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Life on the Edge: Exploring Deep Ocean Habitats

Cool Corals

Focus
Biology and ecology of *Lophelia* corals

Grade Level
9-12 (Life Science)

Focus Question
What do scientists know about the basic biology and ecology of *Lophelia* corals?

Learning Objectives
Students will be able describe the basic morphology of *Lophelia* corals and explain the significance of these organisms.

Students will be able to interpret preliminary observations on behavior of *Lophelia* polyps, and infer possible explanations for these observations.

Students will be able to explain why biological communities associated with *Lophelia* corals are the focus of major worldwide conservation efforts.

Materials
❒ Copies of "Preliminary Studies of *Lophelia pertusa* Polyp Behavior," one for each student group

Audio/Visual Materials
❒ Chalkboard, marker board, or overhead projector with transparencies and markers for group discussion

Teaching Time
One 45-minute class period, plus time for student research

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Continental shelf
Continental slope
Hard bottom
Lophelia pertusa
Deep-water coral
Trawling

Background Information
For hundreds of years, thousands of fishermen have harvested U.S. coastal waters of the Atlantic Ocean and Gulf of Mexico. Yet, the marine habitats of the adjacent outer continental shelves and slopes are poorly studied and in many cases completely unknown. Until recently, most scientists assumed that these habitats did not support large or productive biological communities. Although no one had actually visited the edges of the continental shelves for a first hand look, they believed that the extensive commercial fisheries depended upon migrations from other areas and/or nutrients carried in from deeper or coastal waters. But once they actually began exploring the area more thoroughly, scientists found many diverse and thriving benthic communities.

Between North Carolina and Florida, several unique habitats are found where the topography of the outer continental shelf is extremely rugged and swept by the powerful currents of the Gulf Stream. Hard or "live" bottom habitats support diverse biological communities that include valuable fish and invertebrate resources. On the edge of the continental shelf where depths range from 80 to 250 m, hard bottom communities provide the foundation for the food web of many commercially important species. But while scientists have studied many hard bottom communities within the range of SCUBA gear, they know very little about about the ecology of these communities in deeper waters.

Even deeper, on the middle of the continental slope, the deep-sea coral *Lophelia pertusa* forms another almost-unexplored habitat. Here, in depths of 400 to 700 m, branches of living coral grow on mounds of dead coral branches that can be several meters deep and hundreds of meters long. Unlike 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. Scientists suspect that many other organisms may also inhabit deep-sea coral reefs, including commercially important fishes and crustaceans. But they don't know for sure, because most of the hard bottom and deep-sea coral habitats on the edge and slope of the continental shelf are still unexplored.

The 2003 Life on the Edge Expedition will search previously unexplored hard bottom habitats and deep coral banks on the edge and slope of the continental shelf adjacent to the coasts of North and South Carolina and define the biological communities living in these habitats. In this activity, students will research basic information on *Lophelia pertusa* and interpret results of a preliminary study of polyp behavior in this species.

Learning Procedure

1. Review the general geographic location and form of the continental shelf adjacent to the U.S. Atlantic coast. Tell students that very little is known about the ecology of the edge and slope of the shelf, but that recent explorations have found diverse and thriving benthic communities. Visit http://oceanexplorer.noaa.gov for more background information about the Life on the Edge Expedition, and http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup10_lophelia.html for more background on *Lophelia* reefs.

2. Tell students that their assignment is to prepare a written report on *L. pertusa* which should include:
   - a brief summary of the biology of this species (what kind of animal is it and what its general characteristics are);
   - preferred habitat (where is it found, and what the general physical conditions in this habitat are);
   - associations with other species;
   - significance to humans; and
   - interactions with humans.

