oceanservice.noaa.gov

NOAA National Ocean Service Education: Who Has the Data?

Monitoring Coral Reefs / Grades 9-12 / Life Science, Earth Science

---

Focus Question

What types of data do scientists collect to monitor coral reefs, and how are these data used?

Learning Objectives

- Students will be able to access data on selected coral reefs and manipulate these data to characterize these reefs.
- Students will be able to explain the need for baseline data in coral reef monitoring programs.
- Students will be able to identify and explain five ways that coral reefs benefit human beings.
- Students will be able to identify and explain three major threats to coral reefs.

Links to Overview Essays and Resources Useful for Student Research

http://oceanservice.noaa.gov/topics/oceans/coralreefs
http://www.sanctuaries.noaa.gov/about/ecosystems/coralwelcome.html
http://www.coris.noaa.gov/activities/assessment.html#monitor
See specific citations on "Coral Monitoring Data Worksheet" of this Lesson Plan.

Materials

- "Coral Monitoring Data Worksheet," one copy per student group (Click here for separate printable worksheet)
- Grid (approximately 2 mm square) photocopied onto transparencies; one for each student group
- (optional) Computers with internet access; if students do not have access to the internet, you can download copies of the reef habitat images cited under "Learning Procedure;"

you can also download copies of other materials cited under “Learning Procedure” and on the worksheet, and provide copies of these materials to each student or student group

Audio/Visual Materials

None

Teaching Time

Two 45-minute class periods, plus time for student research

Seating Arrangement

Groups of 3-4 students

Maximum Number of Students

32

Key Words

Coral Reefs
Aquarium
Symbiosis
Zooxanthellae
Broadcast spawning

(top)

Background Information

Coral reefs are some of the most biologically productive and economically valuable ecosystems on Earth. Benefits provided by coral reefs include protecting shorelines from erosion and storm damage, supplying foods that are important to many coastal communities, and providing recreational and economic opportunities. In addition, the highly diverse biological communities associated with coral reefs are new sources of powerful antibiotic, anti-cancer and anti-inflammatory drugs that have the potential to benefit the entire human race.

Despite these benefits, many coral reefs are threatened by human activities as well as natural processes. Sewage and chemical pollution can cause overgrowth of algae, oxygen depletion, and poisoning. Poor land management and deforestation can lead to excessive runoff and sedimentation that can smother living reefs and reduce light needed by many shallow-water corals. Fishing with heavy trawls, poisons, and explosives damages the physical structure of reefs as well as the coral animals that build them. Careless tourists, boat anchors, and collection for the aquarium trade also cause mechanical damage. Thermal pollution from power plants and

unusually hot weather cause physiological stress that kills coral animals and leaves the reef structure vulnerable to erosion. Oil spills, fuel discharges, and anti-fouling chemicals from boats add additional stress. 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 continue to increase on a global scale.

In addition to stress from human activities, coral reefs are also subject to natural threats. Hurricanes and cyclones can break corals loose and scatter them into areas where they cannot survive. Severe storms also cause impacts on coastal areas that increase sedimentation and runoff. Unusually low tides can leave corals exposed to high temperatures, solar radiation, and the risk of drying out. Heavy rains can lower salinity to dangerous levels.

High temperatures associated with phenomena such as El Nino cause severe damage through thermal stress. Shallow-water reef-building corals are found primarily in tropical latitudes (less than 30° north or south of the equator) and live near the upper limit of their thermal tolerance, so temperatures one or two degrees above normal can result in thermal stress. One of the most striking responses to thermal stress is known as "bleaching." Most reef-building corals have single-cell algae (zooxanthellae) living within their tissues. These algae play an important role in the corals' nutrition and growth. Pigments in the algae are also responsible for most of the corals' color. Under thermal stress, some corals may expel these algae, causing the corals to appear bleached. Some corals may recover and acquire replacement algae, but others may die. Corals are also subject to predation and disease. Rates of disease outbreaks in corals appear to be increasing, and many researchers believe that at least part of the reason is that the corals have been weakened by other stress factors.

