OCEAN CLASSROOM

Oceans of Research

Lesson 2

EDUCATOR GUIDE

THE
UNIVERSITY
OF RHODE ISLAND
GRADUATE SCHOOL
OF OCEANOGRAPHY

Guiding Questions

"What are some research techniques that oceanographers use?"

"How can data tell a story?"

Background

This activity was modified from a lesson created at Oregon State University using data collected during a research cruise on the University of Rhode Island Graduate School of Oceanography's research vessel, R/V Endeavor and presented in a doctoral dissertation by Ph.D. candidate Chris Orphanides and his dissertation committee member, Dr. Melissa Omand. The dissertation encompassed multiple areas of research within the study area; however, this activity focuses on only one of the research topics, the interconnection between North Atlantic Right Whales, the plankton that they feed on, and physical and chemical factors that affect plankton distribution.

Important Terms

CTD— an instrument that measures conductivity, temperature and depth in the water column. (Depth is typically a derived value based on pressure since pressure increases uniformly with depth.)

Conductivity— a measure of how well water conducts electricity; one way to measure the salinity of ocean water.

Plankton Tow— a mesh net specifically designed for collecting plankton, that is dragged through the water either vertically or horizontally. As water flows out, planktonic organisms are concentrated in the back of the net, called the cod end.

Plankton— Organisms that float in or drift with the currents in a body of water. Most plankton are very small, but many are not. Plankton are broken up into two distinct groups: phytoplankton, which photosynthesize, and zooplankton, who feed on phytoplankton and/or other zooplankton. Plankton make up the base of most ocean food chains or webs.

Sight Survey— a method used to observe marine mammals (species, numbers, behavior, etc.).

Bathymetry— the measurement of depth of water in oceans, seas or lakes.

The Activity Setting: R/V *Endeavor* Research Cruise

In this activity, students will act as "science parties" aboard the R/V *Endeavor* (which will be retired in 2025 and replaced with the R/V *Narragansett Dawn*). The CTD and plankton tow data in this activity were collected on an *Endeavor* cruise in April 2018, and marine mammal data was collected during that cruise and supplemented with additional survey data collected in the same general location in the weeks just before and after the *Endeavor* cruise by NOAA Fisheries. Pictures and videos of research efforts in this lesson are from a 2018 cruise aboard the *Endeavor,* which involved full days of sight surveys, with CTD and Plankton Tow activities happening periodically each day as well.

The Research Tasks

Students will form "science parties" with a chief scientist and analyze data collected from the study area off the southern coast of Rhode Island. Next the students will form new groups of six, with two students from each of the science parties. They will communicate the results of their data analysis to their peers, and collaborate to develop a response to the research question.

For the CTD science parties: after reading their instructions and background information, those science parties assigned the CTD data will observe their map showing the data collection stations and take note of any features such as the distance of each sampling station from shore and the bathymetry of the study area. Once oriented with the map, students will begin their data analysis by studying the provided graphs of CTD data and identifying any patterns between salinity, temperature, density and depth (specifically looking for the potential presence of a pycnocline). Students will work together to answer the discussion questions, then prepare to share results and conclusions with their peers.

For the Plankton Tow science parties: after reading their instructions and background information, the science parties assigned plankton tow data will observe the map of the sample collection station in relation to other data collection stations. Once oriented with the map, they will begin their data analysis. Students will research the different types of plankton found in the sample, then construct a bar graph of the percentage of each of the species/types of plankton collected in the plankton tow net. (See Teacher Materials for example). Students will answer discussion questions then prepare to share results and conclusions with their peers.

For the Marine Mammal Survey science party: after reading their instructions and background information, each science party assigned marine mammal survey data will observe the map of the marine mammal sightings in relation to the CTD and plankton tow data collection sites. Once these tasks are completed, students will answer discussion questions and prepare to share their results and conclusions with their peers.

Activity

Time required Four 50-minute periods

Target Audience Middle School/High School

Lesson Objectives

Students will:

- Get a better understanding of three types of marine science data collection (CTD, Plankton Tow and Marine Mammal Surveys).
- Practice analyzing and interpreting data.
- Work collaboratively within their own "science party" and with members of other "science parties" to answer a research question based on data.

