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2007 Cayman Island Twilight Zone Expedition

A Piece of Cake

(adapted from the 2003 Charleston Bump Expedition)

Focus
Spatial heterogeneity in deep-water coral communities

Grade Level
5-6 (Life Science)

Focus Question
What types of habitats are likely to be found on the deep fore reefs of Little Cayman Island?

Learning Objectives
Students will be able to explain what a habitat is, and describe at least three functions or benefits that habitats provide.

Students will be able to describe some habitats that are typical of deep-water hard bottom communities.

Students will be able to explain how organisms such as deep-water corals and sponges add to the variety of habitats in areas such as the Cayman Islands.

Materials
- ❒ One half or whole sheet cake
- ❒ Icing in various colors
- ❒ Candies or other edible materials for modeling habitat features

Audio/Visual Materials
- ❒ Chalkboard, marker board, or overhead projector with transparencies for brainstorming sessions.

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

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Fore Reef
Habitat
Deep-water coral
Sponge
Microhabitat

Background Information
Coral reefs provide habitats for some of the most diverse biological communities on Earth. Most people have seen photographs and video images of shallow-water coral reefs, and many have visited these reefs in person. Historically, scientists have believed that reef-building corals were confined to relatively shallow depths because many of these corals have microscopic algae called zooxanthellae (pronounced "zoh-zan-THEL-ee") living inside their soft tissues. These algae are often important for the corals' nutrition and growth, but require sunlight for photosynthesis. The maximum depth for reef-building corals was assumed to be about 150 m, since light levels below this depth are not adequate to support photosynthesis. Recently, though, ocean explorers have discovered extensive mounds of living

coral in depths from 400 m to 700 m – depths at which there is virtually no light at all! These deep-water corals do not contain zooxanthellae, and do not build the same types of reef that are produced by shallow-water corals. But branches of deep-water coral species such as *Lophelia pertusa* grow on mounds of dead coral branches that can be several meters deep and hundreds of meters long. Recent studies indicate that the diversity of species in deep-water coral ecosystems may be comparable to that of coral reefs in shallow waters, and that there are just as many species of deep-water 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.

Learning Procedure

[NOTE: Portions of this activity were adapted from "Edible Devonian Marine Ecosystem" by Naturalists at Falls of the Ohio State Park, Clarksville, Indiana, on the Geologic and Paleontologic Cook Book Web site. (See "Resources" below.)

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/.

2. Review the concept of habitats. Have students brainstorm what functions or benefits an organism receives from its habitat. The students' list

should include food, shelter (protection), and appropriate nursery areas. Lead an introductory discussion of the Cayman Island Twilight Zone Expedition. You may want to show students some images from the Ocean Explorer and/or National Ocean Service Web sites (oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html, and nos.noaa.gov/education/kits/corals, respectively).

Tell students that detailed surveys of deep coral fore reefs (the part of a reef that is farthest from shore and adjacent to deep water where the reef structure ends) are just beginning, but we can have a general idea of what to expect based on explorations in other deep-water habitats.

3. Tell student groups that they are to find out what sorts of habitats explorers on the 2007 Cayman Island Twilight Zone Expedition might find. Have students read relevant essays from the Expedition's Web site, and visit http://www.wwf.org.uk/filelibrary/pdf/darwin_mounds.pdf for information about a recently discovered group of hard-bottom habitats in the United Kingdom's 200 nautical mile offshore zone. Have students find pictures or illustrations of typical organisms. In addition to printed reference books, the Ocean Explorer Gallery (oceanexplorer.noaa.gov/, click on "Gallery"), and http://biodidac.bio.uottawa.ca have lots of images suitable for downloading.

4. Have each group present their research findings. Discuss and list the types of habitats that may be found in the Cayman Islands, and the kinds of organisms explorers are likely to see from a research submersible. Have students describe what functions or benefits organisms receive from each habitat type.

5. Tell students that the class is going to construct an edible model of the kinds of habitats they hypothesize will be found in the Cayman Islands. The base of the model will be a sheet cake (half or whole, depending upon how many students you have, how much space is needed to model the hypothetical habitats, and how hungry the students are).

   Have students brainstorm what kinds of edible features can be added to the cake to make the habitat model. Mounds of icing can be used for boulders, and when hardened can be sculpted to form caves and overhangs. Sponges might be modeled with small pieces of sponge cake (of course), and strings of rock candy (made by hanging pieces of string in a saturated sugar solution) could represent branching corals. Of course, there are many more possibilities, and your students will probably have a pretty good idea of potential model elements.

