Investigation: Feeding the Million Mounds of Deep-Sea Coral

Overview

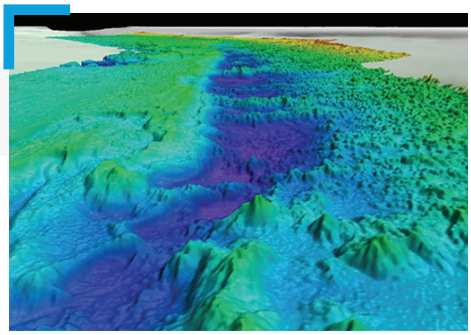
TOPIC: Deep-Sea Coral

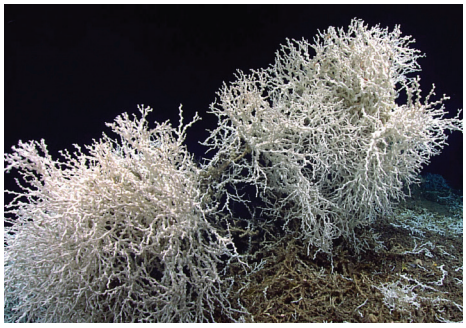
FOCUS: Students ask how the deep-sea corals in the Million Mounds coral region of the southeastern U.S. access necessary resources, specifically food, through interactions with living and non-living parts of their ecosystem. In particular, students investigate how the fast-moving Gulf Stream current supplies food to the stationary deep-sea coral.

GRADE LEVEL: 6th-8th

TIME NEEDED: One 45-50 minute class period

PHENOMENON (DRIVING QUESTION): How do the deep-sea corals in the Million Mounds coral region get the food they need to grow and reproduce?





The "Million Mounds" coral region is a vast area of deep-sea corals about 100 miles off the coasts of Georgia and Florida. The predominant species of deep-sea coral here is *Lophelia pertusa*, a white, branching, stony coral. *Images courtesy of NOAA Ocean Exploration.*

OBJECTIVES/ LEARNING OUTCOMES: Students will:

- Analyze and interpret data on currents and plankton movement to determine why conditions off the coasts of Florida and Georgia support the growth and reproduction of deep-sea coral *(Lophelia pertusa)*.
- Construct a scientific explanation based on evidence that the deep-sea coral populations in the Million Mounds coral region depend on interactions with living and non-living parts of their ecosystem.
- Use patterns in data from scientific sources as evidence to predict ocean currents that would likely support deep-sea coral growth.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Performance Expectations (PEs): MS-LS2-1

Disciplinary Core Ideas (DCIs)
LS2.A: Interdependent Relationships in Ecosystems

Crosscutting Concepts (CCs)
Patterns
Cause and Effect

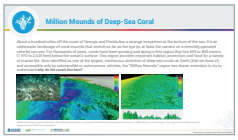
Science & Engineering Practices (SEPs)
Analyzing and Interpreting Data
Engaging in Argument from Evidence

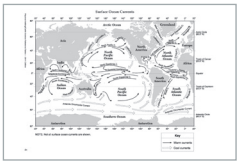
COMMON CORE CONNECTIONS
ELA/Literacy RST.6-8.1; RST.6-8.7

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS
Principle 1: FC c; Principle 5: FCs f, g; Principle 7: FC a

Overview cont.

MATERIALS:





Million Mounds Coral Region Slides 1-10 *(for student groups; print or digital copies)*

- Slides 1-5: Introduction to Million Mounds coral region phenomenon
- Slide 6: Surface ocean currents of the U.S. East Coast and Gulf Coast
- Slides 7-9: Looking for Patterns *(for print only, digital sources provided below)*
- Slide 10: Map of Global Deep-Sea Coral Observations

Looking for Patterns: Ocean Currents and Deep-Sea Coral Observation Data
(Digital sources to display for class or share with students for online learning.)

