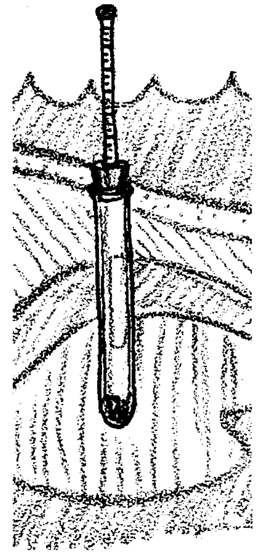
The Hydrometer

Key Concepts

1. Currents are large-scale water movements in the sea.
2. The three main causes of currents in the ocean are:
   - wind
   - earth's rotation
   - density differences in ocean waters.
3. Oceanographers measure the water's salt content, or salinity, in grams of salt per kilogram of sea water (g/kg) which is usually expressed as parts per thousand (‰).
4. Average ocean salinity is approximately 35 ‰.
5. A hydrometer is a tool used to determine salinity of a water sample.



Background

Differences in the density of ocean waters are one of the major causes of ocean currents. Perhaps you have been swimming in the ocean and observed that in one spot the water tasted really salty while in another, it tasted not so salty, in fact almost fresh. No, it wasn't an illusion. Salinities near shore vary due to the addition of fresh water by rivers and rainfall. Local conditions of temperature and water circulation may also increase or decrease salinity. On a larger scale, salinities also vary. Notice the variation of salinity in these bodies of water:

Red Sea= 40 ‰

Mediterranean Sea= 38 ‰

"Average" sea water= 35 ‰

Black Sea= 18 ‰
Baltic Sea= 8 ‰

In order to locate and study the effects different salinities have on ocean environments, marine scientists use an instrument called a hydrometer. A hydrometer is basically a weighted, glass cylinder.

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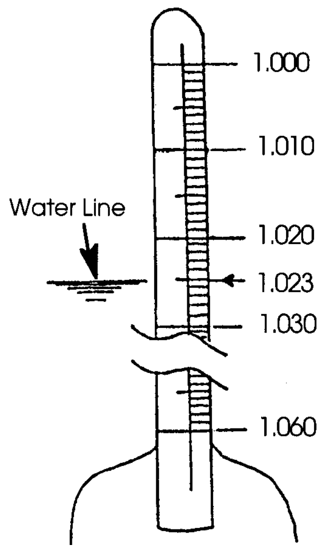
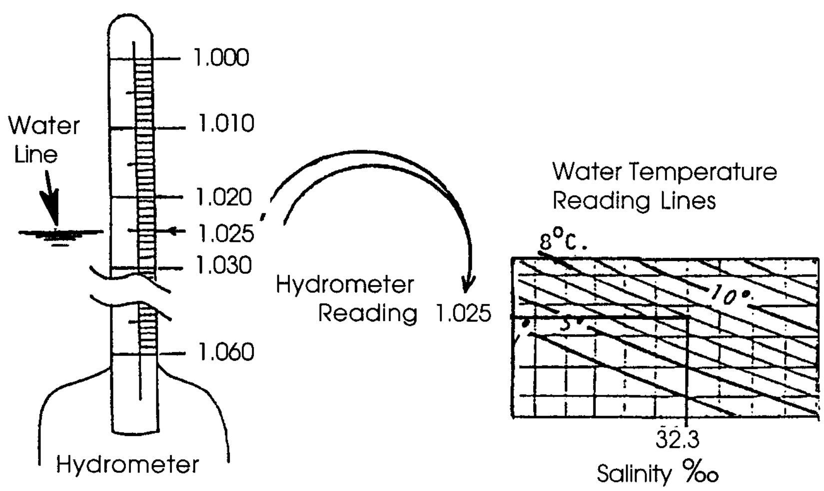


The cylinder has a thin glass tube at the top with a scale. The saltier the water, the higher the hydrometer floats. The higher the hydrometer floats, the higher the reading on the hydrometer scale.