Materials

- Oceans of Research PowerPoint-2
- Oceans of Research Student Resource handouts
- Reading (online or printed): https://www.sailorsforthesea.org/programs/ocean-watch/great-south-channel-where-marine-life-meets-feast-every-spring
- Colored Pencils
- Rulers
- Computers (at least one per group)
- Poster materials

Setup

1. Open PowerPoint
2. Preload videos if preferred
3. Prearrange students into groups. Depending on class size, either divide the class into three groups (one group per research area), or six (two groups per research area).
4. Assign one of the data activities to each group (CTD, Plankton Tow, Marine Mammals)
5. For each group, print out at least one packet of Student Resources per group, preferably one per student.

Day 1 Introduction

[Slide 2]

6. Begin class with an overview of the day, then review concepts from Lesson 1.
   a. Include a discussion about what data are and why data is important.
   b. Have students recall the four main fields of oceanography.
   c. Have students recall why we conduct oceanographic research.

2. Explain that the activity will have them acting as scientists on one of URI's research vessels, the R/V *Narragansett Dawn*. They will be using real data collected off the southern coast of New England and will have to work together to analyze the data and prepare to share the results with members of the other "science parties." As in real life, the new interdisciplinary teams will collaborate to answer a research question and present their findings to the rest of the class.

[Slides 3 and 4]

3. Explain the activity setting to students: their science parties have just completed a multi-day cruise on the R/V *Narragansett Dawn.*
   a. Show students actual photos from a research cruise taken on the R/V *Endeavor* (pictures from the April 2018 cruise).

4. The cruise had multiple types of scientists on board, studying a variety of things including oceanographic data (collected using the CTD and flow through sensors), plankton and marine mammals.
   a. Guiding Question: "What fields of oceanography are these topics representing?"
   b. Four different data collection techniques were used on the cruise:
      A CTD— to measure conductivity (which is used to calculate salinity), temperature and depth (which is calculated from pressure readings), as well as density and other variables.
      A Plankton Tow to collect samples of plankton at different locations and depths, supplemented by a Video Plankton Recorder (VPR), which collects in situ photographic data of plankton.
      Marine Mammal Surveys— using binoculars to observe location of marine mammals, number of individuals, species and behavior, supplemented by aerial surveys conducted by airplane in the weeks before and after the cruise.

Day 1

(Continued)

[Slide 5]

5. Begin by showing students the photo of a CTD being deployed off the side of the R/V *Oceanus* for data collection.

6. Explain to students that the two plots represent data collected on a single CTD deployment.
   a. Example Guiding Question: "For the first graph, we have temperature along the top of the graph, or the x-axis. On the left side, or the y-axis, we have depth (which is represented by "pressure.") What do you notice about how the temperature changes with depth?"
   b. Example Guiding Question: "For the second graph, we have depth on the y-axis and salinity on the x-axis. What do you notice about how salinity changes with depth?"

[Slide 6 and 7]

7. Begin by explaining to students what "plankton" are.
   a. Example: "Plankton are organisms that live in water and have little to no control over how the currents move them. They include organisms that will stay small, as well as baby organisms which will grow to be larger, like jellyfish, siphonophores, or squid."
   b. If time, show students the following TEDTalk, "The Secret Life of Plankton." https://youtu.be/xFQ_fO2D7f0 (Run time: 6:02)

8. Show the students two examples of plankton (both crustaceans): krill (a type of euphausiid) and a copepod, *Calanus finmarchicus,* which is relatively abundant in the waters off New England.

9. Explain to students the process of a plankton tow.
   a. Example: A tow can be conducted either vertically in the water column while the vessel is stationary, or horizontally as the vessel moves. They can be done at a variety of depths for any length of time. The plankton are trapped in the net, and then collect at the bottom of a canister. Samples are taken from the canister, stored in a preservative such as formalin or ethanol, and then analyzed in a lab. Samples are sorted and counted for species and abundance.
   b. Another type of plankton tow is an in-situ recording device, called a Video Plankton Recorder. This device is towed through the water at a specific depth and, using a strobe and camera, images of the plankton passing through the device are captured and recorded for subsequent identification using a variety of software.