- Global Surface Ocean Currents Map (Physical Science/Earth Science Reference Tables)
- Global Ocean Surface Currents Properties Table (University of Miami)
- Deep-sea Coral Observations Map
  (NOAA Deep-Sea Coral Research and Technology Program)

Videos

- Million Mounds (4:17) NOAA Ocean Exploration
- Making Waves - Episode 123: Ocean Currents (3:23) NOAA National Ocean Service
- Currents Model: Ocean currents push phytoplankton — and pollution — around the globe faster than thought (0:20) Princeton University

Optional:

- Currents Article: Ocean currents push phytoplankton — and pollution — around the globe faster than thought (Princeton University). Additional information about the transport of phytoplankton - and pollution - in currents shown in the video with the same name.
- What are plankton? (NOAA Ocean Service). Additional information about plankton, a primary food source of deep-sea corals.
- What is marine snow? (NOAA Ocean Service). Additional information about how organic matter makes it to the bottom of the ocean.
- How fast is the Gulf Stream? (NOAA Ocean Service). Ocean fact about the Gulf Stream Current.

EQUIPMENT:

- Computer and projector for class viewing of videos and ocean currents data
- White board and dry erase marker or online platform to record class findings
- Student notebooks for students to record their observations, questions, and explanations
- *Optional: Student laptops or tablets for extensions and/or additional research*

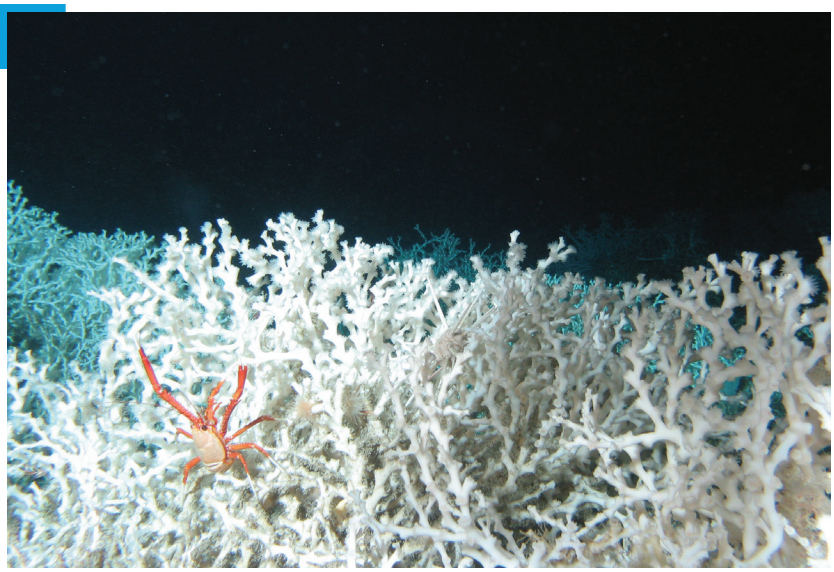
SET-UP INSTRUCTIONS:

- Cue up the Million Mounds Coral Region slides, all videos, and the ocean currents and deep-sea coral observations reservations for student viewing.
  - *If projecting these for the class is not an option, print or share digital copies with students.*

Educator Guide

Background

Deep-sea corals defy most of the characteristics that come to mind when one thinks about coral reefs. Deep-sea corals thrive in cold, dark waters and are found deeper than 50 meters (164 feet) beneath the surface of the ocean. This puts them out of reach from the sun's rays, so they do not rely on symbiotic algae living in their tissues to make their food via photosynthesis, like their shallow-water relatives. Instead, they must capture food from the waters around them. Deep-sea corals are also sessile creatures, unable to move from their location on the seafloor. They filter feed using tiny tentacles on each **polyp** to stun and trap microscopic food particles, like plankton, from the surrounding waters and pull it towards their mouths. Like many deep-sea animals, food limits where corals are found.



Lophelia pertusa is the dominant deep-sea coral species of the Million Mounds Coral Region. The branching shape of this coral provides habitat and a feeding base for many other deep-sea species like the squat lobster *(Euminida picta)* seen here. *Image courtesy of NOAA Ocean Exploration.*

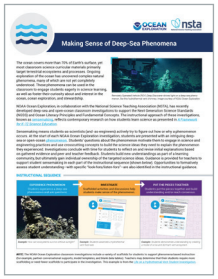
Deep-sea coral (and sponge) communities are found across the globe, especially on continental margins. One of the largest, continuous stretches of deep-sea corals on Earth (that we know of) is located in the deep waters off the coasts of Georgia and Florida. This area is known as the "Million Mounds" coral region and is an underwater landscape consisting of large coral mounds that stretch as far as the eye, or camera on the remotely operated vehicle (ROV), can see. The warm, fast moving waters of the Gulf Stream current transport the large amount of food that is necessary to support such an ecosystem.

