Okeanos Explorer ROV Imagery
Supplemental Datasheet #1 for Cruise 12.02

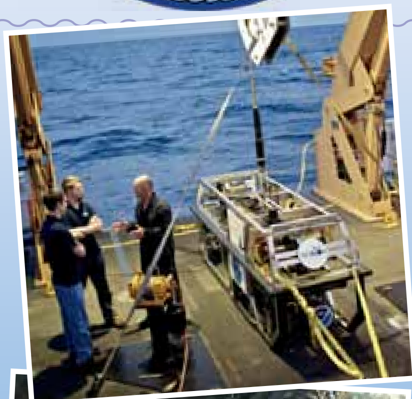



Image captions/credits on Page 2.

supplemental
datasheet

This Supplement provides data that can be analyzed using techniques developed in the lesson, "Tools for Classroom Explorers – How to Use Video Imagery from Underwater Robots" to investigate discoveries made during the NOAA Ship Okeanos Explorer Gulf of Mexico 2012 Expedition.

Focus
Video from remotely operated vehicles and exploration activities during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition

Grade Level
5-12 (Physical Science/Earth Science)

Focus Question
How can we use images obtained by underwater robots during exploration activities of the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition?

Learning Objectives
- Students will describe how video imagery obtained with remotely operated vehicles (ROVs) is part of the exploration strategy used during the NOAA Ship *Okeanos Explorer's* Gulf of Mexico 2012 Expedition.
- Students will use laser calibration to estimate the size of organisms in underwater video.
- Students analyze ROV imagery obtained aboard the *Okeanos Explorer* during the Gulf of Mexico 2012 Expedition to make inferences about deep-ocean habitats and organisms.

Materials
- Copies of the *ROV Imagery Student Investigation Guide #1 for Cruise 12.02*; one copy for each student group
- Watch or stopwatch, one for each student group
- Computers with Internet access

Background for the Gulf of Mexico 2012 Expedition
Background information about the mission of the NOAA Ship *Okeanos Explorer* and its ROV and video imagery capabilities is provided in the lesson, *Tools for Classroom Explorers – How to Use Video Imagery from Underwater Robots*.

Images from Page 1 top to bottom:
Bobby Mohr, Tom Kok, and Jeff Williams discuss 'the plan' on the back deck. Image courtesy of the NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar21-2-hires.jpg

Anchor resting on the top of the Site 15429 wreck. *Lophelia* coral is also visible.
After a great first marine archaeology dive on March 27, everyone was excited about exploring a second target. Site 15429 was initially located in 2009 with the National Institute for Undersea Science and Technology's (NIUST) *Eagle Ray* autonomous underwater vehicle (AUV). The data showed a potential vessel resting on the seafloor. The remotely operated vehicle (ROV) dive confirmed what several members of the Science Team expected. The wreck appears to be a hotspot for *Lophelia* coral. It was a great day for both the marine archaeologists and the biologists. Image courtesy of NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar29_hires.jpg

Image of gridded bathymetry shown as a wireframe and draped over gridded backscatter data. Ever since the Team on Leg I of the Gulf of Mexico expedition mapped the DeSoto Canyon area in early March 2012, there was lots of speculation about one specific seafloor feature in approximately 400 meters of water. Not only did the feature seem to be the one spot of significant relief in an otherwise fairly flat area, but it also showed up in the backscatter data as a very 'hard' target. Image courtesy of NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar28_update_hires.jpg

Through the power of technology, scientists on the ship and on shore are able to view and learn about the complex ecosystems in the Gulf of Mexico. Deep-sea corals flourish in the dark depths of the Gulf of Mexico, providing foundations that attract lush communities of other animals, including brittle stars, anemones, crabs, and fish. This diversity of life on the seafloor may be out of sight, but it is has been squarely on the minds of scientists seeking to determine the short- and long-term ecological impacts of the Deepwater Horizon oil spill. Image courtesy of the NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar24-2-hires.jpg

The purpose of the Gulf of Mexico 2012 Expedition is to explore unknown and poorly known ocean areas in the Gulf of Mexico. Specifically, the northern West Florida Escarpment, the DeSoto Canyon in the northeastern Gulf, the vicinity of the Deepwater Horizon or Macondo Well, and deepwater shipwrecks (Figures 1 – 5). A major objective of the expedition is to use the *Okeanos Explorer's* state-of-the-art ocean exploration capabilities to investigate the diversity and distribution of deep-sea habitats and marine life in the target areas. Even after extensive investigations following the Deepwater Horizon blowout event in 2010, much of the Mississippi Canyon area where the event occurred remains unexplored. Throughout the deep Gulf of Mexico the situation is much the same: the ecology and even the basic distribution of seeps and deep-sea ecosystems remain poorly understood. For additional information about the Gulf of Mexico 2012 Expedition, please see the *Gulf of Mexico 2012 Okeanos Explorer Expedition Education Module* http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/edu/edu.html.

