THE LIVING SEA™

TEACHER'S GUIDE

THE LIVING SEA is an IMAX/OMNIMAX® motion picture produced by MacGillivray Freeman Films in association with Nauticus—The National Maritime Center, the Ocean Film Network, White Oak Associates, Inc., and Dr. Robert Ballard, Director of Marine Exploration at Woods Hole Oceanographic Institution.

Introduction

Sea water is a sort of "Earth tea," containing the dissolved atoms of probably every element on our planet.

In the film **THE LIVING SEA**, we understand the widest perspective of the oceans; that of a single, global system and its importance to all life on earth.

In a way, we are the ocean and the ocean is us. Life probably began in the ocean and thrived there for more than three billion years before some proto-amphibian gathered up its courage and slopped onto the dirt! All of us—humans, wombats and redwoods—still carry an ocean inside. Our blood, eggs, the fluid behind the corneas of our eyes and the insides of our cells are salt water. Just as about three-fourths of the earth's surface is salt water, about three-fourths of each of us is salt water.

Above and beyond the personal, the ocean has a profound effect on our planet and on ourselves. It moderates and affects weather. The majority of the earth's oxygen is generated by ocean plants, and most of the earth's reservoir of carbon dioxide (a gas critical to plant survival and the control of climate) is dissolved in the ocean. The ocean provides us with an immense amount of food and other natural resources, and ninety percent of the world's trade is transported on its waves. If it weren't for the ocean, there probably would be no life on earth.

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HOW DOES THE OCEAN MOVE?

Water is in constant motion in the ocean and much of that motion occurs within currents. The term current usually refers to water flowing horizontally (parallel to the ocean's surface), but masses of water also can move vertically. Currents can be rapid and almost river-like (such as the Gulf Stream) or they can be slow and diffuse.

What causes water to move? Ultimately, the sun does the job. Warm water expands and cold water contracts. Ocean water is warmer at the equator (the sun shines on it more) than at the poles. Equatorial water is actually about three inches thicker than polar water, because it is warmer and has expanded slightly. This global difference creates a very slight slope and warm equatorial water flows "downhill" (poleward) in response to gravity. However, this movement is only the beginning. Surface water also is propelled by winds. Winds move water through friction between moving air molecules and water molecules. As the surface water molecules begin to move, they pull with them some of the molecules below, which triggers the current.

WORDS TO KNOW

Current: *usually refers to water flowing horizontally, but masses of water also can move vertically.*

KEY IDEAS

1 *The ocean water is moved by currents. Currents are created by the sun warming the waters in certain areas, like at the equator. The warmer water has expanded slightly, creating a slope. The warm water runs downhill toward the poles. The winds also help trigger currents by propelling surface waters.*

2 *Ocean currents can affect the weather. If the current off a coast is cold, the wind blowing across it will lose heat, creating cold weather. Winds blowing over a warm current pick up moisture and heat.*

Water also moves vertically. As mentioned previously, winds can drive surface water away from the coast and deep water can move upward (upwelling). However, water also moves downward. Ocean water sinks when it is saltier or colder than surrounding water. A prime example of this takes place in Antarctica, where Antarctic Bottom Water is formed. This is the densest water in the ocean and it is created in the winter when sea ice forms. This ice only takes up about 15% of the ocean's salt and the rest forms an extremely cold brine. This sinks to the bottom and spreads northward from Antarctica. In the Pacific Ocean, this water actually may reach the Aleutian Islands off Alaska, a trip that takes about 1,600 years.

Ocean currents have a profound effect on the weather. An example is the perhaps apocryphal remark of Mark Twain: "The coldest winter I ever spent was a summer in San Francisco." Summer months there are cool, windy and foggy. On the other hand, Washington, D.C.—at about the same latitude but on the Atlantic Ocean—has hot and muggy summers. The reason for this difference is that the City by the Bay sits on the edge of the cold California Current. Winds approaching the California coast lose heat to this cold water and chill San Francisco. Washington, D.C., is hit by winds that have flowed over the warm Gulf Stream, picking up heat and moisture as they pass over that current.

ACTIVITY: CHAPTER 3

A CURRENT AFFAIR

Deep currents are generated by differences in salinity and temperature between two bodies of water.

Salinity Currents: Salt water is more dense than fresh water and sinks below it. In the first experiment, the blue salt water on top will soon replace the clear fresh water below. Similarly, in the second half of the exercise, the clear tap water above will remain on top of the blue salt water.

Temperature Currents: Like salt water, cold water is more dense than hot water. When placed on top, it will sink down and displace the hotter water. Hot water will sit on top of cold water. However, as the temperatures equalize, they will begin to mix.

Purpose: Students will create their own water currents, using differences in water salinity and water temperature.

