2006 Exploring Ancient Coral Gardens

Easy as Pi

(adapted from The Charleston Bump 2003 Expedition)

Focus
Structural complexity in benthic habitats

Grade Level
5-6 (Life Science/Mathematics)

Focus Question
How do living and non-living structures affect benthic habitats?

Learning Objectives
Students will be able to describe the importance of structural features that increase surface area in benthic habitats.

Students will be able to quantify the relative impact of various structural modifications on surface area in model habitats.

Students will be able to give examples of organisms that increase the structural complexity of their communities.

Materials
- ❒ Modelling clay
- ❒ Marbles, golf balls, or other spherical objects
- ❒ Wooden dowels, matchsticks, or similar objects; diameter approximately 6 mm or less

Audio/Visual Materials
- ❒ Chalk board, 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
Davidson Seamount
Habitat
Deep-water coral
Sponge
Structural complexity

Background Information
Seamounts are undersea mountains formed by volcanic processes, either as isolated peaks or as chains that may be thousands of miles long with heights of 3,000 m (10,000 ft) or more. Compared to the surrounding ocean waters, seamounts have high biological productivity, and provide habitats for many species of plant, animal, and microbial organisms. Recently, increasing attention is being directed toward deep water coral species found on seamounts. In contrast to shallow-water coral reefs, deep-sea coral communities are virtually unknown to the general public and have received much less scientific study. Yet, deep-water coral ecosystems may have a diversity of species comparable to that of corals reefs in shallow waters. Because many seamount species are endemic (that is, they are found nowhere

else), these ecosystems may be a unique feature of seamounts, and are likely to be important for several reasons. First, because of their high biological productivity, these communities are directly associated with important commercial fisheries. Moreover, deep-sea corals have been identified as promising sources for new drugs to treat cancer and other diseases, as well as natural pesticides and nutritional substances. Recent discoveries suggesting that some corals may be hundreds of years old means that these organisms can provide important records of past climactic conditions in the deep ocean. Apart from these potential benefits, deep-sea corals are part of our world heritage—the environment we hand down from one generation to the next.

Despite their importance, there is growing concern about the impact of human activities on these ecosystems. Commercial fisheries, particularly fisheries that use trawling gear, cause severe damage to seamount habitats. Scientists at the First International Symposium on Deep Sea Corals (August, 2000), warned that more than half of the world's deep-sea coral reefs have been destroyed. Ironically, some scientists believe that destruction of deep-sea corals by bottom trawlers is responsible for the decline of major fisheries such as cod.

In addition to impacts from fisheries, deep-sea coral communities can also be damaged by oil and mineral exploration, ocean dumping, and unregulated collecting. Other impacts may result from efforts to mitigate increasing levels of atmospheric carbon dioxide. One proposed mitigation is to sequester large quantities of the gas in the deep ocean, either by injecting liquid carbon dioxide into deep ocean areas where it would form a stable layer on the sea floor or by dropping torpedo-shaped blocks of solid carbon dioxide through the water column to eventually penetrate deep into benthic sediments. While the actual impacts are not known, some scientists speculate that since coral skeletons are made of calcium carbonate, their growth would probably decrease if more carbon dioxide were dissolved in the ocean.

The Davidson Seamount, located about 75 miles southwest of Monterey, CA, was the first geological feature to be described as a "seamount" in 1933. The now-extinct volcanoes that formed this and other nearby seamounts were different from typical ocean volcanoes. While the typical undersea volcano is steep-sided, with a flat top and a crater, seamounts in the Davidson vicinity are formed of parallel ridges topped by a series of knobs. These observations suggest that the ridges were formed by many small eruptions that occurred 3 to 5 million years apart. Typical undersea volcanoes are formed by more violent eruptions that gush out lava more frequently over several hundred thousand years.

Although it was the first recognized seamount and is relatively near the U.S. coast, the Davidson Seamount is still 99.98% unexplored. In 2002, a NOAA-funded expedition to the Seamount found a wide variety of organisms, including extensive deep-water coral communities. Among many intriguing discoveries were observations of animals that had never been seen live before, as well as indications that some coral species may be several hundred years old (visit http://oceanexplorer.noaa.gov/explorations/02davidson/davidson.html and http://montereybay.noaa.gov/reports/2002/eco/ocean.html for more information about the 2002 Expedition).