The Gulf of Mexico 2011 Expedition (http://oceanexplorer.noaa.gov/okeanos/explorations/ex1105/welcome.html) demonstrated that the *Okeanos Explorer's* deepwater multibeam sonar system can be used to map the location of gaseous seeps, and this capability will be used to search for hydrocarbon seeps in all of the areas to be explored. While much of the exploration of deepwater ecosystems in the Gulf of Mexico has been driven by their association with hydrocarbon seeps that may indicate the presence of undiscovered petroleum deposits, these are also unique biological communities whose importance is presently unknown. (For more about hydrocarbon seeps and their associated ecosystems, please see *Lessons from the Deep: Exploring the Gulf of Mexico's Deep-Sea Ecosystems Education Materials Collection*; http://oceanexplorer.noaa.gov/edu/guide/welcome.html.)

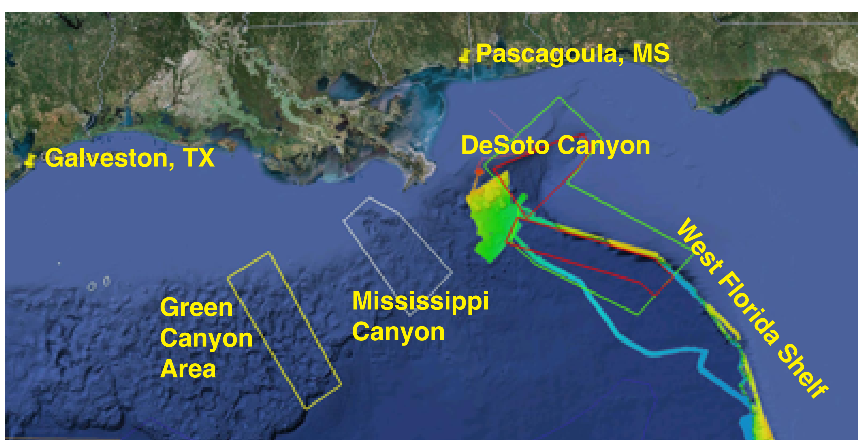


Figure 1 – Google Earth map showing general priority areas for the Gulf of Mexico 2012 Expedition.

