# Lesson 11: GHOST TOWN Human Impacts on Coral Reef Health

#### **PURPOSE/QUESTION**

Students will analyze sea surface temperature to identify corals at risk of bleaching and other environmental degradation.

#### **GRADE LEVEL**

9-12

#### TIME TO COMPLETE

2-3 50 minute time periods

#### **STANDARDS**

See appendix below-page 9

#### **LEARNING OUTCOMES**

- Students will examine sea surface temperatures around the world.
- Students will consider impacts of sea surface temperature trends on coral reefs.
- Students will learn how ocean acidification and other environmental trends are affecting coral reefs.

#### STUDENT OBJECTIVES

- Access sea surface temperature data.
- Plot time series data and analyze trends for weekly sea surface temperatures around the world.
- Analyze the relationship between latitudinal locations and sea surface temperatures.
- Learn about other stresses on coral reefs.

#### **TEACHER BACKGROUND**

Climate change is among the greatest threats to coral reef ecosystems worldwide. As sea surface temperatures rise due to climate change, coral bleaching and disease events will occur more often and be more severe. At the same time, carbon emissions from fossil fuel burning are being absorbed by the oceans, causing the ocean waters to become more acidic. These global impacts on oceans are compounded by local environmental degradation from pollution, over use, over fishing, and other human activities.

Bleaching occurs when the colorful algae that corals need to survive become toxic and are expelled, turning the coral white. For milder bleaching events, the algae and coral can recover within a few weeks or months. But, severe bleaching events can kill the coral and have devastating impacts on the marine ecosystems it supports. Even a small increase in the sea surface temperature (0.5-1.5°C) over several weeks or a large temperature increase (3-4°C) over a few days can lead to bleaching. Solar irradiance (exposure to the sun's ultraviolet rays), pollution, reef exploitation, and ocean acidification can also lead to bleaching.

The oceans have absorbed about a quarter of the carbon emitted to the atmosphere by burning fossil fuels (half has remained in the atmosphere and the rest has gone into the terrestrial biosphere, mostly forests). The removal of some of the excess carbon from the atmosphere has slowed the pace of global warming. But adding carbon to the oceans is also causing them to become more acidic, which makes it difficult for corals and other marine life to form shells and exoskeletons. From the mid 1700s to the 1990s, the sea surface pH decreased from 8.25 to around 8.14. Ocean pH levels is expected to drop even further by 2100 as carbon dioxide emissions continue.

#### **PREREQUISITES**

- Equator
- Tropics
- pH Scale

#### **MATERIALS & TOOLS**

- Computer with Internet
- Microsoft Excel
- Color printer (optional)
- Calculator

#### **VOCABULARY**

- Coral Reef
- Coral Bleaching
- Sea Surface Temperature
- Ocean Acidification

#### **LESSON LINKS**

- Live Access Server
- Opening MY NASA Data microsets in <u>Microsoft Excel</u>
- NOAA's Science on a Sphere: Human Impacts on Marine Ecosystems
- Science on a Sphere: Reefs at Risk





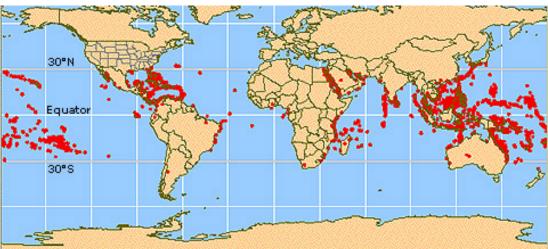








### PART 1: Sea surface temperature map



Locations of major stony coral reefs around the world.

Source: National Oceanic and Atmospheric Administration (NOAA) Ocean Service Education.

#### **ESSENTIAL QUESTIONS**

- 1. Compare your map of sea surface temperatures to the map of locations of coral reefs above. What would you estimate is the lowest temperature that corals can tolerate?
- 2. Corals are susceptible to bleaching if temperatures exceed 30°C. What areas might be at risk of coral bleaching events on this particular week?

