POLAR TREC
Learning Resources

Details

Completion Time: About 1 period

Permission: Download, Share, and Remix

That Sinking Feeling: Density Currents Lab

Overview

Density currents drive 3D movements within the world's oceans that dwarf surface currents by volume. Density-driven movements due to temperature/salinity differences keep the world's oceans well mixed & help to re-distribute heat from tropical areas towards polar areas. Resultant upwelling creates some of the world's richest ocean ecosystems. Density movements known as turbidity currents are the world's largest mass wasting events and re-distribute sediment across thousands of kilometers of sea floor.

Objectives

- Students will manipulate three variables affecting water density (Salinity, Temperature, and Turbidity) and observe the effect on water movement.
- Students will associate polar regions with the creation of cold, hypersaline water.
- Students will deduce how sediment accumulating on continental shelves can eventually re-distribute to abyssal plains.
- Students will connect the importance of density currents to nutrient cycling in marine ecosystems.

Lesson Preparation

- It is most helpful if students have already explored the concept of density prior to doing this lab.
- It is also helpful if students have been introduced to ocean currents prior to this lab.
- In addition to the materials above, each group needs something to prop their tubes up with to form about a 20˚ angle from horizontal. I like using a counter edge but boxes, ring stands, or anything else suitable can be used. I just use masking tape to secure the tubes so they won't roll off.

Procedure

- Demonstrate how to fill tubes nearly full (leave about

Materials

- Capped clear 1.5" PVC tubes approx. 1 meter long- 1 per group of no more than 4 students. See Resources section.
- Blue-dyed ice cubes, 1+ per group (a few drops of blue food color in each ice cube works nicely).
- Red-dyed salt, approx. 1 tsp. per group. See Resources section.
- Small (50ml or so) beaker, 1 per group.
- Plastic teaspoon, 1 per group.
- Powdered tempera poster paint (brown looks like mud but any color works)- approx. 1 tsp. per group.
- Sealable container to mix paint in, like film canister or Baby Soda Bottles. See Resources section.
- Masking tape, paper towels.

4" of headroom) and lean against a counter edge or box so they will repose at about a 20˚ angle. If a counter edge isn't suitable, use a box, rock, ring stand, etc. to accomplish this. Use masking tape to prevent the tube from rolling off & spilling its contents.
- Explain to students that they will only need one tube-full of water if they sequentially do the ice, then the salt, and then the paint (directions on student sheet.)
- Explain clean-up procedures. The paint will be much easier to rinse out shortly after doing the lab rather than letting it settle overnight.
- Distribute blue ice cubes, dyed salt, and paint to each group. Determine the time allowed to complete the lab & let the students at it! A second day for post-lab discussion may be needed.

Extension
- Students can research deep-sea circulation patterns, which are amazingly complex and cross multiple ocean basins.
- Students can research the immense volume of water moving away from polar regions in bottom currents.
- Students can investigate how a CTD cast can be used to measure salinity & temperature vs. depth, & collect samples from different water masses. For example: http://www.polartrec.com/expeditions/international-continental-shelf-survey/journals/2010-08-10
- Students can investigate how an XBT can quickly yield a temperature profile for a water column. For example: http://www.polartrec.com/expeditions/international-continental-shelf-survey/journals/2010-08-08

Resources
http://www.polartrec.com/expeditions/international-continental-shelf-survey/journals/2010-08-08

Notes on materials used in the lab:
Clear PVC pipe, caps, and cement are available online (such as http://www.clearpvcpipe.com) and makes for very durable pipes good for other experiments such as deposition of sediments. Other clear tubes (such as those sold at hardware stores to protect fluorescent lights) may also work but I found them to be harder to cap and not as rugged as PVC.

Red food coloring works but I like crushed fizzy tub tints since they are dry and don't stain clothes or skin (http://www.stevespanglerscience.com/product/1156.)

"Baby Soda Bottles" (unbreakable, sealable giant test tubes.) (http://www.stevespanglerscience.com/product/1156)

Assessment
Evaluation consists of post-lab discussion and feedback given on sketches and answers to questions. Formal assessment may include test questions relating to density currents.

