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2004 Gulf of Alaska Expedition

Architects of Seamount Ecosystems

Focus
Morphology and ecological function in habitat-forming deep-sea corals

Grade Level
7-8 (Life Science)

Focus Question
How does the physical form of deep-sea corals contribute to their ecological function?

Learning Objectives
Students will be able to describe at least three ways in which habitat-forming deep-sea corals benefit other species in deep-sea ecosystems.

Students will be able to explain at least three ways in which the physical form of habitat-forming deep-sea corals contributes to their ecological function.

Students will be able to explain how habitat-forming deep-sea corals and their associated ecosystems may be important to humans.

Students will be able to describe and discuss conservation issues related to habitat-forming deep-sea corals.

Materials
❒ (Optional) Images of seamounts and deep-sea corals (see Learning Procedure)

Audio/Visual Materials
❒ (Optional) Copies of images of seamounts and deep-sea corals

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

Seating Arrangement
Classroom style or groups of 3-4 students

Maximum Number of Students
30

Key Words
Endemic
Seamount
Deep-sea coral
Bottom trawling
Form and function
Corallidae
Isididae
Paragordiidae
Primnoidae
Antipathidae
Oculinidae
Caryophylliidae
Stylerasteriidae

Background Information
Seamounts (also called "guyots") are undersea mountains that are generally thought to be the remains of underwater volcanoes, often with heights of 3,000 m (10,000 ft) or more. There are an estimated 30,000 seamounts in all of the Earth's ocean, but only a few hundred have been visited by explorers, and far fewer have been intensively studied. Volcanoes that can form seamounts are often associated with the movement of the tectonic

plates that make up the Earth's crust. Where these plates move apart (for example, along the mid-ocean ridge in the middle of the Atlantic Ocean) a rift is formed, which allows magma (molten rock) to escape from deep within the Earth and harden into solid rock known as basalt. Where tectonic plates come together, one plate may descend beneath the other in a process called subduction, which generates high temperatures and pressures that can lead to explosive volcanic eruptions (such as the Mount St. Helens eruption which resulted from subduction of the Juan de Fuca tectonic plate beneath the North American tectonic plate). Volcanoes can also be formed at hotspots, which are thought to be natural pipelines to reservoirs of magma in the upper portion of the Earth's mantle.

In the late 1960's, biologists searching for new commercial fishing grounds discovered that seamounts have high biological productivity compared to surrounding ocean waters, and provide habitats for a variety of plant, animal, and microbial species, many of which were previously unknown. Deep-sea corals are often conspicuous, and provide essential habitat for other organisms in seamount ecosystems. Seamounts and plateaus near Australia and New Zealand were found to have large populations of deep water fish with firm, tasty flesh. One species, the orange roughy (*Hoplostethus atlanticus*), is now common in North American markets. But fish stocks on seamounts were quickly diminished by commercial fishing vessels. Some studies report that deep-water trawlers have reduced orange roughy populations by as much as 90%. In addition, bottom trawling severely damages entire bottom communities: trawling is known to have removed 85% of the living cover from some seamounts (Malakoff, 2003). In February 2004, concern for this large-scale destruction of virtually unexplored ecosystems led 1,136 scientists from 69 countries to release a statement calling for governments and the United Nations to protect deep-sea coral and sponge ecosystems.

This same concern has stimulated scientific research on seamounts. The few existing surveys of seamounts suggest that many seamount species are endemic (found on only one or a few adjacent peaks). Recent research has shown that obscure, bottom-dwelling species may contain powerful drugs that directly benefit humans. On some seamounts, up to half the fishes and invertebrates are estimated to be unique. Seamounts may serve as "stepping stones" that allow other species to expand their ranges, and may also help individuals of some species migrate over long distances.

