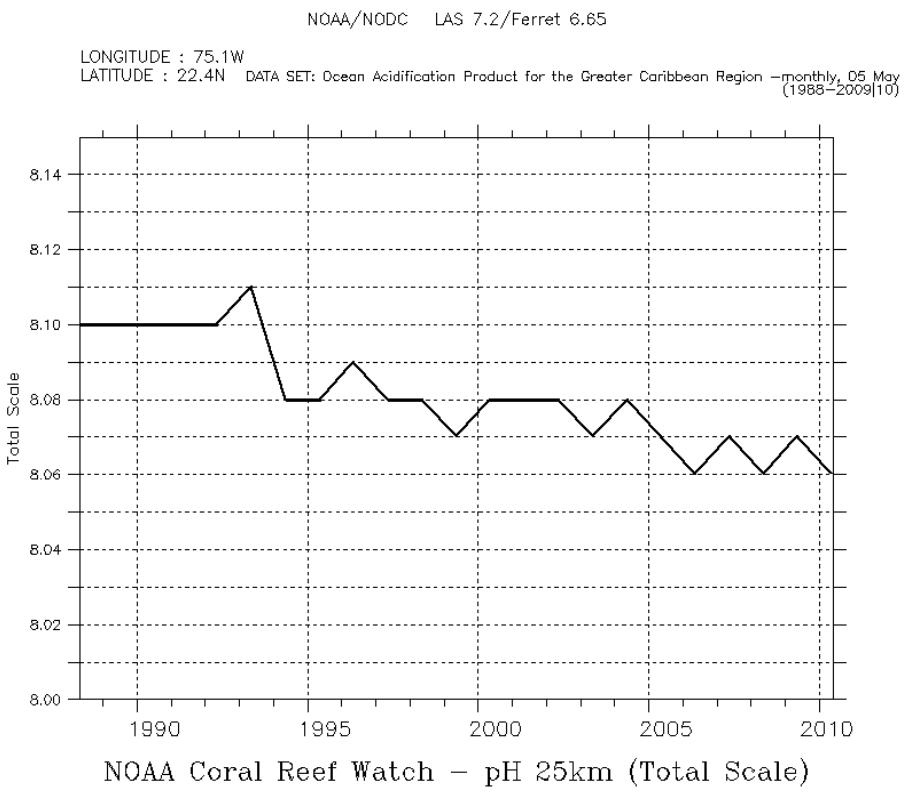
8. Review the importance of the log scale when measuring pH. Small changes in pH can represent larger and larger changes in H+ ion concentration [H+], which can cause decreased alkalinity in Earth's oceans. A decrease of only 0.1 is equivalent to about a 26% increase in [H+]. For high school students, this would be a good time to review how to calculate [H+] from pH values using the formula: - pH = log [H+]

9. Give each student a copy of the Student Master, pH Time-Series Graph, 1988 to 2010. Students should use the graph to answer the questions on the Master:

Answers:

1. pH 8.10
2. pH 8.07
3. The graph shows a gradual decrease in pH over time.
4. The pH decreased from 8.10 to 8.07 between 1989 and 2009. The water is still alkaline, but it has become less alkaline.
5. On a logarithmic scale, changes increase by greater and greater values. A pH 0.1 change represents greater and greater [H+] as you move down the pH scale.

