A SEA OF DATA

A High School Learning Module Focused on Oceanography, Research and Exploring Marine Science Data

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Introduction

Timeframe: 6 fifty-minute periods, 8 fifty-minute periods with near real-time data extension

Target Audience: 9th-12th Grade

Curriculum Overview

In the following lessons, students will build their science and data literacy skills while gaining foundational knowledge about marine science research. They will investigate sets of marine science data collected on Oregon State University research vessels and explore real oceanographic data being collected off the Oregon Coast. In the first lesson, students will build their foundation in understanding of oceanographic concepts by learning about the who, what, when, where and why of local marine science research. In Lesson 2, students will be introduced to more practical applications of oceanographic research by exploring 3 data sets collected off of the Oregon Coast. Using the Jigsaw Cooperative Learning Technique, students will work in small groups and participate in a specific data-focused task that will include reading and analyzing data, as well as employing graphing and mapping skills. Students will then practice science communication skills and demonstrate their understanding of the content by presenting their findings to their fellow students in a poster format. If teachers have access to the required technology and additional time, there is an extension lesson via the Northwest Association of Networked Ocean Observing Systems (NANOOS). This lesson allows students to not only explore a near real-time data portal, but connect what they have learned about water quality, plankton, upwelling and the Oregon Coast by using an interactive data portal. This lesson requires access to an internet-enabled computer lab or Google Chromebooks, and includes a lab demonstration of upwelling. Finally, students will reflect on key concepts learned through small group discussions and with their larger class.

Objectives

Students will:

- Learn why understanding and evaluating data is an important skill in today's world
- Build a foundation in oceanographic knowledge by learning about the who, what, when, where and why of marine science research and data
- Learn about a variety of techniques used to collect marine science data
- Evaluate sets of real oceanographic data collected off of the Oregon Coast
- Synthesize results and communicate information with their classmates
- Explore real-time marine science data

Essential Questions

- What are the disciplines of marine science research?
- Why is marine science research important?
- Why is being able to interpret data important?
- What can marine science data tell us?
- How are different parts of an ocean ecosystem related?

Next Generation Science Standards

PERFORMANCE EXPECTATIONS

- HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales
- 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

- HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem
- HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species

DISCIPLINARY CORE IDEAS

- LS2.C. Ecosystem Dynamics, Functioning and Resilience
- LS4.D. Biodiversity and Humans

SCIENCE AND ENGINEERING PRACTICES

- Using Mathematics and Computational Thinking

CROSSCUTTING CONCEPTS

- Cause and Effect (LS45)

A SEA OF DATA: Lesson 1

Timeframe: One 50-minute period

Target Audience: 9th-12th Grade

Suggested Materials:

- "A Sea of Data" PowerPoint.

Lesson Objectives

Students will:

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

Essential 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 used?
- Why is understanding data an important skill?

Setup

- Open PowerPoint
- Preload videos if Internet connectivity is an issue

Background Information:

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 (199 feet maximum length) 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

The RCRV Project

The Regional Class Research Vessel (RCRV) Project at Oregon State University (OSU) has received grant funding from the National Science Foundation (NSF) to oversee the design and construction of three new RCRVs, the first of which (*R/V Taani)* will be operated by OSU. These RCRVs will have the capacity to produce real-time marine science data. The *R/V Taani* will allow OSU and other 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.

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. 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 are, 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 key 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 sea floor, 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 Oregon State University) 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 studying ice melt in the Arctic.

Oregon has a unique coastline and oceanographic phenomena that make it a great place for oceanographic research! For example, we have "upwelling" off of our coast that results from Summertime winds blowing surface waters away from the shoreline, resulting in cold, nutrient dense water "welling up" from the deep. This nutrient dense water coming to the surface results in an explosion of biological activity, making the Oregon Coast a hot-spot for biodiversity which attracts researchers from all over the world. Additionally, Oregon provides insight into many large-scale issues. It is a place that has been hit by ocean warming and ocean acidification, a place with large storms and complex wave patterns that are being investigated as a potential source of marine renewable energy.

From a depth perspective, the majority of research has taken place in shallower waters. Recently, more effort has been made to explore and understand deeper areas of the ocean like the "Twilight Zone," and the "Abyssal Zone." The E/V Nautilus YouTube Page on deep sea exploration has many educational videos on this matter: https://www.youtube.com/channel/UC1KOOWHthbQVXH2kZue3_xA.

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 policy-makers and managers on how to best manage our marine resources, and inspire and engage a new generation of future researchers.

Activity (Lecture):

[Slide 1: Introduction]

1) Introduce the curriculum to the class by sharing that they are going to be talking about data, through the lens of oceanographic research.
2) Begin by asking students to brainstorm with their table groups (or neighbors) what they think 'big data' are.
3) 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 are and how data are used?"*

[Slide 2: Big Data]

1) 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: The RCRV Project]

1) 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.
2) Discuss that these vessels will have the ability to produce and beam back large amounts of real-time oceanographic data.
3) 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.

[Slide 4: Who]

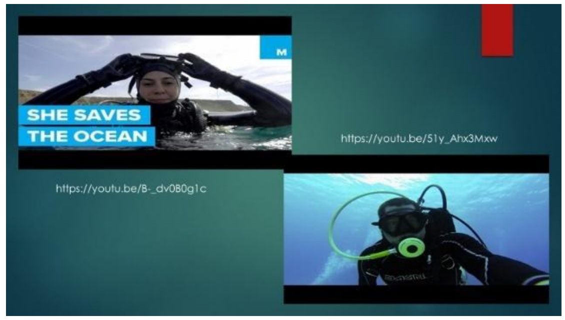
1) Ask students what they think an oceanographer is.
2) Explain that oceanographers are those who study the ocean, and work in many different areas, on many specialized projects. Mention that oceanographers often go through many years of schooling to get into this field.
3) Ask students if any of them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

[Slide 4 continued: What]

1) 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?"*
2) As each area is identified, ask students what they think oceanographers in each of the areas do.
   a. "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?"
3) 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. "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."

4) 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.
5) 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.

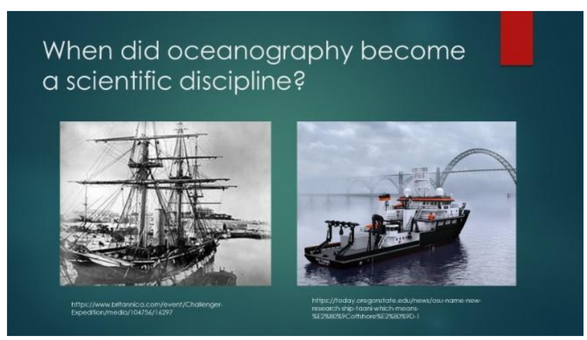
[Slide 5: What (Video Examples)]



1) 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 (4:03 total)
    b. Day at Work: Ichthyologist (Fish Biologist): https://www.youtube.com/watch?v=51y_Ahx3Mxw (3:37 total)

2) 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]



1) To begin, ask students when they think oceanography officially became a scientific discipline. What do they think the first oceanographers did?
2) Explain to students 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.

3) 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.

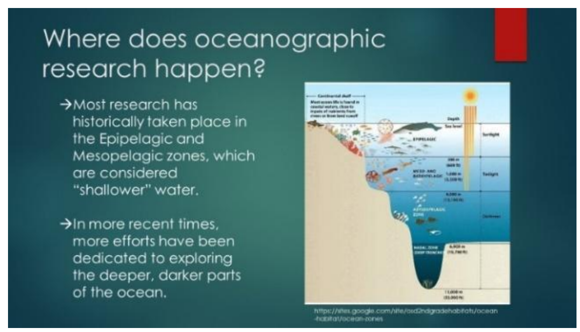
[Slide 7: Where (Geographically + Focus on Oregon)]

1) Explain that oceanographic research happens all over the world, from blue whale research in New Zealand to studying how the ocean is changing on the Oregon Coast.
2) Now bring the focus to Oregon, explaining that it is a very popular place for all types of oceanography due to unique phenomena and programs which heavily support research (like at OSU). Researchers from all over the world come to Oregon 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's happening here, 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.*"
    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 Gray 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 that lowers the pH of seawater that can lead to other changes in ocean chemistry."

d. For geological oceanographers, we live in a very exciting location with a lot of tectonic activity. Example – *"Oregon is located on the 'Cascadia subduction zone', where two of Earth's plates are slowly 'subducting' beneath the sea. This means that the Juan de Fuca plate is slowly being forced underneath the North American Plate, which creates all kinds of geological formations and can cause earthquakes. These earthquakes are actually being generated often, but are generally too small for us to feel."*

[Slide 8: Where (Depth)]



1) Research also takes place at different *depths* of the ocean, not just different geographic locations.
2) 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]

1) 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 then 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 breath, 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."*

2) 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. Ships – *"Sometimes, ships 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 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."*

Wrap up:

1) If time allows, show students the following video from the College of Earth, Ocean and Atmospheric Science at Oregon State University to summarize everything covered in this lecture.
    a. https://youtu.be/LrCCM6cAPZ4 (5:24 total)
2) 1-Minute Papers Technique:
    a. Have students each fill out the 1-minute paper template (see Appendix). These can be turned in to teachers for review OR alternatively shared aloud with the class.

Assessment:

1) Did students actively participate in brain-storming and discussion?
2) Did student reflections in the 1-minute papers indicating understanding of the following key concepts:
    a. Data are important in our daily lives
    b. The ability to understand data are is important for a variety of reasons
    c. The who, what, when, where and why of oceanography

A SEA OF DATA: Lesson 2

Timeframe: 4 fifty-minute periods

Target Audience: 9^{th}-12^{th} Grade

Lesson Materials:

- A Sea of Data PowerPoint
- A Sea of Data graph handouts
- A Sea of Data instruction handouts
- A Sea of Data background handouts
- A Sea of Data map handouts
- A Sea of Data data-sheets
- Colored Pencils
- Rulers
- Poster materials

Objectives

Students will:

- Get a better understanding of three types of marine science data collection (CTD, Plankton Tow and Marine Mammal Surveys)
- Work collaboratively as their own "science party"
- Practice analyzing and interpreting data

Essential Questions

- What are some research techniques that oceanographers use?
- How can data tell a story?

