Sanctuaries of Deep-Sea Coral Communities

Grade Level

6–8 or higher

Timeframe

45 minutes or more

Materials

- Computer, projector and screen
- Visual materials (all available to download)
- Text documents (all available to download)

Key Words

Biodiversity, community, deep-sea corals, distribution, ecosystem, habitat, monitoring, substrate, temperature

Standards

NGSS: MS-LS2-4.
CCSS: W.6.10. SL.6.4.
Ocean Literacy Principles: 5, 6, 7.
Climate Literacy Principles: 3.
Details at end of lesson

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&

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A deep-sea coral community at Greater Farallones National Marine Sanctuary: Can you identify these three organisms? Photo: Ocean Exploration Trust/NOAA National Marine Sanctuaries; Animals: Venus fly trap anemone, soft coral colony, brittle star

Activity Summary

This lesson focuses on species found in deep-sea coral communities and environmental factors that influence their presence and abundance. Students investigate two or more national marine sanctuaries, protected ocean sites on the West Coast. They learn to identify soft corals, hard corals, invertebrates, and fish found within these deep-sea communities. Students will view videos of real scientific transects taken with remotely operated vehicles (ROVs), and record data on the presence of specified species. They will then graph and analyze their data to evaluate the composition of deep-sea coral communities according to habitat type, depth and temperature.

Learning Objectives

Students will:

- Describe physical and biological components of the deep sea.
- Analyze data to draw conclusions about species diversity and abundance in different habitats.
- Explain how scientists analyze data by using recorded video.
- Explain the importance of characterizing habitats and being able to describe the various habitat types found in deep-sea coral communities.
- Argue from evidence about how a change in deep-sea communities could impact deep-sea ecosystems.

Background Information

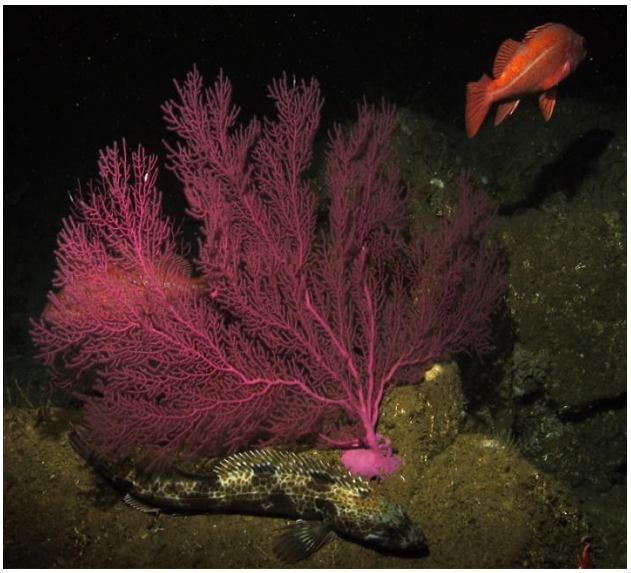
National marine sanctuaries are a network of underwater areas in the ocean and Great Lakes that protect America's most iconic natural and cultural marine resources. Channel Islands National Marine Sanctuary is located just offshore from southern California, and Greater Farallones National Marine Sanctuary is located off of the northern and central California coast. Both sanctuaries harbor a variety of habitats and an abundance of life, including endangered species.

Greater Farallones National Marine Sanctuary has many geologic features that result in a variety of seafloor habitats including underwater banks on the sea shelf, canyons, and a variety of mixed habitat including sand, mud, bedrock, boulders, and smaller rocks. The seafloor at Channel Islands National Marine Sanctuary is composed of soft bottom habitats and rocky reefs. The rocky features provide more opportunities for deep-sea communities to take hold, while the softer sediments that make up the majority of the seafloor habitat are significant carbon sinks, collecting and storing carbon indefinitely, unless disturbed by some activity.