#### **PROCEDURE**

- 1. Examine a map of weekly sea surface temperature for August 23, 2010.
  - a. In Live Access Server (Advanced Edition), click the *Choose Dataset* button. Then choose, *Oceans* > Weekly Sea Surface Temperatures (NAVOCEANO). A map will automatically appear.
  - b. Change the contour fill levels so that it is more apparent which places have especially high sea surface temperatures. Click **Set plot options**. In the box for "Color fill levels", enter: (-inf)(5,30,1)(inf)
  - c. Set the date to August 23, 2010. Then click Update Plot.
  - d. Print or save the map that you created.



Healthy coral reef near St. Croix, U.S. Virgin Islands. Source: NOAA



Coral reef near Guam after a bleaching event.

Source: NOAA













#### PART 2: Temperature trends for coral reefs around the world

#### **ESSENTIAL QUESTIONS PART 2**

- 1. Examine the two charts created in the Excel spreadsheet for the corals near the Philippines. What years were these corals at greatest risk of experiencing bleaching? What, if any, trend over time has there been for temperature exceeding 30°C at the Philippines location?
- 2. How many weeks on average are the coral reefs in each location exposed to sea surface temperatures exceeding 30°C each year?
- 3. What do you notice about the latitudes where the reefs exposed to high temperatures are located?
- 4. Which, if any, reefs are experiencing a trend over time in the number of weeks they are exposed to waters exceeding the temperature threshold? What do you think might be the cause of the trend?

#### **PROCEDURE**

- 1. Start by examining weekly sea surface temperature time series data for the coral reefs off the coast of Philippines (latitude = 11.0°N, longitude = 127.0°E).
  - a. Under "LINE PLOTS", select: Time Series
  - b. Enter the latitude and longitude for the Philippines location into the appropriate boxes just below the small grey map on the left of the screen.
  - c. Set the time settings in Date Range to be January 6, 1997 and December 31, 2010.
  - d. Click *Update Plot* and a time series plot will appear.
  - e. We want to access the data used to create this plot, so that we can do our own calculations. Click the **Show Values** button and then click **OK** to accept the defaults. The data will appear in the second window.
  - f. Follow the instructions in the Eco-Schools CCC Tech Tips Sheet to import the data into the Microsoft Excel worksheet for this lesson. Put the raw data in the tab titled "Philippines\_Weekly RAW". Then copy the temperatures into the Excel sheet "Philippines\_Weekly" under the column titled "Weekly Sea Surface Temperatures (°F) (\*Unfiltered)".
  - g. The number of weeks with temperature exceeding 30°C and two charts will automatically be created.
  - h. Answer Essential Question 1 above.
- Divide into small groups. Each group will retrieve time-series data for a different coral reef around the world, so that we can compare what has been observed for the Philippines' corals with other corals.
  - Use the table of coral reefs and their latitude and longitude coordinates to assign a different coral to each group.
  - Each group should follow the directions from Step 1 above, but using the latitude and longitude coordinates for their new coral reef.
- 3. Class discussion about the findings from each small group, using Essential Questions 2-4 above.

| Coral Reef<br>Location         | Latitude | Longitude |
|--------------------------------|----------|-----------|
| Philippines                    | 11.0°N   | 127.0°E   |
| Great Barrier Reef             | 18.3°S   | 148.3°E   |
| Hawaii - Kāne'ohe<br>Bay, Oahu | 22.0°N   | 157.0°W   |
| Sunda Islands                  | 10.0°S   | 110.0°E   |
| Northern Indian<br>Ocean       | 18.0°N   | 90.0°E    |
| Western Australia              | 22.3°S   | 111.5°E   |
| Tuvalu                         | 7.35°S   | 178.4°E   |



#### **PART 3: Other stresses on corals**

#### **ESSENTIAL QUESTIONS PART 3**

- 1. Why is the ocean becoming more acidic?
- 2. Pick a location from the chart above. Based on the aragonite data for 1770 and 2010, has there been a decline in pH for this location? This is a visual observation. Be sure to use the color key below to determine your response.
- 3. Is the coral in this location also affected by increasing sea surface temperature, based on your analysis in Parts 1 and 2?
- 4. Now look at the aragonite data for 2100. Will the coral reef at your location be threatened by ocean acidification if this model projection is correct?
- 5. What are some ways that humans have had a harmful influence on the world's marine ecosystems?
- 6. Based on the animation of *Harmful Human Influences*, what are some locations that have been highly affected? Which of these locations correspond with locations of coral reefs?
- 7. Are any coral reefs affected by the triple threat; increasing sea surface temperatures, ocean acidification, and other human influences? What steps might we take to protect these corals?

