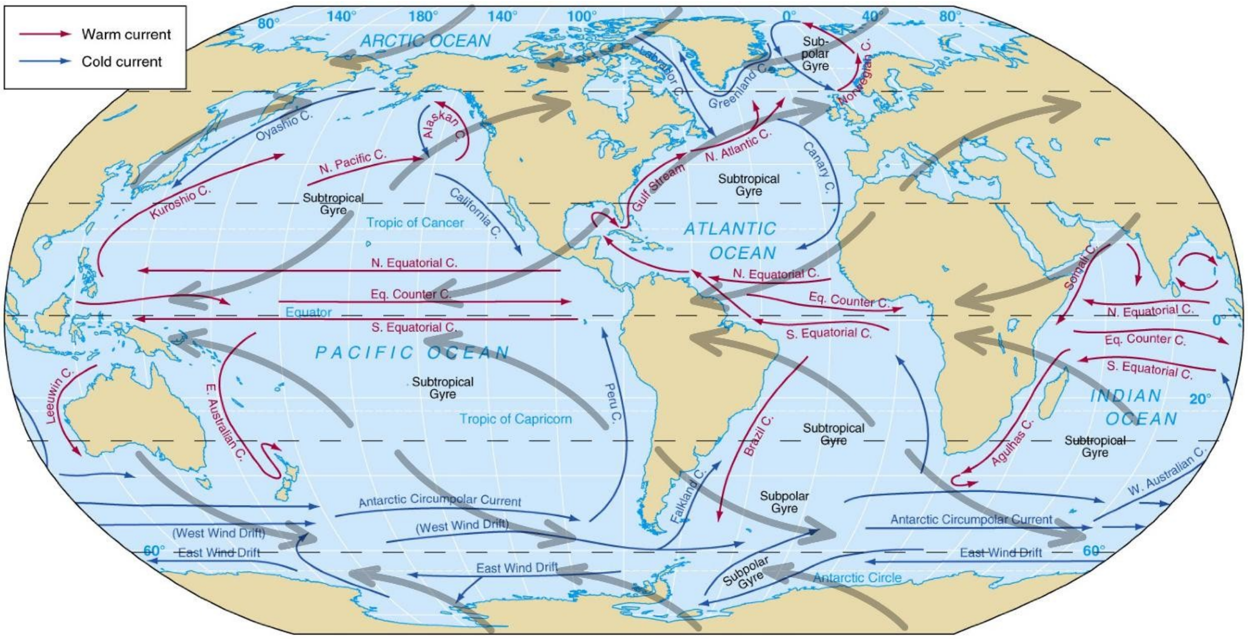
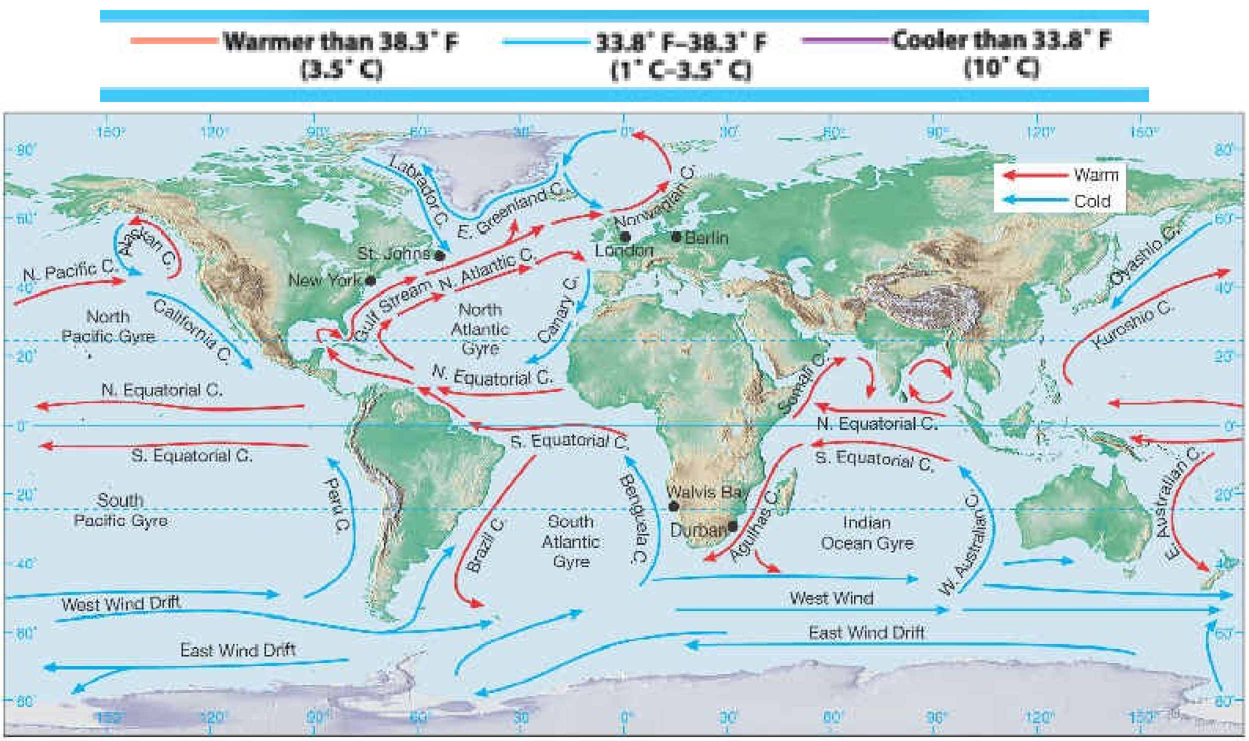
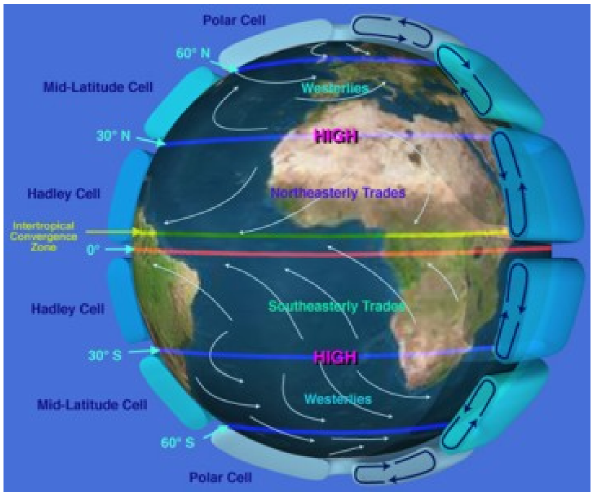
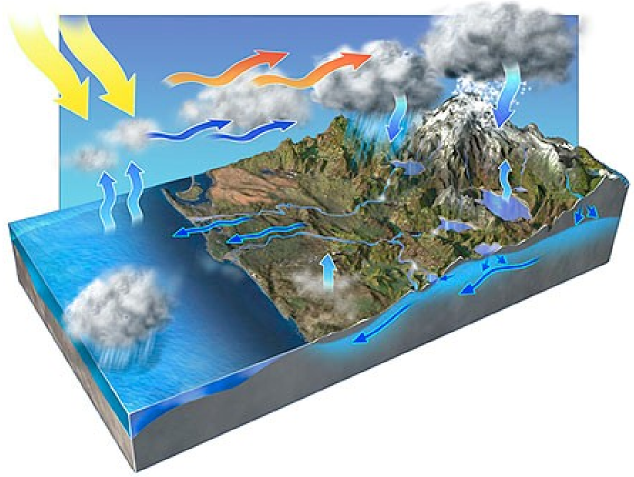
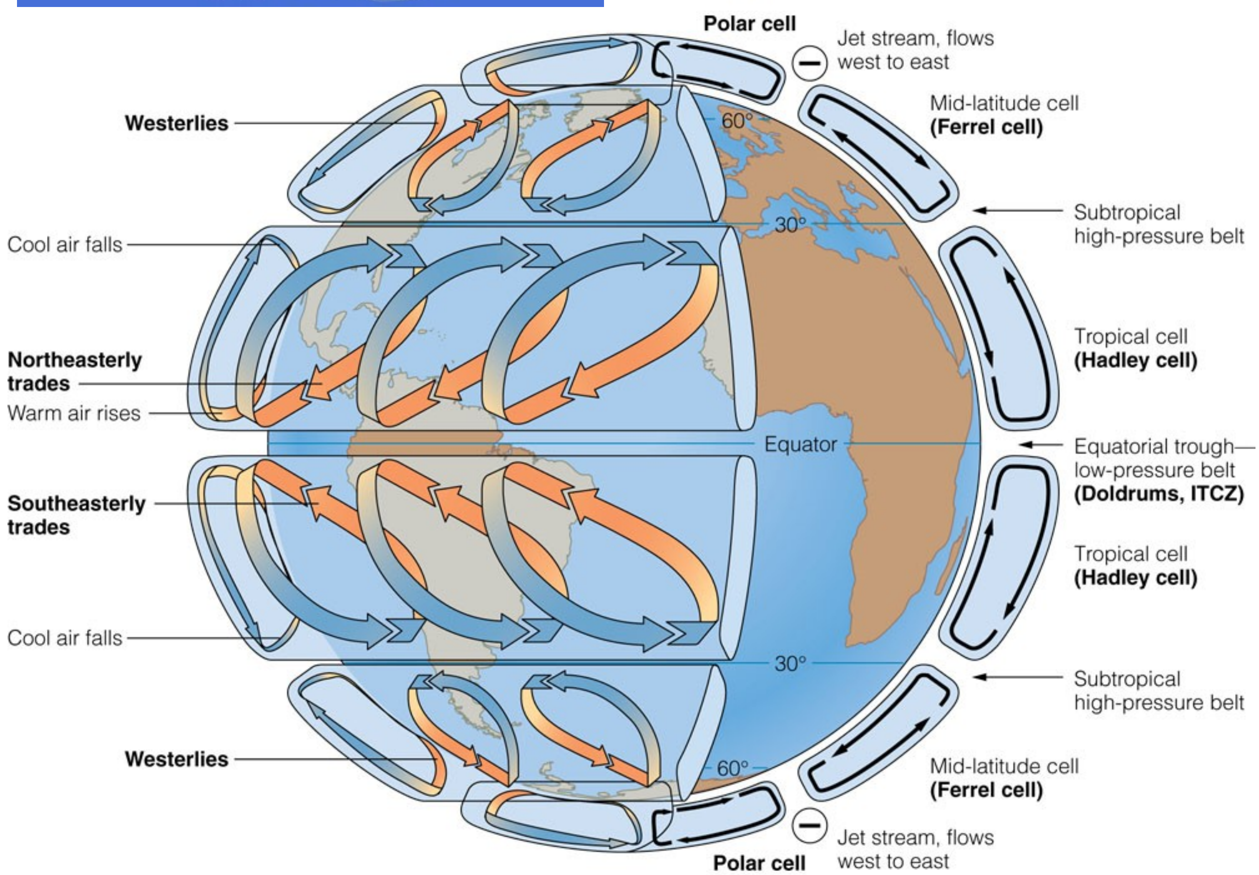
Descriptive Oceanography

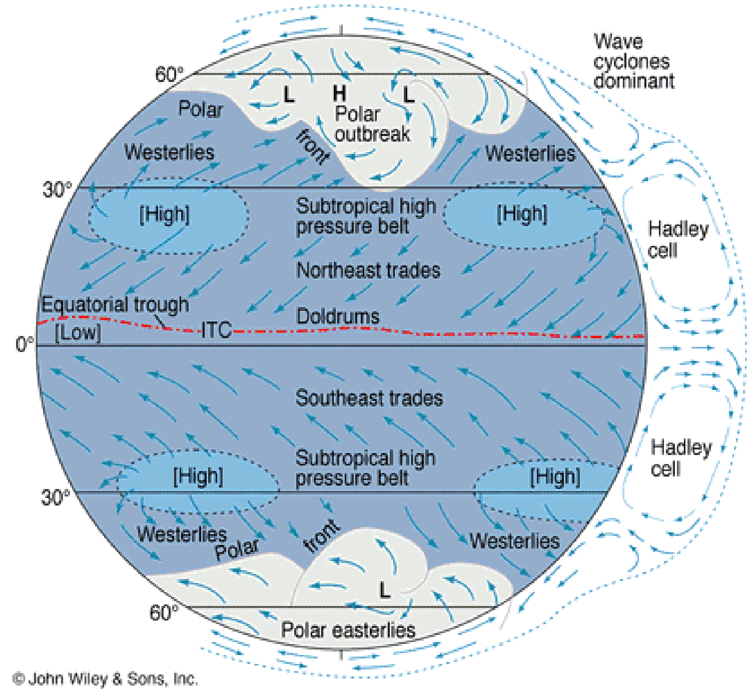


