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The Gulf of Mexico Deepwater Habitats Expedition

Design a Reef!

Focus

Niches in coral reef ecosystems

Grade Level

7-8 (Life Science)

Focus Question

What are the major functions that organisms must perform in a coral reef ecosystem?

Learning Objectives

Students will be able compare and contrast coral reefs in shallow water and deep water.

Students will be able to describe the major functions that organisms must perform in a coral reef ecosystem.

Students will be able to explain how these functions might be provided in a miniature coral reef ecosystem.

Students will be able to explain the importance of three physical factors in coral reef ecosystems.

Students will be able to infer the fundamental source of energy in a deep-water coral reef ecosystem.

Materials

- ❐ (Optional) Turn-key miniature coral reef aquarium kit, or student-designed components (see Learning Procedure, Step 5)

Audio/Visual Materials

- ❐ Chalkboard, marker board with markers, or overhead transparencies for group discussions

Teaching Time

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

Seating Arrangement

Groups of 4-6 students

Maximum Number of Students

30

Key Words

Ahermatypic
Hermatypic
Niche
Zooxanthellae
Lophelia pertusa
Chemosynthetic
Photosynthesis

Background Information

Deep-water coral reefs were discovered in the Gulf of Mexico nearly 50 years ago, but very little is known about the ecology of these communities or the basic biology of the corals that produce them. In contrast, deep-water coral reefs near the coasts of Europe have been intensively studied, and scientists have found a great abundance and variety of species associated with these communities. *Lophelia pertusa* is the dominant coral species in these communities. Technically, *Lophelia* is ahermatypic (non-reef-building), but branches of living coral grow on mounds of dead coral branches that can be several meters deep and hundreds of meters long. Unlike hermatypic corals that produce reefs in shallower waters, *Lophelia* does not have symbiotic algae and receives nutrition from plankton and particulate material captured by its polyps from the surrounding water. *Lophelia* mounds alter the flow of currents and provide habitats for a variety of filter feeders. Several commercially-important species are associated with *Lophelia* reefs in European waters, and scientists suspect that the same may be true for deep-water reefs in the Gulf of Mexico. But they don't know for sure, because most of these communities are almost entirely unexplored.

Most reports of *Lophelia* reefs in the Gulf of Mexico were the result of investigations directed toward hydrocarbon seepage and/or chemosynthetic communities. Scientists studying deep-water reefs on the Norwegian continental shelf have found that many large *Lophelia* banks occur at sites where there were relatively high levels of light hydrocarbons present in the sediments. The reason for this correlation is not known, nor is it known whether a similar correlation exists in the hydrocarbon-rich Gulf of Mexico.

As scientists have begun to learn more about *Lophelia* reefs, there is increasing concern that these reefs and their associated resources may be in serious danger. Many investigations have reported large-scale damage due to commercial fishing trawlers, and there is also concern about damage that might result from exploration and extraction of fossil fuels. The primary objectives of the Gulf of Mexico Deepwater Habitats Expedition are:

- to locate deep-water coral reefs in the Gulf of Mexico;
- to describe biological communities and geological features associated with these reefs; and
- to improve our understanding of the ecology of *Lophelia* and deep-water reef communities.

This activity is designed to acquaint students with some of the ecological roles that are typical of coral reefs, and to provide a basis for student inferences about the ecology of deep-water reef communities.

Learning Procedure

1. Briefly review Background Information on the Gulf of Mexico Deepwater Habitats Expedition, and deep-water reefs. Be sure students understand that these reefs have a high diversity of species and large number of individual organisms like coral reefs in shallower water, but are virtually unexplored in the Gulf of Mexico. Compare and contrast deep-water reef corals (e.g., *Lophelia pertusa*) with reef-building corals in shallow water. Visit http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup10_lophelia.html for more background on *Lophelia* reefs.

2. Review the concept of "niche." A simple way to explain this idea is to think of an organism's niche as its occupation: that is, where, when and on what it feeds; where it lives; who its enemies are, etc. Have students brainstorm the characteristics they would use to describe the niche of an organism living on a coral reef.

3. Tell students that they are going to design a functioning model of a coral reef ecosystem that could be put together in your classroom. To prepare for this task, their assignment is to research the various occupations (niches) that need to be filled to make a coral reef ecosystem work, and what kinds of organisms fill these roles in a shallow water coral reef. You may want to get the thought processes started by brainstorming some of these roles. Students may recognize the need for a source of energy (which implies one or more food chains), some means for disposing of wastes, a source of oxygen, etc.

   You may want to direct your students to http://www.vims.edu/bridge/reef.html for background information on coral reef ecosystems.

