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## 2007 Cayman Island Twilight Zone Expedition

# Treasures in Jeopardy

## (adapted from the 2005 Florida Coast Deep Corals Expedition)

### Focus
Conservation of deep-sea coral reefs

### Grade Level
7-8 (Life Science)

### Focus Question
How can deep-sea coral reefs be protected from damage by human activities?

### Learning Objectives
Students will be able to compare and contrast deep-sea coral reefs with their shallow-water counterparts.

Students will be able to explain at least three benefits associated with deep-sea coral reefs.

Students will be able to describe human activities that threaten deep-sea coral reefs.

Students will be able to describe actions that should be taken to protect deep-sea coral reef resources.

### Materials
❒ Access to the internet, or copies of materials cited in "Learning Procedure"

### Audio/Visual Materials
None

### Teaching Time
One or two 45-minute class periods, plus time for student research

### Seating Arrangement
Groups of two to four students

### Maximum Number of Students
30

### Key Words
Deep-sea coral
Conservation
Pharmaceuticals
*Lophelia*
*Oculina*

### Background Information
Coral reefs are one of the most species-rich ecosystems on Earth. Shallow-water coral reefs have been widely studied and well-publicized, in contrast to reefs formed by deep-water corals. Recent studies suggest that deep-water reef ecosystems may have a diversity of species comparable to that of corals reefs in shallow waters, and have found deep-water coral species on continental margins worldwide. One of the most conspicuous differences between shallow- and deep-water corals is that most shallow-water species have symbiotic algae (zooxanthellae) living inside the coral tissue, and these algae play an important part in reef-building and biological productivity. Deep-water corals do not contain symbiotic algae (so these corals are termed "azooxanthellate"). Yet, there are just as many species of deepwater corals (slightly more, in fact) as there are species of shallow-water corals.

Because of the high species diversity found on shallow- and deep-water reefs, these ecosystems are proving to be very promising sources of powerful new antibiotic, anti-cancer and anti-inflammatory drugs. In addition, these reefs provide habitat for important food resources, and shallow reefs are an important part of coastal recreation and tourism industries and protect shorelines from erosion and storm damage. Despite the direct importance of coral reefs to many aspects of human well-being, shallow- and deep-water reefs are both threatened by human activities. Shallow-water reefs are damaged by sewage, chemical pollution, careless tourists, boat anchors, and abnormally high temperatures that result in thermal stress. Commercial fisheries, particularly fisheries that use trawling gear, cause severe damage to both shallow and deep-water habitats. Deep-sea coral communities can also be damaged by oil and mineral exploration, ocean dumping, and unregulated collecting.

Around the world, shallow water coral reefs have been intensively studied by scientists using self-contained underwater breathing (SCUBA) equipment, while deep coral systems are being investigated with submersibles and remotely operated underwater vehicles (ROVs). Recent explorations have found a third type of coral ecosystem between depths of 50 m and 150 m: light-limited deep reefs living in what coral ecologists call the "twilight zone." These reefs have been studied much less than shallow and deep-water reefs because they are beyond the safe range of conventional SCUBA equipment, yet are too shallow and close to shore to justify the use of expensive submersibles and ROVs. The few studies of twilight zone reefs suggest that these ecosystems not only include species unique to this depth range, but may also provide important refuges and nursery habitats for corals and fishes that inhabit shallower reefs. This is particularly important in areas where shallow reefs are severely stressed, since twilight zone coral ecosystems may provide a natural option for recovery.

Scientific exploration of twilight zone coral reef ecosystems is urgently needed to provide information for their protection, as well as to identify potentially important sources of drugs and other biological products from organisms that are endemic to these systems. Helping to meet this need is the primary focus of the 2007 Ocean Explorer Cayman Island Twilight Zone Expedition.

According to scientists concerned about the future of deep coral reef systems, these systems are at a disadvantage in gaining public empathy because most people will never see them. Consequently, a key part of efforts to protect deep-sea coral reefs involves educating the public about these valuable resources. In this lesson, students will develop materials that can be used as part of this kind of education activity.

## Learning Procedure

1. To prepare for this lesson, review the introductory essays for the 2007 Cayman Island Twilight Zone Expedition at http://oceanexplorer.noaa.gov/explorations/07twilightzone/welcome.html.

   If you are not already familiar with coral reefs, you may also want to review the coral reef tutorials at nos.noaa.gov/education/kits/corals/, and http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup10_lophelia.html for more background on *Lophelia* reefs.

