Cool Corals

FOCUS
Biology and ecology of shallow and deep water corals

GRADE LEVEL
9-12 (Life Science)

FOCUS QUESTION
What are the similarities/differences between shallow- and deep water corals?

LEARNING OBJECTIVES
- Students will design inquiry questions to help them answer the focus question.
- Students will research the biology and ecology of shallow- and deep water corals.
- Students will compare and contrast the biological and ecological data on both types of corals.
- Students will organize their findings to present the information related to the inquiry questions upon which they based the conclusion to the focus question.

MATERIALS
- KNL Chart Handouts
- Web and print resource list for information on shallow- and deep water corals

AUDIO/VISUAL MATERIALS
- Chalkboard, marker board, or overhead projector with transparencies and markers for group discussion

TEACHING TIME
Two 45-minute class periods, plus time for student research

SEATING ARRANGEMENT
Groups of 4-6 students

MAXIMUM NUMBER OF STUDENTS
30

KEY WORDS

Continental shelf	Continental slope
Hard bottom	*Oculina varicosa*
Deep water coral	Polyp
Zooxanthellae	Symbiosis
Anthropogenic	Turbidity
Coral reef	Coral bleaching
Bioherm	Remotely Operated Vehicle

BACKGROUND INFORMATION

Coral reefs are the most luxuriant and complex of all benthic communities; and they are found all around the world. In the continental United States, however, Florida is the only state to have extensive shallow coral reef formations near its coasts. These reefs extend from near Stuart, on the Atlantic coast, to the Dry Tortugas, west of Key West, in the Gulf of Mexico. The most prolific reef development occurs seaward of the Florida Keys. Florida's reefs are spectacular and rival those of many Caribbean areas. Approximately 6,000 coral reefs are found between Key Biscayne and Dry Tortugas (from http://www.dep.state.fl.us/coastal/habitats/coral.htm).

Corals are colonial animals, and individual coral animals are called polyps. A coral polyp is very similar to a tiny sea anemone, but extracts calcium carbonate from the water and forms a calcareous skeletal cup. Large numbers of these polyps grow together in colonies of delicately branched forms or rounded masses. Most shallow-water coral colonies also have symbiotic algae, called zooxanthellae, living in their skeletons. The coral provides protection and access to light for the algae and, in turn, algae provide nutrients for the polyps from photosynthetic activity. These shallow-water reef-building corals require warm, clear, shallow, clean water and a hard substrate to which they can attach. Shallow-water corals require water temperatures above 18°C and the optimum temperature is 23°C to 25°C. Therefore, their growth is restricted to tropical water between 30 N latitude and 30 S latitude and away from cold water currents. Waters at depths greater than 50-100 m are too cold for significant secretion of calcium carbonate. Also, reefs are not usually found in turbid waters where sediments limit light penetration, which affects the efficiency of photosynthesis in zooxanthellae (from A.C. Duxbury and A.B. Duxbury, 1997, "Introduction to the World Oceans", 5th edition, William C. Brown Publishing Co., Tropical Coral Reefs, p. 460-477).

Corals, however, do not only grow in shallow tropical waters. For centuries, humans have known about deep water corals, but until recently, few knew about the widespread distribution and incredible diversity of deep water coral structures. Deep water corals live in cold, deep waters beyond the reach of sunlight; however, like shallow corals, they require a hard surface on which to settle and grow. Colonies of deep water corals come in a variety of shapes and sizes, including mounds, conical-shaped reefs, or delicately branching trees. Some of the largest structures are several centuries old, making deep water corals among the oldest living organisms on Earth! Moreover, recent research indicates that deep water coral reefs are more abundant than their better-known shallow-water relatives (from A. Rogers, "The Biology, Ecology and Vulnerability of Deep Water Coral Reefs" http://www.iucn.org/themes/marine/pdf/AlexRogers-CBDCOP7-DeepWaterCorals-Complete.pdf).