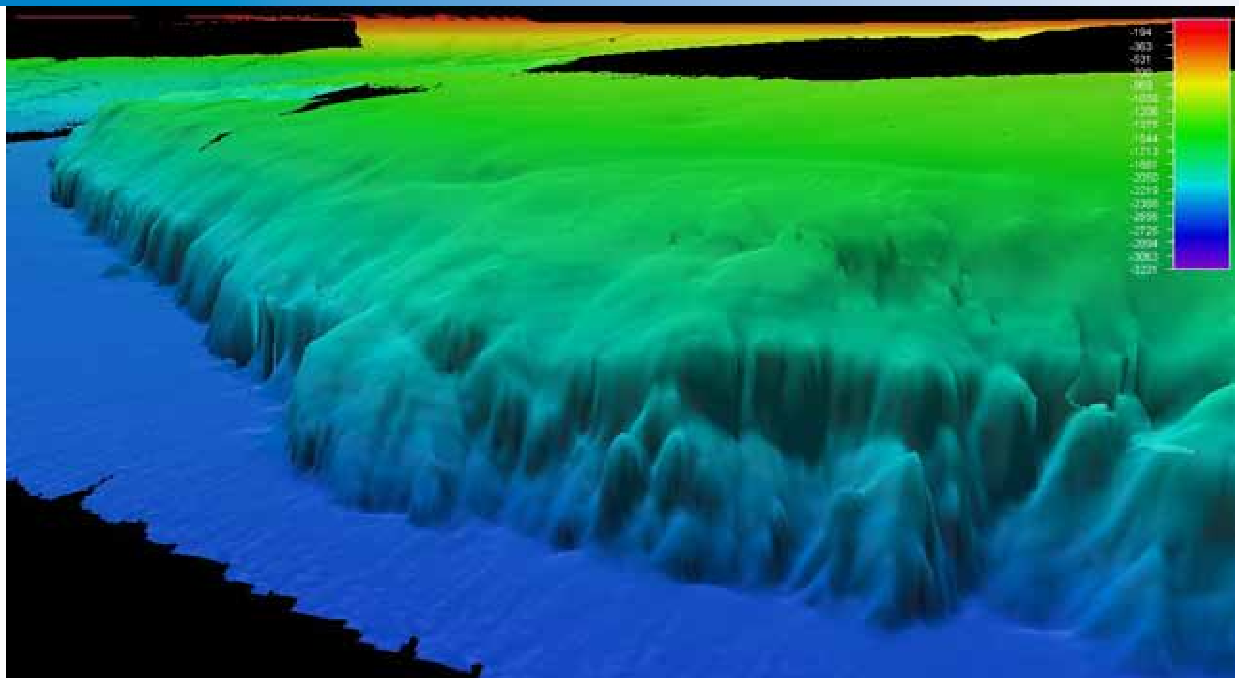


Figure 2 – Bathymetry of the West Florida Escarpment. The base of the escarpment (2,600 meters depth) is shown in blue with the upper rim more than 600 meters above. The expedition will identify at least four dive sites that cover the diverse soft sedimented and hard carbonate rock bottom between 2,300 and 400 meters to explore the physical structure of the seafloor and biodiversity on soft and hard bottom habitats (Multibeam data from EX1105, EX1106, and this expedition, EX1202). Image courtesy of the NOAA *Okeanos Explorer* Program. [*http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/hires/science-1-hires.jpg*]

Figure 3 – Bamboo corals (with an attached crinoid) on a scarp wall in the DeSoto Canyon area (2,055 meters depth). Image courtesy of the NOAA *Okeanos Explorer* Program. [*http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/hires/science-3-hires.jpg*]

Figure 4 – Corals and associated animals living with them in the vicinity of the Deepwater Horizon oil spill (within 11 kilometers) as captured by a time-lapse camera image. Image courtesy of C. Fisher and T. Shank, Woods Hole Oceanographic Institution. [*http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/science/media/science-2-600.jpg*]

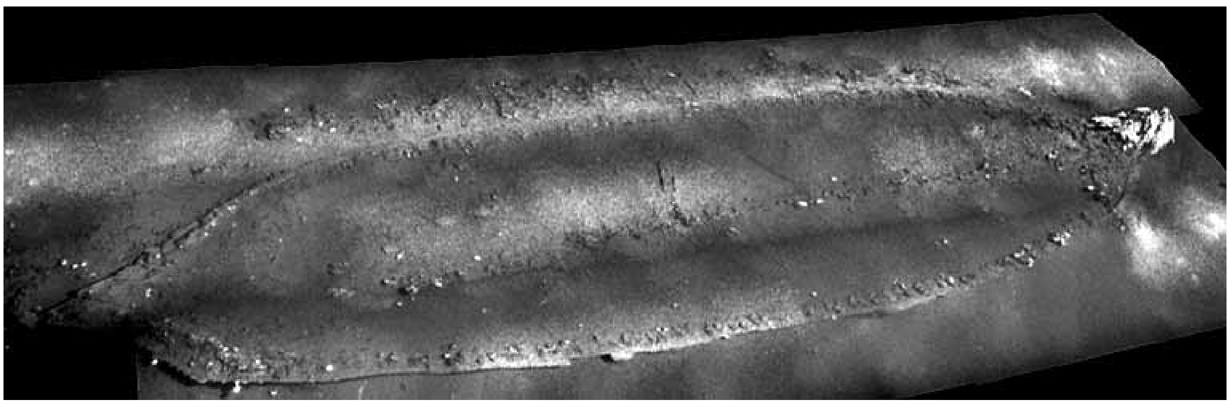


Figure 5 – Mosaic of the Ewing Bank Wreck at 621 meters depth in the Gulf of Mexico. This three-dimensional perspective of the Ewing Bank Wreck was produced by "draping" the photo mosaic over the multibeam bathymetry. The photos and multibeam data were collected with the C-Surveyor autonomous underwater vehicle. Image courtesy of C & C Technologies, Inc.; video courtesy of *Lophelia* II 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks Exploration. [*http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/hires/science-4-hires.jpg*]

This Datasheet guides student investigations of video data obtained by the ROV *Little Hercules* during the Gulf of Mexico 2012 Expedition. The audio track includes conversations and comments by scientists and the ROV pilot during a dive to explore the West Florida Escarpment.