Numerous seamounts have been discovered in the Gulf of Alaska, many of which occur in long chains that parallel the west coast of the U.S. and Canada. In 2001 and 2002, Ocean Exploration expeditions studied the long Axial-Cobb-Eikelberg-Patton chain. The Ocean Exploration 2004 Gulf of Alaska Expedition will investigate the northernmost chain that stretches roughly 900 km from Kodiak Seamount at the Alaskan Trench to Bowie Seamount off of the Queen Charlotte Islands. Particular attention is being directed toward deep-sea coral communities associated with these seamounts.

In this activity, students will research deep-sea corals, and draw inferences about how their morphology contributes to their ecological function in seamount ecosystems.

Learning Procedure

1. Explain that seamounts are the remains of underwater volcanoes, and that they are islands of productivity compared to the surrounding environment. Tell students that expeditions to seamounts often report many species that are new to science and many that appear to be endemic to a particular group of seamounts.

   You may want to show images of seamount communities from http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html or http://www.mcbi.org/DSC_statement/coral_images.htm, or direct students to these sites. Point out deep-sea corals, and tell students that these animals are an important part of seamount ecosystems.

2. Assign students or student groups one of the following families of habitat-forming deep-sea corals:

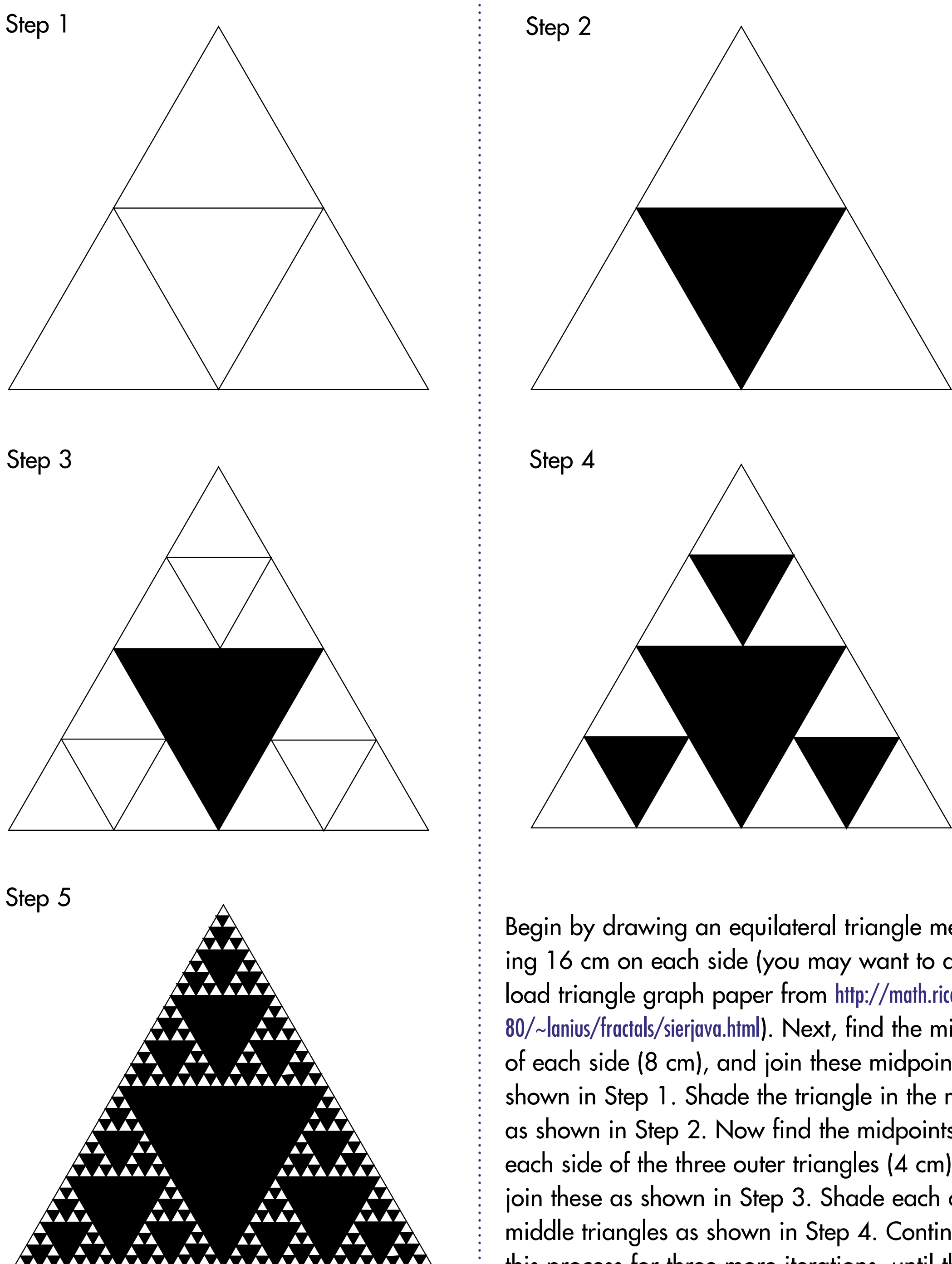
   Corallidae
   Isididae
   Paragordiidae
   Primnoidae
   Antipathidae
   Oculinidae
   Caryophylliidae
   Stylerasteriidae

