

## CASE STUDY 2: Exploring Cold Seeps

### What are Cold Seeps?

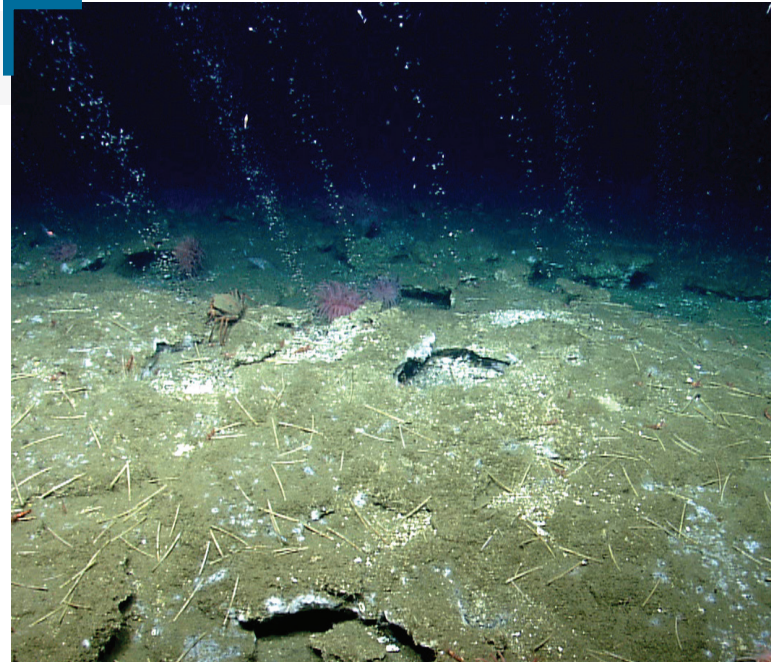
Cold seeps are locations where hydrocarbon-rich fluid seeps up from below the seafloor, often as methane gas or hydrogen sulfide.

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.

This activity will guide you through exploration of cold seeps, using the **Ocean Explorer**

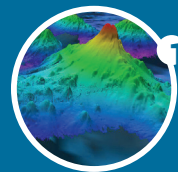
**Digital Atlas** (a searchable, interactive expedition data map) and a free version of **Fledermaus**, a powerful interactive mapping data visualization software used by ocean explorers, providing you first-hand experience using these tools to explore multibeam sonar capabilities in 3D.

**Multibeam sonar** is one of the most powerful tools available for modern deep-sea exploration, and can create high-resolution maps, three dimensional models, or even “fly-through” videos that simulate a trip across an area being mapped. This activity will also introduce you to the NOAA Office of Ocean Exploration and Research website and the **Northeast U.S. Canyons Expedition** where these cold seeps were studied.



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 along the periphery of the seepage area. *Image courtesy of the NOAA Office of Ocean Exploration and Research.*

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.



Learn more about cold seeps on the NOAA OER Theme pages.

