NWHI, CURRENTS AND POLLUTION

Concepts

Currents are the oceans major means of distributing sea water around the globe. With them they carry pollution and marine debris that has a direct effect on the shores and animals of the NWHI .

Standards Addressed

SC.8.5.1, 8.8.6, 8.8.7

Duration

1 $^{1/2}$ hour

Source Material

NOAA

Vocabulary

Currents
Surface Circulation
Deep Circulation
Gyre
Coriolis Effect

Ocean Currents

Summary

Students will learn what causes ocean currents and how they play a role in distributing marine debris and pollution around the world. They will also learn what causes the Coriolis Effect and El Nino.

Objectives

- Students will watch an internet video on ocean currents and complete a worksheet based on what the learned
- Students will practice their understanding of the Coriolis Effect by playing an internet based game on this phenomena
- Students will gain an understanding of global impacts that currents could cause due to global warming

Materials

Computer with Internet connection (audio enabled)
Ocean current handout
Ocean current worksheet

Making Connections

Students may recall personal experiences when they have experienced an El Nino year and how it differed from a 'normal' year weather-wise. They may also realize why certain marine debris that they have encountered at the beach made its way to Hawaii from other geographic areas.

Teacher Prep for Activity

Activity 1: NOAA Internet Video

Copy Ocean Current Internet Lesson worksheet so that each student has a copy. Be familiar with Ocean Current Internet Video, lesson 8 http://www.learningdemo.com/noaa/

Activity 2: Coriolis Effect

Become familiar with Coriolis Effect game on NOAA website, lesson 8 http://www.learningdemo.com/noaa/

Background

Currents are cohesive streams of seawater that circulate through the oceans. Some are short-lived and small, while others are vast flows that take centuries to complete a circuit of the globe. Currents are caused by winds, gravity, and variations in water density in different parts of the ocean. There are two distinct current systems in the oceans–**surface circulation**, which stirs a relatively thin upper layer of the sea, and **deep circulation**, which sweeps along the deep-sea floor.

The dominant pattern of surface circulation is the **gyre**–a well-organized, roughly circular flow. Five enormous gyres spin in subtropical waters, two in both the Atlantic and Pacific Oceans, and one in the Indian Ocean. Smaller polar gyres stir the northern Atlantic and Pacific. One surface current circles endlessly around Antarctica.

These gyres are made up of currents set in motion by winds and gravity, and steered by the placement of the continents and the rotation of the Earth. Wind is the most important cause of surface currents. Winds and gravity start water moving, but the currents that form don't flow parallel to the wind or straight down the steepest surface. Instead, the currents move at an angle to the force that generates them–a phenomenon called the **Coriolis Effect**. The Coriolis Effect occurs because the earth's surface rotates faster at the equator than at the poles.

Procedure

Activity 1: NOAA Internet Video on Ocean Currents

1. Distribute background information and Ocean Current worksheet packet to each student.
2. Have each student or small groups of students navigate to the NOAA website and upload the Ocean Current Lesson # 8 video (http://www.learningdemo.com/noaa/).
3. Have students begin watching Ocean Currents Internet video lesson, ~ 10 minutes. Students should be taking notes as they watch the video.
4. Upon completion of video, students should begin to answer questions provided on the Ocean Currents worksheet. If students need to go back throughout the video to locate correct answers they will have the option to do so on their computers, or they can use the background information that was provided by teacher at the beginning of the lesson.
5. If time allows, discuss question answers in class.

Activity 2: The Coriolis Effect Game

1. From the Ocean Currents lesson webpage (http://www.learningdemo.com/noaa/), have students navigate to the Coriolis Effect game.
2. Have the students read the direction and practice their knowledge of the Coriolis Effect.
3. Ask the students to raise their hand to volunteer to demonstrate how the Coriolis Effect works using the game as example.

Assessments

Questions Formulated
Worksheets Completed

Resources

http://www.learningdemo.com/noaa/

Ocean Currents [Text from http://www.learningdemo.com/noaa/ Lesson 08]

Introduction

When poets and storytellers speak of the ocean they are often struck by its constant, restless motion, from the rolling deep of the open sea to the crashing coastal surf. Even the most casual observer is impressed by the swirl of tides or the march of waves against the shore. But few note the silent, subtle passage of currents. Yet the power of currents to move and control the seas is unmatched.

