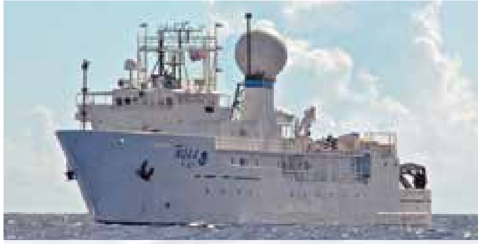


NOAA Ship *Okeanos Explorer:* America's Ship for Ocean Exploration. Image credit: NOAA. For more information, see the following Web site: *http://oceanexplorer.noaa.gov/okeanos/welcome.html*

Section 2: Key Topic – Ocean Exploration

Calling All Explorers

(adapted from the 2002 Submarine Ring of Fire Expedition)

Focus

Recent explorers of deep-sea environments

Grade Level

9-12 (Life Science/Earth Science)

Focus Question

What are the skills and motivations of modern ocean explorers?

Learning Objectives

- Students will describe what it means to be an explorer, both modern and historic.
- Students will explain the importance of curiosity, exploration, and the ability to document what one studies.
- Students will discuss the importance of ocean exploration.

Materials

- Copies of *Part I: Ocean Explorers Web Quest Guide;* one for each student group
- Copies of *Part II: Individual Explorers Reflections Sheet*; one for each student
- Materials for Optional Activity (see Learning Procedure, Step 5):
  – Copies of *Create a Geocache*; one copy for each student group
  – GPS receivers; one for each student group is ideal, but it is possible to complete the activity with fewer units or even just one (see Learning Procedure, Step 1)

Audiovisual Materials

- (Optional) Video or computer projection equipment for viewing interviews with ocean explorers

Teaching Time

Four or five 45-minute class periods, plus time for student research. If Background Information is read aloud and discussed with students, an extra 20 minutes of introductory time is needed before the lesson is begun.

Seating Arrangement

Part I: Groups of two to four students
Part II: Classroom style

Maximum Number of Students

32

Ocean Exploration and Research

Key Words and Concepts

Okeanos Explorer
Exploration
Documentation
Biodiversity
Extreme environments

Background Information

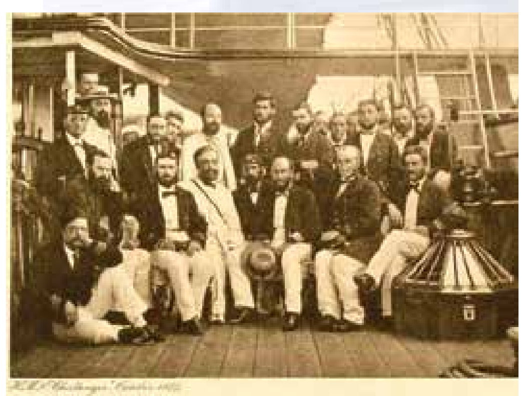
NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

> ***"We know more about the dead seas of Mars than our own ocean."***
> *– Jean Michel Cousteau*

Our current estimation is that 95% of Earth's ocean is unexplored. At first, this may be hard to believe, particularly if we look at recent satellite maps of Earth's ocean floor. These maps seem to show seafloor features in considerable detail. But satellites can't see below the ocean's surface. The "images" of these features are estimates based on the height of the ocean's surface, which varies because the pull of gravity is affected by seafloor features. And if we consider the scale of these maps, it is easy to see how some things might be missed. To show our planet's entire ocean, a typical wall map has a scale of about 1 cm = 300 km. At that scale, the dot made by a 0.5 mm pencil represents an area of over 60 square miles! The fact is, most of the ocean floor has never been seen by human eyes.