In response to growing concern for the future of coral reefs, the President of the United States established the Coral Reef Task Force (CRTF) in 1998 to protect and conserve coral reefs. The CRTF has prepared a plan to reduce human threats to coral reefs and to improve our understanding of coral reef ecosystems. Strategies for reducing human threats include:

- Expanding and strengthening coral reef marine protected areas (MPAs);
- Reducing damage caused by extractive uses such as overfishing;
- Reducing habitat destruction and pollution;
- Restoring damaged reefs; and
- Creating an informed public.

Strategies to improve our understanding of coral reef ecosystems include:

- Comprehensive mapping, inventory and monitoring of U.S. reefs; and
- Research on coral reef ecology, bleaching, diseases, and best management practices for successful coral reef conservation.

As co-chair of the CRTF, and as directed by the Coral Reef Conservation Act of 2000, NOAA has the responsibility to conserve coral reef ecosystems. NOAA's coral reef conservation efforts are carried out primarily through its Coral Reef Conservation Program (CRCP). Under this

program, NOAA works with scientific, private, government, and nongovernmental organizations at the local, federal, and international levels to address conservation actions.

Among other actions, the CRCP undertakes a variety of mapping and monitoring activities to understand locations of coral reef ecosystems, how they function, how human activities impact reef processes, and how managers and the public can reduce or eliminate these impacts.

Mapping and monitoring are an essential part of coral reef conservation. The purpose of this activity is to acquaint students with sources of information and data on coral reef monitoring, and to provide hands-on experience with manipulating and interpreting some of these data.

(top)

Learning Procedure

1. Photocopy a grid (approximately 2mm squares) onto transparencies, and have students use the transparencies to count the number of grid squares contained in each of the habitat regions shown on the habitat maps. The total number of squares for each habitat type can be used to quantify the relative area occupied by each habitat.

2. Direct students to the Corals Tutorial at: http://oceanservice.noaa.gov/education/tutorial_corals/. You may want to assign different tutorial sections to each student group. Have each student or student group complete one version of the Subject Review (downloadable), and lead a discussion to review the answers.

3. Briefly review the purpose and activities of the U. S. Coral Reef Task Force (CRTF) and the NOAA Coral Reef Conservation Program (CRCP), and highlight the monitoring functions that are intended to identify threatened reef areas and to improve understanding of reef ecosystems (visit http://www.coralreef.gov for more information on the CRTF and http://coralreef.noaa.gov for more information on the CRCP).

4. Tell students that their assignment is to use online data to investigate selected coral reefs. Assign one of the following marine protected areas in the Florida Keys to each student group:

    - Carysfort/South Carysfort Reef
    - French Reef

- Molasses Reef
- Conch Reef
- Hen and Chickens
- Davis Reef
- Alligator Reef
- Sombrero Key
- Looe Key
- Western Sambos/Eastern Sambos
- Sand Key

5. Provide each student group with a "Coral Monitoring Data Worksheet." Have each student group complete the tasks described, and prepare a written report containing answers to the questions on the worksheet.

6. Lead a discussion of students' results. Students should realize that a primary purpose of habitat and fish census data is to establish baselines that can be compared with subsequent surveys to detect changes in coral reef systems. Discuss the variability of habitats in marine protected areas of the Florida Keys. Students should recognize that there is often considerable variability among habitats, even though the habitats are in the same geographic area. An important part of developing a comprehensive understanding of coral reef ecosystems is knowing how reefs change over time in response to various types of environmental change. Students' examination of sea surface temperature data should reveal that during the period January 1, 2001 – December 31, 2004, Sombrero Key (the monitoring station located in the Florida Keys) was:

- Exposed to "HotSpot" > 1 conditions during August and September 2001, August 2002, July and August 2003, and July and August 2004;
- There was likely to have been some bleaching as a result of thermal stress (Alert Level 1) in August 2003 and August 2004
- Not exposed to conditions defined as Alert Level 2
- Conditions defined as Alert Level 2 were measured during August 2005 and August and September 2007

Students should recognize that fish census data from St. Croix, USVI, are typical of many healthy coral reef systems in that while there are a large number of different species present, only a few of these are present in large numbers, and there are many more small fishes than large ones. The two most abundant species were *Halichoeres bivittatus* and *Thalassoma bifasciatum*, and the two species with the greatest number of large (> 30 cm) individuals were *Caranx chrysos* and *Sparisoma viride*.