   Tell students (or student groups) that their assignment is to research their assigned family and prepare a report that includes:
   (a) The taxonomic position of the family (phylum, class, order);
   (b) A physical description of corals included in the family (appearance and type of skeletal structure);
   (c) Depth range over which the corals occur;
   (d) Ways in which corals in the family provide and modify habitat for other species;
   (e) How the physical form of the corals contributes to their function in the ecosystem
   (e) Ways in which these corals or associated species may be important to humans; and
   (f) Management and conservation issues.

   Some Web sites that may be useful for students' research are listed under "Resources."

3. Lead a discussion of students' research results. The following points should emerge during this discussion:
   - Taxonomy:
     Corallidae – Phylum Cnidaria, Class Anthozoa, Subclass Alcyonaria, Order Gorgonacea
     Isididae – Phylum Cnidaria, Class Anthozoa, Subclass Alcyonaria, Order Gorgonacea
     Paragordiidae – Phylum Cnidaria, Class Anthozoa, Subclass Alcyonaria, Order Gorgonacea
     Primnoidae – Phylum Cnidaria, Class Anthozoa, Subclass Alcyonaria, Order Gorgonacea
     Antipathidae – Phylum Cnidaria, Class Anthozoa, Subclass Zoantharia, Order Antipatharia
     Oculinidae – Phylum Cnidaria, Class Anthozoa, Subclass Zoantharia, Order Scleractinia
     Caryophylliidae – Phylum Cnidaria, Class Anthozoa, Subclass Zoantharia, Order Scleractinia
     Stylerasteriidae – Phylum Cnidaria, Class Hydrozoa, Order Stylasterina
   - Deep-sea corals are found off all U.S. coasts, including Alaska and Hawaii;
   - Radiocarbon dating has established that some coral colonies are 10,000 - 12,000 years old (around the end of the last Ice Age);
   - Two-thirds of known coral species live in deep, cold water, and are suspension feeders;
   - The majority of deep-sea corals have not been located; very few deep-sea coral reefs have been intensively studied;
   - Deep-sea coral colonies may host hundreds of other organisms (e.g., more than 2,000 individual animals and hundreds of species, including worms, crabs, shrimp and fishes were found in a small coral colony with a head the size of a basketball);
   - Deep-sea corals provide multiple benefits to other species, including shelter, protection from predators, nursery areas, reduction of strong currents, and feeding areas;
   - The branching growth form of deep-sea corals contributes to their ecological function by providing numerous small spaces within the coral colonies that serve as sheltered areas in which other organisms may live (you can illustrate this effect by constructing a Sierpinski triangle as in Figure 1 – repeatedly dividing a fixed space produces an infinite series of increasingly smaller spaces that in nature are potential