<https://oceanexplorer.noaa.gov/edu/themes>

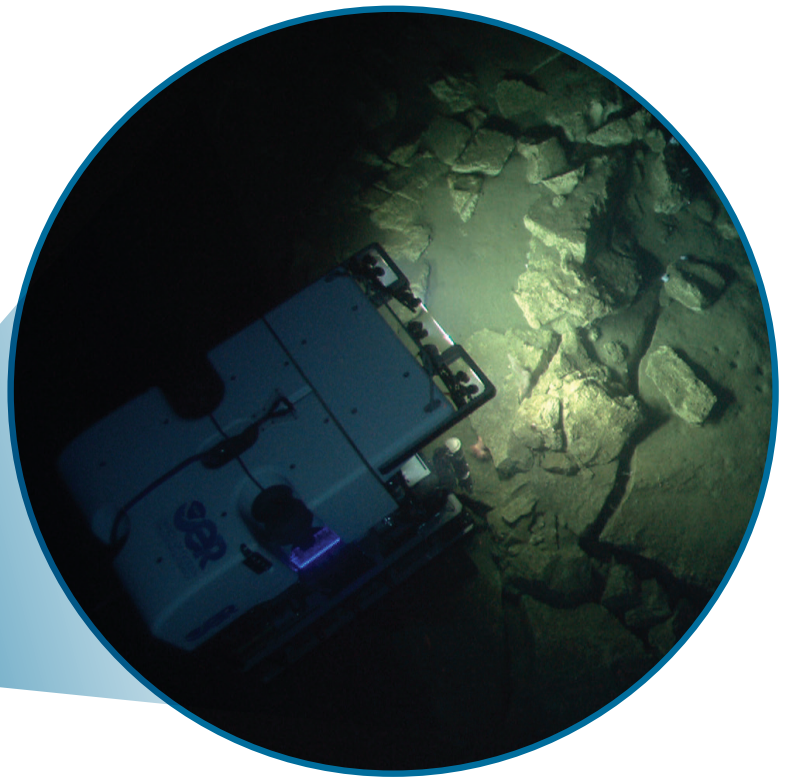


**Exclusive Economic Zones (EEZs)** are areas of the sea, generally extended 200 nautical miles from a country's coastline. Within this zone, coastal countries retain special rights to exploration and the use of marine resources.



The 36-day **Northeast U.S. Canyons Expedition** complemented work done through the 2012 Atlantic Canyons Undersea Mapping Expeditions (ACUMEN).

<https://oceanexplorer.noaa.gov/okeanos/explorations/acumen12/welcome.html>



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

Now that you know more about cold seeps, let's use the **OCEAN EXPLORATION DIGITAL ATLAS**, to explore them.

# Exploring Cold Seeps with Multibeam Sonar Tools

## TOOL 1: Exploring Cold Seeps with the Ocean Exploration Digital Atlas

The Ocean Exploration Digital Atlas is a map-based interactive online atlas tool provided by NOAA's National Centers for Environmental Information (NCEI). The atlas links to information about past expeditions of NOAA's Office of Ocean Exploration and Research missions that began in 2001. This atlas orients users to expedition locations and provides experiences exploring data and associated discoveries from specific expeditions.

**Note:** For a more detailed step-by-step tool guide of how to use the Ocean Exploration Digital Atlas, see the *Watching in 3D: Exploring with Multibeam Sonar activity package introduction*.

### 1. OPEN THE OCEAN EXPLORATION DIGITAL ATLAS:

- ▶ <https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm>

### 2. CHOOSE YEAR AND VESSEL:

2013; *Okeanos Explorer*; Search.  
The dots that appear are all the 2013 *Okeanos Explorer* expeditions.

### 3. CHOOSE EXPEDITION:

2013 *Okeanos Explorer* Northeast U.S. Canyons Expedition (EX1304L1).



**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 (this was the fourth cruise for 2013), and the segment or leg (this was the first leg of cruise 04).

# Exploring Cold Seeps with Multibeam Sonar Tools *cont.*

**Digital Atlas**  
Discover the world of data and information

Ocean Exploration and Research

Search Layers Help

Use any combination of the provided dropdown lists to define search criteria

Year:  
 2014  
 2013  
 2012  
 2011  
 2010

Ocean Places:  
All

Mission Groups:  
All

Platforms:  
All

Enter Search Text:  
ocean explorer

Search

8 Cruises Displayed

Reset Map

Okeanos Explorer (EX1304L1): Northeast U.S. Canyons Exploration - 2013

GIS Rest Service

Data Sets:

Bathymetry Mosaic

Ship Track

Dive Locations

Dive Tracks

Plot on Map

1) 2013 - Okeanos Explorer (EX1305): Summer Ecosystem Monitoring Survey [More Details...](#)

2) 2013 - Okeanos Explorer (EX1304L2): Northeast U.S. Canyons Exploration [More Details...](#)

3) 2013 - Okeanos Explorer (EX1304L1): Northeast U.S. Canyons Exploration [More Details...](#)

4) 2013 - Okeanos Explorer (EX1303): New England Seamount Chain Exploration [More Details...](#)

5) 2013 - Okeanos Explorer (EX1302): Ship Shakedown, Patch Test and Exploration, NE Canyons [More Details...](#)

6) 2013 - Okeanos Explorer (EX1301): Ship Shakedown and Patch Test Exploration, NE Canyons and Seamounts [More Details...](#)

4. **PLOT ON MAP:** Click on the GIS Tools tab in the pop-up window, select the appropriate boxes (all four for this mission) and click Plot on Map.

