Lesson Plan
Designing Tools for Ocean Exploration:
Taking a closer look at deep sea and shallow water corals

Focus
Comparing Deep-Sea and Shallow-Water Coral Habitats and Designing Tools for Ocean Exploration

Focus Questions
1. How are deep-sea and shallow water corals similar and different?

2. What environmental conditions need to exist in order to have healthy corals in the deep sea and shallow warm water habitats?

3. What tools and technology do scientists need to be able to learn about deep sea and shallow water coral habitats?

Learning Objective
- Students will research deep sea and shallow water coral reef habitats and be able to make comparisons and contrasts about them
- Students will be able to list environmental conditions that are required for healthy corals (deep sea and shallow water habitats)
- Students will experiment with tools to identify technology needs for accessing coral habitats for research

Grade Level
9-12

Materials
Web and print resource list for information on deep-sea and shallow water corals (See Resources)

Supplies for Simulated Ocean (per class)
- ☐ One container (Tupperware containers or coolers – minimum of 12" Deep and 2 feet by two feet square)
- ☐ Sand / rocks / gravel / bricks – mixed together and place in the bottom of the container enough to cover the bottom to about 2-3 inches deep)
- ☐ Water (add salt if desired) - enough to fill the container to several inches from the top
- ☐ 3 bottles of dark food coloring (at least three colors to make water dark)

Supplies for bottom dwelling "Organisms" (per class)
- ☐ 10-20 "simulated clams" – buttons, pennies, or tinfoil (rolled into a ball the size of a pea)
- ☐ 10-20 "simulated worms" – wire, fishing line, small springs 1-2 inches in length
- ☐ 20-40 "simulated crustaceans" – rice, beans

Supplies to Make Ocean Exploration Tools (per class)
- ☐ 1 roll wire
- ☐ 1 roll fishing line
- ☐ 1 pair panty hose

- ☐ 1 box washers
- ☐ 3 garden hose sections
- ☐ 15 fishing weights
- ☐ 10 paper cups
- ☐ 1 box of paper clips
- ☐ 2 PVC pipe 1" diameter X 6" long sections
- ☐ 1 box plastic or paper straws
- ☐ 1 roll of duct tape
- ☐ 3- 6 plastic soda bottles (20 oz)
- ☐ 3-6 magnets
- ☐ 1 roll of string
- ☐ 10 toilet or paper towel rolls
- ☐ 3-6 pens/ pencils
- ☐ 3-6 pair of scissors
- ☐ 10 corks
- ☐ 10 film containers
- ☐ Roll of pennies
- ☐ Plastic wrap
- ☐ 3 bottles of glue / rubber cement

You may add or delete materials. These are suggestions of items that can be used by students to design sampling tools.

Printed Materials

Mission Statement (pg. 8)

Audio Visual Materials

- ☐ Internet
- ☐ Videos of shallow and deep sea corals

Shallow coral reef video, NOAA Coral Reef Conservation Program
http://coralreef.noaa.gov/education/educators/resourcecd/additional/resources/living_reef.mov

Deep-sea corals found in Olympic Coast and Monterey Bay National Marine Sanctuaries, NOAA-video
http://olympiccoast.noaa.gov/education/teaching_resources/videos/coral_sampler_wa_ca_video.html

Teaching Time

Three 45-minute period

Seating Arrangement

Classroom style and cooperative groups of four to five students

Maximum Number of Students

30

Key Words

Ahermatypic
Biodiversity
Calcium carbonate
Continental Shelf
Continental Slope
Deep-Sea Coral
Ecosystem
Hermatypic
Infauna
Invertebrate
National Marine Sanctuaries
Photic Zone
Polyps
Rocky reef
Sediment
Submersible
Topography
Trawling
Zooxanthellae

Background Information

Coral reefs are one of the most diverse and complex communities in the world and are found almost worldwide. Of the 14 **National Marine Sanctuaries** and Marine National Monument's in the United States and island nations, twelve of the fourteen contain coral habitats and species.

Biology of Shallow Water Corals

Corals are colonial animals, and

individual coral animals are called **polyps**. A coral polyp is similar to the sea anemone, except coral extracts **calcium carbonate** from the water to form a calcareous skeleton. Large numbers of these polyps grow together forming colonies of branched, plate or rounded forms. Most shallow reef-building corals are **hermatypic,** having symbiotic algae, called **zooxanthellae**, living within their tissues. Coral provides protection and access to light for the zooxanthellae. In exchange, zooxanthellae provide nutrients for the polyps from photosynthetic activity. These shallow-water reef-building corals require warm, clear, shallow 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 and 30°S and away from cold water currents. Water deeper than 50 to 100 meters, is too cold for significant secretion of calcium carbonate. Also, reefs are not usually found in turbid waters where sediments limit light penetration, inhibiting photosynthesis in zooxanthellae (Duxbury and Duxbury, 1997).