Procedure

1. To prepare for this activity:
   a. Ensure that students are familiar with procedures described in the lesson, *Tools for Classroom Explorers – How to Use Video Imagery from Underwater Robots*.
   b. Download the video file EX1202_video_1.mov from http://oceanexplorer.noaa.gov/okeanos/edu/resources/media/movies/ex1202_video_1_video.html, and install on equipment that students will use to view this file. This

video may be viewed on separate computers used by individual student groups, or by the class as a whole.

c. Review questions on the *ROV Imagery Student Investigation Guide #1 for Cruise 12.02* using the video clip downloaded in Step 1(b). Make copies of the *Guide* for each student group.

d. Review the Mission Plan and Background Essays for the Gulf of Mexico 2012 Expedition (linked from oceanexplorer.noaa.gov/okeanos/explorations/ex1202/welcome.html). You may also want to consider assigning these as the basis for short student reports to give a more complete impression of the expedition's activities.

2. Briefly review the purpose of the Gulf of Mexico 2012 Expedition. If assigned, have students present their reports based on Daily Updates and Mission Logs.

3. Provide each student group with a copy of *ROV Imagery Student Investigation Guide #1 for Cruise 12.02*, and caution them to read through the *Guide* before watching the video, since some questions are related to particular segments identified by elapsed time from the beginning of the video. If students will be viewing the video individually, have them work at their own computers to answer the Investigation Guide questions. Otherwise, show the video to the entire class, then have each group answer the questions. If time permits, it is best to view the video once to listen to comments and conversations between explorers and to obtain a sense of the areas investigated by the ROV, then view it again to answer *Investigation Guide* questions.

Mention that the explorers heard talking in the video frequently mention "associates," which refers to organisms that are often seen together. You may want to briefly discuss the concepts of symbiosis, mutualism, commensalism, and parasitism. In the broadest sense, symbiotic means that two organisms live together, and could be considered a synonym for associate. Associate is preferred, however, since very little is known about the actual relationships between most deep-sea organisms and this term is even more general than symbiotic. Mutualism refers to symbiotic relationships in which both organisms benefit; commensalism refers to relationships in which one organism benefits and the other is unaffected; and parasitism refers to relationships in which one organism benefits and the other is harmed.

A pagurid hermit crab carries a sea anemone on its borrowed shell. Image courtesy of the NOAA *Okeanos Explorer* Program.

4. Discuss students' answers to *Investigation Guide* questions. This discussion should include:
   - Pteropods are free-swimming planktonic sea snails that are an important food source for many fishes including salmon, mackerel, herring, and cod. Ocean acidification from higher atmospheric concentrations of carbon dioxide has been shown to interfere with shell formation in pteropods.

   - *Sargassum* that falls from shallower depths is an important source of organic carbon in the deep ocean.

   - A worm was associated with the *Sargassum* shown in the video. It appeared soon after the image zoomed in on the *Sargassum*, about 0:57.

   - The symbiotic relationship between the anemone and pagurid hermit crab is a well-known example of mutualism. The anemone receives free transportation, as well as scraps of food that float upward when the crab feeds. The stinging cells (nematocysts) of the anemone provide the crab with protection from predators such as octopus. As the crab grows, it eventually leaves its borrowed shell for a larger one; but when that happens, the crab removes the anemone from the old shell and places it on the new one. So, the crab doesn't want to escape from the "burden" of the anemone, even though it could!

   - The crab-anemone association involves three animals: the crab, the anemone, and the deceased mollusc that produced the shell occupied by the crab.

   - Corals and crinoids are found in high densities in the vicinity of the area included in the video segment at 3:44.

   - The *Bathypathes* coral seen at 4:20 is approximately 40 cm tall.

   - Associates seen at 4:50 are a paramuricid coral and an *Asteroschema* ophiuroid.

   - A given species of brittle star is usually associated with only one coral species.