pH Data



Questions

1. What was the average pH of water in the study area for the year 1989?

2. What was the average pH of water in the study area for the year 2009?

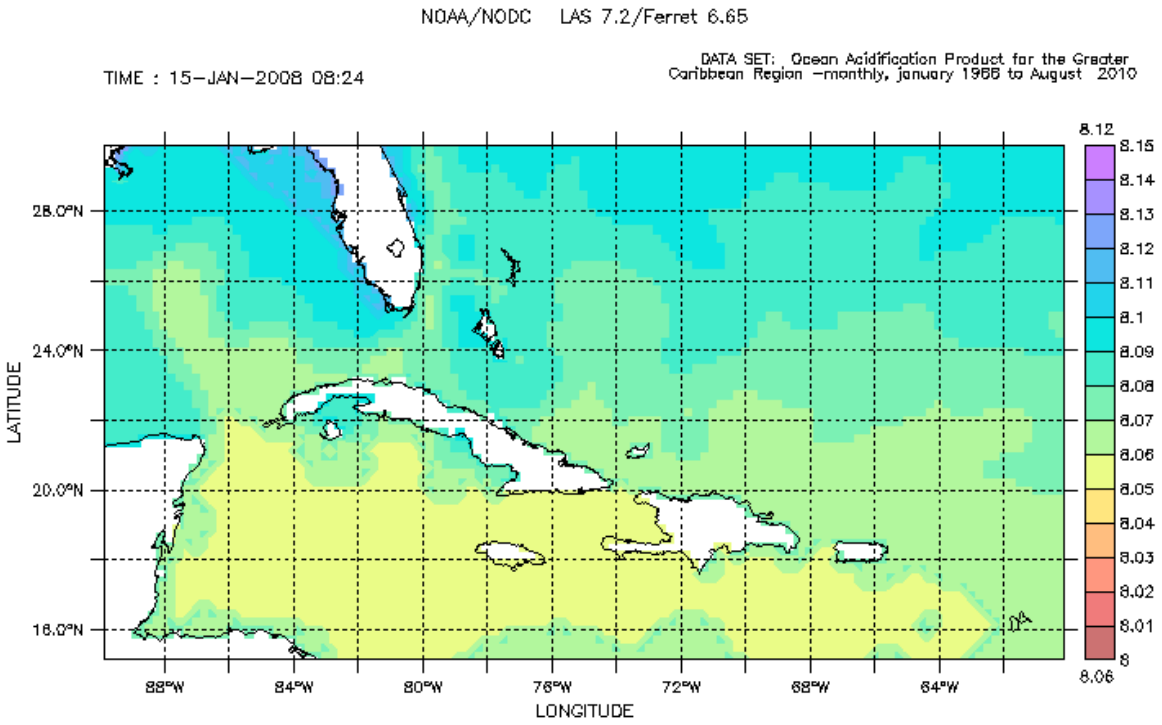
3. How would you describe the overall slope of the pH graph line?

4. For this time period, has the water become more acidic or more basic?

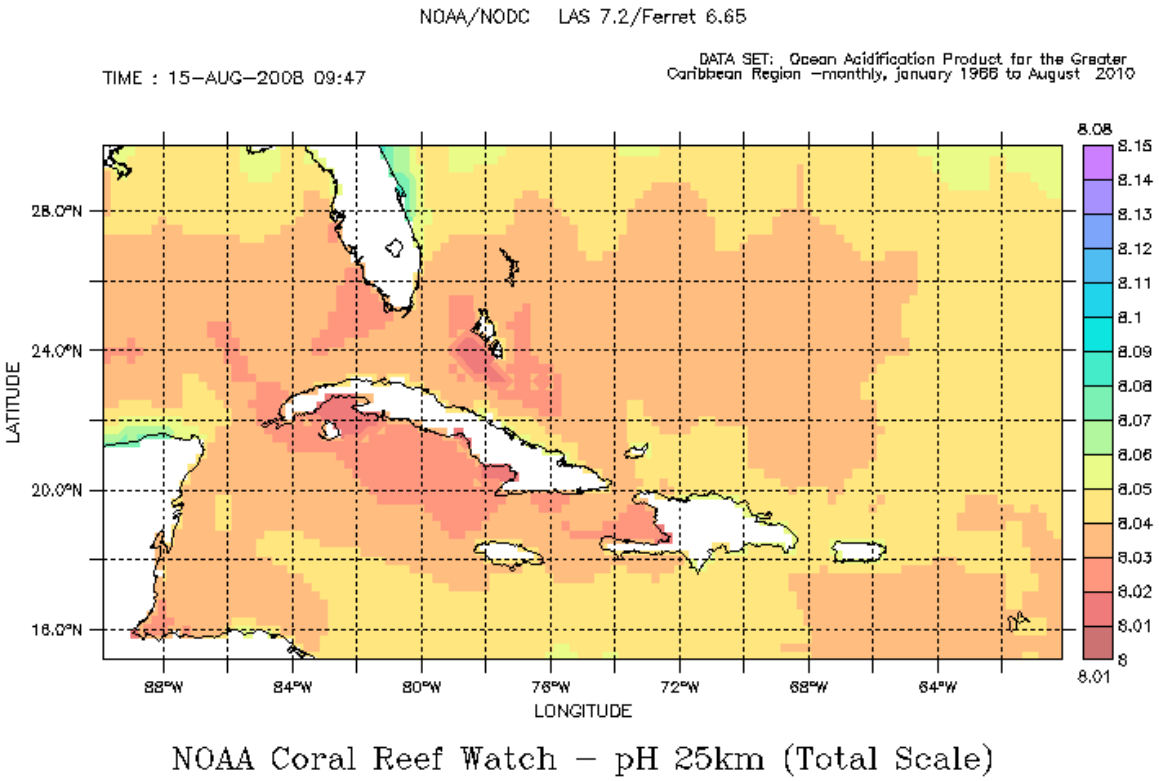
Look at the following table. pH is measure of the H+ concentration in a solution. The second column shows the amount of concentration of H+ ions for different pH values.

