Plan an Ocean Expedition!

Grade Level

5–8 or higher

Timeframe

60 minutes or more

Materials

- Computer, projector and screen
- Visual materials (all available to download)
- Text documents (all available to download)

Key Words

Autonomous underwater vehicle (AUV), exploration, *Okeanos Explorer*, multibeam sonar, remotely operated vehicle (ROV), research, telepresence technology, uncrewed surface vessel (USV)

Standards

NGSS: MS-LS2-4. LS2.C
CCSS: W.6.10. SL.6.4.
Ocean Literacy Principles: 7, 6.
Details at end of lesson

A NOAA crew readying the ROV *Odysseus* for deployment
Photo: Courtesy Ralf Meyer, Green Fire Productions

Activity Summary

Students plan an expedition to a national marine sanctuary or monument. They choose a phenomenon to investigate, select personnel they will hire and technology they will use. Students create a research question, mission statement, expedition budget and justify how their choices support the mission. They use a project format of their choice to try to persuade the class about the need to fund the voyage. Enrich/Extend options include an easy way to create small ROVs with your students using low-cost items.

Learning Objectives

Students will:

- Create a research question and expedition mission statement based on a topic related to a national marine sanctuary and their own interests
- Describe the activities that will take place during the expedition to fulfill their mission
- Create a detailed budget of personnel and technology expenses
- Justify the importance of their expedition and explain how it will further our understanding of the ocean

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National Geographic Society

&

National Marine Sanctuary Foundation

Background Information

National marine sanctuaries and marine national monuments are a network of underwater areas in the ocean and Great Lakes that protect America's most iconic natural and cultural marine resources. They are hubs for science, education, exploration and recreation. Some sanctuaries, such as Mallows Bay–Potomac River and Wisconsin Shipwreck Coast, are protected because of their underwater cultural heritage. Both of these sites harbor the remains of ships and other vessels that continue to intrigue archaeologists. Other sanctuaries and monuments are sites of unique and critical marine habitats.

Both sanctuaries and monuments are federally protected areas, but there are differences in how they are protected. They are designated under two different acts and managed by different agencies. (See the link at the end of this section to learn more.)

At any given time, researchers are in sanctuaries and monuments exploring the deep, monitoring kelp forests, tracking coral reef health and more. Because so little of the ocean has been explored and we have much to learn, the next generation of explorers and researchers will find great opportunities for discovery, innovation and investigation.

Exploration Technology

In 2008 the NOAA Ship *Okeanos Explorer* was commissioned as "America's Ship for Ocean Exploration." It is 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. To fulfill its mission, the *Okeanos Explorer* has specialized capabilities for finding new and unusual features in unexplored parts of our ocean, and for gathering key information that will support more detailed investigations by subsequent expeditions.

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 uncrewed submersibles. Some of the most exciting discoveries in modern ocean exploration have been made with the assistance of underwater robots. Recent technological developments have made the ocean and its mysteries more visible than ever before. With these new "technological eyes," many new species, new ecosystems and new metabolic processes have been discovered. In addition, telepresence, technology that allows scientists to participate in expeditions from remote locations, is an economical way for many other scientists to share ideas and expertise with onboard colleagues.

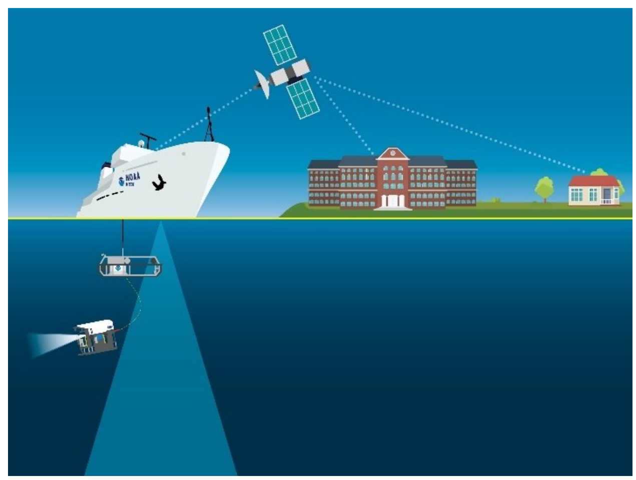


Illustration of NOAA Ship *Okeanos Explorer* using telepresence to deliver data to shore. Graphic: NOAA Ocean Exploration

Teamwork

Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, videographers and data scientists.