#### **PROCEDURE**

Many other changes are affecting our oceans in addition to increases in the temperature. Here we examine how changes in ocean pH and human influences on the ocean might be affecting corals.

- 1. Look at ocean acidification from Science on a Sphere using Google Earth.
  - a. Go to: <a href="http://sos.noaa.gov/datasets/Ocean/ocean">http://sos.noaa.gov/datasets/Ocean/ocean</a> acid.html and read about how corals are affected by ocean acidification and the ocean acidity data set.
  - b. Go to: <a href="http://www.pmel.noaa.gov/co2/dg/Aragonite/aragonite4.kml">http://www.pmel.noaa.gov/co2/dg/Aragonite/aragonite4.kml</a> to download the ocean acidification data into Google Earth.
  - c. Explore the data set by rotating the earth and moving it through time. Note that the colors are proportional to the amount of aragonite present in the ocean. Aragonite is a form of calcium carbonate that corals and pteropods use to make their external skeletons or shells. If aragonite is low, then these organisms cannot make shells and will die. The color bar is located here →
- 2. Look at the Extent of Harmful Human Influences on Global Marine Ecosystems.
  - a. Go to: <a href="http://sos.noaa.gov/datasets/Ocean/marine\_impacts.html">http://sos.noaa.gov/datasets/Ocean/marine\_impacts.html</a> and read about how humans are impacting the oceans.
  - b. Go to: <a href="ftp://public.sos.noaa.gov/oceans/marine\_impacts/media/">ftp://public.sos.noaa.gov/oceans/marine\_impacts/media/</a> to download a movie of this data set (.mov runs in QuickTime, .mpg runs in RealTime).
  - c. Explore the data set by running the animation multiple times and stopping it to look at specific locations. For this movie note that orange denotes harmful human impacts bluish color denotes less harmful human impacts.

| 4.78  | Less Co <sub>2</sub> , |
|-------|------------------------|
| 4.6   | More                   |
| 4.43  | Aragonite,             |
| 4.25  | Healthy Corals         |
| 4.07  |                        |
| 3.9   |                        |
| 3.73  |                        |
| 3,55  |                        |
| 3.38  |                        |
| 3,2   |                        |
| 3.03  |                        |
| 2,65  |                        |
| 2.68  |                        |
| 2,5   |                        |
| 2.33  |                        |
| 2,15  |                        |
| 1.97  |                        |
| 1.8   |                        |
| 1.62  |                        |
| 1,45  |                        |
| 1.27  | More Co <sub>2</sub> , |
| 1,1   |                        |
| 0.925 | Less<br>Aragonite,     |
| 0.75  | Unhealthy              |
|       | Unnealthy              |













#### **TOOLS FOR ASSESSMENT**

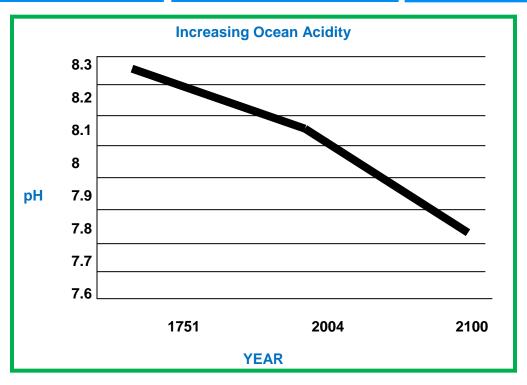
- Concept Quiz found on pg.
   16
- Essay found on pg. 19
- Foldables®
- Student Reading and Science Notebook Assessment Tool – found in the folder for this lesson

### WEBSITES FOR FURTHER LEARNING

- Coral Bleaching
- State of our Oceans
- Ocean Acidification Database
- Recent Ocean Acidification

