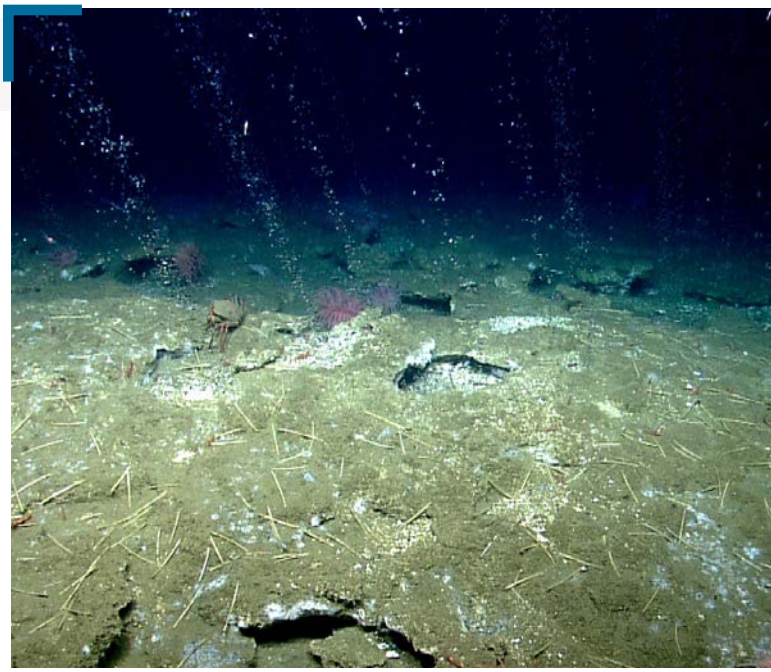
CASE STUDY 2: Exploring Cold Seeps

What are Cold Seeps?

Cold seeps are locations where hydrocarbon-rich fluid seeps up from below the seafloor, often as methane gas or hydrogen sulfide.

Unlike hydrothermal vents, which occur at the edges of tectonic plates where new seafloor is formed in fiery processes, cold seeps lie within plates and leak fluids and gases that are at or close to ambient deep-sea water temperatures. Cold seeps can form above geologic faults or salt deposits or at places where canyons cut into sediments that trap fluid and gas. Some cold seeps develop where warm ocean water causes special methane-containing deposits (gas hydrates) to release their gas. Like hydrothermal vents, cold seeps often host biological communities that use chemical, not photosynthetic, processes to derive their energy.



Methane bubbles flow in small streams out of the sediment on an area of seafloor offshore Virginia. Quill worms, anemones, and patches of microbial mat can be seen in and around the seepage area.
Image courtesy of the NOAA Ocean Exploration.

This activity will guide you through exploration of cold seeps, using the NOAA Ocean Exploration Data Atlas a searchable, interactive expedition data map) and a demonstration video of Fledermaus, a mapping data visualization software used by ocean explorers to view multibeam sonar data and imagery in 3D. Multibeam sonar is one of the most powerful tools available for modern deep-sea exploration, and can create high-resolution maps and three dimensional models.

You will also be introduced to the NOAA Ocean Exploration website and the Northeast U.S. Canyons Expedition where these cold seeps were studied.

Four key technologies are used to gather baseline information on areas of ocean exploration:

Listen
Multibeam sonar mapping system

Test
Conductivity, Temperature and Depth profilers (CTDs)

Photograph
Remotely Operated Vehicles (ROV)