Incredibly, not only is Florida home to shallow coral reefs, it is the only place *in the world* to have extensive populations of the deep water coral *Oculina varicosa*. Off the central eastern coast of Florida, between Cape Canaveral and Ft. Pierce, at depths of 70-100 m along the edge of the continental shelf, *O. varicosa* forms a unique and complex habitat called the *Oculina* Bank. Here, branches of living coral grow on mounds of dead coral branches that can be several meters high and hundreds of meters long. Unlike corals that produce reefs in shallower waters, *O. varicosa* does not have symbiotic algae and receives nutrition from plankton and particulate material captured by its polyps from the surrounding water. *O. varicosa* mounds alter the flow of currents and provide essential habitats for a variety of invertebrates and recreationally and commercially important fishes and crustaceans.

Because the deep *Oculina* reef habitat exists nowhere else in the world, it provides an excellent opportunity for scientific studies. On-going research strives to learn more about the biology, population status, and ecological role of these unique and vulnerable deep water corals and the ecosystem these unique corals support. In an effort to protect these fragile corals from human activities such as trawling and dredging, fishery managers designated 300 square miles of the *Oculina* Bank as a Habitat Area of Particular Concern (OHAPC). This designation prohibits the use of habitat damaging fishing gear such as trawls, fish traps, or bottom long lines to help protect the fragile coral. Additionally, the southern area of the OHAPC has been

closed to bottom fishing, creating an Experimental Closed Area for studies of the snapper and grouper species associated with the coral while providing additional protection from fishing gear.

The 2005 *Ivory Tree Coral Expedition* will continue research and monitoring objectives within the OHAPC, including further mapping of the OHAPC and quantification of fish and invertebrate populations. In this activity, students will research basic information on shallow- and deep water corals and compare the similarities and differences between the two.

LEARNING PROCEDURE

1. Engage students in a discussion of corals reefs by writing the focus question, "*What are the similarities and differences between shallow- and deep water corals?"* on the board.
2. Using the KNL (Knowledge, Needs, and Learned) Chart Handout, encourage students to share what they know about these marine communities, and about the organisms that create and live in them.
3. Tell students that they will research shallow-water and deep water corals. Divide the class into two groups and assign each group one of the types of corals.
4. Divide each of the two groups into the following subjects: Corals Up Close, Coral Communities, and Threats to Coral Reefs.
5. Groups will then design questions based on what they need to know in order to answer the focus question. (Alternatively, the teacher can assign a question to each group.) Examples of questions include, but are not limited to:

   Corals Up Close
   - What are the different morphological forms of corals?
   - Do physical characteristics differ between shallow and deep water corals?
   - How does each type (shallow/deep) reproduce?
   - How does each type (shallow/deep) eat?
   - When do they eat?
   - How do they grow?
   - How are coral reefs created?

   Coral Communities
   - Where are shallow and deep water coral reefs found?
   - What physical conditions are needed for each type type (shallow/deep) of coral to grow?
   - Are shallow and deep coral reefs found in Florida?
   - Approximately how many species of plants and animals (or percentage of the world's species) live among each of these reefs?
   - Why do so many animals inhabit coral reefs?
   - How do specific species use coral reefs?
   - What is the symbiotic relationship between coral polyps and zooxanthellae?

   Threats to Coral Reefs
   - What are some of the natural threats to coral reefs?
   - What are some of the human threats to coral reefs?
   - What is trawling?
   - How does overfishing affect coral reef communities?
   - How do land-based human activities affect coral reefs?
   - How might a boater or diver affect coral reefs?
   - How can we protect coral reefs?
   - Do threats differ between shallow and deep coral reefs?
   - Should we protect coral reefs, and if so, how?

6. Once the groups have developed the inquiry questions, assign one or two questions to each group member.
7. Students will research the answers to the assigned inquiry question(s) developed by the class using internet, library, and printed handout materials.

8. Each subgroup will organize their data and make a presentation to the class, which includes sources, vocabulary, and the inquiry questions addressed. Allow time for students to ask questions.