✓ GIS stands for Geographic Information Systems.

5. **LOOK CLOSER:** Click on the map and holding the left cursor down, move to the right and zoom in until you find Dive 3.

6. **DIVE IN:** Look for your dive, indicated with a star and EX1304L1 Dive 3. *What do you think the ship was doing here to make those green lines on the map? Can you think of anything in your life that makes similar patterns? The green line is the ship's track, or where it "mowed the lawn."*

\* EX1304L1 DIVE 3

Check longitude and latitude to make sure you are at Dive 3!

Longitude: -69.26 Latitude: 39.90  
(provided in decimal format)

Now that you have found your dive, try the second tool, **FLEDERMAUS**, to explore cold seeps even further.

✓ The color red is used to indicate the shallowest point, followed by orange, yellow, green, blue and purple, with purple being the deepest.

## Exploring Cold Seeps with Multibeam Sonar Tools *cont.*

### TOOL 2: Exploring Cold Seeps with Fledermaus

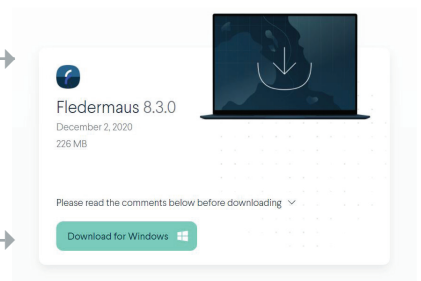
An important technique for studying multibeam images uses a three-dimensional data visualization system called Fledermaus. Fledermaus software allows the user to view and manipulate 3D models of seafloor features, providing insight into the geological structure of an area and helping to pinpoint ideal locations for further exploration.

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

**Note:** For a more detailed step-by-step tool guide of how to use Fledermaus software, see the [Watching in 3D: Exploring with Multibeam Sonar activity package introduction](#).