Deep-sea Corals

All West Coast sanctuaries harbor deep-sea coral and sponge communities. They are often called “rainforests of the deep” because of the habitat they provide. Deep-sea corals and sponges provide shelter, especially for larval and juvenile fish and invertebrates, areas for breeding and brooding, and food for many species of fishes and invertebrates. Corals add habitat complexity, altering the sea floor by adding a large structure for other organisms, such as brittle stars, basket stars and crinoids (sea lilies), to climb up and to reach higher into the water column to capture food.

Corals are often associated with the warm, clear waters of the tropics, yet scientists have discovered nearly as many species of cold-water deep-sea corals as shallow-water species. Deep-sea corals are found at 50 meters (164 feet) or below. Unlike shallow-water corals, deep-sea corals do not depend on symbiotic photosynthetic algae. Instead, they obtain energy by trapping plankton and other organic matter in passing currents. Thus, they thrive in areas with little to no sunlight and in cold waters 4–12˚C (39–54˚F). Deep-sea corals require a hard substrate, such as rock, on which to establish and grow. They are generally absent in areas with a soft muddy or sandy seafloor.



A deep-sea coral community on a rocky substrate at Channel Islands National Marine Sanctuary. Photo: Marine Applied Research and Exploration

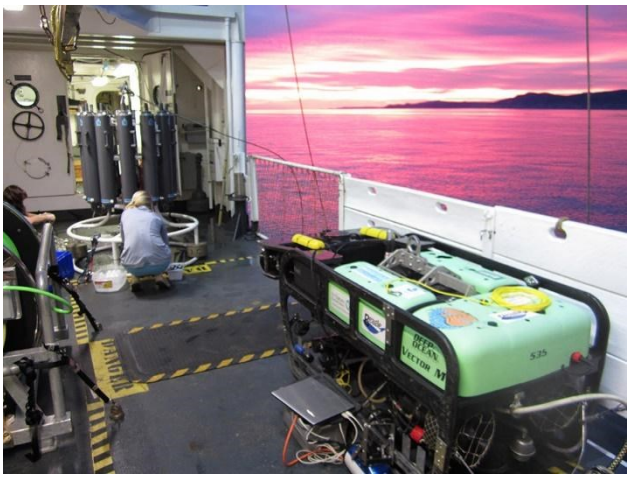
Deep-sea corals grow extremely slowly, only a few mm to cm per year (Roark 2005, 2009). Many live for hundreds of years, with some colonies living over 4,000 years! Once damaged, a coral colony may take decades if not centuries to regrow back to its original size and complexity. They are especially vulnerable to human disturbances on the seafloor, such as fishing gear from bottom trawling, marine debris and activities associated with energy (oil, gas and wind) exploration and development. The health of the substrate on which corals grow

is important for the health of coral and the surrounding ecosystem.

Ecosystem Monitoring in the Deep Sea

Monitoring an ecosystem involves identifying both the physical and biological resources that are present and measuring how they change over time. Mapping and conducting a species inventory, characterizing the habitat and recording environmental factors can accomplish the first step. Scientists use ROVs for exploration and record "video transects." Attached to a boat by a long cable or tether, a ROV is a motorized vehicle with cameras and sensors operated by a person at the ocean's surface, like an underwater robot. Physical factors are observed and recorded at various points along a horizontal line, or transect, usually at a specific depth. Increments along the transect are typically evenly spaced, and when combined with similar transects, they describe the environment, and may reveal changes in areas due to water depth, temperature or other phenomena. Transects allow scientists to construct models of an ecosystem while only studying small portions of it. The model then allows scientists to predict the effects of natural or human-caused events in an ecosystem.

Once data has been collected, experts review videos and still images several times. They identify the habitat and how frequently it changes during the transect, identify the species size and abundance, and how the species use the habitat. Then, all the data is compiled and analyzed in graphs and charts and used to create models that explain species interactions with one another and their habitat, as well as how species respond to changing ocean conditions and human impacts. All of the data collection, analysis and modeling allow scientists to better understand these special ecosystems so that we can make informed decisions about how to protect them.



