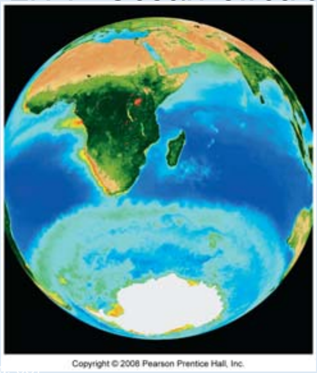
CHAPTER 7 Ocean Circulation



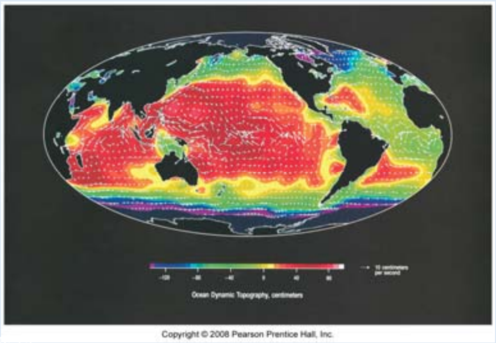
Ocean currents

- Moving seawater
- Surface ocean currents
  - Transfer heat from warmer to cooler areas
  - Similar to pattern of major wind belts
  - Affect coastal climates
- Deep ocean currents
  - Provide oxygen to deep sea
- Affect marine life

Types of ocean currents

- Surface currents
  - Wind-driven
  - Primarily horizontal motion
- Deep currents
  - Driven by differences in density caused by differences in temperature and salinity
  - Vertical and horizontal motions

Measuring surface currents



Measuring deep currents

- Floating devices tracked through time
- Chemical tracers
  - Tritium
  - Chlorofluorocarbons
- Characteristic temperature and salinity

Surface currents

- Frictional drag between wind and ocean
- Wind plus other factors such as
  - Distribution of continents
  - Gravity
  - Friction
  - Coriolis effect cause
- Gyres or large circular loops of moving water

Ocean gyres

- Subtropical gyres
  - Centered about 30º N or S
- Equatorial current
- Western Boundary currents
- Northern or Southern Boundary currents
- Eastern Boundary currents

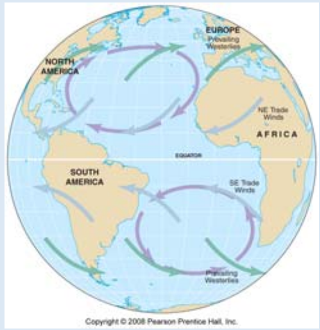


Fig. 7.4

Other surface currents

- Equatorial countercurrents
- Subpolar gyres

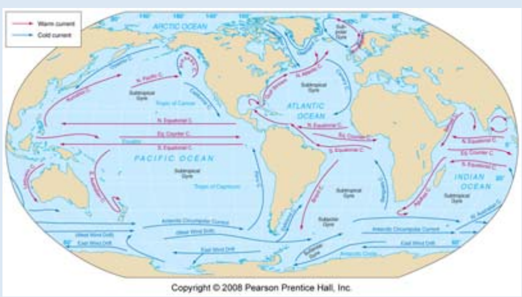


Fig. 7.5

Ekman spiral

- Surface currents move at angle to wind
- Ekman spiral describes speed and direction of seawater flow at different depths
- Each successive layer moves increasingly to right (N hemisphere)

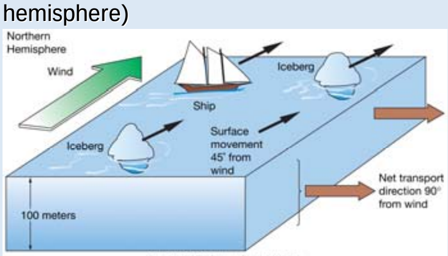


Fig. 7.6

Ekman transport

- Average movement of seawater under influence of wind
- 90º to right of wind in Northern hemisphere
- 90º to left of wind in Southern hemisphere

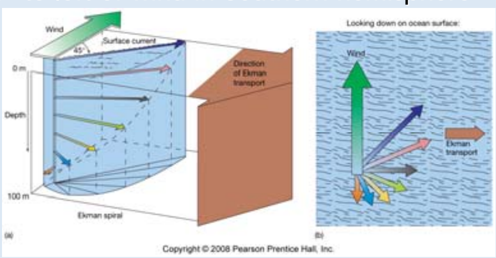


Fig. 7.7

Geostrophic flow

- Ekman transport piles up water within subtropical gyres
- Surface water flows downhill (gravity) and
- Also to the right (Coriolis effect)
- Balance of downhill and to the right causes geostrophic flow around the "hill"

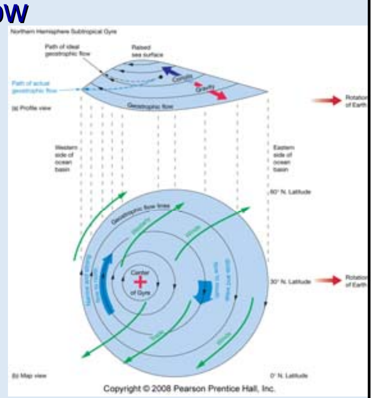


Fig. 7.8

Western intensification

- Top of hill of water displaced toward west due to Earth's rotation
- Western boundary currents intensified
  - Faster
  - Narrower
  - Deeper
  - *Warm*

