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2006 Olympic Coast Deep Corals Expedition

Deep Gardens
(adapted from the Florida Coast Deep Corals 2005 Expedition)

Focus
Deep-sea coral reefs

Grade Level
5-6 (Life Science)

Focus Question
How do deep-sea coral reefs compare to coral reefs in shallow tropical waters?

Learning Objectives
Students will be able to compare and contrast deep-sea coral reefs with their shallow-water counterparts.

Students will be able to describe three types of coral associated with deep-sea coral reefs.

Students will be able to explain three benefits associated with deep-sea coral reefs.

Students will be able to explain why many scientists are concerned about the future of deep-sea coral reefs.

Materials
- ❒ Access to the internet, or copies of materials cited in "Learning Procedure"
- ❒ Copies of "Deep-Water Coral Reefs Report Guide," one copy for each student or student group
- ❒ Bulletin board or poster board

Audio/Visual Materials
- ❒ None

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Classroom style

Maximum Number of Students
30

Key Words
Deep-sea coral
Lophelia pertusa
Cnidaria

Background Information
For hundreds of years, fishermen have harvested coastal waters of the Pacific Northwest. Yet, the deepwater habitats that support these fisheries are poorly studied and in many cases completely unknown. On deeper portions of the continental shelves, hard or "live" bottom habitats support diverse biological communities that provide the foundation for the food web of many commercially-important species. Deep-water corals, particularly corals belonging to the genus *Lophelia*, form reefs that may have a diversity of species comparable to that of corals reefs in shallow waters. Often, sponges and soft corals are important parts of these reefs as well. But although shallow coral reefs have been studied extensively, scientists know very little about about the ecology of coral communities in depths beyond the range of SCUBA gear.

The Olympic Coast National Marine Sanctuary (OCNMS) is an area of 3,310 square miles off of Washington State's Olympic Peninsula, as well as 135 miles of shoreline that includes some of the last remaining wilderness coastline in the lower 48 states. The seaward boundary of the Sanctuary extents 40 miles offshore to depths of 1,400 m, and encompasses most of the continental shelf, as well as a variety of marine habitats including kelp beds, subtidal reefs, rocky and sandy intertidal zones, submarine canyons and plankton-rich upwelling zones. Acoustic surveys between 2001 and 2004 revealed deep, hard-bottom areas that scientists believe may include extensive coral and sponge communities. These habitats are part of one of the most productive marine ecosystems in North America, and support many commercial fisheries, including halibut, hake, salmon, and rockfish. The overall mission of the OCNMS was to protect the Olympic Coast's natural and cultural resources by conserving its resources as well as encouraging uses that are compatible with conservation.

A growing concern among managers of the OCNMS is the impact of bottom-fishing on deep-water coral and sponge habitats. Species that form deep-water habitats typically have long life-spans, slow growth rates, and fragile structures that make them particularly vulnerable and slow to recover from physical damage. Many investigations have reported large-scale damage to deep-water reefs caused by commercial fishing trawlers. There is also concern about damage that might result from other activities such as exploration and extraction of fossil fuels, and trenching for installation of submarine cables. Because the mission of the OCNMS is to protect the Olympic Coast's resources for the use and enjoyment of future generations, there is an urgent need to locate deep-sea coral and sponge communities so appropriate protective actions can be taken.

The central objective of the Olympic Coast Deep Corals Expedition was to document the location and condition of deep-sea coral and sponge communities in the Olympic Coast National Marine Sanctuary. The Expedition used an underwater robot called ROPOS (Remotely Operated Platform for Ocean Science) owned by the Canadian Scientific Submersible Facility to obtain video and photographic documentation of deep-sea coral and sponge communities, as well as to collect biological samples from these communities for species identification. Specific objectives of the Expedition included:

- Locating and mapping deep-sea coral and sponge communities in the Sanctuary;
- Characterizing diversity, abundance, and health of living marine resources associated with these communities; and
- Documenting the impact of fishing activities on these communities.

In this lesson, students will explore the variety of corals found on deep-water coral reefs, potential benefits that these reefs offer, and why scientists are concerned about their future.