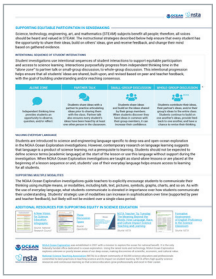
The Million Mounds coral region is largely dominated by the deep-sea coral species, *Lophelia pertusa*. *L. pertusa* is a stony (hard) coral, meaning as it grows, it creates a skeleton made of calcium carbonate. This skeleton is also left behind after the animal dies. Over time, as new corals grow on top of the skeletons of deceased corals, mounds form. The large coral mounds in the Million Mounds coral region were formed over hundreds of thousands of years. This vast community provides habitat, protection, and food for a variety of marine life.

Educator Note

A variety of student interaction techniques and examples of student questions are provided throughout this activity to engage students in the process of sensemaking to move their learning forward.

Learn more about the instructional strategies and tools included in the NOAA Ocean Exploration student investigations.





FOR MORE INFORMATION:

- Deep-Sea Corals - What Are They?
  Fact Sheet

- Deep-Sea Corals and Sponges - Rainforests of the Deep
  Fact Sheet

- Charting the "Million Mounds" of Deep-Sea Coral
  Exploration Note

Educator Guide cont.

Experience the Phenomenon

Tell students that they will be watching part of a video about a population of deep-sea coral. Ask students to record observations and questions that arise as they watch the video and observe the slides.

Start the Million Mounds Video at the beginning and **pause at 0:31** *("...deep-sea corals thrive")* to avoid giving students the answer to the **Driving Question:** ***How do the deep-sea corals in the Million Mounds coral region get the food they need to grow and reproduce?*** Encourage students to record their observations and questions. Next, show the video from 0:49 to 2:32 *("... the living coral on top")*. Pause and encourage students to again record their observations and questions.

TEACHING NOTE

To avoid providing students with the answer to the Driving Question you will need to start and stop the video strategically. After students have constructed their own explanations, you will play the entire video at the end of the lesson. *Video courtesy of NOAA Ocean Exploration.*

Project slides 1-5 of the Million Mounds slide deck. Emphasize the following points:

- *This huge population of deep-sea coral lives off the coast of Florida and Georgia, 600 to 800 meters (1,970 to 2,625 feet) below the ocean's surface.*
- *The video focuses on the deep-sea coral species* Lophelia pertusa, *however, other coral species also contribute to mound-building.*
- Lophelia pertusa *deep-sea corals are animals.*
- Lophelia pertusa *corals are stationary (they can't change their location).*

Note: *If students ask if the deep-sea corals are bleached (coral bleaching), reiterate that healthy* Lophelia pertusa *corals are naturally white.*

Direct students to individually brainstorm and write any additional questions they have about *Lophelia pertusa* and the Million Mounds coral region.

Ask students to work in small groups to classify their questions about the Million Mounds coral region. Challenge them to classify their questions into no more than three categories (Students are likely to create thematic categories such as food/feeding, age, how the corals get there, etc.). Instruct students to label their categories (labels can be in the form of questions) and to be prepared to share their question categories with the class.

Facilitate a whole-class discussion of questions about the Million Mounds coral region by asking groups to share their categories and identify which category contained the most questions. Summarize students' questions and after some brief discussion, point out that questions about what *Lophelia pertusa* eat and how they get their food are common among many or all of the groups. Hone in on:

- *What do the deep-sea corals in the Million Mounds coral region eat?*
- *How do they get the food they need to grow and reproduce? (or similar)*

Task students to think about other organisms on Earth that are stationary (or sessile - can't change their location). How do they get their food? Give students independent thinking time to record their ideas and then ask students to share one example with a partner (or add to a partner's idea). Bring students back together to share examples and create a class record that can be easily observed by all students.