Day 1

(Continued)

[Slide 8]

10. Explain to students what a marine mammal survey is.
    a. Example: "Marine mammal sight surveys often involve a lot of standing around on the viewing platform waiting to spot something. Once a marine mammal is spotted, the researcher gives directions to the captain (approximate direction and distance) and the vessel is moved into a position for optimal observation using binoculars, a camera, or even a drone. While actively surveying researchers are 'on effort.' Often, marine mammal researchers will collect information along a transect, which is a designated path that can be repeatedly followed over time to collect information. These transects are often used to collect "absence" and "presence" data which records whether an animal is present at a location or not. Researchers also record the number of species, their behavior, and if they are male or female (only possible for some species). When this information is compiled, it can tell researchers a lot about the relationship between where whales are and when. By adding in observations about behavior, researchers can often determine how these animals are utilizing these areas (for feeding, breeding, migrating, etc.)."

[Slide 9]

11. If time, show students portions of the following videos.
    a. Gray Whale off the Oregon Coast: https://www.youtube.com/watch?v=pNu7dv1Rp78
    b. North Atlantic Right Whales off the Virginia coast: https://youtu.be/RGYhvMmKHmw

[Slide 10]

12. Assign students to science party groups (CTD, Plankton Tow and Mammal Surveys) if time allows.

13. *Wrap-up/Homework:* Assign students a reading about a previous study conducted in the Great South Channel, just northeast of the study area they will focus on. (https://www.sailorsforthesea.org/programs/ocean-watch/great-south-channel-where-marine-life-meets-feast-every-spring) The Great South Channel is a prime springtime feeding ground for North Atlantic Right Whales. Information from this reading will assist students in answering research questions about their study area.

Day 2 Science Parties Meet

[Slide 11]

14. Set the scene by explaining to students they are acting like oceanographers who have just "finished" another Endeavor research cruise collecting similar data. Their individual science parties are each going to be looking at a different set of real data collected at sampling stations off the Rhode Island coast.

[Slide 12]

15. Read the Research Question aloud and explain that this is the question science parties will be answering collaboratively at the end of the activity.

[Slide 13]

16. Organize students into science parties for the activity (CTD, Plankton Tow and Mammal Surveys) and have them collect the required materials for their groups. Once everyone is settled, assign one person from each party as the "Chief Scientist."

17. The Chief Scientist will help assign jobs to the other members of their party. For example, the Chief Scientist can read directions, one person can scan data, one person can graph (or all students can make graphs), one person can record results, etc. The science party will need to work together to make sure things run smoothly and all tasks are completed on time.

18. Begin by having each party read their research activity instructions and confirm they understand their assigned tasks.

19. Allow students to work through their tasks, answering questions as needed, and making sure students are on the right track with their discussion questions (see Appendix for teacher answer keys). Each member of the science party should be prepared to share the following information in the next phase of the activity:
    a. What data collection technique they had, what data was collected and how.
    b. What their task was.
    c. What their results were.
    d. Findings from the discussion questions (any patterns or trends, any anomalies, and why they think they are important).

Day 3 Interdisciplinary Groups Collaborate & Prepare Posters for Presentation

[Slide 14]

20. Explain to students that scientists from multiple disciplines often collaborate, sharing their expertise to better understand and answer a research question. Here, students should connect the pieces of the "jigsaw" to understand that the three data sets collected tell a story when put together. Chemical and physical water properties can impact where and how much plankton there are, which can in turn impact how many marine mammals (that feed on plankton) there are in an area. The combination of data sets can tell us a story about how the ecosystem is working, and what would potentially happen to it if circumstances changed. To do this, one or two students (depending on class size) from each of the science parties will join to form a new group with each of the disciplines represented. Have each student/pair of students from each science party share the information listed above in step 18.

