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Charleston Bump Expedition

Keep It Complex!

Focus
Effects of habitat complexity on biological diversity

Grade Level
9-12 (Life Science)

Focus Question
How does structural complexity of benthic habitats affect biological diversity of species living in those habitats?

Learning Objectives
Students will be able to describe the significance of complexity in benthic habitats to organisms that live in these habitats.

Students will be able to describe at least three attributes of benthic habitats that can increase the physical complexity of these habitats.

Students will be able to give examples of organisms that increase the structural complexity of their communities.

Students will be able to infer and explain relationships between species diversity and habitat complexity in benthic communities.

Materials
❒ Copies of "Species Distribution in Benthic Habitats," one for each student group

Audio/Visual Materials
❒ Chalkboard, marker board, or overhead projector with transparencies for brainstorming sessions.

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

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Charleston Bump
Habitat
Diversity
Diversity index
Species richness
Species evenness
Structural complexity

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.

As the Gulf Stream flows around and over the Charleston Bump it is deflected, producing eddies, gyres, and upwellings downstream (to the north). These kinds of water circulation patterns are associated with increased concentrations of nutrients and marine organisms in many other areas of the Earth's oceans, and may be an important factor to the productivity of the southern U.S. continental shelf.

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). One of the most conspicuous features of biological habitats on the Charleston Bump is spatial variety. Rock formations include flat pavements, boulders, caves, and overhangs. On top of this foundation, branching corals, sponges, and other animals add to the variety, creating countless "microhabitats" in many sizes. Numerous studies have shown that currents, sediment types, and physical structures are correlated with variations in the abundance and variety of organisms in marine biological communities.

Scientists often use the term "species diversity" to describe the abundance of species and individuals within an area (or environment). The simplest measure of species diversity is the number of species present in an area. This is called species richness. But there is more to diversity than just the number of species present. A community that has more or less equal numbers of individuals within the species present is usually thought of as more diverse than a community that is dominated by one species. For example, samples from two separate communities might each contain the same seven species, with distribution of individuals as follows:

Species	Number of Individuals	
	Community 1	Community 2
Species a	44	8
Species b	2	8
Species c	2	8
Species d	2	8
Species e	2	8
Species f	2	8
Species g	2	8
Total	**56**	**56**

Our notion of what "diversity" means leads us to consider Community 2 as more diverse than Community 1, even though they both have the same number of species and total individuals. [NOTE: You can demonstrate this more tangibly with an activity from The Moonsnail Project's mini-lecture on diversity at http://www.moonsnail.org/Mini_Diversity.htm; this site also has a related activity demonstrating the effect of sample size on diversity estimates].

Because of the importance of both species evenness and species richness to our idea of diversity, some measures of diversity include a way of including both concepts. One commonly used measure of species diversity that includes proportions of individuals is the Shannon-Weaver information function which is:

$$H = -\Sigma\, p_i \ln p_i$$

Where:
H is the diversity index
ln is the natural logarithm
i is an index number for each species present in a sample
p_i is the number of individuals within a species (ni) divided by the total number of individuals (N) present in the entire sample

To calculate the diversity index H, you multiply the proportion (p_i) of each species in the sample times the natural log of that same value (ln p_i), then sum (Σ) the values for each species, and finally multiply by minus 1.

The table below illustrates the calculation:

	Number of Individuals	Proportion (p_i)	$\ln(p_i)$	$p_i\ln(p_i)$
Species a	3	3÷47 = 0.064	-2.749	0.064 • -2.749 = -.176
Species b	5	5÷47 = 0.106	-2.244	0.106 • -2.244 = -.238
Species c	10	10÷47 = 0.213	-1.546	0.213 • -1.546 = -.329
Species d	6	6÷47 = 0.128	-2.056	0.128 • -2.056 = -.263
Species e	12	12÷47 = 0.255	-1.366	0.255 • -1.366 = -.348
Species f	7	7÷47 = 0.149	-1.904	0.149 • -1.904 = -.284
Species g	4	4÷47 = 0.085	-2.465	0.085 • -2.465 = -.123
Total	47			-1.761 (= $\Sigma p_i \ln p_i$)
H				-1 • $\Sigma p_i \ln p_i$ = 1.761

So, the diversity index H = 1.761.