Student ideas may include:

- *Stationary organisms rely on their prey coming to them (swimming or drifting by).*
- *Stationary organisms must have a mechanism to catch or trap their prey.*
- *Stationary organisms have special shapes and/or structures to help them access prey.*

If students don't bring up the branching aspect of deep-sea *Lophelia pertusa* coral formation or the mounds they form, you might ask, "What shape(s) did the *Lophelia pertusa* have in the video? How were the deep-sea coral mounds in the video formed? What advantage might these mounds have to these deep-sea corals?" Listen for students to share ideas about the branching structures and mounds lifting deep-sea corals off of the seafloor into shallower waters with more food.

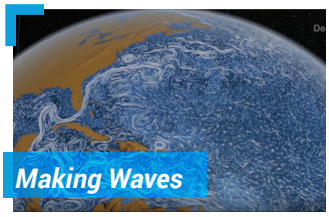
Instruct students to create an initial explanation of how they think deep-sea corals in the Million Mounds coral region get the food they need to grow and reproduce. Encourage students to use words, pictures, symbols, etc. to communicate their thinking. Then tell students to put their explanations away.

Educator Guide cont.

Investigate

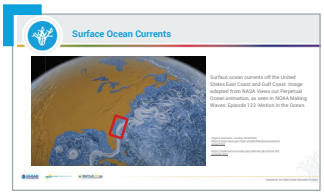
To address the question *What do deep-sea corals eat?* tell students deep-sea corals eat plankton. Consider sharing the article What are plankton? with students.

To frame the investigation, first note that many students suggested that characteristics of the Million Mounds coral region help the deep-sea coral populations access plankton. Tell them they will begin by investigating the ecosystem of the Million Mounds coral region in more detail, starting with the body of water in which the corals are found.



Video courtesy of NOAA Ocean Service.

Explain that the Million Mounds coral region is in the Atlantic Ocean off the coasts of Florida and Georgia. Show them a brief introduction to tides, winds, and currents - show the beginning of the video Ocean Currents - Making Waves, Episode 123 (3:23, NOAA National Ocean Service), and *stop at 1:36.* Ask students to observe the animated map (showing the movement of water/ocean currents) in the area off the coasts of Florida and Georgia and identify what they notice.

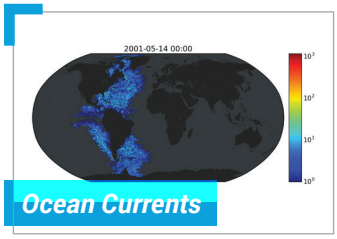


Project Slide 6 of the Million Mounds Coral Region slides. Ask students to record their observations and questions about this screenshot from the video. Ask students to discuss their ideas with a partner, then ask for volunteers to share their observations and questions with the class. Sample student responses:

- *There is a thick white line on the map off the coast of Florida and Georgia. I wonder what that means.*
- *I think this map means that the water moves differently off the Atlantic coast of Florida than how it moves off the Gulf Coast of Florida.*
- *I think this map shows that the water moves more quickly near Florida and Georgia.*
- *I think this map shows that water moves more slowly near Florida and Georgia.*

Confirm that within the world's ocean basins there are currents, bodies of water moving in a specific direction. Some of these currents are fast, and some are slow.

Tell students that they will now think about how the movement of water affects the movement of plankton.



Video courtesy of Princeton University.

Project the video Ocean currents push phytoplankton — and pollution — around the globe faster than thought (0:20 mins., Princeton University). In small groups, ask students to create a group list of observations, particularly what they observe near the location of the Million Mounds coral region. Do not ask the groups to share their lists at this time.

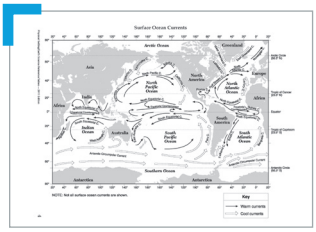
TEACHING NOTE

The goal of this video is for students to notice that phytoplankton move in a particular pattern and at different speeds in different spots. This should set up their understanding to make the connection to currents in the next stage.

