PolarTREC Learning Resources

Details

- Antarctica
- Less than a week (1-2 periods)
- Download and Share
- Middle School and Up

Exploring the Ocean: CTDs

Overview

Oceanography is the study of the ocean. It covers a wide range of topics from marine life to the geology of the sea floor to the physical properties of the ocean. Physical oceanographers study the physical components of the ocean including light, waves, tides, currents and the composition of sea water. The physical properties of the ocean can change with location and depth. Studying these properties can tell us a lot about the ocean, including information on current movement, nutrient content, heat transfer and how much life can be supported in an area. This lesson investigates how physical oceanographers study bodies of ocean water and their properties using CTDs. It allows students to analyze real data, practice reading graphs and graphing data themselves. Students will also create a salinity density column and deduce the source of unknown water samples using salinity and relative density.

Objectives

- Students will learn how oceanographers study properties of the ocean.
- Students will learn how to better analyze graphs and graph real-world data.
- Students will understand how temperature and salinity impact ocean water density.
- Students will create a salinity density column.
- Students will use reasoning to identify unknown water samples.

Lesson Preparation

Background Information:
Students should have an understanding of density and how materials with different density interact. Students

Materials

Part 1:
- CTD PowerPoint
- CTD Movie
- Worksheet 1: Analyzing Real World CTD Data

Part 2:
- Worksheet 2: Relative Density (or a lab notebook)
- Clear test tubes, about 15-30 mL (or 10 mL graduated cylinders)
- Test tube holder (or cup/jar to hold test tubes)
- Plastic transfer pipettes, 2-5 mL (or clear plastic straws)
- Beakers, 400-600 mL (or large, clear plastic cups)
- 5 flasks, 1-2L (or clear plastic pitchers/bottles)
- 5 stir plates with stir bars (or long stir sticks)
- ¼, ½ and 1 cup measuring cups
- 10 cups table salt
- Food coloring, 5 different colors
- 5 stock solutions of different salinities:
    - Fresh water + food coloring
    - ¼ cup salt to 1 L fresh water + food coloring
    - ½ cup salt to 1 L fresh water + food coloring

should also have a general understanding of how temperature and pressure affect density.
Students should have a basic understanding of how to read a graph and what data are. It is helpful if students have been introduced to basic oceanography and ocean currents prior to this lab.

Material Preparation:
Prepare 5 batches of water of different salinities and different colors according to directions below. Place on stir plates if available. Label solutions A, B, C, D, E in non-sequential order.

Procedure

Part 1: Introduction and Data Activity
Go over the PowerPoint lecture with the students, introducing the importance of studying the properties of ocean water. Watch the video of CTD deployment to demonstrate how oceanographers study the ocean using CTDs. Review real-world data collected from CTD casts. As a group or individually, allow students to complete their worksheet 1. Discuss the data from the CTD and worksheet.

Part 2: Lab Activity
The lab technicians forgot to write down which water samples were collected where during the CTD! All you have is unknown water samples and the data from the CTD (Show data chart) to sort this out. With what you've learned, do you think you can determine which water sample came from where?

Allow students to brainstorm ways as a group. Matching temperature and pressure won't work as the water is no longer at pressure and temperature has already changed since it has been brought up from depth. The best solution is to match relative salinities! If students can determine the relative salinities of the samples, they can compare it to the data from the CTD cast and determine where each sample was taken from.

Using the pipettes, students will carefully layer the water in

Materials

- 1 cup salt to 1 L fresh water + food coloring
- 2 cup salt to 1 L fresh water + food coloring (Note: a darker color will be needed for this solution)
- Paper Towels

their test tubes to determine the relative density of each solution and rank them from lowest salinity to highest salinity. After determining the relative salinities of the unknown samples, students will compare their results to the data from the CTD cast to determine the location the samples were taken and the "actual" salinities.

[NOTE: The real salinities of the samples will not correspond to the graph. Solutions are of exaggerated salinities for the purpose of this exercise.]