Eastern Boundary Currents

- Eastern side of ocean basins
- Tend to have the opposite properties of Western Currents
- Cold
- Slow
- Shallow
- Wide

Ocean currents and climate

- Warm ocean currents warm air at coast
  - Warm, humid air
  - Humid climate on adjoining landmass
- Cool ocean currents cool air at coast
  - Cool, dry air
  - Dry climate on adjoining landmass

Ocean currents and climate

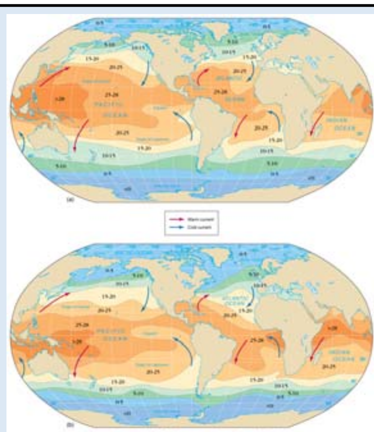


Fig. 7.9

Diverging surface seawater

- Surface seawater moves away
- Deeper seawater (cooler, nutrient-rich) replaces surface water
- Upwelling
- High biological productivity

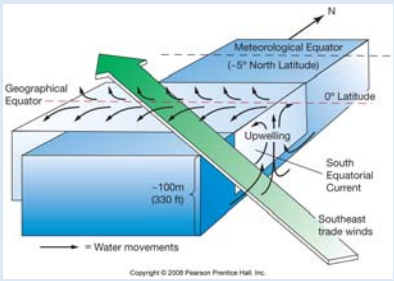


Fig. 7.10

Converging surface seawater

- Surface seawater moves towards an area
- Surface seawater piles up
- Seawater moves downward
- Downwelling
- Low biological productivity

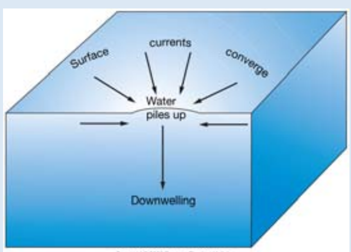


Fig. 7.11

Coastal upwelling and downwelling

- Ekman transport moves surface seawater onshore (downwelling) or
- Offshore (upwelling)

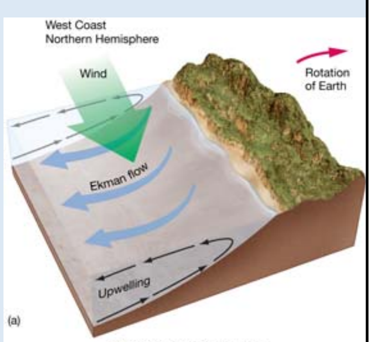


Fig. 7.12a

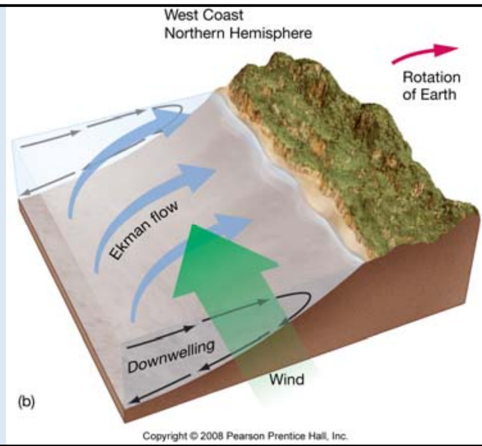
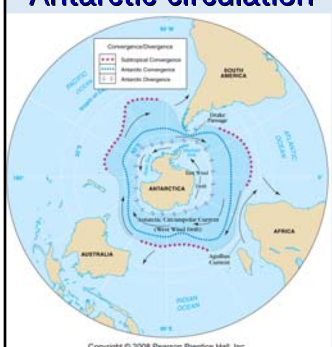


Fig. 7.12b

Antarctic circulation



- Antarctic Circumpolar Current (West Wind Drift)
- Encircles Earth
- Transports more water than any other current

Fig. 7.14

Gulf Stream

- Best studied
- Meanders or loops
- Warm-core rings
- Cold-core rings
- Unique biological populations

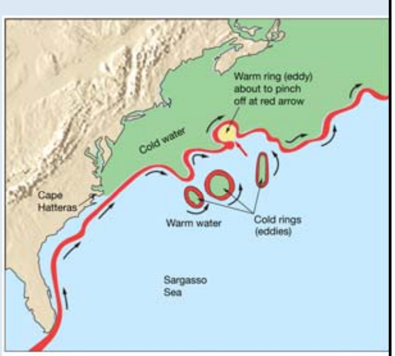


Fig. 7.17b

Atmospheric and oceanic disturbances in Pacific Ocean

- Normal conditions
  - Air pressure across equatorial Pacific is higher in eastern Pacific
  - Strong southeast trade winds
  - Pacific warm pool on western side
  - Thermocline deeper on western side
  - Upwelling off the coast of Peru