For more background on species diversity, visit the Moonsnail Project's mini-lecture on diversity (referenced above), and the Arbor Project's web page on bird biodiversity at http://www.cees.iupui.edu/Outreach/SEAM/Biodiversity_Exercise.htm.

This activity is based on an investigation of the relationship between physical factors and biological diversity in a deep-sea benthic community.

Learning Procedure

1. Review 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. 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." 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 physical conditions such as currents, sediment type, various rock formations and organisms with complex physical forms (like branching corals and sponges) can create numerous microhabitats and as a result can provide food, shelter, and nursery places for many different kinds of organisms. Using images from the Ocean Explorer website and/or http:

//pubs.usgs.gov/of/of01-154/index.htm, prepare a list of organisms likely to be found on the Charleston Bump that can increase the structural complexity of their communities.

2. Lead a discussion about the concept of biodiversity. Show students the sample data given in the first table in "Background Information" and ask them which of the two communities they intuitively feel is most diverse. This should lead to the concepts of species richness and evenness. Say that the Shannon-Weaver information function is a commonly used index of diversity that incorporates both concepts of species richness and evenness. Work through the sample calculation, and be sure students understand the steps involved.

3. Tell students that a key objective of the 2003 Charleston Bump Expedition is to study relationships between physical complexity of benthic habitats and biological diversity within these habitats. Distribute copies of "Species Distribution in Benthic Habitats" to each student group. Tell students that they are to calculate the Shannon-Weaver diversity index for each of the habitats included in the study, and use this index to compare the biodiversity of the habitats. You may want to divide the assignment among the student groups (each group calculating the diversity index for one or two groups of data). You may also want to suggest that students use a spreadsheet program to speed the calculation process. One approach is to set up columns in the spreadsheet to make the calculations described in the sample diversity index calculation in "Background Information," then enter the species data for the appropriate communities.

4. Have student groups summarize their results on an overhead transparency, marker board, etc. This summary should resemble the following:

	Mixed #1	Mixed #2	Mud #1	Mud #2	Cobbles & Boulders #1	Cobbles & Boulders #2
Diversity Index H	1.34	1.15	1.18	0.72	1.64	1.35

Have each student write an individual analysis of these results, including inferences and explanations about relationships between species diversity and habitat complexity in benthic communities. Lead a group discussion of these results. Students should recognize that species groups on the most spatially complex substrates (cobbles and boulders) had the highest diversity, groups on the most uniform substrate (mud) had the lowest diversity, and groups on mixed substrates had diversities in between the other two groups. Students should realize (you may have to point this out), however, that this study only included species living on the surface of the three substrate types. If organisms living beneath the surface were included, the results might have been quite different, since the infauna of many benthic communities on the deeper portions of the continental shelf can be quite diverse.

Discuss the importance of spatial variety to biological diversity in benthic communities. Branched shapes, highly folded surfaces, and porous structures such as sponges, gravel, or loose sediment can multiply available surface area by orders of magnitude, and are an important feature of many biological structures (such as lungs, gills, and other surfaces where diffusion takes place). Surface area is significant to many organisms as a point of attachment or from which to graze microbial films. The same shapes and structures also often create a variety of enclosed spaces that increase the diversity of shelter types available within the community. Based on this discussion, have students describe the features of the most diverse benthic habitat they can imagine, and compare this hypothetical vision to what scientists actually find during the 2003 Charleston Bump Expedition.

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 contrasting and comparing the importance of diversity in ocean communities to their own communities.

Connections to Other Subjects

English/Language Arts, Earth Science, Mathematics

Evaluation

Individual and group reports in Step 4 provide opportunities for assessment.

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 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"

http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html – Summary report of the 2001 Islands in the Stream Expedition

http://www.moonsnail.org/Mini_Diversity.htm – The Moonsnail Project's mini-lecture on diversity

http://www.cees.iupui.edu/Outreach/SEAM/Biodiversity_Exercise.htm – The Arbor Project's web page on bird biodiversity

Hecker, B. 1990. Variation in megafaunal assemblages on the continental margin south of New England. Deep-Sea Research 37:37-57 – The technical journal article on which this activity is based.

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
- Behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

- Environmental quality

For More Information

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