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Life on the Edge: Exploring Deep Ocean Habitats

Ring Detectives

Focus
Warm- and cold-core rings in the Gulf Stream

Grade Level
7-8 (Physical Science/Earth Science)

Focus Question
What are Gulf Stream rings, and why are they significant?

Learning Objectives
Students will be able to describe the overall flow of the Gulf Stream, and explain how it affects biological communities in the North Atlantic Ocean.

Students will be able to describe Gulf Stream rings, and explain how they are formed.

Students will be able to compare and contrast warm-core rings and cold-core rings.

Students will be able to explain how Gulf Stream rings may affect biological communities on the edge and slope of the continental shelf adjacent to the coasts of North and South Carolina.

Materials
❒ Computers with internet access

Audio/Visual Materials
None

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

Seating Arrangement
Groups of 4-6 students

Maximum Number of Students
30

Key Words
Continental shelf
Continental slope
Hard bottom
Lophelia pertusa
Gulf Stream
Warm-core ring
Cold-core ring

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. Strong currents associated with the Gulf Stream are expected to have a significant influence on these communities. This lesson focuses on another prominent feature that may also be important: Gulf Stream rings.

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.

   Review the general location and circulation pattern of the Gulf Stream. Ask students to list some ways that the Gulf Stream may affect biological communities on the edge and slope of the continental shelf adjacent to the coasts of North and South Carolina.

2. Tell students that their assignment is to investigate a feature of the Gulf Stream known as "Gulf Stream rings." Each student group should prepare a written report that will include:
   - a description of Gulf Stream rings;
   - an explanation of how Gulf Stream rings are formed;
   - at least one satellite image illustrating warm- and cold-core rings; and
   - a discussion of at least three ways in which Gulf Stream rings may be significant to biological communities on the edge and slope of the continental shelf.

3. Have each student group present the results of their research. At some point you may want to briefly discuss meanders in general. Flowing water rarely moves in a constant direction. Think about streams or even water flowing over a windshield; meanders are common, because this flow pattern often consumes less overall energy than flow in a constant direction. Student presentations should include most of the following points:
   - The flow of the Gulf Stream parallels the U.S. coast off Florida, Georgia, and South

Carolina. North of Cape Hatteras, the Gulf Stream begins to flow away from the coast.

- The Gulf Stream separates the cold continental slope water (less than 10° C) to the north and west from the warm Sargasso Sea (15° – 25°C) to the south and east.
- The flow of the Gulf Stream is not constant. Like most flowing water, the Gulf Stream meanders over distances as great as 350 km. Sometimes these "side trips" form loops and become separated from the main water mass. These separated loops are known as "Gulf Stream rings."
- If the Gulf Stream meanders to the north, a piece of warm water from the Sargasso Sea may become trapped inside the loop of the meander. If the loop separates from the Gulf Stream, it becomes a warm-core ring (Figure 1). Warm-core rings have a clockwise (anticyclonic) circulation.
- If the Gulf Stream meanders to the south, a piece of cold water from the continental slope may become trapped inside the loop of the meander. If the loop separates from the Gulf Stream, it becomes a cold-core ring (Figure 2). Cold-core rings have a counterclockwise (cyclonic) circulation.
- Cold-core rings may last for several years, usually have diameters ranging from 150 to 300 km, and may extend as deep as the ocean floor (4,000 to 5,000 meters).
- Warm-core rings usually last for less than a year, have diameters of 100 to 200 km, and do not extend as deep, though they may be deep enough to reach the continental shelf and slope.
- Gulf Stream rings play an important role in the transport and redistribution of heat and salinity from one water mass to another, as well as in exchanging heat and water with the atmosphere. The turbulence associated with rings also contributes to the distribution of nutrients in highly productive areas like the Grand Banks.
- Both warm- and cold-core rings trap and transport organisms.
- Cold-core rings typically cover as much as 15% of the Sargasso Sea, while warm-core rings usually occupy 40% of the continental slope water.

The BRIDGE Connection

www.vims.edu/BRIDGE/ – Click on "Ocean Science" in the navigation menu to the left, then "Physics," then "Currents" for resources on the Gulf Stream.

The "Me" Connection

Have students write a short essay on how Gulf Stream rings might directly or indirectly affect their own lives.

Connections to Other Subjects

English/Language Arts, Life Science

Evaluation

Written reports prepared in Step 2 and oral reports in Step 3 provide opportunities for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest discoveries by the Life on the Edge Expedition, and to find out what researchers are learning about deep-water hard-bottom communities.

Visit http://www.k12science.org/curriculum/gulfstream/ for more activities on the Gulf Stream.

Resources

http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup10_lophelia.html – Background on *Lophelia* reefs from the 2001 Islands in the Stream Expedition

http://www.k12science.org/curriculum/gulfstream/ – The Gulf Stream Voyage website developed and managed by the Center for Improved Engineering and Science Education (CIESE) at Stevens Institute of Technology in Hoboken, NJ

http://fermi.jhuapl.edu/student/phillips/ – Background information on the Gulf Stream

http://kingfish.coastal.edu/marine/gulfstream – Tutorial on the Gulf Stream

http://www.imcs.rutgers.edu/mrs/education/education.htm – Rutgers Coastal Ocean Observation Lab with classroom activities

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"

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

- Motions and forces
- Transfer of energy

Content Standard C: Life Science

- Populations and ecosystems

Content Standard D: Earth and Space Science

- Structure of the Earth's system.

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments

For More Information

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