OCEAN CLASSROOM

Oceans of Research

Lesson 1

EDUCATOR GUIDE

THE
UNIVERSITY
OF RHODE ISLAND
GRADUATE SCHOOL
OF OCEANOGRAPHY

Guiding Questions

"Who are oceanographers? (Describing the diversity of people and jobs in the field)"

"What are the different types of oceanographic research?"

"When and where is oceanographic research conducted?"

"Why is oceanographic research conducted and why should we care about how it is used?"

"Why is understanding data an important skill?"

Background

Important Terms

Anthropogenic — an issue that is directly caused by human action

Upwelling — a seasonal process where wind blows surface water directing it away from shore, and cold, nutrient-dense deep water rises to the surface to replace it

Regional Class Research Vessel — a moderately sized research vessel (max. length = 199 feet) that conducts oceanographic research in a particular region

Near real-time data — data that is collected and has some sort of quality control before being delivered to stakeholders, so that there is a slight delay

Real-time data — data that is collected and beamed back to shore with almost no delay

RCRV Project Overview

The Regional Class Research Vessel (RCRV) Project at Oregon State University (OSU) received grant funding from the National Science Foundation (NSF) to oversee the design and construction of three new RCRVs. The first research vessel, R/V *Taani,* will be operated by OSU along the U.S. Pacific coast; the second vessel, R/V *Narragansett Dawn,* will be operated by the East Coast Oceanographic Consortium [University of Rhode Island (URI), University of New Hampshire (UNH) and Woods Hole Oceanographic Institution (WHOI)] along the U.S. Atlantic coast; and the third RCRV will be operated by Mississippi State University in the Gulf of Mexico. R/V *Taani* is expected to launch in 2022 and R/V *Narragansett Dawn* in 2025. These RCRVs will have the capacity to produce real-time marine science data and will allow marine researchers to utilize many oceanographic tools and conduct a variety of research activities. This research will provide them, as well as educators and their students, an enormous amount of crucial, marine science data that can be used to educate the public, inform decision-making within our state and region, and potentially help address critical marine science issues. (For more information on the R/V *Narragansett Dawn* go to https://web.uri.edu/gso/research/narragansett-dawn/)

Big Data & Data Literacy

Despite the accessibility of existing data, many students do not have the data literacy skills they need to properly understand data-activities in the classroom. In fact, only 21% of 16- to 24-year-olds consider themselves to be data literate (QLIK, 2018). Students often struggle with understanding what data is, understanding what to do with data, and understanding how data relates to them. This curriculum seeks to remedy these three challenges through a combination of lectures, discussions, and data-focused, hands-on activities.

Big data refers to large sets of complex data. Middle and high school students today now have access to enormous amounts of data at the touch of a button. Data informs and drives nearly every aspect of society, including cell phone services, retail services, manufacturing and financial services, as well as scientific research (Jagadish et al., 2014). No matter what career path students may choose to pursue, understanding what data is, how data is collected, how it is used, and why it is important are crucial. Clearly, oceanographers are not the only data users and sources of data, but they provide an excellent example and contextualized learning opportunity for today's students.

Who are oceanographers?

Oceanographers are simply put – people who study the ocean! They are a diverse group of people who come from all over the globe and from a variety of backgrounds.

What do oceanographers do?

Oceanography, while generally known as being the study of the ocean, is broken down into four key areas (which themselves can be broken down into many, many specialties!). The four traditional areas are biological oceanography, chemical oceanography, physical oceanography, and geological oceanography (US Department of Commerce-a).

Biological oceanographers, also known as marine biologists, study the plants and animals that live in the marine environment. Generally, their interests revolve around determining the numbers of organisms, and how these organisms change over time, interact with one another, and interact with the world around them. To conduct their research, they often use field observations and experiments.