Extension

- Students can use provided data sets to create their own graphs in Excel or another graphing program.
- Students can use water that is warmed/chilled to create new, unique density columns and explore how temperature affects density.
- Students can further explore concepts of density with related lessons at www.polartrec.com
  - Ocean Currents and Salinity
  http://polartrec.com/resources/lesson/ocean-currents-and-salinity
  - That Sinking Feeling: Density Currents Lab
  http://www.polartrec.com/resources/lesson/sinking-feeling-density-currents-lab
  - Sea Ice Impact and Density
  http://www.polartrec.com/resources/lesson/sea-ice-impact

Resources

NOAA: What is a CTD?
http://www.pmel.noaa.gov/eoi/PlumeStudies/WhatIsACTD/CTDMethods.html

National Oceanography Centre: CTDs
http://noc.ac.uk/research-at-sea/nmfss/nmep/ctd

Window to the Universe CTDs
http://www.windows2universe.org/earth/Water/CTD.html

NASA: Thermohaline Circulation
http://pmm.nasa.gov/education/videos/thermohaline-circulation-great-ocean-conveyor-belt

NOAA: The Global Conveyor Belt
http://oceanservice.noaa.gov/education/tutorial_currents/05conveyor1.html

Window to the Universe Circulation
http://www.windows2universe.org/earth/Water/circulation1.html&edu=high

Window to the Universe Density
http://www.windows2universe.org/earth/Water/density.html&edu=high

Assessment

Evaluation consists of post-lab discussion and feedback given on worksheets and graphs. Formal assessment may include teacher's own test questions related to physical oceanography, CTDs and density.

Credits

This lesson was developed in a joint effort between educators and researchers during the PolarTREC 2015 East Antarctic Ice Stream Dynamics expedition.

Dominique Richardson, Cabrillo Marine Aquarium (dominique.richardson@gmail.com); Dr. Frank Nitsche, Lamont-Doherty Earth Observatory; Dr. David Porter, Lamont-Doherty Earth Observatory; Dr. Guy Williams, University of Tasmania; Dr. Alex Fraser, Hokkaido University; Dr. Raul Guerrero, National University of Mar del Plata.

Science Standards

Next Generation Science Standards (NGSS)

Science and Engineering Practices:
Analyzing and Interpreting Data
Planning and Carrying Out Investigations
Engaging in Argument from Evidence
Obtaining, Evaluating, and Communicating Information

Middle School 6-8
MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how

well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

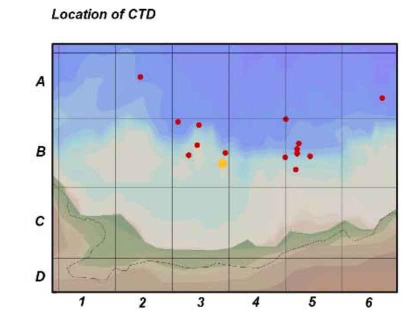
Other Grades
4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.
5-PS1-3. Make observations and measurements to identify materials based on their properties.
HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

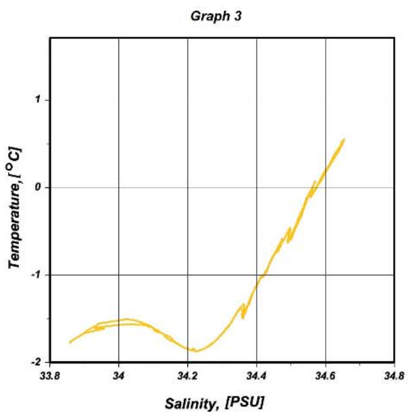
Common Core State Standards (California)
5.0A Analyze patterns and relationships
5.G Graph points on the coordinate plane to solve real-world and mathematical problems.
6.NS Solve real-world mathematical problems by graphing points.
7.RP Analyze proportional relationships and use them to solve real-world mathematical problems.
8.SP Investigate patterns and association in bivariate data.