### STUDENT READING RESOURCES

- <u>Great Barrier Reef A Fragile</u> <u>Empire</u>
- Climate Change Seeps Into the Sea
- The Ability of Coral Reefs to Regenerate after Catastrophic Events
- From sea to carbon cesspool:
   Preventing the world's marine ecosystems from falling victim to ocean acidification



Mongabay



















#### **LESSON 11-APPENDIX**

#### Tech Tips for Eco-Schools USA Climate Change Connections Curriculum

#### How do I import data into an Excel spreadsheet?

- 1. Access data from My NASA Data:
  - a. Once you have all the parameters set for your desired data set (and have clicked "Update Plot" to have your preferences processed), click the "Show Values" button. A new window will pop up with a Table of Values.
  - b. The first several lines of the Table will provide information that describes the data set, often called "metadata", such as the name of the variable, what subset of the data is included in the file, and what time range. Make sure to keep this metadata with the rest of the data when you copy it into Excel. This way you'll be able to easily keep track of which data you have!
- 2. Copy the data from the browser (note that these instructions are for Internet Explorer running on a PC, and may need to be modified for other platforms):
  - a. In this new window, select all. You can do this by clicking anywhere in the window and then typing "Ctrl-A". Or you can right-click in the window, which will pop up a menu, and then choosing "Select All" from the options.
  - b. Next, copy this data. Again there are two options. You can use the keyboard shortcuts, and type "Ctrl-C". Or you can right-click and choose "Copy" from the pop-up menu.
- 3. Paste the data into Excel:
  - a. Now open your Excel worksheet and go to the tab where you want to put the raw data. Click in the A1 cell.
  - b. Paste the data, either by typing "Ctrl-V", by clicking "Paste" (located at the left under the "Home" tab), or by right-clicking in the A1 cell and choosing "Paste".
- 4. Convert the data from text to columns:
  - a. Now, we have the data in Excel, but we can't manipulate it very well because all the data for each row is lumped into one cell. We want to split out each data value into its own cell.
  - b. Starting at the row where the column headers are located (probably around row 7), highlight the A column down to the end of the data.
  - c. Click on the Data tab at the top of the window, and then choose the "Text to Columns" wizard (located a little to the right of center).
  - d. A dialogue box will pop up to help you through the process.
  - e. The first page of the wizard asks you to identify whether the data is "Delimited" or "Fixed width". In most cases, the My NASA Data data will be "Fixed Width", so select that option and click "Next".
  - f. The next page of the wizard gives you a chance to check whether the column breaks make sense and to adjust them as necessary. Make any changes that are needed. Or, go back and switch to "Delimited" on page 1 if you notice that the columns are not lining up as you expected. Once you are satisfied with the columns, click "Next".
  - g. The final page of the wizard allows you to designate what kind of data values are in each column and a destination for the data. For the purposes of the CCC curriculum, we'll just accept the defaults and click "Finish".
  - h. Now your data should be in beautiful columns and the values should make sense. It's always a good idea to double check that nothing crazy happened!



#### My NASA Data isn't working! What should I do?

- Double check that you entered everything correctly. Especially check that you have the right data set and that you have entered dates and latitude/longitude values within the range of available data. Usually the user interface will prevent you from entering invalid data ranges, but sometimes there are glitches.
- 2. Refresh the browser and/or restart the browser. Occasionally, a fresh start is the easiest way to clear out any mistakes or glitches.
- 3. Update your browser and/or JAVA. If you have older versions of the software, then you might find that some functionality is lost.
- 4. If you're still struggling, consider whether problem might be at the My NASA Data website. It might be a temporary problem, in which case taking a break and returning to the site at a later time could be a good choice. Or it could be a more significant problem, in which case you'll want to explore the "help" resources provided by My NASA Data (link in upper right hand corner of page).
- 5. Ask your Eco-Schools contact for help or email <a href="mailto:eco-schoolsusa@nwf.org">eco-schoolsusa@nwf.org</a>!

#### How do I print or save a map or graph?

- 1. Use the "Print" button to generate a version of your map or graph that is suitable for saving or printing. Once you click on the "Print" button, a new window will pop up with your map or graph.
- 2. Print a map or graph by using the print option on your browser.
- 3. Save a map or graph in one of two ways:
  - a. By choosing "Save as" in the browser. Use the defaults to save as a "Web Archive, single file (\*.mht)".
  - b. By right clicking and choosing "Save picture as..." Use the defaults to save as a \*.png file
- 4. When saving, make sure to give your new file a descriptive name and put it somewhere that you'll remember!