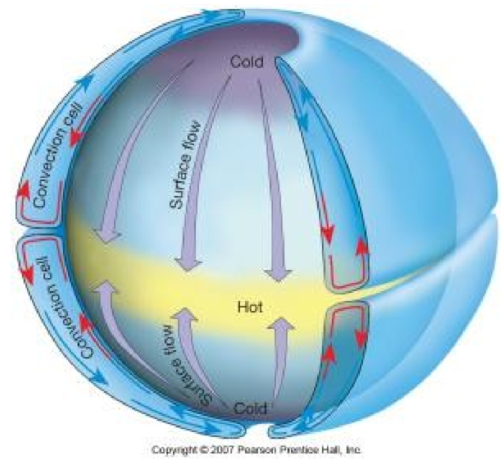


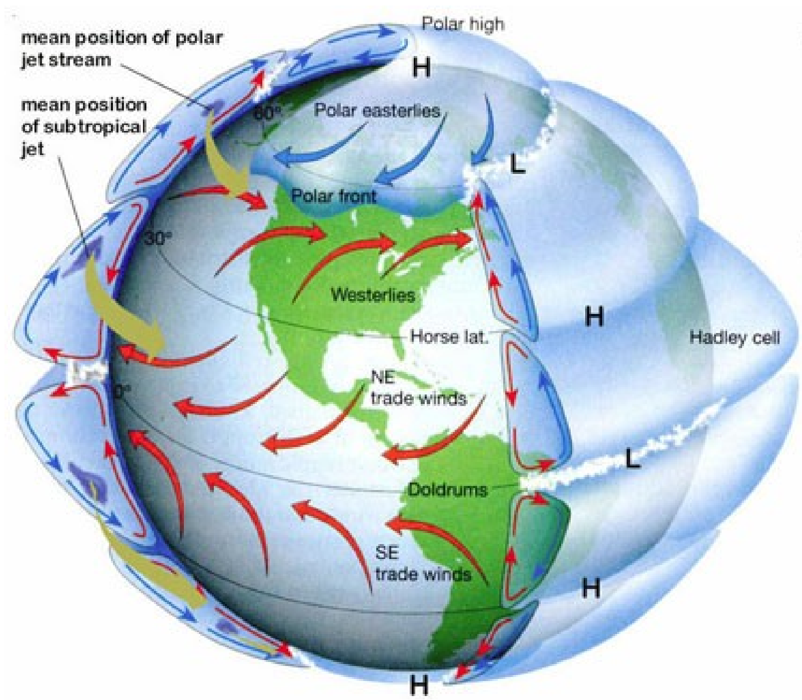

Polar Cell
60° N
Mid-Latitude Cell
Westerlies
30° N
HIGH
Hadley Cell
Northeasterly Trades
Intertropical Convergence Zone
0°
Hadley Cell
Southeasterly Trades
30° S
HIGH
Mid-Latitude Cell
Westerlies
60° S
Polar Cell




