



**Océano Profundo 2015:
Exploring Puerto Rico's Seamounts, Trenches and Troughs**

Diving Deeper

Grade Level

6-12 (Physical Science)

Focus

Data and information products from remotely operated vehicle operations during missions of the NOAA Ship *Okeanos Explorer*

Focus Question

How can we access observations, images, and other data collected through remotely operated vehicle dives during NOAA Ship *Okeanos Explorer* missions?

Learning Objectives

- Students will be able to access information products collected through remotely operated vehicle dives during NOAA Ship *Okeanos Explorer* missions.

Materials

- Computers with Internet access
- Copies of the "Diving Deeper Guide for Exploring *Okeanos Explorer* ROV Information Products;" one copy for each student or student group

Audio-Visual Materials

- (Optional) Interactive white board

Teaching Time

One 45-minute class period

Seating Arrangement

Groups of two to four students

Maximum Number of Students

30

Key Words

NOAA Ship *Okeanos Explorer*
Remotely Operated Vehicles (ROVs)
ROV *Deep Discoverer*
Digital Atlas

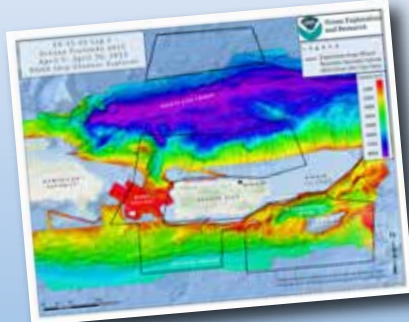


Image captions/credits on Page 2.

lesson plan

Background Information

On August 13, 2008, NOAA Ship *Okeanos Explorer* was commissioned as “America’s Ship for Ocean Exploration;” the only U.S. federal ship whose sole assignment is to systematically explore our largely unknown ocean for the purposes of discovery and the advancement of knowledge. Since her commissioning, the *Okeanos Explorer* has traveled the globe, exploring the Indonesian Coral Triangle; benthic environments in the Galápagos; geology, marine life, and hydrothermal systems of the Mid-Cayman Rise; deep-sea habitats in the northern Gulf of Mexico; and deep-sea ecosystems of the U.S. Atlantic coast.

Okeanos Explorer missions typically use an exploration strategy that involves three major activities:

- Underway reconnaissance;
- Water column exploration; and
- Site characterization.

Underway reconnaissance involves mapping the ocean floor and water column while the ship is underway, and using other sensors to measure chemical and physical properties of seawater. Water column exploration involves making measurements of chemical and physical properties “from top to bottom” while the ship is stopped. In some cases these measurements may be made routinely at pre-selected locations, while in other cases they may be made to decide whether an area with suspected anomalies should be more thoroughly investigated. Site characterization involves more detailed exploration of a specific region, including obtaining high quality imagery, making measurements of chemical and physical seawater properties, and obtaining appropriate samples.

From February through April, 2015, scientists aboard the *Okeanos Explorer* used this strategy to explore largely uncharted deep-sea ecosystems and seafloor areas in the vicinity of Puerto Rico and the U.S. Virgin Islands. Legs 1 and 2 of the Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs Expedition focused on mapping the seafloor where very little high-resolution topographic data were previously available. During Leg 3 of the expedition, critical deep-water environmental data was collected during some of the deepest remotely operated vehicle (ROV) dives ever conducted in the region.

Okeanos Explorer missions are always full of surprises, because they often take place in locations literally no one has gone before. To help share the excitement of ocean exploration, NOAA’s Office of Ocean Exploration provides live video feeds during the Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs expedition (<http://oceanexplorer.noaa.gov/okeanos/media/exstream/exstream.html>). More detailed information about ROV dives is also available

Images from Page 1 top to bottom:

Mission map showing the operating areas, with priority areas outlined in black, for Leg 3 of Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs. Created with ESRI ArcMap software and data displayed is provided by ESRI, Delorme, GEBCO, USGS, NOAA NGDC, and others. Image courtesy of NOAA *Okeanos Explorer* Program.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1502/background/plan/media/leg3-hires.jpg>

A trachymedusae just above the seafloor along the west wall of Mona Canyon. It is very difficult to collect information about deep-sea jellyfish as they break up in nets and are hard to keep intact if collected. Image courtesy of NOAA *Okeanos Explorer* Program, Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1502/logs/apr13/media/jelly-hires.jpg>

Remotely operated vehicle *Deep Discoverer* is deployed for a dive. Image courtesy of NOAA *Okeanos Explorer* Program, Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1502/logs/apr10/media/d2-hires.jpg>

Internally, sea cucumbers are similar, but their exteriors can be completely transparent or a variety of colors, flattened, or spikey, like this one. Image courtesy of NOAA *Okeanos Explorer* Program, Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1502/logs/apr13/media/cuke-hires.jpg>

via the National Coastal Data Development Center’s map-based Digital Atlas (http://www.ncddc.noaa.gov/website/google_maps/OE/mapsOE.htm). This lesson describes how to obtain data collected during ROV dives, including summary reports, geographic track of the ROV during the dive, sensor data, video clips, and still images.

