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2004 Estuaries to the Abyss Expedition

What's In That Cake?

Focus
Exploration of deep-sea habitats

Grade Level
5-6 (Life Science)

Focus Questions
How can scientists study organisms in deep-sea habitats on the Charleston Bump?

Learning Objectives
Students will be able to explain what a habitat is, and describe at least three functions or benefits that habitats provide.

Students will be able to describe some habitats that are typical of the Charleston Bump.

Students will be able to describe and discuss at least three difficulties involved in studying deep-sea habitats.

Students will be able to describe and explain at least three techniques scientists use to sample habitats such as those found on the Charleston Bump.

Materials
- ❑ At least two cakes or one cake for each student group, approximately 22 cm square or round
- ❑ Icing in various colors
- ❑ Candies or other edible materials for modeling habitat features
- ❑ Cardboard boxes large enough to cover cakes, one for each cake
- ❑ Piece of cardboard or foamcore, approximately 30 cm x 50 cm with a 3 cm x 22 cm "window" cut out of the center, one for each student group
- ❑ Large-diameter drinking straw (6mm or more), one for each student group
- ❑ Tweezers, one for each student group

Audio/Visual Materials
None

Teaching Time
Two or three 45-minute class periods, plus time for student research

Seating Arrangement
Classroom style

Maximum Number of Students
30

Key Words
Charleston Bump
Blake Plateau
Charleston Gyre
Precipitation
Supersaturated

Background Information
The Blake Plateau is a large sediment deposit located on the continental slope of the United States off the coasts of Florida, Georgia, South Carolina, and North Carolina. Depths on the plateau range from 400 to 1250 meters. On

the eastern edge of the Plateau, the Blake Ridge extends in a direction roughly perpendicular to the continental rise for more than 500 km to the southwest. To the east of the Ridge, water depths increase sharply to more than 4,000 m. The Blake Ridge has been extensively studied over the past 30 years because of the large deposits of methane hydrate found in the area, (visit http://198.99.247.24/scng/hydrate/about-hydrates/about_hydrates.htm for more information about methane hydrates and why they are important).

About 130 km east of the Georgia-South Carolina coast, a series of rocky scarps, mounds, overhangs, and flat pavements rise from more than 700 m at the surface of the Blake Plateau to within 400 m of the sea surface. This hard-bottom feature is known as the Charleston Bump.

The Charleston Bump was first discovered in the 1970's when scientists noticed an eastward deflection in the Gulf Stream off the coast of South Carolina. The cause of this deflection turned out to be the Charleston Bump, which also produces wave-like oscillations that roll northward toward Cape Hatteras. These waves produce another circulatory feature known as the Charleston Gyre. The Gyre is a reverse circulation that forms in the trough of the first wave downstream of the Charleston Bump, and resembles the dangerous hydraulics that form beneath waterfalls and river rapids (see "Eddies, Gyres, and Drowning Machines" at http://oceanexplorer.noaa.gov/explorations/03bump/background/edu/edu.html for more information).

In 1979, scientists correlated satellite observations of the Gyre with measurements made from a research ship that showed elevated phytoplankton pigment concentrations within the Gyre, suggesting that this circulation was associated with upwelling currents that bring nutrients to the surface and enhance phytoplankton growth. Despite these observations, and even though waters over the Charleston Bump have been important to commercial fishing for many years, the ecology of the Bump was not studied until very recently. Prior to these studies, it was generally assumed that fisheries were the result of migrations from other areas and/or nutrients carried in from deeper or coastal waters. And although no one had actually looked at the surface of the Charleston Bump, it was assumed that benthic communities were scattered and relatively unproductive. Once scientists actually began exploring the area more thoroughly, they found many diverse and thriving benthic communities.