Lesson

Currents are cohesive streams of seawater that circulate through the oceans. Some are short-lived and small, while others are vast flows that take centuries to complete a circuit of the globe. [The Gulf Stream Current, which shows up in this temperature coded satellite image as a broad dark orange swath, has followed this course through the North Atlantic for millennia.] In contrast, the small eddy currents that spin off the Gulf Stream die out within a few months.

Currents are caused by winds, gravity, and variations in water density in different parts of the ocean. There are two distinct current systems in the oceans–surface circulation, which stirs a relatively thin upper layer of the sea, and deep circulation, which sweeps along the deep-sea floor.

The dominant pattern of surface circulation is the gyre–a well-organized, roughly circular flow. Five enormous gyres spin in subtropical waters, two in both the Atlantic and Pacific Oceans, and one in the Indian Ocean. Smaller polar gyres stir the northern Atlantic and Pacific. One surface current circles endlessly around Antarctica.

These gyres are made up of currents set in motion by winds and gravity, and steered by the placement of the continents and the rotation of the Earth. Wind is the most important cause of surface currents. When strong, sustained winds blow across the sea, friction drags a thin layer of water into motion.

The movement of the very topmost layer of the sea pulls on the water just beneath, which then in turn starts the layer under it moving. Energy from the wind is quickly dissipated, so wind-driven currents slow down with depth, and finally die out within a few hundred meters of the surface.

Surface currents are also triggered by gravity. The top of the sea is not flat but has broad hills and valleys. Where currents converge or run into a continent, water piles up. The major ocean gyres circle around a low mound a meter or so high. And in summer, intense sunlight can heat and expand seawater, raising the surface by several centimeters in the tropics.

Currents run down these gentle slopes under the pull of gravity. Winds and gravity start water moving, but the currents that form don't flow parallel to the wind or straight down the steepest surface. Instead, the currents move at an angle to the force that generates them–a phenomenon called the Coriolis effect.

The Coriolis Effect occurs because the earth's surface rotates faster at the equator than at the poles. It influences the paths of moving objects that are only loosely in contact with the ground, from currents to winds to airplanes.

When objects move toward higher, slower moving latitudes, they outpace the rotation of the surface, and seem to veer toward the east. [If this plane left Miami heading straight at Chicago, it would miss its target unless it corrects for the Coriolis Effect.] When objects move toward lower, faster moving latitudes, they lag behind the rotation of the surface. [This plane from Valparaiso veers toward the west and misses its destination of Santa Cruz by not adjusting for the Coriolis Effect.] The Coriolis deflection is to the right in the northern hemisphere, and to the left in the southern hemisphere.

The movements of currents are also constrained by the shape of the ocean basins. When a current runs into a continent, it must turn aside. The complex interplay between wind, gravity, Coriolis Effect, and topography determines the location, size, shape, and direction of the surface current gyres. [For example, consider this North Atlantic gyre. Like all the subtropical gyres, it is triggered by 2 of Earth's prevailing winds–the trade winds and the westerlies.]

The trade winds start a current that is turned by the Coriolis Effect into a westward flow along the equator. The Equatorial Current gets warmer and warmer as it travels across the tropics. On the other side of the gyre, winds known as the westerlies, combined with the Coriolis deflection, push mid-latitude water to the east. Called the North Atlantic Current, this flow loses heat to the atmosphere.

The eastern and western currents of the gyre begin where the equatorial and mid-latitude currents are blocked by land. On the Atlantic's western boundary, the Gulf Stream moves away from the equator and flows north. The Gulf Stream is the strongest, deepest, and fastest part of the gyre, and it transports an enormous amount of heat toward the poles. Finally, the slow and very shallow Canary Current runs south along the eastern edge of the Atlantic, carrying cold water to the equator to complete the gyre. A single trip around this circuit takes about 10 years.

