Plastics in Motion

Created by Center for Alaskan Coastal Studies

Essential Questions:

How do people affect coasts and the ocean?
How do physical processes influence human effects on marine ecosystems?

Enduring Understandings

- Watersheds, rivers, wetlands, and the one big ocean of the world are an interconnected system.
- Climate patterns cause physical changes in the environment.
- Physical changes in the environment can challenge the conditions for life.
- Marine ecosystems are dynamic, with physical changes occurring on a daily, seasonal, and long-term basis.
- Weather systems and ocean systems have major influences on each other and the transport of solids and liquids in the ocean.

Objectives

Students will understand that air and water have different densities at different temperatures and that these density differences drive global and local patterns of air and water movement in wind and currents. They will recognize how the Coriolis effect influences wind and current patterns, and how this can create ocean gyres. They will create a flowchart of plastic movement to the ocean, detailing how physical factors power this movement and how people can stop it.

Concept

Temperature-dependent gradients of density drive the movement of air and water in winds and currents. As hot air or water rises, cool air moves in to fill the space left behind. This movement is deflected by the rotation of the earth, called the Coriolis effect. Marine debris is transported by both winds and currents. Debris large and small tends to accumulate in ocean gyres, such as the North Pacific and North Atlantic gyres.

Materials

- Science notebooks
- Pencils
- Tape
- Small strips of paper
- 2 or more thermometers
- Clear density tube or graduated cylinder
- Food coloring (blue and red)
- Hot water
- Cold water
- Computer/laptop and projector or SmartBoard
- Internet connection
- Globe or map of Earth
- Sphere or cylinder that can be drawn on
- Dry-erase markers

Background

This lesson focuses on winds and currents that move marine debris around the world. The lesson is mainly based on global rather than local systems, but can include local components. The first subject in the lesson is the movement of heat and cold on earth and to see how they interact when they meet. The second step is to look at the different densities of hot and cold water and air. The third step is to look at the Coriolis effect on global wind and current systems. Finally, applying these concepts to local wind and current factors helps connect students to surroundings.

Preparation

Identify a door or window to the outside that can be opened, and move furniture for easy access to this spot. Prepare insulated containers of hot and cold water. If you have not done a density experiment before, practice pouring the cold and hot water before demonstrating it to the class. Set up a computer and projector or SmartBoard to show the Majestic Plastic Bag mockumentary (http://www.youtube.com/watch?v=GLgh9h2ePYw). Also load the NOAA Global Science Investigator for marine debris in the North Pacific Gyre (http://www.csc.noaa.gov/psc/dataviewer/#view=mdebris). Research to find out if there is local drift card information available for your area.

Introduction

Begin by showing the "Majestic Plastic Bag" mockumentary on YouTube (http://www.youtube.com/watch?v=GLgh9h2ePYw). At the conclusion of the video, ask students to write their reaction in their science journal. As a group, brainstorm different pathways plastics follow to the ocean. Have students sketch a quick flowchart of a piece of plastic's journey to the ocean.

Procedures & Activities

Explain to students that marine debris are transported by winds and currents, which are driven by temperature differences in water and air masses. Choose one or more of the following activities to explore this concept:

Hot Air/Cold Air Demonstration

Conduct a temperature demonstration by asking for two volunteers. Crack open a door or large window that leads outside. Have one volunteer hold a thermometer at the top and another person hold one at the bottom. Read and record the temperatures. The top temperature should be higher than the lower temperature, demonstrating that heat rises and cold air fills in below it. Explain to students that hot and cold air have different densities. Because molecules in cold air are less energetic and move more slowly, it is denser than warm air, where molecules are more energetic. The more dense cold air sinks as less dense hot air rises.

Water Density Tube

Next, reiterate this concept by creating a density tube with water. Add a drop of red food coloring to hot water and a drop of blue food coloring to cold water. Ask students to make a prediction in their science notebooks about what will happen when the cold and warm water are put in the same density tube. Pour hot water into the density tube or graduated cylinder. Holding the density tube at an angle, carefully and slowly pour the cold water into a density tube so that the water runs along the side of the container before mixing with the cold water. Observe as a class what happens to the less dense hot water and denser cold water.