The 2001 "Islands in the Stream" and 2003 "Investigating the Charleston Bump" Ocean Exploration expeditions found a series of very complex habitats on the Charleston Bump with numerous fishes and invertebrate species involved in communities that we are just beginning to understand. Major habitat types include steep, rocky slopes more than 25 m high; rock pavements without attached growth; areas of live coral and sponges on hard bottom pavements or rocks; broken pavement-rubble; low ledges, ridges, outcrops, and terraces; soft bottom (mud, silt, etc); coral mounds; and more extensive coral "fields." A key objective of the 2004 Estuary to the Abyss Expedition is to identify organisms that live in these habitats, and begin to study the ecological relationships between these organisms. A major challenge for scientists is how to accurately sample these habitats given the constraints of a hostile environment, as well as the need to minimize damage to the habitats caused by sampling.

In this activity, students will create edible models of Charleston Bump habitats, and devise ways to study and sample these habitats under less-than-ideal conditions.

Learning Procedure

[NOTE: Portions of this activity were adapted from "Edible Devonian Marine Ecosystem" by Naturalists at Falls of the Ohio State Park, Clarksville, Indiana, on the Geologic and

Paleontologic Cook Book website. Visit http://www/uky/edu/KGS/education/cookbook.html for more edible education ideas!]

1. Prepare cakes and gather decorating materials. You may want to have students volunteer to bring their own cakes (be sure to specify the size!). A standard box of cake mix will make two 22 cm round or square cakes. If cakes are iced, the icing should be uniformly spread over the surface, and be a single color to provide a "clean slate" for the students to work from.

2. Review the location and significance of the Charleston Bump and the 2001 and 2003 Ocean Exploration Expeditions to the area. The Web site 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 Web site 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 oceanexplorer Web site and/or http://pubs.usgs.gov/of/of01-154/index.htm.

   Discuss 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. 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. 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.

   Tell students that one of the challenges faced by scientists studying deep-sea communities is how to obtain information about the organisms living in the habitats without destroying the habitats or the scientists themselves. Point out that early scientific expeditions used dredges or trawls to sample deepwater areas, but that these techniques basically destroy whatever they sample. Being able to use deep-diving submersibles to visit these communities in person has many advantages, but also puts the scientists in greater danger from the extreme conditions in the deep-sea environment. Ask students to list some of these dangers. Their list should include extreme pressure, low temperatures, and darkness.

   Tell students that they are going to simulate some of these challenges in their classroom, and devise ways to study unfamiliar habitats under difficult conditions.

3. The first task for exploring new environments is to obtain a general idea of what types of habitats and organisms may be present. Tell student groups that they are to find out what sorts of habitats and organisms the 2001 and 2003 Ocean Exploration Expeditions found on the Charleston Bump. Have students read relevant trip logs from these expeditions at the Web sites listed above, and 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. Have each group present their research findings. Discuss and list the types of habitats found on the Charleston Bump, and the kinds of organisms that may be found in these habitats. Have students describe what functions or benefits organisms receive from each habitat type. Be sure students understand that previous expeditions have only identified a fraction of

the organisms that are probably present, so their list should consider habitats that may not have been sampled as yet. The combined list of habitats should include:

- steep, rocky slopes more than 25 m high
- rock pavements
- live corals and sponges
- broken pavement-rubble
- low ledges, ridges, outcrops, and terraces
- soft bottom (mud, silt, etc.)
- coral mounds;
- coral "fields."

5. Tell students that each group is going to construct an edible model of some of the habitats and organisms found on the Charleston Bump. Their model should contain at least three habitat types and at least one organism that uses each of the three habitats. The base of the model will be a cake. Have students brainstorm what kinds of edible features can be added to the cake to make the habitat model. Mounds of icing can be used for boulders, and when hardened can be sculpted to form caves and overhangs. Sponges might be modeled with small pieces of sponge cake (of course), and strings of rock candy (made by hanging pieces of string in a saturated sugar solution) could represent branching corals. Of course, there are many more possibilities, and your students will probably have a pretty good idea of potential model elements.

   Each group should prepare a written record of the habitats modeled, the organisms included for each habitat, and where the organisms are located. Be sure each group keeps their work secret from the other groups. When models are finished, they should be placed under a cardboard box so they cannot be seen.

6. Lead a discussion of techniques that could be used to sample organisms living in the eight major habitats found on the Charleston Bump.