**1. DOWNLOAD THE (FREE) SOFTWARE (educators and/or students):**

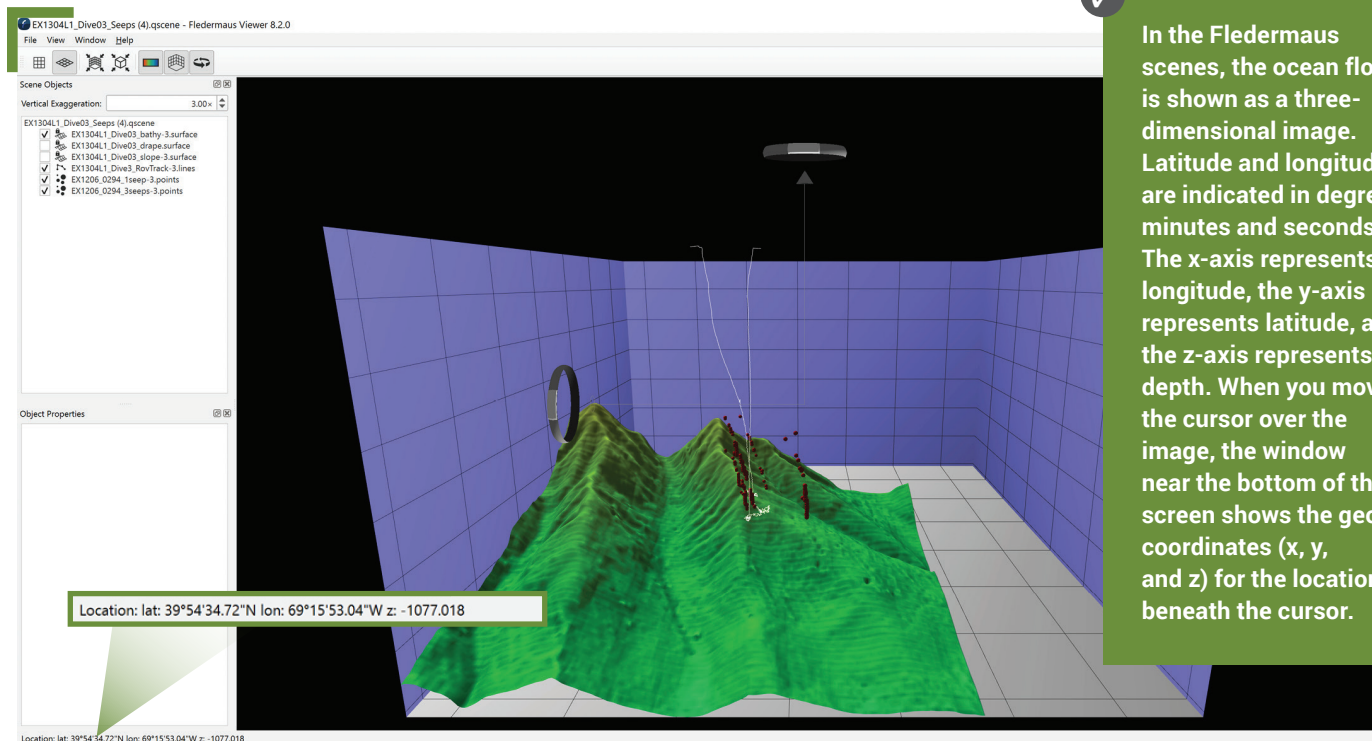
Download the Fledermaus Viewer software (8.2.2 or newer) from the dropdown menu at <https://www.qps.nl/downloads/fledermaus/>. Fill in the contact form, selecting the version appropriate to your operating system. You will receive a link via email to download the program.



**2. CHOOSE SCENE:** Download this interactive, 3D scene file of Cold Seeps and save it onto your hard drive:

▶ [https://www.ncei.noaa.gov/waf/OER-Media/ex1304l1/EX1304L1\\_Dive03\\_Seeps.qsz](https://www.ncei.noaa.gov/waf/OER-Media/ex1304l1/EX1304L1_Dive03_Seeps.qsz).

Then open the Viewer, and in the top left, select File and then Open Scene. Choose the scene you downloaded and this will open the 3D Cold Seeps scene file created from the multibeam sonar data collected as the ship traveled over and mapped the seafloor in this region.

