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Charleston Bump Expedition

A Tough Neighborhood

Focus
Adaptations of benthic organisms to deep water, hard substrates, and strong currents.

Grade Level
9-12 (Life Science)

Focus Question
What are some morphological or physiological adaptations that allow organisms to survive in the physical environment of the deep ocean?

Learning Objectives
Students will be able to describe at least three attributes of the deep ocean physical environment that are radically different from ocean habitats near the sea surface.

Students will be able to explain at least three morphological or physiological adaptations that allow organisms to survive in the physical environment of the deep ocean.

Students will be able to identify at least three organisms with adaptations to the deep ocean environment that are found (or may be found) on the Charleston Bump.

Materials
None

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

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

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Charleston Bump
Deep-sea habitat
Adaptations

Background Information
The Blake Ridge is a large sediment deposit located approximately 400 km east of Charleston, South Carolina on the continental slope and rise of the United States. The crest of the ridge extends in a direction that is roughly perpendicular to the continental rise for more than 500 km to the southwest from water depths of 2,000 to 4,800 m. About 130 km east of the Georgia-South Carolina coast, a series of rocky scarps, mounds, overhangs and flat pavements rise from the surface of the Blake Plateau to within 400 m of the sea surface. This hard-bottom feature is known as the Charleston Bump. While the Blake Ridge has been extensively studied over the past 30 years because of the large deposits of methane hydrate found in the area, benthic communities on the continental shelf of the United States are virtually unexplored (visit http://198.99.247.24/scng/hydrate/about-hydrates/about_hydrates.htm for more information about methane hydrates and

why they are important). Although this area has been important to commercial fishing for many years, until recently it was generally assumed that benthic communities of the continental shelf were scattered and relatively unproductive,and that useful fisheries were the result of migrations from other areas and/or nutrients carried in from deeper or coastal waters. But once scientists actually began exploring the area more thoroughly, they found many diverse and thriving benthic communities.

The 2001 "Islands in the Stream" Expedition to the Charleston Bump found a series of very complex habitats, and numerous fishes and invertebrate species involved in communities that we are just beginning to understand. (Visit http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html, and click on logs from September 27, 28, and 29 for more information). These species live under physical conditions that are quite different from those in shallower waters. Two of the most obvious differences are water pressure and light. Water pressure increases by one atmosphere (14 pounds per square inch) for every 10 m of depth, so organisms on the Charleston Bump are living under water pressure that is 40 times greater than the pressure at the ocean surface. Scientists who want to collect living specimens must use pressurized collection chambers, since most deep-water organisms die quickly when they are brought to the surface.

Light is virtually absent in the deep ocean, which means that deep-sea organisms cannot rely on vision to find food and mates and to maintain various interspecific and intraspecific associations. Lack of light, of course, also precludes photosynthesis and contributes to a general scarcity of food in the deep ocean. As a result, the overall density of organisms is low in many parts of the deep ocean, and many of these organisms are relatively small with low metabolic rates. Chemosynthetic communities in the vicinity of hydrothermal vents and cold seeps are an exception, since they are not dependent upon photosynthesis as a primary food source. Visit http://www.bio.psu.edu/cold_seeps and http://www.bio.psu.edu/hotvents for virtual tours of cold seep and hydrothermal vent communities.

Water movement presents another set of challenges for life on the Charleston Bump. As the Gulf Stream flows around and over the Charleston Bump it is deflected, producing eddies, gyres, and upwellings downstream (to the north).

Most deep ocean waters have sufficient oxygen to support life. Most deep-sea water originates at the surface of the Arctic or Antarctic Oceans, where oxygen-rich cold water sinks and flows north or south into the deep oceans. The oxygen in these waters does not appear to be depleted by the respiration of deep-water organisms, presumably because the overall density of these organisms is quite low and these organisms typically have low metabolic rates (exceptions to this generalization are some species that live in the vicinity of seamounts and deep-sea chemosynthetic communities). Temperature, too, is relatively stable in the deep ocean, typically about 5° C at 1,000 m depth, although water temperatures in the vicinity of hydrothermal vents can vary by nearly 400° C (the water does not boil because of the high pressure) in the space of a few meters.