Deep-Water Corals

However, corals do not only grow in shallow tropical waters. For centuries humans have known about deep-water corals but until recently, little was known of the widespread distribution and diversity of deep water coral structures. Deep-water corals also referred to as cold-water corals or deep-sea corals, are a diverse collection of organisms that occur in deeper or colder oceanic waters. Unlike the well-studied shallow-water tropical corals, these corals inhabit deeper waters on continental shelves, slopes, canyons, and seamounts in waters ranging from 50 m to over 2,000 m in depth. Since deep-sea corals are generally below the lighted zone, (**photic** zone) they lack symbiotic algae (zooxanthellae) characteristics of most reef building shallow water tropical corals and are termed **ahermatypic**. Unlike their shallow water relatives, which rely heavily on photosynthesis to produce food, deep-sea corals take in plankton and organic matter with polyps for all of their energy needs. Deep-sea corals are also often extremely long-lived, slow growing animals, characteristics that make them particularly vulnerable to physical disturbance.

The high **biodiversity** associated with deep-sea coral communities has shown potential value for commercially important fishes as they rely on deep-sea coral habitat for protection from predators and for enhanced feeding opportunities. Furthermore, deep-sea corals may provide significant opportunities for advancing pharmaceutical and medicinal applications. For example, several deep water sponges—often associated with deep-sea coral communities—have unusual qualities that may potentially aid in the development of drugs for cancer, heart disease, and other medical treatments. *(NOAA Coral Reef Conservation Program)* Moreover, recent research indicates that deep-water coral reefs are more abundant than their better-known shallow-water relatives (IUCN, 2004).

Accessing Deep-Sea Habitats

Access to these habitats has historically been challenging due to the physical challenges that exist in these deep-water areas. Extreme pressure, cold

temperature, and being outside SCUBA range limits exploration to these areas. Advancing deep-sea technology has allowed scientists to gain access to these regions. Remotely operated vehicles and submersibles have been designed to deal with these physical conditions and have opened up a new frontier for exploration in the ocean. With less than 5% of the ocean being explored, there's a lot of work to do!

PREPARATION

For Day 1

Review background information

Set up audio/video equipment

Access internet videos of shallow and deep sea corals on web or from local library. These videos are Quicktime format (.mov) and can be saved to a local computer from the internet to show in the classroom.

For Day 3

Set up Simulated Ocean

1. Arrange sand, rocks, gravel, and / or bricks on the bottom of a container to create "bottom topography".

2. Arrange critters on the bottom and in the sand.

3. Slowly add water to container, leaving several inches open at the top.

4. Mix three colors of food coloring to make the water dark so students cannot see the bottom.

LEARNING PROCEDURE

Day 1

The activities of Day 1 are to introduce students to deep-sea and shallow-water corals and allow students to conduct research in teams.

1. Introduce coral videos. Show videos to students without audio. Ask students to take notes on what they see using their observation skills.

2. Engage students in a discussion of corals by asking the focus question:

   How are deep-sea and shallow water corals similar and different?

3. Create two columns on the board (see example) Have students volunteer what they know about these marine animals / ecosystem.

Deep-sea coral	Shallow-water coral

4. Divide the class into two groups and assign each group to either shallow-water or deep-sea coral ecosystem

Ask students to work in their groups to research assigned corals – either shallow-water or deep-sea. Ask them to be prepared to discuss the following focus questions during the next classroom discussion.

How are deep-sea and shallow-water corals similar and different?

What environmental conditions need to exist in order to have healthy corals in the deep-sea and shallow warm water habitats?

What tools and technology do scientists need to be able to learn about deep sea and shallow water coral habitats?

Day 2

The activities of Day 2 allow students to share information learned from their research, and explore techniques in ocean exploration.

1. Continue the discussion of corals by revisiting the focus question and sharing their findings from research from Day 1. *How are deep-sea and shallow water corals similar and different?*

2. Redirect the class to their original list of similarities and differences of deep-sea and shallow water corals that they generated on Day 1. Create two columns on the board. Have students volunteer what they now know about these marine animals / ecosystem.

3. Discuss what environmental conditions need to exist in order to have healthy corals in the deep-sea and shallow warm water habitats?
4. In assigned groups ask students to discuss techniques that scientists use to explore deep-sea and shallow water habitats. Share thoughts as a class as to what technology is needed for each habitat.

Day 3

The activities of Day 3 are to choose the Investigation Teams, to design the sampling tools and to test the sampling tools in the Simulated Ocean.

Set up Ocean Exploration Supplies

1. Divide supplies for making ocean exploration tools for each group (there should be 4-5 students per group). Each group should have a wide variety of materials to use, however they may not use all of these supplies.

2. Place material into a box or on a tray to give to each group.

3. Teacher will introduce Simulated Ocean and Ocean Exploration Supplies and break the class into small groups (4-5 students per group).