[Slide 15]

21. Once students have shared all of their results/findings with the rest of their group, students should work together to make connections between their findings and a better picture of what is happening in the study area. Specifically, how does the oceanographic data (CTD, depth) relate to the plankton survey results, and in turn to the presence of marine mammals (in this case, North Atlantic Right Whales)? Communicating data and findings are an important part of science, and they will practice this by creating a brief poster presentation demonstrating their data sets, assigned tasks, what they found (results) and why they think it is important (conclusions).

Posters

22. Have each interdisciplinary group create an informative poster that explains:

- **a.** What data was collected and how.
- **b.** What their results were.
- **c.** Findings from the discussion questions (any patterns or trends, any anomalies, and why they think they are important) and how they support their answer to the research question.

23. Allow students in class time to brainstorm and create posters.

Day 4

Interdisciplinary Group Presentations and Wrap up

24. Have groups present their posters. Allow students to ask questions once each presentation is over and have presenters respond to the best of their abilities.

25. Wrap-up discussion:
- What did you learn about marine science research?
- What did you learn about marine science data?
- Do you feel like you have a better understanding of research and data?
- Why is it important to be able to find and understand data?
- What kind of things can data help us do?
- How do you think this information relates to you?

26. **Extension Question:** What additional information would help scientists better understand what is happening here, or might happen in the future, given the potential for additional offshore wind turbine development in the area, as well as ongoing ocean warming and global climate change?

Assessment

1. Did students actively participate in presentations and discussion?

2. Did student presentations and discussion responses demonstrate their ability (to some degree) to:
   a. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem?
   b. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations?
   c. Use mathematical representations to support and revise explanations based on evidence about factors affecting populations in ecosystems?

Educational Standards

Next Generation Science Standards

MS-LS2 Ecosystems **Interactions, Energy, and Dynamics**

- *MS-LS2-1* Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- *MS-LS2-4* Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

HS-LS2 Ecosystems **Interactions, Energy, and Dynamics**

- *HS-LS2-2* Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

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Lesson 2: Science Parties

ANSWER KEY

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Instructions

Make sure your party has copies of the plankton background sheet, plankton tow data sheet, a plankton tow map, a blank graph sheet, different colored pens or pencils, and access to a computer.

1. Read your background sheet.

2. Your science party will be looking at a set of real plankton tow data. The data are from a single plankton sampling tow conducted with a bongo net. The bongo sampling location we are working with is represented by a red square near the east end of the long green line on the study area map. Take a look at the map.

   a. What do you notice about the tow location?

It's in a relatively deep area south of Martha's Vineyard; lots of whale sightings in this area; near/within proposed wind turbine development area; etc.

   b. What do you think the ocean conditions (depth, wind, etc.) are in this location?

Fairly deep water, probably windy, etc.

3. Now take a look at your data sheet. The table lists the plankton species/types that were identified in the bongo tow, along with the total number of each that was collected.

   a. Within your group, divide up the species found and spend a few minutes researching the plankton on the Internet, including its scientific classification, range, life cycle, etc.; record your notes on the data sheet below the table.

   b. On the data sheet, complete the table for percentage of each species/type. First add up the total number of organisms found. Then divide the number of each type by the total and multiply by 100. Record each percentage in the table.

See table below for answers.

   c. Using your graph sheet, make a bar graph showing the percentage of each type of plankton. On the x-axis add the species names and label the axis "Plankton species/Types". Label the y-axis "Percentage" and label it from 0 to 100.

See graph.

Instructions *(Continued)*

4. Once you have completed your research and graphs, answer the following questions:

   a. What patterns do you notice in the graph?

80% of the plankton collected were Calanus finmarchicus *or* Pseudocalanus; C. finmarchicus *outnumbers* Pseudocalanus *by 2:1 ratio; none of the other species/types exceeded 5% of the sample, and most were below 1%*

   b. What is the primary type(s) of plankton collected and why might this be important?

Primarily copepods--important food source for right whales

   c. Why do you think it's important we have real, recent data for things like plankton?