(top)

The Bridge Connection

The Bridge is a growing collection online marine education resources. It provides educators with a convenient source of useful information on global, national, and regional marine science topics. Educators and scientists review sites selected for the Bridge to insure that they are accurate and current.

http://www.vims.edu/bridge/reef.html

The "Me" Connection

Have students write a short essay on why coral reefs are personally important and what specific actions individuals might take to reduce threats to coral reefs.

Extensions

1. Online data introduced in this activity can be used for a wide variety of additional activities related to coral reefs and coral reef management. Many of these data can be accessed through "Discover NOAA's Data" at the CoRIS home page (http://coris.noaa.gov/) and the "Corals Roadmap to Resources" http://oceanservice.noaa.gov/education/tutorial_corals/supp_corals_roadmap.html)

2. For more lesson plans and activities related to coral reefs, visit the education web pages for NOAA's Ocean Explorer Cayman Islands Twilight Zone 2007 Expedition at http://oceanexplorer.noaa.gov/explorations/07twilightzone/background/edu/edu.html.

(top)

Resources

http://www.oneocean.org/overseas/200009/coral_bleaching_the_hows_and_whys_and_whats_next.html Diamante-Fabunan, D. 2000. Coral Bleaching: the Whys, the Hows and What Next? OverSeas, The Online Magazine for Sustainable Seas.

http://www.crc.uri.edu/download/COR_0011.PDF – "Coral Bleaching: Causes, consequences and response;" a collection of papers from the ninth international coral reef symposium.

http://www.nmfs.noaa.gov/habitat/habitatconservation/publications/Separate Chapters/Cover and Table of Contents.pdf – "The State of Deep Coral Ecosystems of the United States," 2007 report from NOAA providing new insight into the complex and biologically rich habitats found in deeper waters off the U.S. and elsewhere around the world.

http://www.latimes.com/news/local/oceans/la-oceans-series,0,7842752.special – "Altered Oceans," five-part series from the Los Angeles Times on the condition of Earth's ocean; published July 30 – August 3, 2006

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

Content Standard D: Earth and Space Science

- 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

(top)

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1. The Earth has one big ocean with many features.

- Fundamental Concept h. Although the ocean is large, it is finite and resources are limited.

Essential Principle 5. The ocean supports a great diversity of life and ecosystems.

- Fundamental Concept f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or

spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

Essential Principle 6. The ocean and humans are inextricably interconnected.

- Fundamental Concept e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
- Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).
- Fundamental Concept g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Essential Principle 7. The ocean is largely unexplored.

- Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

(top)

Student Worksheet

1. Obtain a map of benthic habitats for your assigned area:

    a. Point your web browser to http://coris.noaa.gov/. This is the home page for NOAA's Coral Reef Information System (CoRIS), which is designed to be a single point of access to NOAA coral reef information and data products.

    b. Click on "Discover NOAA's Data," then "Browse," then "Browse Data Descriptions."

c. Select “Place Keywords - Multiple Pages.” Click on the letter “F,” then scroll down to “Florida” and find the entry for “florida_keys_benthic_habitat_1992.“ Click on “FAQ” then 5.How can I download or order the data?.”

d. Select the link to “http://flkeysbenthicmaps.noaa.gov” then click on the link to “Maps” on the right side of the page.

e. Click on “Protected Areas,” then click on the name of the reef area that has been assigned to your group. A window will open with a benthic habitat map for the selected area.

f. Scroll down to the bottom of the page and click on “Legend” and print a copy of the map legend.

2. Return to the previous page (with the benthic habitat map) and copy the map image into an image processing program such as Adobe Photoshop. Save the image as a TIFF or JPEG file. Print a color copy of the file onto an 8.5 in x 11 in page, and calculate the area of each habitat by placing a transparent grid over the image and counting the number of grid squares contained in each habitat.