Technically, a hydrometer measures the **specific gravity** of a liquid. Specific gravity is the ratio of the density of a substance relative to the density of pure water at 4° Celsius. The specific gravity of pure fresh water at 4° Celsius is 1.000. This provides the standard. As something (like salt) is added to pure water, the density of the water increases and the hydrometer reads above 1.000. The terms density and specific gravity are usually used interchangeably. Density which equals the mass per unit volume is usually expressed in grams/cubic centimeter (cc or cm3) or grams/milliliter (g/ml). Since temperature, as well as salinity, affects the density of a water sample, the reading on the hydrometer must be corrected for temperature in order to ascertain the density due only to salt content. A correction graph is used for this purpose. To use the graph, one must know the temperature of the water in degrees Celsius and the hydrometer density reading. The procedure used to reveal the salinity of the water sample in parts per thousand (‰) is outlined below:



Density differences due to temperature and salinity are discussed in "Currents: Moving Water" and provide additional background for "The Hydrometer".

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Materials

For the class:

- "standard water"
- unknown solution A,B,C

For each pair of students:

- 12 x 75 to 15 x 150mm test tubes
- one hole stopper to fit
- 50 No. 2 lead shot
- 4mm ID glass tubing x about 120mm
- wax candle
- matches
- 100ml graduated cylinders
- index card
- scissors
- paper
- pencil

Teaching Hints

Through the activity "The Hydrometer" your students will construct simple hydrometers with which they will measure the density of various solutions. These same hydrometers are used in "Heating It Up", an activity dealing with the effect of salinity on the density of water. These activities provide your students with some "hands-on" experiences with the factors which cause ocean currents. The "Analysis and Interpretation" sections endeavor to relate the activities to the situation in the oceans. It is often difficult for students to see that the forces which they observe on a small scale in the laboratory are sufficient to cause the vast movement of water seen in the oceans. As you work through and discuss the activities, stress that the forces are, indeed, the same.

Duplicate the activity pages. One set is recommended per student. "The Hydrometer" is a laboratory activity best performed in pairs or small groups. The hydrometer construction is straight-forward. Demonstrate how to safely insert the glass tube into the rubber stopper. Materials substitutions can reduce the size of groups. For example, tall, thin jars may be used instead of graduated cylinders. It is possible to run "The Hydrometer", "Heating It Up", and "Ol' Sea Salt" activities on consecutive days with a general follow-up discussion after all three have been completed. Alternatively, discussions after the completion of each of the activities and before commencing the next

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activity helps insure that your students are "on the right track" before proceeding to the next activity. The abilities of your class will determine the strategy you employ.

It is helpful to have a completed hydrometer on display during "The Hydrometer". Distilled water serves as the "standard water" for calibration.

Suggested solutions for "The Hydrometer" are: solution A = 3.5% NaCl (A 3.5% NaCl solution may be made by adding 35 grams of NaCl to 1000ml of distilled water); solution B = 5% NaCl and solution C = 1% ethyl alcohol.

Key Words

current - large-scale movement of ocean waters

density - mass per unit volume of a substance. More dense seawater tends to sink, less dense seawater tends to rise in the ocean.

hydrometer - instrument used to measure density or specific gravity of a liquid

salinity - measure of the quantity of dissolved salts in seawater

Extensions

1. Have students use their soda straw hydrometers to compare the behavior of the hydrometer in other liquids: mineral oil, rubbing alcohol, vinegar, etc.

Answer Key

The Hydrometer

1. Solution B (5% NaCl) has the greatest amount of salt in the water.
2. Solution A (3.5% NaCl) is most likely sea water.
3. Answers will vary depending on the length of the card in the glass tube. Recall that each line represents a density change of .001 g/ml.

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4. The densities of the hypothetical solutions are as follows:

A. 1.000 g/ml

B. 1.004 g/ml

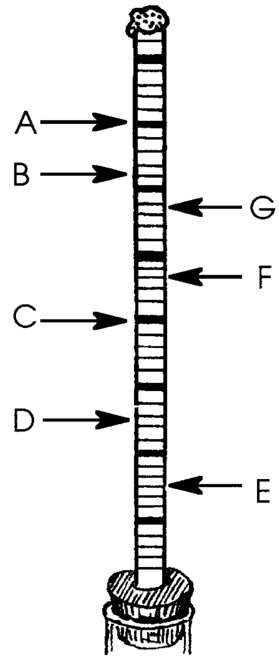
C. 1.015 g/ml

D. 1.022 g/ml

E. 1.028 g/ml

F. 1.012 g/ml

G. 1.006 g/ml



5. Ocean water with the greatest density is found at the greatest depths. This question relies on information found in "Currents: Moving Water" or on deductions made by your students from the information in "The Hydrometer".