Share
Telepresence technologies

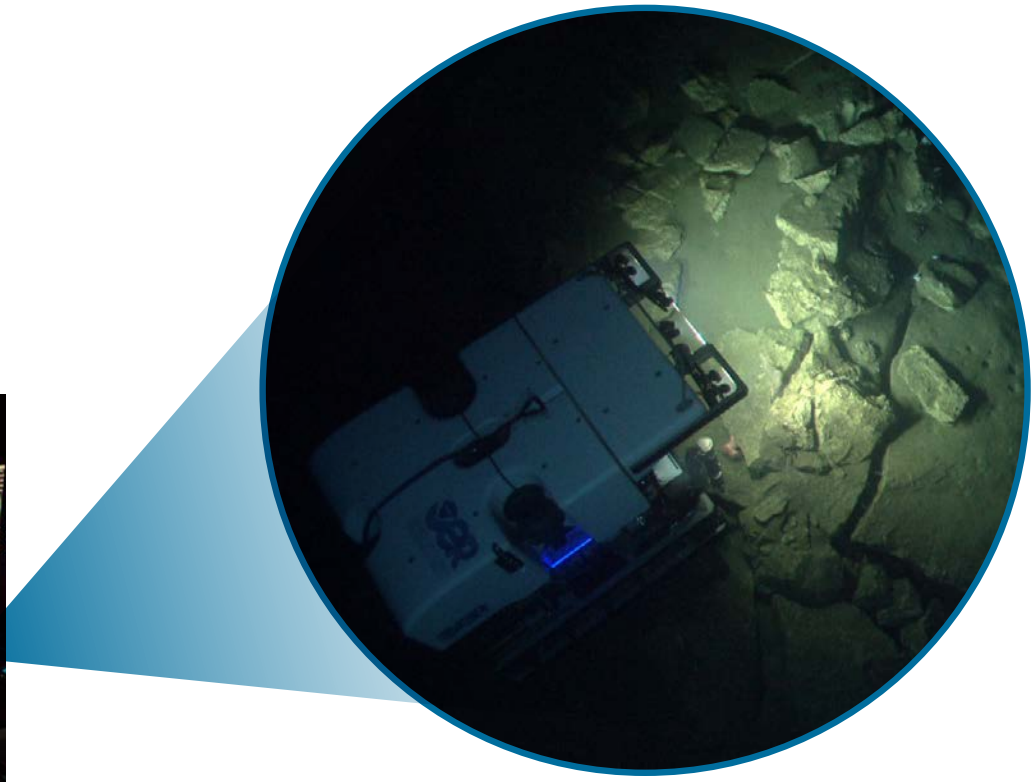
What Cold Seeps are we Exploring?

The cold seeps we will explore in this activity were discovered during the Northeast U.S. Canyons Expedition in summer 2013. During this expedition, a team of scientists and technicians both at-sea and on shore conducted exploratory investigations on the diversity and distribution of deep-sea habitats and marine life along the Northeast U.S. Canyons and at Mytilus Seamount, located within the U.S. Exclusive Economic Zone. During this mission, the exploration team observed deep-sea coral communities, undersea canyons, seamounts and cold seeps.

The expedition also marked the first time NOAA's 6,000 meter remotely operated vehicle (ROV), *Deep Discoverer* and the *Seirios* camera sled and lighting platform were used in a full telepresence enabled ocean exploration with NOAA Ship *Okeanos Explorer*. When these systems were deployed from the ship, the expedition team was able to provide scientists and audiences onshore with real-time video footage from deepwater areas in important, largely unknown, U.S. waters.

Exclusive Economic Zones (EEZs) are areas of the sea, generally extended 200 nautical miles from a country's coastline. Within this zone, coastal countries retain special rights to exploration and the use of marine resources.

Check here for more information on the U.S. EEZ.



Scientists pilot the ROV *Deep Discoverer* for the first time. *Images courtesy of NOAA Ocean Exploration.*

Student Investigation: Exploring Cold Seeps with Multibeam Sonar Tools

TOOL 1: Exploring Cold Seeps with the NOAA Ocean Exploration Data Atlas

Now that you know more about cold seeps, let's use the NOAA Ocean Exploration Data Atlas to explore these features.