Setup:

- Open PowerPoint
- Preload videos if preferred
- Prearrange students into groups of 3 or 4
- Assign one of the data activities to each group (CTD, Plankton Tow, Marine Mammals)
- For the CTD Groups: print out 1-2 background sheets, 1-2 sets of instructions, 1 map, 1 set of data, and four blank graphs
- For the Plankton Tow Groups: print out 1-2 background sheets, 1-2 sets of instructions, 1 map, 1 set of data and four blank graphs

- For the Marine Mammal Groups: print out 1-2 background sheets, 1 set of instructions, 1 map, 1 graph and 1 set of data

Teacher Background Information:

Important Terms

- CTD: an instrument that measures conductivity, temperature and depth in the water column. When graphing results from a CTD, “pressure” is used to represent “depth,” since pressure increases as depth increases.
- Conductivity: 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 cod end.
- Biomass: When graphing results from a plankton tow, biomass is often measured as “finalcarbon.”
- 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.
- Sight Survey: a method used to observe marine mammals (species, numbers, behavior, etc.).
- Newport Line: a series of seven sampling stations that covers 25 miles perpendicular to the Oregon Coast.

The Activity Setting: R/V Oceanus Research Cruise

In this activity, students will act as “science parties” aboard the *R/V Oceanus* (which will be retired in 2020 and replaced with the *R/V Taani).* The CTD and plankton tow data in this activity were collected on an *Oceanus* cruise from September of 2014. Marine mammal data from the 2014 cruise was unavailable, so marine mammal survey data from a National Marine Fisheries Service cruise is used in its place. This data was collected in the same general location, at a similar time, and utilized similar survey methods to an *Oceanus* cruise. Pictures and videos of research efforts in this lesson are from a 2018 cruise aboard the *Oceanus,* 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 conduct data analysis of data collected from three stations along the Newport Line. They will then communicate the results to their peers.

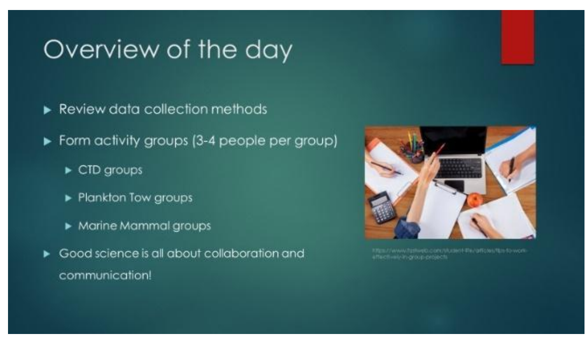
For the CTD science parties: after reading their instructions and background information, those science parties assigned the CTD data will observe their map showing the three collection stations and take note of any interesting features. This should include the large canyon visible on the left side of the map and the distance of each of the sampling station from shore. Once oriented with the map, students will begin their data analysis. They will start by graphing the temperature vs pressure data, then salinity vs pressure data (pressure is often used as representative of depth, since pressure increases with depth). Once the graphs are complete, students will answer their discussion questions and identify any correlations and/or trends between salinity, temperature and depth, in relation to their map. If finished early, students should create a third graph of pressure (depth) vs oxygen and analyze it in the same fashion. (See Teacher Materials for examples). Once finished, students will prepare to share their results with their peers via a poster presentation.

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 three collection stations and take note of any interesting features. This should include the large canyon visible on the left side of the map and the distance of each of the sampling stations from shore. Once oriented with the map, they will begin their data analysis. These students will construct three graphs, one for each sampling station. Make sure they pay close attention to the Site ID column in the data sheet. For each site, students will identify 3-5 of the species with the largest measurement of biomass (labelled as *finalcarbon),* and construct bar graphs with *finalcarbon* on the y-axis and species on the x-axis. (See Teacher Materials for examples). Students will answer discussion questions then prepare to share results and conclusions with their peers via a poster presentation.

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 three sampling stations and take note of any interesting features. This would include the large canyon visible on the left side of the map and the distance of each of the sampling stations from shore. Once oriented with the map, students will begin their data analysis. Students should start by mapping each species using latitude and longitude coordinates (see Teacher Materials for example map). Students will then construct a bar graph of species abundance for the data-set (see Teacher Materials for example graph). Once these tasks are completed, students will answer discussion questions and prepare to share their results and conclusions with their peers via a poster presentation.

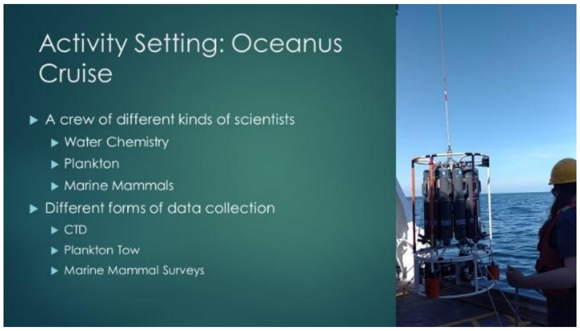
Activity:

[Slide 10]



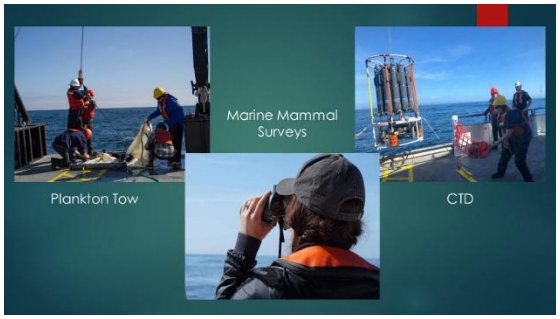
1) Begin class with an overview of the day, then review concepts from the previous day.
    a. Include a discussion about what data are and why data is important.
    b. Have students recall the 4 main fields of oceanography.
    c. Have students recall why we conduct oceanographic research.
    d. Explain that the activity will have them acting as scientists on one of OSU's research vessels, the *R/V Oceanus*. They will be using real data collected off the coast of Oregon and will have to work together to analyze the data and share results with the rest of their "science party."

[Slide 11]



1) Explain the activity setting to students: their science parties have just completed a multi-day cruise on the OSU Research Vessel the *R/V Oceanus*.
    a. Show students actual photos and video from a research cruise taken on the *Oceanus* (pictures and footage from the September 2018 cruise).
2) 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?"*

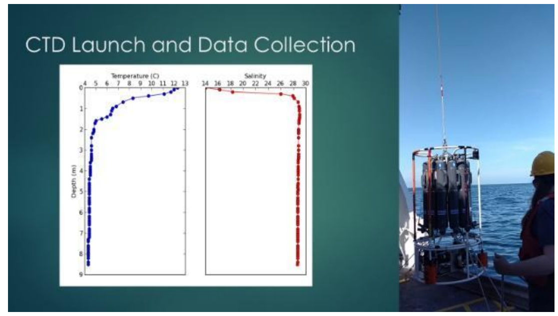
[Slide 12]



1) Three different data collection techniques were used on the cruise.
2) A CTD – to measure conductivity (which is used to calculate salinity), temperature and depth (which is calculated from pressure readings).
3) A Plankton Tow – to collect samples of plankton at different locations and depths.
4) Marine Mammal Surveys – using binoculars and drones to observe location of marine mammals, number of individuals, species and behavior.

[Slide 13]

1) Begin by showing students the embedded video of a CTD being deployed off of the side of the *R/V Oceanus* for data collection.



2) 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 14]

1) Begin by explaining to students what "plankton" actually 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 (6:02 length)

2) Show the students pictures of what a nighttime plankton tow deployment looks like, as well as two examples of plankton.
3) Explain to students the process of a plankton tow.

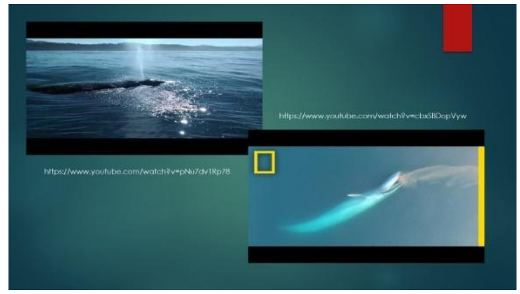
a. Example – "*A tow can be conducted either vertically in the water column while the vessel is stationary, or horizontally as the vessel moves. They can be done at a variety of depths for any length of time. The plankton are trapped in the net, and then collect at the bottom of a cannister. Samples are taken from the cannister and then analyzed in a lab. Samples are sorted for species and abundance. "Biomass" can be recorded to determine how many plankton there were per volume samples then extrapolated to provide an estimate for a larger area. This is done by weighing a sample, drying it at extreme heat to remove the water, then weighing it again."*

[Slide 15]

1) Explain to students what a marine mammal survey is.

   a. Example – *"marine mammal sight surveys, it is often 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 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 16]

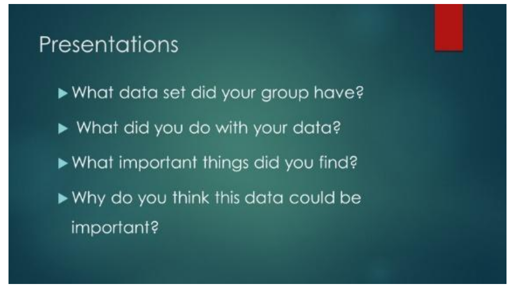


1) If time, show students the following videos captured during OSU marine mammal surveys.
    a. Gray Whale off the Oregon Coast: https://www.youtube.com/watch?v=pNu7dv1Rp78
    b. Blue Whale Feeding in New Zealand: https://www.youtube.com/watch?v=cbxSBDopVyw

[Slide 17]

1) Set the scene by explaining to students they are acting like oceanographers who have just "finished" another Oceanus 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 along the "Newport Line."
2) 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 as the "Chief Scientist."
3) 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, 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.
4) Begin by having each party read their research activity instructions and confirm they understand their assigned tasks.
5) 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).

[Slide 18]



1) Explain to students that communicating data and findings are an important part of science, and that they will practice this by creating a brief poster presentation demonstrating their data set, assigned tasks, what they found (results) and why they think it is important (conclusions).
2) Have each science party create an informative poster that explains:
    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).
3) Allow students in class time to brainstorm and create posters.