Using a remotely operated vehicle (ROV), scientists from Channel Islands National Marine Sanctuary will explore the sanctuary's deep-water ecosystems. Photo: Charleston Lab

Learn more about deep-sea corals:

"Deep-Sea Corals: What Are They?": https://oceanexplorer.noaa.gov/edu/materials/deep-sea-corals-fact-sheet.pdf

"Deep-Sea Corals: Rainforests of the Deep": https://oceanexplorer.noaa.gov/edu/materials/rainforests-of-the-deep-fact-sheet.pdf

"Deep-Sea Corals and Sponges: Foundation Species": https://oceanexplorer.noaa.gov/edu/materials/DSC-foundation-species-fact-sheet.pdf

Roark, E.B. (2009). "Extreme longevity in proteinaceous deep-sea corals." PNAS: https://www.pnas.org/doi/10.1073/pnas.0810875106

Vocabulary	
Abundance	The number of individuals of a species found within a specific area
Biodiversity	A measure of the variety of species found in a given ecosystem
Community	An association of populations of two or more different species occupying the same geographical area at the same time
Ecosystem	A system formed by the interaction of a community of organisms with their environment
Monitoring	Tracking changes in an environment over time
Substrate	The surface or material on which an organism lives, grows or obtains its nourishment
Remotely operated vehicle (ROV)	A machine that is equipped with sensors, cameras and motors used to investigate habitats below the surface of the ocean and is attached to a vessel with a tether and operated remotely
Transect	A measurement along a line from top to bottom with known intervals, measuring physical and/or biological conditions

Preparation

- Download (or prepare to show) all associated videos, the slideshow, and text materials for this lesson.
- Make copies of (or share online) species identification guides and data sheets for students.

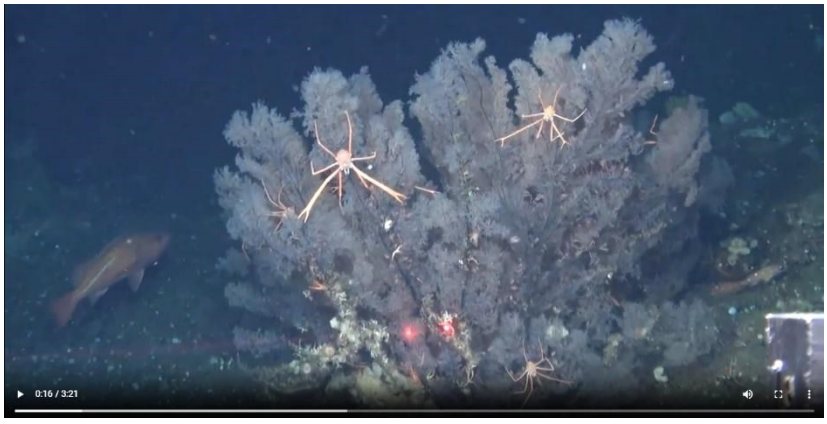
Procedure

Engage

- Ask students to imagine they are deep-sea scientists. They have been tasked with exploring the environment at the bottom of the ocean, most of which has not been explored. They will need to document the species they see. Ask the following questions, which you could project from slide 1 of the "Sanctuaries of Deep-Sea Corals" presentation or write on the board:
    - What do you think the deep ocean looks like? What type of environment is it?
    - How would you explore the deep ocean? What technology would you use?
    - What types of organisms live there? How might you measure the health of their ecosystems?
- Ask students to think about the questions and then discuss them with a partner (think-pair-share). Ask them to record their ideas in science notebooks using words and pictures.
- After a few minutes, ask students to share their ideas.
- Use the next slides in the "Sanctuaries of Deep-Sea Corals" presentation to engage students with questions about ocean phenomena. Encourage students to share ideas about the images with a neighbor and/or the whole class. Explanations are shown in the slide Notes, but we encourage you to leave some questions unanswered. Explain that the images are all from national marine sanctuaries and that they will get to explore them today like deep-sea scientists.