Polar cell
Jet stream, flows west to east
Westerlies
60°
Mid-latitude cell (Ferrel cell)
Cool air falls
30°
Subtropical high-pressure belt
Tropical cell (Hadley cell)
Northeasterly trades
Warm air rises
Equator
Equatorial trough—low-pressure belt (Doldrums, ITCZ)
Southeasterly trades
Tropical cell (Hadley cell)
Cool air falls
30°
Subtropical high-pressure belt
Westerlies
60°
Mid-latitude cell (Ferrel cell)
Jet stream, flows west to east
Polar cell







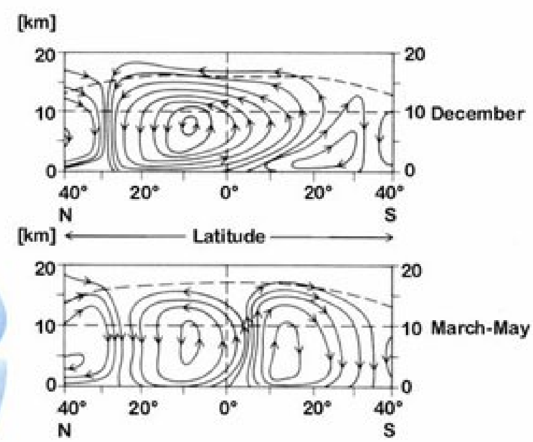
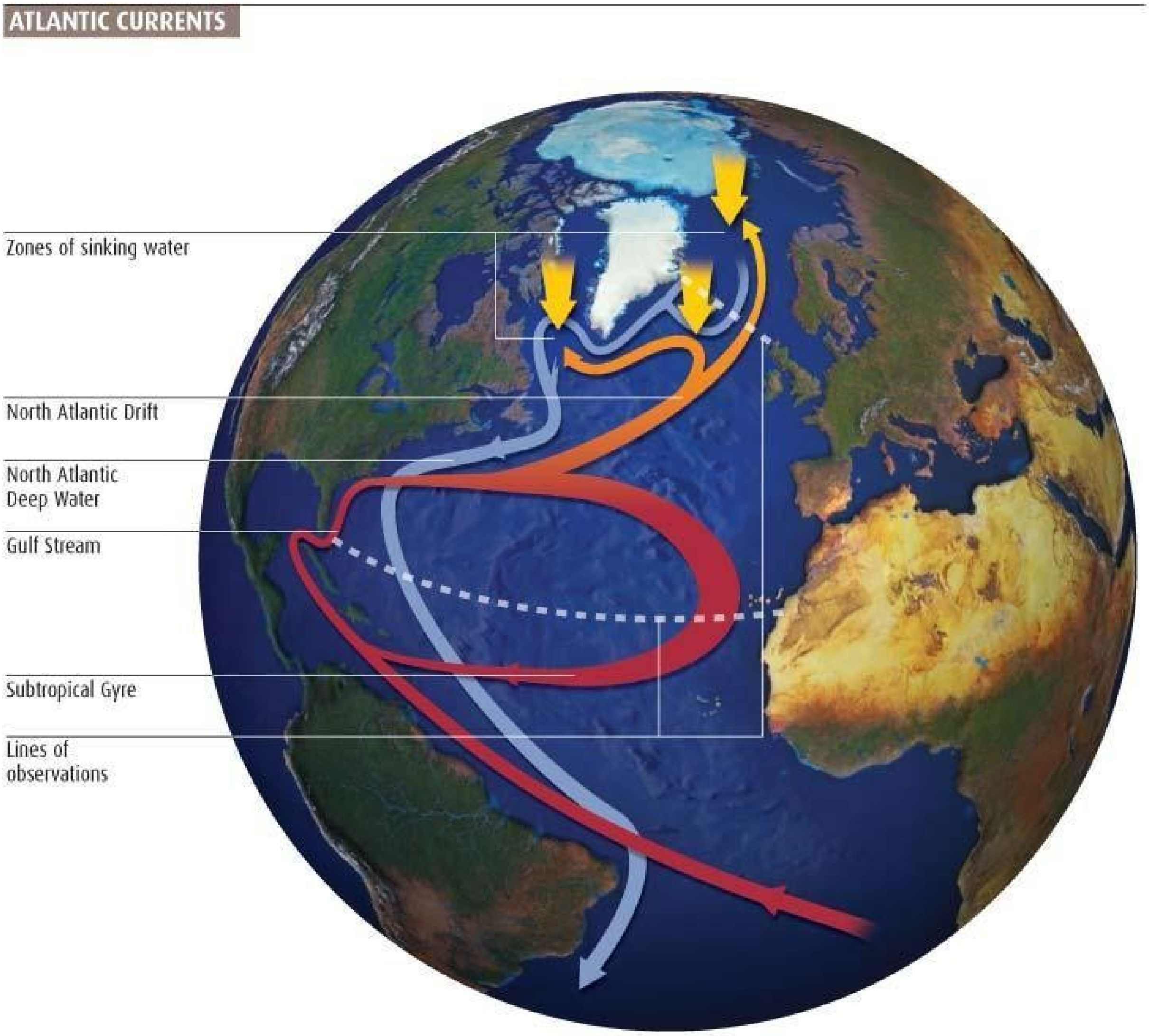
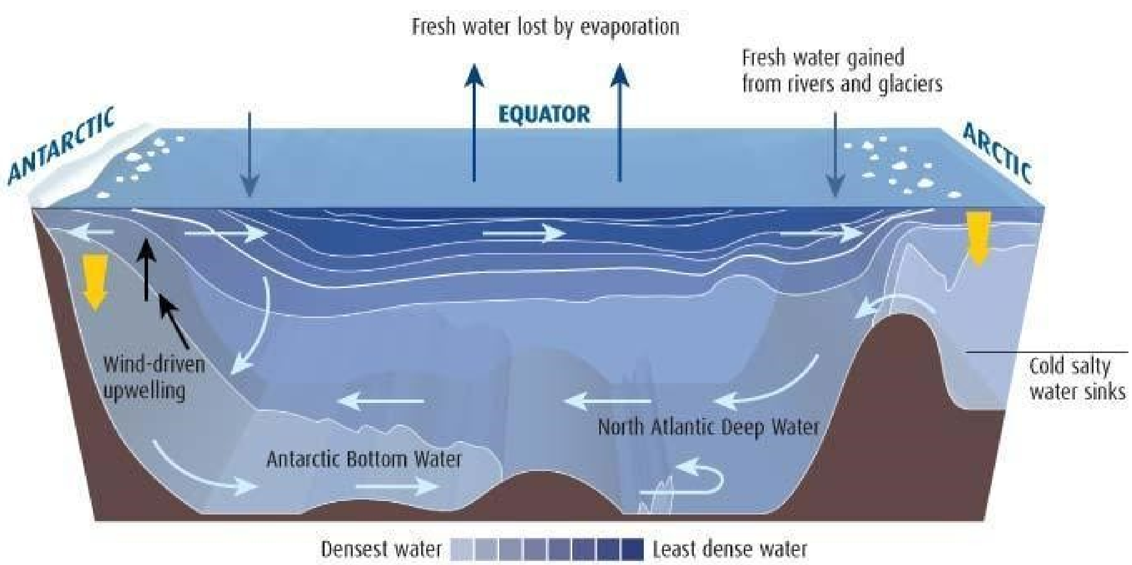