So that we know what food is available for whales and other marine organisms, in terms of both quality (energy value) and quantity… It is also important to collect baseline prey information prior to offshore wind development to see if the zooplankton prey resources may change in distribution. number, or quality.

5. Be prepared to give a brief overview to your classmates about what your party did and found with the data. You should be prepared to talk about the following:

   a. What your data set was
   b. What your analysis task was
   c. What the results were
   d. Discuss any hypotheses you have or any questions
   e. Why you think it's important

Data

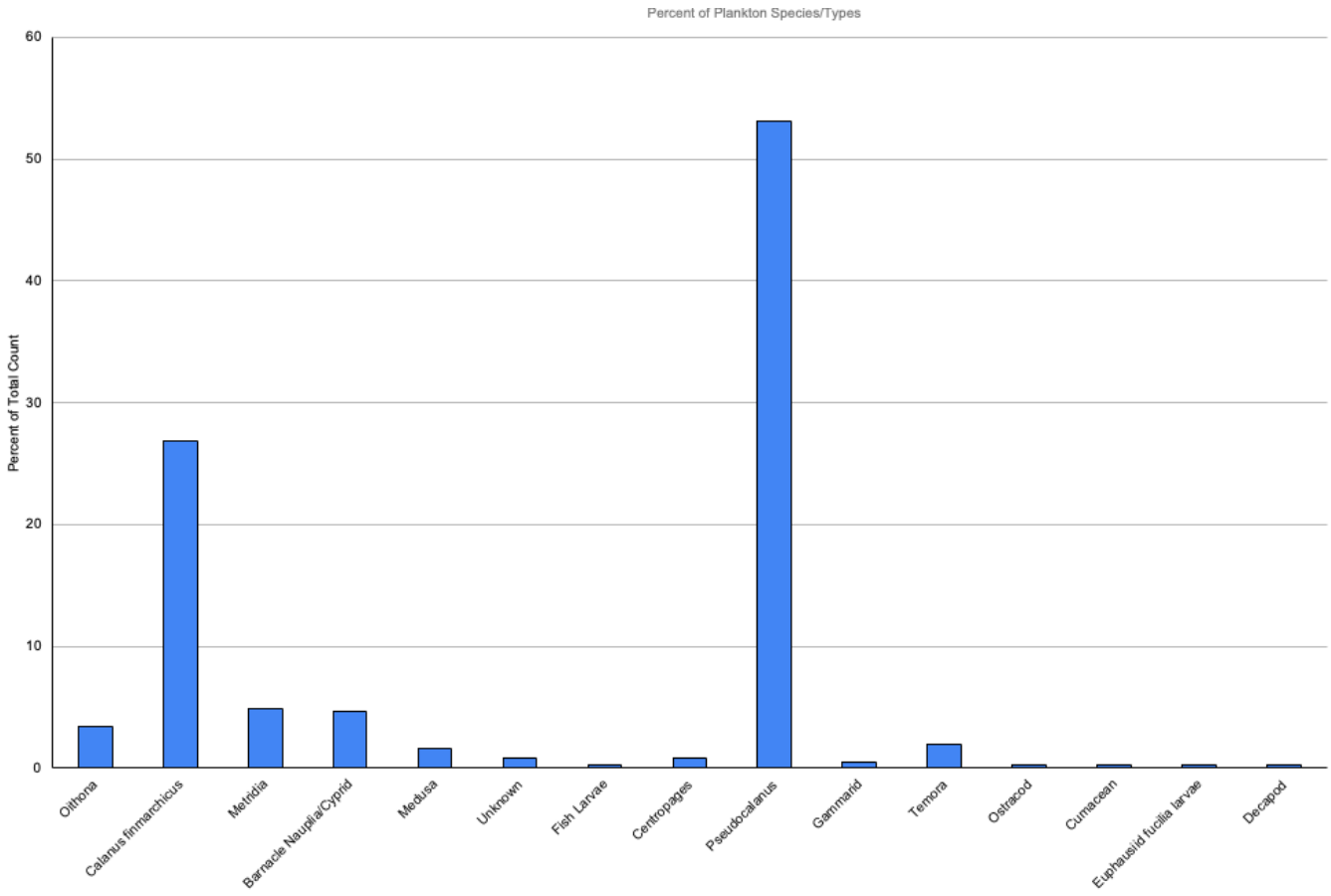
During the Endeavor research cruise, plankton data was collected by two different methods: using bongo net tows and by video plankton recorder (VPR) tows. The VPR data included many of the organisms identified in the bongo net casts, but also included a large percentage of a fragile ctenophore, Mertensia. Scientists believed the lack of Mertensia in the bongo net sample was due to the fragile gelatinous organisms not surviving the intensive rinsing needed to flush the zooplankton to the cod end of the net.