[*Slide 18 continued]*

1) Have science parties present their posters. Allow students to ask questions once each presentation is over and have presenters respond to the best of their abilities.
2) Here, students should connect the pieces of the "jigsaw" to understand that the three data sets collected tell a story when put together. Water quality 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.

Optional Lesson 3 – near real-time data extension:

1) This lesson will take two, 50-minute class periods.
2) "Well, well, well" – a lesson developed by NANOOS, which allows students to not only explore an oceanographic data portal, but connect what they have learned about water quality, plankton levels, and upwelling on the Oregon Coast while utilizing near real-time data. This lesson requires access to a computer lab or Google Chromebooks, and includes

a lab demonstration of upwelling. This lesson should be conducted after the poster presentations are completed, but before the final discussion.

- Source: http://www.nanoos.org/education/pdfs/well_well_well.pdf

A SEA OF DATA: Lesson 4

Timeframe: One 50-minute period

Target Audience: 9th-12th Grade

Suggested Materials:

- A Sea of Data PowerPoint

Lesson Objectives

Student's Will:

- Reflect on and discuss what they have learned about oceanography
- Reflect on and discuss what they have learned about data
- Reflect on and discuss why the field of oceanography and data are important
- Reflect on and discuss why this field and data are relevant to them

Essential Questions

- Why is science research important?
- Why is it important to be able to find and understand data?
- What can data help us accomplish?
- How is marine science research and data relevant to us?

Setup

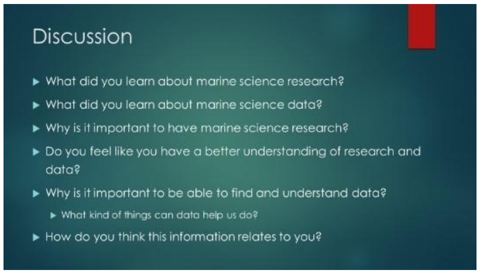
- Open PowerPoint

Activity

[*Slide 19]*

1) Once presentations and/or "well, well, well" are complete, gather students for a final discussion about the key topics in the lessons; oceanography, research and data.
2) The following questions can be included in the discussions:

a. What did you learn about marine science research?
b. Why is it important?
c. What did you learn about marine science data?
d. Do you feel like you have a better understanding of research and data?
e. Why is it important to be able to find and understand data?
f. What kind of things can data help us do?
g. How do you think this information relates to your life?



Assessment:

1) Did students participate in class discussion and demonstrate an understanding of the basics of oceanography?
2) Did students accurately interpret and demonstrate an understanding of different types of data collection methods and the data they produce?
3) Did students accurately graph and interpret their individual data sets?
    a. For example, the CTD students should show understanding that there is a relationship between salinity, depth/pressure, and temperature.
4) Did students actively participate in group presentations?
5) Did students actively participate in the final class discussion and demonstrate an understanding of oceanography, marine research and the importance of data?

Additional Resources:

The RCRV Project at Oregon State University is committed to assisting teachers in pursuing data-focused learning in their classrooms. Please visit the RCRV website for general information about the project, ship design and capabilities, timelines and frequently asked questions. The RCRV outreach page is being continuously updated with new information about professional development opportunities, lesson plans, contacts and other helpful resources. As the project progresses and the R/V Taani goes live (projected for 2022), some lesson plans will integrate real-time data collected from the vessel.

- Regional Class Research Vessel (RCRV) Homepage: https://ceoas.oregonstate.edu/ships/rcrv/

- RCRV Education & Outreach Page: https://ceoas.oregonstate.edu/ships/rcrv/outreach/

Additionally, there are a variety of other programs that also provide data-focused learning activities and resources for teachers that may be helpful.

- The Monterey Bay Aquarium Research Institute (MBARI) Education And Research: Testing Hypotheses (EARTH) Program: https://www.mbari.org/products/educational-resources/earth/
- The Consortium for Ocean Science Exploration and Engagement (COSEE) http://www.cosee.net/resources/educators/
- Oceans of Data Institute (ODI): http://oceansofdata.org/
- The National Oceanic and Atmospheric Administration (NOAA) Data in the Classroom: https://dataintheclassroom.noaa.gov/
- The National Estuarine Research Reserve System (NERRS) https://coast.noaa.gov/nerrs/education/

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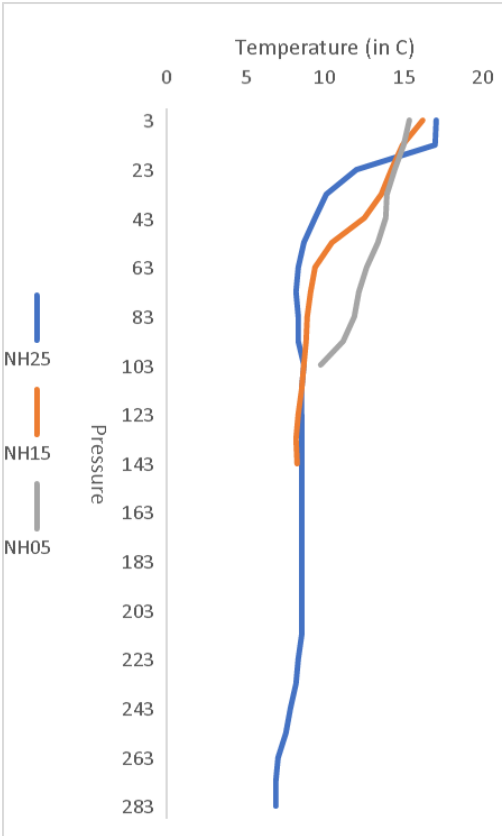
Appendix B: Teacher Materials

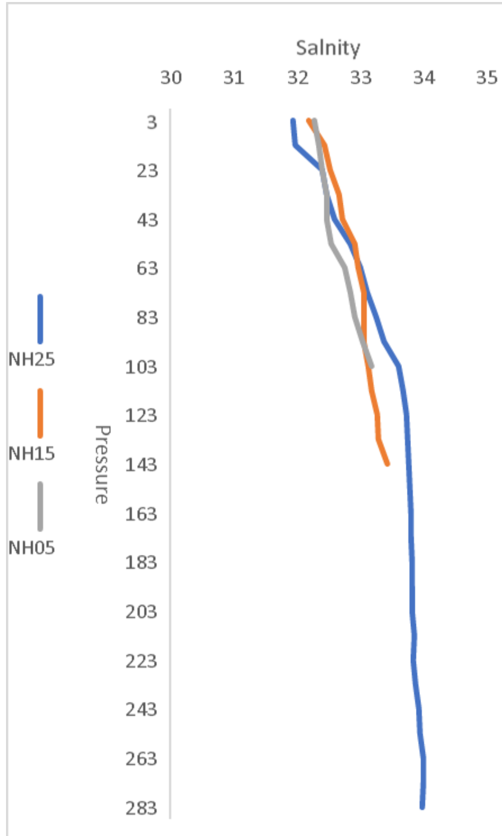
CTD SCIENCE PARTY INSTRUCTIONS (Teacher Guide)

Make sure your science party has copies of the CTD background sheet, the CTD data set, a map, two blank graph sheets and three different colored pens or pencils.

1) Read your background sheet.
2) Your science party will be looking at a set of real CTD (conductivity, temperature and depth) data. The oceanographic data are all from the same day but were collected at three different sampling stations along the Newport line. The three stations we are working with are represented by “NH05,” “NH15,” and “NH25.” Take a look at your map of CTD stations.
    a. What do you notice about the three different sites?
        i. They are equally spaced apart.
    b. How do you think the ocean conditions (depth, wind, etc.) might vary at each site? Do you notice anything about the seafloor? Once you’ve come up with some ideas, share with your teacher to see if you’re on the right track.
        i. There is a large canyon to the left of the map.
        ii. The depth increases as you get further from shore.
3) Now take a look at your data sheet, be sure to ask for help if you are confused about it.
4) Next, locate your graph sheets. You are going to make one graph for salinity (x-axis) vs pressure (y-axis), and a second graph for temperature (x-axis) and pressure (y-axis).
    a. You should have three different colored lines on each graph, one for each station.

b. Remember that you can utilize "pressure" as a representation for depth. See example graphs below:





5) Once you have completed your graphs, double check you are on the right track.
   a. What kind of patterns do you notice?
      i. Salinity increases with pressure/depth, temperature decreases with pressure/depth.
   b. Do any of the measurements differ between stations? If yes, which ones? Can you come up with an explanation or a hypothesis for why they might be different?
      i. Example: depth increases with NH Station as you get further from shore.
   c. Why do you think it is important that real, current data is available for things like temperature and salinity off of our coast? Who could benefit from that information?

   i. Examples include: it can help identify how ocean conditions are changing, it can help identify environmental preferences for species, it can help fishermen find the right area for target species, etc.

