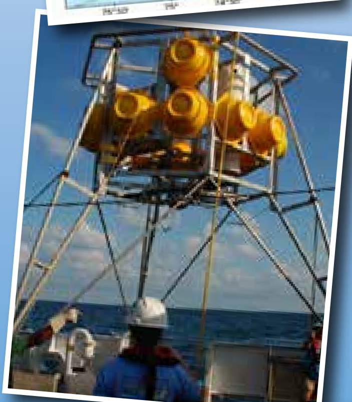
Deepwater Canyons 2013 - Pathways to the Abyss

Seep Creep

(Supplemental Lesson to *Life is Weird* from the Deepwater Canyons 2012 Expedition)



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lesson plan

Focus

Exploration of cold-seep ecosystems

Grade Level

7-8 (Life Science)

Focus Question

What kinds of benthic fauna give clues about the presence of cold seeps?

Learning Objective

- Students will interpret observations from ROV surveys to construct explanations that link the distribution of benthic fauna to their proximity to cold seeps.

Materials

- ❏ Copies of Mission Log listed in Learning Procedure, Step 1, one for each student group; or Internet access to this material
- ❏ Copies of *Guidance for Mission Log Review*; one copy for each student

Audio-Visual Materials

- ❏ (Optional) Interactive white board

Teaching Time

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

Seating Arrangement

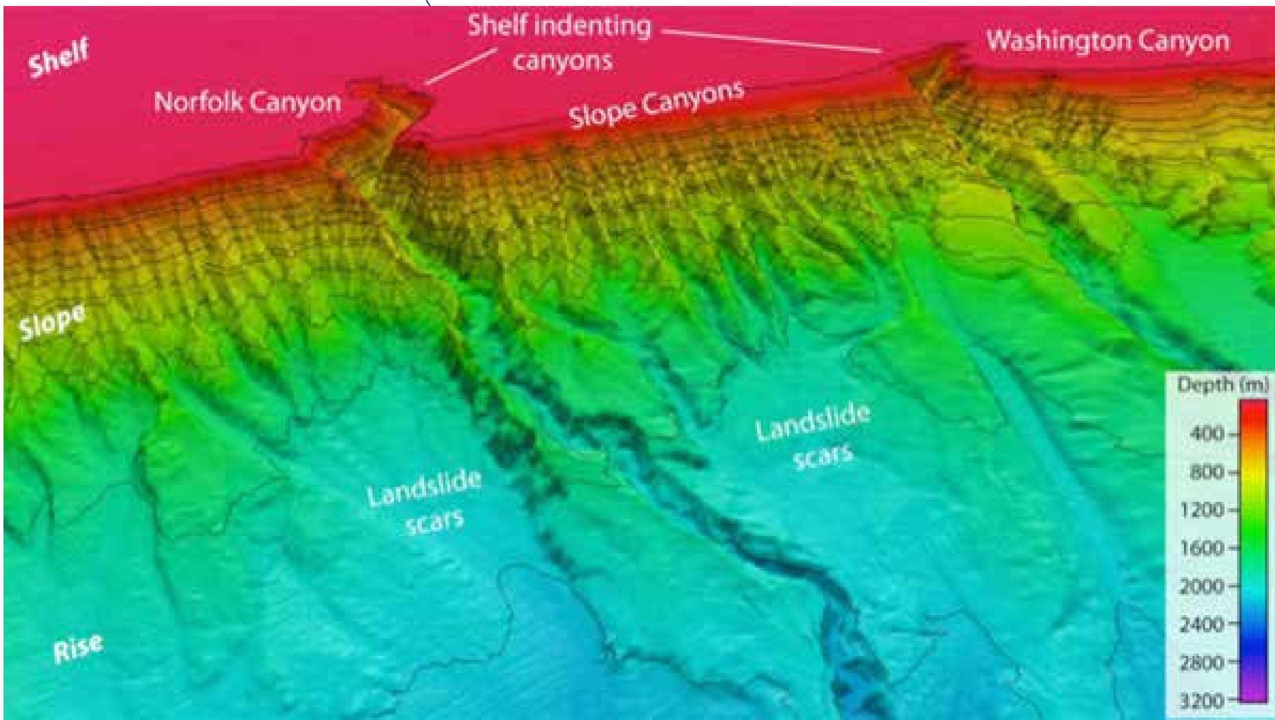
Groups of two or three students

Maximum Number of Students

30

Key Words

Atlantic canyon
Benthic community
Cold seep
Methane hydrate
Chemosynthesis



Deep submarine canyons are perhaps the most striking feature of the continental margin of the eastern United States. Most of these canyons are relatively minor features, but several are incredibly extensive and cut quite deeply into the seafloor. This image shows the Norfolk and Washington Canyons along the continental margin offshore of Virginia. Image courtesy of USGS. http://oceanexplorer.noaa.gov/explorations/11midatlantic/background/seafloormapping/media/seafloormapping_fig3.html