   - Ophiuroid arms are sometimes clipped off or removed by predators.

   - Ocean explorers want to capture close-up video of ophiuroid central disks because this feature helps identify the brittle star.

   - *Seirios* helps isolate *Little Hercules* from water motion, so the ROV can be nearly motionless.

- Associates seen at 8:05 are an *Iridigorgia* coral, a crinoid, and a shrimp.
- The shrimp seen at 8:34 is female, since eggs are visible on the shrimp's abdomen.
- Associates seen at 11:00 are a sponge and several polychaetes.
- Associates seen at 13:10 are a paramuricid coral and an ophiuroid.
- In Figure 1, the approximate height of the paramuricid coral is 3 cm. The approximate height of the column of the white anemone is 1.2 cm.

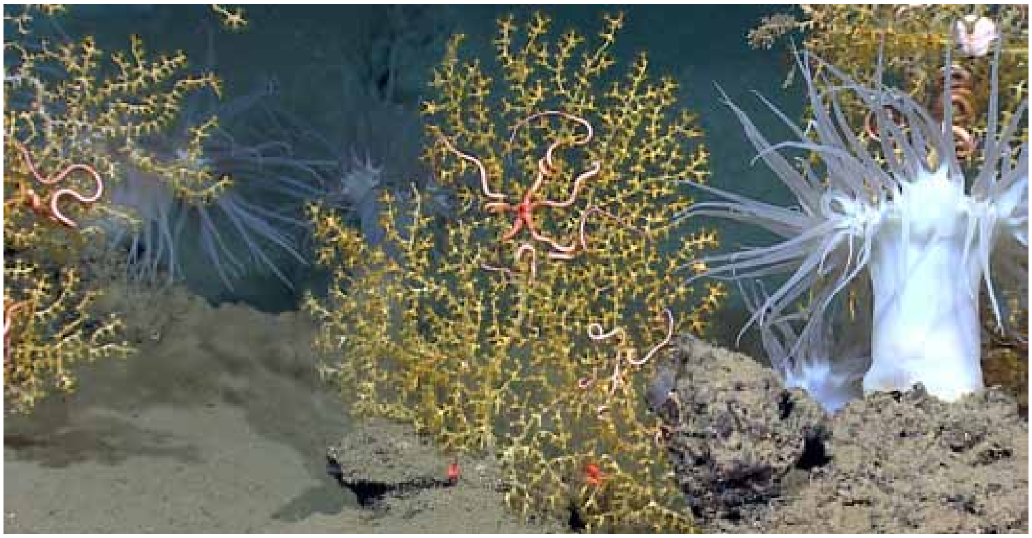


Figure 1. A brittlestar living on a paramuricid coral adjacent to a large white anemone. Laser dots are 10 cm apart. Image courtesy of NOAA *Okeanos Explorer* Program.

- In Figure 2, the approximate height of the black coral is 66 cm.