Share the Global Surface Ocean Currents Map (www.nysd.gov) and Global Ocean Surface Currents Properties (University of Miami) table with students. The map shows location of currents and the table presents current flow [volumetric rate of transport (Sv)] for each named current.

Again in their groups, task students to identify patterns between the three data sets they've seen so far (use slides or handouts):

- Global Surface Ocean Currents Map
- Global Ocean Surface Currents Properties Table
- Ocean Currents - Making Waves, Episode 123 (0:00 - 1:36)



Adapted from Reference Tables for Physical Setting/ Earth Science.

Table courtesy of the University of Miami.

Consider replaying the Ocean currents push phytoplankton — and pollution — around the globe faster than thought video to support students in identifying patterns.

Educator Guide cont.

Investigate cont.

Ask student groups to share the patterns they identified with the class. Record the patterns shared, making sure the list is visible to all students.

As a class, **ask** students to describe the location of the Million Mounds coral region using the information gleaned from the three data sets. **Direct** students to revise their initial explanation of how the deep-sea corals in the Million Mounds coral region get the food they need to grow and reproduce, citing relevant evidence from data (related phenomena, location and speed of ocean currents, and distribution of [phyto]plankton).

If students need prompting, consider asking:

- *What do the deep-sea coral eat? How do the deep-sea coral get the plankton?*
- *Why do you think some areas of the ocean have more plankton than other areas?*

Remind students to include in their explanation how the deep-sea corals depend on interactions from living (prey) and non-living (ocean current) parts of their ecosystem.

EXPECTED STUDENT RESPONSE (ESR)

The deep-sea coral in the Million Mounds coral region must catch prey in order to grow and reproduce. To support this large number of corals, there would need to be a lot of prey that pass by the corals because they cannot move. Currents with higher transport (Sv) numbers move faster and move more plankton than currents with lower transport (Sv) numbers. The Gulf Stream current off the coast of Florida and Georgia has a rate of flow up to 150 Sv. This is the highest number of all the currents listed in the Global Ocean Surface Currents Properties Table. The Gulf Stream moves a lot of water and provides a large amount of plankton necessary to support the deep-sea coral population.

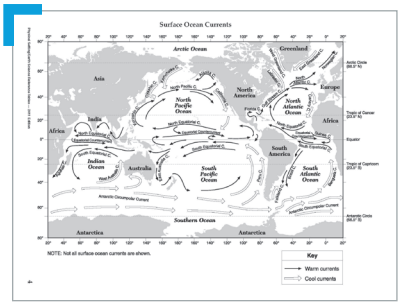
Put the Pieces Together

Note to students that in their investigation they discovered a connection between a fast-moving current and the presence of deep-sea coral. Guide them next to consider if this is a pattern that might be observed in other parts of the ocean.

Ask student pairs to again look at the Global Surface Ocean Currents Map and predict one place where they might look to find a lot of deep-sea coral (other than the Million Mounds coral region). Students should support their ideas with evidence from the map and what they have learned about deep-sea coral, plankton, and currents.

If students need prompting, consider asking:

- *What conditions supported deep-sea coral growth at the Million Mounds coral region?*
- *Are there other fast-moving currents on the map?*



Global Surface Ocean Currents Map. *Adapted from Reference Tables for Physical Setting/ Earth Science.*

Introduce students to the Deep-sea Coral Observations Map and ask them to consider how well the presence of fast-moving currents might predict the presence of deep-sea coral.

Map courtesy of NOAA Deep-Sea Coral Research and Technology Program.

Ask students to share their ideas about the connection between fast-moving currents and deep-sea coral, and facilitate a class discussion to solidify student ideas.

EXPECTED STUDENT RESPONSE (ESR)

Responses will vary depending on which locations students choose but, in general, students should note that deep-sea corals have been found in locations where there are fast-moving currents.

Show the entire NOAA Million Mounds video to students.

TEACHING NOTE

This lesson focuses on surface currents, but some students may ask about other types of currents. For more information about deep-water currents and the "Global Conveyor Belt" see the Extensions at the end of this investigation.

Educator Guide cont.

Extensions

- Explore the NOAA Deep-Sea Coral and Sponge Map Portal with students. Use the data query function of this interactive map to filter deep-sea coral and sponge observations by taxon, region, date, depth, and more.