Although the gyres dominate, a number of other currents also make important contributions to surface circulation. For example, the very warm Equatorial Countercurrent, which flows eastward, can help trigger the unusual weather pattern called El Nino. A much colder flow, called the Labrador Current, travels along the west side of Greenland. This current is notorious for flushing icebergs, including the one that sank the Titanic, into the heavily traveled North Atlantic shipping lanes.

Many surface currents - the ones with names - have been in constant motion for millennia. Other currents are temporary–longshore, rip, and upwelling currents only run in certain seasons or weather conditions. Longshore currents flow along coastlines when waves run into the shore at an angle. They bulldoze great volumes of sand along the shore, causing beaches to disappear and harbors to fill in. Rip currents form where obstacles channel water away from the shoreline. Many an unwary swimmer and beachcomber has been swept out to sea after stumbling into a rip.

Upwelling occurs when winds push surface water away from the shore, and deeper water rises to fill the gap. These cold currents bring nutrients to the surface and stimulate high plant and animal productivity. Deep-water circulation has a scale, pace, and power very different from surface circulation. Deep currents twist together into a continuous stream that loops through all the oceans, called the global conveyer belt. With a volume more than 16 times the combined flow of all the world's rivers, the conveyer belt slowly but steadily empties one ocean into another, and over the course of 1,000 years, turns the water in them upside down.

This vast, global circulation is driven by density variations in the ocean. Sometimes called thermohaline circulation because it depends on temperature and salinity, the conveyer begins on the surface of the sea near the poles. There, the water gets very cold, chilled by low air temperatures to freezing and below. Polar seawater also gets saltier, because when sea ice forms, the salt is left behind. As seawater gets colder and saltier, its density increases, and it starts to sink toward the bottom. Surface water is pulled in to replace the sinking water, and in its turn, eventually becomes cold and salty enough to sink. Thus, a current begins.

The conveyer belt begins at the surface of the North Atlantic where great amounts of water cool and sink off the coast of Greenland. Hemmed in by the continents, this new deep water can only flow south, past the equator, all the way to the far ends of Africa and South America. As the current travels around the edge of Antarctica, fresh streams of cold water sink into and recharge the conveyer belt.

Two sections split off and turn northward, one into the Indian Ocean, the other into the Pacific. Both these currents warm up and become less and less dense as they travel, enough that they eventually rise back toward the surface. Drawn by the inexorable pull of the conveyer belt, these now warm waters loop back the way they came and eventually return to the North Atlantic to begin the long journey all over again.

Global Impact

Currents are an integral and dynamic part of the world's oceans–they help determine the characteristics and behavior of seawater, and the distribution and abundance of marine life. But currents are surprisingly important to landlocked creatures like us as well because they partially regulate the global climate and govern the productivity of fishing grounds.

Upwelling, the rise of deeper water to the surface, occurs only on 10% of the ocean. But that small area makes up half of the world's fisheries. The cool, nutrient-filled water in upwelling currents support blooms of algae and seaweed, the base of the food chain for many clams, crustaceans, and fish. Herring, anchovy, and sardines, three of the most widely harvested fish, are especially concentrated in upwelling zones. Such sea life is an increasingly large component of man's food supply.

Currents play an important role in the Earth's climate system. Overall, ocean currents moderate the planet's temperature extremes. Warm flows, like the western boundary currents, carry heat from the tropics toward the poles. Cold flows, such as the eastern boundary currents, bring cooler temperatures to low latitudes. On a regional scale, some areas are even more strongly affected. Because Western Europe is bathed in warm waters and winds coming east across the Atlantic, its climate is much warmer and milder than other areas at the same latitude, such as northern Canada and Alaska.

Although the ocean currents that affect climate are large and vigorous, scientists are beginning to suspect that they are surprisingly easy to disrupt. It is possible that global warming could severely alter current patterns, at least in the short term. If there is more rainfall in the North Atlantic, and significant melting of glacial and sea ice, a layer of warm fresh water could form at the sea surface. This layer could block the formation and sinking of cold salty water there, and turn off the global conveyer belt.

Once the conveyer belt, and its northward pull on warm surface currents, shuts down, average temperatures in much of Europe would plunge 10-20° F. Unlike many other causes of climate change, catastrophic cooling due to the loss of the global conveyer belt could be quite rapid, taking just a few years or decades.