Explore

- Ask students to form science teams of four. Distribute or share the link to the organism ID guide and data sheet. It is recommended that each student have their own ID guide and data sheet.
    - Ask one student in each group to specialize in one of the four groups of organisms on the organism ID guide (corals, sponges, invertebrates and vertebrates).
    - Explain that each team member will watch for their type of organisms in videos taken at the sanctuaries. Students will attempt to identify and count the following for their assigned group of organisms: the number of times they see their organism, type, and any characteristics they noticed about it. They will also make observations about the nonliving parts of the environment.
- Briefly guide students through the process of filling out the data sheet.
    - Tell students that any of the species may be abundant or absent in any given habitat; no transect will have all of the species on the ID guide.
    - The top of the data sheet should be labeled with the sanctuary name, habitat type (students will determine this when the video is played), depth, and temperature.
    - Point out how there are separate columns for Common Name, Scientific Name, and each of the one-minute segments of the transects (0–1, 1–2, and 2–3 minutes).
    - The last column is for Total Abundance. After the transect is complete, each student will tally up their total assigned species they counted and assign an abundance rating (single, few, many, abundant) for the **overall** transect. Guidelines for these ratings are below. Point out the codes/key for total abundance at the bottom of the data sheet: S, F, M, and A.
- Invite students to watch three transect videos (approximately three minutes each) and record species abundance using the organism ID guide and data sheets. Alternatively, you can show the videos to students as an entire group.
    - Channel Islands – Deep 1 – The Footprint video (>100 meters deep; rocky): https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/education/teachers/deep-coral-communities/deep1.mp4



- Channel Islands – Shallow 1 – Carrington video (<100 meters deep; rocky): https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/education/teachers/deep-coral-communities/shallow1.mp4
- Greater Farallones – Soft Bottom Transect video: https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/education/teachers/deep-coral-communities/gfnms3.mp4
- During the transect, students can either use tally marks to note how many times they see a particular species, or continuously count and then record species numbers. Explain that this task can be challenging for certain species. Encourage students to count or estimate the best they can.
- Explain that students may pause the videos briefly during the three segments if they want extra time to count a dense patch of organisms or identify species. Give students time reminders, if needed.
- As the students view each transect video, they will identify the substrate type (soft or rocky bottom, or mixed type).
- After each transect is complete, students should tally their assigned species count and assign an abundance category for the entire transect:
  - Single (S): One solitary individual or colony
  - Few (F): 2–10 individuals or colonies
  - Many (M): 11–50 individuals or colonies
  - Abundant (A): 50+ individuals or colonies
- After the class has completed all transects, ask students to share their individual data with their respective group so that each student has an abundance code for every species on the data sheet. (Each student should have a completed data sheet for each sanctuary habitat.)

- Students graph their abundance data for different species and sites.
  - In order to visualize the data, students will create a graph for each of the sanctuary transects. You may choose to give students a choice of using the graph template provided or a computer-based program, such as Microsoft Excel or Google Sheets. It may be best to assign each group to graph a different transect.
  - Using their graphs, have students compare and contrast species abundance and diversity in each transect.
  - Have each group answer the Transect Data and Ecosystem Monitoring Questions.

Explain

- In a full class discussion, ask one group to share their data table from one of the sanctuary sites. Ask the class to share whether their observations were similar. Discuss the importance of observer consistency. Ask students if they found it challenging to identify species and record data collected with ROVs.

- Ask students to share their observations about similarities and differences between sites.
    - Which site(s) had the greatest diversity of organisms?
    - Which site(s) had the greatest abundance of organisms?
    - Why do they think there are differences between sites?
- Highlight the importance of differences in substrate types, depth, and temperature and their impact on diversity and abundance. Why might rocky habitats harbor more organisms than soft bottom habitat? Fill in gaps, correct misunderstandings, and clarify meanings of terms as they arise in discussion. Use slides in the presentation as visual aids. You could also add that there are many species that live within or below the seafloor that are not seen during transects.
- Ask students to reflect on how a change in these deep-sea communities, such as the destruction or growth of deep-sea corals, could impact other changes to deep-sea ecosystems. Encourage students to argue from evidence they collected in the transect activities to support how changes in the physical or biological components of the ecosystems might impact the populations of the organisms found there.