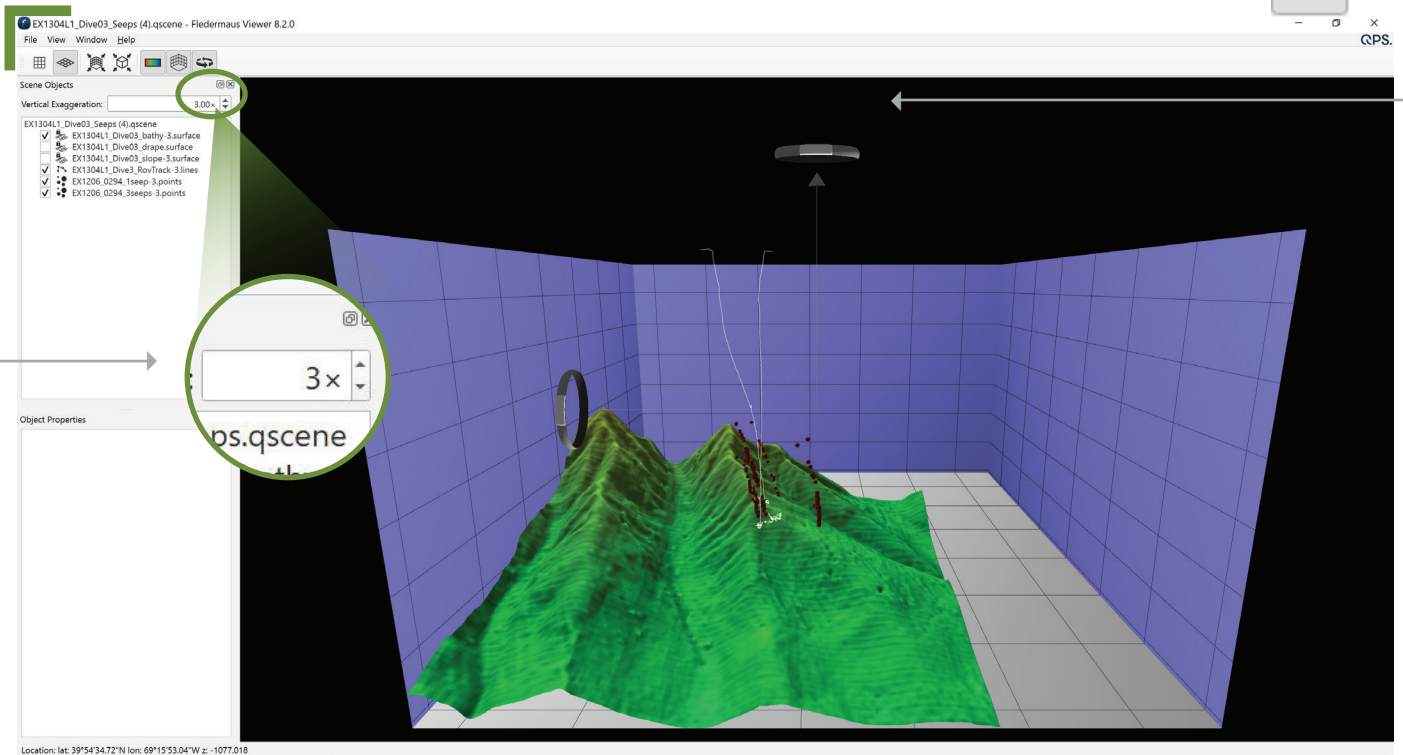


✓ In the Fledermaus scenes, the ocean floor is shown as a three-dimensional image. Latitude and longitude are indicated in degrees, minutes and seconds. The x-axis represents longitude, the y-axis represents latitude, and the z-axis represents depth. When you move the cursor over the image, the window near the bottom of the screen shows the geo coordinates (x, y, and z) for the location beneath the cursor.

## Exploring Cold Seeps with Multibeam Sonar Tools *cont.*

**3. INTERACT:** While the actual size is 1.00x, you'll notice the vertical exaggeration is set at 3.00x, which exaggerates the image in order to view the structure in more detail. Change the exaggeration to 6.00x and see what happens. The rings on the left and at the top of the image can be used to manipulate the view, too.

**4. INTERACT FURTHER:** In the Scene Objects box, different views of the region being explored can be selected. Checking the first box will provide a false color map of the region with purple being the deepest points and red being the shallowest points. Checking the third box will show the slope. Checking the fourth box will show the track of the ROV. Checking the fifth and sixth boxes will reveal the bubbles from methane seeps discovered during the expedition. To return to the original scene file if needed, use the second icon in the top toolbar.



- 5. EXPLORE:**
- *What is the shallowest point in this region?*
  - *What is the deepest point in this region?*
  - *What appears to be one of the steepest points in this region?*
  - *How deep did the ROV travel when exploring this area?*
  - *Why is the red row of bubbles leaning to the west vs. being perfectly vertical?*
  - *Why did the scientists select the dive locations? If you were the scientist leading this expedition and exploring this region for the first time, where would you choose to send the ROV?*
  - *What considerations do you think need to be made when deciding what regions to select for further exploration?*

Now that you have explored cold seeps, check out the [EXPEDITION WEB PAGES](#) on the NOAA Office of Ocean Exploration and Research website for more information and resources. 