Student Name__________________

Ocean Current Internet Lesson Questions

Instructions: Watch the internet lesson on currents and answer the following questions. All answers will be addressed on the video. You may pause and rewind in order to ensure that answers are what you believe to be correct. Please feel free to attach an extra piece of paper if needed to complete answers.

1) What is a current?
2) What three (3) things cause currents?
3) What are the two distinct current systems?
4) What is the dominant pattern of surface circulation?
5) What is the most important cause of surface currents?
6) Where are the two places where the ocean surface is highest?
7) What causes the Coriolis Effect?
8) What direction is the Coriolis Deflection in the Northern and Southern Hemispheres?
9) What four (4) factors determine the location, size, shape, and direction of a gyre?
10) What current can trigger an El Nino?
11) Where does the global current conveyor belt begin?

Ocean Current Internet Lesson Questions

1) What is a current?
   Cohesive streams of sea water that circulate through the oceans

2) What three (3) things cause currents?
   Wind, gravity, and density

3) What are the two distinct current systems?
   Surface circulation and deep circulation

4) What is the dominant pattern of surface circulation?
   Gyre

5) What is the most important cause of surface currents?
   Wind

6) Where are the two places where the ocean surface is highest?
   Near continents and where currents meet

7) What causes the Coriolis Effect?
   Earth's surface rotates faster at equator than at the poles

8) What direction is the Coriolis Deflection in the Northern and Southern Hemispheres?
   North = right, South = left

9) What four (4) factors determine the location, size, shape, and direction of a gyre?
   Wind, gravity, Coriolis Effect, and topography

10) What current is can trigger an El Nino?
    Equatorial counter-current

11) Where does the global current conveyor belt begin?

North Atlantic Ocean

Student Name__________________

Ocean Current Internet Lesson Questions (25 points total)

Instructions: Watch the internet lesson on currents and answer the following questions. All answers will be addressed on the video. You may pause and rewind in order to ensure that answers are what you believe to be correct. Please feel free to attach an extra piece of paper if needed to complete answers.

1) What is a current? (1)
   Cohesive streams of sea water that circulate through the oceans
2) What three (3) things cause currents? (3)
   Wind, Gravity, Density
3) What are the two distinct current systems? (2)
   Surface circulation and deep circulation
4) What is the dominant pattern of surface circulation? (1)
   Gyre
5) What is the most important cause of surface currents? (1)
   Wind
6) Where are the two places where the ocean surface is highest? (2)
   Near continents and where currents meet
7) What causes the Coriolis Effect? (1)
   Earth's surface rotates faster at equator than at the poles
8) What direction is the Coriolis Deflection in the Northern and Southern Hemispheres? (2)
   North=right, south=left
9) What four (4) factors determine the location, size, shape, and direction of a gyre? (4)
   Wind, gravity, Coriolis effect, and topography
10) What current can trigger an El Nino? (1)
    Equatorial counter current
11) Where does the global current conveyor belt begin? (1)
    North Atlantic Ocean

Ocean Current Internet Lesson Questions

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11) Where does the global current conveyor belt begin?

North Atlantic Ocean

Student Name______________________

Ocean Currents Post-Quiz Questions

Complete the quiz to the best of your ability with the knowledge that you now have following the lesson. This will demonstrate how much you have learned from the Pre-Quiz.

1) What is a current?

2) What three (3) things cause currents?

3) What are the two distinct current systems?

4) Where are the two places where the ocean surface is highest?

5) What current can trigger an El Nino?

Student Name______________________

Ocean Currents Post-Quiz Questions

Complete the quiz to the best of your ability with the knowledge that you now have following the lesson. This will demonstrate how much you have learned from the Pre-Quiz.

1) What is a current?
Cohesive streams of water that circulate through the oceans

2) What three (3) things cause currents?
Wind, Gravity, Density.

3) What are the two distinct current systems?
Surface Circulation and Deep Circulation

4) Where are the two places where the ocean surface is highest?
Near Continents and where currents meet

5) What current can trigger an El Nino?
Equatorial counter current