  Example: Filter observations for *Lophelia pertusa*.

  - Open the NOAA Deep-Sea Coral and Sponge Map Portal in a browser.
  - Deselect all map layers except for "Coral-Sponge locations" from the menu on the right side of the page.
  - Select "Data Query" from the top menu.
  - Under "Taxon" (left column), select "Phylum/Order/Family/Genus" (this will change the menu in this section)
  - Under "Phyla," select "Cnidaria" to *remove sponge observations.*
  - *To filter for* Lophelia *make the following taxonomic selections:*
    - Order: Scleractinia
    - Family: Caryophyllidae
    - Genus: *Lophelia*
  - Click "search" at the bottom and the map will re-load with just data of interest.

- **Ask** students to share what other factors might affect the growth, survival, and reproduction of deep-sea coral. These factors include ocean current patterns, deep-sea temperatures and oxygen levels, the type of ocean floor surface (substrate), human impacts, and competition for plankton with other species.

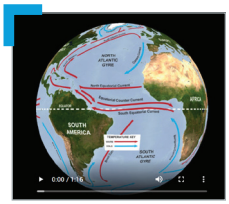
Marine snow (organic material falling from upper waters to the deep ocean) is also a major food source for deep-sea coral.

- Deep Coral Communities Curriculum (National Marine Sanctuaries)

  This curriculum takes students into the deep sea to identify the soft corals, hard corals, invertebrates and fishes found in these communities and to investigate the unique biology of deep-sea corals. Learn the threats these animals face and what we can do to help protect them.

Video courtesy of NOAA Ocean Exploration.

- Explore the role of coral as a foundation species with the Laying the Foundation for Deep-sea Coral Gardens investigation (NOAA Ocean Exploration) or just show the video Ancient Coral Gardens (3:27, NOAA Ocean Exploration).



- To expand student understanding of ocean currents, including deep-ocean currents, explore the NOAA Science on a Sphere Ocean Circulation visualizations.

Assessment

Many opportunities exist within this lesson to formatively assess student learning. Consider collecting students' predictions before sharing the map which identifies locations of deep-sea corals.

LOOK FORS:

- Students making connections between the size of a population and the availability of resources. Students should reason that large deep-sea coral populations will exist where there is a large amount of their prey, plankton.
- Students making connections between the three pieces of evidence: Ocean Currents - Making Waves, Episode 123 video, Global Surface Ocean Currents Map, and the Global Ocean Surface Currents Properties table. Students should note that locations with high concentrations of particles match the locations of currents with high transport (Sv) values, and the reason these locations would be likely locations of deep-sea corals is because there will be sufficient plankton to meet their energy needs.

Investigation: Feeding the Million Mounds of Deep-Sea Coral

Page 1:
- Million Mounds coral region (images): https://oceanexplorer.noaa.gov/ex10years/stories/million-mounds.html

Page 2:
- Million Mounds Coral Region (slides): https://oceanexplorer.noaa.gov/edu/materials/million-mounds-coral-region.pdf
- Surface Ocean Currents Map (pdf): https://www.unatego.org/Downloads/ESRT2.pdf
- Global Ocean Surface Currents Properties (webpage): https://oceancurrents.rsmas.miami.edu/properties.html
- Global Deep-Sea Coral Observations (map): https://oceanexplorer.noaa.gov/edu/materials/dsc-observations-map.jpg
- Million Mounds (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex2107/gallery/gallery.html#cbpi=/okeanos/explorations/ex2107/gallery/media/million-mounds.inc
- Making Waves (video): https://oceanservice.noaa.gov/podcast/apr14/mw123-currents.html
- Currents Model (video): https://player.vimeo.com/video/163414696
- Currents (article): https://www.princeton.edu/news/2016/04/19/ocean-currents-push-phytoplankton-and-pollution-around-globe-faster-thought
- What are plankton? (article): https://oceanservice.noaa.gov/facts/plankton.html
- What is marine snow? (webpage): https://oceanexplorer.noaa.gov/facts/marinesnow.html
- How fast is the gulf stream? (webpage): https://oceanservice.noaa.gov/facts/gulfstreamspeed.html