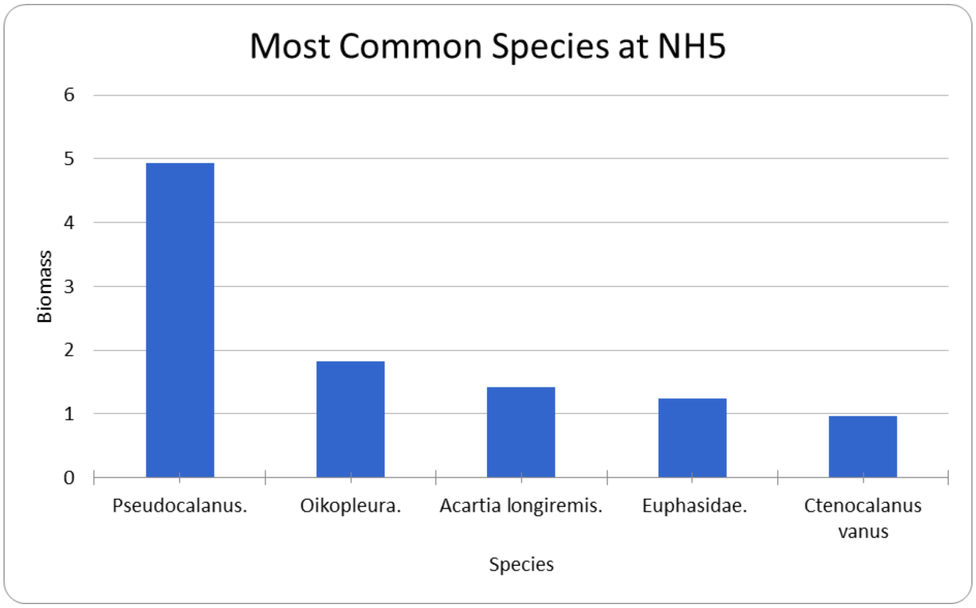
6) If you complete your graphs and discussion early, create a third graph looking at pressure vs. oxygen concentration, then complete the discussion questions.
7) Be prepared to give a brief overview to your classmates about what your science party did and found with the data. You should be prepared to talk about:
   i. What your data set was
   ii. What your analysis task was
   iii. What the results were
   iv. Any hypotheses you might have or additional questions
   v. Why you think it's important

PLANKTON TOW SCIENCE PARTY INSTRUCTIONS (Teacher Guide)

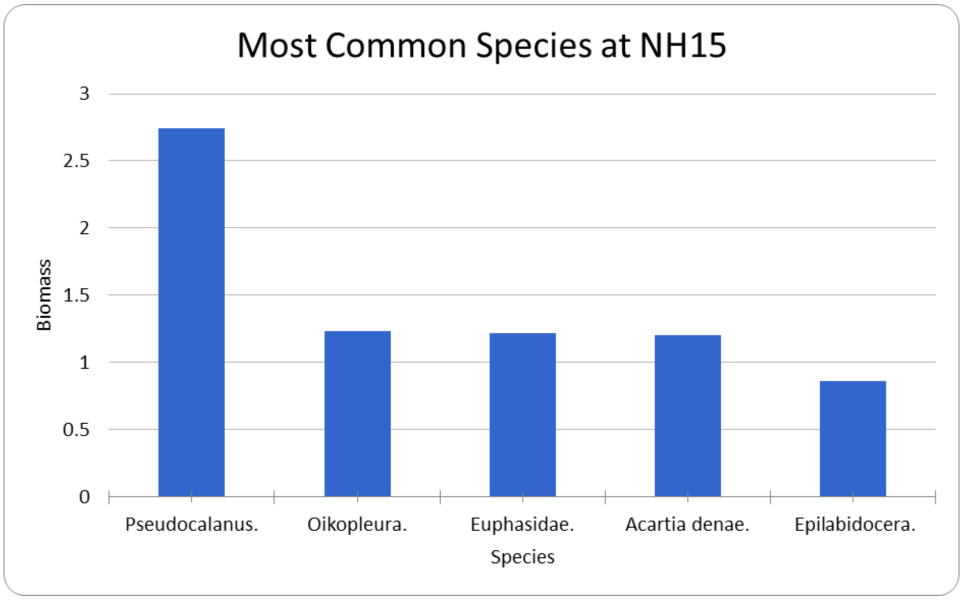
Make sure your group has copies of the plankton background sheet, plankton tow (PT) data sheet, a PT map, 3-4 blank graph sheets and different colored pens or pencils.

1) Read your background sheet.
2) Your science party will be looking at a set of real plankton tow data. The data are from the same day but three different sampling stations along the Newport line. The three stations we are working with are represented by "NH05," "NH15," and "NH25." Take a look at your map of plankton tow stations.
    a. What do you notice about the three different sites?
        i. They are equally spaced apart.
        ii. NH 05 is close to shore while NH25 is the furthest out.
        iii. The seafloor around NH25 looks different than NH05 and NH15.
    b. How do you think the ocean conditions (depth, wind, etc.) varies at each site? Do you notice anything about the seafloor? Once you've come up with some ideas, share with your teacher to see if you're on the right track.
        i. There is a large canyon to the left of the map.
        ii. The depth increases as you get further from shore.
3) Now take a look at your data sheet, pay attention to the columns labeled "Station," "Genus Species" and "FinalCarbon**." Remember, the "FinalCarbon" column is how we measure biomass.** Be sure to ask for help if you are confused about anything. For each of the three stations, look at your data sheet and circle or highlight the 3-5 species that have the highest biomass or "FinalCarbon" measurements.
4) Now, using your graph sheets, make 3 bar graphs, one for each station showing the species and associated biomasses you identified in Step 3. On the x-axis, add the species names. On the y-axis, add the "Final Carbon measurements."
   See highest counts for each station and example graphs below –
    a. NH 5:
        i. Pseudocalanus.
        ii. Oikopleura.

   iii. *Euphasidae.*
   iv. *Acartia longiremis.*
   v. *Ctenocalanus vanus.*



b. NH15:
   i. *Acartia denae.*
   ii. *Euphasidae.*
   iii. *Oikopleura.*
   iv. *Pseudocalanus.*
   v. *Epilabidocera.*



c. NH25:

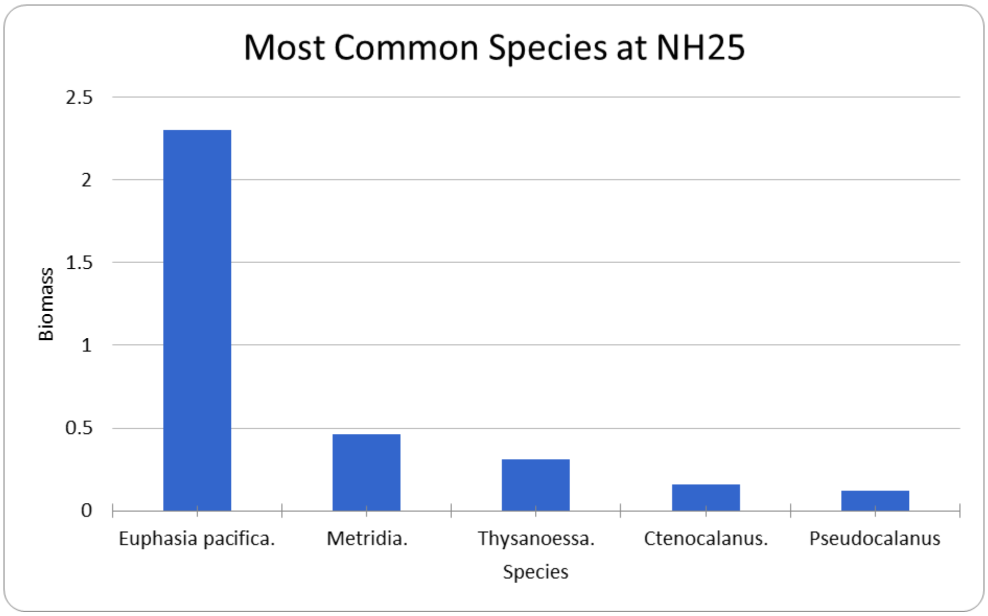
i. Euphasia pacifica.

ii. Metridia.

iii. Thysanoessa.

iv. Ctenocalanus.

v. Pseudocalanus.



5) Once you have completed your graphs, answer the following questions:

a. What patterns do you notice? Do any of the measurements differ between stations? If yes, which ones?

i. Examples include: Pseudocalanus appeared in all three stations and had a large biomass in the first two stations but not the last. Oikopleura appeared in the first two stations but not the last. Ctenocalanus appeared in the first and the last stations but not the second.

b. Can you come up with an explanation for why these samples might be different?

i. Examples include: different plankton are found in different environmental conditions and currents which may occur in different locations. Certain types of plankton are preferred by predators and may be removed through heavy feeding.

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

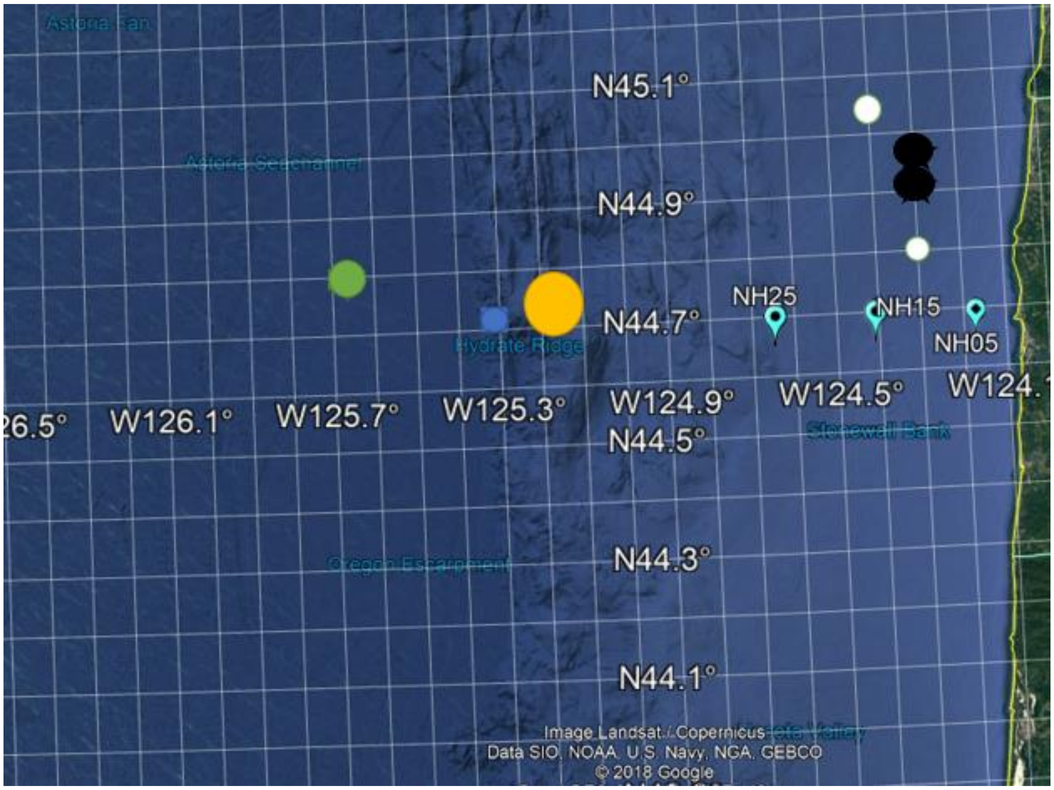
   i. Examples include: It can tell us about currents, productivity or the nutrient content in the water (if there are a lot of plankton in the water there are probably a lot of nutrients – **like from upwelling**!) and can help predict where predators may be found.