4. Using Ocean Exploration Supplies, student groups will develop ocean exploration tools to explore Simulated Ocean. There are many materials from which students can choose to design the sampling tools. Their mission is to study species and habitat diversity in the area. See attached "Mission statement".

5. Student groups will report out to entire class on tool design and data findings.

THE "ME" CONNECTION

Have students write a short essay on how both deep-sea and shallow coral reefs are important to their own lives.

Have students research their watershed, where does rain-water go after it hits the ground in their town? Which creek, river does it connect to? Where does that river lead to on the coast? What type of ocean habitat is connected to your watershed? Are there corals there?

CONNECTIONS TO OTHER SUBJECTS

English / Language Arts; Physical, Ecological, and Biological Sciences

EVALUATION

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

EXTENSIONS

- Go on a snorkel trip to a shallow water reef.
- Go to http://aquarius.uncw.edu/live to view live webcams of Aquarius underwater laboratory and send a question to an Aquanaut.
- Have students participate in a debate on issues surrounding threats to deep-sea and shallow water coral reefs and efforts to conserve them.
- Have each group create a poster presentation on their topics.
- Log on to http://sanctuaries.noaa.gov/missions/welcome.html to view past and upcoming NOAA National Marine Sanctuaries Expeditions and to find out what researchers are learning about deep-sea and shallow water coral communities.

STUDENT RESEARCH LINKS/RESOURCES

- ☐ http://www.oar.noaa.gov/oceans/t_deepseacorals.html (NOAA Ocean Exploration and Undersea Research website on Deep-Sea Corals)
- ☐ http://www.oar.noaa.gov/oceans/t_technology.html (NOAA Ocean Exploration and Undersea Research website highlighting Technologies and Capabilities for Ocean Research and Exploration)
- ☐ http://www.nurp.noaa.gov/DSCorals.htm NOAA Undersea Research Program publication on Conservation of Deep-Sea Corals
- ☐ http://sanctuaries.noaa.gov/missions/2010coral_west/ (Expedition Web Page for Deep-Sea Coral Cruises of 2010 on West Coast of US)
- ☐ http://sanctuarymonitoring.org/regional_docs/monitoring_projects/100370_dsc.pdf (NOAA Fisheries Service journal on Deep-Sea Corals, includes facts, biology, species, images, threats, etc.)
- ☐ http://sanctuaries.noaa.gov/ (Office of National Marine Sanctuaries website)
- ☐ http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html (Videos of Coral habitats)
- ☐ http://marinelife.noaa.gov (photos, videos, and Sanctuary Encyclopedia)

- ☐ http://www.signalsofspring.net/aces/webquest.cfm?ecosystem=reef (Multiple Student Research Links about Coral Reef habitats)

- ☐ http://coralreef.noaa.gov/ (NOAA Coral Reef Conservation Program website)

National Science Education Standards

Science as Inquiry – Content Standard A:

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

Science and Technology – Content Standard D

- Abilities of technological design
- Understanding about science and technology

Science in Personal and Social Perspectives – Content Standard F:

- Science and technology in Local, National, and Global Challenges

National Geography Standards

Ocean Literacy Principle 1: The Earth has one big ocean with many features.

Ocean Literacy Principle 5: The Ocean supports a great diversity of life and ecosystems.

Ocean Literacy Principle 6: The Ocean and humans are inextricably interconnected.

Ocean Literacy Principle 7: The Ocean is largely unexplored.

For More Information

Deep-Sea Corals issue of "Current: The Journal of Marine Education"

Link has articles and activities related to Deep-Sea Corals
http://www.mcbi.org/what/current.htm

NOAA's Coral Reef Conservation Program-Educator Resources
http://coralreef.noaa.gov/education

Acknowledgement

Portions of this lesson plan are based on:

Cool Corals, 2007, South Atlantic NOAA Deep Water Teachers' Workshop – Grades 9-12 (Life Science), Biology and Ecology of Shallow and Deep Water Corals
And modified from multiple lesson plans available at http://oceanexplorer.noaa.gov

Life on the Edge: Exploring Deep Ocean Habitats "Cool Corals"
Designing Tools for OceanExploration
Deep Sea Coral Biodiversity

Credit

Cool Corals, 2007 South Atlantic NOAA Deep Water Teachers' Workshop – Grade 9-12
(Life Science), Biology and Ecology of Shallow and Deep Water Corals

Designing Tools for Ocean Exploration, Deep East 2001 – Grades 9-12, Overview: Ocean Exploration

Mission Statement

We are on a scientific mission in (choose location in your region).

The Chief Scientist proposal is to sample the sediment type, infauna, and water in the research area.

The purpose of this is to study species and habitat diversity in the area.

To accomplish this, your team will be taking habitat and water samples.

The topography is rugged and we wish to sample microhabitats; including mounds, burrows, and wave features.

Your research area depth is greater than 1,000 meters. As such, your habitat samples will be taken from an occupied submersible.