3. Provide each student group with a copy of "Preliminary Studies of *Lophelia pertusa* Polyp Behavior." Each group should graph the data and answer the following questions:

a. Why did scientists want to avoid exposing the corals to visible light?
[To avoid exposing the corals to an unnatural physical factor (light) that might affect their behavior, since these corals normally live in very deep waters where there is virtually no light.]

b. How did the scientists control their experiment for possible effects of infrared light?
[They didn't.]

c. In the second experiment, why did the scientists have one colony that was not exposed to sand?
[To provide a control for the experimental treatment.]

d. Other researchers have suggested that *L. pertusa* polyps are permanently expanded. Do data from this study support this idea?
[No.]

e. Do *L. pertusa* polyps extend and retract at the same rate?
[No; the rate of extension is slower than the rate of retraction.]

f. Why might *L. pertusa* polyps suddenly retract?
[Because they are disturbed by some external factor; or because a rapid retraction could produce a more vigorous water movement (possibly useful for exchanging water in the coelenteron cavity or for expelling waste products of metabolism); or . . .]

g. Why might *L. pertusa* periodically extend and contract?
[To exchange water in the coelenteron cavity or expel waste products of metabolism; or …]

h. Does sand appear to have an effect on *L. pertusa* polyps? If so, what is the effect?
[Yes, it appears to reduce extension of the polyps.]

4. Lead a group discussion about *Lophelia pertusa* and the results of preliminary experiments on the behavior of *L. pertusa* polyps. Student reports should address the questions listed above, and should include most of the following points:
   - *L. pertusa* is a scleractinian (stony) coral with a branched growth form; live corals are often found growing on mounds of dead branches that form deep-water reefs.
   - About 20 of 703 known species of deep-sea scleractinians build reef structures.
   - *L. pertusa* is distributed throughout the Earth's oceans except in polar regions, usually in depths ranging from 200 m to 1,000 m at temperatures between 6° C and 8° C; live *L. pertusa* reefs have been reported from depths greater than 3,000 m.
   - Growth rates of *L. pertusa* have been estimated at 4 – 5 mm per year, which is slower than that of reef-building corals in shallow water.
   - Deep-sea corals often are long-lived and may be hundreds of years old.
   - The branching growth form of *L. pertusa* provides a variety of habitats for other species.
   - Complex biological communities are associated with *L. pertusa* reefs on continental shelves, slopes, and seamounts.
   - Biological diversity on *L. pertusa* reefs has been reported to be about three times greater than on surrounding soft bottom habitats.
   - About 800 species have been reported to be associated with these reefs in the North Atlantic.
   - Very little is known about reproduction in *L. pertusa*, but colonies of the coral have been found on oil rigs that are far away from known locations of natural reefs, suggesting that this species may have long-lived planktonic larvae (this would be advantageous for the potential recolonization of damaged areas).
   - *L. pertusa* reefs have been known to fishermen for centuries and are considered good fishing areas, especially for gillnets and longlines.
   - Scientists paid little attention to reports of *L. pertusa* reefs until the 1990's, at least partially because the deep-sea environment was very difficult to explore prior to that time.
   - Use of heavy bottom trawls in recent years has greatly increased damage to *L. pertusa* reefs from fishing activities.
   - Trawling causes mechanical damage to *L. pertusa* reefs, and stirs up large quantities of silt; siltation is believed to be a major cause of *L. pertusa* reef degradation on a

global scale.
- Silt has been reported to suppress growth rates of adult *L. pertusa* polyps and to reduce the diversity of associated species.
- Oil exploration and extraction activities can also damage *L. pertusa* reefs by increasing sedimentation and discharging toxic chemicals.

In the course of the discussion, ask why so much attention is suddenly being directed toward *L. pertusa* reefs. Students should recognize that the extent and diversity of these reefs (like many other biological communities in the deep ocean) simply wasn't known until recently, and the potential benefits of other species associated with these reefs are still unknown. The availability of deep-sea exploration technology has been critical to gaining a better understanding of these systems and the extent to which they are threatened. The relationship of these reefs to productive fisheries has been known to fishermen for many years, and the recent introduction of heavy "rock hopping" trawl gear poses a new threat of major destruction. Apart from ethical or moral considerations, it is simply in our best interest to protect potentially useful resources.