6) Be prepared to give a brief overview to your classmates about what your science party did and found with their data. You should be prepared to talk about the following:
   i. What your data set was.
   ii. What your analysis task was.
   iii. What the results were.
   iv. Discuss any hypotheses you have or any questions.
   v. Why you think it’s important.

MARINE MAMMAL SCIENCE PARTY INSTRUCTIONS (Teacher Guide)

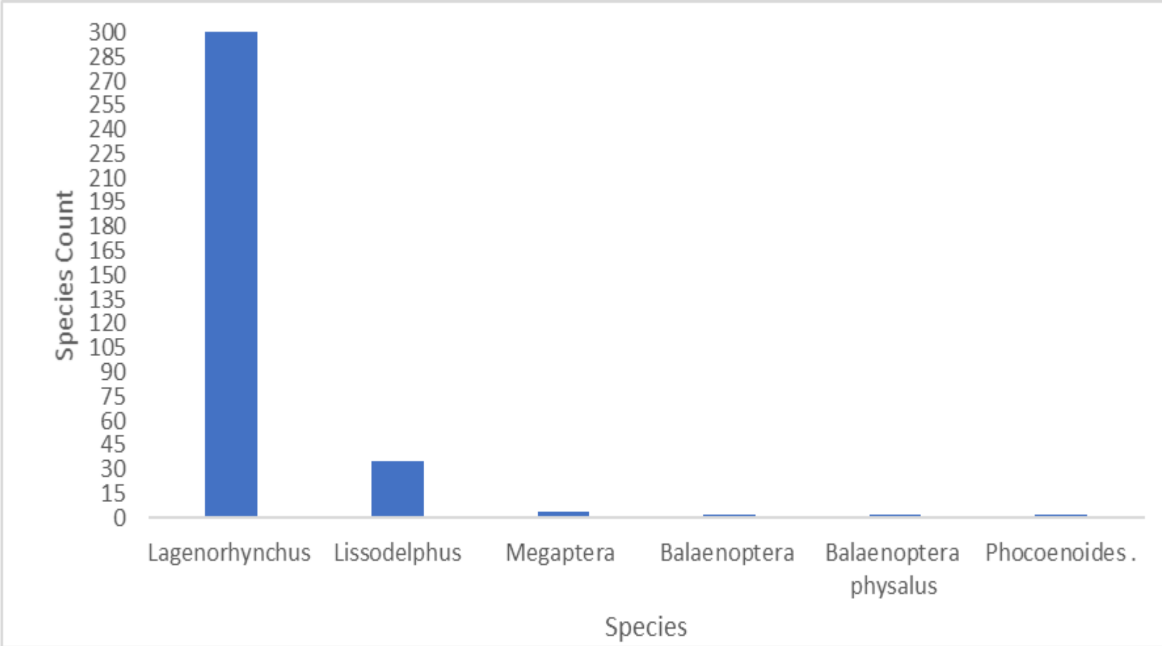
Make sure your science party has copies of the marine mammal background sheet, the marine mammal data sheet, a blank map and three different colored markers or pencils.

1) Read your background sheet, paying close attention to the most commonly found species of whales, dolphins and porpoises found in Oregon.
2) Your party will be looking at a set of marine mammal survey data. These data are real and collected from the Oregon Coast. Locate your map.
    a. On your map, you will see three points labeled "NH05," "NH15," and "NH25." These are stations along the Newport line where the CTD and Plankton Tow data were also collected.
3) Now, 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 there.
4) On your map, locate the latitude and longitude lines. Begin to fill in the locations of where these animals were spotted. Decide on a system that shows what kind of animal it is, whether that's a color, shape, labelling it, etc.
    a. Be sure to provide a key so others can interpret your completed map. See an example map below, where the different species and species counts are represented circles. Here, the different colors represent different species, and the different sizes represent different counts. Students could also use different shapes or labels to represent this as well.



5) Once you have finished your map, locate your blank graphing sheet. On the x-axis, list each of the species you identified on your map. On the y-axis, put numbers of individuals. Make a bar graph showing how many individuals of each species was recorded. See correct species counts and an example bar graph below:

   a. Megaptera – 4 total.
   b. Lagenorhynchus – 315.
   c. Lissodelphus – 35.
   d. Balaenoptera – 2.
   e. Balaenoptera physalus – 2.
   f. Phocoenoides - 2.



6) Discuss the following questions with your party.

   a. Does one species occur in a certain area more than another? If yes, why do you think that is?

      i. Megaptera, (the Humpback Whales) were seen closer to stations 5 and 15. A potential explanation could be a potential food source is found there. Phocoenoides, Lissodelphis and Lagenorhynchus were seen farther away from the stations. Potential explanations could include a different food source further away, avoidance of predators, preference for deeper water, etc.

   b. Pay attention to the location of the stations where CTD and plankton tow data were collected. Are there any species that seemed to gather near one of the stations? Were there species that were seen farther out?

      i. The Balaenoptera were more dispersed among stations. Students may notice that some species were located near a canyon or other geological structures. This question is more about getting students to look for trends in numbers and think critically about why certain species could gravitate to a certain area.

   c. Do you see a species in the surveys that is not listed on the species chart on your background sheet? If so, why do you think this species was seen off the coast?

    i. Yes – *Lissodelphus* is not included on the commonly seen list. This is the Right Whale Dolphin, and possible explanations for their presence could include: they are migrating, following a food source, avoiding predators, or their distribution has changed due to change in ocean conditions, etc.

d. What are some other measurements the science team could make, other than just presence/absence data?
    i. Possible suggestions include behavior (this is important, especially if they are feeding!) and relationship (a mom and calf for example).
e. Why do you think this "presence/absence" data is important?
    i. What could it be used for?
        1. Presence and absence can help tell us about preferred habitats, where preferred food sources are located, where predators may be/not be, etc. It can also inform marine spatial planning- which helps us decide where to allow/not allow fishing, place wave energy devices, develop marine protected areas, etc.
f. Be prepared to give a brief overview to your classmates about what your science party did and found with your data. You should be prepared to talk about:
    i. What your data set was
    ii. What your analysis task was
    iii. What the results are
    iv. Discuss any hypotheses you have or any questions
    v. Why you think it's important to collect this type of data

Appendix C: Student Materials

THE 1-MINUTE PAPER

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

1. What are the 3-5 most important things you have learned during this session?

2. What questions stand out in your mind?

3. Is there anything you did *not* understand?

CTD SCIENCE PARTY INSTRUCTIONS

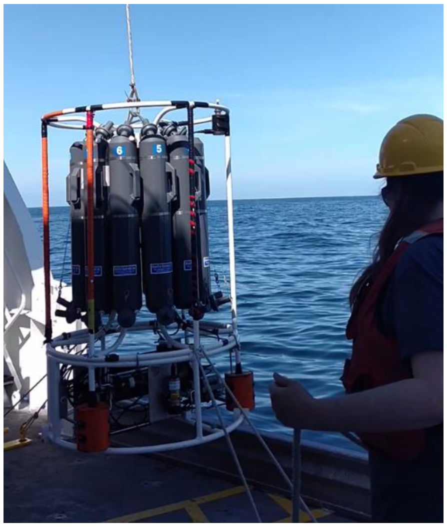
Make sure your science party has copies of the CTD background sheet, the CTD data set, a map, 2-3 blank graph sheets and three different colored pens or pencils.

1) Read your background sheet.
2) Your party will be looking at a set of real CTD (conductivity, temperature and depth) data. The oceanographic data are all from the same day, but at three different sampling stations along the Newport line. The three stations we are working with are represented by "NH05," "NH15," and "NH25." Take a look at your map of CTD stations.
    a. What do you notice about the three different sites?
    a. How do you think the ocean conditions (depth, wind, etc.) varies at each site? Do you notice anything about the seafloor? Once you've come up with some ideas, share with your teacher to see if you're on the right track.
3) Now take a look at your data sheet, be sure to ask for help if you are confused about it.
4) Next, locate your graph sheets. You are going to make one graph for salinity (x-axis) vs pressure (y-axis), and a second graph for temperature (x-axis) and pressure (y-axis).
    a. You should have three different colored lines on each graph, one for each station.
    b. Remember that you can utilize "pressure" as a representation for depth here.
5) Once you have completed your graphs, double check you are on the right track.
    a. What kind of patterns do you notice first?
    b. 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?
    c. 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?
6) If you complete your graphs and discussion early, create a third graph looking at pressure vs. oxygen concentration, and complete the discussion questions.
7) Be prepared to give a brief overview to your classmates about what your science party did and found with their data. You should talk about:
        i. What your data set was
        ii. What your analysis task was

iii. What the results were
iv. Any hypotheses you might have or additional questions
v. Why you think it's important