Classroom Draftometer Observations

Explain that as water or air warms, it rises. This creates a sort of vacuum below, which is filled by cool air or water. Build simple "draftometers" with students by having them tape a small strip of paper hanging vertically from a pencil. Have students hold the pencil horizontally with the paper hanging down. Any movement of the paper will identify areas of air movement in the classroom. Allow students a few minutes to measure drafts around the classroom and see for themselves how small air masses are flowing throughout the classroom based on differences in temperature and thus density. If you have extra thermometers, have them measure the temperature in low-lying drafty areas and compare it to the temperature above these drafty areas.

Current Predictions and the Coriolis Effect

Introduce a globe or map of the Earth. Ask the class to consider which areas of the earth are warm and cold and what would happen to the air and water in those areas. Ask students to sketch a basic map of the Earth in their science journals and predict the direction of winds and currents based on areas of the Earth that are hot and cool.

Once all students have made their predictions, explain that the warm equatorial water/air rises and moves the north and the cool polar air/water flows along the surface toward the equator. The zones where warm and cold converge are the areas that create the main currents and winds on earth. The currents and winds interact with each other, which changes their direction from what you might predict. The winds and currents are also deflected by the rotation of the Earth. This is called the Coriolis effect, and deflects winds

and currents to the right in the northern hemisphere and to the left in the southern hemisphere.

For more advanced classes, you may choose to demonstrate the Coriolis effect by using a cylinder or sphere that can be drawn on with a dry erase marker. Spin the object and have a student draw a line from the center to the top and then from the center to the bottom. The lines should be curved-pointing the same direction. This shows how objects moving across the rotating earth are pushed.

Effect of Real Currents and Winds on Marine Debris

Show an actual global current and global wind model. Use the Global Science Investigator to demonstrate the path of drifter buoys into the North Pacific Gyre (http://www.csc.noaa.gov/psc/dataviewer/#view=mdebris). Discuss the transport of plastic and floating debris across the globe's ocean. Explain that there is really only one ocean, and water moves around it in surface and deep ocean currents. As currents are deflected to the right (or to the left in the southern hemisphere), this creates a circular pattern. Water tends to "pile up" within these circular currents, called gyres. Currents concentrate marine debris in these gyres, creating what are sometimes referred to as "ocean garbage patches." A good supplemental activity that illustrates the movement of marine debris by ocean currents can be found in the Alaska Seas and Rivers Curriculum, Grade 7, Investigation 1 – Where Did the Rubber Bath Toys Go? (http://seagrant.uaf.edu/marine-ed/curriculum/grade-7/investigation-1.html)

Finally, bring the concepts of wind and current to a local level. If you are located near the ocean, discuss whether your area experiences a day breeze on hot days. This is caused when the sun heats the land, causes warm air to rise from it. This space is then filled by cool air off the ocean. The reason the winds don't come straight off the ocean? Coriolis effect! Talk about the factors that drive heat and cold in your area and how they might affect local transport of debris. Ask students to write in their science notebooks to explain a local weather or current pattern based on the information presented in this lesson. Discuss some of the areas local bodies of water are likely to "receive" debris from, and where local debris may end up. Use local drift card models to confirm predictions if available.

Wrap-Up & Extensions

Ask students to revisit the flowchart they created at the beginning of the lesson. Have them identify the different physical factors that affected the transport of their plastic piece to the ocean. These physical factors will include the movement of air and water due to density gradients and the Coriolis effect, but students should also consider such factors as tides and gravity. Ask them also to identify three ways that they could interrupt this flow of plastic to the ocean (i.e., proper disposal of plastic, recycling, reusable bags, cleaning up litter, filtering technology, etc.)

This activity pairs well with Gyre Lesson 6: Plastic Gyre Dangles.

Evaluation

The initial flow charts serve as a pre-assessment, while the revised flow charts should illustrate student understanding of how weather systems and ocean systems affect each other and the transport of solids and liquids in the ocean, as well as the connection of watersheds to the ocean. Review the science journals for understanding of basic concepts of density-based movement of water and air and how this concept can be applied to understanding of currents, wind and local weather patterns.

Sponsors

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