Learning Procedure

1. To prepare for this lesson, read the introductory essays for the Olympic Coast Deep Corals Expedition at http://oceanexplorer.noaa.gov/explorations/06olympic.

2. Briefly review the basic biology and classification of the phylum Cnidaria (for an easy introduction to the phylum, check out http://www.ucmp.berkeley.edu/cnidaria/cnidaria.html). You may also want to view and possibly download the video of deep-sea corals from http://oceanexplorer.noaa.gov/explorations/02alaska/logs/summary/media/movies/deepseacoral_video.html. Alternatively, you may want to have students research answers to a series of questions based on the following list. Here are some points that you may want to include in this review:
   - 'Cnidaria' means 'stinging nettle' in Greek; the name comes from the stinging cells called nematocysts, which are the primary distinguishing characteristic of the phylum; nematocysts often contain toxins; some box jellies

have toxins powerful enough to kill humans.
- All Cnidarians live in water.
- Cnidarians are radially symmetrical.
- There are two body plans among the Cnidaria: the "jellyfish plan" is called a medusa, which has an umbrella-shaped body with the mouth facing downwards, surrounded by tentacles; the "flower plan" is called a polyp, which has a body resembling the trunk or stem of a plant with its mouth facing upwards, also surrounded by tentacles; the other end of the polyp is usually attached to a fixed surface.
- Cnidarians have nerve cells and muscles, but do not have organs such as brains, hearts, circulatory or excretory systems.
- Cnidarians have simple digestive systems without an anus; the mouth is used for output as well as input.
- Most cnidarians are carnivorous; many feed on small particles of detritus and plankton, but others are able to capture and eat large prey.
- Some cnidarians, including many corals, have symbiotic single-celled algae called zooxanthellae that use photosynthesis to produce food that their cnidarian hosts are able to use; corals that do not have zooxanthellae are called azooxanthellate.
- Many cnidarians, including many corals, are colonial, with many individual animals living together as one organism.
- Cnidarians maintain their shape with fluids inside their bodies (this is called a hydrostatic skeleton).
- Some cnidarians also produce a hard internal skeleton of limestone (this is what makes some of the hard structures that form coral reefs).
- Some corals are used to make jewelry; coral reefs protect many coastal areas from erosion and storm damage, provide habitat and nursery areas for fishes that provide food for many people around the world, and support tourist industries in many countries; some reef-dwelling organisms are the source for important pharmaceuticals.
- The phylum Cnidaria is divided into four classes (there more classes, but they only contain extinct species): class Anthozoa includes the corals, anemones, and sea pens; class Cubozoa includes the highly toxic box jellies; class Hydrozoa includes hydroids, fire corals, and animals resembling jellyfish like the Portuguese man-of-war; class Scyphozoa includes the true jellyfish.
- The life cycle of many cnidarians includes a polyp phase as well as a medusa phase, but there is never a medusa phase in the Anthozoa (for more about cnidarian reproduction, see the lesson plan, "Architects of the Deep Reef" at http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_architects.pdf).

3. Assign one of the following coral species or groups to each student:
   Acanella sp.
   Antipatharia
   Callogorgia sp.
   Gorgonia sp.
   Hydrocoral
   Lophelia pertusa
   Madrepora occulata
   Octocoral
   Oculina varicosa
   Paragorgia
   Primnoa
   Scleractinia

   Tell students that their assignment is to find, copy, and label (with the name of the coral) a photograph of their assigned coral, and prepare a brief report (three to five paragraphs) that includes answers to questions on the "Deep-Water Coral Reefs Report Guide." You may choose to provide copies of the following articles, or provide the url links, or allow students to discover these (or others) on their own:

   "What are deep-sea corals?" by Lance Morgan; Current 21(4):2-4; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/What_are_DSC.pdf

"Trawlers Destroying Deep-Sea Reefs, Scientists Say," by John Pickrell; National Geographic News, February 19, 2004 (http://news.nationalgeographic.com/news/2004/02/0219_040219_seacorals.html)

4. Create a collage of deep-sea corals by having each student place the labeled photograph of their assigned coral on a bulletin board or a piece of poster board. Some notes about classification and common names are provided below (note that some authorities use alcyonaria instead of octocorallia):