Specialized personnel are also required to run a research vessel, including a captain, engineers, navigators, remotely operated vehicle (ROV) pilots and other crew members. In this activity, students will learn about the roles of various personnel, as well as technology they use, to plan a successful expedition.

Learn more:

"Expeditions." NOAA Ocean Exploration: https://oceanexplorer.noaa.gov/explorations/explorations.html

"Exploration Tools." NOAA Ocean Exploration: https://oceanexplorer.noaa.gov/technology/technology.html

"Monuments and Sanctuaries: What's the Difference?" NOAA's Office of National Marine Sanctuaries: https://sanctuaries.noaa.gov/about/monuments-and-sanctuaries-whats-the-difference.html

"NOAA Ocean Exploration Operations on NOAA Ship *Okeanos Explorer*": https://oceanexplorer.noaa.gov/okeanos/welcome.html

"Underwater Cultural Heritage." The Ocean Foundation: https://oceanfdn.org/underwater-cultural-heritage

Vocabulary	
Autonomous underwater vehicle (AUV)	Independent underwater robot. AUVs are untethered from a ship, allowing the robot to complete pre-planned missions without direct control from an operator.
Drifter	A device that collects data about ocean currents
Environmental DNA (eDNA)	The genetic material shed by organisms in the water column
Environmental satellite	A machine that is launched into space and moves around Earth to collect data about ocean features, such as currents, sea surface temperatures and whale migration
Geographic information system (GIS)	A computer-based system used for organizing and analyzing data related to positions on Earth's surface; used for mapping
Human-occupied vehicle (HOV)	A submersible that transports a small team of scientists and pilots underwater for a short period of time
Magnetometer	A passive instrument that measures changes in the Earth's magnetic field
Multibeam sonar	A tool that uses sound waves to map the seafloor and detect objects in the water column or along the seafloor: Multibeam sonar sends out multiple, simultaneous sonar beams at once in a fan-shaped pattern.
Photogrammetry	A method of digitally creating a three-dimensional (3D) structure using two-dimensional images
Remotely operated vehicle (ROV)	A submersible robot connected to a ship with a tether
Sonar	A tool that uses sound waves to map the seafloor and detect objects in the water column or along the seafloor
Submersible	An underwater robot deployed from a ship to the sea, where it records and collects information from the ocean for scientific analysis
Submersible collector	A part of a submersible designed to collect organisms found in the deep ocean

Technical diving	All diving methods that exceed the limits imposed on depth and/or immersion time for recreational scuba diving
Telepresence technology	Technologies that allow a person to feel, interact and collaborate as if they were present at one location when in fact they are at a different location; used by scientists to participate in expeditions remotely
Trawls	Nets towed behind a boat to collect organisms
Uncrewed surface vessel (USV)	A device that roams the ocean's surface like a boat, collecting oceanographic and atmospheric data

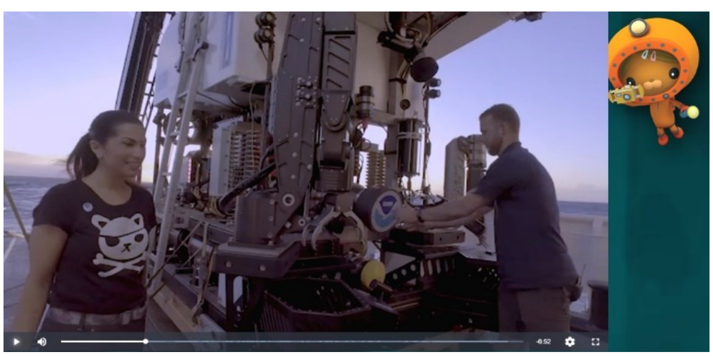
Preparation

- Print copies of the "Plan an Expedition!" handout, one per student or pair of students.
- Prepare to show one or more videos listed below with a data projector, or for students to view them with a partner.
- Prepare to show the national marine sanctuaries website (https://sanctuaries.noaa.gov) and a list of recent NOAA Ocean Exploration expeditions: https://oceanexplorer.noaa.gov/explorations/explorations.html.
- Arrange for students to have access to online research: a computer lab, tablets, etc. If possible, you could also arrange for students to visit a library and have the support of a librarian and/or technology specialist for their research projects.