OPEN THE ATLAS LINK

- https://www.ncei.noaa.gov/maps/ocean-exploration-data-atlas/

INPUT THE EXPEDITION DETAILS:

Minimum Y(ear): 2013
Maximum Y(ear): 2013
Expedition Name: EX1304L1 (select code in the left hand drop down menu) - Northeast U.S. Canyons Expedition (expedition name will appear in the right hand sidebar)
Platform Name (vessel): NOAA Ship *Okeanos Explorer*

EX1304L1: "EX" is used as an abbreviation for the NOAA Ship *Okeanos Explorer*, the last two digits of the year of the cruise (13), the number of the cruise (fourth cruise-04 for 2013), and the segment or leg (first leg-L1 of cruise-04).

CLICK ZOOM TO RESULTS

PLOT ON MAP: Use your center mouse button to zoom in until the names of the ROV dives appear.

LOOK CLOSER: Holding the left mouse button down, shift the map and zoom in to find the Remotely Operated Vehicle (ROV) Dive 3 (EX1304L1_DIVE 03). Discuss the following questions with your group.

1. What do you think the ship was doing here to make those lines on the map? Can you think of anything in your life that makes similar patterns? _____

_____

DIVE IN: Zoom in to get a closer look at the dive area.

2. What do you notice? _____

ZOOM OUT: Zoom out to see where this seep site sits on the globe.

3. Describe its location. _____

_____

4. Zooming in and out around the dive site, what other seafloor features do you notice/recognize on the map?

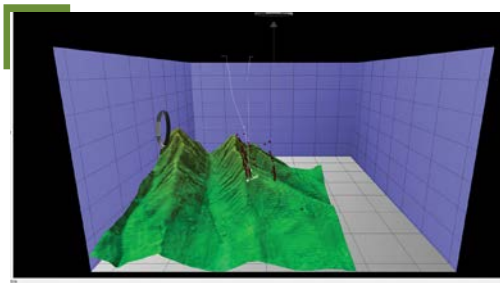
_____

Student Investigation: Exploring Cold Seeps with Multibeam Sonar Tools *cont.*

TOOL 2: Exploring Cold Seeps with Fledermaus

Now that you have found this ROV dive, you will view a video exploration of cold seeps within a platform called Fledermaus. This is a three-dimensional data visualization system used to view and manipulate 3D models of seafloor features, provide insight into the geological structure and associated water column of an area and help to pinpoint ideal locations for further exploration. Use the video to help you discuss and answer the questions below.

Fledermaus, pronounced "FLEE-der-mouse," is the German word for bat.



WATCH: **CASE STUDY 2 FLEDERMAUS VIDEO**

EXPLORE: **Based on your video observations, answer the questions below.**

1. What is the shallowest point in this region? _____ What is the deepest point in this region? _____
2. What appears to be the steepest slope in this image in degrees? _____
3. How deep did the ROV travel when exploring this area? _____

THINK ABOUT IT

4. Why do you think the red row of bubbles are leaning to the west vs. being perfectly vertical?_____
   _____
5. Why do you think the scientists selected this dive location? _____
   _____
6. If you were the scientist leading this expedition and exploring this region for the first time, where would you choose to send the ROV?_____
   _____
7. What considerations do you think need to be made when deciding what regions to select for further exploration? _____
   _____

Student Investigation: Exploring Cold Seeps with Multibeam Sonar Tools *cont.*

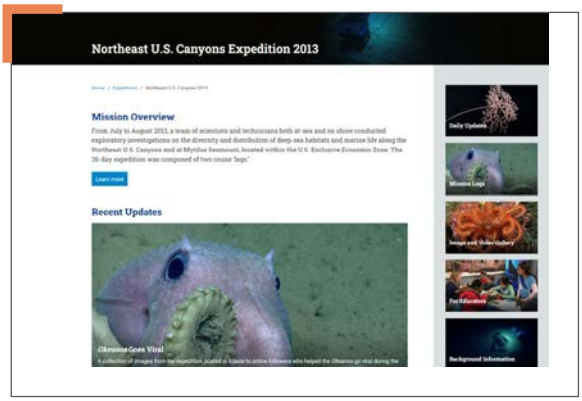
TOOL 3: Expedition Web Pages

Now that you have explored the 3D map of these cold seeps, check out the Northeast U.S. Canyons Expedition EXPEDITION WEB PAGE on the NOAA Ocean Exploration website to learn more about what was studied here and some of the discoveries that were made.