   Acanella sp. (common name: bamboo coral; class Anthozoa, subclass Octocorallia)

   Antipatharia (common name: black coral; class Aanthozoa, subclass Hexacorallia, order Antipatharia)

   Callogorgia sp. (common name: gold coral; class Anthozoa, subclass Octocorallia)

   Gorgonia sp. (common name: sea fan; class Anthozoa, subclass Octocorallia)

   Hydrocoral (common name: fire coral; class Hydrozoa, order Milleporina)

   Lophelia pertusa (class Anthozoa, subclass Zoantharia, order Scleractinia)

   Madrepora occulata (class Anthozoa, subclass Zoantharia, order Scleractinia)

   Octocoral (common name: soft coral; class Anthozoa, subclass Octocorallia)

   Oculina varicosa (common name: ivory tree coral; class Anthozoa, subclass Zoantharia, order Scleractinia)

   Paragorgia (common name: bubblegum coral; class Anthozoa, subclass Octocorallia)

   Primnoa (common name: red trees; class Anthozoa, subclass Octocorallia)

   Scleractinia (common name: stony coral; class Anthozoa, subclass Zoantharia, order Scleractinia)

5. Lead a discussion of students' answers to worksheet questions. Be sure students understand that deep-sea coral reefs:
   - Are at least as diverse as their shallow-water counterparts;
   - Provide habitat for many other species (some of which are important human food species);
   - Probably include organisms that can provide useful drugs to treat human diseases; and
   - Are severely threatened by human activity, particularly bottom trawling and longlining.

   The following points should be included:
   - The majority of coral species live in colder, deeper waters.
   - *Lophelia pertusa* is found on deep-sea reefs on continental margins worldwide.
   - Because deep-sea exploration is difficult, our knowledge of deep-sea environments is very limited, and this has led to the widespread assumption that coral reefs are confined to shallow waters.
   - Gorgonians, alcyonaceans, pennatulaceans, and stoloniferans belong to the subclass Alcyonaria or Octocorallia and are collectively referred to as octocorals or soft corals.
   - Only members of the order Scleractinia actually form true coral "reefs."
   - Some deep-sea reefs in the North Atlantic have been found to harbor as many as 1,300 invertebrate species.
   - Growth and reproduction in deep-sea corals is very slow.
   - Some deep-sea corals may be hundreds of years old; one individual has been dated at

1,800 years old.

- At present, the greatest threat to deep-sea coral communities is bottom trawling.
- In addition to deep-sea corals, sponges also form highly diverse communities in the deep ocean.

The Bridge Connection

http://www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Ocean Science Topics," then "Biology," then "Invertebrates," then "Other Inverts" for links to more information about Cnidaria

The "Me" Connection

Have students write a short essay on how deep-sea coral reefs could be of personal importance, and how they might be personally affected by the widespread destruction of these reefs.

Connections to Other Subjects

English/Language Arts, Earth Science

Assessment

Written reports and discussions in Steps 3 and 4 provide opportunities for assessment.

Extensions

1. Have students visit http://oceanexplorer.noaa.gov/explorations/06olympic to explore the discoveries made during the Olympic Coast Deep Corals Expedition.

2. See the July 2005 issue of *Current: the Journal of Marine Education* for a special issue on deep-sea corals (available online at http://www.mcbi.org/what/current.htm), including three lesson plans for Grades 5 - 12.

Resources

http://oceanexplorer.noaa.gov/explorations – Web site for NOAA's Ocean Exploration Program

Pickrell, J. 2004. Trawlers Destroying Deep-Sea Reefs, Scientists Say. National Geographic News. http://news.nationalgeographic.com/news/2004/02/0219_040219_seacorals.html

http://www.mcbi.org/what/current.htm – A special issue of *Current: The Journal of Marine Education* on deep-sea corals.