Chemical oceanographers, also known as marine chemists, study the chemistry of the ocean. They are interested in the composition of seawater, how the chemistry of the ocean varies over time and location, and the processes that affect the ocean's chemistry. Marine chemists work on a variety of issues, including pollution, ocean acidification, and how the chemistry of the ocean impacts and is impacted by organisms, currents, and other factors. They often use a combination of field work (taking water samples) and lab work (analyzing water samples).

Geological oceanographers, also known as marine geologists, explore the seafloor and the processes that create the associated features (canyons, seamounts, etc.). Studying the seafloor allows marine geologists to "look back in time" and identify a variety of activities that happened to form the modern oceans, such as earthquakes, volcanic eruptions, spreading of the seafloor, and how ocean circulation and climate may have changed over time. Marine geologists often utilize sonar mapping of the seafloor and take large core samples of the sediment to analyze.

Physical oceanographers study the physical processes of the ocean, including wave formation, movement of currents, erosion processes, transmission of light and sound through water, and the interaction of the ocean and the atmosphere. There are many ways for physical oceanographers to conduct their research. Some may use field research (using technology like gliders or hydrophones) while others may conduct lab research using a wave simulation pool or computer models.

Although defined separately, these fields are not isolated and frequently overlap in research. All oceanographers need to have background knowledge in each of the four areas but tend to be specialized in one of them.

When did oceanography become a science?

Historically, oceanography began as explorers started to map the oceans and identify specific phenomena, like currents. These efforts were motivated by everything from curiosity and wanting to expand personal knowledge, to economic incentives like finding a route to access goods from far-away lands. Benjamin Franklin made the first scientific study on the Gulf Stream, gave it its name, and published the first map of it in 1770. In 1873, the British vessel HMS Challenger left for what is considered to be the first true oceanographic expedition. The expedition lasted three years and resulted in both a book and the declaration of oceanography as a discipline at the University of Edinburgh (McDaniel, Sprout, Boudreau, & Turgeon, 2012).

In modern times, oceanography is a wide-reaching scientific discipline with oceanographers all over the world working for a variety of organizations such as universities (like the University of Rhode Island) and government agencies (like the National Oceanic and Atmospheric Association [NOAA]).

Where does oceanography happen?

Geographically, oceanography is a discipline that happens all over the world, from marine mammal biologists studying blue whales in New Zealand to geological oceanographers studying volcanism in the North Atlantic. New England has a unique coastline and oceanographic phenomena that make it a great place for oceanographic research! For example, we have a broad continental shelf with major undersea canyons along the shelf edge that drop thousands of feet to the deep ocean floor. The steep-walled canyons are formed mainly by erosion of the continental slope and lower continental shelf. Within and around the canyons, upwelling of deep, cold water brings nutrients to the surface. These nutrients support large quantities of plankton, krill, forage fish, and schools of squid, which in turn, nurture an abundance of marine animals such as whales, dolphins, turtles, and migratory fish. In fact, three of the largest canyons as well as four enormous seamounts (undersea mountains) are within the Northeast Canyons and Seamounts National Marine Monument, located 130 miles off the coast of Cape Cod in southern New England. The seamounts are considered "biological islands in the deep-sea", and support a variety of species of deep-sea (cold-water) corals, sponges and anemones. Exploration of this hotspot for biodiversity attracts researchers from all over the world. In addition, the coast of New England provides insight into many large-scale issues. It is a place that has been hit by ocean warming, sea level rise, and ocean acidification, and is also a place where offshore wind and tidal projects are being developed as sources of marine renewable energy.

From a depth perspective, most of the research has taken place in shallower waters. Recently, more effort has been made to explore and understand deeper areas of the ocean like the canyons and the Abyssal Zone. The E/V *Nautilus* YouTube Page on deep sea exploration (https://www.youtube.com/channel/UC1KOOWHthbQVXH2kZue3_xA) and the NOAA Ship *Okeanos Explorer* YouTube channel (https://www.youtube.com/playlist?list=PL05ED679DD1E1DB17) have many educational videos on this topic.