pH	[H+]	[H+](exp. as *y* x 10^{-9})	Change in [H+]
8.2	6.8 x 10^{-9} M	6.8 x 10^{-9} M	----------
8.1	7.9 x 10^{-9} M	7.9 x 10^{-9} M	1.6 x 10^{-9} M
8.0	1.0 x 10^{-8} M	10.0 x 10^{-9} M	2.1 x 10^{-9} M
7.9	1.3 x 10^{-8} M	13.0 x 10^{-9} M	3.0 x 10^{-9} M

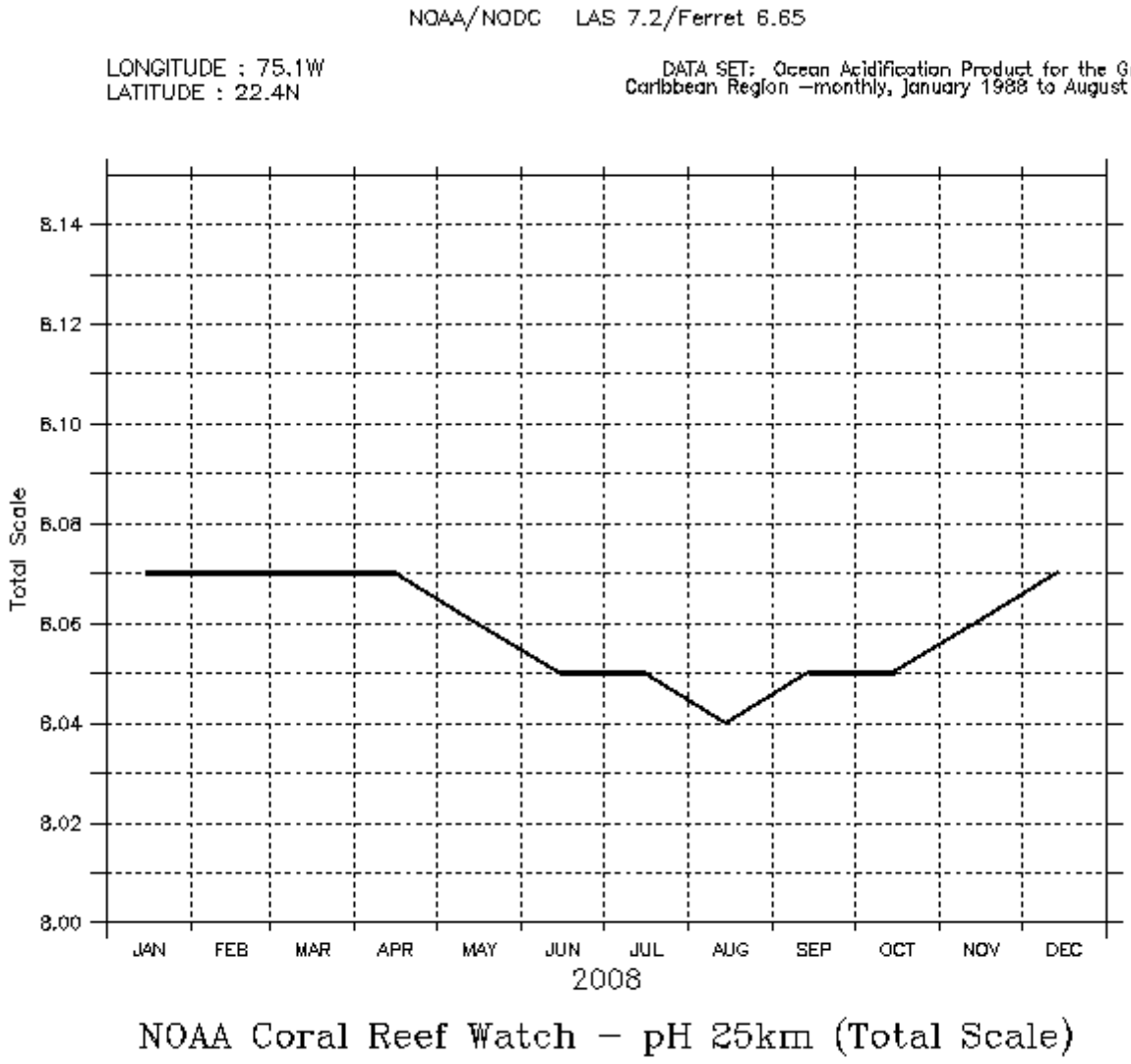
5. What evidence do you see in the table for pH being measured on a logarithmic scale?