#### How do I find my latitude and longitude?

A number of sites help you find your latitude and longitude. For example:

- 1. http://itouchmap.com/latlong.html
- 2. <a href="http://www.findlatitudeandlongitude.com/">http://www.findlatitudeandlongitude.com/</a>



### HYPER LINKS WEB ADDRESSES PREREQUISTIE KNOWLEDGE AND SKILLS

Equator

http://en.wikipedia.org/wiki/Equator

• Tropics

http://mynasadata.larc.nasa.gov/science-glossary/?page\_id=672?&letter=T

pH scale

http://www.gcsescience.com/aa24.htm

#### **VOCABULARY**

Coral reef

http://coris.noaa.gov/about/what are/

Coral bleaching

http://www.com.univ-mrs.fr/IRD/atollpol/ecorecat/ukblanch.htm

Sea surface temperature

http://mynasadata\_larc.nasa.gov/science-glossary/?page\_id=672?&letter=S

Ocean acidification

http://www.sos.noaa.gov/Datasets/dataset.php?id=174

#### **LESSON LINKS**

Live Access Server, LAS

http://mynasadata.larc.nasa.gov/live-access-server/

Opening My NASA Data in Excel

http://mynasadata.larc.nasa.gov/opening-my-nasa-data-microsets-in-excel/

- NOAA's Science on a Sphere: Human Impacts on Marine Eco-Systems http://www.sos.noaa.gov/Datasets/dataset.php?id=143
- NOAA's Science on a Sphere: Reefs at Risk

http://www.sos.noaa.gov/Datasets/dataset.php?id=148

#### WEBSITES FOR FURTHER LEARNING

- Coral Bleaching This is a page from Microdocs: short attention span science videos, does a great
  job of quickly helping students understand the issues related to reef health through text and video.
  http://www.stanford.edu/group/microdocs/coralbleaching.html
- State of our Oceans This site displays graphics and text related to coral health and the impending negative effects to be expected in the future.

http://www.australiangeographic.com.au/journal/state-of-our-oceans.htm

• Ocean Acidification Database – The database consists of an ever-expanding archive on the response of marine organisms to ocean acidification.

http://www.co2science.org/data/acidification/acidification.php

• Recent Ocean Acidification – A page of the EPA and housed under Climate Change Indicators in the United States, this page shows acidity levels in the ocean, which are strongly affected by the amount of carbon dioxide dissolved in the water.

http://www.epa.gov/climatechange/science/indicators/oceans/acidity.html



#### STUDENT READING RESOURCES

- Great Barrier Reef A Fragile Empire
  <a href="http://ngm.nationalgeographic.com/2011/05/great-barrier-reef/holland-text">http://ngm.nationalgeographic.com/2011/05/great-barrier-reef/holland-text</a>
- Climate Change Seeps into the Sea http://www.nasa.gov/topics/earth/features/climate\_acidocean.html
- The Ability of Coral Reefs to Regenerate after Catastrophic Events http://www.co2science.org/articles/V14/N18/C1.php
- From Sea to Carbon Cesspool: Preventing the World's Marine Ecosystem from Falling Victim to Ocean Acidification

http://oceanacidification.wordpress.com/?s=from+sea+to+carbon+cesspool

#### **LESSON 11-STANDARDS**

#### **National Science Education Standards**

#### **Unifying Concepts and Processes**

- Systems, Order, and Organization
- Evidence, Models, and Explanations
- Change, Constancy, and Measurement
- Equilibrium

#### Standard A - Science as Inquiry

- Abilities necessary to do scientific inquiry
- · Understanding about scientific inquiry

#### Standard B - Physical Science

Interactions of energy and matter

#### Standard C - Life Science

- Interdependence of Organisms
- Matter, energy, and organization in living systems

#### Standard D - Earth and Space Science

- Energy in the earth system
- Geochemical cycles

#### Standard E - Science and Technology

Understandings about science and technology

#### Standard F – Science in Personal and Social Perspectives

- Environmental quality
- Natural and human and induced hazards
- Science and technology in local, national, and global challenges



#### **National Education Technology Standards**

#### **Standard 1: Creativity and Innovation**

- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

#### Standard 3: Research and Information Fluency

- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
- Process data and report results

#### Standard 4: Critical Thinking, Problem Solving, and Decision Making

• Collect and analyze data to identify solutions and/or make informed decisions.