Why do we conduct oceanographic research?

"We know more about the dead seas of Mars than our own ocean."
— Jean-Michel Cousteau

The ocean is still a vastly unexplored place, with up to 95% of it still an unfamiliar place to humans. Yet, oceanographic research is not wandering the ocean for the sake of wandering. Research is crucial in assessing overall ocean health, identifying significant issues, and finding solutions to address these issues. Human health is explicitly intertwined with ocean health, as it regulates our climate, provides us with oxygen and food provisions, and potentially holds new energy sources and important substances that could be developed into new drugs (US Department of Commerce-b). Oceanographic research can help provide insight into keeping the balance between our health and ocean health, inform policymakers and managers on how to best manage our marine resources, and inspire and engage a new generation of future researchers.

Activity

Time required 50-minute period

(May become two periods if review video is used along with the assessment.)

Target Audience Middle School/High School

Lesson Objectives

Students will:

- Understand the who, what, when, where and why of oceanographic research
- Understand why being able to interpret data is an important skill

Suggested Materials

"Oceans of Research Lesson 1" PowerPoint.

Setup

Open PowerPoint

Preload videos if Internet connectivity is an issue

Wrap Up

If time allows, show students the following video from the College of Earth, Ocean and Atmospheric Science at Oregon State University to reinforce concepts covered in this lecture:
https://youtu.be/LrCCM6cAPZ4 (Run time: 5:24)

Quick Check: Have students each fill out the Quick Check (could allow three minutes or more). These can be turned in to teachers for review *or* alternatively shared aloud with the class.

Assessment

Did students actively participate in brainstorming and discussion?

Did student reflections in the Quick Check indicating understanding of the following key concepts:

a. Data is important in our daily lives.
b. The ability to understand data is important for a variety of reasons.
c. The who, what, when, where and why of oceanography, and how data collection and analysis is an essential part of oceanography.

Activity

(Continued)

[Slide 1: Introduction]

4. Introduce the curriculum to the class by sharing that they are going to be talking about data, through the lens of oceanographic research.
5. Begin by asking students to brainstorm with their table groups (or neighbors) what they think ‘big data’ means.
6. After defining it, have students discuss the importance of data in their daily lives, as well as the importance of “data literacy.”
   a. “Does anyone know how data affects your daily life?”
   b. “Why do you think it is important for people to be able to understand what data is and how data is used?”

[Slide 2: Big Data]

4. Once students have shared their ideas, discuss that not only does data drive most services and aspects of their daily lives, but data literacy is also an important skill to have in current and future careers.
   a. “You live in a unique situation—you have almost unlimited access to huge amounts of data at the touch of a button. Whether you decide you want to be a scientist or not, most careers require candidates who are comfortable working with some sort of data.”

[Slide 3: RCRV Project]

5. Explain that the Regional Class Research Vessel (RCRV) project at Oregon State University (OSU) is overseeing the design and construction of three new regional class research vessels. [Note on boat vs. ship vs. vessel: “Vessel is a catch-all term, like ‘watercraft’, which describes any floating object used for the carriage of people or goods. Generally smaller and less complex vessels are ‘boats’, whilst larger and more complex vessels are ‘ships’. As a general rule, you can put a boat on a ship, but you can’t put a ship on a boat.“ http://www.theshippinglawblog.com/2010/07/q-are-terms-boat-ship-and-vessel.html]
6. Discuss that these vessels will have the ability to produce and beam back large amounts of real-time oceanographic data.
7. Finally, lead into the who, what, when, where and why of oceanography, so students have a strong foundation to move forward with data work in the following lessons.