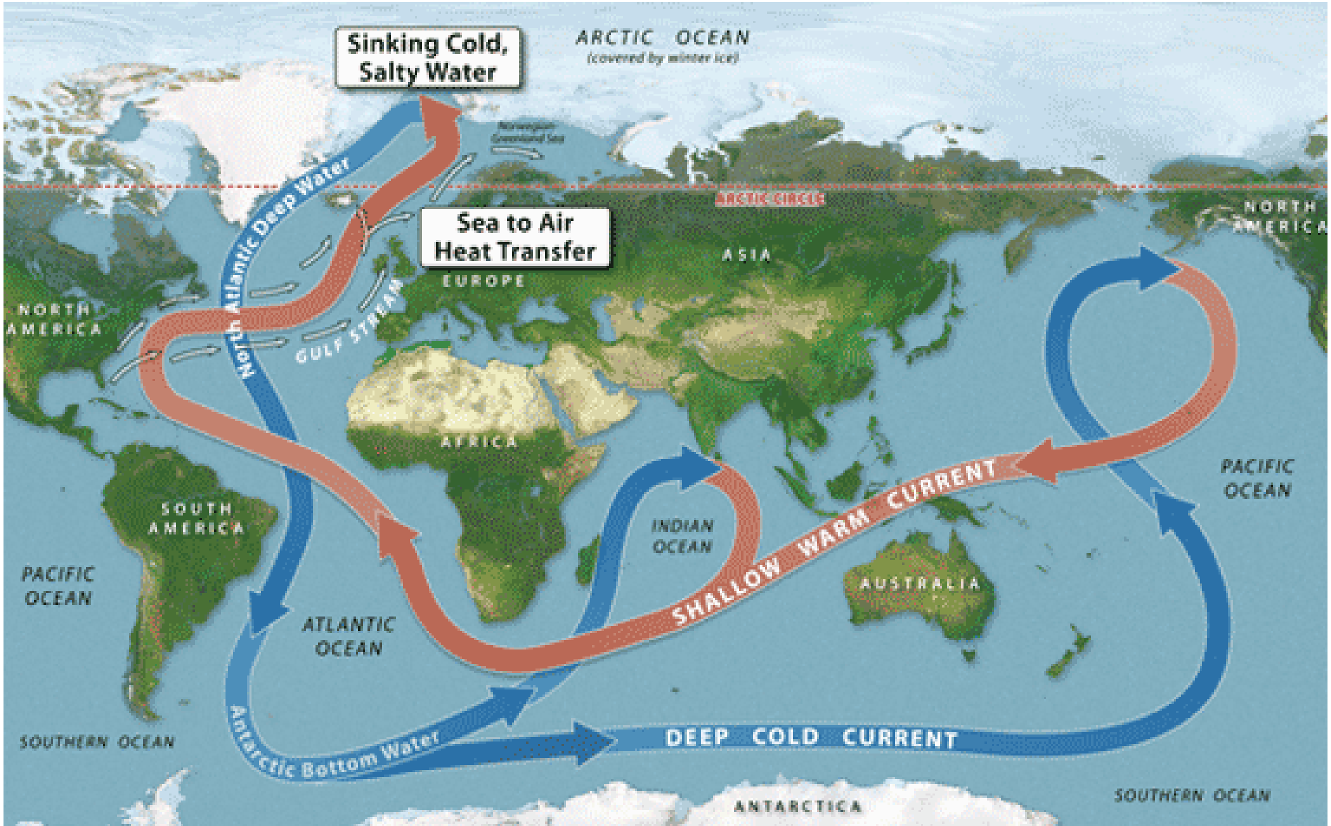
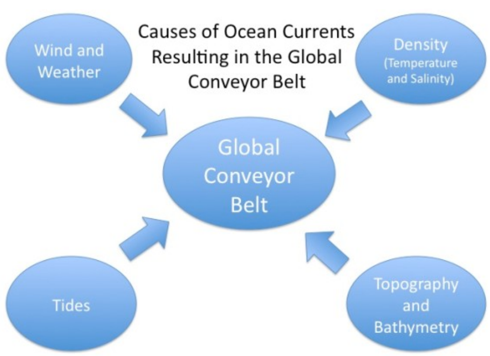


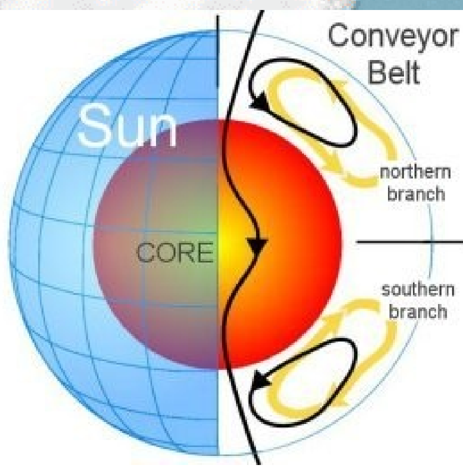
Fig.10 Idealized global circulation proposed for the three-cell circulation model of a rotating earth, left.
Right, profiles of the circulating pattern of the Hadley cells