Procedure

Engage

- Show students a brief video (or clip) of an ocean research ship on an expedition. "The Octonauts and NOAA Ship *Okeanos Explorer*" (8:43) is a fun option: https://oceanexplorer.noaa.gov/octonauts.



Screenshot from "The Octonauts and NOAA Ship *Okeanos Explorer*"

- A short video about exploration could also help get students excited to plan their own expedition. Options include:
    - A virtual reality video from the sanctuaries, such as Shipwreck Alley in Thunder Bay National Marine Sanctuary, Lake Huron: https://sanctuaries.noaa.gov/vr/thunder-bay/shipwreck-alley

    - "Octopus Wonderland: Return to the Davidson Seamount" in Monterey Bay National Marine Sanctuary: https://nautiluslive.org/video/2020/10/27/octopus-wonderland-return-davidson-seamount
    - Other videos from Nautilus Live: https://nautiluslive.org/photos-videos
- Ask students: Have you heard about other ocean expeditions? If so, what was the purpose of those expeditions? What did leaders do and discover on those expeditions?
- Project a map of the national marine sanctuaries and monuments found here: https://sanctuaries.noaa.gov. Ask students if they have heard of and/or visited a sanctuary or monument before. Briefly explain what sanctuaries and monuments are and that they are centers of research, exploration, education and recreation. (See the Background Information section above for more information.)

Explore

- Pass out copies of the "Plan an Expedition!" handout, one per student or pair of students. Ask them to imagine they are an ocean explorer planning their next voyage.
- Show students the national marine sanctuaries website at https://sanctuaries.noaa.gov, which can help give them ideas about environments and/or organisms they might investigate. Suggest that exploring recent expeditions could also help them with ideas: https://oceanexplorer.noaa.gov/explorations/explorations.html. These pages are listed at the top of the handout.
    - One expedition they might explore online to help them plan is "Microbial Ecosystem Services on Seamounts in the Papahānaumokuākea Marine National Monument": https://oceanexplorer.noaa.gov/explorations/21mess/welcome.html.
- Briefly show students NOAA's Exploration Tools page, which lists technologies (e.g., ROVs, sonar, video cameras and equipment) that might help them make important discoveries: https://oceanexplorer.noaa.gov/technology/technology.html.

- Ask students to answer the questions on the handout to help them prepare the purpose of their exploration, mission statement and budget. Tell them that after they organize the information, they can prepare to share it with the class. They can prepare a short presentation, video, poster or another engaging product of their choice.

- Point out the rubric on the last page of the handout so they know how they will be assessed. Tell students they should fill out the “Your Score” column and turn it in to you when they are ready to present.