Activity

(Continued)

[Slide 4: Who]

8. Ask students what they think an oceanographer is.
9. Explain that oceanographers are those who study the ocean, and work in many different areas, on many specialized projects. Mention oceanographers often go through many years of schooling to get into this field.
10. Ask students if any of them can name a famous oceanographer.
    a. Some examples are Jacques Cousteau, Sylvia Earle, Bob Ballard, James Cameron

[Slide 4 (cont.): What]

11. Begin by showing students the four pictures of oceanographers in each main area of study, then ask them if they can identify what the four areas are.
    a. Example guiding question: "There are four different areas of oceanography represented by these four pictures. Can anyone guess what areas these pictures may be representing?" (Hint: think of the different disciplines in science in general.)
12. As each area is identified, ask students what they think oceanographers in each of the areas do.
    a. Example: "Yes, this is a biological oceanographer, which means they study plants and animals in the ocean. What kind of things do you think they would be interested in researching?"
13. As each area of study is identified, provide further explanation into what these oceanographers do and the types of collection methods they might use.
    a. Example "They are interested in the numbers of marine organisms, their distributions, and how these organisms develop, relate to one another, adapt to their environment, and interact with it. To accomplish their work, they may use field observations, computer models, or laboratory and field experiments."
14. Make sure to explain to students that these fields often overlap, and that data from one area can often inform or relate to another area.
15. Make sure all four areas have been identified, and that the associated interests and potential research methods have been discussed before moving on to the next slide.

Activity

(Continued)

[Slide 5: What] *(Video Examples)*

16. To highlight how oceanographers in the same field vary widely in their work, show students two "day in the life" videos of biological oceanographers.
    a. When Your Job Is Saving the Ocean | How She Works https://www.youtube.com/watch?v=B-_dv0B0g1c (Run time: 4:03)
    b. Day at Work: Ichthyologist (Fish Biologist) https://www.youtube.com/watch?v=51y_Ahx3Mxw (Run time: 3:37)

17. Ask students to identify the differences between the two biological oceanographers' work.
    a. Example of differences: one works with live animals and one works with dead animals, one works in the field and one works in a lab, etc.

[Slide 6: When]

18. To begin, ask students when they think oceanography officially became a scientific discipline. What do they think the first oceanographers did?

19. Explain that oceanography (while not explicitly called oceanography), began with explorers and merchants. The first true oceanographic expedition occurred on the HMS *Challenger* (left picture on slide) and sparked the eventual designation of oceanography as a scientific discipline.

20. Explain to students that ocean exploration and research is much more advanced these days, with research ships being superior in everything from plumbing and sleeping quarters, to food and research instruments.

Activity

(Continued)

[Slide 7: Where] *(Geographically, plus focus on New England)]*

21. Explain that oceanographic research happens all over the world, from blue whale research in New Zealand to studying how the ocean is changing in the Gulf of Maine.

22. Now bring the focus to southern New England, explaining that it is a very popular place for all types of oceanography due to unique phenomena and programs which heavily support research (like URI's Graduate School of Oceanography and the Woods Hole Oceanographic Institute on Cape Cod). Researchers from all over the world come to New England to study its coastal and marine environments.

- **a.** For physical oceanographers, there is the physical process of upwelling. Example explanation of upwelling – Imagine using your hands to spread apart the water in a pool or bathtub, what happens? Water from the bottom rushes in. This is essentially what happens on the west coast of the US, but wind is what separates the water from the shore. When the water from the deep comes up it is cold and full of nutrients, which means there is a lot of biological activity due to all of the available nutrients. In other places, such as along the East Coast, the mechanism is slightly more complex, and involves mixing and upwelling along an underwater "frontal system" created where colder, fresher water flowing down from the Arctic meets the warmer, saltier water flowing northward along the Atlantic coast in the Gulf Stream. This density-driven frontal system forms along the shelf break, resulting in upwelling of nutrient rich water from the deep ocean, feeding the phytoplankton that form the base of the marine ecosystem food web (source: https://www.whoi.edu/oceanus/feature/taking-the-long-view-of-an-ocean-ecosystem/)
- **b.** For biological oceanographers, there is the explosion of activity that results from upwelling, unique animals adapted to live in our sometimes-harsh climate, and animals that migrate through our waters each year such as Humpback and Right whales.
- **c.** For chemical oceanographers, there are unique processes to observe like ocean acidification. Example explanation: "Chemical oceanographers have access to studying the effects of what is called 'ocean acidification.' This is when increased carbon dioxide interacts with water, producing a weak acid (one that does not fully ionize in water) that lowers the pH of seawater and can lead to other changes in ocean chemistry." Rising water temperatures in coastal New England waters have accelerated ocean acidification.