Enrich/Extend

- Add Olympic Coast Transect video (which shows a muddy bottom with some boulders and small rocks): https://sanctuaries.noaa.gov/education/teachers/deep-coral-communities/ocnms1.mp4

- Add Cordell Bank Transect 1 video (which shows a mixed habitat and abundant feather stars): https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/education/teachers/deep-coral-communities/cb-transect1.mp4
- Add Monterey Bay Transect video (which shows Davidson Seamount, a pristine undersea mountain habitat): https://sanctuaries.noaa.gov/education/teachers/deep-coral-communities/mbnms2.mp4. Davidson is one of the largest known seamounts in U.S. waters. It is populated with a diversity of deep-sea corals. It has been called "An Oasis in the Deep," hosting large coral forests, vast sponge fields, crabs, deep sea fishes, shrimp, basket stars and high numbers of rare and unidentified benthic species.

- Show the first two minutes of the "Exploring Deep-Sea Coral Communities of West Coast National Marine Sanctuaries" video: https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/education/teachers/deep-coral-communities/intro-video.mp4.
- Conduct a virtual quadrat survey of a shallow coral reef ecosystem. See "Coral Bleaching Virtual Survey" (Unit 1: Lesson 4) of the Coral Check-up Lesson Series: https://www.papahanaumokuakea.gov/new-education/curriculum/coral-lessons
- Ask students to reflect on why it is important to have marine sanctuaries. Discuss how the future might look if these ecosystems are both protected and conversely unprotected from human-caused threats. Incorporate threats from marine debris, marine heatwaves and ocean acidification in the discussion. Students could explore this "Deep-Sea Habitats" StoryMap to learn more: https://sanctuaries.noaa.gov/about/deep-sea-habitats-in-nms-of-the-west-coast.html. Invite students to brainstorm actions that people can take to mitigate these threats and how fragile deep-sea coral communities might thrive from special protection.

Evaluate

- Review student answers to the Transect Data and Ecosystem Monitoring Questions.
- Ask groups to summarize their findings in the data collection/analysis activities in short class presentations, using their graphs as visual aids.
- Ask students to summarize what they learned in the deep-sea explorations and class discussions. These can be recorded in science notebooks or on separate paper. Students also might choose to add illustrations with labels to their written accounts.

Education Standards	
Next Generation Science Standards	Ecosystems: Interactions, Energy, and Dynamics • MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Science and Engineering Practices: • Engaging in Argument from Evidence Crosscutting Concepts: • Cause and Effect • Systems and System Models
Common Core State Standards	Writing: W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Speaking and Listening: SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes.

Education Standards	
Ocean Literacy Principles	5. The ocean supports a great diversity of life and ecosystems. (e, f) 6. The ocean and humans are inextricably interconnected. (e, g) 7. The ocean is largely unexplored. (b, d, e)
Climate Literacy Principles	3. Life on Earth depends on, is shaped by, and affects climate. (a, c) (If the last Enrich/Extend activity is completed.)

Additional Resources

This lesson was adapted from the Deep Coral Communities Curriculum for grades 9–12. See the complete curriculum with additional resources including an interactive poster at https://sanctuaries.noaa.gov/education/teachers/deep-coral-communities.

Deep-Sea Coral Resource Collection:
https://sanctuaries.noaa.gov/education/teachers/coral-reef/sea-coral.html

West Coast Sanctuaries' Deep-sea Habitats StoryMap:
https://sanctuaries.noaa.gov/about/deep-sea-habitats-in-nms-of-the-west-coast.html

Deep-sea corals lesson plans from NOAA Ocean Exploration:
https://oceanexplorer.noaa.gov/edu/themes/deep-sea-corals/lessons.html

"Deep-Sea Coral Habitat." NOAA Fisheries:
https://www.fisheries.noaa.gov/national/habitat-conservation/deep-sea-coral-habitat

"Deep-Sea Corals." Smithsonian: https://ocean.si.edu/ecosystems/coral-reefs/deep-sea-corals

Coral Reef Ecosystems Resource Collection:
https://sanctuaries.noaa.gov/education/teachers/coral-reef

For More Information

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