   Once the model is completed, you may want to have your students use it to explain about deep-water hard-bottom habitats to another group of students, perhaps a younger class. Their presentation can conclude with students assuming the role of top consumers, and having direct interaction with the model system (they can eat the cake).

The BRIDGE Connection

www.vims.edu/BRIDGE/ – Click on "Ocean Science" in the navigation menu to the left, then "Biology," then "Invertebrates," then "Other Inverts," for resources on corals and sponges. Click on "Ecology" then "Deep Sea" for resources on deep sea communities.

The "Me" Connection

Have students write a short essay describing their personal habitat, what benefits or functions it provides, and what other organisms are involved in creating this habitat.

Connections to Other Subjects

English/Language Arts, Earth Science

Assessment

You may want to have students prepare written reports (either individually or in groups) prior to the group discussion in Step 4.

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. For more information, activities, and lessons about coral reefs, visit the National Ocean Service Coral Reef Discovery Kit at oceanservice.noaa.gov/education/kits/corals/welcome.html.

3. Visit http://www/uky/edu/KGS/education/cookbook.html for more edible education ideas.

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

Easy as Pi [http://oceanexplorer.noaa.gov/explorations/03bump/background/edu/media/03cb_pi.pdf] (4 pages, 252k) (from the 2003 Charleston Bump Expedition]

Focus: Structural complexity in benthic habitats (Life Science/Mathematics)

In this activity, students will be able to describe the importance of structural features that increase surface area in benthic habitats and quantify the relative impact of various structural modifications on surface area in model habitats. Students will also be able to give examples of organisms that increase the structural complexity of their communities.

Friend, Foe, or . . . [http://oceanexplorer.noaa.gov/explorations/05stepstones/background/education/ss_2005_friend-foe.pdf] (5 pages, 331k) (from the North Atlantic Stepping Stones 2005 Expedition)

Focus (Life Science) - Symbiotic relationships with corals

In this activity, students will be able to define and describe symbiotic, mutualistic, commensal, parasitic, facultative and obligatory relationships between organisms; describe at least three species that have symbiotic relationships with corals; and discuss whether these relationships are mutualistic, commensal, or parasitic.

Architects of the Deep Reef [http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_architects.pdf] (5 pages, 388k) (from the Gulf of Mexico Deep Sea Habitats 2003 Expedition)

Focus: Reproduction in Cnidaria (Life Science)

In this activity, students will be able to identify and describe at least five characteristics of Cnidaria coral, compare and contrast the four classes of Cnidaria, and describe typical reproductive strategies used by Cnidaria. Students will also be able to infer which of these strategies are likely to be used by the deep-sea coral *Lophelia pertusa*, and will be able to describe the advantages of these strategies.

Chemists Without Backbones [http://oceanexplorer.noaa.gov/explorations/03bio/background/edu/media/Meds_ChemNoBackbones.pdf] (4 pages, 356k) (from the 2003 Deep Sea Medicines Expedition)

Focus: Benthic invertebrates that produce pharmacologically active substances (Life Science)

In this activity, students will be able to identify at least three groups of benthic invertebrates that are known to produce pharmacologically-active compounds and will describe why pharmacologically-active compounds derived from benthic invertebrates may be important in treating human diseases. Students will also be able to infer why sessile marine invertebrates appear to be promising sources of new drugs.

Keep Away [http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_keepaway.pdf] (5 pages, 424k) (from the 2003 Gulf of Mexico Deep Sea Habitats Expedition)

Focus: Effects of pollution on diversity in benthic communities (Life Science)

In this activity, students will discuss the meaning of 'biological diversity' and compare and contrast the concepts of 'variety' and 'relative abundance' as they relate to biological diversity. Given information on the number of individuals, number of species, and biological diversity at a series of sites, students will make inferences about the possible effects of oil drilling operations on benthic communities.

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.

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

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.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.oceanicresearch.org/ – The Oceanic Research Group Web site; lots of photos, but 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.science.fau.edu/drugs.htm – An overview article on drugs from the sea

http://spikesworld.spike-jamie.com/science/index.html — Web site with lots of background and activities on multiple science topics, including microorganisms

http://www.uky.edu/KGS/education/cookbook.htm – The Geologic and Paleontologic Cookbook

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

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
- Understanding about scientific inquiry

Content Standard C: Life Science

- Populations and ecosystems

Content Standard D: Earth and Space Science

- Structure of the Earth system

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments

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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