#### Standard 5: Digital Citizenship

• Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

#### **Standard 6: Technology Operations and Concepts**

- Understand and use technology concepts
- Select and use applications effectively and productively
- Troubleshoot systems and applications
- Transfer current knowledge to learning of new technologies

## National Council of Teachers of Mathematics – Math Standards and Expectations Algebra

- Understand patterns, relations, and functions
- Use mathematical models to represent and understand quantitative relationships
- Analyze change in various contexts

#### Measurement

Understand measurable attributes

#### **Data Analysis and Probability**

Develop and evaluate inferences and predictions that are based on data

#### **Process**

- Connections
  - Recognize and apply mathematics in contexts outside of mathematics
- Representation
  - Use representations to model and interpret physical, social, and mathematical phenomena



#### **Climate Literacy Principles**

- Principle 1: The sun is the primary source of energy for earth's climate system.
- **Principle 2:** Climate is regulated by complex interactions among components of the Earth system.
- Principle 3: Life on Earth depends on, is shaped by, and affects climate.
- Principle 4: Climate varies over space and time through both natural and man-made processes.
- **Principle 5:** Our understanding of the climate system is improved through observations, theoretical studies, and modeling
- Principle 6: Human activities are impacting the climate system.
- Principle 7: Climate change will have consequences for the earth system and human lives.

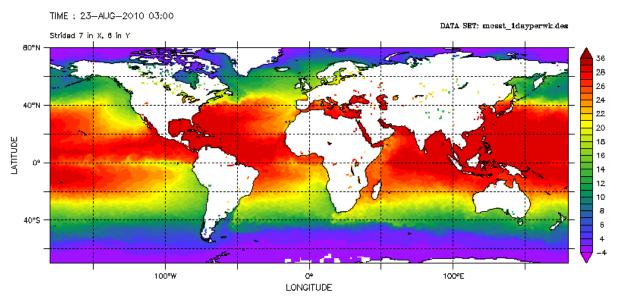
#### **Energy Literacy Principles**

- **Principle 1:** Energy is a measurable quantity that follows physical laws.
- **Principle 2:** Physical Earth processes are the result of energy flow through the earth system.
- Principle 3: Biological Earth processes depend on energy flow through the earth system.
- Principle 7: The energy choices made by individuals and societies affect quality of life.

#### **LESSON 11-ESSENTIAL QUESTIONS ANSWER KEY**

1. Compare your map of sea surface temperatures to the map of locations of coral reefs above. What would you estimate is the lowest temperature that corals can tolerate?

LAS 7.+/Ferret 6.1 NOAA/PMEL



Weekly Sea Surface Temperature (MCSST) (degC)

[Most coral reefs in the map are located between latitudes 30° North and 30° South. According to the map for the week of August 23, 2010, sea surface temperatures in this equatorial region typically are above about 24°C. So, we can infer that most corals prefer temperatures above about 24°C.]

2. Corals are susceptible to bleaching if temperatures exceed 30°C. What areas might be at risk of coral bleaching events on this particular week?

[The darkest red areas are at risk of coral bleaching, including:

- a) The western tropical Pacific Ocean
- b) The northern Indian Ocean
- c) Mid-Atlantic and the Caribbean 1

#### **ESSENTIAL QUESTIONS PART 2**

1. Examine the two charts created in the Excel spreadsheet for the corals near the Philippines. What years were these corals at greatest risk of experiencing bleaching? What, if any, trend over time has there been for temperature exceeding 30°C at the Philippines location?

[The sea surface temperature near the Philippines was greater than 30°C every year from 1997 to 2010 except in 2000. The years that this location was at greatest risk for bleaching are 2010 (18 weeks with temperatures greater than 30°C), 2007 (13 weeks), 1998 (10 weeks), 2009 (8 weeks), and 2002 (7 weeks). There does appear to be an increasing temperature trend for this location.]