The table below lists the species/types of plankton collected in the bongo net tow. Follow the instructions given above to complete the table and graph.

Organism	Count	% of Total Count
Oithona	13	**3.4**
Calanus finmarchicus	104	**26.9**
Metridia	19	**4.9**
Barnacle Nauplia/Cyprid	18	**4.7**
Medusa	6	**1.6**
Unknown	3	**0.8**
Fish Larvae	1	**0.3**
Centropages	3	**0.8**
Pseudocalanus	205	**53.1**
Gammarid	2	**0.5**
Temora	8	**2.0**
Ostracod	1	**0.3**
Cumacean	1	**0.3**
Euphausiid fucilia larvae	1	**0.3**
Decapod	1	**0.3**
TOTAL:	**386**	**99.1 (due to rounding)**

Plankton Tow Graph Sheet

Sample Graph



Instructions

Make sure your science party has copies of the CTD background sheet, the CTD data graphs, and CTD maps.

1. Read your background information. In particular, pay attention to the bathymetry (ocean bottom depths) in the study area, and the location and bathymetry of the Great South Channel.

2. Your party will be looking at a set of real CTD data. The oceanographic data are all from the same day, but at four different sampling stations within the study area south of Rhode Island. The four stations we are working with are represented by "CTD001," "CTD002," "CTD003," and "CTD004." Take a look at your map of CTD stations.
   a. What do you notice about the four different sites?

CTD-1 and -2 are closer to and about the same distance from shore; CTD-3 and -4 are farther out, with -3 the farthest from shore; lots of whale sightings in this area; near/within proposed wind turbine development area; etc.

   b. How do you think the ocean conditions (depth, wind, etc.) varies at each site?

CTD-1 and -2 are closer to shore, likely shallower water, less windy; CTD-3 and -4 are farther out in deeper water, probably more windy, etc.

3. Now take a look at the four graphs of Salinity, Density and Temperature vs. Depth. Be sure to ask for help if you are confused about how to read them.
   a. What kind of patterns do you notice on individual graphs?

They all have a nearly vertical profile with a slight bend/jump partway down.

   b. What kind of patterns do you notice for specific variables (temperature, density, salinity) across multiple graphs?

Temperature: stays consistent at about 5ºC from surface down to the "squiggle", then decreases/increases less than 0.5º, then stays consistent again to bottom of graph; Density and Salinity show similar pattern--consistent then a small change then consistent again to bottom

   c. Can you identify a pycnocline, thermocline, and/or halocline on each of the graphs, and if so, at what depth?

Yes in CTD-1, -2, and -4: at CTD-1 it's at about 22-25m; at CTD-2 it's at 11-13m; at CTD-4 it's at 33-35m; in CTD-3 the clines are indistinct, with only a slight variation from about 35-52m.

Instructions *(Continued)*

d. Do any measurements differ between stations? If yes, which ones? Can you come up with an explanation or a hypothesis for why they might be different?

At CTD-2 the temperature is slightly colder than at the other three stations, could be colder water flowing in from Nantucket Sound to the northeast; at CTD-3 the upper water salinity is higher than it is at the other three locations but similar to deeper water salinity at those three locations, which may have fresh water inflow from rivers and estuaries

e. Why do you think it's important we have real, current data for things like temperature and salinity off of our coast? Who could benefit from that information?