Images from Page 1 top to bottom:
Submarine canyons are dominant features of the outer continental shelf and slope of the U.S. East coast from Cape Hatteras to the Gulf of Maine. Image courtesy of Steve W. Ross, UNC-W. http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/canyons/media/studyarea.html

Netherlands Inst. of Sea Research BOBO benthic lander that will be used in the Middle Atlantic deepwater canyons. Image courtesy of Steve Ross, UNC-W. http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/benthiclanders/media/bobo.html

A goosefish is well camouflaged in any habitat. Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM. http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug27/media/goosefish.html

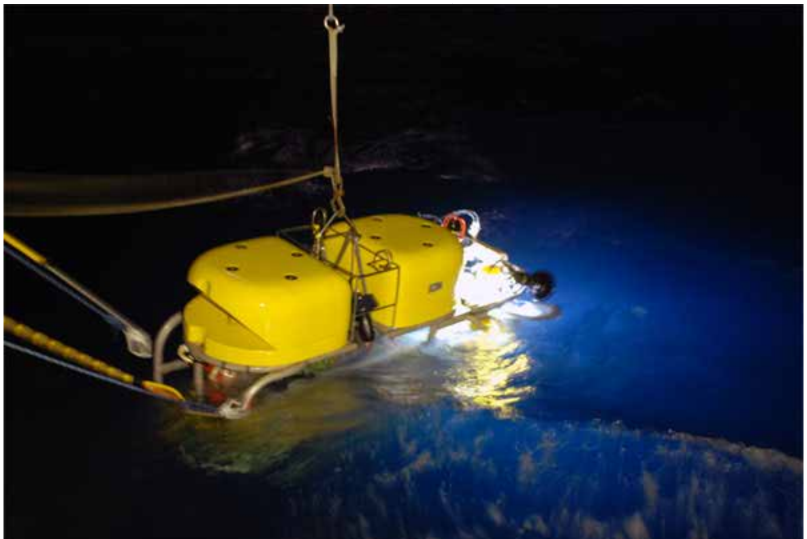
A *Lophelia* coral colony seen in Baltimore Canyon. Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM. http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/sept13/media/lophelia1-hires.jpg

Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

Background information about deepwater canyons off the east coast of the United States is provided in the Expedition Education Module for the Deepwater Canyons 2012 – Pathways to the Abyss Expedition [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/edu.html], and the *Life is Weird* lesson plan [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_weird78.pdf].

The purpose of the Deepwater Canyons 2013 - Pathways to the Abyss Expedition is to extend work begun in 2012 to explore and investigate deepwater coral and hard bottom communities and shipwreck sites on the continental slope off Virginia, Maryland, and Delaware. This work includes bathymetric mapping, collection of photographic imagery and samples using a remotely operated vehicle, and deploying long-term monitoring instruments to measure physical and chemical conditions including temperature, salinity, turbidity, dissolved oxygen, and



Lights, camera, action! The *Kraken II* remotely operated vehicle used for the 2012 expedition was built for science and was equipped with all the tools needed for collecting deepwater specimens. Image courtesy of the Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.
http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/sept30/media/kraken.html

bottom currents. In 2012, most of this effort was concentrated on Baltimore Canyon. In 2013, the focus will shift to Norfolk Canyon.

Mid-Atlantic canyons may also include chemosynthetic communities whose food webs are based on the energy of chemical compounds, in contrast to photosynthetic communities whose food webs are based on photosynthesis that uses energy from the sun. The first chemosynthetic communities were discovered in 1977 near the Galapagos Islands in the vicinity of underwater volcanic hot springs called hydrothermal vents, which usually occur along ridges separating the Earth's tectonic plates. Hydrogen sulfide is abundant in the water erupting from hydrothermal vents, and is used by chemosynthetic bacteria that are the base of the vent community food web. Another type of chemosynthetic community is found in areas where gases (such as methane) and liquid hydrocarbons seep out of sediments. These areas, known as cold seeps, are commonly found along continental margins, and (like hydrothermal vents) are home to many species of organisms that have not been found anywhere else on Earth.

