U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service

Lesson 8: Currents

Overview

Lesson 8 presents the mechanisms that drive surface and deep ocean currents. The process of global ocean circulation is presented, emphasizing the importance of this process for climate regulation. In the activity, students play a game focused on the primary surface current names and locations.

Lesson Objectives

Students will:

1. Define currents and thermohaline circulation
2. Explain what factors drive deep ocean and surface currents
3. Identify the primary ocean currents

Lesson Contents

Standards Addressed

National Science Education Standards, Grades 9-12
Unifying concepts and processes
Physical science

Ocean Literacy Principles
The Earth has one big ocean with many features

DCPS, High School
Earth Science
ES.4.8. Explain special properties of water (e.g., high specific and latent heats) and the influence of large bodies of water and the water cycle on heat transport and therefore weather and climate
ES.1.4. Recognize the use and limitations of models and theories as scientific representations of reality
ES.6.8 Explain the dynamics of oceanic currents, including upwelling, density, and deep water currents, the local Labrador Current and the Gulf Stream, and their relationship to global circulation within the marine environment and climate

Lesson Outline[1]

I. Introduction

Ask students to describe how they think ocean currents work. They might define ocean currents or discuss the drivers of currents (wind and density gradients). Then, ask them to list all the reasons they can think of that currents might be important to humans and organisms that live in the ocean. Some ideas include:

- Aid in marine navigation
- Aid the migration of marine species
- Transport nutrients
- Regulate climate
- Support the presence of marine life as human resources for fishing or recreation

II. Lecture Notes

Use the PowerPoint for Lesson 8 (File: Lesson 8 – Currents.ppt) to present the following information. Distribute the Student Handout before you begin for students to take notes on key information.

Today we're going to learn about ocean currents (slide 3)

1. An **ocean current** is a regular movement of large amounts of water along defined paths.

2. These currents move through the deep ocean and surface water.

Thermohaline circulation (THC) (slides 5 and 6)

1. **Thermohaline circulation** refers to the global circulation of Earth's ocean waters driven by density differences that are controlled by temperature and salinity. Note that "thermo" refers to temperature and "haline" refers to salinity.

2. The worldwide system of ocean currents driven by thermohaline circulation is called the "global conveyor belt."

3. The global conveyor belt is important because it in part regulates Earth's climate. For example warm waters brought from the tropics northward in the Atlantic Ocean allow North America and Europe to have somewhat moderate temperatures. Factors which might slow or stop the conveyor belt could cause changes to temperatures in Europe and other parts of the world.

What drives currents? (slide 7)

1. Density gradients, which result in layering of ocean water, drive deep ocean currents.

[1] Unless otherwise indicated, all websites provided or referenced in this guide were last accessed in November, 2010.

2. Wind is one of the primary forces that drives surface currents.

Note: After finishing the PowerPoint, you may want to pull up the NOAA website at the link below that includes an animation of the THC (on the second page). Walking through the three short pages may help the students visualize the global conveyor belt.

http://oceanservice.noaa.gov/education/kits/currents/06conveyor.html

III. Additional Web Resources

1. Background information:
   http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_1.html
   http://oceanservice.noaa.gov/education/kits/currents/welcome.html

IV. Student activity

The activity for this lesson is a game about ocean currents. The *"A Jason-1 Oceanic Adventure: Voyage on the High Seas"* board game is provided courtesy of the Jason-1 Mission, NASA/Jet Propulsion Laboratory. This game is included in the Lesson 8 folder. You may also request free hard copies of the game by contacting Annie Richardson at: annie.h.richardson@jpl.nasa.gov.