6. a. The approximate density of melting polar ice is 1.000 g/ml.

   b. The approximate density of seawater near ice that is beginning to form is something greater than 1.025 g/ml. This question relies on information found in "Currents: Moving Water" and is designed to provide continuity between activities.

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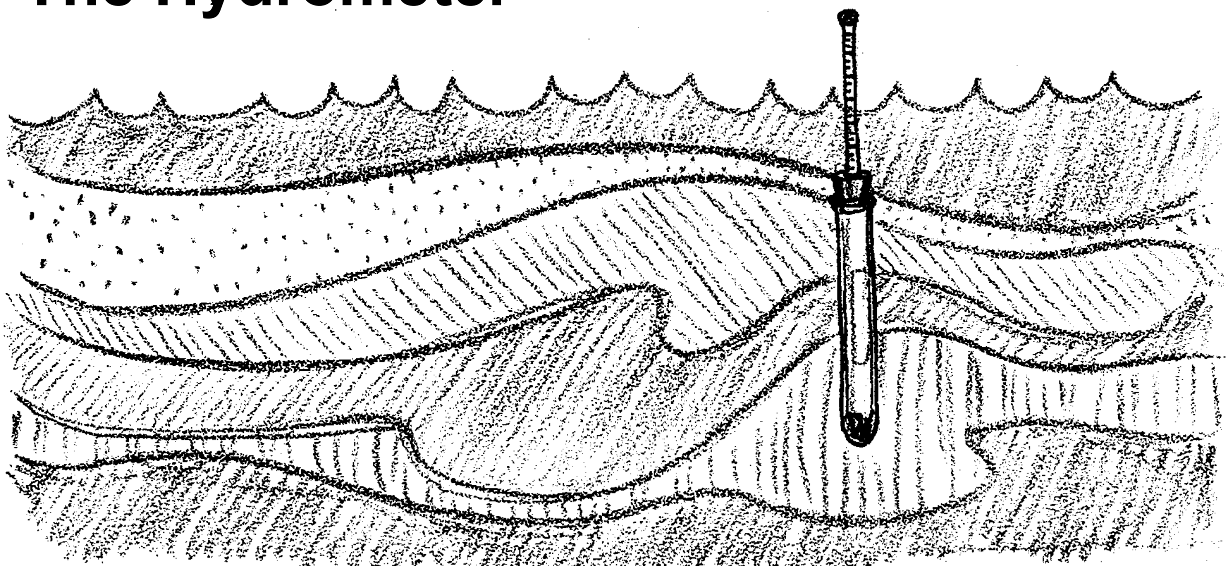
The Hydrometer



Before you can look at some of the factors that cause ocean currents you need to have the proper tools.

You may be familiar with such standard measuring devices as the thermometer, balance, and graduated cylinder. In this activity you will make a commonly used special measuring device called a hydrometer. It is used to measure very small differences in the density (or “heaviness”) of water. As you have seen, not all sea water has the same density. These density differences are very important.

Materials:

- 12 x 75 to 15 x 150mm test tubes
- one hole stopper to fit
- 50 No. 2 lead shot
- 4mm ID glass tubing X about 120mm
- wax candle
- matches
- 100ml graduated cylinders
- “standard water”
- unknown solution A,B,C
- index card
- scissors
- paper
- pencil

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Procedure:

1. Obtain an index card. Use a pencil to mark the edge of a notecard every 1/16 inch (pardon the use of a four letter word but in this case it is exactly what is needed). Make every 5th mark extra heavy (twice as wide a line).

2. Obtain a piece of glass tubing and scissors. Use scissors to trim off the marked edge of the card. Slip the strip of card into the glass tube.

3. Obtain a wax candle and matches. Light the candle. Completely seal off one end of the tube by dipping it in candle wax. Next trim off any paper sticking out of the glass tube.

4. Insert the unwaxed end of the glass tube in a rubber stopper. Be very careful not to break the tube or cut yourself. If you wet the outside of glass tube it will go in to the stopper more easily.