Cold-seep communities have been found at two locations on the east coast continental slope. These communities may signal the presence of other unusual ecosystems, potentially important energy resources and areas that may be susceptible to submarine landslides that can trigger tsunamis. An historic example of this hazard was the 1929 Grand Banks submarine landslide, which produced a tsunami 3 to 8 m high. That tsunami killed 28 people along the Newfoundland coast, even though this area was sparsely populated at the time. A similar tsunami along the present-day Atlantic coast might be much more devastating.

The fact that the Pathways to the Abyss expeditions take place over several subsequent years gives students (as well as expedition scientists) the opportunity to compare conditions in several deepwater canyons, and to see how observations in one area can be used to guide explorations in other locations. In the 2012 *Life is Weird* lesson, students investigated cold-seep ecosystems and interdependent relationships within these systems. In this lesson, students will use observations from the Deepwater Canyons 2012 - Pathways to the Abyss Expedition to make inferences from distributions of benthic animals that give clues to the presence of cold seeps. In addition, mission logs from the 2013 expedition will allow students to compare their inferences with actual discoveries as the 2013 expedition unfolds.

Learning Procedure

1. To prepare for this lesson:
   a. Review the background essays for the Deepwater Canyons 2013 - Pathways to the Abyss Expedition [http://oceanexplorer.noaa.gov/explorations/13midatlantic/welcome.html].If students have not completed the *Life is Weird* lesson, you may also want to review background information for this lesson as well [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_weird78.pdf].

   b. Ensure that students will have access to the Mission Log, *Baltimore cold seeps re-discovered!!* (August 26, 2012) by Sandra Brooke and Steve Ross (http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug26/aug26.html).

2. Briefly describe deepwater canyon habitats. Introduce the Deepwater Canyons 2013 - Pathways to the Abyss Expedition and tell students that this is a continuation of an expedition that began exploring this area in 2012. Mention some of the reasons for exploring these habitats, which include the facts that similar sites in other areas are known to support important fisheries and other biological resources, and that cold-seep communities may exist in some locations. If students are not familiar with cold-seep habitats, briefly describe these (see the Expedition Education Module for the *Lophelia* II 2012: Deepwater Platform Corals Expedition, http://oceanexplorer.noaa.gov/explorations/12lophelia/background/edu/edu.html, for more details). Point out the significance of methane hydrate deposits, including their positive potential as a new energy source as well as their negative potential for triggering underwater landslides that can result in tsunamis.

3. Provide each student group with copies of the Mission Log referenced in Step 1b or Internet access to this material. Tell students that their assignment is to review this Log, and prepare a short summary that addresses questions on the *Guidance for Mission Log Review* document.

4. When students have completed their reviews, lead a discussion of their results. The following points should be included:

   1) LORAN stands for long-range navigation, and is a position-finding system that uses low frequency radio signals from fixed radio beacons based on land. This system has been phased out in many countries and has been replaced with GPS technology. The most accurate positions determined with LORAN equipment are plus or minus about 185 m.

2) The Mission Log states that dead mussel shells were seen after about one hour. Since the entire dive lasted a little more than six hours, the location of the dead mussel shells should be about one-sixth the total length of the dive track. The Mission Log also states that the ROV followed the 420 m contour around a knoll, which appears as a shaded area in the lower left corner of the figure. The ROV track is considerably thicker and irregular at the approximate location latitude 38°2′32″ North, longitude 79°49′47″ West, suggesting that the ROV was moving back and forth over a small area.

3) The irregularity of the first half of the dive track for Dive ROV-12-NF-08 might be caused by the ROV moving slowly around the areas where cold-seep organisms were seen. The fact that the second half of the dive is much less irregular suggests that fewer organisms were seen, or that the scientists wanted to cover as much area as possible to estimate the overall size of the cold-seep site.

4) The length of the ROV track in a north-south direction is about 700 m.

5) The Mission Log indicates that there were substantial numbers of many different kinds of organisms. This does not suggest water conditions that are low in dissolved oxygen.

6) Mussels are not directly capable of chemosynthesis, but they can obtain nutrition from organic materials that are produced by symbiotic microorganisms that produce these materials through chemosynthesis.

