The Gulf of Mexico Deepwater Habitats Expedition

Keep Away

Focus
Effects of pollution on diversity in benthic communities

Grade Level
5-6 (Life Science)

Focus Question
How does pollution affect biological diversity in benthic communities?

Learning Objectives
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 information on number of individuals, number of species, and biological diversity at a series of sites, students will be able to make inferences about the possible effects of oil drilling operations on benthic communities at these sites.

Materials
- ❒ Copies of "Biological Data from Grab Samples Collected in the Vicinity of the Ekofisk Oilfield, North Sea," one copy for each student group
- ❒ Graph paper

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

Teaching Time
One 45-minute class period

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Lophelia pertusa
Diversity
Diversity index
Species richness
Species evenness
Pollution

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 spe-

cies 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.

In this activity, students will graph data from an investigation of the effects of oil drilling on marine benthic communities, and use these graphs to make inferences about these effects.

Learning Procedure

1. Briefly review Background Information on the Gulf of Mexico Deepwater Habitats Expedition, and deep-water reefs. Compare and contrast deep-water reef corals (e.g., *Lophelia pertusa*) with reef-building corals in shallow water. 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. Point out that there is a strong possibility that deep-water reefs contain many species that are currently unknown to science, and some of these may be directly beneficial to humans (for example, as sources of new drugs to combat human disease). At the same time, there is growing concern that these reefs are threatened by human activity, particularly fishing and petroleum exploitation, that may destroy valuable resources before they can be discovered. Visit http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup10_lophelia.html and http://www.oceana.org/uploads/oceana_coral_report.pdf for more background on deep-water reefs.

2. Review the concept of biological diversity. 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. [NOTE: You can demonstrate this 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.]

   Species diversity tends to increase at the edges of environments (ecotones) where conditions are more variable. Species diversity is often used as a measure of environmental health; diversity is generally expected to decline in a stressed environment. For more background and activities on species diversity, visit the Moonsnail Project's mini-lecture on diversity (http://www.moonsnail.org/

Mini_Diversity.htm), and the Arbor Project's web page on bird biodiversity at http://www.cees.iupui.edu/Outreach/SEAM/Biodiversity_Exercise.htm.

3. Tell students that they are going to analyze data from an investigation of the effects of oil drilling on marine benthic communities. Their assignment is to use their analyses to make inferences about these effects.

   Provide each student group with a copy of "Biological Data from Grab Samples Collected in the Vicinity of the Ekofisk Oilfield, North Sea" (grab samples are samples collected from the sea bottom with a device that resembles a giant clam shell). Have students sort the data into four groups: samples collected less than 500 m from the drilling platform, samples collected between 500 and 1,000 m, samples collected between 1,000 and 3,000 m, and samples collected more than 3,000 m from the platform. For each of these four groups, students should find the mean number of individuals, mean number of species, and mean diversity. Students should then construct three bar graphs, one each for mean number of individuals, mean number of species, and mean diversity, with the distance interval on the horizontal axis.

4. Lead a discussion of students' results. Means for each interval should be:

Distance from Drilling Platform (meters)	Mean Number of Individuals	Mean Number of Species	Mean Diversity
0-500	412	57	1.73
500-1,000	294	104	2.20
1,000-3,000	254	148	2.05
>3,000	152	113	2.05

   Ask students which of the four groups they would expect to be most affected by drilling operations, and how this group differs from the other groups. Students should identify the group of samples collected less than 500 m from the platform as the most likely to be affected, and should notice that this group has more individuals, fewer species, and lower diversity than the other groups. A probable explanation for these observations is that fewer species were able to tolerate effects produced by drilling operations, so the number of species and diversity were decreased; but individuals belonging to species that could tolerate these conditions faced less competition from other species, and so there were more individuals of the tolerant species.

   Ask students to infer what is happening at sites 500 – 1,000 m from the drilling platform. Here the number of species is less than at sites farther away from the platform, but more than at sites closer to the platform. This suggests that conditions at the 500 – 1,000 m sites were unfavorable to some species found at more distant sites, but still tolerable to others that are missing from sites closer to the platform. The number of individuals at the 500 – 1,000 m sites was higher than any of the other sites, perhaps because of reduced competition. Since the number of species was still fairly high, this increase in individuals caused the diversity to be higher (remember that diversity considers numbers of individuals as well as number of species).

   Ask students to interpret results from the groups that were 1,000 – 3,000 m and >3,000 m from the drilling platform. The diversity of these two groups is identical, yet the more distant group has fewer species and fewer individuals. One possible explanation is that low levels of pollution at the 1,000 – 3,000 m sites caused some species to disappear, but this allowed other species to come into the area. Another possibility is that these sites in these two groups were influenced by one or more factors other than the drilling platform.

The BRIDGE Connection

http://www.vims.edu/bridge/reef.html; www.vims.edu/bridge/vents.html; and www.vims.edu/bridge/geology.html

The "Me" Connection

Have students write a short essay describing how biological diversity is important to their own lives.

Connections to Other Subjects

English/Language Arts, Mathematics

Evaluation

Graphs prepared in Step 3 provide an opportunity for assessment. In addition, you may want to have each group prepare a written interpretation of their results prior to the group discussion in Step 4.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up with the latest Gulf of Mexico Deepwater Habitats Expedition discoveries, and to find out what explorers are learning about deep-water coral communities

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

Gray, J. S., K. R. Clarke, R. M. Warwick, and G. Hobbs. 1990. Detection of initial effects of pollution on marine benthos: an example from the Ekofisk and Eldfisk oilfields, North Sea. Marine Ecology Progress Series 66: 285-299 – 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
- Populations and ecosystems

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

For More Information

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Student Handout

Biological Data from Grab Samples Collected in the Vicinity of the Ekofisk Oilfield, North Sea

(from Gray, et al., 1990)

Distance from Drilling Platform (meters)	Number of Individuals	Total Number of Species	Diversity
120	362	47	1.60
235	462	67	1.86
340	392	42	1.63
450	432	72	1.83
600	274	84	2.00
720	314	124	2.40
850	289	99	2.10
950	299	109	2.30
1150	260	140	2.01
1250	248	156	2.09
2375	244	138	2.04
2800	264	158	2.06
3100	140	105	2.03
3800	164	121	2.07
4200	148	118	2.10
4900	156	108	2.00