

CORAL REEF LESSON PLAN

Focus: Management of coral reefs

Grade Level: 9-12

Connections to the Curriculum: Earth Science, Geography, Biology, Life Science

Connections to the National Science Education Standards:

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Content Standard C: Life Science

- Interdependence of organisms
- Matter, energy, and organization in living systems.
- Behavior of organisms

Content Standard D: Earth and Space Science

- Energy in the earth system
- Geochemical cycles

Content Standard E: Science and Technology

- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

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

Connections to the National Geography Standards:

Standard 4: "The physical and Human characteristics of places"

Standard 14: "How human actions modify the physical environment"

Overview:

Coral reefs are some of the most productive and important ecosystems on earth, and they are vanishing at an alarming rate. Students will learn what coral reefs are and about the different types of reefs, the ecology surrounding these biological playgrounds, and the human impact on them. Additionally, this lesson will provide an opportunity for students to debate whether human contact should be impeded around coral reefs, a constructive approach for defending controversial environmental issues.

Focus Questions

What are coral reefs and where might you find them? Are there different types of coral reefs and different types of coral?

Why are coral reefs important, and what can be done to protect them from major threats?

Learning Objectives:

Students will

- understand what coral reefs are, where they are located, and how humans impact their future.
- gather the knowledge to critically reason and debate issues about coral reef issues.
- be able to identify and explain five ways that coral reefs benefit human beings.
- be able to identify and explain three major threats to coral reefs.
- be able to describe major components of the Coral Reef Early Warning System.
- be able to identify and discuss actions that can be undertaken to reduce or eliminate threats to coral reefs.
- Be able to obtain and analyze several types of oceanographic data from remote-sensing satellites.

Materials

- Computers with internet access
- Copies of “Coral Reef Subject Review”
- Imax film “Blue Planet”
- Copies of “Satellite Imagery Worksheet”

Teaching Time

Two or three 45-minute class periods

Number of Students

Thirty

Key Vocabulary Word List

coral	zooplankton	habitats
symbionts	algae	calcium carbonate
zooxanthellae	photosynthesis	biodiversity

Extensions

Students or student groups can prepare a report on a specific aspect of coral biology, ecology, or management. Some possible topics include:

- coral diseases
- natural and anthropogenic hazards
- oil spills on coral reefs
- coral reef restoration
- species diversity on coral reefs
- benthic habitats associated with coral reefs

- relationships between coral reefs and seagrass or mangrove ecosystems

See Roadmap to Resources: Corals

(http://www.nos.noaa.gov/education/corals/supp_coral_roadmap.html) for links to information on relevant topics.

Development:

Give students a brief overview of coral reefs by explaining that they are composed of small invertebrates, called coral polyps that live in colonies. Coral reefs are one of the most biologically productive ecosystems on Earth. Most people have seen images of brightly colored fishes and other reef-dwelling organisms, yet many do not understand why these systems are personally important. Programs and articles about coral reefs typically point out benefits that include protecting shorelines from erosion and storm damage, supplying foods that are important to many coastal communities, and providing recreational and economic opportunities. These benefits are obviously important to people who live near reefs, but there is another aspect of coral reefs that can benefit everyone: the highly diverse biological communities are new sources of powerful antibiotic, anti-cancer and anti-inflammatory drugs.

Despite their numerous benefits to humans, many coral reefs are threatened by human activities. Sewage and chemical pollution can cause overgrowth of algae, oxygen depletion, and poisoning. Fishing with heavy trawls and explosives damages the physical structure of reefs, as well as the coral animals that build them. Careless tourists and boat anchors also cause mechanical damage. Thermal pollution from power plants and global warming cause physiological stress that kills coral animals and leaves the reef structure vulnerable to erosion. Many of these impacts are the result of ignorance; people simply aren't aware of the importance of coral reefs or the consequences of their actions, but the damage and threats to reefs continues to increase on a global scale.

Some of the most severe damage appears to be caused by thermal stress. Shallow-water reef-building coral live primarily in tropical latitudes (less than 30 degrees north or south of the equator). These corals live near the upper limit of their thermal tolerance. Abnormally high temperatures result in thermal stress, and many corals respond by expelling the symbiotic algae (zooxanthellae) that live in the corals' tissues. Since the zooxanthellae are responsible for most of the corals' color, corals that have expelled their algal symbionts appear to be bleached. Because zooxanthellae provide a significant portion of the corals' food and are involved with growth processes, expelling these symbionts can have significant impacts on the corals' health. In some cases, corals are able to survive a "bleaching" event and eventually recover. When the level of environmental stress is high and sustained, the coral may die.