Figure 1 – Constructing a Sierpinski Triangle



Begin by drawing an equilateral triangle measuring 16 cm on each side (you may want to download triangle graph paper from http://math.rice.edu:80/~lanius/fractals/sierjava.html). Next, find the midpoint of each side (8 cm), and join these midpoints as shown in Step 1. Shade the triangle in the middle as shown in Step 2. Now find the midpoints of each side of the three outer triangles (4 cm), and join these as shown in Step 3. Shade each of the middle triangles as shown in Step 4. Continue this process for three more iterations, until the midpoints measure 0.5 cm, shading the middle triangles after each iteration until the drawing appears similar to Step 5. Theoretically the process can continue indefinitely.

habitats for a wide variety of organisms);

- The branching growth form of deep-sea corals also increases the surface area available to other organisms (particularly microorganisms);
- The branching growth form of deep-sea corals reduces the force of strong currents that are often found in the vicinity of seamounts, making it possible for more delicate species to live in seamount communities (see "Forests of the Deep" for a simple demonstration of the effect of a branched surface on water currents);
- Deep-sea coral reefs provide essential habitat for many commercially-important fish species, including red porgy, amberjack, snappers, groupers, and orange roughy;
- Besides supporting commercial fisheries, deep-sea coral communities may also contain other species that can provide new pharmaceuticals; recent research has discovered a variety of deep-sea bottom-dwelling invertebrates that produce powerful drugs that can be used to treat cancer, inflammatory diseases, and heart disease;
- Skeletons of deep-sea corals contain records of climate change over thousands of years;
- Destructive fishing gear, particularly bottom trawls, is one of the greatest threats to deep-sea coral ecosystems. Areas where an extensive amount of deep-sea coral is known to have been destroyed by trawling include Canada, Scotland, Norway, Australia, New Zealand, and the east coast of the United States.

The BRIDGE Connection

www.vims.edu/bridge/ – Click on "Ocean Science" in the navigation menu to the left, then "Ecology," then "Coral" for resources on corals and coral reefs.

The "Me" Connection

Have students write a short essay on how seamounts and their associated deep-sea corals might be potentially important to their own lives.

Connections to Other Subjects

English/Language Arts, Mathematics, Earth Science

Evaluation

Written reports prepared in Step 2 provide opportunities for assessment.

Extensions

Have students visit http://oceanexplorer.noaa.gov to find out more about the 2004 Gulf of Alaska Expedition and about opportunities for real-time interaction with scientists on current Ocean Exploration expeditions.

Resources

Etnoyer, P. and L. Morgan. 2003. Occurrences of Habitat-forming Deep Sea Corals in the Northeast Pacific Ocean. Report to NOAA's Office of Habitat Conservation. (available online at http://www.mcbi.org/destructive/DSC_occurrences.pdf)

http://www.americanoceans.org/fish/ohpa-coral.pdf – Fact sheet on deep-sea corals

http://www.terranature.org/deepsea_coral.htm – Article about scientists' call for protection of deep-sea coral ecosystems

http://www.terranature.org/trawlingScientists_ban.htm – Text of Scientists' Statement on Protecting the World's Deep-sea Coral and Sponge Ecosystems

http://www.savecorals.com/news/FS_cradle_of_life.pdf – Article, "Deep Sea Corals: The Cradle of Sea Life"

Malakoff, D. 2003. Deep-sea mountaineering. Science 301:1034-1037. – Article on seamounts and deep-sea coral communities

http://www.mcbi.org/DSC_statement/coral_images.htm – Images on the Marine Conservation Biology Institute's Web page

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

http://pubs.usgs.gov/of/of01-154/index.htm – U. S. Geological Survey Open-File Report 01-154 "Sea-Floor Photography from the Continental Margin Program"

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

http://www.earthref.org/databases/SC/main.htm – Digital archive of seamount maps

http://seamounts.sdsc.edu/ – Compendium of seamount-related research

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
- 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
- Science and technology in society

For More Information

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