3. When the area of all habitats has been calculated, add the area measurements for each habitat type and prepare a table showing these areas.

4. Add all the measurements together, then divide this number into the total area for each habitat type to calculate the relative area (percent of total) for each habitat.

5. Construct a pie chart showing the relative areas for each type of habitat.

6. Coral bleaching events often occur in areas where the sea surface temperature is 1°C or more above the normal maximum temperature. Find out whether coral reefs in the Florida

Keys have been exposed to water temperatures that could cause "bleaching." From the entries under "Florida" in step 1c, find the entry for "avhrr_cur_sst_timeseries_sombrero_reef." Click on "FAQ," then "1.How should this data set be cited?" and select the link to http://coralreefwatch.noaa.gov/satellite/current/sst_series_24reefs.html, to open the "SST/DHW Time Series and Satellite Bleaching Alerts" page.

This page contains links to sea surface temperature (SST) data for 24 selected coral reef locations beginning in the year 2000. These data are obtained from the Advanced Very High Resolution Radiometer (AVHRR), which provides information on sea surface temperature (SST) for the entire Earth on a daily basis. The AVHRR is carried on NOAA's Polar Orbiting Environmental Satellite (POES).

"Coral bleaching HotSpots" are defined as sea surface temperatures that are greater than the normal maximum temperature. Some coral bleaching events have been noted in areas where the HotSpots are greater than 1° C. More often, coral bleaching results from thermal stress that accumulates over several days or weeks. "Degree Heating Weeks" (DHWs) indicate the accumulation of thermal stress that coral reefs have experienced over the past 12 weeks. One DHW is equivalent to one week of sea surface temperatures one stat Celsius greater than the expected summertime maximum. Two DHWs are equivalent to two weeks at one degree above the expected summertime maximum OR one week of two degrees above the expected summertime maximum.

HotSpots and DHWs are used to define a series of "alert levels" that are issued from NOAA Coral Reef Watch's Satellite Bleaching Alert System for 24 selected reef sites around the globe. Definitions of alert levels are:
No Stress = No thermal stress (no HotSpots)
Watch = Low-level thermal stress (0 < HotSpot < 1)
Warning = Thermal stress is accumulating (HotSpot >= 1 and 0 < DHW < 4)
Alert Level 1 = Bleaching expected (HotSpot >= 1 and 4 <= DHW < 8)
Alert Level 2: Significant bleaching expected (HotSpot >= 1 and DHW >= 8)

Click on the "Data" link for the location that is in or near the Florida Keys.
During the period January 1, 2001 – December 31, 2004:

- Were corals at this location ever exposed to HotSpot > 1 conditions? When?
- In what years was there likely to have been some bleaching as a result of thermal stress?
- In what years was there likely to have been significant bleaching?
- Have conditions defined as Alert Level 2 ever been measured at this site?

7. Point your web browser to http://biogeo.nos.noaa.gov/. This is the home page for NOAA's Biogeography Program that is responsible for developing knowledge and products on living marine resource distributions and ecology throughout the Nation's

estuarine, coastal and marine environments, and to provide managers and scientists with an improved ecosystem basis for making decisions.

a. In the pull-down menus near the top of the page, click on "Ecosystems," then on "Coral Reefs." In the menu on the left side of the new page, click "Caribbean Coral Reef Ecosystem Monitoring." Now, click on the "Quick Link to Reef Fish Database" button.
b. Click on "Fish Queries" in the pull-down menus near the top of the page.
c. Set Query Parameters as follows:
   Region = "Virgin Islands St. Croix
   Year = All
   Month = All
   Structure = All
   Permanent/Random = All
   Management = All
   Trophic Level = All
   Family = All
   Species = All
   Under "Query Selection," click the button next to "Full Data Download." Click "Save as Text" to download a data file containing results of fish surveys in the vicinity of St. Croix, USVI. These data are much easier to analyze if you open the file with a spreadsheet program such as Microsoft Excel®.
d. Identify:
   - Which two species had the largest number individuals?
   - Which two species had the largest number individuals whose length was greater than 30 cm?

(top)