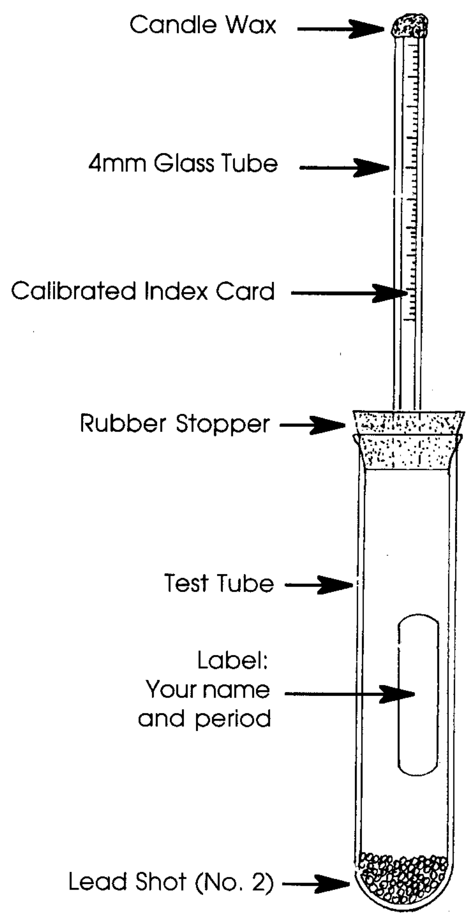
5. Write the names of everyone in your group on a small piece of paper with a pencil. Put the paper in your test tube with names showing.

6. Obtain about 50 lead shots. Put the lead shots in the test tube and then put in the stopper. Your hydrometer should look something like the one on the right.

7. Obtain a 100ml graduated cylinder. Fill your graduated cylinder with 85ml of "standard water" which has a density of 1.000 g/ml.

8. Carefully lower your hydrometer into the graduated cylinder. If it sinks and stays on the bottom, take out some of the lead shots. If it floats with most of the scale out of the water, add more lead shots. Keep doing this until the water comes as close to the second dark line from the top as possible.

9. A final adjustment is made by tightening or loosening the stopper a tiny amount. Keep adjusting your hydrometer until the water line is right at the second dark line.



HYDROMETER

10. Once the hydrometer has been adjusted do not move the tube or the stopper or it will be necessary to go back and adjust it again.

11. The second dark line now shows a density of 1.000 g/ml. Each line below that line represents increase in density of 0.001 g/ml.

12. Discard the “standard water”. DO NOT return the standard solution to the original container. Pour it down the sink.

13. In your graduated cylinder obtain 85ml of solution A. Use your hydrometer to find the density of solution A. Record the density of solution A:

    (Hint: remember each line below the second dark line equals a density increase of .001 g/ml. Simply count the lines, multiply by .001 g/ml and add to 1.000 to find the density of A.)

14. Repeat step 13 for solutions B and C. Record the densities of solutions B and C in the space below:

    Density of solution B:

    Density of solution C:

Analysis and Interpretation

1. Adding salt to water increases the water’s density. Which solution has the greatest amount of salt in the water?

2. The density of sea water is 1.025 g/ml. Which solution is most likely sea water?

3. If your hydrometer is properly calibrated and sinks to the top line, what is the density of the solution?

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4. What is the density of solutions which sink to each of the marks?

A. ________

B. ________

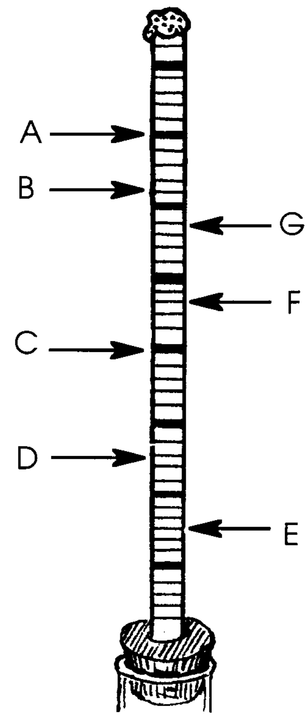
C. ________

D. ________

E. ________

F. ________

G. ________



5. Where in the oceans would you expect to find the water with the greatest density?

6. a. What would be the approximate density of melting polar ice? (Hint: read the paragraph following question 4 in the reading entitled "Currents: Moving Water".)

b. What would be the approximate density of sea water near ice that is beginning to form?