ocean explorer
oceanexplorer.noaa.gov

The Gulf of Mexico Deepwater Habitats Expedition

Let's Go to the Video Tape!

Focus
Characteristics of biological communities on deep-water reef habitats

Grade Level
9-12 (Life Science)

Focus Question
How do species diversity and number of biological organisms vary among deep-water reef habitats?

Learning Objectives
Students will be able to recognize and identify some of the fauna groups found in deep-sea coral reef communities.

Students will be able to infer possible reasons for observed distribution of groups of animals in deep-sea coral reef communities.

Students will be able to discuss the meaning of "biological diversity," and will be able to compare and contrast the concepts of "variety" and "relative abundance" as they relate to biological diversity.

Given abundance and distribution data of species, students will be able to calculate an appropriate numeric indicator that describes the biological diversity of a community.

Materials
❒ Copies of "Results of a Video Survey on a Deep-water *Lophelia* Reef," one copy for each student group

Audio/Visual Materials
None

Teaching Time
One 45-minute class period

Seating Arrangement
Groups of 2-4 students

Maximum Number of Students
30

Key Words
Lophelia pertusa
Deep-water coral
Habitat
Biological diversity
Diversity index
Species richness
Species evenness

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.

Scientists on the expedition plan to make extensive use of video recordings to document fauna associated with *Lophelia* reefs, since bottom time is too limited to completely observe these organisms directly from a manned submersible. In this lesson, students will analyze data from a similar study, and make inferences about factors that may affect the distribution of organisms on and around *Lophelia* reefs.

Learning Procedure

1. Briefly review Background Iinformation 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 biological diversity. Two measurements are frequently used by scientists to describe the abundance of species and individuals within an area (or environment):
   - **Species Diversity (S)** - the number of species in the environment; and
   - **Species Evenness (or equitability)** - a measure of how evenly individuals are distributed among these species. Evenness is greatest when species are equally abundant.

   The simplest measure of species diversity is the number of species present in an environment. This is called "species richness". But there is more to diversity than just the number of species in an environment. 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.

Species diversity is often used as a measure of environmental health. A stressed environment typically has a lower number of species with one or two species (those adapted to the stress) having many more individuals than the other species. Species diversity tends to increase at the edges of environments (ecotones) where conditions are more variable. 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.

	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.

3. Provide students or student groups with copies of "Results of a Video Survey on a Deep-water *Lophelia* Reef." Tell students that they are to compare the communities of macrofauna on the five habitats, and make inferences about possible causes for patterns they observe. Say that they should consider total number of species and the biological diversity (calculated as explained above) in each habitat. You may want to assign one or two habitats to each group to reduce the time required to do the diversity calculations. Students should consider "unidentified" organisms as representing one species, and omit unquantified species from diversity calculations. Each group should prepare a brief written report in which they summarize their results and make inferences about factors that may affect the distribution organisms in these habitats.

4. Lead a discussion of students' results and inferences. Students should observe that diversity was highest in the dead *Lophelia* habitat, and lowest on the silt/clay bottom. Possible explanations for this are that dead *Lophelia* would provide a great deal of spatial variety and consequently many different types of shelter that could accommodate a wide range of organisms. Living *Lophelia* habitats might have a similar spatial variety, but the living corals might have defense mechanisms to reduce competition for space with other species. The silt/clay bottom would obviously have much less spatial variety, few solid points of attachment for sessile species, and could present fouling problems for filter feeders.

   The *Lophelia* rubble habitat had the lowest number of species, but the highest average density of individuals. This suggests that this habitat may be unsuitable for many of the species found in other habitats. Since species that can live in the rubble environment face less competition from other species, more individuals of rubble-tolerant species could exist in this habitat.

   None of the species observed in the mixed stone habitat was confined to this habitat alone, but also occurred in *Lophelia* and/or the silt/clay habitats. Studies of other *Lophelia* reefs have shown that biological communities on these reefs are not unique to *Lophelia* habitats, but usually occur elsewhere as well.

   Invite students to comment on the video survey methodology. Students should realize that this technique gives only a partial picture of the communities being studied. Two obvious examples are microbial organisms and organisms dwelling with the sediments. Both are invisible to the video camera, but almost certainly present. Both groups are very important components of many deep-sea bottom communities and are probably present in large numbers. Inclusion of these species could significantly change the overall impression of the biological communities associated with these habitats.