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 *L. pertusa* reefs might be potentially important to their own lives.

Connections to Other Subjects

English/Language Arts; Earth Science

Evaluation

Reports prepared in Steps 2 and 3 provide opportunities for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest discoveries by the Life on the Edge Expedition, and to find out what researchers are learning about deep-water hard-bottom communities.

Resources

http://oceanica.cofc.edu/activities.htm – Project Oceanica website, 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, J. M. and R. Anderson. 2000. Laboratory studies of *Lophelia pertusa* - preliminary studies of polyp behaviour. http://www.sams.ac.uk/dml/projects/benthic/lophaqua.htm – The technical report upon which part of this lesson is based.

Fosså, J. H., P. B. Mortensen, and D. M. Furevik 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. http://www.imr.no/Dokumenter/fossa.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

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
- Interdependence of organisms
- Behavior of organisms

Content Standard D: Earth and Space Science

- Geochemical cycles

Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Environmental quality

For More Information

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Student Handout

Preliminary Studies of *Lophelia pertusa* Polyp Behavior
(adapted from Roberts and Anderson, 2000)

Scientists who conducted this study used time-lapse video recording to study polyp behavior. The recordings were made using infrared light to avoid potential effects of exposing the corals to visible light. Light from an infrared-emitting diode was diffused through a translucent screen. A coral branch in an aquarium was placed between the video camera and the screen so that the branch produced a silhouette. This allowed the scientists to see when polyps were extended and when they were retracted into the calices (a calyx is the "cup" formed by the coral skeleton that shelters the individual coral polyps).

At the beginning of the first experiment, the corals were gently tapped to cause them to retract. An image of the coral branch was recorded at 20-minute intervals. When the experiment was completed, the scientists measured the diameter of each calyx recorded at the beginning of the experiment, and compared this measurement to the diameter of the same calyx at 20-minute intervals. If the polyps were extended or partially extended, the diameter would appear larger than if the polyps were retracted (and hence out of sight in the silhouette). To compensate for size differences among the polyps, a "corrected index of extension" was calculated by dividing the amount of extension by the calyx diameter:

Corrected Index of Extension = (Extended Diameter - Calyx Diameter) ÷ Calyx Diameter

A second experiment was conducted to investigate the effect of sand deposition on polyp behavior; the scientists used a pump to drop sand onto one colony while a second colony was left undisturbed. Time-lapse video recordings were made of both colonies at 20-minute intervals for 24 hours.

Table 1 contains data from a single polyp in the first experiment. Data from the second experiment are summarized in Table 2.

Table 1

Time	Corrected Index of Extension	Time	Corrected Index of Extension	Time	Corrected Index of Extension
1900	0.41	0020	0.43	0540	0.04
1920	0.44	0040	0.45	0600	0.07
1940	0.46	0100	0.47	0620	0.14
2000	0.47	0120	0.02	0640	0.16
2020	0.39	0140	0.00	0700	0.23
2040	0.42	0200	0.03	0720	0.29
2100	0.44	0220	0.06	0740	0.35
2120	0.47	0240	0.08	0800	0.28
2140	0.50	0300	0.11	0820	0.28
2200	0.48	0320	0.10	0840	0.32
2220	0.42	0340	0.00	0900	0.40
2240	0.43	0400	0.02	0920	0.43
2300	0.45	0420	0.04	0940	0.34
2320	0.47	0440	0.07	1000	0.35
2340	0.47	0500	0.10		
0000	0.48	0520	0.02		

Student Handout

Table 2

Polyp Number	Treatment	Mean Corrected Index of Extension Over 24 hours
1	sand	0.07
3	no sand	0.35
4	sand	0.08
6	sand	0.05
8	no sand	0.36
12	no sand	0.39
13	sand	0.03
15	no sand	0.40
19	sand	0.11