2. How many weeks on average are the coral reefs in each location exposed to sea surface temperatures exceeding 30°C each year?

| Coral Reef Location            | Latitude | Longitude | Average # of Weeks<br>with Temp > 30°C<br>each year |
|--------------------------------|----------|-----------|---|
| Coral Reel Location            | Latitude | Longitude | 5.0   |
| Philippines                    | 11.0 N   | 127.0 E   | 5.8   |
| Great Barrier Reef             | 18.3 S   | 148.3 E   | 0.6   |
| Hawaii - Kāne'ohe Bay,<br>Oahu | 22.0N    | 157.0 W   | 0   |
| Sunda Islands                  | 10.0 S   | 110.0 E   | 1.4   |
| Northern Indian Ocean          | 18.0 N   | 90.0 E    | 2.9   |
| Western Australia              | 22.3 S   | 111.5 E   | 0   |
| Tuvalu                         | 7.35 S   | 178.4 E   | 7.9   |

- 3. What do you notice about the latitudes where the reefs exposed to high temperatures are located? [The coral reefs that were exposed to sea surface temperatures exceeding 30°C are located between about 20°N and 20°S. Locations furthest away from the equator such as Hawaii (22.0°N) and Western Australia (22.3°S) had no weekly average sea surface temperatures exceeding 30°C.]
- 4. Which, if any, reefs are experiencing a trend over time in the number of weeks they are exposed to waters exceeding the temperature threshold? What do you think might be the cause of the trend? [Four locations appear to have an increasing trend: Sunda Islands, Northern Indian Ocean, Philippines, and Tuvalu. Global warming is likely responsible for the increasing temperature.]













#### **ESSENTIAL QUESTIONS PART 3**

- Why is the ocean becoming more acidic?
   [The ocean is becoming more acidic (decreasing in pH) due to the ongoing uptake of man-made carbon dioxide from the atmosphere.]
- 2. Pick a location from the chart above. Based on the aragonite data for 1770 and 2010, has there been a decline in pH for this location? This is a visual observation. Be sure to use the color key below to determine your response.

| Coral Reef Location            | Approx.<br>aragonite value<br>in 1770 | Approx. aragonite value in 2010 | Approx. aragonite value in 2100 |
|--------------------------------|---------------------------------------|---------------------------------|---------------------------------|
| Philippines                    | 3.75 - 4.25                           | 3.0 - 3.25                      | 2.0 - 2.5                       |
| Great Barrier Reef             | 3.5 - 4.5                             | 2.5 - 3.0                       | 1.5 – 2.0                       |
| Hawaii - Kāne'ohe Bay,<br>Oahu | 3.75 – 4.5                            | 3.0 – 3.5                       | 2.0 – 2.5                       |
| Sunda Islands                  | 3.75 – 4.25                           | 2.75 – 3.25                     | 2.0 – 2.5                       |
| Northern Indian Ocean          | 3.5 - 4.25                            | 3.0 - 3.5                       | 2.0 – 2.75                      |
| Western Australia              | 3.75-4.25                             | 2.75-3.25                       | 2.0-2.5                         |
| Tuvalu                         | 4.0-4.75                              | 3.25-3.75                       | 2.25-2.75                       |

- 3. Is the coral in this location also affected by increasing sea surface temperature, based on your analysis in Parts 1 and 2?
  [Four locations appear to have an increasing temperature trend: Sunda Islands, Northern Indian Ocean, Philippines, and Tuvalu.]
- 4. Now look at the aragonite data for 2100. Will the coral reef at your location be threatened by ocean acidification if this model projection is correct?

  [See table from response to Question 2. All locations show increasingly acidic conditions.]
- 5. What are some ways that humans have had a harmful influence on the world's marine ecosystems? [The world's marine ecosystems have been harmed by overfishing, pollution, over-exploitation by tourists, etc.]



6. Based on the animation of *Harmful Human Influences*, what are some locations that have been highly affected? Which of these locations correspond with locations of coral reefs?