The BRIDGE Connection

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

The "Me" Connection

Have students write a short essay describing the major groups of organisms in their own biological community, and how they are connected to other communities.

Connections to Other Subjects

English/Language Arts

Evaluation

Written reports prepared in Step 4 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 researchers are learning about deep-water coral communities.

Assign one or more of the biological groups found in these habitats to each student group, and have the groups prepare short presentations on their assigned group including a description of the animal, habitat, food source(s) and feeding habits and an illustration.

Resources

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

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

Mortensen, P. B., M. Hovland, T. Brattegard, and R. Farestveit. 1995. Deep water bioherms of the scleractinian coral *Lophelia pertusa* (L) on the Norwegian shelf: Structure and associated megafauna. Sarsia 80:145-158. – The technical journal article upon which this activity is based

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

Content Standard F: Science in Personal & Social Perspectives

- Natural resources
- Environmental quality

For More Information

Paula Keener-Chavis, National Education Coordinator/Marine Biologist
NOAA Office of Exploration
2234 South Hobson Avenue
Charleston, SC 29405-2413
843.740.1338 843.740.1329 (fax)
paula.keener-chavis@noaa.gov

Acknowledgements

This lesson plan was produced by Mel Goodwin, PhD, The Harmony Project, Charleston, SC for the National Oceanic and Atmospheric Administration. If reproducing this lesson, please cite NOAA as the source, and provide the following URL:
http://oceanexplorer.noaa.gov

Student Handout

Results of a Video Survey on a Deep-water *Lophelia* Reef

(adapted from Mortensen, et al., 1995)

Organism	Density of Individuals (No. of Individuals/10m^2)				
	Silt/Clay Bottom	Mixed Stone	*Lophelia* Rubble	Dead *Lophelia*	Living *Lophelia*
Porifera					
Crustose sponges	*	*	*	*	*
Other sponges	*	*	*	*	*
Phakellia ventilabrum	0.17	1.98	0.44	0.67	0.03
Isops phlegraei	0.10	2.19	0.13	1.41	0.81
Axinella infundibuliformis	0.03	0.29	0.31	0.17	
Geodia sp.				0.07	
Cnidaria					
Cerianthus lloydii	*	0.01			
Paragorgia arborea		0.04	0.03	0.28	0.43
Paramuricea placomus		0.02		0.05	0.19
Trachymuricea kuekenthali				0.10	0.07
Primnoa resedaeformis		0.01		0.29	0.69
Actinostola callosa				0.02	0.07
Bolocera tuediae	0.02	0.02	0.03	0.10	0.09
Unidentified anthozoa					0.03
Unidentified stylasterid		0.01		0.02	
Unidentified hydroid		*			0.01
Polychaeta					
Unidentified sabellid				0.02	0.03
Crustacea					
Unidentified brachyuran					*
Lithodes maja		0.01		*	
Munida sarsi	0.34	0.29	4.03	0.33	0.31
Echiuridae					
Unidentified Echiuridae	0.02	0.02	0.090	0.03	0.31
Mollusca					
Neptunea despecta	*				
Acesta excavata		0.04		0.14	0.52
Bryozoa					
Unidentified bryozoan		0.03			

Student Handout *(continued)*

Organism	Density of Individuals (No. of Individuals/10m²)				
	Silt/Clay Bottom	Mixed Stone	*Lophelia* Rubble	Dead *Lophelia*	Living *Lophelia*
Echinodermata					
Unidentified asteroid	0.03				0.01
Cidaris cidaris	0.02	0.02		0.12	0.04
Hathrometra sarsii			0.06	0.03	0.19
Henricia sanguinolenta	0.14	0.07	0.03	0.12	0.11
Unidentified ophiuroid		0.02	0.03		
Parastichopus tremulus	0.08	0.02			
Teleostei					
Pollachiusvirens	1.10	1.39	3.25	3.03	1.15
Brosme brosme	0.02	0.02		0.02	0.03
Sebastes sp.	0.07	0.33	0.78	0.90	2.61
Chimaera monstrosa	0.03	*			
Gadus morhua					0.01
Unidentified teleost	0.09	0.02			*

* – present but not quantified