Activity

(Continued)

   d. For geological oceanographers, we have a broad continental shelf with major undersea canyons along the shelf edge that drop thousands of feet to the deep ocean floor. The steep-walled canyons are formed mainly by erosion of the continental slope and lower continental shelf. In addition, there is a chain of enormous seamounts (undersea mountains) extending in a southeasterly direction just off the edge of the continental shelf, southeast of Cape Cod. The oldest and tallest of these seamounts is Bear Seamount, which is located within the Northeast Canyons and Seamounts National Marine Monument. These seamounts are actually “guyots”, extinct volcanoes that resulted from the movement of mantle plume hot spots due to seafloor spreading from the Mid-Atlantic Ridge.

[Slide 8: Where (Depth)]

23. Research also takes place at different depths of the ocean, not just different geographic locations.

24. Explain to students the different zones of the ocean, and how research efforts have varied by zone.
    a. Example Guiding Question: “What do you notice about the different zones of the ocean shown in this figure?”
    b. Answers may include: different types of organisms present and different levels of light in each zone.

[Slide 9: Why]

25. Ask students to identify some reasons we would want to conduct marine science research and use marine science data.
    a. Curiosity— “We still know more about the surface of the moon than we know about the oceans.”
    b. The oceans are key to our survival— “The oceans are important to your survival in many ways, including that they produce an estimated 45% of the oxygen we breathe, provide billions of us with food, help regulate our weather and climate, and could even provide us with new medicines.”
    c. Knowing more about an issue can help us solve the issue— “The ocean is currently faced with some very important issues, many of them being anthropogenic, which means caused directly by humans.”

Activity

(Continued)

26. Ask students to identify some human-caused impacts to the ocean, and explain how research and data could be used to address these problems. Examples shown on this slide in the PowerPoint include:

- **a.** *Plastic pollution*— "Measuring how much plastic is in the ocean, how many animals ingest the plastic or are harmed by it, and identifying where plastic is coming from can help us to control the production, use and flow of it."
- **b.** *Coral die off*— "When water gets warmer, the symbiotic organisms that live within coral and provide it with food leave, which means the coral will turn white and die. Data that shows how the water is changing, how fast it's changing and why it's changing can help us take steps to keep coral healthy. Coral are the foundation of the coral reef ecosystem so it's important to preserve them or numerous other organisms that depend on them for survival risk perishing too."
- **c.** *Sea surface temperature*— "Measurement and modeling of sea surface temperatures can help scientists create models to study and better understand short and long-term changes to weather, climate and ocean currents due to global warming." In this image, the sea surface temperatures range from near freezing (0°C–purple color) to about 28°C (dark red color), as indicated on the scale at the bottom of the photo. In this image you can see an eddy (swirl) along the northern fringe of the relatively warm Gulf Stream.
- **d.** *Ships*— "Sometimes, vessels can be troublesome for animals like whales. Large ships carrying cargo or people (like a cruise ship) can create a lot of noise, which can be disorienting to whales. Ships and smaller vessels can also affect animals who are hunting or migrating as many use sounds for locating prey and navigating. Research and data help us identify potential impacts, explore ways we can produce less noise, and help us determine alternate shipping routes to avoid striking animals."

Quick Check

Please answer these three questions to the best of your abilities:

1. What are three to five of the most important things you have learned during this session?

2. Is there anything you did not understand?

3. What questions do you have?