Surface Ocean Currents

Background

Surface ocean currents are generated by the winds of the atmosphere. The surface current direction is affected by wind direction, Earth rotation, and land interference. The trade winds, westerlies and polar easterlies influence the direction of surface ocean water movement. Earth's rotation causes the movement of free moving bodies to include ocean water to be deflected. Ocean bodies in the northern and southern hemisphere deflection opposite of each other. And finally, the continental landmasses interfere with the continuous movement of ocean water. This interference is seen as ocean flow around the continents. Only in the southern hemisphere is there a continuous ocean current that can be found as ocean water flows between Antarctica and Australia.

As surface currents move they also move either of their warm or cold temperatures to new locations. The redistributing of warm water to colder locations and cold water to warmer locations helps to lessen the extreme temperatures of the equator and poles. Moderate temperatures and climate found in the mid-latitudes are the result of this warm and cold temperature mixing.

Learning Objectives

Understand winds, Earth's rotation, and land mass interference affect surface ocean current flow
Explain the mixing of extreme water temperatures to cause moderate climate

Directions

1. Using the *Ocean Currents Map and your Ocean Currents Notes*, answer the following questions in complete sentences.
2. Honors: Map where the rubber duckies traveled when they went overboard.
    a. Bonus if you can show where other items traveled that went overboard (shoes, sporting equipment, etc)

Analysis and Conclusion

1. What are names of the currents that make up the Indian Ocean Gyre.
2. What is the name of the current the travels southward along the east coast of Australia.
3. Why is the climate of the British Isles more moderate than the climate of other places at the same latitude?
4. What is the name of the current that travels uninterrupted around the earth?
5. What is the name of the current that flows southerly along the west coast of the United States?
6. Is this current warm or cold and how does it affect the climate of the west coast?
7. What are the names of the two currents that flow at the equator?
8. Name the two currents that flow in opposite directions. (Hint: Check the southern hemisphere)
9. What is the name of the current that cools the northeast boundary of the United States?
10. How would the climate of Florida be affected if the Gulf Stream were to reverse direction?
11. Because of the influence of the Earth's rotation (Coriolis effect), what is the general motion of surface currents in the North Atlantic Ocean? _____ In the South Pacific Ocean? _____

Deep Ocean Currents

Background

In addition to the wind-driven surface currents, the ocean has cold, dense currents that flow very slowly (about 4 feet per second), deep beneath its surface. These deep currents generally move much more slowly than do the surface currents. They are produced as cold, dense water of the polar regions sinks and flows beneath warmer ocean water toward the equator.

The movement of polar waters is a result of density differences. When water is cooled, it contracts, and the water molecules move closer together. This contraction makes the water more dense, and as a result, it sinks. When water is warmed, it expands and the water molecules move further apart. Because the warm water is less dense, remains above the cold water.

The higher density of polar waters is also a result of an increase in the salinity of the water. Salinity is the amount of salt to water. Salinity may increase in polar regions where water is frozen in icebergs and sea ice because when polar water freezes, most of the salt remains in the unfrozen water. Dense and more saline polar water sinks and forms a deep current that flows beneath the less dense ocean water. There is little mixing between the two layers. The deep-current layer rises only when winds blow surface water aside, causing the deep water to rise toward the surface as an upwelling.

The temperature of the water near Antarctica is close to the freezing point of the ocean water, -2ºC. The salinity is also high at 35 $^{0}/_{00}$. These two factors make the water off the coast of Antarctica the densest and coldest ocean water in the world. This dense, cold water sinks to the ocean bottom and very, very slowly moves northward. It forms a deep-water current called Antarctic Bottom Water. The Antarctic Bottom Water moves along the ocean bottom for thousands of kilometers, reaching into the northern oceans to a latitude of approximately 40º N. This dense, cold water takes several hundred years to make the trip.

The salty waters of the equatorial Atlantic are transported north by the Gulf Stream. Due to their high salinity, and the cooling that occurs at high latitudes, these waters sink, become North Atlantic Deep Water, and begin to circulate. Circulation that occurs as the result of such density contrasts is called thermohaline circulation (thermo=heat; haline=salt). Approximately half of all deep waters originate in the North Atlantic. Additional deep waters are added to thermohaline circulation by cooling and sinking in the Antarctic region, primarily in the Weddell Sea. Deep waters gradually circulate into the Indian and Pacific Oceans on a time scale of approximately 1000 years. Eventually, deep waters return to the sea surface by diffuse upwelling in these oceans, to complete the circulation (continuity of flow).

Learning Objectives

1. Explain how water temperature and salinity concentration affect the movement of deep ocean water
2. Explain how deep ocean currents and surface currents work together to create ocean conveyor system that transfers warm and cold temperatures by convection.

Analysis and Conclusion

1. Ocean water is composed of pure water and_____.
2. What causes the salinity of the ocean to change?
3. How does an increase of temperature affect the volume of ocean water?
4. How does an increase of temperature affect the density of ocean water?
5. How does a decrease of water salinity and density affect the rate of travel of deep ocean currents?

Bonus 1 to 6 points

- Predict the climate for the mid-latitude states of the United States. Be sure to support your predict with logical ideas. Use 5-10 sentences to explain.
- Name the surface currents that would carry a message in a bottle from the southeast tip of Australia to the northwest tip of Africa. Be sure to name the currents in the order in which the bottle would travel.
- Research "Deep Ocean Currents and Their Affect on Earth's Climate"
- http://www.pfel.noaa.gov/research/climatemarine/cmfoceanatm/cmfoceanatm2.html
- http://oceanexplorer.noaa.gov/facts/climate.html
- http://education.nationalgeographic.com/education/media/ocean-currents-and-climate/?ar_a=1
- http://www.nc-climate.ncsu.edu/edu/k12/.oceancirculations
- **Global Winds and Surface Currents**
  http://www.windows2universe.org/earth/Water/ocean_currents.html
  http://www.classzone.com/books/earth_science/terc/content/visualizations/es2401/es2401page01.cfm?chapter_no=visualization
- **Global Winds**
  http://earth.nullschool.net/#current/wind/isobaric/1000hPa/orthographic=-83.76,49.80,590
- **Ocean Conveyor Animations**
  http://bcs.whfreeman.com/thelifewire/content/chp58/5802003.html
  http://svs.gsfc.nasa.gov/vis/a010000/a010000/a010031/oceanconvey.mpg
- **Sea Turtles and Ocean Currents**
  http://education.nationalgeographic.com/education/media/ocean-drifters/?ar_a=1
- Then answer the following questions:
  - Explain how the Gulf Stream reaches from the North Equatorial Current to the Norwegian Sea.
  - Explain the downwelling of cold dense water in the North Atlantic Ocean.
  - What two factors affect the density of ocean water in the North Atlantic Ocean?
  - How does the North Atlantic Ocean become saltier in winter?
  - What pushes the ocean current against the eastern coast of North and South America?
  - Where is the heaviest water in the world found?
  - Explain how the ocean conveyor belt distributes cold water to the equator and warm water to the poles.
  - Explain the potential affect on Earth's climate that a disruption of the ocean conveyor belt might have.