



Life on the Edge: Exploring Deep Ocean Habitats

Going for the Green

FOCUS

Seasonal variation in primary production over the southeastern U.S. continental shelf

GRADE LEVEL

5-6 (Life Science/Earth Science)

FOCUS QUESTION

How does primary production vary at different times of the year in the ocean over the southeastern U.S. continental shelf?

LEARNING OBJECTIVES

Students will be able to use satellite imagery to obtain information on chlorophyll concentration at selected locations in the Earth's oceans.

Students will be able to explain the relationship between chlorophyll concentration and primary production.

Students will be able to describe seasonal variations in primary production over the southeastern U.S. continental shelf, and suggest possible explanations for these variations.

Students will be able to describe the potential significance of observed variations in primary production to biological communities.

MATERIALS

- Computers with internet access
- Copies of "How to Retrieve Sea Surface Chlorophyll Data Collected by SeaWiFS," one copy for each student group

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
Primary production
Chlorophyll
SeaWiFS

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 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. Although they are

mainly focused on bottom habitats, scientists also plan to gather data on biological communities at the ocean surface because their previous research has indicated that surface plankton and the alga *Sargassum* serve as primary carbon sources (i.e., they are the primary producers in the food web). Primary production is affected by water temperature and the availability of nutrients. The Gulf Stream is expected to have a major influence on primary production in this area, since water temperature and availability of nutrients are known to affect photosynthetic processes.

In this activity, students will use satellite data to make inferences about primary production over the southeastern U.S. continental shelf at different times of the year.

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 concept of food webs and primary production. Tell students that the most familiar food webs are based on photosynthesis, but that other (chemosynthetic) food webs also exist. Visit http://www.bio.psu.edu/cold_seeps and <http://www.bio.psu.edu/hotvents> for more information about chemosynthetic food webs in hydrothermal vent and cold seep communities. Be sure students understand the role of chlorophyll in photosynthesis, and what factors may affect how much photosynthesis takes place. These factors include sunlight, carbon dioxide, nutrient availability, and quantity of organisms capable of photosynthesis. Remind students that cold water can hold more dissolved carbon dioxide than warm water.

Tell students that they will be using satellite data to make inferences about primary production in the area being studied by the Life on the Edge Expedition. Explain that these data are collected by a Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite which measures the color of the world's oceans. Color is directly related to photosynthetic activity, because the visible color in most of the world's oceans varies with the concentration of chlorophyll and other plant pigments present in the water, so the oceans appear greener where more phytoplankton are present. The SeaWiFS satellite can view all of the Earth's oceans (except where the oceans are obscured by clouds) every 48 hours. Data are available via the internet for education and research purposes.

2. Tell students that their assignment is to investigate how the chlorophyll concentration varies at the surface of the ocean over the southeastern U.S. continental shelf, and to use this information to make inferences about primary production in the area. Provide each student group with a copy of "How to Retrieve Sea Surface Chlorophyll Data Collected by SeaWiFS." Suggest that each group should obtain data from at least one image collected in mid-spring, mid-summer, mid-fall, and mid-winter. Point out that not every image will be suitable because of cloud cover on some days. Each group should prepare a written report including the images they analyzed, and their inferences about seasonal variation in primary production in the area being studied by the Life on the Edge Expedition.

If time is available, you may also want to have your students examine records of sea surface temperature at <http://marine.rutgers.edu/mrs/sat.data2.html>. Students should click on the southeast U.S. coastal region, then select the desired dates to display maps of sea surface temperature. These maps may be used to

locate the Gulf Stream and may be compared with images of chlorophyll distribution to see if temperature appears to have an effect on surface productivity.

3. Have each group make an oral presentation of their results, and infer what factors may have been responsible for observed changes. Students may notice that chlorophyll concentration is higher along the coastlines, and may infer that this is due to increased levels of nutrients in coastal waters, particularly in the spring when melting snow increases runoff. They should also notice that there is more chlorophyll present in the fall than in the spring because the summer sunlight has allowed phytoplankton to bloom in the area. Students should also notice that chlorophyll concentrations in the vicinity of the Gulf Stream are relatively low, and may infer that this suggests low nutrient concentrations.

THE BRIDGE CONNECTION

www.vims.edu/BRIDGE/ – Click on "Ocean Science" in the navigation menu to the left, then "Biology," then "Plankton" for resources on phytoplankton and the use of satellites to study primary production.

THE "ME" CONNECTION

Have students write a short essay on how knowledge of primary production in the ocean surface could be of practical benefit to people other than scientists.

CONNECTIONS TO OTHER SUBJECTS

English/Language Arts, Physical 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 explorers are

learning about deep-water hard-bottom communities.

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

Visit <http://octopus.gma.org/surfing/summary.html>, and <http://www.imcs.rutgers.edu/mrs/education/education.htm> for more activities using satellite imagery.

Visit <http://seawifs.gsfc.nasa.gov/SEAWIFS.html> for more background and activities related to the SeaWiFS project.

RESOURCES

<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, New Jersey

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

<http://octopus.gma.org/surfing/summary.html> – Activities using satellite imagery

<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”

<http://seawifs.gsfc.nasa.gov/> – the SeaWiFS website

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 D: Earth and Space Science

- Structure of the Earth system

Content Standard E: Science and Technology

- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments

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. If reproducing this lesson, please cite NOAA as the source, and provide the following URL:
<http://oceanexplorer.noaa.gov>

Student Handout

How to Retrieve Sea Surface Chlorophyll Data Collected by SeaWiFS

1. Go to the SeaWiFS browser page at http://seawifs.gsfc.nasa.gov/cgi/seawifs_browse.pl. You will see a global map displaying recent sea surface temperature information. Beneath the map are links to navigate to sea surface temperature images for other dates.
2. Click on a month to retrieve data from a specific month in the present year, or click on "Previous Year" link to select months from earlier years. A new global map will appear.
3. Click on a portion of the global map to retrieve records from a specific geographic location. For this lesson, click near the southeastern coast of the United States. A new page will open headed "Multiple Hits," and a series of thumbnail maps will be displayed for the month specified. The earliest dates are on the left.
4. Click on one of the thumbnail maps that provides good coverage of the sea surface (white areas have no data, usually because of cloud cover). The entire map will be displayed on the left side of the screen. The date is shown near the middle of the screen. Use your web browser to copy the map, then paste it into a word processing program for use in your report. Be sure to label the pasted map with the correct date.
5. Click on the rainbow-colored scale to show the chlorophyll concentration that corresponds to the various colors on the map. Copy this scale and paste it into your word processing document as well.
6. Click on "Yearly" and repeat Steps 2 through 4 to retrieve more maps for other dates.