

Oceanography Exercise 6
ATMOSPHERIC AND OCEAN CIRCULATION

Longer Answers

- (1) In atmospheric circulation near the equator, what is a Hadley cell? Explain what energy drives this circulation. A diagram with appropriate labels may help your explanation.
 - (a) How do the Hadley cells drive the Trade Winds, and why do they blow from east to west?
 - (b) What is the relationship between the Hadley cells north and south of the equator and the high salinity (36 to 37 ‰) in the surface waters of the Atlantic Ocean about 20 to 25° north and south of the equator?

- (2) The same basic physics applies to circulation in the atmosphere and the ocean.
 - (a) Diagram and describe cyclonic and anticyclonic atmospheric circulation in the Northern Hemisphere. What weather systems (high or low pressure) and weather conditions are associated with each (cyclonic and anticyclonic), and why?
 - (b) Diagram and describe a warm-core and a cold-core eddy of the Gulf Stream, and relate each to cyclonic or anticyclonic circulation. In cross sections of each eddy, how do the isotherms differ?

- (3) Explain the processes that create the gyre in the North Atlantic Ocean (i.e., the clockwise flow of surface water and the mound of water in the Sargasso Sea). This is an interaction between atmospheric circulation and ocean circulation. To help organize your answer, consider the following:
 - (a) What fairly constant wind systems start the motion of the water?
 - (b) Explain how Ekman transport (in the Northern Hemisphere) operates, and how it creates the mound of water in the Sargasso Sea. The highest part of the bulge of water is northeast of the Bahamas Islands.
 - (c) Geostrophic flow is described as a balance between a pressure gradient and Coriolis acceleration. Starting with the bulge of water in the Sargasso Sea, what is the pressure gradient, and how would water move if no other forces were acting on it?
 - (d) Once the water is moving in response to the pressure gradient, how does Coriolis acceleration change the direction of water flow? What is the resulting pattern of circulation in the North Atlantic Ocean?

- (4) What is a western boundary current? Give two examples (with names and geographic locations). Compare the flow characteristics of the western boundary current in the North Atlantic Ocean with the flow of the Canary Current on the eastern side of the basin. Why is there a difference?

The average flow of the Mississippi River is about 8000 cubic meters per second. This is equivalent to a cube of water that is 20 meters on a side ($20\text{ m} \times 20\text{ m} \times 20\text{ m} = 8000\text{ m}^3$). The flow of the western boundary current in the North Atlantic Ocean is 50 Sverdrups; a Sverdrup is a volume of flow named after a Norwegian physical oceanographer, 1 Sverdrup (Sv) is equal to one million cubic meters of water per second ($10^6\text{ m}^3 / \text{sec}$).

How many Mississippi Rivers would be needed to equal the flow of the western boundary current?

What size container is equivalent to $50 \times 10^6\text{ m}^3$ (what are the dimensions of the cube)? Is this a large swimming pool, a football stadium, or something larger?

If it is larger than a football stadium, what is the volume equivalent in number of stadiums? The Glass Bowl stadium is approximately $150\text{ m} \times 150\text{ m} \times 75\text{ m}$.

- (5) Put it all together: Explain how the atmospheric high pressure system in the central South Pacific Ocean (near Tahiti) affects upwelling along the coast of Peru, and why does this support a large population of seabirds near the Galapagos Islands.
- Diagram how the prevailing winds on the eastern edge of the high pressure cell drive coastal upwelling along Peru. Explain this in terms of Ekman transport. Include a vertical cross section perpendicular to the coast that shows the water movement and the shape of the thermocline.
 - How does this upwelling support a large fishing industry for anchovies?
 - What happens during an El Niño event?
What happens to the distribution of atmospheric pressure in the western and eastern Pacific?
What happens to the upwelling off Peru? (And why does this happen?)