CTD SCIENCE PARTY BACKGROUND

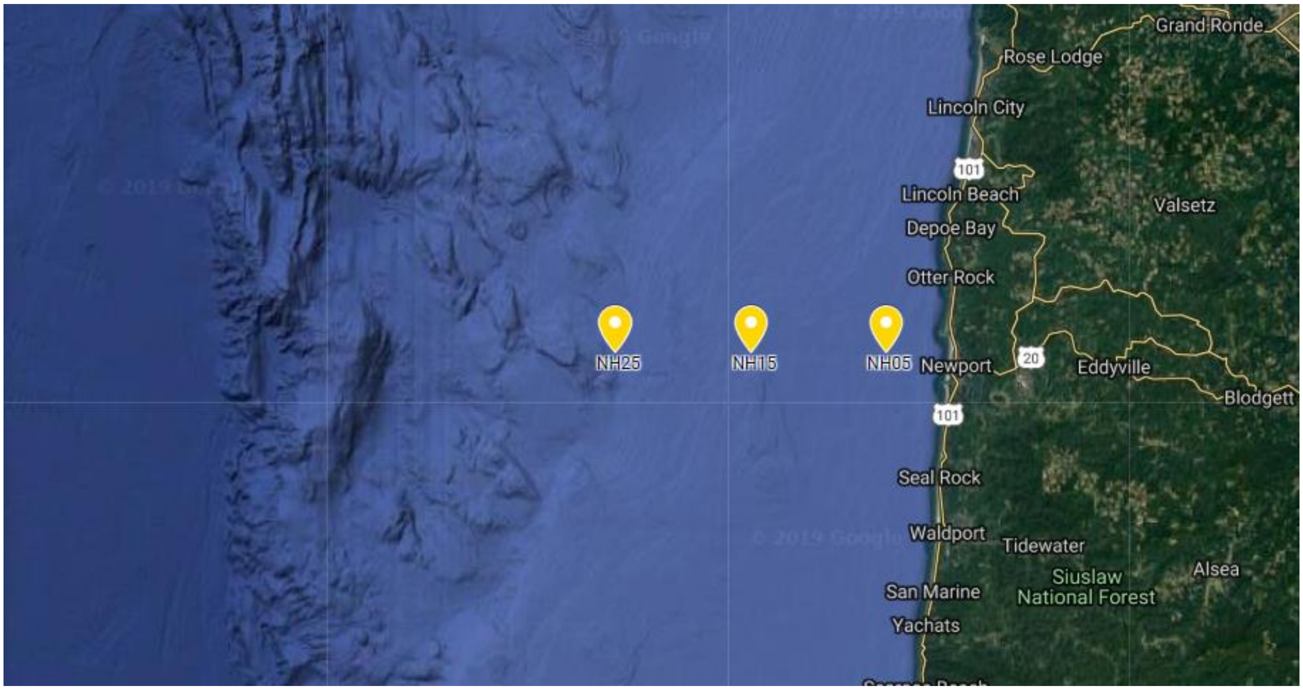
- What is a CTD?
  - A device that takes measurements through the water column. Measurements include *conductivity* and *temperature* in relation to *depth*.
    - Conductivity is a measurement of how well water conducts electricity, and is related to salinity.
    - Salinity is how "salty" the water is.
    - Temperature is how cool or warm the water is.
- **On many CTD graphs, depth is related by "Pressure."** This is because as you descend deeper into the water, the pressure will grow by 1 *atmosphere (atm)* every 10 meters depth.
  - An *atmosphere* is a measurement of pressure. 1 atmosphere = the amount of pressure gravity is exerting on you when you are sitting in class, or on an object on the surface of the water.
  - So, at 10 meters depth = 2 atmospheres. (1 atmosphere at the surface + 1 atm for the first 10 meters). 20 meters depth = 3 atmospheres, and so on.
- How do the bottles work?
  - Each bottle can be triggered to close at a variety of depths, to study changes throughout the water column.

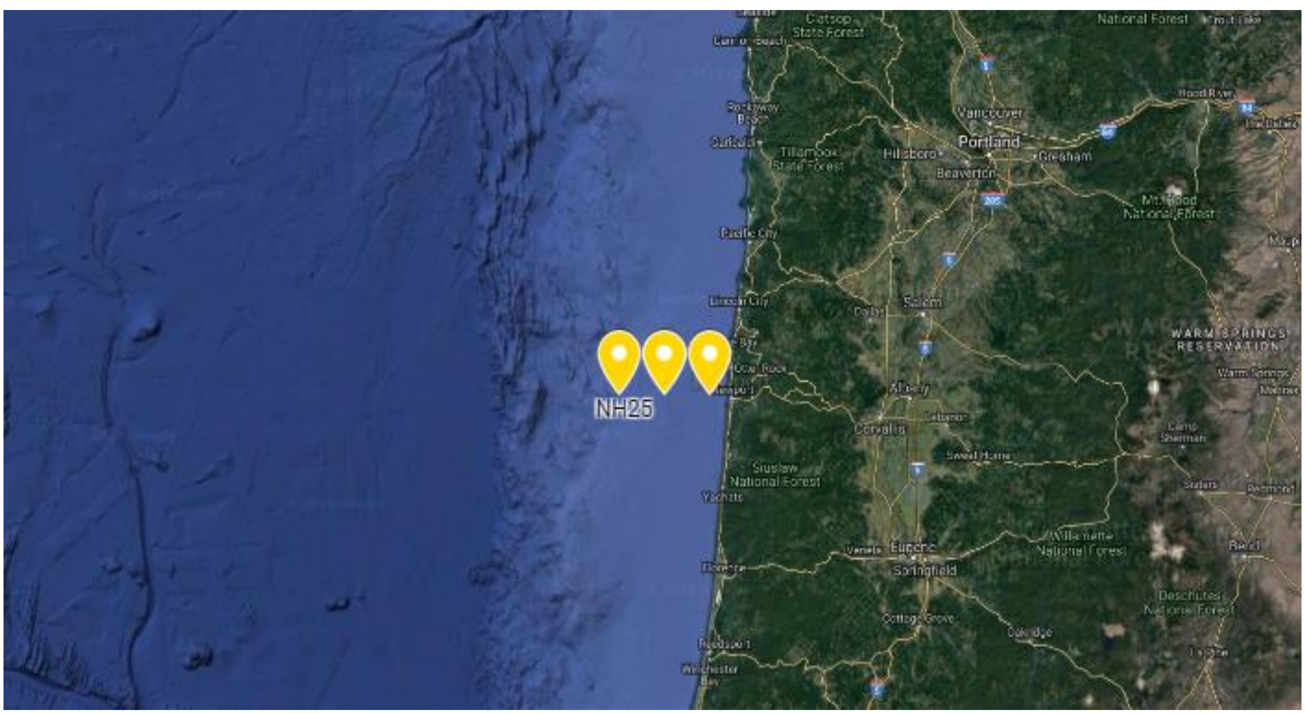


Images from September 2018 R/V Oceanus Cruise

NEWPORT LINE STATION MAP

(The same map, one zoomed in and one zoomed out).





CTD GRAPHS

CTD GRAPHS

CTD SCIENCE PARTY DATA

CTD SITE LOCATION	Date	Pressure	Temperature (in C)	Salinity	Oxygen (ml/L)
093014NH25	30-Sep-14	3	17.1086	31.9439	5.31257
093014NH25	30-Sep-14	13	17.0061	31.9794	5.47155
093014NH25	30-Sep-14	23	12.0323	32.3964	6.3451
093014NH25	30-Sep-14	33	10.113	32.4707	5.95099
093014NH25	30-Sep-14	43	9.3967	32.5896	5.55405
093014NH25	30-Sep-14	53	8.7062	32.8352	5.0913
093014NH25	30-Sep-14	63	8.3669	33.0043	4.89443
093014NH25	30-Sep-14	73	8.1937	33.109	4.69139
093014NH25	30-Sep-14	83	8.3221	33.248	4.3644
093014NH25	30-Sep-14	93	8.3489	33.3845	4.00404
093014NH25	30-Sep-14	103	8.7246	33.6143	3.05248
093014NH25	30-Sep-14	113	8.5859	33.6789	2.6563
093014NH25	30-Sep-14	123	8.5825	33.7381	2.3777
093014NH25	30-Sep-14	133	8.582	33.7587	2.26832
093014NH25	30-Sep-14	143	8.58	33.7746	2.17581
093014NH25	30-Sep-14	153	8.5826	33.7899	2.06632
093014NH25	30-Sep-14	163	8.5632	33.8002	1.99046
093014NH25	30-Sep-14	173	8.5691	33.8072	1.9509
093014NH25	30-Sep-14	183	8.557	33.8128	1.93573
093014NH25	30-Sep-14	193	8.5536	33.8173	1.90262
093014NH25	30-Sep-14	203	8.5305	33.8227	1.88952
093014NH25	30-Sep-14	213	8.5893	33.8567	1.90546
093014NH25	30-Sep-14	223	8.3532	33.8441	1.87263
093014NH25	30-Sep-14	233	8.2033	33.8689	1.89057
093014NH25	30-Sep-14	243	7.8423	33.9245	1.91331
093014NH25	30-Sep-14	253	7.5376	33.9514	1.87617
093014NH25	30-Sep-14	263	7.0344	34.0012	1.76914
093014NH25	30-Sep-14	273	6.9243	33.9962	1.68933

093014NH25	30-Sep-14	283	6.9138	33.9902	1.68367
093014NH15	30-Sep-14	5	16.2707	32.1782	5.53941
093014NH15	30-Sep-14	10	14.984	32.4314	6.06095
093014NH15	30-Sep-14	15	14.2566	32.5239	6.28383
093014NH15	30-Sep-14	20	13.6366	32.6675	6.42766
093014NH15	30-Sep-14	25	12.5121	32.7162	5.92987
093014NH15	30-Sep-14	30	10.4528	32.9068	5.39595
093014NH15	30-Sep-14	35	9.3798	32.9734	4.87735
093014NH15	30-Sep-14	40	9.1578	33.0509	4.71132
093014NH15	30-Sep-14	45	8.9394	33.0592	4.61839
093014NH15	30-Sep-14	50	8.8757	33.0578	4.55618
093014NH15	30-Sep-14	55	8.6735	33.1219	4.37003
093014NH15	30-Sep-14	60	8.555	33.1818	4.29622
093014NH15	30-Sep-14	65	8.3538	33.2651	4.10412
093014NH15	30-Sep-14	70	8.2361	33.2901	4.12298
093014NH15	30-Sep-14	75	8.2912	33.4281	3.58782
093014NH05	30-Sep-14	5	15.414	32.2789	5.57483
093014NH05	30-Sep-14	10	15.054	32.3449	5.67728
093014NH05	30-Sep-14	15	14.4574	32.4064	5.64087
093014NH05	30-Sep-14	20	13.9518	32.4754	5.68947
093014NH05	30-Sep-14	25	13.8801	32.463	5.75205
093014NH05	30-Sep-14	30	13.3908	32.5478	5.70263
093014NH05	30-Sep-14	35	12.6497	32.7516	5.82816
093014NH05	30-Sep-14	40	12.1973	32.8526	5.80533
093014NH05	30-Sep-14	45	11.9274	32.9213	5.90807
093014NH05	30-Sep-14	50	11.1979	33.0446	5.49866
093014NH05	30-Sep-14	55	9.7402	33.1874	4.43337