To play this game, you will need to print eight separate pages of the game board (Files: Board_1.pdf through Board_8.pdf) and tape them together as follows:

Board_1	Board_2	Board_3
Board_4	Board_5	Board_6
Board_7	Board_8	Board_9

The instructions are included in file Lesson 8 – Instructions.pdf. Other files you will need to play this game are:

- Lesson 8 – Game pieces.pdf (Note: Pennies or paper clips could also be used as game pieces.)
- Lesson 8 – Discovery cards.pdf
- Lesson 8 – Quiz cards.pdf

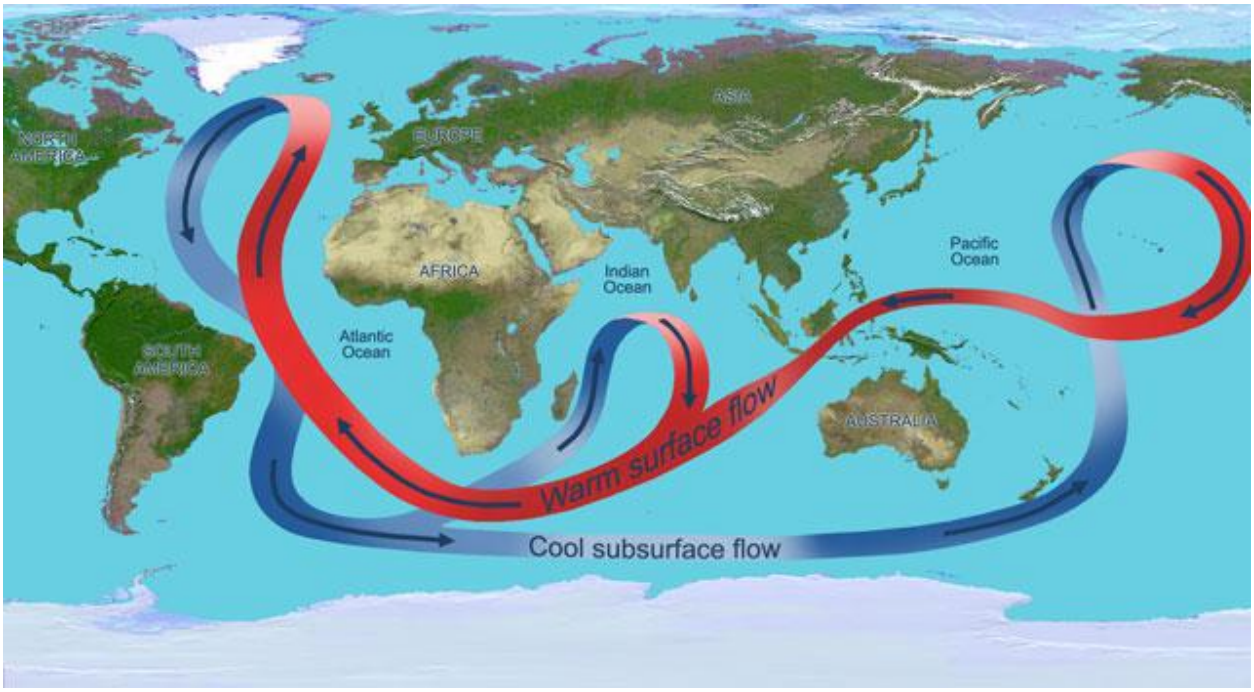
Extra quiz cards are found on the next page of this document.

Extra Quiz Cards– Voyage on the High Seas

What is the shortest route from South America to Africa? The Equatorial Countercurrent Points +5, -5	This body of water is surrounded by the North Equatorial, Gulf Stream and Canary Currents Sargasso Sea Points +5, -5	The North Equatorial Current circulates in which direction? Clockwise, or West to East Points +5, -5	This is the only current to surround a continent completely. Antarctic Circumpolar Current Points +5, -5
This current takes you down the east coast of South America. Brazil Current Points +5, -5	What is the shortest route from the east coast of Africa to south Asia? Equatorial Countercurrent Points +5, -5	The North Equatorial Current will take you from North America to this spot, the deepest part of the ocean. Marianas Trench Points +5, -5	Winds are light in an area called the doldrums and don't help increase sailing speeds. Are the doldrums closer to the equator or the poles? The equator Points +5, -5
The Gulf Stream circulates between which two continents? North America and Europe Points +5, -5	This current completes circulation in the South Pacific, moving northward along the coast of South America. Peru Current Points +5, -5	As you sail east out of Hudson Bay, which current moves you south toward the Gulf Stream? Labrador Current Points +5, -5	This current moves you from the west coast of North America south towards Mexico. California Current Points +5, -5
This current flows south from Europe toward Africa. Canary Current Points +5, -5	Which current moves near the Great Barrier Reef? East Australian Current Points +5, -5	What is the shortest route from southern Australia to the southernmost part of South America? South Pacific Current Points +5, -5	This current moves between the North Equatorial and North Pacific Currents near Asia. Kuroshio Current Points +5, -5