Prior to the 1980's, coral bleaching events were isolated and appeared to be the result of short-term events such as major storms, severe tidal exposures, sedimentation,

pollution, or thermal shock. There is a direct relationship between bleaching and water temperature stress. Coral bleaching events often occur in areas where the sea surface temperature is 1 degree celcius or more above the normal maximum temperature.

Using high-resolution satellite imagery and the GPS (Global Positioning System) technology, the National Oceanic and Atmospheric Administration (NOAA) has made comprehensive maps of reefs in Puerto Rico, the U.S. Virgin Islands, the eight main Hawaiian Islands and the Northwestern Hawaiian Islands. Maps of all shallow U.S. coral reefs are expected to be completed by 2009. NOAA monitors reefs using a system of specially designed buoys that measure air temperature, wind speed and direction, barometric pressure, sea temperature, salinity and tidal level, and transmit these data every hour to scientists. Satellites are also used to monitor changes in sea surface temperatures and algal blooms that can damage reefs. Research and restoration projects on selected coral reefs are conducted by NOAA'S National Undersea Research Program.

The first part of this lesson is intended to:

- introduce students to coral reefs and improve their understanding of why these systems are important, how they are threatened, and what can be done to protect restore these unique and valuable ecosystems;
- introduce students to some of the data available from remote-sensing tools that can be used by anyone who wants to study the Earth's oceans.

In the second part of this lesson, students design and prepare educational programs to improve public awareness of the importance of coral reefs and what needs to be done to reduce or eliminate harmful impacts from human activities. This activity offers many opportunities for cross-curricular activities, and may be extended over several weeks.

Learning Procedure

Part 1

1. Direct students to the coral reef tutorials at

<http://www.nos.noaa.gov/education/education/welcome.html>.

Student groups can be assigned different tutorial sections. Each group can complete one version of the Coral Reef Subject Review, and lead a discussion to review the answers. It is important for the students to understand the relationship between coral animals and their symbiotic algae (zooxanthellae), and that many corals under various types of stress will expel their zooxanthellae.

Briefly explain the purpose and activities of the U.S. Coral Reef Task Force (CRTF), and highlight the monitoring functions that are intended to identify reef area threatened by thermal stress or algal blooms.

2. Briefly describe some of the satellites and sensors that currently provide various types of oceanographic data:

Information on oceanographic conditions is available from various satellites. NOAA'S Polar Operational Environmental Satellite (POES) carries the Advanced Very High Resolution Radiometer (AVHRR), which provides information on sea surface temperature (SST) for the entire Earth on a daily basis. NASA'S Terra and Aqua satellites cross the equator in the morning and afternoon, providing coverage of the entire Earth surface every 1-2 days. These satellites carry Moderate Resolution Imaging Spectrometers (MODIS) that provide information on chlorophyll-a as well as SST. NASA'S QuikSCAT satellite carries the SeaWinds sensor that provides global information on wind speed and direction near the ocean surface. Data from these (and other satellites) are available free via the internet.

Distribute copies of "Satellite Imagery Worksheet" to each student or student group. Tell students that their assignment is to use satellite data to answer the questions on the worksheet. When students have completed the worksheet, point out that the CRTF's monitoring program keeps track of selected oceanographic conditions on an hourly or daily basis at twenty-four coral reef sites. You may want to have students visit

http://www.osdpd.noaa.gov/PSB/EPS/CB_indices/coral_bleaching_indices.html

to check out current conditions at these reefs.

Students can investigate the history of temperature conditions at each of the three reefs listed on the "Satellite Imagery Worksheet" over the period 1997 to present, using data at http://orbit-net.nesdis.noaa.gov/orad/sub/sst_series_24reefs.html and http://orbit-net.nesdis.noaa.gov/orad/sub/sst_series_24reefspath.html (use Grand Bahama Island (GBI) instead of Lee Stocking Island for this exercise). Ask whether temperatures have reached the coral bleaching threshold at any of these reefs during this time period. Students should recognize that the threshold has been exceeded at:

- Glover's Reef
- Grand Bahama Island
- Sombrero Reef

3.