2. If your students are not familiar with the Cnidaria, briefly review the basic biology and classification of this phylum (for an easy introduction, check out http://www.ucmp.berkeley.edu/cnidaria/cnidaria.html; for a suggested list of points to be reviewed, see the "Deep Gardens" lesson.

   Briefly review deep-water coral reefs, and contrast these reefs with the more familiar shallow-water reefs. Tell students that deep-water reefs are important in a variety of ways, but are significantly jeopardized by human activity (keep the discussion very general at this point, since students will be researching details as part of their assignment). Say that because of their location, deep-water reefs and their associated benefits and problems are largely unknown to the general public. Consequently, there is an urgent need for public education as a first step toward protecting these valuable resources. You may want to show part of all of a video by Peter Etnoyer from the 2002 Ocean Explorer Gulf of Alaska Expedition, which includes many images of deep-water corals (http://www.oceanexplorer.noaa.gov/explorations/02alaska/logs/summary/media/movies/deepseacoral_video.html).

3. Tell students that their assignment is to develop a poster that could be used as part of efforts to educate the general public about the importance of deep-water coral reefs and the need to protect them. Each poster should address the following questions (students may want to use these questions as headings on their poster):
   - What are deep-water coral reefs?
   - Where are they found?
   - How are deep-water coral reefs different from coral reefs in shallow water?
   - Why are deep-water coral reefs important?
   - What is the problem?
   - What needs to be done?

   Encourage students to use images of deep-sea corals and coral reefs as part of their poster.

   You may want to direct students to the July 2005 issue of Current: the Journal of Marine Education which is a special issue on deep-sea corals (available online at http://www.mcbi.org/Current_Magazine/Current_Magazine.htm), or allow them to discover this (and other resources) on their own.

4. Lead a group discussion of students' posters. Each poster should include the following points:
   - Deep-water coral habitats occur at depths of 70 to greater than 1000 m.
   - Deep-sea corals are known from all the world's oceans.
   - Deep-water corals often lack symbiotic algae (zooxanthellae) that are typical of shallow-water corals.
   - Typical deep-water corals include *Lophelia pertusa*, *Oculina varicosa*, hydrocorals (family Stylasteridae), black corals (order Antipatharia), bamboo corals (family Isididae), and sea fans (order Gorgonacea) [note that images of all these are readily available on the internet].
   - *Oculina* and *Lophelia* dominate deep reefs off the southeastern coast of the United States.
   - Coral is an important habitat-provider on *Oculina* and *Lophelia* reefs.
   - *Lophelia* reef systems in the northeast Atlantic include more than 1,300 species of fish and invertebrates.
   - Only a small percentage of deepwater reefs have been mapped or have had their biological resources characterized.
   - Very little is known about deep-sea coral distribution, population dynamics, ecology, or about how these corals function in providing habitat for other species.
   - Many new species of deep-sea corals have been discovered on seamounts.
   - Many seamount species are endemic (they do not occur anywhere else) and are therefore exceptionally vulnerable to extinction.
   - Some deep-sea sponges and corals are sources of new pharmaceuticals that can be extremely valuable in treating human diseases. Examples include:
     - Discodermolide: isolated from the sponge *Discodermia dissolute*; may treat cancers which are resistant to other drugs
     - E7389: isolated from the sponge *Lissodendoryx* sp.; in clinical trials for the treatment of lung cancer and other cancers
     - Dictyostatin-1: isolated from a sponge from the order Lithistida; may be more effective than Taxol as an anti-cancer drug
     - Topsentin: isolated from the sponge *Spongosporites ruetzleri*, shows promise as an anti-inflammatory agent to

treat arthritis and skin irritations, as well as for the treatment of Alzheimer's disease and to prevent colon cancer

- Bone Grafts: shallow tropical corals have been used as bone grafts for more than 10 years, but deep-sea species have not been used though recent research shows that bamboo corals (family Isididae) have a skeletal structure and dimensions that are almost identical to bone.
- Collagen: Gorgonin, found in bamboo corals, closely resembles collagen, an important component of bone that also can be used for controlled release of medicines, and as a foundation for tissue rebuilding.