Normal conditions

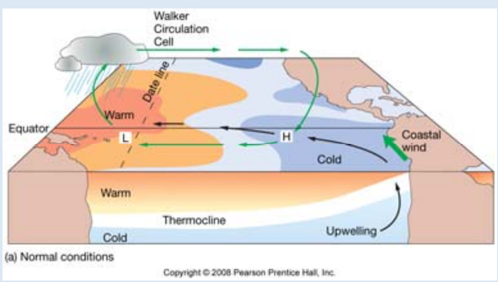


Fig. 7.20a

Atmospheric and oceanic disturbances in Pacific Ocean

- El Niño-Southern Oscillation (ENSO)
  - Warm (El Niño) and cold phases (La Niña)
  - High pressure in eastern Pacific weakens
  - Weaker trade winds
  - Warm pool migrates eastward
  - Thermocline deeper in eastern Pacific
  - Downwelling
  - Lower biological productivity
    - Corals particularly sensitive to warmer seawater

El Niño-Southern Oscillation (ENSO): Warm phase (El Niño)

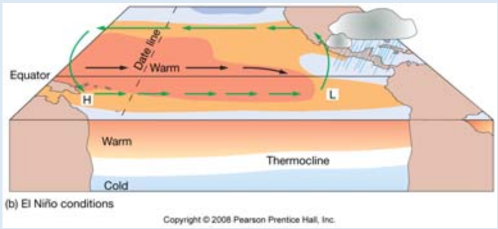


Fig. 7.20b

El Niño-Southern Oscillation (ENSO): cool phase (La Niña)

- Increased pressure difference across equatorial Pacific
- Stronger trade winds
- Stronger upwelling in eastern Pacific
- Shallower thermocline
- Cooler than normal seawater
- Higher biological productivity

El Niño-Southern Oscillation (ENSO) Cool phase (La Niña)

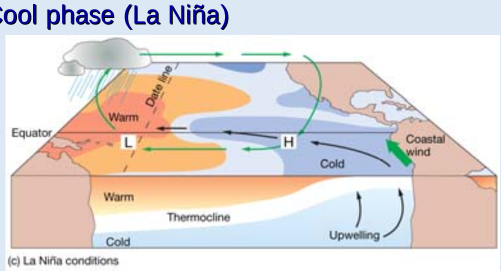


Fig. 7.20c

ENSO events

- El Niño warm phase about every 2 to 10 years
- Highly irregular
- Phases usually last 12 to 18 months

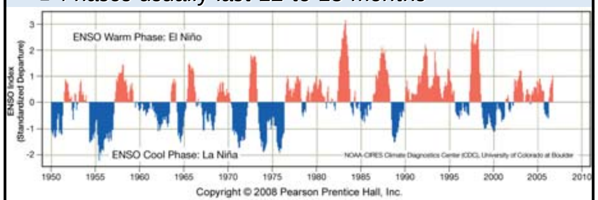


Fig. 7.22

ENSO events

- Strong conditions influence global weather, e.g., 1982-1983 El Niño
- Flooding, drought, erosion, fires, tropical storms, harmful effects on marine life

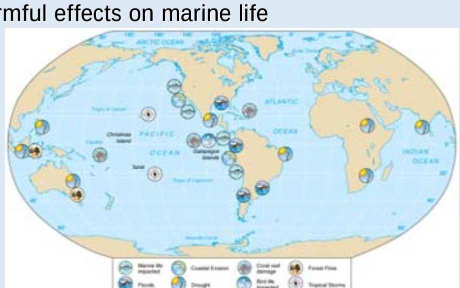


Fig. 7.21

Thermohaline circulation

- Below the pycnocline
- 90% of all ocean water
- Slow velocity
- Movement caused by differences in density (temperature and salinity)
  - Cooler seawater denser
  - Saltier seawater denser

Thermohaline circulation

- Selected deep-water masses
  - North Atlantic Deep Water
- Cold surface seawater sinks at polar regions and moves equatorward

Conveyor-belt circulation

- Combination deep ocean currents and surface

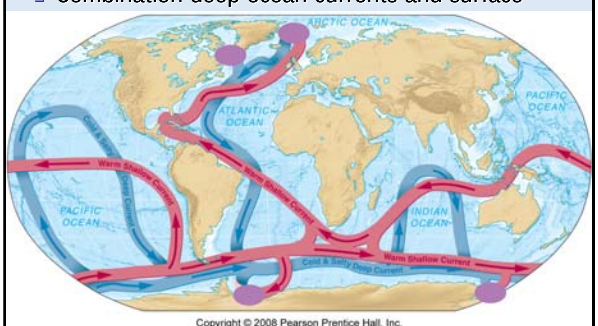


Fig. 7.27

Deep ocean currents

- Cold, oxygen-rich surface water to deep ocean
- Dissolved O_2 important for life and mineral processes
- Changes in thermohaline circulation can cause global climate change
  - Example, warmer surface waters less dense, not sink, less oxygen deep ocean

End of CHAPTER 7
Ocean Circulation