Lead a discussion of how data from the CRTF monitoring program help protect coral reefs. Student will probably realize that these data cannot directly improve the condition of reefs, since the root problem appears to be climate conditions that are beyond human control (at least in the short term). These data are very useful, however, in identifying sites that are at risk of environmental stress so that scientists and resource managers can learn more about the response of corals and coral reef systems to these conditions.

Ask students to discuss why coral reefs are at risk, and what they think can or should be done to reduce or eliminate the negative impacts of human activity on coral reefs. There is a strong possibility that a significant part of the current risk to coral reef systems is the result of human activity, particularly as it relates to global warming. Meaningful actions to address this type of issue depend upon widespread

understanding of the problem and commitment to workable solutions. Education is key to understanding and commitment. Students can brainstorm how to get out these key messages, what audiences should be targeted to receive these messages, and how these messages can be most effectively delivered.

Part 2

Students or student groups will prepare one or more public education programs about coral reefs, based on the results of their brainstorming sessions in Step 3. Encourage students to consider various media, including publications, visual presentations, drama, music, etc. (there are many possibilities).

Resources

http://www.nos.noaa.gov/education/corals/supp_coral_roadmap.html

-NOAA's National Ocean Service Web site's Roadmap to Resources about corals, with links to many other sources of coral reef data, background information, and reports

http://coastwatch.noaa.gov/cw_dataproduct.html -description and links to satellite remote sensing ocean data provided by NOAA CoastWatch

<http://coastwatch.noaa.gov/interface/interface.html> - search page for satellite remote sensing ocean data provided by NOAA CoastWatch; use navigation bar at left to select geographic region, type of data, and date range

<http://www.coral.noaa.gov/index.shtml> - NOAA's Coral Health and Monitoring Program home page, with links to coral reef data, maps, and other resources.

<http://www.osdpd.noaa.gov/PSB/EPS/SST/climohot.html> - coral bleaching hotspot chart.

http://www.osdpdnoaa.gov/PSB/EPS/CB_indices/coral_bleaching_indices.html -

Tropical Ocean Coral Bleaching Indices for 24 coral reef sites

Ariadne, D. and D. Diamante-Fabunan. 2000. Coral Bleaching: the Whys, the How's and What Next? OverSeas, The Online Magazine for Sustainable Seas

http://www.oneocean.org/overseas/200009/coral_bleaching_the_how_and_whys_a_and_whats_next.html

Hughes, T.P., et al.2003. Climate Change, Human Impacts, and the Resilience of Coral Reefs. <http://ioc.unesco.org/coralbleaching/Hughes%20et%20al.pdf>

http://www.crc.uri.edu/comm/download/Coral_1-4.pdf- "Coral Bleaching: Causes, Consequences and Response;" a collection of papers from Intl. Coral Reef Symposium October 2002

Coral Reef Lesson Plan
Satellite Imagery Worksheet
www.oceanservice.noaa.gov

Two conditions that have been linked to coral bleaching are water temperatures that exceed 30 degrees Celsius and little or no surface wind. Your assignment is to use satellite data to investigate whether these conditions have occurred during the past week at three coral reef area. These reefs are:

- Sombrero Reef in the Florida Keys, located at 25.0 degrees N, 81.5 degrees W;
- Lee Stocking Island in the Bahamas, located at 23.5 degrees N, 76.5 degrees W; and
- Grover's Reef, in Belize, located near 16.5 degrees N, 88.0 degrees W.

Follow these steps to obtain the necessary information:

1. Go to <http://coastwatch.noaa.gov>
2. Click on "Data Products"
3. Click on "CoastWatch Ocean Products Server"
4. Under "POES-SST," click on "products"
5. Click on "CoastWatch Regional Nodes"
6. Click on "Caribbean"
7. Click on "Access CoastWatch Caribbean satellite data"
8. Click on the icon for "Database Query"
9. Build your query:
 - a. Check "all dates"
 - b. Uncheck "WC" and "EC" under "Regions," and check the boxes for Florida Keys, Belize, and Bahamas.
 - c. Select "daytime SST" under "Types"
10. Click "Submit"
11. Select the most recent images for each of the three reefs, and determine the sea surface temperature.
12. Under "Browse Imagery" in the menu bar at the top of the page, click on "Day-old Surface winds"
13. Determine the strength of surface winds at each of the three reef locations