- Deep-sea corals usually inhabit places where natural disturbance is rare.
- Many deep-sea corals are slow-growing and may require decades or even centuries to regenerate if they are damaged; but it really isn't known whether these species are capable of repopulating a given area at all if they are destroyed.
- Deep reefs worldwide are being impacted by destructive fishing methods, such as trawling, which destroys the delicate corals.
- Damage from bottom trawling is a global threat to deep-water coral reefs.
- In addition to bottom-trawl fishing, oil and gas production, cable laying, mining, and coral harvest may also negatively impact deep-water coral reefs.
- Protecting the benefits offered by deep-sea coral reefs depends upon measures like the Deep Sea Coral Protection Act (DSCPA) which was introduced in the U.S. House and Senate in 2003-2004. Provisions of the Act include:
  - Freezing the footprint of bottom trawls in all fishery management regions;
  - Preventing trawling from expanding into previously untrawled regions until deep-sea corals in those regions are surveyed and mapped; and
  - Implementing a comprehensive research plan to collect information on deep-sea coral locations and life history.

5. Brainstorm ways that information included in students' posters could be communicated to larger audiences. If possible, display some of the posters at events where they might be seen by other students, parents, and members of the general public.

## The Bridge Connection

http://www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Ocean Science Topics," then "Biology," then "Invertebrates," then "Other Inverts" for links to more information about Cnidaria.

## The "Me" Connection

Have students write an "op-ed" style essay in which they explain why deep-water coral reefs are personally important and what steps individuals can take to help ensure their protection.

## Connections to Other Subjects

English/Language Arts, Earth Science

## Evaluation

Posters and group discussions provide opportunities for assessment.

## Extensions

1. Visit oceanexplorer.noaa.gov to keep up to date with the latest Cayman Island Twilight Zone Expedition discoveries, and to find out what researchers are learning about deep fore reef communities.

2. Visit the Marine Conservation Biology Institute Web site (http://www.mcbi.org) for more information about deep-sea corals and strategies for their protection.

3. Visit http://oceanservice.noaa.gov/education/kits/corals/supp_coral_lessons.html for more activities on coral reefs and how they may be protected.

## Multimedia Learning Objects

http://www.learningdemo.com/noaa/ – Click on the links to Lessons 3 and 12 for interactive multimedia presentations and Learning Activities on deep-sea corals and biotechnology.

## Other Relevant Lesson Plans from the Ocean Exploration Program

**Big Fleas Have Little Fleas** [http://oceanexplorer.noaa.gov/explorations/03mountains/background/education/media/mts_fleas.pdf] (7 pages, 1Mb) (from the 2003 Mountains in the Sea Expedition)

Focus: Physical structure in benthic habitats (Life Science)

In this activity, students will recognize that natural structures and systems often display recurrent complexity over many scales of measurement, infer the importance of structural complexity to species diversity and abundance in benthic habitats, and discuss ways that octocorals may modify seamount habitats to make these habitats more suitable for other species.

**Climate, Corals, and Change** [http://oceanexplorer.noaa.gov/explorations/06davidson/background/edu/climate.pdf] (14 pages, 441k) (from the 2006 Exploring Ancient Coral Gardens Expedition)

Focus (Physical Science - Paleoclimatology)

In this activity, students will be able to explain the concept of "paleoclimatological proxies" and describe at least two examples, describe how oxygen isotope ratios are related to water temperature, and interpret data on oxygen isotope ratios to make inferences about the growth rate of deep-sea corals. Students will also be able to define "forcing factor" and will be able to describe at least three forcing factors for climate change and discuss at least three potential consequences of a warmer world climate.

**Design a Reef!** [http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_aquarium.pdf] (5 pages, 408k) (from the Gulf of Mexico Deep Sea Habitats 2003 Expedition)

Focus: Niches in coral reef ecosystems (Life Science)

In this activity, students will compare and contrast coral communities in shallow water and deep water, describe the major functions that organisms must perform in a coral ecosystem, and explain how these functions might be provided in a miniature coral ecosystem. Students will also be able to explain the importance of three physical factors in coral reef ecosystems and infer the fundamental source of energy in a deep-water coral community.

**Biodiversity of Deep Sea Corals** [http://oceanexplorer.noaa.gov/explorations/03mountains/background/education/media/mts_deepseacoral.pdf] (3 pages, 1Mb) (from the Mountains in the Sea 2003 Expedition)

Focus: Deep-sea corals

In this activity, students will research life found on tropical coral reefs to develop an understanding of the biodiversity of the ecosystem; students will research life found in deep-sea coral beds to develop an understanding of the biodiversity of the ecosystem; students will compare the diversity and adaptations of tropical corals to deep-sea corals.