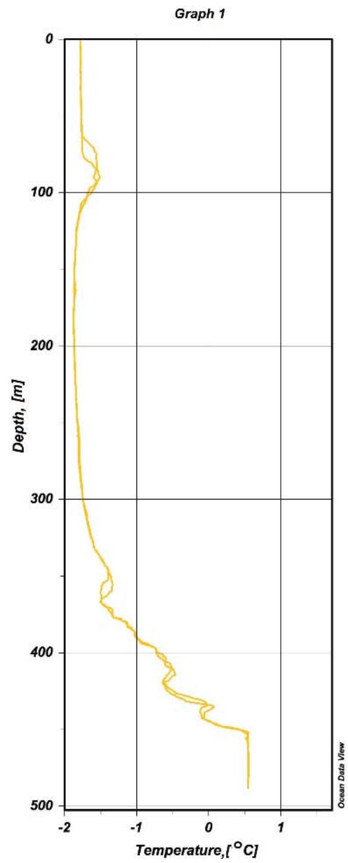
Files/Attachments

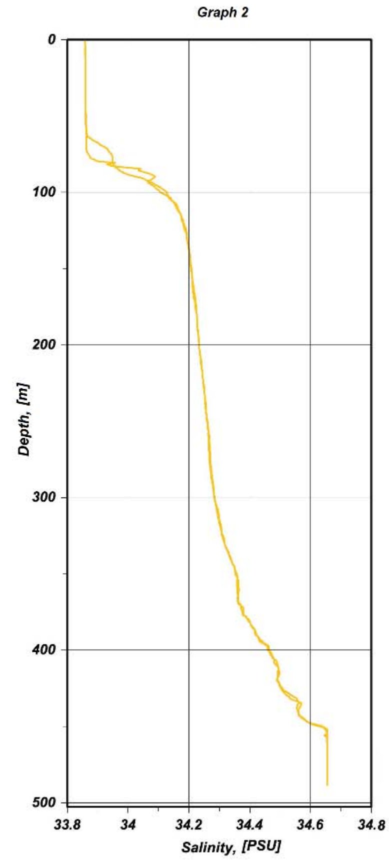
See Materials List

Worksheet: Analyzing Real World CTD Data









These graphs depict data from a CTD conducted in East Antarctica. Using the graphs above, answer the following questions.

1. In Graph 1, what variables are represented?
2. In Graph 2, what are the axes? What is the Y axis? Why is this variable on the Y axis?
3. What depth is the warmest?
4. What is the salinity at 150m?
5. How does salinity correlate with depth?
6. What is the highest temperature recorded during this cast?
7. At what depth does temperature decrease the most?
8. If the trend in the relationship between temperature and salinity were to continue as it is now, what would you predict the temperature of water with salinity 34.7 to be?
9. Generally, how does salinity vary with depth in this location?
10. In what location (provide the grid letter and number) was this CTD taken?
11. What is represented by graph 3?
12. Would you expect all of the CTD locations to have the same profile? Why or why not?
13. How many casts were conducted in this general area?
14. What conclusions can you draw from this profile?

Graph the following data collected during another CTD Cast. Label your axes. How many water masses, of different salinities, can you infer from your graph? Do you think your answer would change if you were provided with temperature data as well? Why or why not?

Depth (m)	Salinity (psu)
0	33.9
100	33.9
150	34.2
200	34.2
250	34.3
300	34.4
350	34.4

Depth (m)	Salinity (psu)
400	34.6
450	34.7
500	34.7
1000	34.7
1500	34.7
2000	34.7
2500	34.7

Worksheet: Relative Density

The lab technicians forgot to write down which water samples were collected at what depths during the CTD! All you have are bottles of water, with unknown salinities, and the data from the CTD (below) to sort this out. With what you've learned, do you think you can determine which water sample came from where?

What variable will you use to determine where the water samples were collected? Why?

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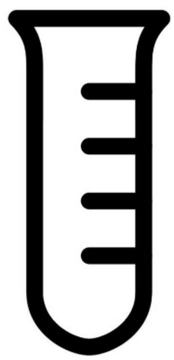
Using experimentation, determine the relative density of each solution. Rank them from lowest density to highest density.



1) ________________________

2) ________________________

3) ________________________

4) ________________________

5) ________________________

Which water was the densest? What does this mean in terms of salinity?

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Which water was the least dense? What does the mean in terms of salinity?

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Match the water samples to the graph. Which water samples were taken from which section of ocean? What are their true salinities? [NOTE: The colors of your samples may not match the false color graph!]