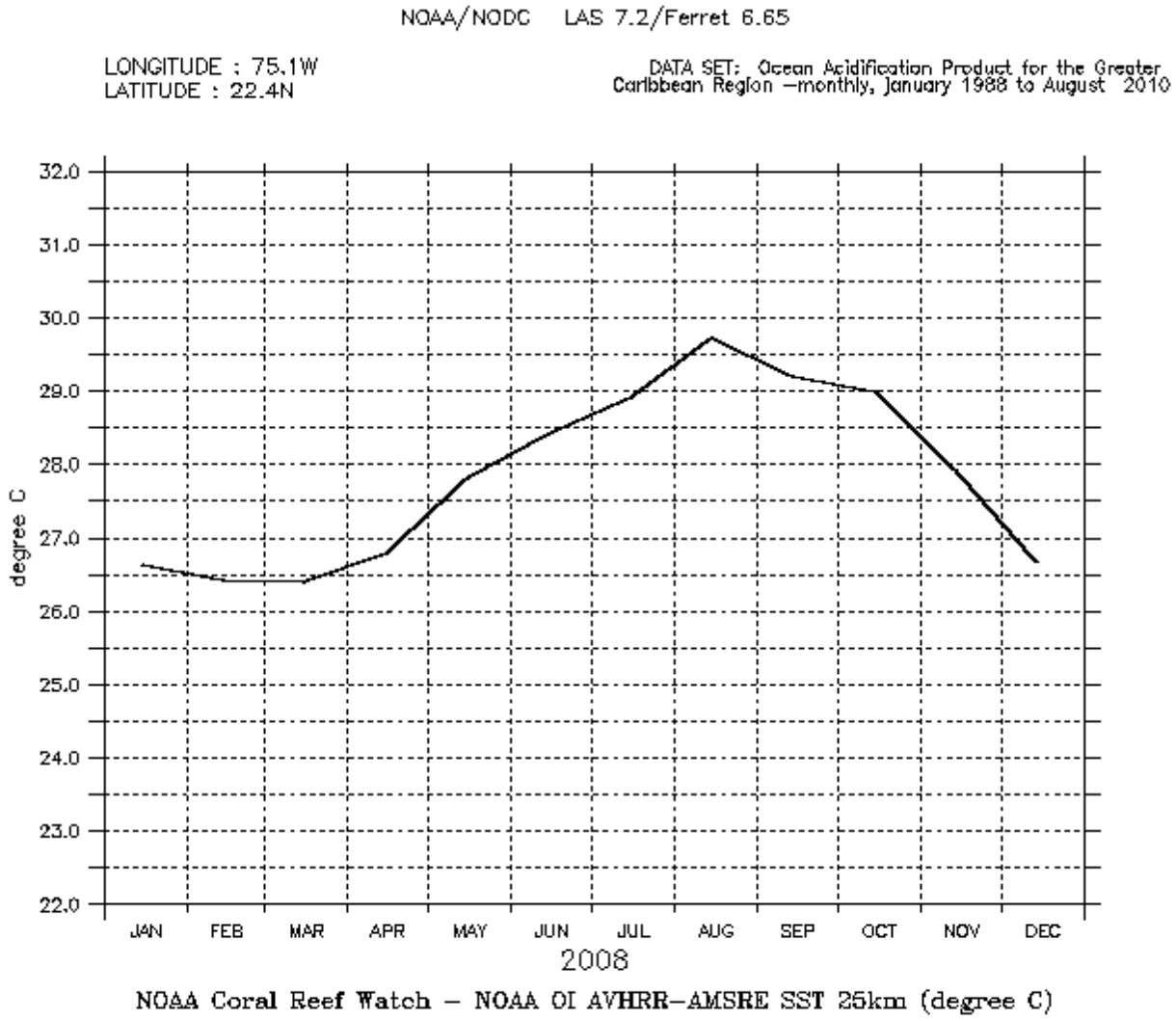
pH January 2008



pH August 2008


NOAA/NODC LAS 7.2/Ferret 6.65
LONGITUDE : 75.1W
LATITUDE : 22.4N
DATA SET: Ocean Acidification Product for the Greater Caribbean Region —monthly, January 1988 to August 2010
Total Scale
8.14
8.12
8.10
8.08
8.06
8.04
8.02
8.00
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2008
NOAA Coral Reef Watch – pH 25km (Total Scale)

pH 2008



Sea surface temperature 2008