State the following ground rules for sampling:

- all samples must be collected from the deep-diving submersible
- it is important to minimize damage to the habitats being sampled
- it isn't possible to sample every centimeter of a habitat, so sampling must be distributed over the entire study area
- time is severely limited, so it is important to get as much information as possible in a short amount of time

Photographic and video recordings are one of the most important sampling tools since they can cover large areas, cause no damage to the habitats (although bright lights may cause temporary or permanent blindness to light-sensitive organisms), and provide a permanent record of observations that can be studied in greater detail when scientists return from their dives.

When sampling unexplored areas, scientists often steer their submersible along a series of pre-determined paths called "transects" that cover the entire area. For example, this would be like sampling a football field at night by walking with a flashlight along every ten-yard line; the entire field would be covered, but only a small fraction would actually be seen. If a site has been previously visited, scientists may concentrate their sampling and observations on features of particular interest.

Samples of rocks and larger organisms such as corals and sponges can be collected with the submersible's manipulator arm. Scoops, cores, and suction devices may also be used to sample organisms living on living and non-living surfaces, as well as organisms in soft bottom habitats.

Be sure students realize that regardless of the sampling techniques used, some organisms will almost certainly escape detection, particularly those able to move rapidly away from a source of disturbance, such as fishes, squids, and many burrowing animals.

7. Tell students that their challenge is to sample an unknown environment (cake) to determine the habitats and organisms present. Since we are working with deep-sea environments, there will be some constraints on the sampling:
   - A total of two minutes will be allowed for the entire sampling program.
   - No more than 5% of the model may be damaged.
   - Samples may only be taken through a "window" 3 cm wide.
   - No more than 5 windows can be sampled.

   Provide each group with a pair of tweezers (simulating the submersible's manipulator arm), a large-diameter drinking straw (simulating a core sampler), and a piece of cardboard with a 3 cm x 23 cm slot (simulating the sampling window). Have each group write down their sampling strategy, indicating which students will be responsible for collecting each type of sample. One or two students may be assigned to record visual observations to simulate video recording.

   Working with one group at a time, provide the group with an unknown cake. Signal the start of the two-minute sampling period, and allow the group to begin their sampling program. Be sure that no more than five windows are sampled. Call out elapsed time every 15 seconds so that the group can pace their sampling activities.

   When all groups have completed their sampling, have each group prepare a written report on the habitats and organisms discovered in their model environment. Since they won't know what the various modeling materials are supposed to represent, they will have to identify the various features sampled by a description (red boulder, yellow gummy bear, etc).

8. Lead a discussion in which each group presents their report, and compares their findings with the records of the group that created the model. Have students verify that no more than 5% of the model has been damaged by the sampling procedure. Discuss ways in which sampling could be improved. Have students compare and contrast their sampling techniques with those actually used by scientists exploring the Charleston Bump. Point out that it would have been even more realistic if the entire sampling process were done in total darkness with only a small flashlight to guide the sampling effort.

   Following this discussion (and depending upon the condition of the cakes), invite students to assume the role of top consumers and have a direct interaction with their model environments (they can eat the cake).

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 on how explorations of areas like the Charleston Bump could be of direct benefit to their own lives.

Connections to Other Subjects

English/Language Arts, Physical Science, Life Science

Evaluation

Reports and records prepared in Steps 4, 5, and 6 provide opportunities for assessment.

Extensions

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

2. Visit http://oceanexplorer.noaa.gov/explorations/03bump/background/edu/edu.html for additional education activities related to exploration of the Charleston Bump.

Resources

oceanexplorer.noaa.gov/explorations/ 03bump/background/plan/plan.html – Simulated flyover of the Charleston Bump

http://www.bigelow.org/virtual/index_bath.html – Web resources for information and classroom activities on ocean bottom topography

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

http://www/uky/edu/KGS/education/cookbook.html – The Geologic and Paleontologic Cookbook

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
- 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 E: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Populations, resources, and environments

Content Standard G: History and Nature of Science
- Nature of science

For More Information

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