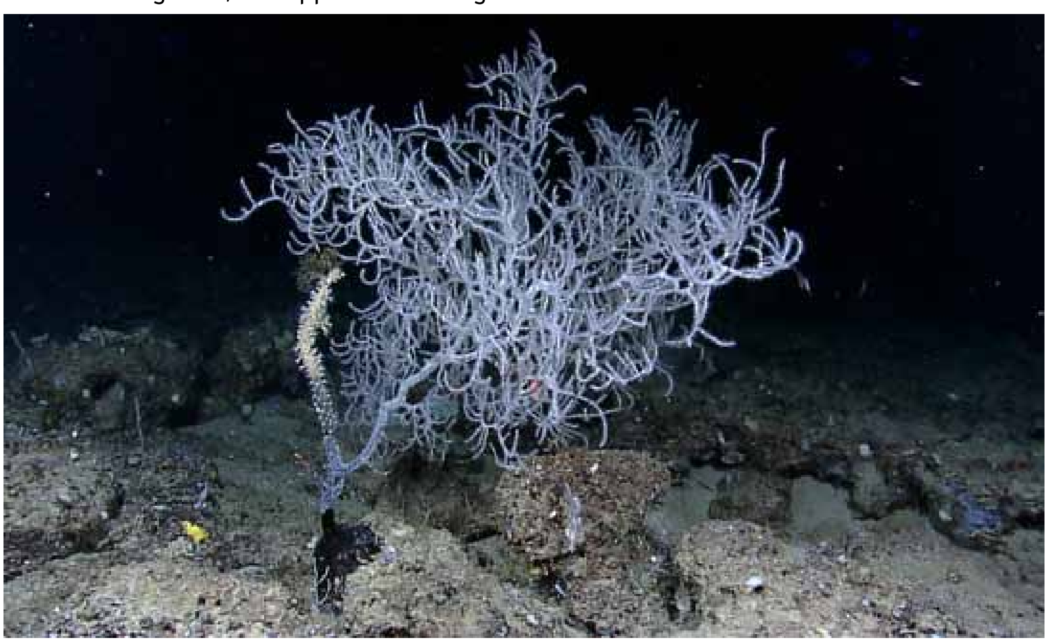


Figure 2. A A *Leiopathes* black coral colony at 425 meters depth on the West Florida escarpment. Red lasers are visible on the branches and polyps near the middle of the screen, 10 centimeters apart. They indicate that this basal axis of the colony is about 1.7 centimeters in diameter. This suggests an age between 400-1000 years old, based on published growth rates for black corals in the Gulf of Mexico (Prouty *et. al,* 2011). Image courtesy of NOAA *Okeanos Explorer* Program.

- Students may comment on periods within the video during which nothing appears to be happening. Point out that the ROV dive during which this video was made required more than nine hours to complete, and that for much of this time there was not much to see. When interesting organisms and features are located, explorers often spend a lot of time moving the ROV into the best position to capture high-quality images. Time is also needed to re-position the *Okeanos Explorer* as the ROV moves along its dive track. The ship's dynamic positioning system allows it to remain in a very precise location during these dives. Successful dives depend upon a high level of coordination between the ship's crew, pilots of *Little Hercules* and *Seirios*, video operators, and scientists on the ship and in Exploration Command Centers thousands of miles away. At some points in the video you can hear some of the many conversations that are involved in maintaining this kind of complex collaboration over many hours during the dive.

Close up image of a brittle star with arms wrapped around a paramuricid coral. The scale across the bottom of the field of view is approximately 10 centimeters. Image courtesy of NOAA *Okeanos Explorer* Program.

A squat lobster (right) sitting next to a crinoid (left). Image courtesy of the NOAA *Okeanos Explorer* Program.

ROV Imagery
Student Investigation Guide #1 for Cruise 12.02

Be sure to read through the following questions BEFORE you watch the video, EX1202_video_1.mov! These questions are linked to specific points in the video that are identified by the time in minutes and seconds elapsed from the beginning (so, 6:23 means six minutes and twenty-three seconds from the beginning of the video). Use a watch or stopwatch to keep track of the elapsed time. The time cord visible in the video won't work for this, because it is not referenced to the beginning of this video clip. You may need to use the Internet or other reference materials to answer some questions.

1. **0:12** – What are pteropods?

2. **1:00** – Science Team Lead Tim Shank says that the marine alga *Sargassum* seen in the video has "fallen down." How is *Sargassum* significant in the deep ocean?

3. **1:35** – What animal was associated with the *Sargassum* shown in the video? Did you see it before Tim mentioned it?

4. **2:40** – Tim Shank comments that the anemone appears to be very heavy, and the hermit crab is "laboring to move that anemone around." Why would the crab do this; why not just move to another shell without an anemone and avoid all the heavy work?

5. **2:45** – How many different animals are involved in the association seen in this segment?

6. **3:44** – What animals are found in high densities in the vicinity of this video?

7. **4:20** – Watch for the two laser dots in the center lower third area of the video screen. These dots are 10 cm apart. Pause the video at 4:32, and use the dots to estimate the height of the *Bathypathes* coral.

8. **4:50** – What associates are seen in this segment?

9. **5:43** – Do brittle stars usually move around among several different coral species?

10. **6:09** – Why are ophiuroid arms sometimes clipped off or missing?

11. **6:24** – Why do ocean explorers want to capture close-up video of ophiuroid central disks?

12. **6:59** – How does *Seirios* help *Little Hercules* remain motionless when it is stopped for video recording?

13. **8:05** – What associates are seen in this segment?

14. **8:34** – What is the sex of the shrimp in this segment? How do you know?

15. **11:00** – What associates are seen in this segment?

16. **13:10** – What associates are seen in this segment?