## Exploring Cold Seeps with Multibeam Sonar Tools *cont.*


### TOOL 3: Expedition Web Pages

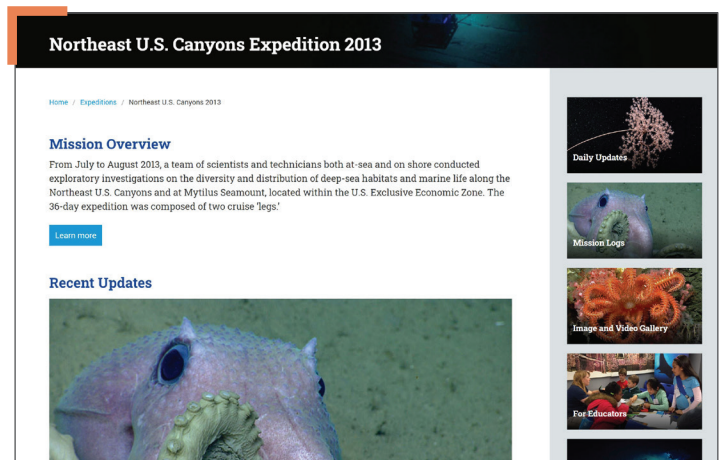
Each expedition has specific web pages on the [NOAA Office of Ocean Exploration and Research website](http://oceanexplorer.noaa.gov). The Northeast U.S. Canyons Expedition web pages contain more information about the cold seeps that were discovered.

- ▶ <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/welcome.html>

Here you can...

- meet the explorers
- watch a mission summary video
- read daily updates
- read mission logs
- read the mission plan
- view beautiful imagery, videos and more!

This web page can also be accessed by repeating steps 1-3 of the [Ocean Exploration Digital Atlas](#) and selecting the Summary tab (see page 3). 



#### 1. BE THE EXPLORER

##### a. What happened?

- ▶ On the [Northeast U.S. Canyons Expedition web page](#), click [Daily Updates](#).
  - READ the updates from Leg 1 Dive 3, July 11, 2013 and Dive 4 on July 12, 2013.
  - WATCH the highlight videos from the ROV dives on these dates.
  - Now ask yourself:
    - *How is the Okeanos Explorer exploration strategy at work during this exploration?*
    - *What did you see that you would want to explore further? What would you want to know if you could go back?*
    - *What was the goal of this dive?*
    - *What do the bacterial mats found tell the scientists?*
    - *How big is the methane hydrate they found (the red lasers are 10 cm apart)?*
    - *What organisms did they find during these dives?*

##### b. Why does it matter?

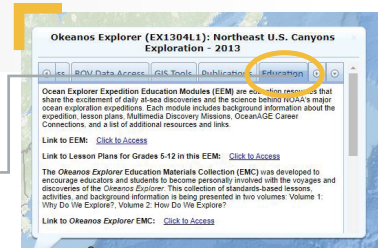
- ▶ • READ the background essay [Exploration of Cold Seeps on the North Atlantic Continental Margin](#).
- ▶ • READ the Mission Log from July 12, [Chemosynthetic Communities and Gas Hydrates at Cold Seeps South of Nantucket](#).
  - Now ask yourself:
    - *What is the biological significance of the discovery of these methane seeps?*
    - *What is the global significance of the discovery of these methane seeps?*



## For Educators: Additional Resources and Extension

### 1. EDUCATION TAB

- ▶ In the **Ocean Exploration Digital Atlas** instructions on page 3 of this lesson, repeat steps 1-3, select the **Education** tab for a variety of supplemental educational resources.



### 2. COLD SEEPS THEME PAGE

- ▶ The **Cold Seeps Theme** page provides additional essays, lessons, images, videos and more.

### 3. FURTHER READING

- ▶ Skarke, A, et. al. *Widespread methane leakage from the sea floor on the northern US Atlantic margin*. Nature Geoscience 7, 657–661. Published online 24 August 2014.
- ▶ Fountain, H. *Methane Is Discovered Seeping From Seafloor Off East Coast, Scientists Say*, The New York Times.