Learning Procedure

1. To prepare for this lesson:
 - a. Review procedures on the *Diving Deeper Guide for Exploring Okeanos Explorer ROV Information Products*. You may want to develop some additional questions or assignments based on the Dive Summary Report and still images that the students will retrieve when they work through the steps in the *Guide*. Depending upon specific curriculum objectives, you may also want to look at data from CTDs and other sensors carried aboard the ROV and camera sled as a basis for additional activities.
 - b. Review background information about the Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs Expedition (<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1502/welcome.html>).
 - c. You may also want to review and possibly download a video tour of the *Deep Discoverer* ROV used on the Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs Expedition (http://oceanexplorer.noaa.gov/okeanos/explorations/ex1302/new_rov_video.html)
2. Briefly introduce the NOAA Ship *Okeanos Explorer*, which is the only U.S. ship whose sole assignment is to systematically explore Earth’s largely unknown ocean for the purposes of discovery and the advancement of knowledge. Review the overall strategy for ocean exploration used aboard *Okeanos Explorer*, and the primary technologies involved with this strategy (discussed above). Briefly describe the Océano Profundo 2015: Exploring Puerto Rico’s Seamounts, Trenches, and Troughs Expedition, emphasizing that most of the areas explored by the expedition have never been seen before. Optionally, show students a video tour of the *Deep Discoverer* ROV used on Leg 3 of the expedition.
3. Tell students that they are going to learn how to obtain images and other data collected during ROV dives. Give each student or student group a copy of the “Diving Deeper Guide for Exploring *Okeanos Explorer* ROV Information Products,” and have them complete it.
4. Discuss students’ ideas for ways in which they might use *Okeanos Explorer* ROV information products. These may include illustrations for reports or posters, data sources for comparing oceanographic

conditions in different locations, or as a source of video clips that could be used for various projects. Note that the video clip file can be quite large, and may take a long time to download. The video trailers for individual dives, however, download quickly and include a narrative commentary about the relationship of dive observations to the overall mission purpose. The trailer for Phoenix Canyon also includes video of the eel attack (<http://oceanexplorer.noaa.gov/oceanos/explorations/ex1404/logs/leg3-dive01/ex1404-l3-dive1.html>), and images of a king crab show laser dots that are 10 cm apart and can be used to estimate the size of objects in the video frames.

The BRIDGE Connection

www.vims.edu/bridge/ - Click on "Research and Data Connections" in the menu on the left side of the page, then select "Virtual Expeditions" for activities and links to online activities about various types of exploration activities.

The "Me" Connection

Have students write a brief essay discussing how they personally use (or might use) *Okeanos Explorer* ROV information products.

Connections to Other Subjects

English/Language Arts, Earth Science

Assessment

Participation in class discussions provides opportunity for assessment.

Extensions

Visit <http://oceanexplorer.noaa.gov/oceanos/explorations/explorations.html> for links to individual voyages of discovery by NOAA Ship *Okeanos Explorer*

Multimedia Discovery Missions

<http://oceanexplorer.noaa.gov/edu/learning/welcome.html> Click on the links to Lesson 3 Deep-sea Corals, and Lesson 14 Seamounts.

Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

Earth's Ocean is 95% Unexplored: So What?

(from the INDEX-SATAL 2010 Expedition) http://oceanexplorer.noaa.gov/oceanos/explorations/10index/background/edu/media/so_what.pdf

Focus: Importance of deep ocean exploration (Life Science/Earth Science)

Students describe at least three different deep ocean ecosystems, explain at least three reasons for exploring Earth's deep ocean, and

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explain at least three ways that deep ocean ecosystems may benefit humans.

To Explore Strange New Worlds

(from the *Okeanos Explorer* Education Materials Collection, Volume 2: How Do We Explore?) http://oceanexplorer.noaa.gov/okeanos/edu/lessonplans/media/hdwe_78_toexplore.pdf

Focus: Strategies for exploring unknown areas on Earth

Students describe requirements for explorations of unknown areas on Earth; discuss factors that influenced exploration strategies of the Lewis and Clark and *Challenger* Expeditions; describe the overall exploration strategy used aboard the NOAA Ship *Okeanos Explorer*; and describe how fractal geometry models natural systems, and how scale influences exploration strategy and results.

A Day in the Life of an Ocean Explorer

(from the *Okeanos Explorer* Education Materials Collection, Volume 2: How Do We Explore?) http://oceanexplorer.noaa.gov/okeanos/edu/lessonplans/media/hdwe_56_dayinlife.pdf

Focus: Telepresence and communications for ocean exploration

Students identify the basic requirements for human communication; describe at least three ways in which humans communicate; discuss the importance of scientific communication; and explain the concept of telepresence, how it is implemented aboard NOAA Ship *Okeanos Explorer*, and how it is used to increase the pace, efficiency, and scope of ocean exploration.

Other Resources

The Web links below are provided for informational purposes only. Links outside of the *Ocean Explorer* web site have been checked at the time of this page’s publication, but the linking sites may become outdated or non-operational over time.