White bacterial mats indicate seep activity. Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.
http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug26/media/whitebacterialmats.html

7) Mussels found at the cold-seep site can obtain nutrition by filter feeding or from organic materials produced by symbiotic microorganisms through chemosynthesis.

8) Mats of white bacteria seen during Dive ROV-12-NF-08 suggested the ROV might be getting close to an active cold seep.

5. Have student groups take turns reviewing Mission Logs from the Deepwater Canyons 2013 - Pathways to the Abyss Expedition, and make brief (5 – 10 minute) oral reports about new discoveries, and how observations and events reported in these Logs compare to results from the 2012 expedition.

The BRIDGE Connection

www.vims.edu/bridge/ – Scroll over "Ocean Science Topics" in the navigation menu to the left, then "Habitats," then "Coastal," then "Coral" for resources on corals and coral reefs. Click on "Physics" for resources on ocean currents.

The "Me" Connection

Have students write a short essay about how discoveries in deepwater canyons might one day affect their own lives.

Connections to Other Subjects

English Language Arts, Mathematics, Earth Science

Assessment

Student reports and class discussions provide opportunities for assessment.

Extensions

Have students visit http://oceanexplorer.noaa.gov/explorations/13midatlantic/welcome.html to find out more about the Deepwater Canyons 2013 - Pathways to the Abyss Expedition.

Multimedia Discovery Missions

http://oceanexplorer.noaa.gov/edu/learning/welcome.html Click on the links to Lessons 3, 5, 6, and 8 for interactive multimedia presentations and Learning Activities on Deep-Sea Corals, Chemosynthesis and Hydrothermal Vent Life, Deep-Sea Benthos, and Ocean Currents.

Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

Please see the *Life is Weird* lesson [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_weird78.pdf].

Other Resources

Ross, S. W., S. D. Brooke, R. Mather, CSA Ocean Sciences Inc. 2013. Exploration and Research of Mid-Atlantic Deepwater Hard Bottom Habitats and Shipwrecks with Emphasis on Canyons and Coral Communities. Cruise Report to U.S. Department of the Interior, Bureau of Ocean Energy Management. Contract No. M10PC00100

For additional resources, please see the *Life is Weird* lesson [http://oceanexplorer.noaa.gov/explorations/12midatlantic/background/edu/media/dwc12_weird78.pdf].

Correlations to Next Generation Science Standards (NGSS)

The objective of this lesson addresses the following Performance Expectations:

Objective: Students will interpret observations from ROV surveys to construct explanations that link the distribution of benthic fauna to their proximity to cold seeps.

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
[Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]
[Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

Correlations to Common Core State Standards for English Language Arts

RI.4 – Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings
SL.1 – Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 9-12 topics, texts, and issues, building on others' ideas and expressing their own clearly.
L.4 – Determine or clarify the meaning of unknown and multiple-meaning words and phrases, choosing flexibly from a range of strategies.

L.6 – Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.

The Earth has one big ocean with many features.

Fundamental Concept b. An ocean basin's size, shape and features (such as islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.

Essential Principle 5.

The ocean supports a great diversity of life and ecosystems.

Fundamental Concept e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Fundamental Concept f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

Fundamental Concept g. There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps rely only on chemical energy and chemosynthetic organisms to support life.

Essential Principle 6.

The ocean and humans are inextricably interconnected.

Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Essential Principle 7.

The ocean is largely unexplored.

Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Send Us Your Feedback

In addition to consultation with expedition scientists, the development of lesson plans and other education products is guided by comments and suggestions from educators and others who use these materials. Please send questions and comments about these materials to: oceanexeducation@noaa.gov.