above the Pacific during the northern hemispherical winter (upper scan) and during the transitional periods (lower scan) - according to Reiter 1975

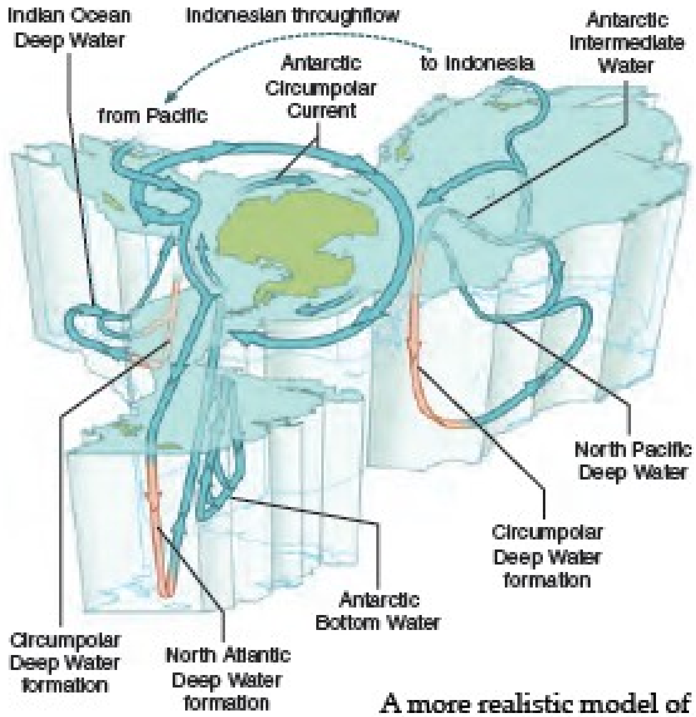

ATLANTIC CURRENTS
Zones of sinking water
North Atlantic Drift
North Atlantic
Deep Water
Gulf Stream