Page 3:
- *L. pertusa* (image): https://oceanexplorer.noaa.gov/explorations/19deepsearch/logs/photolog/photolog.html#cbpi=/explorations/19deepsearch/background/corals/media/img2.html
- Deep-sea Coral Communities (map): https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm
- NOAA/NSTA Sensemaking Guide (pdf): https://oceanexplorer.noaa.gov/edu/materials/NOAA-NSTA-sensemaking-phenomenon.pdf
- Deep-Sea Corals - What Are They Fact Sheet: https://oceanexplorer.noaa.gov/edu/materials/deep-sea-corals-fact-sheet.pdf
- Deep-Sea Corals and Sponges - Rainforests of the Deep Fact Sheet (pdf): https://oceanexplorer.noaa.gov/edu/materials/rainforests-of-the-deep-fact-sheet.pdf
- Charting the "Million Mounds" of Deep-Sea Coral Exploration Note (pdf): https://oceanexplorer.noaa.gov/edu/materials/million-mounds-exploration-notes.pdf

Page 4:
- Million Mounds (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex2107/gallery/gallery.html#cbpi=/okeanos/explorations/ex2107/gallery/media/million-mounds.inc
- Million Mounds Coral Region (slides): https://oceanexplorer.noaa.gov/edu/materials/million-mounds-coral-region.pdf

Page 5:
- What are plankton? (webpage): https://oceanservice.noaa.gov/facts/plankton.html
- Making Waves (video): https://oceanservice.noaa.gov/podcast/apr14/mw123-currents.html
- Million Mounds Coral Region (slides): https://oceanexplorer.noaa.gov/edu/materials/million-mounds-coral-region.pdf
- Currents Model (video): https://player.vimeo.com/video/163414696
- Global Surface Ocean Currents Map (pdf): https://www.unatego.org/Downloads/ESRT2.pdf
- Global Ocean Surface Currents Properties (webpage): https://oceancurrents.rsmas.miami.edu/properties.html

Page 6:
- Global Ocean Surface Currents Properties (webpage): https://oceancurrents.rsmas.miami.edu/properties.html
- Global Surface Ocean Currents Map (pdf): https://www.unatego.org/Downloads/ESRT2.pdf
- Global Deep-Sea Coral Observations (map): https://oceanexplorer.noaa.gov/edu/materials/dsc-observations-map.jpg
- Million Mounds (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex2107/gallery/gallery.html#cbpi=/okeanos/explorations/ex2107/gallery/media/million-mounds.inc

Page 7:
- Deep-Sea Coral and Sponge Map Portal (webpage): https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm
- Deep Coral Communities Curriculum (webpage): https://sanctuaries.noaa.gov/education/teachers/deep-coral-communities/
- Laying the Foundation for Deep-sea Coral Gardens (webpage): https://oceanexplorer.noaa.gov/edu/themes/deep-sea-corals/lessons/foundation-for-deep-corals.html
- Ancient Coral Gardens (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/dailyupdates/coral-garden/coral-garden-1280x720.mp4
- NOAA Science on a Sphere Ocean Circulation visualizations (webpage): https://sos.noaa.gov/catalog/datasets/ocean-circulation-labeled-currents/
- Making Waves (video): https://oceanservice.noaa.gov/podcast/apr14/mw123-currents.html
- Global Surface Ocean Currents Map (pdf): https://www.unatego.org/Downloads/ESRT2.pdf
- Global Ocean Surface Currents Properties Table (webpage): https://oceancurrents.rsmas.miami.edu/properties.html

Partners

OCEAN EXPLORATION

SCHMIDT OCEAN INSTITUTE

NAUTILUSLIVE.ORG OCEAN EXPLORATION TRUST

Created in cooperation with the National Marine Sanctuary Foundation under federal award NA19OAR0110405 for the Deep Ocean Education Project.

Information and Feedback

We value your feedback on this activity, including how you use it in your formal/informal education settings. Please send your comments to: **oceanexeducation@noaa.gov**. If reproducing this activity, please cite NOAA as the source, and provide the following URL: https://oceanexplorer.noaa.gov.