Morgan, L. E. 2005. What are deep-sea corals? *Current* 21(4):2-4; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/What_are_DSC.pdf

Frame, C. and H. Gillelan. 2005. Threats to deep-sea corals and their conservation in U.S. waters. Current 21(4):46-47; available online at http://www.mcbi.org/what/what_pdfs/Current_Magazine/Threats_Conservation.pdf

Roberts, S. and M. Hirshfield. Deep Sea Corals: Out of sight but no longer out of mind. http://www.oceana.org/fileadmin/oceana/uploads/reports/oceana_coral_report_final.pdf — Background on deep-water coral reefs

http://www.oceanicresearch.org/ – The Oceanic Research Group Web site; lots of photos, but note that they are very explicit about their copyrights; check out "Cnidarians: Simple but Deadly Animals!" by Jonathan Bird, which provides an easy introduction designed for classroom use

http://www.mesa.edu.au/friends/seashores/index.html – "Life on Australian Seashores" by Keith Davey on the Marine Education Society of Australasia Web site, with an easy introduction to Cnidaria, including their method of reproduction.

http://www-biol.paisley.ac.uk/courses/Tatner/biomedia/units/cnid1.htm – Phylum Cnidaria on Biomedia of the Glasgow University Zoological Museum on the Biological Sciences, University of Paisley, Scotland Web site; includes explanations of the major classes, a glossary of terms, diagrams and photos.

http://www.calacademy.org/calwild/2000fall/stories/seavenoms.html – Article from California Wild: "Stinging Seas - Tread Softly In Tropical Waters" by Gary C. Williams; an introduction to the venomous nature of tropical cnidarians, why and how they do it

http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html – Ocean Explorer photograph gallery

http://oceanexplorer.noaa.gov/explorations/02alaska/logs/summary/media/movies/deepseacoral_video.html – Online video of deep-sea corals from the Ocean Explorer 2002 Gulf of Alaska Expedition

http://olympiccoast.noaa.gov/ – Web site for the Olympic Coast National Marine Sanctuary

http://www.nccos.noaa.gov/ – Web site for the NOAA's National Centers for Coastal Ocean Science, which conduct and support research, monitoring, assessments, and technical assistance for coastal stewardship and management; and participated in the Olympic Coast Deep Corals Expedition

http://www.nurp.noaa.gov/ – Web site for the National Undersea Research Program, which provides scientists with the tools and expertise for investigations in the undersea environment, including submersibles, remotely operated vehicles, autonomous underwater vehicles, mixed gas diving gear, underwater laboratories and observatories, and other cutting edge technologies

http://www.nwfsc.noaa.gov/ – Web site for the Northwest Fisheries Science Center, which studies living marine resources and their habitats in the Northeast Pacific Ocean and in freshwater rivers and streams in Washington, Oregon, Idaho, and Montana.

National Science Education Standards

Content Standard A: Science As Inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science
- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

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
- Risks and benefits
- Science and technology in society

Content Standard G: History and Nature of Science
- Science as a human endeavor
- Nature of science

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
The Earth has one big ocean with many features.
- *Fundamental Concept h.* Although the ocean is large, it is finite and resources are limited.

Essential Principle 5.
The ocean supports a great diversity of life and ecosystems.
- *Fundamental Concept d.* Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
- *Fundamental Concept e.* The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Essential Principle 6.
The ocean and humans are inextricably interconnected.

- *Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
- *Fundamental Concept c.* The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
- *Fundamental Concept e.* Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
- *Fundamental Concept g.* Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Essential Principle 7.
The ocean is largely unexplored.

- *Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
- *Fundamental Concept c.* Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.
- *Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- *Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

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Student Handout
Deep-Water Coral Reefs Report Guide

1. Are more coral species found in warm, shallow water or cold, deep water?

2. What is one species of deep-sea coral that is found in large reefs on the European continental margin from Norway to Portugal?

3. Why have coral reefs been considered to be confined to shallow waters?

4. Gorgonians, alcyonaceans, pennatulaceans, and stoloniferans belong to the subclass _________ and are collectively referred to as_________ .

5. Only members of the order __________ actually form true coral "reefs."

6. Some deep-sea reefs in the North Atlantic have been found to harbor ________ invertebrate species.

7. How rapidly do deep-sea corals grow and reproduce?

8. How long do deep-sea corals live?

9. At present, what is the greatest threat to deep-sea coral communities?

10. In addition to deep-sea corals, what other invertebrates form highly diverse communities in the deep ocean?