Temperature and salinity affect populations of marine organisms; current/ongoing data collection can help scientists identify trends such as ocean warming due to climate change.

Instructions

Part 1: Survey

Make sure your party has copies of the marine mammal background sheet, the marine mammal data sheet, maps of the study area, and a computer.

1. Read your background sheet listing the most common species of whales, dolphins and porpoises found off the southern coast of Rhode Island and Massachusetts, along with the most recent estimated population of the West Atlantic Stock of each species.

2. For the purposes of this study, you will be focusing on one species in particular: the North Atlantic Right Whale. Your science party will be looking at a set of marine mammal survey data collected during the R/V Endeavor research cruise on April 7, 2018, and by the North Atlantic Right Whale Consortium (NARWC) between March 18 and April 20, 2018.

3. Locate your zoomed in map of the study area. Use the map key to identify the Endeavor and NARWC sighting locations. The map also shows where the CTD and Plankton Tow data were collected.

4. Take a look at your data. This is a simplified view of marine mammal survey data. It has the species name, the latitude and longitude the animal was spotted at, and how many individuals were present.

5. Discuss the following questions with your party:
   a. How does the population of North Atlantic Right Whales compare to the other marine mammal population? How does it compare to other whale populations?

NARW population is very small compared to other marine mammal populations, especially dolphins and seals. … NARW population is comparable to the Blue Whale population, and much smaller than the other whale species populations.

   b. How many of the survey observations noted more than one whale at a time? Why do you think that is?

Endeavor observations were all one whale at a time; for the NARWC sightings, nine of 30 had more than one whale, with a maximum of six whales in one sighting.

   c. Notice the location of the stations where CTD and plankton tow data were collected. Were any of the marine mammal observations located near these sampling stations?

Yes, because data was specifically collected in an area where whales were observed.

Instructions *(Continued)*

d. Why do you think the "presence/absence" data is important?

Ex. It helps to identify any areas where whales are more likely to travel and feed, in part to develop/enforce management strategies for their protection.

e. What are some other observations the science team made besides presence/absence? Why do you think this information is important? What could it be used for?

What was the whale's behavior when observed and how was it identified--body vs. blow?
… Evaluate certainty of ID; determine depths whales are present at in this area
… Management strategies; population estimates?

f. What other data might be important for scientists to collect during a marine mammal survey?

Weather conditions, water quality parameters, presence of other marine mammals, plankton concentrations, etc.

Instructions *(Continued)*

Part 2: Online Research

7. North Atlantic Right Whale Observations on WhaleMap: This is an interactive map showing the locations of right whales over the past two weeks based on visual or acoustic observations. Spend a few minutes exploring the map before answering the questions below.
   a. Go to: https://whalemap.ocean.dal.ca/
   b. Scroll down and read through the Map Key below the map, then go back to the map.
   c. Zoom in on the area where most right whales are located (gray and red dots). Click on some of the dots and note the information presented. How many of the whales are adults with calves?

Varies, typically none

   d. Where are most of the whales located? Based on the season, why do you think they are there?

In winter whales migrate south to calving grounds; in summer they migrate north to feeding grounds

2. Use this website to answer the following questions about the North Atlantic Right Whale (NARW):
   https://www.fisheries.noaa.gov/species-directory/marine-mammals
   a. What is the size range for NARWs, from calf to adult?

up to 52 feet

   b. What is the normal lifespan of a NARW?

up to 70 years

   c. What do NARW eat and how?

primarily copepods; filtered through baleen plates

   d. What are some of the threats to NARW?

vessel strikes and fishing gear entanglement

   e. Where are the two Critical Habitat Areas for NARW located and why are they designated as such?

Off the coast of New England (foraging area) and off the southeast U.S. coast from Cape Fear, North Carolina, to below Cape Canaveral, Florida (calving area)

3. Be prepared to give a brief overview to your classmates about what your science party did and found with your data. You should talk about:
   a. What your data set was
   b. What your analysis task was
   c. What the results are
   d. Discuss any hypotheses you have or any questions
   e. Why you think it's important to collect this type of data