Materials: You will need two 1-liter clear plastic soda bottles, index cards, food coloring, table salt and measuring spoons.

Salinity Currents

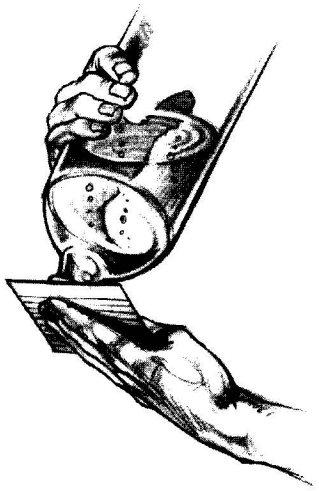
Procedure: In this experiment, students will fill one bottle with just tap water and the other with tap water, salt and food coloring. They will predict what will happen to the colored water before doing the experiment, then will observe and record the direction of the actual water flow. Have them write down their predictions on their worksheets.

1 Divide students into small groups, each with an adult, or do this as a class.

2 Have students fill both bottles with room-temperature tap water. Add approximately 1 Tbl. of salt and 8 drops

of blue food coloring to one bottle and shake well. Don't add anything to the water in the other bottle. Make sure both bottles are completely filled to the top.

3 Have a student place a index card over the mouth of the colored-water bottle and turn it upside down. Do this over a dish to prevent spillage. The students should hold the card in place as they turn the bottle over, then gently remove their hand from the card. The upward air pressure will hold the card in place. Center the upside down bottle directly over the mouth of the upright bottle containing the clear water. Place the bottles in a dish to catch spills and slowly slide the card from between the bottles. Observe the results for a few minutes. Color the illustrations on the worksheet to show how the colored water moved and where it ended up.



4 Now the students can empty and rinse the bottles and do the experiment again, but this time turn the clear bottle upside down. Again, record your predictions and what actually happens.

Temperature Currents

Procedure: This experiment is similar to the preceding one, except that in this experiment you will fill two bottles with water of different temperature. Again, after preparing the bottles, make sure to predict what will happen to the colored water after the card is removed.

1 Fill one bottle with ice-cold tap water, add 8 drops of blue food coloring and shake well. Fill the second bottle with hot tap water. Make sure both bottles are completely filled to the top.

2 Align the bottles over each other with the index card separating the contents as directed in step 2 of the activity above. Slowly slide the card from between the bottles. Observe the results for a few minutes. Color the illustrations on the worksheet to show how the colored water moved and where it ended up.

3 Empty the bottles and do the experiment again, but this time turn the clear hot water bottle upside down.

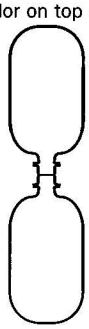
Activity Age Modifications: Preschool-3rd grade can do this project as a class with the teacher leading and asking for volunteers. 4th-6th grade would do the project in small groups with an adult. Within each small group, students would be chosen for each of the following positions; recorders, experiment performers, and observers. 7th grade and above would do the same as the group above, but more independently.

Salinity Currents

Part 1: Colored salty water on top.

Predictions

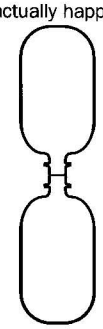
1 Predict the final color on top and bottom when the colored salty water starts on top. Shade the area where the color will be after the card is removed.



Results

2 Now show what actually happened.

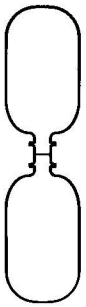
3 Are the results different then your predictions? Why do you think they are different?



Part 2. Clear, fresh water on top.

Predictions

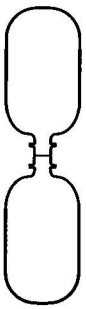
1 Predict the final color on top and bottom when the clear fresh water starts on top. Shade the area where the color will be after the card is removed.



Results

2 Now show what actually happened.

3 Are the results different then your predictions? Why do you think they are different?

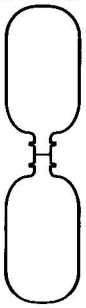


Temperature Currents

Part 1. Colored cold water on top.

Predictions

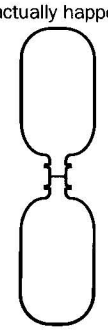
1 Predict the final color on top and bottom when the cold water starts on top. Shade the area where the color will be after the card is removed.



Results

2 Now show what actually happened.

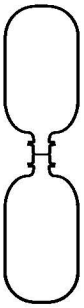
3 Are the results different then your predictions? Why do you think they are different?



Part 2. Hot water on top.

Predictions

1 Predict the final color on top and bottom when the hot water starts on top. Shade the area where the color will be after the card is removed.



Results

2 Now show what actually happened.

3 Are the results different then your predictions? Why do you think they are different?