Historically, explorers have been driven by a variety of motives. For some, the primary reason to explore was to expand their knowledge of the world. For others, economic interests provided powerful incentives, and many expeditions have launched on missions such as finding a sea route to access the spices of Asia; or quests for gold, silver, and precious stones. Political power and the desire to control large empires motivated other explorations, as did the desire to spread religious doctrines. In the case of space exploration, additional reasons have been offered, including understanding our place in the cosmos, gaining knowledge about the origins of our solar system and about human origins, providing advancements in science and technology, providing opportunities for international collaboration, and keeping pace with other nations involved in developing space technology. The first ocean exploration for the specific purpose of scientific research is often considered to be the voyage of HMS *Challenger*, conducted between 1872-1876 (visit *http://oceanexplorer.noaa.gov/explorations/03mountains/background/challenger/challenger.html* and *http://www.coexploration.org/hmschallenger/html/AbouttheProject.htm* for more information about the *Challenger* Expedition and comparisons with modern oceanographic exploration).

On August 13, 2008, the NOAA Ship *Okeanos Explorer* was commissioned as "America's Ship for Ocean Exploration;" the only U.S. ship whose sole assignment is to systematically explore our largely unknown ocean for the purposes of discovery and the advancement of knowledge. To fulfill its mission, the *Okeanos Explorer* has specialized capabilities for finding new and unusual features in unexplored parts of Earth's ocean, and for gathering key information that will support more detailed investigations by subsequent expeditions. These capabilities include:



The science and ship crew of the HMS *Challenger* in 1874. The original crew of 216 had dwindled to 144 by the end of the long expedition. Image credit: NOAA.

A spectacular photo of the NOAA Ship *Okeanos Explorer* Control Room while ROV operations are underway. Image courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.

During preliminary operations near Guam, Indonesian scientist Dr. Michael Purwoadi makes the first 'call' using telepresence from the NOAA Ship *Okeanos Explorer* to colleagues in the newly-established Jakarta Exploration Command Center. Image courtesy of NOAA OER.

Okeanos Explorer **Vital Statistics:**

Commissioned: August 13, 2008; Seattle, Washington
Length: 224 feet
Breadth: 43 feet
Draft: 15 feet
Displacement: 2,298.3 metric tons
Berthing: 46, including crew and mission support
Operations: Ship crewed by NOAA Commissioned Officer Corps and civilians through NOAA's Office of Marine and Aviation Operations (OMAO); Mission equipment operated by NOAA's Ocean Exploration and Research Program

For more information, visit http://oceanexplorer.noaa.gov/okeanos/welcome.html.
Follow voyages of America's ship for ocean exploration with the *Okeanos Explorer* Atlas at *http://www.ncddc.noaa.gov/website/google_maps/OkeanosExplorer/mapsOkeanos.htm*

- Underwater mapping using multibeam sonar capable of producing high-resolution maps of the seafloor to depths of 6000 meters;
- Underwater robots (remotely operated vehicles, or ROVs) that can investigate anomalies as deep as 6,000 meters; and
- Advanced broadband satellite communication and telepresence.

Capability for broadband telecommunications provides the foundation for telepresence: technologies that allow people to observe and interact with events at a remote location. This allows live images to be transmitted from the seafloor to scientists ashore, classrooms, newsrooms and living rooms, and opens new educational opportunities, which are a major part of *Okeanos Explorer's* mission for advancement of knowledge. In addition, telepresence makes it possible for shipboard equipment to be controlled by scientists in shore-based Exploration Command Centers. In this way, scientific expertise can be brought to the exploration team as soon as discoveries are made, and at a fraction of the cost of traditional oceanographic expeditions.

Curiosity, desire for knowledge, and quest for adventure continue to motivate modern explorers. But today, there are additional reasons to explore Earth's ocean, including:

- **Climate Change** – The ocean has a major influence on weather and climate, but we know very little about deep-ocean processes that affect climate.
- **Energy** – Ocean exploration contributes to the discovery of new energy sources, as well as protecting unique and sensitive environments where these resources are found.
- **Human Health** – Expeditions to the unexplored ocean almost always discover species that are new to science, and many animals in deep-sea habitats have been found to be promising sources for powerful new antibiotic, anti-cancer and anti-inflammatory drugs.
- **Ocean Health** – Many ocean ecosystems are threatened by pollution, overexploitation, acidification and rising temperatures. Ocean exploration can improve understanding of these threats and ways to improve ocean health.
- **Research** – Expeditions to the unexplored ocean can help focus research into critical areas that are likely to produce tangible benefits.
- **Innovation** – Exploring Earth's ocean requires new technologies, sensors and tools, and the need to work in extremely hostile environments is an ongoing stimulus for innovation.
- **Ocean Literacy** – Ocean exploration can help inspire new generations of youth to seek careers in science, and offers vivid examples of how concepts of biology, physical science, and Earth science are useful in the real world.