Data was collected in Sept 2014 via the R/V Oceanus

PLANKTON TOW SCIENCE PARTY INSTRUCTIONS

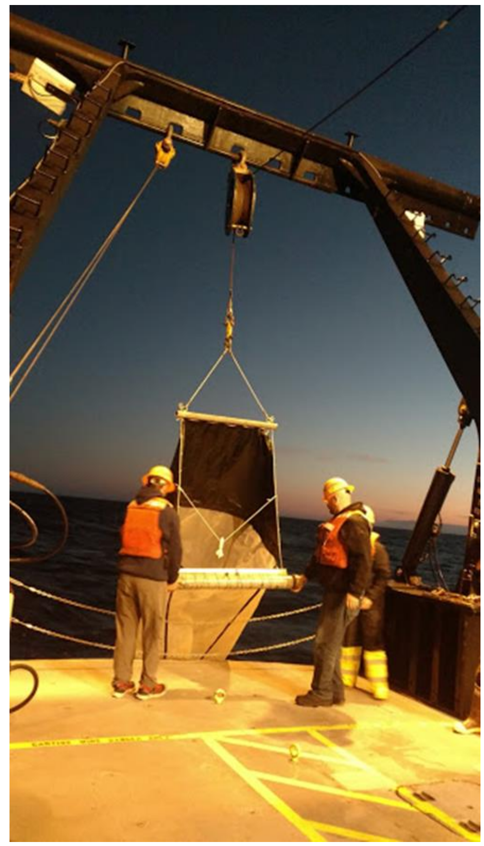
Make sure your party has copies of the plankton background sheet, plankton tow (PT) data sheet, a PT map, 3-4 blank graph sheets and different colored pens or pencils.

1) Read your background sheet.
2) Your science party will be looking at a set of real plankton tow data. The data are from the same day, but three different sampling stations along the Newport line. The three stations we are working with are represented by “NH05,” “NH15,” and “NH25.” Take a look at your map of plankton tow stations.
    a. What do you notice about the three different sites?
    b. How do you think the ocean conditions (depth, wind, etc.) varies at each site? Do you notice anything about the seafloor? Once you’ve come up with some ideas, share with your teacher to see if you’re on the right track.
3) Now take a look at your data sheet, pay attention to the columns labeled “Station,” “Genus Species” and “FinalCarbon**.” Remember, the “FinalCarbon” column is how we measure biomass.** Be sure to ask for help if you are confused. For each of the three stations, look at your data sheet and identify 3-5 species that have the highest biomass or “FinalCarbon” measurements.
4) Now, using your graph sheets make 3 bar charts, one for each station showing the species and associated biomasses you identified in Step 3. On the x-axis add the species names. On the y-axis add the “Final Carbon measurements.”
5) Once you have completed your graphs, answer the following questions:
    a. What patterns do you notice? Do any of the measurements differ between stations? If yes, which ones?
    b. Can you come up with an explanation for why these samples might be different?
    c. Why do you think it’s important we have real, recent data for things like plankton?
6) Be prepared to give a brief overview to your classmates about what your party did and found with their data. You should be prepared to talk about the following:
        i. What your data set was
        ii. What your analysis task was

iii. What the results were
iv. Discuss any hypotheses you have or any questions
v. Why you think it's important

PLANKTON TOW SCIENCE PARTY BACKGROUND

- What are plankton?
  - The word *plankton* comes from the Greek word for "wanderer." Plankton are free-floating animals in the water column. There are phytoplankton, which photosynthesize and produce oxygen, and zooplankton, which are predators of phytoplankton and other zooplankton.



- Why are plankton important?
  - They form the basis of the food chain, as well as provide oxygen and other nutrients.
- What is a plankton tow?
  - A plankton tow is the process of dropping a *plankton net* into the water column and towing it for a specific period of time. The plankton is trapped between the fine mesh of the net and transferred into a cannister (or "cod end") at the end of the net.
- How is *biomass* measured?
  - Biomass is measured in your data by "FinalCarbon." This is a measurement used by scientists that involves drying a sample at high temperatures and weighing what remains of the sample, then relating the mass to the volume of water that was sampled.
- Some examples of plankton commonly found off of the Oregon Coast

Oikopleura *Pseudocalanus* *Euphausiid (krill)*

Images:

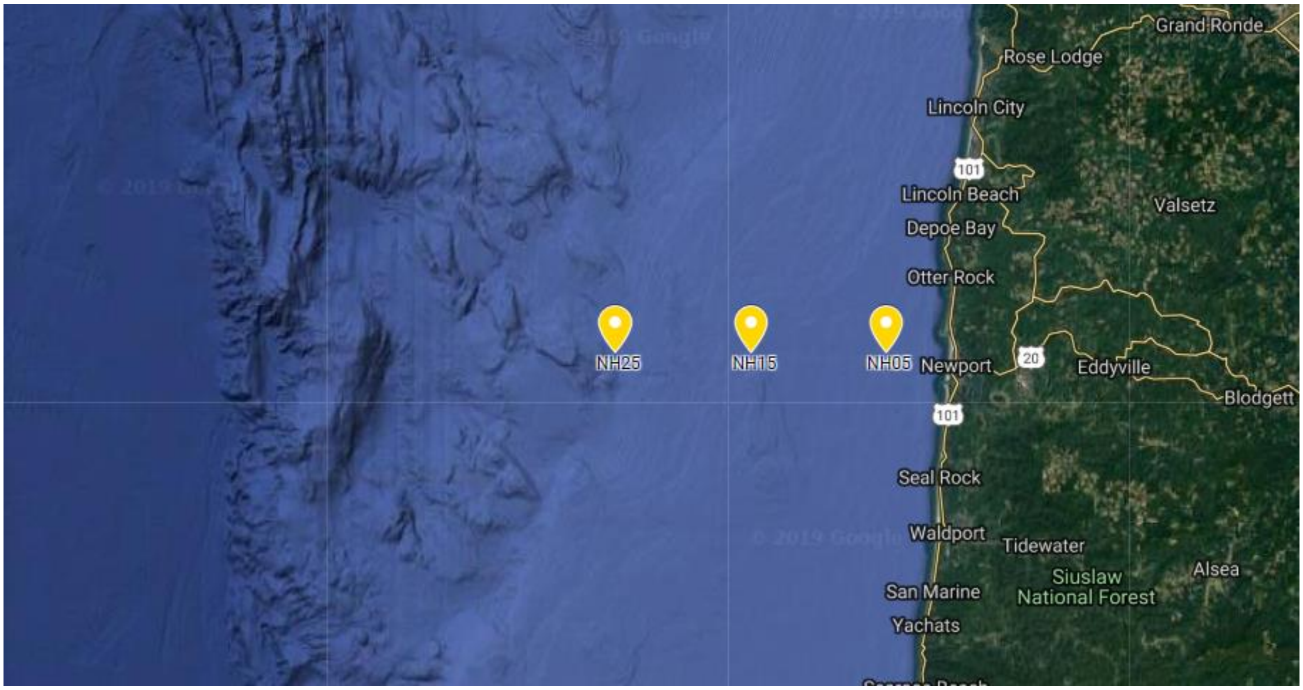
https://scripps.ucsd.edu/zooplanktonguide/species/oikopleura-dioica

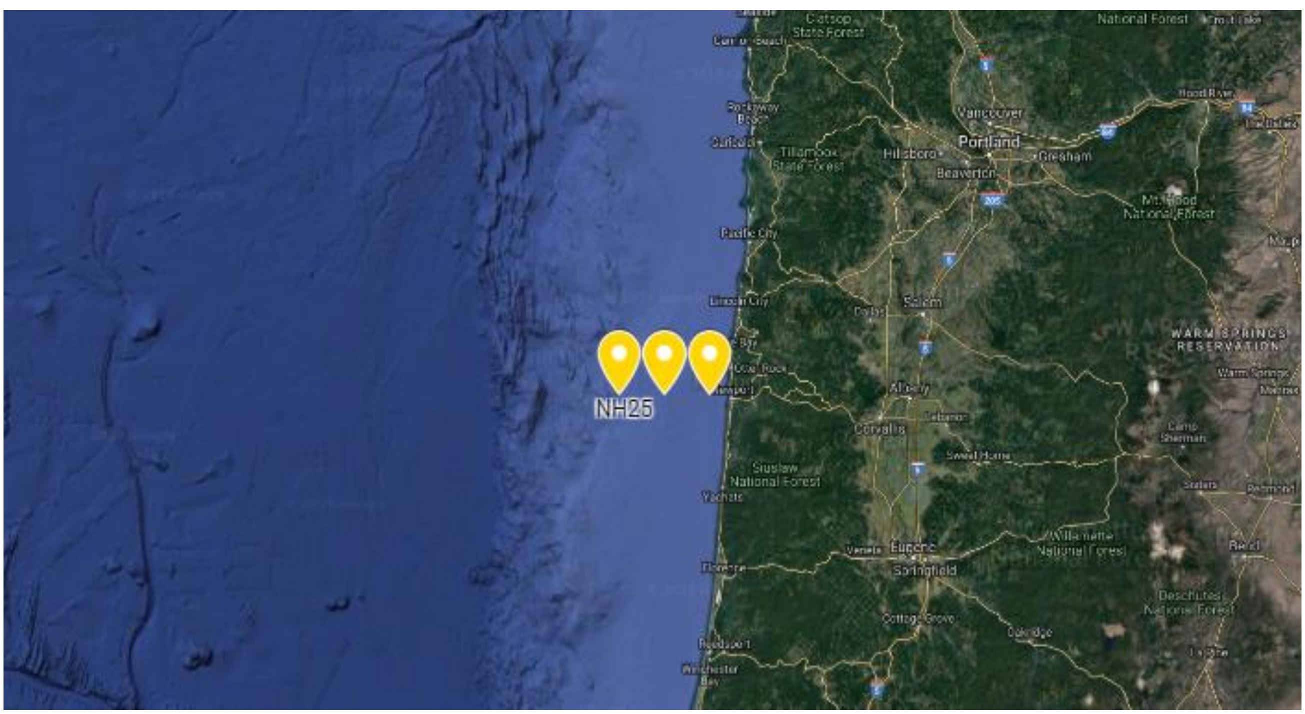
http://www.marinespecies.org/aphia.php?p=taxdetails&id=104165

https://en.wikipedia.org/wiki/Krill#/media/File:Meganyctiphanes_norvegica2.jpg

NEWPORT LINE SAMPLING STATION MAP

(The same map, one zoomed in and one zoomed out).