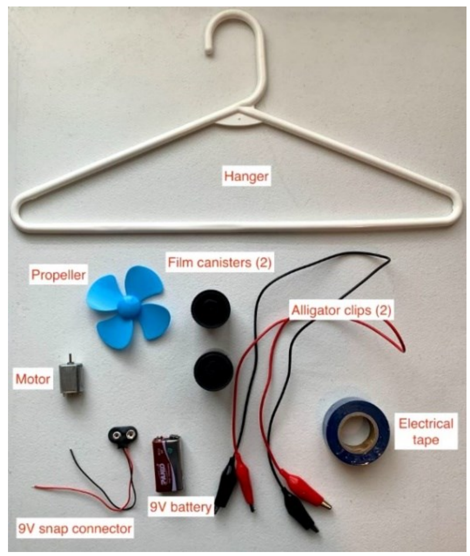
Explain

- As students complete their projects, invite them to share their proposals with the class. As they do, ask the other students to record short summaries of each proposal in science notebooks.
- In a full class discussion ask: What are challenges of exploring the ocean? Discuss student ideas, filling in details such as:
    - Physical challenges include the vast expanse of the ocean, extreme depths, pressure, lack of light and cold temperatures.
        - For example, while satellite altimetry maps of Earth’s ocean floor seem to show seafloor features in considerable detail, 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. Moreover, at the scale of a typical wall map (about 1 cm = 300 km), a dot made by a 0.5 mm pencil represents an area of over 60 square miles (155 sq. km)!
        - Multibeam sonar mapping systems can produce images that are thousands of times more detailed than satellite imagery and at much higher resolution. This technology can identify specific features of seamounts, underwater canyons and shipwrecks.
        - ROVs and other submersibles have been designed to go where conditions are dangerous for humans or it is impossible for humans to go.
    - Limited funding for exploration means not all ocean scientists can join expeditions in person.
        - Telepresence technologies allow people to observe and participate in activities at remote locations. This allows live video to be transmitted from the seafloor to scientists ashore.
        - Telepresence makes it possible for shore-based members of the science community to share their expertise with shipboard scientists and ROV pilots in real time. This allows more scientists to participate in expeditions at a fraction of the cost of traditional oceanographic expeditions.
        - Telepresence technology also makes it possible for the general public to experience some expeditions live!
        - See visuals you can share at https://oceanexplorer.noaa.gov/technology/telepresence/telepresence.html.

- Watch live expeditions of the NOAA Ship *Okeanos Explorer*, E/V *Nautilus* or R/V *Falkor (Too)* at https://deepoceaneducation.org/vessels.

Enrich/Extend

- After the class has shared their proposals, ask them to break into groups to choose the expeditions that should be funded.
  - Tell the class that $10,000,000 is available for ocean exploration grants in the coming year, and that they are all part of the review committee that will decide which proposals should be awarded the funding based on the strength of the proposals and how persuasive they are.
  - The groups can then share their decisions with the teams that they think should be funded.
- Create simple ROVs with the class or invite them to plan their own designs.
  - One possibility uses a coat hanger and other low-cost materials. Learn more on the "Coat Hanger ROV" activity listed with this lesson.
  - More details are here: https://nauticalcharts.noaa.gov/learn/docs/educational-activities/build-underwater-robot.pdf.
  - Test ROV prototypes with a kiddie pool or other large container of water!



Suggested materials for a simple ROV
Photo: Andrea Schmuttermair/NOAA

- Ask students to reflect on how climate change and ocean acidification might be impacting their chosen sanctuaries or monuments. How might those urgent issues be studied with their expeditions? What actions might we take to improve the health of our sanctuaries, global ocean and Earth as a whole that are so interconnected, now and in the future? They may explore the following sites to answer these questions:
  - "Climate Change Actions and Solutions" https://sanctuaries.noaa.gov/management/climate/actions-and-solutions.html
  - "Ocean Acidification Background" https://sanctuaries.noaa.gov/education/teachers/ocean-acidification/background.html

Evaluate

- Review science notebooks and students' documentation of their expedition plans.
- Provide feedback on expedition proposals with the support of the rubric.
- Ask students to reflect on the challenges of exploring the ocean and why it is important to have national marine sanctuaries. This can be done in a class discussion and/or in writing.

Education Standards	
Next Generation Science Standards	Will vary; examples students can meet for relevant projects: Ecosystems: Interactions, Energy and Dynamics • MS-LS2-4: LS2.C: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. Science and Engineering Practices: • Asking Questions and Defining Problems • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information Crosscutting Concepts: • Cause and Effect • Patterns
Common Core State Standards	Writing: W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Speaking and Listening: SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes.
Ocean Literacy Principles	6. The ocean and humans are inextricably interconnected. (c, d, g) 7. The ocean is largely unexplored. (a, b, f)
Climate Literacy Principles	3. Life on Earth depends on, is shaped by, and affects climate. (a, c) (If the last Enrich/Extend activity is completed.)

Additional Resources

"Deep Ocean Education Project." NOAA Ocean Exploration/*Nautilus* Live/Schmidt Ocean Institute: https://deepoceaneducation.org

"Ocean Exploration" lesson. National Geographic Society: https://education.nationalgeographic.org/resource/ocean-exploration-activity

"Ocean Exploration Educational Materials by Theme." NOAA Ocean Exploration: https://oceanexplorer.noaa.gov/edu/themes/welcome.html

For More Information

This lesson was developed by NOAA's Office of National Marine Sanctuaries. If you have any further questions or need additional information, email sanctuary.education@noaa.gov.

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