Recent technological developments have made the oceans more visible than they have ever been before. With these new "technological eyes," new species, new ecosystems, and new metabolic processes have been discovered. With the commissioning of the NOAA Ship *Okeanos Explorer*, a new era of ocean exploration has been launched by our Nation. In the years ahead, ocean explorers are certain to find many more fascinating discoveries about our Ocean Planet—and our intrinsic connections to it. In this lesson, students will learn more about modern ocean explorers: who they are, what they do, and why they are drawn to explore Earth's ocean.

Learning Procedure

1. To prepare for this lesson:
- Review introductory information on the NOAA Ship *Okeanos Explorer* at *http://oceanexplorer.noaa.gov/okeanos/welcome.html*. You may also want to consider

having students complete some or all of the lesson, *To Boldly Go….*

- Review questions on student handouts for Parts I and II, and decide whether to show portions of ocean explorer interviews during class discussions (Step 4).
- Review procedures for optional geocaching activity (Step 5). Determine how many GPS units will be available for student use (many students may have access to suitable units at home; if only a few units are available, these can be shared by having groups complete their assignments on different days). In most cases, items needed to construct geocaches can be provided by the students. To avoid inappropriate items, each group will be required to have their geocache approved before it is hidden.
- If you want your students to explore the Global Positioning System in greater depth, see the "Your Expedition of Discovery" lesson plan from the *Lophelia* II 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks (*http://oceanexplorer.noaa.gov/explorations/09lophelia/background/edu/media/09yourexped.pdf*).

2. If you have not previously done so, briefly introduce the NOAA Ship *Okeanos Explorer*, emphasizing that this is the first Federal vessel specifically dedicated to exploring Earth's largely unknown ocean. Lead a discussion of reasons why ocean exploration is important, and what kinds of people students believe might be involved with modern ocean exploration. Tell students that their assignment is to find out about some modern ocean explorers. Provide each student group with a copy of *Part I: Ocean Explorers Web Quest Guide*.

3. When students have completed Part I, provide individual students with a copy of *Part II: Individual Explorers Reflections Sheet*.

4. Lead a class discussion of students' answers and reflections for Parts I and II.

5. Optional Activity: Your Own Expedition of Discovery -- Most students will be familiar with the concept of the Global Positioning System (GPS), but may not fully understand how the system works. The "Your Expedition of Discovery" lesson (*http://oceanexplorer.noaa.gov/explorations/09lophelia/background/edu/media/09yourexped.pdf*) provides a brief review of GPS, as well as the process of using latitude and longitude to describe a specific location on Earth. You may want to discuss this information with students prior to completing the rest of the activity.

   Give each student group a copy of *Create a Geocache*, and remind students that they are to submit their geocache plan for approval BEFORE beginning the field portion of their assignment. If there are not enough GPS receivers for each group to have their own, tell students how the available units will be scheduled among the groups. Be sure each group has at least one student who is familiar with the operation of the GPS receiver that group will be using.

   Review students' geocache plans. Be sure their proposed sites are not in dangerous areas and that students have appropriate permission to use the sites. An easy way to avoid these issues is to confine the sites to approved portions of the school grounds, but this makes the geocaching "expeditions" somewhat less adventurous.

   Provide each student group with the latitude and longitude of a geocache created by one of the other groups. Remind students about schedules (if any) for using the GPS receivers, and when they are to have their "Geocaching Discovery Expeditions" completed.

Have students discuss their experiences while searching for their assigned geocache, particularly any difficulties they encountered in navigating to a specific geographic location. Since student groups remove the geocaches when (and if) they are found, these geocache locations should not be registered with the official Global GPS Cache Hunt Site.

The BRIDGE Connection

www.vims.edu/bridge/ – Scroll over "Ocean Science Topics," "Human Activities," then "Heritage" for links to resources about the history of ocean exploration.

The "Me" Connection

a. All of Part II: Individual Exploration represents "Me" Connections

b. Visit *http://cfa-www.harvard.edu/space_geodesy/ATLAS/applications.html* for a worksheet that asks students to design a system that incorporates GPS receivers, and encourages students to consider how GPS might be integrated into their daily lives (a component of Project ATLAS (Assisted Transnational Learning using Artificial Satellites), a multidisciplinary, international educational outreach project in which students in the age range of 12—14 years from around the world use satellite and Internet technologies to learn about the world in which they live.

Connections to Other Subjects

English/Language Arts, Physical Earth, Life Sciences, Art/Design

Assessment

Written reports and class discussions provide opportunities for assessment.

Extensions

1. Ask students to investigate career opportunities as ocean explorers, ocean scientists, and others whose careers support ocean science and exploration.
2. Visit *http://celebrating200years.noaa.gov/edufun/book/SurveyMarkHunting.pdf* for another geocaching activity involving survey marks, and an introduction to geodesy (the science of measuring the size and shape of the Earth and accurately locating points on the Earth's surface).
3. Have students find out about "Travel Bugs" (see *http://www.geocaching.com/track*).

Other Resources

See page 217 for Other Resources.

Next Generation Science Standards

Lesson plans developed for Volume 1 are correlated with *Ocean Literacy Essential Principles and Fundamental Concepts* as indicated in the back of this book. Additionally, a separate online document illustrates individual lesson support for the Performance Expectations and three dimensions of the Next Generation Science Standards and associated Common Core State Standards for Mathematics and for English Language Arts & Literacy. This information is provided to educators as a context or point of departure for addressing particular standards and does not necessarily mean that any lesson fully develops a particular standard, principle or concept. Please see: *http://oceanexplorer.noaa.gov/okeanos/edu/collection/wdwe_ngss.pdf.*

Send Us Your Feedback

We value your feedback on this lesson, including how you use it in your formal/informal education settings. Please send your comments to: *oceanexeducation@noaa.gov*

For More Information

Paula Keener, Director, Education Programs
NOAA Office of Ocean Exploration and Research
Hollings Marine Laboratory
331 Fort Johnson Road, Charleston SC 29412
843.762.8818 843.762.8737 (fax)
paula.keener-chavis@noaa.gov

Acknowledgments

Portions of this lesson were adapted from a lesson plan was developed by Kimberly Williams, Miller Place High School, Long Island, NY. This lesson plan was produced by Mel Goodwin, PhD, Marine Biologist and Science Writer, Charleston, SC for NOAA. Design/layout: Coastal Images Graphic Design, Charleston, SC. If reproducing this lesson, please cite NOAA as the source, and provide the following URL: *http://oceanexplorer.noaa.gov*

Part I – Ocean Explorers Web Quest Guide

Welcome, Ocean Explorers! Please proceed to the following Web site:
http://oceanexplorer.noaa.gov/explorations/explorations.html

1. List three places in the deep sea visited by ocean explorers within the past three years.
2. Now proceed to this Web site: *http://oceanexplorer.noaa.gov/edu/oceanage/welcome.html.*
   There are many individuals studying the deep sea or involved with work done there. List at least five, and describe their fields of research or work they have done.
3. Describe what your day might be like if you were a marine mammal biologist.
4. In some ways, deep-sea explorers of modern times are similar to historic explorers. They are brave, curious men and women who are at the cutting edge of their field of interest. They are very unique individuals. One of the senior scientists interviewed on the OceanAGE Web page explains the difference between a submarine and a submersible. Find her name and record what she says about this difference.
5. What is the name of the fish ecologist who wanted to be an astronaut until he realized that the ocean was virtually unexplored and the other-worldly creatures that he wanted to see and study were living right here at home?
6. How do you think that exploring the deep sea is similar to exploring outer space?
7. Which ocean explorer traces his interest in ocean science to a vacation with his parents to the Florida Keys when he was five or six and encountered a manatee?
8. There is a big world waiting for you to explore it, and the technology to do so gets better every day. Yesterday's discoveries are today's necessities. Which explorer looks for marine plants and animals that produce chemicals that can be developed into drugs to treat human diseases?
9. As we learn more about Earth's ocean, we realize that even though the ocean is vast, its resources are limited and need protection. Which marine ecologist looks for "sweet spots" in the ocean, places where life is rich and abundant, and then works with governments and nonprofit organizations to secure protection of those resources for future generations?
10. Which ocean explorer was an insect dietician and sonar operator aboard a U.S. Navy submarine before becoming chief electronics technician aboard the NOAA Ship *Okeanos Explorer*?

   Congratulations, Explorers! You have successfully navigated the Deep Sea Explorer Web Quest! Now you are ready for some quiet reflection on what you learned with your colleagues.

Tell your teacher that you are ready to begin Part II: Individual Exploration!

Part II – Individual Explorers Reflections Sheet

1. Reflect and write about differences and similarities between explorers of the past and modern day explorers. What types of hardships do both have in common?

2. Name some places that have been explored in modern times.

3. Name places that were explored during the early history of humans.

4. Name a place that you have explored. What was unique about it that you think another visitor to that site would not have noticed?

5. Name a place that you would like to explore. What do you think you would find there? Why?

6. Why is it important to document your explorations? What is your favorite way to remember your own adventures?

7. List a few of your science and exploration role models (alive or historic) and why they inspire you. On a sheet of notebook paper or on the computer, compose a letter to one of your science and exploration role models. Write something you would want them to know about you and why you consider them an inspiration.

Teacher Answer Key for
Part I – Ocean Explorers Web Quest Guide

Welcome, Ocean Explorers! Please proceed to the following Web site:
http://oceanexplorer.noaa.gov/explorations/explorations.html

1. Answers will vary. Possible answers include:
   Gulf of Mexico, Chile, Bermuda, Florida, Arctic, Bahamas, Thunder Bay, Rhode Island, Bonaire, Celebes Sea, Cayman Islands, Kermadec Arc

2. Answers will vary. Possible answers include:
   Dr. Peter Auster, Dr. Amy Baco-Taylor, Dr. Robert Ballard, Dr. Roy Cullimore, Dr. Bob Embley, Dr. Peter Etnoyer, Dr. Randy Keller, Dr. Deborah Kelley, Dr. Kristin Laidre, Mr. John McDonough, Mr. Hugo Marrero, Ms. Catalina Martinez, Dr. Charles Mazel, Dr. Shirley Pomponi, Dr. John K. Reed, Dr. Timothy Shank, Dr. Bob Embley, Dr. Edith Widder

3. Answers will vary. Students will probably take information from the interviews with Dr. Kristin Laidre.

4. Dr. Edith Widder says that the difference between a submarine and a submersible is a submarine has enough power to leave port and come back to port under its own power. A submersible has very limited power reserves so it needs a mother ship that can launch it and recover it.

5. Dr. Peter Auster

6. Answers will vary. Some include:
   Humans would need special equipment to survive and explore there.
   Humans know very little about both places.
   Humans get very excited about the prospect of finding life in both places.

7. Mr. Brian Kennedy

8. Dr. Shirley Pomponi

9. Dr. Peter Etnoyer

10. Mr. Richard Conway

Teacher Answer Key for Part II – Individual Explorers Reflections Sheet

1. Answers will vary.

   Some Similarities:
   - Funding for both usually comes from an outside source. Explorers do not usually "own" most of the equipment, but the equipment is usually "cutting edge" for the time it is used by the explorers.
   - Exploration is undertaken by brave, curious individuals.
   - Often explorers seek resources that can be obtained from a newly-discovered site (raw materials, medicines, etc.)

   Some Differences:
   - Today, it is common for different countries to work together on exploratory projects; whereas in the past, many countries wanted to explore for the sake of conquering a particular region.
   - Today, it is not uncommon for men and women to explore together; whereas many of the past explorers were men.

   Hardships may include:
   - Funding for their explorations
   - Broken equipment while they are in the field
   - Lack of maps and directions
   - Discomfort while they are exploring extreme environments for long periods of time
   - Finding like-minded individuals to explore with them

2. Answers will vary, but may include: the deep ocean, space, the Arctic, the Antarctic, the Western coast of the United States, etc.

3. Answers will vary, but may include: navigation around the continents, rivers, new passages from one country to another, etc.

4. Answers will vary.

5. Answers will vary.

6. Answers will vary, and may include:
   - To learn from the past, to remember places and people that we meet, so that others can learn from our work, etc.
   - Students may keep journals, scrapbooks, boxes of memories, etc.

7. Answers will vary.

Create a Geocache

Geocaches are hidden containers, usually concealed outdoors, that are the objects of a high-tech treasure hunting game played throughout the world by people equipped with GPS devices. The basic idea is to locate geocaches and then share your experiences online. There are more than 800,000 active geocaches around the world, and a dedicated Web site (*http://www.geocaching.com*) to assist geocaching enthusiasts. For this activity, you will create a geocache for another student group to find, and test your own GPS skills by searching for a geocache created by one of the other groups.

1. **Planning**–Four things are essential to create a geocache:
   - An appropriate container;
   - An appropriate location in which to hide the container;
   - Something to put into the container; and
   - A GPS receiver so you can accurately record the exact location in which your geocache is hidden.

   Typical geocache containers include water bottles, screw-top plastic storage jars, watertight boxes used on boats to protect cameras and cell phones, and ammunition boxes. It's usually a good idea to put the contents of the cache inside a zip-top plastic bag, just in case the container leaks. Label the container with the word "Geocache" and the name of your school, just in case someone finds it who is not part of your class.

   The most important features of a suitable geocache site are that you have permission to use the site for your geocache, and that the site is not located in a dangerous area.

   What you put inside your geocache is up to you (within obvious limits). Most caches include a logbook and pencil so that finders can record their presence. This doesn't make much sense for this activity, however, since found geocaches will be brought back to your class. Other typical items are a welcome note, small toys, games, or playing cards.

   Be sure you understand how to use the GPS receiver before you head out to hide your geocache.
2. **Approval**–Write a brief description of your geocache, including type of container, what the cache will contain, and where it will be hidden. Be sure that you have permission to use the proposed site. Submit the plan to your teacher for approval.
3. **Assembly**–Put your geocache together according to your approved plan.
4. **Into the Field!** –Take your geocache to the location approved by your teacher, and hide it. Take careful notes about the specific location and use your GPS receiver to find the latitude and longitude of the site. Be sure to record latitude and longitude to at least 3 decimal places. If your GPS receiver uses minutes and seconds instead of decimal degrees, record latitude and longitude to at least 0.1 seconds.

   Write the latitude and longitude of your geocache on an index card, along with any clues you think will help to find the geocache. Remember that the idea is to hide the geocache well enough so someone isn't likely to discover it by accident, but not so well that it can't be found at all!
5. **Join a Geocaching Discovery Expedition** Your teacher will give you an index card from another student group that contains the latitude and longitude of a geocache they created, and may also contain some other clues to help you find it. Obtain any last minute instructions from your teacher, double-check that you know how to use your GPS receiver, then launch your expedition to find the geocache!

   Tip: Make a simple sketch map to help keep you oriented as you search. When you start, find your latitude and longitude using your GPS receiver, then make a mark near the center of a piece of paper and write your latitude and longitude near the mark. This is your starting point. Now draw a vertical arrow to show the direction of north. Rotate the paper so that the arrow points toward north. Now compare your starting location with the latitude and longitude of the geocache you are trying to discover. Assuming you are in North America, if the latitude of the geocache is greater than the latitude of your starting location, you need to go farther north. If the latitude of the geocache is less than the latitude of your starting location, you need to go farther south. Similarly, if the longitude of the geocache is greater than the longitude of your starting location, you need to go farther west, and if the longitude of the geocache is less than the longitude of your starting location, you need to go farther east. You can repeat this process whenever you are uncertain about which way to go.

   Keep track of how long it takes you to discover your assigned geocache. When you have found it, bring it back to class for further discussion.