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Life on the Edge: Exploring Deep Ocean Habitats

What Was for Dinner?

Focus
Use of isotopes to help define trophic relationships

Grade Level
9-12 (Life Science)

Focus Question
How can researchers determine trophic relationships in biological communities?

Learning Objectives
Students will be able to describe at least three energy-obtaining strategies used by organisms in deep-reef communities.

Students will be able to interpret analyses of $\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$ isotope values to draw inferences about energy-obtaining strategies used by organisms in deep-reef communities.

Materials
❒ Copies of "Isotope Analysis Results," one for each student group

Audio/Visual Materials
None

Teaching Time
One 45-minute class period

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Continental shelf
Continental slope
Hard bottom
Lophelia pertusa
Deep-water coral
Isotope analysis
$\delta^{13}C$
$\delta^{15}N$
$\delta^{34}S$

Background Information
For hundreds of years, thousands of fishermen have harvested U.S. coastal waters of the Atlantic Ocean and Gulf of Mexico. Yet, the marine habitats of the adjacent outer continental shelves and slopes are poorly studied and in many cases completely unknown. Until recently, most scientists assumed that these habitats did not support large or productive biological communities. Although no one had actually visited the edges of the continental shelves for a first hand look, they believed that the extensive commercial fisheries depended upon migrations from other areas and/or nutrients carried in from deeper or coastal waters. But once they actually began exploring the area more thoroughly, scientists found many diverse and thriving benthic communities.

Between North Carolina and Florida, several unique habitats are found where the topography of the outer continental shelf is extremely rugged and swept by the powerful currents of the Gulf Stream. Hard or "live" bottom habitats support diverse biological communities that include valuable fish and

invertebrate resources. On the edge of the continental shelf where depths range from 80 to 250 m, hard bottom communities provide the foundation for the food web of many commercially important species. But while scientists have studied many hard bottom communities within the range of SCUBA gear, they know very little about about the ecology of these communities in deeper waters.

Even deeper, on the middle of the continental slope, the deep-sea coral *Lophelia pertusa* forms another almost-unexplored habitat. Here, in depths of 400 to 700 m, branches of living coral grow on mounds of dead coral branches that can be several meters deep and hundreds of meters long. Unlike 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. Scientists suspect that many other organisms may also inhabit deep-sea coral reefs, including commercially important fishes and crustaceans. But they don't know for sure, because most of the hard bottom and deep-sea coral habitats on the edge and slope of the continental shelf are still unexplored.

The 2003 Life on the Edge Expedition will search previously unexplored hard bottom habitats and deep coral banks on the edge and slope of the continental shelf adjacent to the coasts of North and South Carolina and define the biological communities living in these habitats. Scientists plan to use ratios of carbon and nitrogen isotopes to help identify trophic relationships in these communities.

Isotope ratio studies are based on the fact that the amounts of the stable isotopes of carbon (^{13}C), nitrogen (^{15}N), and sulfur (^{34}S) vary depending upon food source. Isotope content is typically compared with a standard, and the results are expressed as delta values, abbreviated $\delta_{(x)}$ in parts-per-thousand (‰; also called "parts-per-mille"). In this activity, students will analyze isotope ratio data to make inferences about the source of food used by four fish species.

Learning Procedure

1. Review the general geographic location and form of the continental shelf adjacent to the U.S. Atlantic coast. Tell students that very little is known about the ecology of the edge and slope of the shelf, but that recent explorations have found diverse and thriving benthic communities. Visit http://oceanexplorer.noaa.gov for more background information about the Life on the Edge Expedition, and http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup10_lophelia.html for more background on *Lophelia* reefs. Tell students that one objective of the expedition is to learn more about the trophic relationships within deep-reef communities and between these communities and other parts of the ocean environment.

   Review the various options available to organisms in deep-reef communities for obtaining energy (food). Students should realize that the fundamental source of food for these communities is probably primary production (by phytoplankton and macro-algae such as *Sargassum*) that occurs in shallower waters, but there are multiple pathways through which this production can be conveyed to the deep-reef community. Briefly discuss the use of isotope analysis for obtaining clues about specific energy-obtaining strategies.

2. Distribute a copy of "Isotope Analysis Results" to each student group. Explain that these are results of studies on muscle tissues of four species of fishes. Muscle tissue was used because it has a longer turnover rate than other tissues, and thus integrates the diet of the fish over several months. Have each group construct a three-dimensional plot of the data (one axis for each of the three isotopes), compare the isotope analysis results with the

information on isotope values for various food sources (also on the handout) and prepare a brief written report on their inferences about the energy obtaining strategy used by each of the four species. Remind students to consider the standard error when deciding how different the isotope compositions are between species.

3. Have each group present their results, and summarize their inferences based on these data. Students should recognize that the isotope composition of vermillion snapper and round scad is similar, and that the isotope composition of tomtate and red porgy is also similar, but different from that of vermillion snapper and round scad. The data also suggest that vermillion snapper and round scad are pelagic feeders, and that tomtate and red porgy feed on benthic and demersal organisms. While $\delta^{15}N$ values were similar for all four species, $\delta^{13}C$ and $\delta^{34}S$ were different for the two groups.

The BRIDGE Connection

www.vims.edu/BRIDGE/ – Click on "Ocean Science" in the navigation menu to the left, then "Ecology," then "Coral" for resources on corals and coral reefs.

The "Me" Connection

Have students write a short essay on their personal strategy for obtaining energy, and how many different pathways ae involved in this strategy.

Connections to Other Subjects

English/Language Arts; Physical Science; Mathematics

Evaluation

Reports prepared in Step 2 provide opportunity for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Life on the Edge 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"

Thomas, C. J. and L. B. Cahoon. 1993. Stable isotope analyses differentiate between different trophic pathways supporting rocky-reef fishes. Marine Ecology Progress Series 95: 19-24. – The technical journal article upon which this activity is based

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

National Science Education Standards

Content Standard A: Science as Inquiry

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

Content Standard B: Physical Science

- Structure of atoms
- Chemical reactions

Content Standard C: Life Science

- Interdependence of organisms

Content Standard F: Science in Personal and Social Perspectives

- Natural resources

For More Information

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Acknowledgements

This lesson plan was produced by Mel Goodwin, PhD, The Harmony Project, Charleston, SC for the National Oceanic and Atmospheric Administration.

Student Handout

Isotope Analysis Results (adapted from Thomas and Cahoon, 1993)

	Mean δ Values (‰ ± standard error)		
Species	$\delta^{13}C$	$\delta^{15}N$	$\delta^{34}S$
Round scad	-17.3 ± 0.10	10.5 ± 0.12	17.1 ± 0.18
Vermillion snapper	-17.4 ± 0.04	10.1 ± 0.08	17.3 ± 0.15
Red porgy	-16.2 ± 0.16	10.6 ± 0.16	16.4 ± 0.17
Tomtate	-15.9 ± 0.20	10.0 ± 0.24	15.8 ± 0.26

Isotope Values for Various Food Sources

Food Source	$\delta^{13}C$	$\delta^{15}N$	$\delta^{34}S$
Plankton	-18.4 – -22.1	10.2 – 11.2	16.9 – 17.7
Pelagic Species	-17.0 – -19.0	11.2 – 15.2	16.8 – 17.2
Benthic Species	-9.8 – -16.1	10.0 – 11.2	15.6 – 16.4