Learning Resources

Credits

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Learning Resources

National Science Education Standards (NSES):

Content Standards, Grades 5-8

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
a. Properties and changes of properties in matter
b. Motions and forces

Content Standard D: Earth and Space Science
a. Structure of the earth system

Content Standard F: Science In Personal and Social Perspectives
c. Natural hazards
d. Risks and benefits

Content Standards, Grades 9-12

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
b. Structure and properties of matter
d. Motions and forces

Content Standard D: Earth and Space Science
a. Energy in the earth system

Content Standard F: Science In Personal and Social Perspectives
e. Natural and human-induced hazards
f. Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science
c. Historical perspectives

Other Standards
n/a

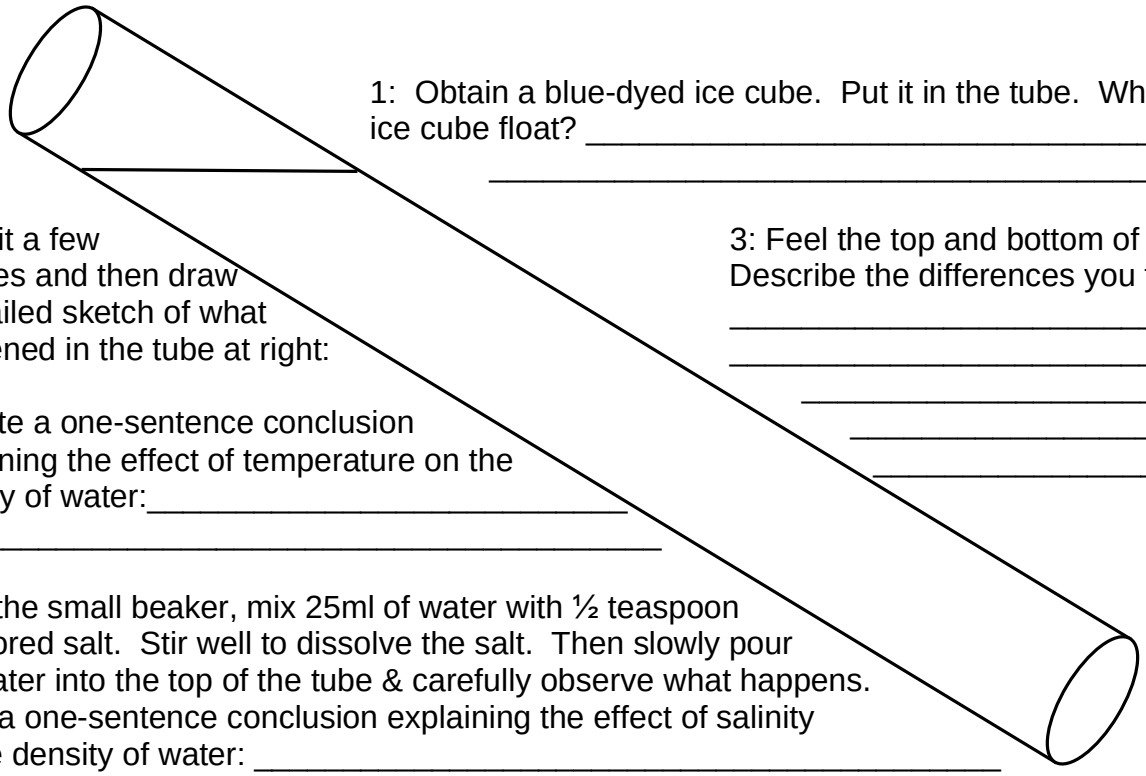
Schmoker / PolarTREC Name: _____

That Sinking Feeling: Density Currents

Date: _____ Per.: _____

Density currents are simple to understand; water that is more dense than the water around it will sink. In this lab you will investigate three variables that affect water density: ***temperature, salinity, and turbidity***.

Set-up: Fill the long clear tube with cold tap water, leaving some air at the top to avoid overflow when you add samples. Lean the tube against the countertops above the lab tables so the tube is slanting down and tape it so it won't roll off. Your tube should be angled about like this:



1: Obtain a blue-dyed ice cube. Put it in the tube. Why does the ice cube float? _____

_____

2: Wait a few Minutes and then draw a detailed sketch of what happened in the tube at right:

3: Feel the top and bottom of the tube. Describe the differences you feel:

_____

_____

_____

_____

_____

4: Write a one-sentence conclusion explaining the effect of temperature on the density of water:_____

_____

5: In the small beaker, mix 25ml of water with ½ teaspoon of colored salt. Stir well to dissolve the salt. Then slowly pour the water into the top of the tube & carefully observe what happens. Write a one-sentence conclusion explaining the effect of salinity on the density of water: _____

_____

6: During winter in arctic regions, the surface of the ocean freezes. As water freezes, salt is excluded (kept out) of ice crystals. The result is water that is very cold and salty below the surface of the ice. Where will this water go? _____

How does this explain the fact that deep ocean temperatures are very cold (3-4 degrees Celsius) even at the equator? _____

_____

7: When cold water that has spread slowly across the bottom hits a barrier like an island or a coast, it may be forced upward in a type of current called upwelling. This brings cold, nutrient-rich water to the surface. Why are areas of upwelling so important to marine life and the people who depend on it, like fishermen? _____

_____

_____

8: How do density currents distribute water thousands of kilometers and keep the world's oceans well mixed? _____