17. In Figure 1, what is the approximate height of the paramuricid coral? What is the approximate height of the column of the white anemone (don't include the tentacles)?

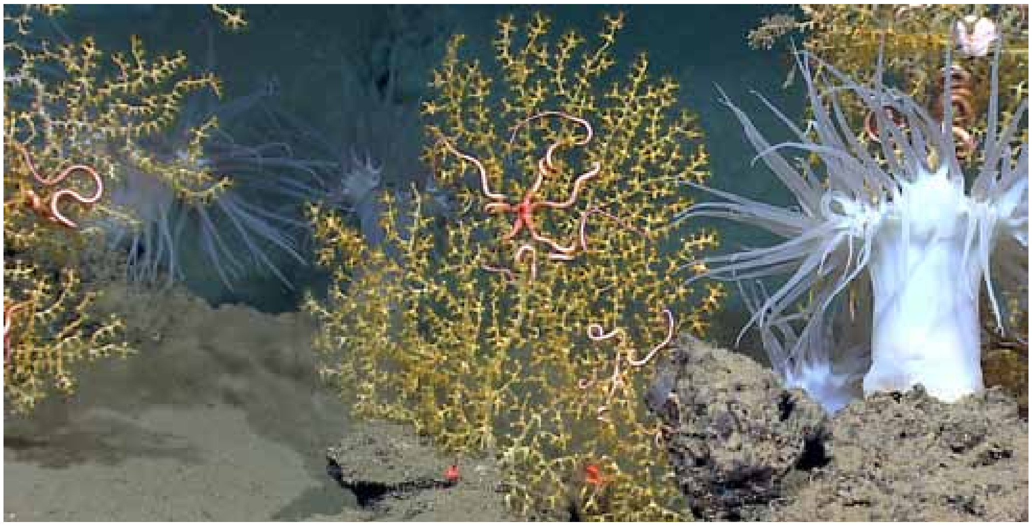
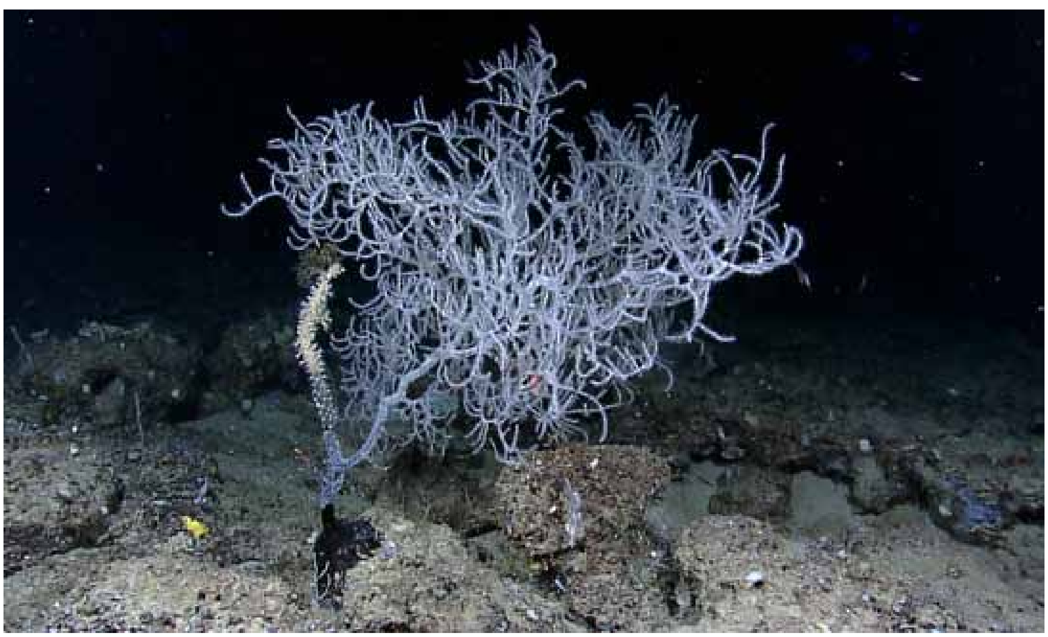


Figure 1. A brittlestar living on a paramuricid coral adjacent to a large white anemone. Laser dots are 10 cm apart. Image courtesy of NOAA *Okeanos Explorer* Program.

18. In Figure 2, what is the approximate height of the black coral?



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