The 2006 Exploring Ancient Coral Gardens Expedition is focussed on learning more about deep-sea corals at Davidson Seamount, with four general goals:

- to understand why deep-sea corals live where they do on the seamount;
- to determine the age and growth patterns of the bamboo coral;
- to improve the species list and taxonomy of corals from the seamount; and
- to share the exciting experience with the public through television and the Internet.

One of the most conspicuous features of deep-water coral habitats on the Davidson Seamount is spatial variety, with coral branches, sponges, and other animals creating countless "microhabitats" in many sizes. In this activity, student will create models that illustrate this spatial variety, and will calculate the effect of various structures on total surface area in their model habitats.

Learning Procedure

1. To prepare for this lesson, read the introductory essays for the 2006 Exploring Ancient Coral Gardens Expedition at http://oceanexplorer.noaa.gov/explorations/06davidson/welcome.html, and review the NOAA Learning Object on deep-sea corals at http://www.learningdemo.com/noaa/.

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 Davidson Seamount and the 2002 and 2006 Ocean Exploration expeditions to the area. You may want to show students some images from the 2002 Expedition Web site (http://oceanexplorer.noaa.gov/explorations/02davidson/davidson.html). Tell students that detailed exploration of the Davidson Seamount is just beginning, but we can have a general idea of what to expect based on explorations in other deep-water, hard-bottom habitats. Explain the concept of "microhabitat." Be sure students understand how the combination of various rock formations and organisms with complex physical forms (like branching corals and sponges) can offer many different types of habitat and as a result can provide food, shelter, and nursery space for many different kinds of organisms. Discuss how a benthic community might benefit from structural modifications that increase available surface area. Depending upon the type of modification, these benefits could include increased shelter for different species, increased availability of food for surface grazers, more sites for larvae to atttach, and more places upon which non-motile organisms may attach.

3. Tell student groups that they are to find out what sorts of habitats the 2006 Exploring Ancient Coral Gardens Expedition might find on the Davidson Seamount. Have students read relevant trip logs from the 2002 Davidson Seamount expedition, and visit http://montereybay.noaa.gov/reports/2002/eco/ocean.html as well as the NOAA Learning Object for Deep-Sea Corals at http://www.learningdemo.com/noaa/ for additional information. Have students pay particular attention to organisms that modify or create habitats (such as branching corals and sponges). Have students find pictures or illustrations of these organisms. In addition to printed reference books, the Ocean Explorer Gallery (http://oceanexplorer.noaa.gov/, click on "Gallery") and http://biodidac.bio.uottawa.ca have lots of images suitable for downloading.

4. Tell student groups that their assignment is to "engineer" a model benthic habitat site to increase the available surface area and habitat variety, based on living and non-living features typical of the habitats they have researched. Have each group begin with a flat surface of modeling clay, approximately 20 cm x 20 cm. Students will then modify this surface by adding various shapes (dowels, spheres and partial spheres, hollowed out shapes repesenting caves and overhangs, circular depressions in the clay surface representing scours, etc.), keeping track of the total surface area available in their model habitat. Potential features include boulders, caves, overhangs, scours (curved depressions in the clay surface), and cylindrical corals. You may want to add more complex shapes such as sponges with holes in their surface or branched corals depending upon available time and students' ambition.

Prior to beginning the modeling assignment, you may want to review formulas for calculating the surface area of various geometric shapes:
Area of a rectangle = Length • Width
Area of a circle = π • (radius)^2
Area of a cylinder = height • π • (radius)^2
Area of a sphere = 4 • π • (radius)^2

Each group will begin with roughly the same area (20 cm • 20 cm = 400 cm^2). As they add features to increase surface area, be sure students remember to substrate the surface area that is lost due to the "footprint" of their object. If they add a half sphere to represent a boulder, for example, they have to subtract the area of the circle occupied by the "footprint" of the boulder. Groups should prepare a written summary of their modifications to the initial flat surface, including calculations of the surface area increase produced by each modification. Tell students that their models will be judged according to the following formula:

Score = (Percent Area Added to the Beginning Surface) • (Number of Different Shapes)

5. Have each group present and discuss their model habitats, explaining what natural features (actually found in deep-water communities) are represented by each shape in the model. Lead a discussion of which organisms and shapes add the most variety to a benthic community. Branched shapes can greatly increase total surface area without occupying very much "footprint" space. Highly folded surfaces can mutliply available surface area by orders of magnitude, and are an important feature of many biological structures (such as lungs, gills, and other surfaces where diffusion takes place). Porous structures such as sponges, gravel, or loose sediment also greatly multiply available surface and provide a different-sized shelter spaces as well as increase surface area. Based on this discussion, have students describe the features of the most diverse benthic habitat they can imagine, and compare this hypothetical vision to what scientists actually find during the 2006 Ocean Exploration expedition to the Davidson Seamount.