THE "ME" CONNECTION
Have students write a short essay on how both deep and shallow coral reefs are important to their own lives.

CONNECTIONS TO OTHER SUBJECTS
English/Language Arts; Earth Science

EVALUATION
Students will be assessed in the gathering, translating, and presentation of facts.

EXTENSIONS
- ✂ Have the students participate in a debate on issues surrounding threats to deep and shallow coral reefs and efforts to conserve them.

RESOURCES
Visit HBOI's @Sea website (http://www.at-sea.org/) for more information on the 2005 *Ivory Tree Coral Expedition*.

Deep Water Corals:
Reed, J.K., 2002, "Deep water *Oculina* coral reefs of Florida: Biology, impacts, and management", *Hydrobiologia*, 471, p. 43-55.

http://www.uncwil.edu/oculina/Sections/coral_biology.htm – for more background on *Oculina* reefs.

http://www.coris.noaa.gov/about/deep/deep.html - NOAA's Coral Reef Information System

http://pubs.usgs.gov/fs/fs108-99/ - the geology of the *Oculina* Bank

http://oceanica.cofc.edu/Oculina2003/ProjectOverview.htm - more on the *Oculina* Bank from Project Oceanica

http://www.bio.fsu.edu/ifre/ifre_research_oculina.html - Studies in the Experimental *Oculina* Research Reserve off the Atlantic Coast of Florida

http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html - web logs from NOAA's 2001 *Islands in the Stream Expedition*

http://oceanexplorer.noaa.gov/explorations/deepeast01/background/corals/corals.html - background information on deep water corals from NOAA's 2001 *Deep East Expedition*

http://map.mapwise.com/safmc/Default.aspx?tabid=60 – information system for the South Atlantic ecosystem including deepwater coral and the *Oculina* Bank from the South Atlantic Fisheries Management Council (SAFMC)

http://ocean.floridamarine.org/efh_coral/ims/viewer.htm - SAFMC's Internet Mapping System for Coral and Benthic Habitats including the *Oculina* Bank

http://www.cool-corals.de/ - on the left hand navigation bar, click on "ACES" (Atlantic Coral Ecosystem Study) for more information on deep water coral communities

http://www.ices.dk/aboutus/pressrelease/coral.asp - International Council for Exploration of the Sea (ICES)

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

Rogers, A. "The Biology, Ecology and Vulnerability of Deep Water Coral Reefs"
http://www.iucn.org/themes/marine/pdf/AlexRogers-CBDCOP7-DeepWaterCorals-Complete.pdf

Shallow Water Corals:

http://www.dep.state.fl.us/coastal/habitats/coral.htm - information on Florida's coral reefs from the Florida Department of Environmental Protection

http://www.fknms.nos.noaa.gov/coraleducation.html - Florida Keys National Marine Sanctuary

http://www.coralreef.noaa.gov/outreach/welcome.html - coral reef information and resource list from NOAA's Coral Reef Conservation Program

http://www.coralreef.org/coralreefinfo/about.html - International Coral Reef Information Network

http://www.seaworld.org/infobooks/Coral/home.html - information from the Sea World Education Department

http://mbgnet.mobot.org/salt/coral/indexfr.htm - biomes of the world

http://www.oceanoasis.org/fieldguide/cnidaria.html - Ocean Oasis Field Guide

SUNSHINE STATE STANDARDS

Processes that Shape the Earth

- (SC.D.2.4)

Processes of Life

- (SC.F.1.4)
- (SC.F.2.4)

How Living Things Interact with Their Environment

- (SC.G.1.4)
- (SC.G.2.4)

The Nature of Science

- (SC.H.3.4)

ACKNOWLEDGEMENTS

This lesson plan is a modified version of the one available at
http://school.discovery.com/lessonplans/programs/BP_coralseas/

Student Handout
KNL Chart

Concept, Term, or Diagram	What do I KNOW?	What do I NEED to know?	What have I LEARNED?