Tips for the Bowl – Currents

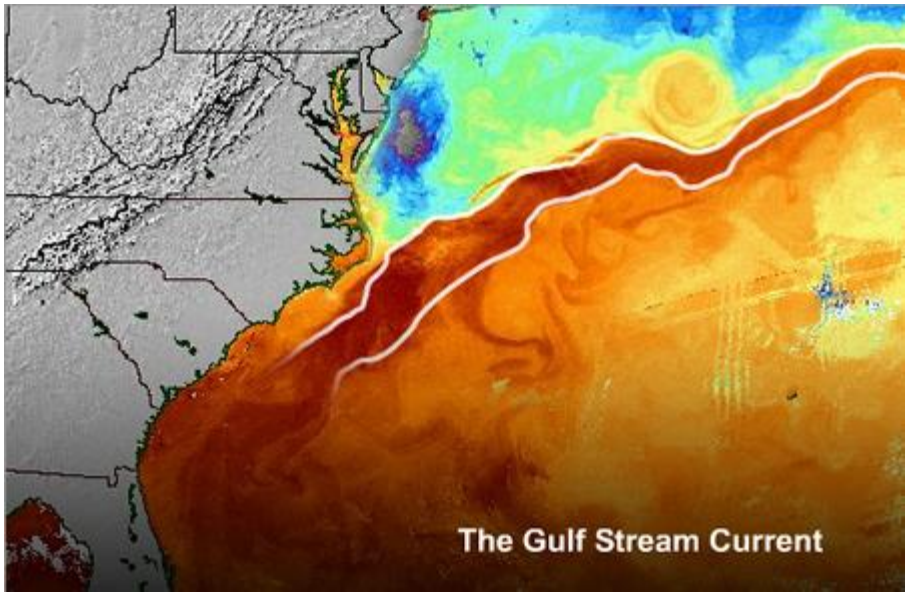
Thermohaline Circulation[2]



Coriolis Effect
The tendency of a moving object in the Northern Hemisphere to deflect right and in the Southern hemisphere to deflect left. This is why currents in the Northern Hemisphere move clockwise and those in the Southern move counterclockwise.

Boundary Currents
Boundary currents refer to currents that fall along a coastline. There are two types – **western boundary currents** and **eastern boundary currents**. They are designated as East or West in reference to the side of the ocean basin where they are located, *not* in reference to the continent. For example, The Gulf Stream occurs along the east coast of the U.S. but is considered a western boundary current because it is located on the western side of the Atlantic Ocean basin. Likewise, the California Current occurs along the west coast of the U.S., but is considered an eastern boundary current because it falls along the eastern end of the Pacific Ocean basin. Eastern and western boundary currents have different and distinct traits:

[2] Photo: http://www.jpl.nasa.gov/news/news.cfm?release=2010-101



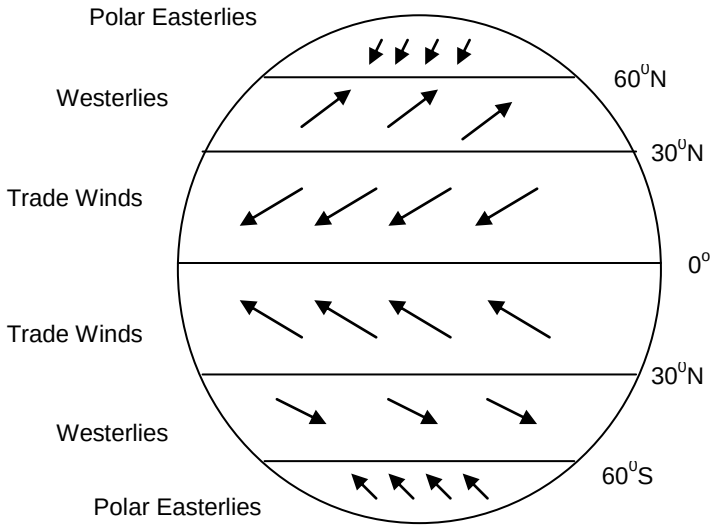
Western Boundary Currents: These currents are relatively warm, fast, deep and narrow. They also typically flow from warmer areas of the tropics to toward the poles. Examples: Gulf Stream and Kuroshio Currents[3].

Eastern Boundary Currents: These currents in contrast are relatively shallow, wide and slow. They typically flow from cooler areas toward the equator. Examples: California and Canary Currents.

Two boundary currents on both sides of Africa not included in this lesson's activity are the Agulhas Current (western boundary current on east coast of Africa) and the Benguela Current (eastern boundary current on west coast of Africa).

Global Wind Circulation Patterns

You learned about "trade winds" in class today. You should also know these global winds and where they occur!



[3]Photo: http://oceanservice.noaa.gov/education/tutorial_currents/04currents3.html

Currents

1. Short answer: This term refers to large-scale ocean circulation driven by differences in water density.
   Answer: Thermohaline circulation (or global conveyor belt)

2. Approximately how long would it take to for the global conveyor belt to complete one full cycle?
   w. 100 years
   x. **1,000 years**
   y. 10 years
   z. 10,000 years

3. Reminder question: Of the following, which is not a driver of ocean currents?
   w. Density gradients in the ocean
   x. Temperature gradients in the ocean
   y. Wind speed
   z. **Eutrophication**

4. Reminder question: Which of the following best describes water beneath the thermocline:
   w. Highly variable in temperature
   x. Warmer than most surface waters
   y. **Relatively uniform and cold in temperature**
   z. Variable by latitude

5. Reminder question: The amount of gases that can be dissolved in seawater depends on temperature and:
   w. Wind speed
   x. Depth
   y. Currents
   z. **Salinity**

6. Short answer: What is the name of the current that runs northward off the east coast of Florida toward the northeastern United States and across the Atlantic Ocean toward northern Europe?
   Answer: The Gulf Stream

7. Which of the following affect(s) the movement of ocean currents?
   w. Wind speed
   x. Land masses
   y. Wind direction
   z. **All of the above**

8. Reminder question: What is the approximate pH of typical ocean water?
    w. Around 6
    x. Around 9
    y. **Around 8**
    z. Around 10

9. The following term is another name for the global "ocean conveyor belt:"
    w. Surface current
    x. Surface circulation
    y. Thermocline circulation
    z. **Thermohaline circulation**

10. Team Challenge Question

1. What are trade winds and why are they important for human life? (2pt)

2. Winds called "westerlies" initiate and blow in which direction? (2pt)

3. If the Gulf Stream stopped running, how would the climates of North America and Europe be affected? (1pt)

ANSWER

1. What are trade winds and why are they important for human life? (2pt)
   Trade winds drive ocean currents between Europe and Africa to Central and South America (1pt). Sailors take advantage of these winds to drive their vessels (1pt).

2. Winds called "westerlies" initiate and blow in which direction? (2pt)
   Westerlies initiate in the west (1pt) and blow west to the east (1pt).

3. If the Gulf Stream stopped running, how would the climates of North America and Europe be affected? (1pt)
   The climates would be much colder.