Oceanography Chapter 9

10% water in the world is tied up in the surface ocean currents.
(above the pycnocline)

- Primary source is wind: Westerlies, Trades, Polar Easterlies

Coriolis deflects winds (and water) and produces the gyres.
>>Gyres-deflection of water into a circular pattern

North Atlantic Gyre: Gulf Stream ⇒ North A. Current ⇒
Canary current ⇒ North EQ. Current

Water of depth moves of an angle to the right of the overlying water ⇒ Ekman Spiral (Fig 9.5)

- Due to friction mostly

Ekman Transport – the sum of all the arrows indicating water direction in the affected layers

- In theory, Ekman Transport is 90° to the right of the wind direction (N. Hemisphere)
  Reality ≈ 45°
- Produces hill of water in Sargasso Sea area.

Geostrophic Gyres- balance between, PGF and Corolis
(Earth Turning)

- 2 in Northern Hemisphere
- 3 in Southern Hemisphere
- WWD (Antarctic Circumpolar Current)

<u>Classified according to their location in the Gyre:</u>

1. **Western Boundary Currents-warm**
   - Gulf Stream, Kuroshio
     ⇓ Westerly Wind driven
     55 million m^3/s
     or 55 sv
   - Form Eddies (turbulent rings)
     1. Cold core –rotate counter clockwise *Table 9.1*
     2. Warm core – rotate clockwise

2. **Eastern Boundary Currents – cold**
   - CA, Benguela, Peru, West Australian
     Small 10-15 sv

3. **Transverse currents**
   - Flow E ⇒W or W ⇒E
   - Tradewind driven: N. Equatorial, S. Equatorial
   - 30 sv westward

Atlantic – 8inches higher
Pacific – 1m (3.3 feet)

Currents generated by the Tradewinds are more narrow and faster then the westerly driven transverse currents of the mid -latitudes.

The Northern Hemisphere transverse currents are interrupted by continents.

Southern Hemisphere – West Wind Drift – carries 100 sv, move than any other current.

(up to 10x)

Westward Intensification: Western boundary currents are faster, deeper, and narrower (up to 20x) then eastern boundary currents.

- Coriolis causes it to make the turn fast and spread out.
  (Figure 9.13)

<u>Countercurrents and Undercurrents</u>

Countercurrents- Flow on the surface in the opposite direction from the main current

Undercurrents- Countercurrents beneath surface currents.

- Cromwell upwells at Galapagos
- Coriolis keeps this current in line

<u>Exceptional Surface Currents</u>

1. Monsoon currents – summer, ITCZ moves north, and the winds blow from the south and the southwest – reverses Gyre to flow clockwise
   (creates Eastward moving Southwest Monsoon Current, instead of the N.E.C)
2. High Latitude Currents
   - Form when larger currents are split and deflected by collision with a continent. Labrador and Greenland currents transport nutrients to the rich fishing area of New Foundland.

Effects of Surface Currents on Climate

Heat Exchange - Transfer occurs at the mid –latitudes

Warm water currents make Northern cities more maritime. **Example:**

Cold water currents make rainfall totals lower. **Example:**

Mark Twain – “Coldest winter I ever spent was a summer in S.F.”
(compare with similar latitudes on East Coast)

DC-cold in winter (Westerly influence), humid – hot in summer

Upwelling and Downwelling (wind – induced vertical circulation)

Wind driven horizontal movement of water can sometimes induce vertical movement in surface water.

1. Equatorial Upwelling – water moving in the currents on either side of the equator is deflected slightly poleward and replaced by deeper water (Fig 9.15)
   - Makes waters nutrient rich-more biological activity
   - Layers of ooze on the Pacific equatorial seabed)

2. Coastal Upwelling – wind blows parallel to the shore, Coriolis effect deflects water to the right, and the resultant Ekman Transport (direction of Ekman Transport is 90° to the right of the wind direction – offshore) moves the water offshore. This water is replaced by rising water from below.
    - Keeps the water cold, but nutrient rich (fig 9.16)

3. Downwelling – water driven toward a coastline will be forced downward, returning seaward along the continental shelf, helps deeper critters.

Langmuir Circulation – wind that blow steady across the ocean can induce long sets of counter – rotational cells in surface water.

Fig. 9.18

- Windows – areas of convergence

ENSO (El Nino Southern Oscillation)-Fig 9.19

Trade winds diminish and than reverse, due to a High Pressure building in the western Pacific.

Results : 1. Sea level rise – 8 inches
2. More evaporation (more rainfall)

El Nino – shows up at Christmas

Normal circulation returns with vigor – La Nina

- Stronger upwelling 1982-1983 El Nino – La Chichon

Thermohaline Circulation- movement of water due to differences in density

Water masses do no easily mix (just like air masses)

5 Common Water Masses:

1. Surface water: to a depth of 200 m (600 ft)
2. Central water: to the bottom of the main thermocline (varies with latitude)
3. Intermediate Water: to about 1500 m (5000 feet)
4. Deep water: Below IW, but not in contact with the bottom, to about 4000m (13k feet)
5. Bottom water: water in contact with the bottom

Ocean is density stratified.

Visualize ocean layering – Temperature - Salinity diagram - figure 9.21

- Many combination of T&S yield the same density

ABW-Antarctic Bottom Water

- 34.65‰ salinity
- 30°F (-0.5° C)
- 1.0279 gl cc

Produced along Antarctic coasts, forms in the Waddell Sea

Flows North: Pacific = 1000 yrs to reach EQ, 600 m to reach 50°
Atlantic: 750 years to reach 40°N

NADW- North Atlantic Deep water

- very little Arctic ocean water gets into the Pacific
- water at Iceland's Latitude cools from 10°-2°C (50-36°C) and sinks

Pacific Deep water (PDW)

- forms along WWD and Kamchatka Peninsula

Both PDW and NADW are less dense than ABW, so they float above it, out of contact with the ocean bottom.

MDW – Mediterranean Deep water

- lots of evaporation (300 k km^3, 72 km^3)
- Produces very saline (38 ‰) water which flows into the Atlantic
- Sits on top of others because it is warmer, and therefore less dense

Researchers can determine the age of deep water by analyzing its DO (dissolved oxygen) content.

- Mix more and lose identity with age.

Figure 9.24 – classic model of thermohaline circulation

Convergence Zones - just like tectonics, the most dense sinks

Sometimes, you can have the same density with different temperatures. They will mix and produce a denser new water (caballing) and sink.
(Look at Fig. 9.21)

Thermohaline Time: 1600 yrs ABW
200-300 yrs to rise
Gyre – 1 year to spin

Contour Currents – faster currents – below the Western boundary currents
Convergence Zones – figure 9.26

- The most pronounced zone is the Antarctic Convergence

Distribution of heat of tropical waters
3D diagram of figure 9.27

Measuring and Studying Currents

1. Float methods

➢ Drift bottle

30k Nikes
29k Rubber duckies

2. Flow method – flows past a fixed object

Cool Gizmos
Drogue – drifts with current
Rubber Duckie
Sofar Float (3500 m)
Ekman Flow Meter – current speed and direction
Transducer for ADLP System
(Acoustic Doppler Current Profiles)

Slocum Glider – probe that uses energy from gravity buoyancy, heat and batteries to power long range exploration of water masses