- https://archive.oceanexplorer.noaa.gov/okeanos/explorations/ex1304/welcome.html

HERE YOU CAN...

- read the Mission Overview
- read the Mission Logs and Daily Updates
- view beautiful imagery, videos and more!



BE THE EXPLORER

What happened?

On the Northeast U.S. Canyons Expedition web page, click Daily Updates.

READ the Daily Updates from July 11, 2013 and July 12, 2013.

WATCH the highlight video from **Dive 3**.

1. What was the goal of this dive? _____

   _____

2. What do the bacterial mats found tell the scientists? _____

   _____

3. How big is the methane hydrate they found (the red lasers are 10 cm apart)? _____

   _____

4. What organisms did they find during these dives? _____

   _____

Why does it matter?

READ the Mission Log from July 12, Chemosynthetic Communities and Gas Hydrates at Cold Seeps South of Nantucket. READ the background essay Exploration of Cold Seeps on the North Atlantic Continental Margin.

5. What is the biological significance of the discovery of these methane seeps? _____

   _____

6. What is the global significance of the discovery of these methane seeps? _____

   _____

Cold Seeps Lesson URLs/Links

Page 1:
- Methane bubbles (photo): https://archiveoceanexplorer.noaa.gov/okeanos/explorations/ex1304/background/coldseeps/media/bubbles.html
- Cold Seeps (factsheet): https://oceanexplorer.noaa.gov/edu/materials/what-are-cold-seeps-fact-sheet.pdf
- Chemosynthesis (factsheet): https://oceanexplorer.noaa.gov/edu/materials/chemosynthesis-fact-sheet.pdf
- Listen: https://oceanexplorer.noaa.gov/edu/materials/multibeam-sonar-fact-sheet.pdf
- Test: https://oceanexplorer.noaa.gov/technology/ctd/ctd.html
- Photograph: https://oceanexplorer.noaa.gov/edu/materials/rov-fact-sheet.pdf
- Share: https://oceanexplorer.noaa.gov/technology/telepresence/telepresence.html
- Multibeam Sonar Fact Sheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/multibeam-sonar-fact-sheet.pdf

Page 2:
- Northeast U.S. Canyons Expedition: https://archive.oceanexplorer.noaa.gov/okeanos/explorations/ex1304/welcome.html
- U.S. EEZ (webpage): https://oceanexplorer.noaa.gov/facts/useez.html
- *Deep Discoverer*: https://oceanexplorer.noaa.gov/technology/subs/deep-discoverer/deep-discoverer.html
- *Seirios:* https://oceanexplorer.noaa.gov/technology/subs/seirios/seirios.html
- *Okeanos Explorer*: https://oceanexplorer.noaa.gov/okeanos/about.html

Page 3:
- NOAA Ocean Exploration Data Atlas: https://www.ncei.noaa.gov/maps/ocean-exploration-data-atlas/

Page 4:
- Fledermaus video, Cold Seeps: https://oceanexplorer.noaa.gov/edu/materials/CaseStudy2_ColdSeeps.mp4

Page 5:
- Northeast U.S. Canyon Expedition Web Page: https://archive.oceanexplorer.noaa.gov/okeanos/explorations/ex1304/welcome.html
- Daily Updates: https://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/dailyupdates.html
- Dive 3 highlights (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/logs/photolog/welcome.html#cbpi=/okeanos/explorations/ex1304/dailyupdates/media/video/dive3/dive3.html
- Chemosynthetic Communities and Gas Hydrates at Cold Seeps South of Nantucket (essay): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/logs/july12/july12.html
- Exploration of Cold Seeps on the North Atlantic Continental Margin (essay): https:// oceanexplorer.noaa.gov/okeanos/explorations/ex1304/background/coldseeps/welcome.html

Information and Feedback

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