### 4. EXTENSION: Student Activity

- ▶ **What's the Big Deal?** In this activity students investigate methane hydrates and build a methane hydrate model.

## Cold Seeps Lesson URLs/Links

- Page 1:**
- ▶ Fly-through videos: <https://oceanexplorer.noaa.gov/explorations/12fire/background/laubasin/laubasin.html>
  - ▶ Methane bubbles (photo): <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/background/coldseeps/media/bubbles.html>
  - ▶ Northeast U.S. Canyons Expedition: <https://oceanexplorer.noaa.gov/oceanos/explorations/acumen12/welcome.html>
  - ▶ Listen (photo): <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-MMBkgnd.pdf>
  - ▶ Test (photo): <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-WCIntro.pdf>
  - ▶ Photograph (photo): <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-URIntro.pdf>
  - ▶ Share (photo): <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-TPbkgnd.pdf>
- Page 2:**
- ▶ Cold Seeps Theme page: <https://oceanexplorer.noaa.gov/edu/themes>
  - ▶ Northeast U.S. Canyons Expedition: <https://oceanexplorer.noaa.gov/oceanos/explorations/acumen12/welcome.html>
  - ▶ *Deep Discoverer*: <https://oceanexplorer.noaa.gov/technology/subs/deep-discoverer/deep-discoverer.html>
- Page 3:**
- ▶ Watching in 3D: Exploring with Multibeam Sonar activity package intro: <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-Watching3Dinstructions.pdf>
  - ▶ Ocean Exploration Digital Atlas: <https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm>
- Page 5:**
- ▶ Watching in 3D: Exploring with Multibeam Sonar activity package intro: <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-Watching3Dinstructions.pdf>
  - ▶ Fledermaus Viewer software: <https://www.gps.nl/downloads/fledermaus/>
  - ▶ Cold Seeps 3D scene file: [https://www.ncei.noaa.gov/waf/OER-Media/ex1304l1/EX1304L1\\_Dive03\\_Seeps.qsz](https://www.ncei.noaa.gov/waf/OER-Media/ex1304l1/EX1304L1_Dive03_Seeps.qsz)
- Page 7:**
- ▶ NOAA Office of Ocean Exploration and Research website: <https://oceanexplorer.noaa.gov/>
  - ▶ Northeast U.S. Canyon Expedition Web Page: <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/welcome.html>
  - ▶ Daily Updates: <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/dailyupdates/dailyupdates.html>
  - ▶ Introduction to Ships of Exploration and Their Strategy for Ocean Exploration: <https://oceanexplorer.noaa.gov/oceanos/edu/collection/media/hdwe-StrategyBkgnd.pdf>
  - ▶ Exploration of Cold Seeps on the North Atlantic Continental Margin (essay): <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/background/coldseeps/welcome.html>
  - ▶ Chemosynthetic Communities and Gas Hydrates at Cold Seeps South of Nantucket (mission log): <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/logs/july12/july12.html>
- Page 8:**
- ▶ Ocean Exploration Digital Atlas: <https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm>
  - ▶ Cold Seeps Theme page: <https://oceanexplorer.noaa.gov/edu/themes>
  - ▶ Widespread methane leakage... (article): <https://www.usgs.gov/news/natural-methane-seepage-us-atlantic-ocean-margin-widespread>
  - ▶ Methane Is Discovered... (article): [https://www.nytimes.com/2014/08/25/science/methane-is-seeping-from-seafloor-off-eastcoast-scientists-say.html?\\_r=0](https://www.nytimes.com/2014/08/25/science/methane-is-seeping-from-seafloor-off-eastcoast-scientists-say.html?_r=0)
  - ▶ What's the Big Deal? (activity): [http://oceanexplorer.noaa.gov/oceanos/edu/collection/media/wdwe\\_bigdeal.pdf](http://oceanexplorer.noaa.gov/oceanos/edu/collection/media/wdwe_bigdeal.pdf)

## Information and Feedback



Ocean Exploration  
and Research

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