[Areas in red indicate where the most harmful human influences have occurred while blue indicates the least amount of human impact. Areas that have had been the most affected by harmful human influences include off to the Caribbean Sea, Atlantic coast of the US, North Sea, South and East China Seas, Mediterranean Sea, western Pacific Ocean, Red Sea, Persian Gulf, and Bering Sea.

Coral reef locations that have been highly affected by Harmful Human Influence include Philippines, Hawaii, Sunda Islands, Northern Indian Ocean, and Tuvalu.

| Coral Reef Location         | Harmful Human Influences |  |
|-----------------------------|--------------------------|--|
| Philippines                 | Moderately High/Medium   |  |
| Great Barrier Reef          | Medium/Low               |  |
| Hawaii - Kāne'ohe Bay, Oahu | Moderately High          |  |
| Sunda Islands               | Very High/High           |  |
| Northern Indian Ocean       | Moderately High/Medium   |  |
| Western Australia           | Medium/Low               |  |
| Tuvalu                      | Moderately High/Medium   |  |

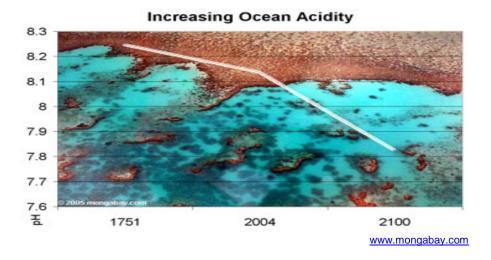
7. Are any coral reefs affected by *the triple threat*: increasing sea surface temperatures, ocean acidification, and other human influences? What steps might we take to protect these corals? Philippines, Sunda Islands, Northern Indian Ocean, and Tuvalu are exposed to all three threats. Steps that can help to protect these corals include: decreasing air and water pollution, decreasing overfishing, and curbing man-made global warming. ]



Name: \_\_\_\_\_\_Date: \_\_\_\_\_

Science Concept Quiz Lesson 11: Ghost Town

The Relationship between Sea Surface Temperature and Coral Reef Health



Using the map above answer the following question. Is this map accurate? How can ocean acidity be increasing over time if the line is going down?

- A. When looking at a pH scale the lower the number, below 7, the more acidic the liquid.
- B. The graph does not show the pH scale correctly; the higher the pH, above 7 the more acidic the liquid.
- c. Coral reefs thrive in a pH of 7 or greater, because the water's pH is acidic, therefore the line should be flipped starting around 7.8 for year 1751.
- D. When looking at a pH scale the lower the number, below 7, the more basic the liquid.

\_\_\_\_\_ points out of 20

I. Answer

A. B. C. D. E.

points out of 15

- II. What is the main concept behind the question?
- 1. Drawing Conclusions
- 2. Finding the Manipulating Variable
- 3. Understanding the pH scale
- 4. Ocean Ecosystems













\_\_\_\_ points out of 25

III. Provide the reasoning for choosing your answer in part II.

\_\_\_\_points out of 40

IV. Why are the other responses in part I not the best answer choice?

1.

2.

3.

4.

Use the rest of this page if more room is needed to fully communicate your thoughts.















#### **TEACHER ANSWER KEY**

- 1. A
- 2. 3
- 3. Answers will vary To answer the question correctly you have to know the pH scale and what the numbers represent. The pH scale goes from 0-14 with 0 being the most acidic and 14 being the most basic.
- 4. Answers will vary -
  - A) Correct Answer
  - B) The graph is correct in showing ocean acidity over time. pH does not become more acidic as the number rises above 7 it becomes more basic.
  - C) Again the graph is correct; the line should not be flipped. Coral reefs do not thrive in acidic conditions which are considered to be below 7 on the pH scale.
  - D) On a pH scale the lower the number below 7 the more acidic the liquid.



Student Name Teacher/Class Date

## Lesson 11: Ghost Town The Relationship between Sea Surface Temperature and Coral Reef Health

Why are coral reefs an important part of ocean ecosystems? Explain your reasoning. What other variables are impacting coral reef health and what suggestions do you have to mitigate the problem?

#### What Is the Expectation?

Use knowledge gained from this lesson along with student readings to support your position

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage













