



The Multi-Talented Underwater Robot

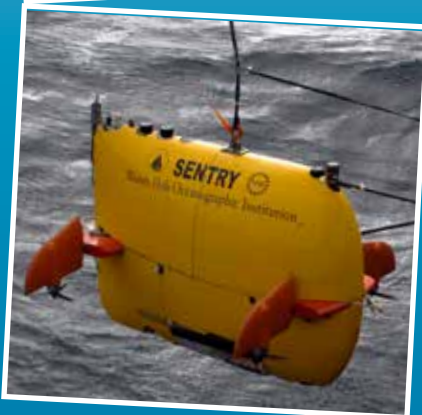


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lesson plan

Focus

Autonomous Underwater Vehicle (AUV) *Sentry*

Grade Level

9-12 (Engineering Design)

Focus Question

How do ocean explorers plan complex missions for autonomous underwater robots?

Learning Objectives

- Students will understand how engineers approach complex real-world problems by breaking them down into smaller, more manageable problems.

Materials

Copies of:

- *NDSF Sentry Fact Sheet** linked from <https://www.whoi.edu/main/sentry>;
- *A Scientists Guide to AUV Sentry Cruise Planning and Proposal Writing** linked from <https://www.whoi.edu/main/sentry>;
(* The links can be found by scrolling down the page to "Additional Resources")
- *AUV Sentry Mission Scenarios* (page 15); one copy for each student or access to these files via student computers or interactive whiteboards.

Audio-Visual Materials

(Optional) Interactive whiteboards

Teaching Time

One or two 45-minute class periods, plus time for student research and preparation

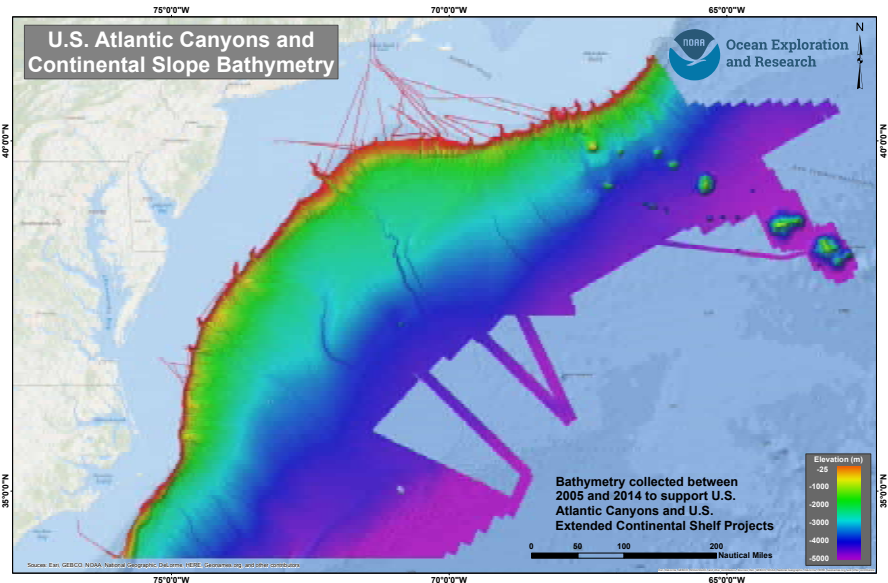
Seating Arrangement

Three groups of students

Maximum Number of Students

30

Map showing existing deepwater mapping data along the east coast. Upcoming expeditions will both capitalize on and expand upon the existing information. Additional expeditions will extend coverage into previously unmapped areas. Water depths are illustrated using different colors. Image courtesy of NOAA OER.



Key Words

Autonomous Underwater Vehicle (AUV)
AUV Sentry

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.

Deepwater canyons are among the most striking features of the continental slope off the east coast of the United States. There are more than 70 of these canyons in depths ranging from about 100 meters to about 3,500 meters, with steep, narrow walls that make exploration difficult. Research during the 1970s and 1980s (Hecker *et al.*, 1980; Hecker and Blechschmidt, 1979) showed that submarine canyons along the mid-Atlantic continental slope could contain unique hard-bottom communities, many of which include high densities of deepwater corals. Similar sites in other areas are known to support important fisheries and other biological resources, but also to be vulnerable to severe damage from human activity and natural events.

At least 660 submarine canyons are known throughout Earth's ocean, and recent studies (De Leo, *et al.*, 2010) suggest that at least some of these may be among the most productive habitats that have been found in the deep sea. Canyons can enhance biological productivity by providing varied and complex habitats, and by concentrating organic material and nutrient-rich sediments that provide food resources in areas

Images from Page 1 top to bottom:

The NOAA Ship *Pisces* underway. Image courtesy NOAA.

<http://www.omao.noaa.gov/learn/marine-operations/ships/pisces>

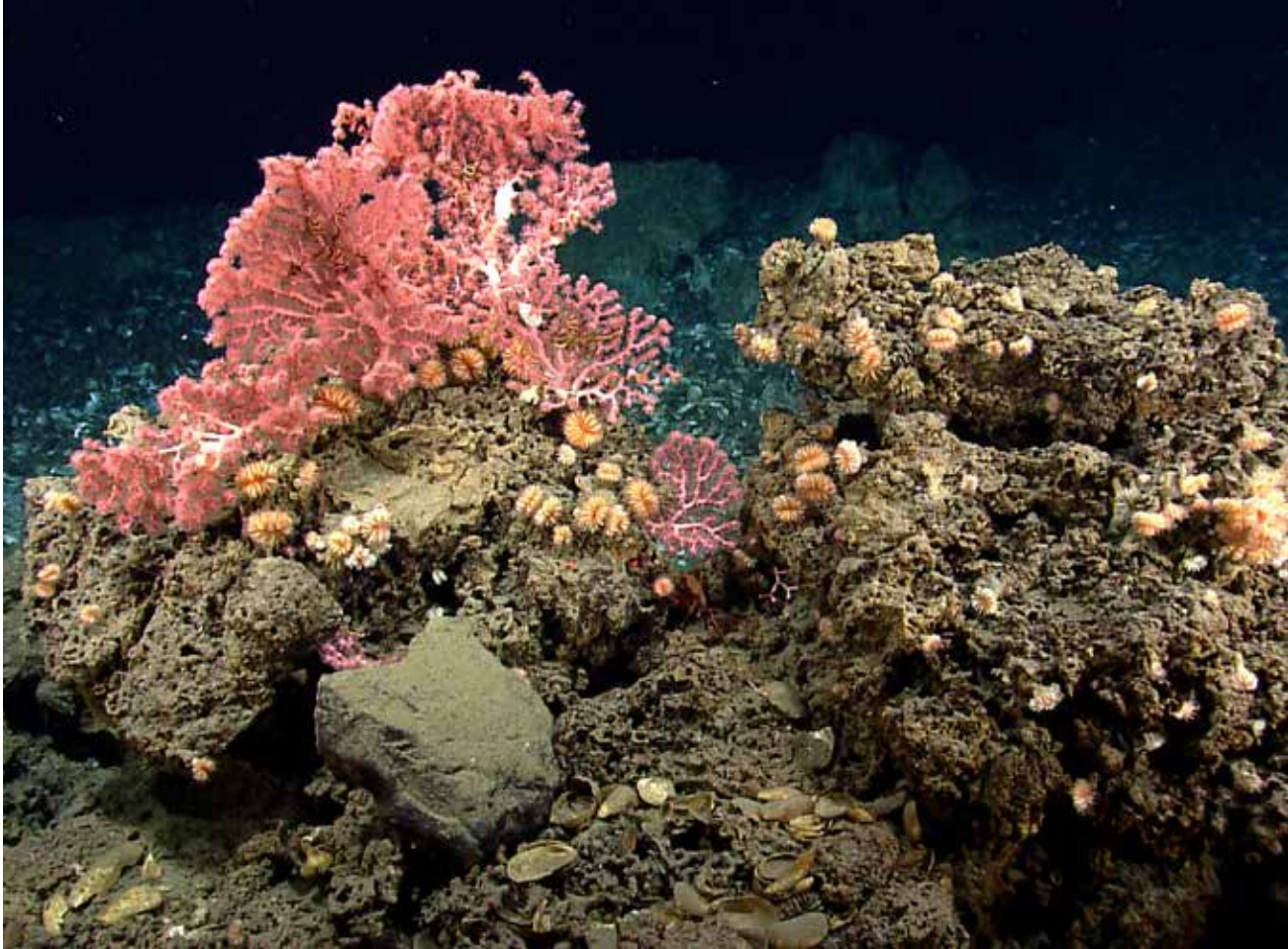
An octopus hides in the rocks in Welker Canyon. Image courtesy of NOAA *Okeanos Explorer* Program, 2013 Northeast U.S. Canyons Expedition.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/media/aug15.html>

Dr. Brendan Roark preps the CTD rosette onboard NOAA Ship *Okeanos Explorer*. Image courtesy of NOAA *Okeanos Explorer* Program, 2013 Northeast U.S. Canyons Expedition.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/logs/aug2/media/ctd-prep.html>

The autonomous underwater vehicle *Sentry* is designed to dive as deep as 6,000 meters (19,685 feet). It is powered by more than 1,000 lithium-ion batteries - similar to those used in laptop computers, though adapted for extreme pressures - which allow it to dive up to 20 hours. Image courtesy of Chris German, INSPIRE: Chile Margin 2012 Expedition, NOAA-OER
http://oceanexplorer.noaa.gov/explorations/12chile/logs/apr23/media/sentry_line.html



Corals, including cup corals and bubblegum corals reside on hard substrate near the edge of a mussel bed. Image courtesy of NOAA *Okeanos Explorer* Program, 2013 Northeast U.S. Canyons Expedition.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/media/july21-hires.jpg>

that are normally food-poor. These resources can support large biomasses of benthic (bottom-dwelling) invertebrates that in turn provide food for a wide variety of bottom-feeding fishes, crustaceans, and other megafauna.

Habitat complexity in submarine canyons results from a combination of geological and biological features. Steep canyon walls, rocky outcrops, hard clay formations, boulders, rock rubble, and soft sediments all provide surfaces upon and within which various benthic organisms may grow. Sessile (non-moving) species such as sponges and cnidarians increase the surface complexity and provide additional habitat for other species. Soft sediment is the major substrate type, and most canyons on the Atlantic continental slope have extensive holes and tunnels produced by crabs, fishes, burrowing anemones, and other animals that further extend the range of available habitats.

Canyons on the U.S. continental slope may also include chemosynthetic communities where food webs are based on the energy of chemical compounds, in contrast to photosynthetic communities where 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.

Methane is produced in many environments by a group of Archaea that obtain energy by anaerobic metabolism through which they break down the organic material contained in once-living plants and animals. When this process takes place in deep ocean sediments, water molecules surround methane molecules, and conditions of low temperature and high pressure allow stable ice-like methane hydrates to form. Methane hydrate is a type of clathrate, a chemical substance

in which the molecules of one material (water, in this case) form an open lattice that encloses molecules of another material (methane) without actually forming chemical bonds between the two materials.

In 1995, Ocean Drilling Program Leg 164 documented extensive deposits of methane hydrates and methane gas on the Blake Ridge, on the continental slope off the coast of South Carolina and Georgia. Scientists are interested in methane hydrates for a variety of reasons, including

their potential as an energy source, their association with unusual biological communities, and their possible role in tsunamis and climate change. An assessment of the tsunami hazard along the U.S. east coast (ten Brink, 2009) by the U.S. Geological Survey with funding from the U.S. Nuclear Regulatory Commission has identified submarine landslides along the submerged continental margin as the primary potential source of dangerous tsunamis to this coast. An historic example of this hazard was the 1929 Grand Banks submarine landslide, which produced a tsunami three to eight meters high. That tsunami killed 28 people along the Newfoundland coast, even though this area was sparsely



Close-up of methane hydrate observed at a depth of 1,055 meters, near where bubble plumes were detected in previous sonar data. Methane hydrates, a hydrate patch and chemosynthetic communities were seen during this dive, but no active seepage was observed. Image courtesy of NOAA *Okeanos Explorer* Program, 2013 Northeast U.S. Canyons Expedition. <http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/media/july11-hires.jpg>



Here is Sentry all buttoned up with its outer shiny yellow skins covering over all the complex components hidden within. Image courtesy of Chris German, INSPIRE: Chile Margin 2012 Expedition, NOAA-OER. http://oceanexplorer.noaa.gov/explorations/12chile/logs/hires/sentry_buttoned_hires.jpg

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populated at the time. A similar tsunami along the present-day Atlantic coast might be much more devastating.

The purpose of the Carolina Canyons Expedition 2016 is to build on previous research conducted on Northeast U.S. canyons to characterize deep sea habitats within the canyons and investigate the biological and geological features in this area, in particular deep-sea coral habitats and cold seeps. The Autonomous Underwater Vehicle (AUV) *Sentry* will be a key technological tool for the expedition’s activities, which include surveying canyon and inter-canyon slope habitats, sampling environmental factors (e.g. depth, salinity, turbidity, hydrography), characterizing benthic habitats, and locating areas where corals are present. In this lesson, students will investigate how complex *Sentry* missions are planned.

Learning Procedure

- 1. To prepare for this lesson:
a. Review background information about the Carolina Canyons Expedition 2016
b. Review information about AUV Sentry at
c. Prepare copies of:
d. You may also want to review two previous Ocean Explorer lessons about AUV Sentry
2. Briefly review the purpose of the Carolina Canyons Expedition 2016 and describe deepwater canyon habitats.

Sentry will be expected to carry out (i.e., surveying the canyon areas and inter canyon slope habitats; sampling environmental factors such as depth, salinity, turbidity and hydrography; characterizing benthic habitats; and identifying areas of coral presence). Be sure students understand that the AUV *Sentry* is part of the National Deep Submergence Facility (NDSF) which is a fleet of deep-sea exploration vehicles operated by Woods Hole Oceanographic Institution, that also includes the Human Occupied Vehicle (HOV) *Alvin* and the Remotely Operated Vehicle (ROV) *Jason/Medea*. The NDSF is sponsored by the National Science Foundation, the Office of Naval Research, and the National Oceanic and Atmospheric Administration; and its deep-sea exploration vehicles are available for use by the entire U.S. oceanographic community. Point out that AUV *Sentry* was designed to have a wide variety of capabilities needed to explore the deep ocean, including functionality to depths of 6,000 meters (19,685 feet), extreme maneuverability, close bottom-following, large payloads, diverse instrumentation, and rapid transit to and from the seafloor.

In addition to ocean exploration expeditions that may be planned several years before they actually happen, AUV *Sentry* missions may be undertaken in response to unforeseen events in Earth's ocean. In either case, the involvement of deep ocean environments means that the problems are almost always complex and the scientists and engineers who operate *Sentry* are likely to be faced with challenges they have not encountered before. Often, the best approach for dealing with these situations is to break complex problems into smaller, more manageable problems.

3. Provide each student group with copies of documents or access to files prepared in Step 1c. Tell each group that their assignment is to review the capabilities of the AUV *Sentry*, imagine that their team has been designated as the Expedition Leader for one of the three *Sentry* mission scenarios, identify which of *Sentry's* capabilities will be needed to achieve the mission's objectives, and what special circumstances need to be considered when planning this mission. Students should refer to mission guidelines provided in *A Scientists Guide to AUV Sentry Cruise Planning and Proposal Writing*, and be prepared to cite specific sections of the *Guide* to support their mission plans. Groups should also be encouraged to obtain additional data from Internet research about the specific incidents and *Sentry* sensors, if these resources are available. Note that students are not

expected to construct actual survey tracks (as they do in *The Ridge Exploring Robot* lesson), but should identify major tasks that need to be accomplished to achieve the mission's purpose. In other words, they should break the overall complex problem into smaller, more manageable tasks.

4. Lead a discussion of student's ideas about mission plans for each scenario. The following points are suggestions; other responses are acceptable as long as they are well-reasoned and supported by data from the resources provided or obtained through students' own research.

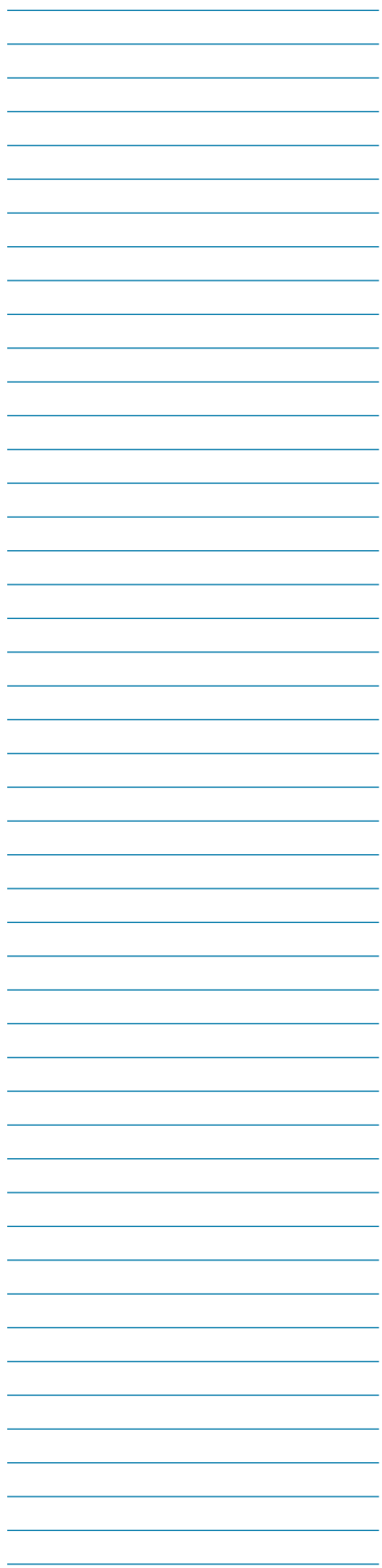
Deepwater Horizon Oil Spill

- **Primary Objective:** Map the location of oil plumes and locate coral communities on the sea floor
- **Major Tasks:**
 - ▶ Survey the area surrounding the *Deepwater Horizon* wellhead, especially downstream of the wellhead;
 - ▶ Detect oil in seawater and record its location;
 - ▶ Locate deepwater coral communities in the survey area
- **Key Sentry Capabilities:**
 - ▶ Ability to dive in deep water;
 - ▶ Precise navigation to locate features of interest;
 - ▶ Multibeam sonar mapping;
 - ▶ Sensors to detect oil;
 - ▶ Current profiling
 - ▶ Underwater photography
- **Special Circumstances:**
 - ▶ Possible presence of oil that might interfere with sensors, photography, and navigation equipment
 - ▶ Presence of many other vessels, including Remotely Operated Vehicles in the area to be surveyed
 - ▶ Possible sea conditions that would prevent *Sentry* launch or recovery

For additional information and lessons about the *Deepwater Horizon* blowout, see the *Lessons from the Deep: Exploring the Gulf of Mexico's Deep-Sea Ecosystems Education Materials Collection* [http://oceanexplorer.noaa.gov/edu/guide/gomdse_edguide.pdf]

Axial Seamount Eruption

- **Primary Objective:** Map the area surrounding the active volcano
- **Major Tasks:**
 - ▶ Precision mapping
 - ▶ Detect and avoid hazardous conditions created by volcanic activity



- **Key Sentry Capabilities:**
 - ▮ Ability to dive in deep water;
 - ▮ Precise navigation to locate features of interest;
 - ▮ Multibeam sonar mapping;
 - ▮ Sensors to detect chemical plumes from volcanic eruptions
- **Special Circumstances:**
 - ▮ Potential for underwater volcanic activity, volcanic debris and/or molten materials in water, high temperatures;
 - ▮ Possible sea conditions that would prevent Sentry launch or recovery

Sinking of the Cargo Ship El Faro

- **Primary Objective:** Find the El Faro’s vessel data recorder
- **Major Tasks:**
 - ▮ Locate area of the ship where the data recorder was installed
 - ▮ Closely inspect these areas for evidence of the data recorder
- **Key Sentry Capabilities:**
 - ▮ Ability to dive in deep water;
 - ▮ Precise navigation to locate features of interest;
 - ▮ Side scan sonar
 - ▮ Underwater video
- **Special Circumstances:**
 - ▮ Shipwreck debris that may interfere with close search for the data recorder
 - ▮ Possible sea conditions that would prevent Sentry launch or recovery

The BRIDGE Connection

www.vims.edu/bridge/ – Mouse over “Ocean Science Topics,” in the menu on the left side of the page, then click on “Human Activities,” then “Technology” for links to resources about submersibles, ROVs, and other technologies used in underwater exploration.

The “Me” Connection

Have students watch the AUV Sentry video clip featuring Sentry engineer Dana Yoerger at http://oceanscape.aquarium.org/explore/general_articles/the-auv-sentry. Note Yoerger’s comments about Sentry being an extension of the people who work with her. Then, have students read the daily log for March 7, 2010 from the INSPIRE: Chile Margin 2010 Expedition <http://oceanexplorer.noaa.gov/explorations/10chile/logs/mar7/mar7.html>, and write a brief essay describing how they think

scientists felt about losing their mechanical colleague, and how they would personally feel under similar circumstances.

Connections to Other Subjects

English/Language Arts, Geography

Assessment

Students discussions and presentations provide opportunities for assessment.

Extensions

Have students visit <http://oceanexplorer.noaa.gov/explorations/16carolina/welcome.html> to keep up to date with the latest Carolina Canyons Expedition 2016 discoveries.

Other Relevant Lessons from NOAA's Ocean Exploration Program

The Ridge Exploring Robot (grades 9-12)

from the INSPIRE: Chile Margin 2010 Expedition

<http://oceanexplorer.noaa.gov/explorations/10chile/background/edu/media/robot.pdf>

Focus: : Autonomous Underwater Vehicles/Marine Navigation (Physical Science)

Students explain a three-phase strategy that uses an autonomous underwater vehicle (AUV) to locate, map, and photograph previously undiscovered hydrothermal vents, design a survey program to provide a photomosaic of a hypothetical hydrothermal vent field, and calculate the expected position of the AUV based on speed and direction of travel.

Son of ABE (sort of) (grades 7-8)

from the INSPIRE: Chile Margin 2012 Expedition

<http://oceanexplorer.noaa.gov/explorations/12chile/background/edu/media/sonofabe.pdf>

Focus: Autonomous Underwater Vehicles (Physical Science)

Students discuss the advantages and disadvantages of using underwater robots in scientific explorations; discuss ways in which the design of the AUV *Sentry* has improved on the design of the AUV *ABE*; and given a specific exploration task, identify key design requirements for a robotic vehicle that is capable of carrying out this task and describe practical approaches to meet identified design requirements. Optionally,

students construct a robotic vehicle capable of carrying out an assigned task.

I, Robot, Can Do That! (grades 7-8)

(from the Lessons from the Deep: Exploring the Gulf of Mexico's Deep-Sea Ecosystems Education Materials Collection)

<http://oceanexplorer.noaa.gov/edu/guide/media/gomdse14irobot78.pdf>

Focus: Underwater robotic vehicles for scientific exploration (Physical Science)

Students describe and contrast at least three types of underwater robots used for scientific explorations, discuss the advantages and disadvantages of using underwater robots in scientific explorations; and given a specific exploration task, identify robotic vehicles best suited to carry out this task.

Tools for Classroom Explorers – How to Use Multibeam Sonar Data (grades 9-12)

(from the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition)

http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/edu/media/ex1202_multibeam.pdf

Focus: Multibeam sonar data and exploration activities during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition missions (Earth Science)

Students describe multibeam sonar, explain why the velocity of sound in water must be measured before maps can be created with the *Okeanos Explorer's* multibeam sonar system, discuss the advantages of multibeam sonar bathymetry compared to two-dimensional topographic bathymetry, and interpret three-dimensional multibeam data of underwater features mapped by the *Okeanos Explorer*.

Tools for Classroom Explorers – How to Use CTD Data (grades 9-12)

(from the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition)

http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/edu/media/ex1202_ctd.pdf

Focus: CTD data and exploration activities during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition (Physical Science/Earth Science)

Students define “CTD” and explain how this instrument is used aboard the *Okeanos Explorer*; explain how relationships between temperature, salinity, pressure, and density in seawater are useful to ocean explorers; and use data from the *Okeanos Explorer* to create and interpret graphs of temperature, salinity, and depth.

Tools for Classroom Explorers – How to Use ROV Imagery (grades 9-12)

(from the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition)

http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/edu/media/ex1202_rov.pdf

Focus: ROV imagery and exploration activities during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition (Earth Science)

Students describe typical applications and limitations of imagery obtained with ROVs, demonstrate how lasers may be used to calibrate images for size and distance measurements, and analyze ROV imagery from the *Okeanos Explorer* to make inferences about deep-ocean habitats and organisms.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer 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/explorations/16carolina/welcome.html> – Follow the Carolina Canyons Expedition 2016 as mission logs and discoveries are regularly posted for your classroom use.

<https://www.whoi.edu/main/sentry> – Web page about the AUV *Sentry*, with links to *Sentry Fact Sheet* and *A Scientists Guide to AUV Sentry Cruise Planning and Proposal Writing*. (The links can be found by scrolling down the page to “Additional Resources”)

De Leo, F. C., C. R. Smith, A. A. Rowden, D. A. Bowden, and M. R. Clark. 2010. Submarine canyons: hotspots of benthic biomass and productivity in the deep sea. *Proc. Biol. Sci.* 277(1695):2783-2792.

Hecker, B. and G. Blechschmidt. 1979. Final Historical Coral Report for the Canyon Assessment Study in the Mid- and

North-Atlantic Areas of the U.S. Outer Continental Shelf. Manuscript report prepared for U.S. Department of the Interior, Bureau of Land Management. Washington, DC. <https://www.data.boem.gov/PI/PDFImages/ESPIS/4/4487.pdf>

Hecker, B. and G. Blechschmidt, and P. Gibson. 1980. Epifaunal Zonation and Community Structure in Three Mid- and North Atlantic Canyons. Final Report for the Canyon Assessment Study in the Mid- and North-Atlantic Areas of the U.S. Outer Continental Shelf. Manuscript report prepared for U. S. Department of the Interior, Bureau of Land Management. Washington, DC. <https://www.data.boem.gov/PI/PDFImages/ESPIS/4/4436.pdf>

ten Brink, U. 2009. Submarine Landslides as Potential Triggers of Tsunamis That Could Strike the U.S. East Coast - First results from systematic sea-floor mapping of the continental slope from Cape Hatteras to Georges Bank. [Internet]. U. S. Geological Survey [cited May 16, 2011]. Available from: <http://soundwaves.usgs.gov/2009/08/fieldwork.html>

Next Generation Science Standards

HS-ETS1 Engineering Design

Performance Expectation

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Crosscutting Concepts

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and

information flows— within and between systems at different scales.

Common Core State Standards Connections:

Mathematics –

MP.4 Model with mathematics.

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.

Earth has one big ocean with many features.

Fundamental Concept h. Although the ocean is large, it is finite, and resources are limited.

Essential Principle 5.

The ocean supports a great diversity of life and ecosystems.

Fundamental Concept b. Most of the organisms and biomass in the ocean are microbes, which are the basis of all ocean food webs. Microbes are the most important primary producers in the ocean. They have extremely fast growth rates and life cycles, and produce a huge amount of the carbon and oxygen on Earth.

Essential Principle 6.

The ocean and humans are inextricably interconnected.

Fundamental Concept e. Changes in ocean temperature and pH due to human activities can affect the survival of some organisms and impact biological diversity (coral bleaching due to increased temperature and inhibition of shell formation due to ocean acidification).

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 c. Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.

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.

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:
oceanexeducation@noaa.gov.

For More Information

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Credit

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AUV Sentry Mission Scenarios

Deepwater Horizon Oil Spill

Around 10:00 pm CDT on April 20, 2010, a gas explosion occurred on the mobile offshore drilling unit *Deepwater Horizon* about 40 miles southeast of the Louisiana coast. The explosion killed 11 workers, injured 17 others, ignited an intense fire that burned until the *Deepwater Horizon* sunk 36 hours later, and resulted in a massive release of crude oil that is now considered the greatest environmental disaster in U.S. history. Researchers rushed to get to the Gulf as quickly as possible to learn what was happening to the deepwater ecosystems found near the leaking wellhead. The AUV *Sentry* was deployed off of ships to map oil plumes and to search for hard bottom on the sea floor, where coral communities might be found.

- What was the primary objective of these *Sentry* missions?
- What were the major tasks that needed to be accomplished to achieve this objective?
- Which *Sentry* capabilities were important to achieve this objective?
- What special circumstances would the Expedition Leader have needed to consider when planning these *Sentry* missions?

Find out more at the Smithsonian Ocean Portal: <http://ocean.si.edu/ocean-photos/auv-sentry>

Axial Seamount Eruption

On April 24, 2015, Axial Seamount, an underwater volcano located off the Oregon coast, began erupting. On August 14, scientist aboard the Research Vessel *Thomas G. Thompson* sailed from Seattle to investigate. Two days later, the AUV *Sentry* was launched from the RV *Thompson* to map the area where the April eruption occurred.

- What was the primary objective of this *Sentry* mission?
- What were the major tasks that needed to be accomplished to achieve this objective?
- Which *Sentry* capabilities were important to achieve this objective?
- What special circumstances would the Expedition Leader have needed to consider when planning these *Sentry* missions?

Find out more at the Oregon Coast Aquarium Oceanscape Network, http://oceanscape.aquarium.org/explore/general_articles/the-auv-sentry

Sinking of the Cargo Ship *El Faro*

On October 1, 2015, the cargo vessel *El Faro* sank during Hurricane Joaquin. All 33 of the *El Faro's* crew perished in the accident. On October 31, the U.S. Navy Ship *Apache* found the ship's wreckage in a depth of about 4570 meters (15,000 feet). Five months later (April 18, 2016), the AUV *Sentry* was aboard the Research Vessel *Atlantis* as she sailed from Charleston, South Carolina to search for the vessel data recorder.

- What was the primary objective of this *Sentry* mission?
- What were the major tasks that need to be accomplished to achieve this objective?
- Which *Sentry* capabilities were important to achieve this objective?
- What special circumstances would the Expedition Leader have needed to consider when planning this *Sentry* mission?

Find out more at the National Transportation Safety Board Press Release website, <http://www.nts.gov/news/press-releases/Pages/PR20160417.aspx>