In this activity, students will research adaptations that allow organisms to survive in the physical environment of the deep ocean, and that might be expected among inhabitants of benthic communities on the Charleston Bump.

Learning Procedure

1. Lead an introductory discussion of the Charleston Bump and the 2001 and 2003 Ocean Exploration expeditions to the area. The website for the 2001 Islands in the Stream expedition is: http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html; click on logs from September 27, 28, and 29. The website for the 2003 Charleston Bump expedition is: http://oceanexplorer.noaa.gov/explorations/explorations.html;

click on "Charleston Bump." You may want to show students some images from the Ocean Explorer website and/or http://pubs.usgs.gov/of/of01-154/index.htm.

Tell students that detailed surveys of the Charleston Bump are just beginning, but we can have a general idea of what to expect based on explorations in other deep-water, hard-bottom habitats. Preliminary observations on the Charleston Bump in 2001 revealed a variety of complex communities involving a variety of different organisms and habitats. Have students list physical conditions that characterize ocean habitats, and identify which of these they believe are radically different on the Charleston Bump compared to ocean habitats near the sea surface.

2. Tell student groups that their assignment is to
   - Identify and describe at least three attributes of the deep ocean physical environment that are radically different from ocean habitats near the sea surface.
   - Identify and explain at least three morphological or physiological adaptations that allow organisms to survive in the physical environment of the deep ocean.
   - Identify and describe at least three organisms with adaptations to the deep ocean environment that are found (or may be found) on the Charleston Bump.

Trip logs from the 2001 Islands in the Stream expedition are a good starting point. A good discussion of the deep-sea environment can be found at http://www.marinebio.com/Oceans/TheDeep/ and http://www.pbs.org/wgbh/nova.abyss/life.bestiary.html

You may want to suggest that students consider the following topics:
   - Food scarcity
   - Abyssal gigantism
   - The effect that lack of sunlight may have on the locomotion and propulsive systems

3. Have each group present their research findings. Discuss and list attributes of the deep ocean physical environment that are radically different from ocean habitats near the sea surface; morphological or physiological adaptations that allow organisms to cope with these conditions; and organisms that possess one or more of these adaptations that may be found on the Charleston Bump. Students should realize that deep-sea conditions are "extreme" only in comparison to parts of the ocean that are more familiar to us. With the appropriate adaptations, these conditions are "normal" and often essential to organisms that live in deep-sea environments. Strong water flow, for example, can enhance the influx of food to filter-feeding organisms and reduce the accumulation of sediment on organisms and substrates. Point out that while photosynthesis is not possible in the absence of light, biological communities in the deep-sea may still receive a significant amount of nutrition from the influx organic material produced by photosynthesis in shallower water. Similarly, the remains of dead organisms that inhabit shallower waters settling to the bottom provide another source of nutrition that originates outside the deep-sea communities.

The BRIDGE Connection

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

The "Me" Connection

Have students write a short essay on what is necessary for humans to survive the physical conditions typical of the deep-sea environment.

Connections to Other Subjects

English/Language Arts, Life Science, Earth Science

Evaluation

You may want to require individual or group written reports prior to presentations and discussion in Step 3.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Charleston Bump Expedition discoveries, and to find out what explorers 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://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html – Summary report of the 2001 Islands in the Stream Expedition

http://www.marinebio.com/Oceans/TheDeep/ – Introduction to physical conditions in deep-sea environments

http://www.pbs.org/wgbh/nova.abyss/life.bestiary.html – Examples of organisms illustrating adaptations to the deep-sea environment

National Science Education Standards

Content Standard A: Science As Inquiry

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

Content Standard B: Physical Science

- Motions and forces

Content Standard C: Life Science

- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Content Standard D: Earth and Space Science

- Energy in the Earth system

For More Information

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