<http://oceanexplorer.noaa.gov/okeanos/edu/welcome.html> – Web page for the *Okeanos Explorer* Education Materials Collection

<http://celebrating200years.noaa.gov/edufun/book/welcome.html#book> - A free printable book for home and school use introduced in 2004 to celebrate the 200th anniversary of NOAA; nearly 200 pages of lessons focusing on the exploration, understanding, and protection of Earth as a whole system

Next Generation Science Standards

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

Performance Expectation HS-PS4-5.

Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information

- Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Disciplinary Core Ideas

PS4.A Wave Properties

- Information can be digitized (e.g. a picture stored as the values of an array of pixels); in this form it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

PS4.B Electromagnetic Radiation

- Photovoltaic materials emit electrons when they absorb light of a high-enough frequency.

PS 4.C Information Technologies and Instrumentation

- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Crosscutting Concepts

Cause and Effect

- Systems can be designed to cause a desired effect.

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D).

Influence of Engineering, Technology, and Science on Society and the Natural World

- Modern civilization depends on major technological systems.

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 7.

The ocean is largely unexplored.

Fundamental Concept a. The ocean is the largest unexplored place on Earth—less than 5% of it has been explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation, and investigation.

Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.

Fundamental Concept d. New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.

Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators, and illustrators. And these interactions foster new ideas and new perspectives for inquiries.

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:

oceaneducation@noaa.gov.

For More Information

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Credit

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Diving Deeper Guide for Exploring *Okeanos Explorer* ROV Information Products

1. Open the Ocean Exploration Digital Atlas (http://www.ncddc.noaa.gov/website/google_maps/OE/mapsOE.htm).
Figure 1 shows the major parts of the Atlas window that are visible when the Atlas first opens:
 - **Map Window** – Shows the geographic locations of selected expeditions. The Search Window on the left determines which expeditions are displayed.
 - **Search Windows** – Allows you to select expeditions by specific years, expedition theme, name, geographic area, type of exploration platform, or any combination of these.
 - **Expedition List Window** – On the right side of the screen, a list of all expeditions displayed on the map, with links to additional details about these expeditions.
 - **Zoom control** – Sets the zoom level.
 - **Scale Bar** – On the bottom left, shows the scale of the current zoom level.
 - **Mouse Position** – Shows, in the bottom right corner, the latitude and longitude of the point in the map window that is directly beneath the cursor, when the cursor is somewhere over the map.
2. To demonstrate how to retrieve data from ROV dives, we will use and *Okeanos Explorer* mission from 2014 that explored deep-sea ecosystems of the U.S. Atlantic coast. In the Search Window, click on the “No Years” button, then click the 2014 checkbox. Now, only the expeditions that took place in 2014 are shown on the map (as yellow dots).
3. In the Expedition List, scroll down to number 17, “*Okeanos Explorer* (EX1404L3): ROV Exploration and Mapping Northeast Seamounts and Canyons.” Click on this text, and the Map Layer will zoom in to the expedition site. Hover your cursor over one of the yellow dots and a label will appear that shows which expedition corresponds to that dot. Move your cursor over the dots until you find the one that corresponds to EX1404L3. Click on this dot.
4. A popup window will appear with four tabs labeled Summary, Data Access, GIS Tools, and Education. The Summary page includes some general information about the expedition, and links to the Expedition Web Site.
5. Click on the Data Access tab, and a new window appears with links to Cruise Summary Products, Archived Collections, and Selected Data Sets. Click on the “Open” link next to “ROV Dive Summary Reports and Data.” A new window will open with fourteen tabs. The left-most tab is an overview of ROV operations conducted during the expedition, and the remaining tabs correspond to individual ROV dives.
6. Click on the tab labeled “1”, and a page will open that shows the geographic track of the ROV during the dive; the date, maximum depth, and total bottom time of the

dive; and links to download a Dive Summary Report, Dive Track, video trailer, data from the CTD and other sensors carried by the ROV and camera sled, video clips, still images, and miscellaneous data files.

7. Click on the “Dive Summary Report” Download link. Shortly, you should have a four-page .pdf file that describes observations made during the dive, including interesting highlights. The report also includes maps showing the location of the dive and a few representative still images. These images include several of the “interesting highlights”, but not the attack by a cutthroat eel on a cranchiid squid.
8. Since the eel attack sounds like it might be interesting, download the still images by clicking the Download link next to “Underwater Still Images.” Soon you will have a zip file that contains nearly 400 images. Unzip the file and open the folder labeled “EX1404L3_DIVE01_20140919.” The images in the folder have long names such as “EX1404L3_IMG_20140919T122110Z_SBROBO_LAUNCH.jpg”. These names are actually very descriptive: The first eight characters identify the expedition, the next three identify the type of file (image), the next sixteen are the date and time that the image was captured, and the remaining capital letters give a general idea about what the image contains (in this case the ROV on deck ready to launch). So let’s see if we can find any images of the eel attack. Search the file for “eel” and we see that there are twelve files that contain “eel” in the file name. Since we’re looking for the attack on a squid, the seven files that also have SQU or SQI in the names are promising. Open these files, and...Yes! We have images of the attack.
9. Look at the Dive Summary Report again, and see if you can find some additional images that correspond to some of the other observations included in the report.