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 structures in their own bodies that increase available surface area, and why these structures are important.

Connections to Other Subjects

English/Language Arts, Physical Science

Assessment

Models and written reports prepared in Step 4 provide opportunities for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Davidson Seamount Expedition discoveries, and to find out what researchers are learning about deep-water corals and seamount communities.

Resources

NOAA Learning Objects

http://www.learningdemo.com/noaa/ – Click on the link to "Lesson 3 – Deep-Sea Corals" for an interactive multimedia presentation on deep-sea corals, as well as Learning Activities and additional information on global impacts and deep-sea coral communities.

Other Relevant Lesson Plans from the Ocean Exploration Program

Friend, Foe, or . . . (http://oceanexplorer.noaa.gov/explorations/05stepstones/background/education/ss_2005_friendfoe.pdf; 5 pages, 331k) (from the North Atlantic Stepping Stones 2005 Expedition)

Focus - Symbiotic relationships with corals (Life Science)

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.

Deep Gardens (http://oceanexplorer.noaa.gov/explorations/05deepcorals/background/edu/media/05deepcorals_gardens.pdf; 8 pages, 359k) (from the Florida Coast Deep Corals 2005 Expedition)

Focus: Comparison of deep-sea and shallow-water tropical coral communities (Life Science)

Students will compare and contrast deep-sea coral communities with their shallow-water counterparts, describe three types of coral associated with deep-sea coral communities, and explain three benefits associated with deep-sea coral communities. Students will explain why many scientists are concerned about the future of deep-sea coral communities.

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)

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.

Volcanoes, Plates, and Chains (http://oceanexplorer.noaa.gov/explorations/02alaska/background/edu/media/volcanoes5_6.pdf; 7 pages, 116k) (from the Exploring Alaska's Seamounts 2002 Expedition)

Focus: Formation of seamounts the Axial-Cobb-Eikelberg-Patton chain, Gulf of Alaska

In this activity, students will be able to describe the processes that form seamounts, describe the movement of tectonic plates in the Gulf of Alaska region and explain the types of volcanic activity that might be associated with these movements, and describe how a combination of hotspot activity and tectonic plate movement could produce the arrangement of seamounts observed in the Axial-Cobb-Eikelberg-Patton chain.

Leaving Home (http://oceanexplorer.noaa.gov/explorations/04mountains/background/edu/media/MTS04.larvae.pdf) (6 pages, 396k) (from the Mountains in the Sea 2004 Expedition)

Focus: Larval recruitment on New England seamounts (Life Science)
Students will be able to explain the meaning of "larval dispersal" and "larval retention" and explain their importance to populations of organisms in the marine environment. Given data on recruitment of organisms to artificial substrates, students will also be able to draw inferences about larval dispersal in these species.

Other Links and Resources

http://oceanexplorer.noaa.gov/explorations/02davidson/davidson.html – Daily logs, photos, video clips, and backgrounds essays on the 2002 Davidson Seamount Expedition

http://montereybay.noaa.gov/reports/2002/eco/ocean.html – Web page from the Monterey Bay National Marine Sanctuary describing the 2002 exploration of the Davidson Seamount

http://www.mbari.org/ghgases/ – Web page from the Monterey Bay Aquarium Research Institute describing MBARI's work on the Ocean Chemistry of Greenhouse Gases, including work on the potential effects of ocean sequestration of carbon dioxide

http://seamounts.edsc.edu/main.html — Seamounts Web site sponsored by the National Science Foundation

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

http://www.mcbi.org/Current_Magazine/Current_Magazine.htm – A special issue of Current: the Journal of Marine Education on deep-sea corals.

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

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/Current_Magazine/Southeastern_US.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/Current_Magazine/Threats_Conservation.pdf

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

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

http://oceanica.cofc.edu/activities.htm – Project Oceanica Web site, with a variety of resources on ocean exploration topics

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
- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard D: Earth and Space Science
- Structure of the Earth system

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 b. An ocean basin's size, shape and features (such as islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates.
- 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 d.* Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur 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.
- *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 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 c.* The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
- *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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