_____

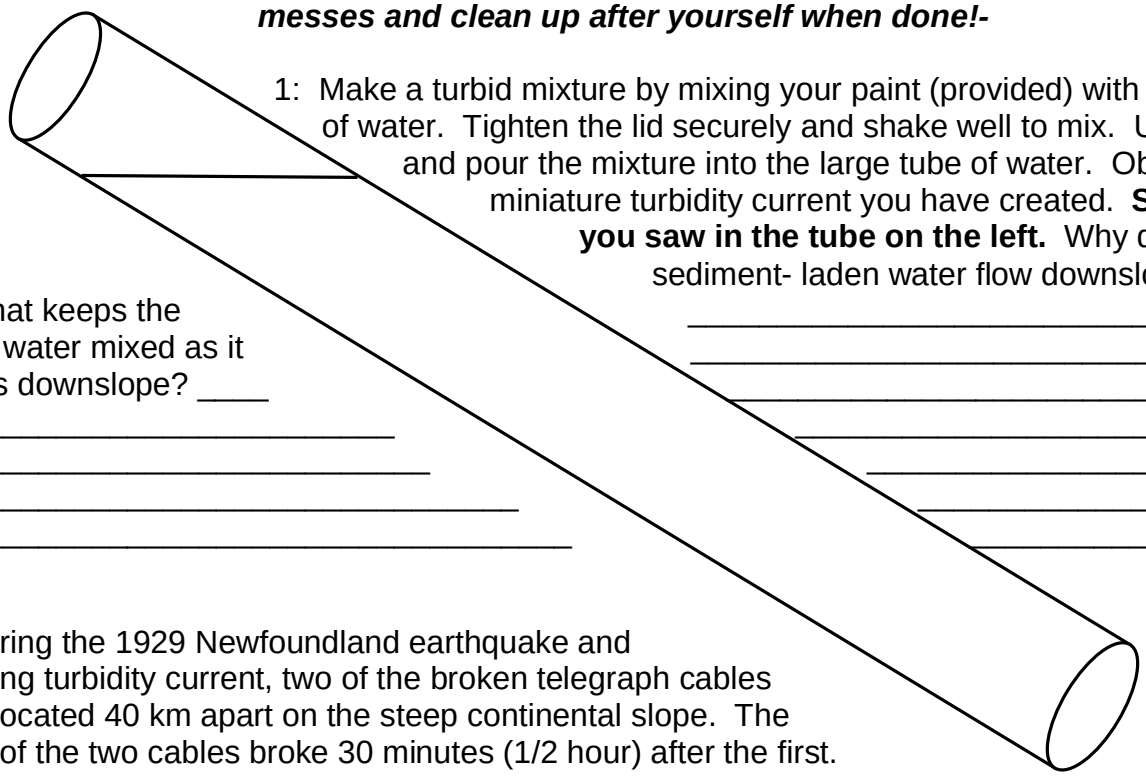
Schmoker / PolarTREC Name: _____

That Sinking Feeling: Density Currents

Date: _____ Per.: _____

In 1929 an earthquake off Newfoundland, Canada caused 12 underwater telegraph cables to break. At first the earthquake itself was blamed, but a puzzling pattern led to the discovery of a previously hidden process. Analysis of the exact time of cable failure showed that the cables snapped sequentially from the shallowest to the deepest over a period of many hours. The culprit was actually a turbidity current that was triggered by the earthquake.

-Use the same tube set-up. No need to pour out the cold & salty water. Be careful to contain messes and clean up after yourself when done!-



1: Make a turbid mixture by mixing your paint (provided) with ½ test tube of water. Tighten the lid securely and shake well to mix. Uncap the lid and pour the mixture into the large tube of water. Observe the miniature turbidity current you have created. **Sketch what you saw in the tube on the left.** Why does sediment- laden water flow downslope?

_____
_____
_____
_____
_____
_____
_____

2: What keeps the turbid water mixed as it travels downslope? ____

_____
_____
_____
_____

3: During the 1929 Newfoundland earthquake and resulting turbidity current, two of the broken telegraph cables were located 40 km apart on the steep continental slope. The lower of the two cables broke 30 minutes (1/2 hour) after the first. What was the average speed of the turbidity current between these two cables? (Show your work.)

4: The last cable to break was located 720 km away from the first to break. It broke 13 hours after the first one broke. What was the average speed of the turbidity current between these two cables? (Show your work.)

Schmoker / PolarTREC Name: _____

That Sinking Feeling: Density Currents

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5: Explain how turbidity currents can transport river-borne sediments from shallow continental shelves to deep abyssal plains. Include the concept of density in your answer, and address how abyssal plains get so flat. _____

_____

_____

_____