Plankton Tow Graph Sheet

PLANKTON TOW SCIENCE PARTY DATA

DATE	SITE	SPECIES	BIOMASS
30-Sep-14	NH05	ACARTIA DANAE	0.08241
30-Sep-14	NH05	ACARTIA LONGIREMIS	1.4184
30-Sep-14	NH05	BARNACLES	0.5237
30-Sep-14	NH05	CALANUS PACIFICUS	0.414149
30-Sep-14	NH05	CALOCALANUS STYLIREMIS	0.017081
30-Sep-14	NH05	CENTROPAGES ABDOMINALIS	0.02113
30-Sep-14	NH05	CHAETOGNATHA	0.034647
30-Sep-14	NH05	CLAUSOCALANUS	0.34906
30-Sep-14	NH05	CORYCAEUS ANGLICUS	0.01217
30-Sep-14	NH05	CTENOCALANUS VANUS	0.96763
30-Sep-14	NH05	DOLIOLETTA GEGENBAURI	0.50735
30-Sep-14	NH05	EUCALANUS	0.06122
30-Sep-14	NH05	EUPHAUSIA PACIFICA	0.1519
30-Sep-14	NH05	EUPHAUSIIDAE	1.24742
30-Sep-14	NH05	EVADNE	0.24006
30-Sep-14	NH05	FISH	0.0396
30-Sep-14	NH05	MESOCALANUS TENUICORNIS	0.0225
30-Sep-14	NH05	OIKOPLEURA	1.8379
30-Sep-14	NH05	OITHONA SIMILIS	0.63334
30-Sep-14	NH05	ONCAEA	0.00108
30-Sep-14	NH05	PARACALANUS PARVUS	0.23947
30-Sep-14	NH05	PODON	0.01691
30-Sep-14	NH05	PSEUDOCALANUS	4.943769
30-Sep-14	NH05	THYSANOESSA SPINIFERA	0.14722
30-Sep-14	NH05	TORTANUS DISCAUDATUS	0.10147
30-Sep-14	NH15	ACARTIA DANAE	1.2074
30-Sep-14	NH15	ACARTIA LONGIREMIS	0.584
30-Sep-14	NH15	BARNACLES	0.005

30-Sep-14	NH15	CALANUS MARSHALLAE	0.0021
30-Sep-14	NH15	CALANUS PACIFICUS	0.0678
30-Sep-14	NH15	CHAETOGNATHA	0.5402
30-Sep-14	NH15	CLAUSOCALANUS PERGENS	0.0584
30-Sep-14	NH15	CORYCAEUS ANGLICUS	0.0031
30-Sep-14	NH15	CTENOCALANUS VANUS	0.0317
30-Sep-14	NH15	DOLIOLETTA GEGENBAURI	0.1758
30-Sep-14	NH15	EPILABIDOCERA LONGIPEDATA	0.8691
30-Sep-14	NH15	EUPHAUSIIDAE	1.2293
30-Sep-14	NH15	EVADNE	0.1981
30-Sep-14	NH15	LIMACINA	0.0142
30-Sep-14	NH15	MESOCALANUS TENUICORNIS	0.1836
30-Sep-14	NH15	METRIDIA	0.0351
30-Sep-14	NH15	MUGGIAEA	0.2701
30-Sep-14	NH15	OIKOPLEURA	1.2737
30-Sep-14	NH15	OITHONA SIMILIS	0.4938
30-Sep-14	NH15	PARACALANUS PARVUS	0.4477
30-Sep-14	NH15	PODON	0.0351
30-Sep-14	NH15	PSEUDOCALANUS	2.7455
30-Sep-14	NH25	ACARTIA DANAE	0.1151
30-Sep-14	NH25	ACARTIA LONGIREMIS	0.0276
30-Sep-14	NH25	BARNACLES	0.0025
30-Sep-14	NH25	CALANUS PACIFICUS	0.0773
30-Sep-14	NH25	CALOCALANUS PAVO	0.0023
30-Sep-14	NH25	CALOCALANUS STYLIREMIS	0.0046
30-Sep-14	NH25	CALOCALANUS TENUIS	0.0125
30-Sep-14	NH25	CANDACIA BIPINNATA	0.0103
30-Sep-14	NH25	CHAETOGNATHA	0.0959
30-Sep-14	NH25	CLAUSOCALANUS ARCUICORNIS	0.0933
30-Sep-14	NH25	CLAUSOCALANUS PAULULUS	0.008

30-Sep-14	NH25	CLAUSOCALANUS PERGENS	0.0651
30-Sep-14	NH25	CORYCAEUS ANGLICUS	0.0008
30-Sep-14	NH25	CTENOCALANUS VANUS	0.1648
30-Sep-14	NH25	EUCALANUS	0.0023
30-Sep-14	NH25	EUPHAUSIA PACIFICA	2.3037
30-Sep-14	NH25	HETERORHABDUS PAPILLIGER	0.0335
30-Sep-14	NH25	LUCICUTIA	0.0251
30-Sep-14	NH25	MESOCALANUS TENUICORNIS	0.1146
30-Sep-14	NH25	METRIDIA	0.4639
30-Sep-14	NH25	OITHONA SIMILIS	0.1153
30-Sep-14	NH25	OITHONA SPINIROSTRIS	0.0161
30-Sep-14	NH25	PARACALANUS PARVUS	0.1032
30-Sep-14	NH25	PSEUDOCALANUS	0.1284
30-Sep-14	NH25	RADIOLARIANS	0
30-Sep-14	NH25	SCOLECITHRICELLA MINOR	0.0161
30-Sep-14	NH25	THYSANOESSA SPINIFERA	0.3105

Data was collected in September 2014, via the R/V Oceanus

MARINE MAMMAL SCIENCE PARTY INSTRUCTIONS

Make sure your party has copies of the marine mammal background sheet, the marine mammal data sheet, a blank map and three different colored pens.

1) Read your background sheet paying close attention to the most commonly found species of whales, dolphins and porpoises found in Oregon.
2) Your science party will be looking at a set of marine mammal survey data. These data are real and collected from the Oregon Coast. Locate your map.
    a. On your map, you will see three points labeled “NH05,” “NH15,” and “NH25.” These are stations along the Newport line where the CTD and Plankton Tow data were also collected.
3) 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.
4) On your map, locate the latitude and longitude lines. Begin to fill in the locations of where these animals were located. Decide on a system that shows what kind of animal it is, whether that’s a color, shape, labelling it, etc.
    a. Be sure to provide a key as well so others can interpret your completed map.
5) Once you have finished your map, get a blank graphing sheet. On the x-axis, list each of the species you identified on your map. On the y-axis, put numbers of individuals. Make a bar graph showing how many individuals of each species was recorded.
6) Discuss the following questions with your party:
    a. Does one species occur in a certain area more than another? If yes, why do you think that is?
    b. Pay attention to the location of the stations where CTD and plankton tow data were collected. Are there any species that seemed to gather near one of the sampling stations?
    c. Do you see a species that was recorded that is not listed on the species chart on your background sheet? If yes, why do you think that is?

d. What are some other measurements the science team could make, other than just presence/absence data?
e. Why do you think this "presence/absence" data is important?
    i. What could it be used for?
f. 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:
    i. What your data set was
    ii. What your analysis task was
    iii. What the results are
    iv. Discuss any hypotheses you have or any questions
    v. Why you think it's important to collect this type of data

MARINE MAMMAL SCIENCE PARTY BACKGROUND

- What species of marine mammals do we have in Oregon?

  The Oregon Department of Fish & Wildlife says that while there are nearly 80 species of whales, porpoises and dolphins, we have about 10 of those species that could be found in our waters.

GRAY WHALE	*Eschrichtius robustus*
BLUE WHALE	*Balaenoptera musculus*
MINKE WHALE	*Balaenoptera acutorostrata*
HUMPBACK WHALE	*Megaptera novaeangliae*
SPERM WHALE	*Physeter catodon*
PACIFIC WHITE SIDED DOLPHIN	*Lagenorhynchus obliquidens*
BOTTLE NOSE DOLPHIN	*Tursiops*
DALL’S PORPOISE	*Phocoenoides dalli*
HARBOR PORPOISE	*Phocoena phocoena*
KILLER WHALE	*Orcinus orca*

https://myodfw.com/wildlife-viewing/species/whales-dolphins-and-porpoises

- How are mammal surveys conducted?

  Usually, a researcher will stand somewhere they have a good view on all sides. Using binoculars or a spotting scope, they will observe the horizon until spotting something interesting, like a splash, to follow.

- What kind of things are collected on a marine mammal survey?

  “Presence/absence” data. This is documenting where the animals are located at any given time, and where they are not.

  Other things that can be documented include variables like number of individuals, species or behavior (for example: feeding).

MARINE MAMMAL SCIENCE PARTY DATA

SPECIES	LAT	LONG	GROUP SIZE
Megaptera novaengliae	**-124.28**	**44.87**	**1**
Balaenoptera	**-124.28**	**44.91**	**1**
Balaenoptera	**-124.28**	**44.93**	**1**
Megaptera novaengliae	**-124.32**	**45.02**	**3**
Lissodelphis borealis	**-125.39**	**44.75**	**35**
Balaenoptera physalus	**-125.3**	**44.7**	**1**
Balaenoptera physalus	**-125.3**	**44.7**	**1**
Phocoenoides dalli	**-125.7**	**44.82**	**2**

Data was collected in 2014, via the Southwest Fisheries Science Center

MARINE MAMMAL SCIENCE PARTY MAP