For More Information

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Credit

Guidance for Mission Log Review

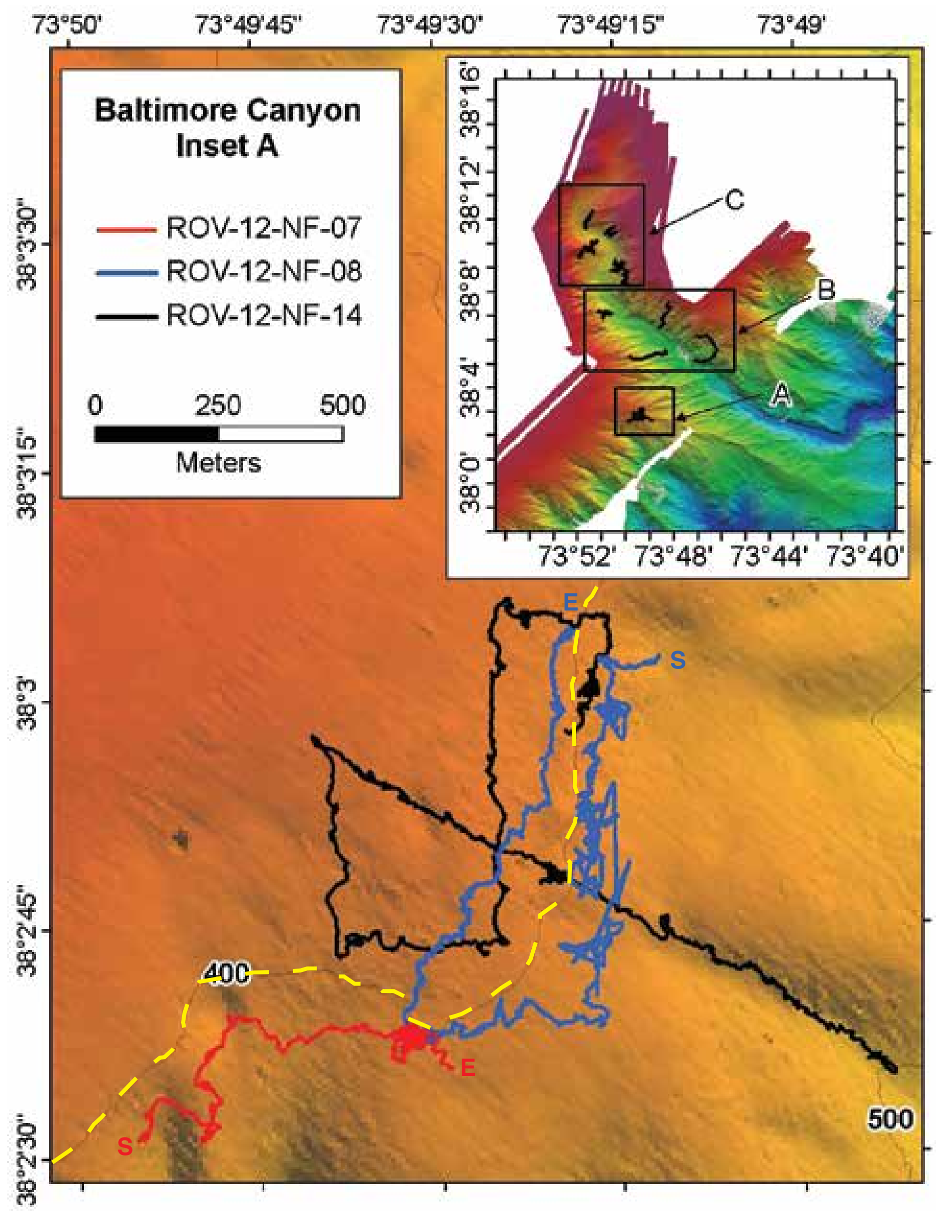
Baltimore cold seeps re-discovered!!

(August 26, 2012) by Sandra Brooke and Steve Ross (http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug26/aug26.html)

1. What is Loran C? How accurate is this system?

2. Refer to Figure 1. Dive ROV-12-NF-07 lasted a total of 369 minutes. From the information provided in the Mission Log, what is the approximate latitude and longitude where scattered dead mussel shells were first seen? What do you notice about the ROV track in this area?

Figure 1.



3. Refer to the dive track for Dive ROV-12-NF-08. The track for about the first half of the dive is much more irregular than the track for the last half of the dive. What do you think might account for this?

4. About how much distance in a north-south direction did the ROV cover while it was investigating the cold-seep site?

5. From the information provided in the Mission Log, do you think the water around the cold-seep site was low in dissolved oxygen?

6. Are mussels capable of chemosynthesis?

7. What are two ways that mussels found at the cold-seep site can obtain nutrition?

8. Besides the mussels, what organism was seen during Dive ROV-12-NF-08 that suggested the ROV was getting close to an active cold seep?

A patch of live mussels, their bright white siphons clearly visible against their dark shells. Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.
http://oceanexplorer.noaa.gov/explorations/12midatlantic/logs/aug26/media/mussels.html