4. Lead a discussion of students' research results in

the context of designing a miniature coral reef ecosystem. Students should recognize that the primary source of energy in coral reef systems is sunlight which is converted to chemical energy by green plants through photosynthesis. Many shallow-water corals contain single-celled algae called zooxanthellae (pronounced zoh-zan-THEL-ee) within their tissues. Chemicals produced by the algae through photosynthesis are transferred to the coral tissues, and the pigments of the algae cause the corals to appear brightly colored. Students should also have discovered that corals also have tentacles equipped with stinging cells (nematocysts) capable of feeding on particulate materials and plankton. Ask students to infer what energy sources might be used by corals living in very deep water where sunlight does not penetrate. Many organisms in deep-sea reef communities are particle feeders and obtain energy from plankton and/or the remains of dead organisms that settle from shallower waters. Be sure students realize that the availability of these materials also depends upon photosynthesis in shallower water, so sunlight is still the fundamental source of energy for these particle-feeding organisms.

Ask students if there is another energy source that does not involve sunlight. Some students may identify chemosynthesis as an alternative to photosynthesis. Organisms that use sulfur as an energy source (e.g., those found in the vicinity of hydrothermal vents; visit http://www.pmel.noaa.gov/vents/home.html for more information) are not dependent on sunlight, and may resemble some of the earliest forms of life on Earth. Other organisms use organic chemicals such as methane or other hydrocarbons as a source of energy (visit http://www.bio.psu.edu/cold_seeps for more information).

But since these hydrocarbons come from the remains of once-living plants and animals that were dependent upon photosynthesis, sunlight is still the fundamental energy source for these organisms even though they are chemosynthetic. Mention that Norwegian scientists have found large *Lophelia* banks at sites where relatively high levels of light hydrocarbons are present in the sediments.

Ask students to identify organisms that could provide an energy source for their miniature coral reef ecosystem. Corals with their associated zooxanthellae are one possibility. Algae (both microscopic and macroscopic) are another possibility, and on natural reefs compete directly with corals for space. Since the algae can grow more quickly than corals, they could overrun a reef ecosystem unless there was a way to keep the algae in check. On natural reefs, grazing fishes and invertebrates fill this niche. You may want to point out that coralline algae are very important to reef growth, and larvae of many corals can only settle on surfaces that have been previously colonized by coralline algae.

So now we have the beginnings of a food chain for our model reef system. Ask students how many more links could reasonably be added to the food chain in the model system. You may need to remind them that energy transfer efficiency between trophic levels is less than 10% (i.e., it takes at least 10 grams of primary producers to support 1 gram of herbivores, and 1 gram of herbivores can support less than 0.1 gram of primary carnivores, etc.). This means that the number of trophic levels in your model ecosystem may be limited. This also calls attention to the issue of size and types of organisms that should be included in the miniature reef ecosystem. Highly active organisms (such as fishes) will probably require supplemental feeding, and leftover artificial food is a major cause of pollution in small aquaria.

This leads to the issue of waste disposal. Be sure they understand that the concept of “waste” is a human invention: in nature, by-products from one organism are “raw materials” for other organisms. This process is essential to natural recycling. Much of this work is done by microorganisms, which need to be present for a model system to work well.

Discuss key physical factors. These include temperature (most shallow-water corals are tropical and need water temperatures between 18°C and 32°C); light (natural sunlight contains substantially more blue wavelengths than most artificial lights); and water movement (very important for the transport of food particles to sessile organisms, as well as for the removal of metabolic byproducts that would be toxic if allowed to accumulate). So, the miniature coral reef ecosystem may need a thermostat-controlled heater, a full-spectrum light with a time switch, and a pump capable of providing good flow rates (usually 5 to 10 times the volume of the aquarium per hour).

5. Now have students explore some practical options for setting up their miniature coral reef ecosystem. Even if it isn't possible to actually do so, students can still learn a great deal from this process. Turnkey kits are commercially available (e.g., from Carolina Biological Supply Company), or they might create their own using information available from the Geothermal Aquaculture Research Foundation at www.garf.org.

6. Have each student group prepare a written report describing how they would set up a miniature coral reef ecosystem, including a description of the niches that would be included in their system.

The Bridge Connection

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

The "Me" Connection

Have students write a short essay describing their niche in the ecosystem of which they are part, and what other niches are important to their own lives.

Connections to Other Subjects

English/Language Arts, Chemistry, Earth Science

Evaluation

Written reports prepared in Step 6 provide an opportunity for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Gulf of Mexico Deepwater Habitats Expedition discoveries, and to find out what explorers are learning about deep-water coral communities.

Resources

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

http://www.carolina.com/tips/02pdfs/march_tips_high.pdf – Article on miniature coral reef aquaria, focussing on a turnkey system

http://saltaquarium.about.com/gi/dynamic/offsite.htm?site=http://www2.hawaii.edu/%7Edelbeek/homerf1.html – Article on "Your First Reef Aquarium: How to Create a Miniature Coral Reef System at Home"

http://saltaquarium.about.com/library/weekly/aa031399.htm – Background article on coral reef aquaria

http://www.garf.org/ – Website for the Geothermal Aquaculture Research Foundation with lots of information about corals in aquaria

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

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science
- Transfer of energy

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

For More Information

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