**Deep Sea Coral Biodiversity** [http://oceanexplorer.noaa.gov/explorations/deepeast01/background/education/media/deepseacorals.pdf] (3 pages, 152k) (from the 2001 Deep East Expedition)

Focus: George's Bank

Students will research life found on tropical coral reefs to develop an understanding of the biodiversity of the ecosystem; students will research life found in deep-sea coral beds to develop an understanding of the biodiversity of the ecosystem; and students will compare the diversity and adaptations of tropical corals to deep-sea corals.

## Other Links and Resources

*The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.*

http://oceanexplorer.noaa.gov – Web site for NOAA's Ocean Exploration program

http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html – Ocean Explorer image gallery

http://www-biol.paisley.ac.uk/courses/Tatner/biomedia/units/cnid1.htm – Phylum Cnidaria on Biomedia of the Glasgow University Zoological Museum on the Biological Sciences, University of Paisley, Scotland Web site; includes explanations of the major classes, a glossary of terms and diagrams and photos

http://www.calacademy.org/research/izg/calwildfall2000.pdf – Article from California Wild: "Stinging Seas - Tread Softly In Tropical Waters" by Gary C. Williams; an introduction to the venomous nature of tropical cnidarians, why and how they do it

http://www.cees.iupui.edu/Education/Workshops/Project_Seam/Exercises/bird_biodiversity_exerciese.htm – Biodiversity exercises from the Center for Earth and Environmental Science, Indiana University – Purdue University, Indianapolis

http://www.mcbi.org/publications/pub_pdfs/Deep-Sea%20Coral%20issue%20of%20Current.pdf – A special issue of Current: the Journal of Marine Education on deep-sea corals.

http://www.mesa.edu.au/friends/seashores/index.html – "Life on Australian Seashores" by Keith Davey on the Marine Education Society of Australasia Web site, with an easy introduction to Cnidaria, including their method of reproduction

http://www.moonsnailproject.org/Mini_Diversity.htm – The Moonsnail Project's mini-lecture on diversity

http://www.oceanicresearch.org/ – The Oceanic Research Group Web site; lots of photos, but note that they are very explicit about their copyrights; check out "Cnidarians: Simple but Deadly Animals!" by Jonathan Bird, which provides an easy introduction designed for classroom use

http://www.ucmp.berkeley.edu/cnidaria/cnidaria.html – Introduction to Cnidaria from the University of California Museum of Paleontology

http://www.wwf.org.uk/filelibrary/pdf/darwin_mounds.pdf – Report on the Darwin Mounds, a recently discovered group of hard-bottom habitats in the United Kingdom's 200 nm offshore zone

Maxwell, S. 2005. An Aquatic Pharmacy: The Biomedical Potential of the Deep Sea. Current 21(4):31-32; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/Pharmacy.pdf

Frame, C. and H. Gillelan. 2005. Threats to deep-sea corals and their conservation in U.S. waters. Current 21(4):46-47; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/Threats_Conservation.pdf

Morgan, L. E. 2005. What are deep-sea corals? Current 21(4):2-4; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/What_are_DSC.pdf

Mortensen, P. B., M. Hovland, T. Brattegard, and R. Farestveit. 1995. Deep water bioherms of the scleractinian coral *Lophelia pertusa* (L) on the Norwegian shelf: Structure and associated megafauna. Sarsia 80:145-158. – The technical journal article upon which this activity is based

Pickrell, J. 2004. Trawlers Destroying Deep-Sea Reefs, Scientists Say. National Geographic News. http://news.nationalgeographic.com/news/2004/02/0219_040219_seacorals.html

Reed, J. K. and S. W. Ross. 2005. Deep-water reefs off the southeastern U.S.: Recent discoveries and research. Current 21(4):33-37; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/Southeastern_US.pdf

Roberts, S. and M. Hirshfield. Deep Sea Corals: Out of sight but no longer out of mind. http://www.oceana.org/fileadmin/oceana/uploads/reports/oceana_coral_report_final.pdf — Background on deep-water coral reefs

## 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**

- Populations and ecosystems
- Diversity and adaptations of organisms

**Content Standard F: Science in Personal and Social Perspectives**

- Populations, resources, and environments
- Science and technology in society

**Content Standard G: History and Nature of Science**

- Nature of science

## 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 c.* Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.

*Fundamental Concept e.* The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

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

*Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.

*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 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 a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

*Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

*Fundamental Concept c.* Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.
*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.

## For More Information

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## Acknowledgements

This lesson plan was produced by Mel Goodwin, PhD, The Harmony Project, Charleston, SC for the National Oceanic and Atmospheric Administration. If reproducing this lesson, please cite NOAA as the source, and provide the following URL: http://oceanexplorer.noaa.gov