Subtropical Gyre
Lines of
observations


Fresh water lost by evaporation
Fresh water gained
from rivers and glaciers
EQUATOR
ANTARCTIC
ARCTIC
Wind-driven
upwelling
Cold salty
water sinks
North Atlantic Deep Water
Antarctic Bottom Water
Densest water
Least dense water

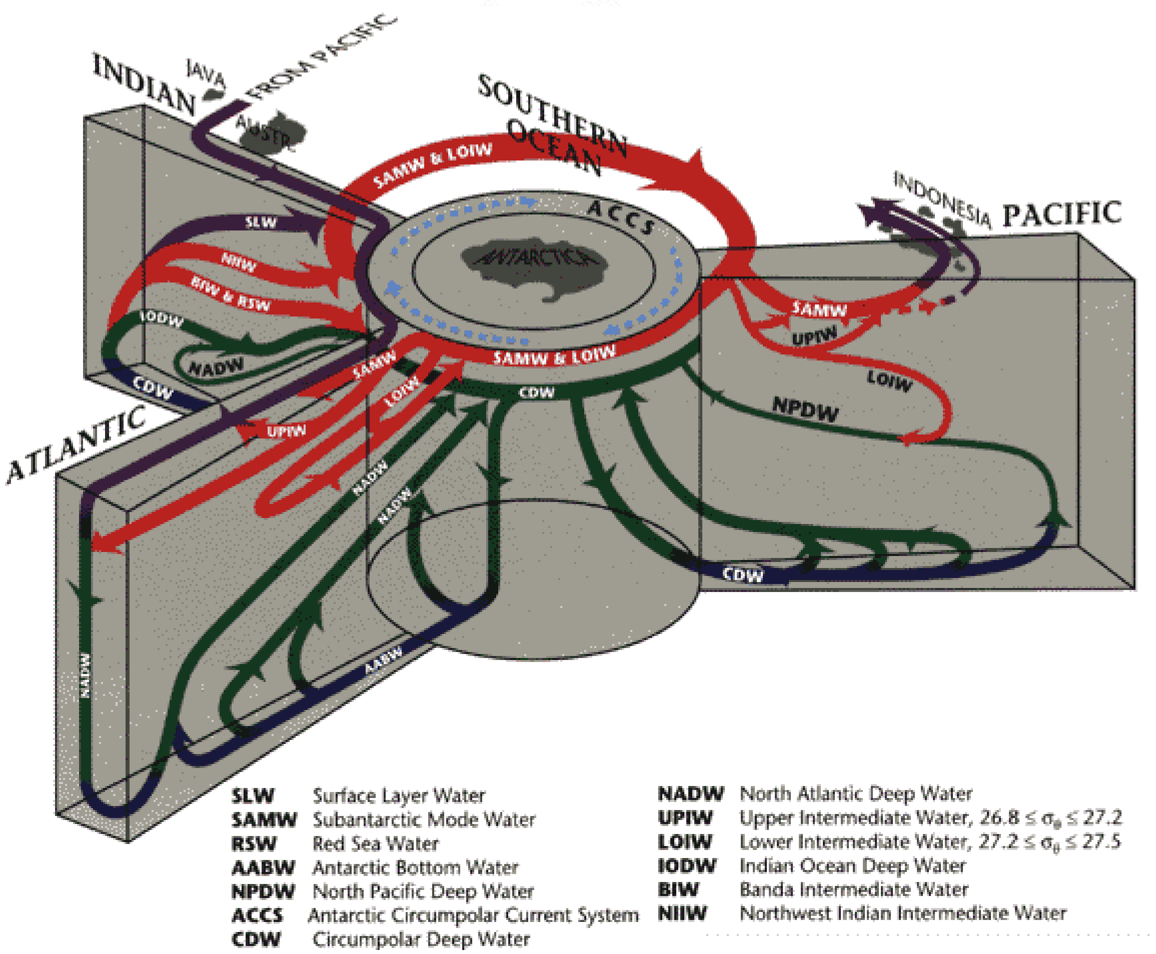

Sinking Cold, Salty Water
ARCTIC OCEAN
(covered by winter ice)
ARCTIC CIRCLE
North Atlantic Deep Water
Sea to Air Heat Transfer
EUROPE
ASIA
NORTH AMERICA
GULF STREAM
AFRICA
SOUTH AMERICA
PACIFIC OCEAN
INDIAN OCEAN
SHALLOW WARM CURRENT
AUSTRALIA
ATLANTIC OCEAN
SOUTHERN OCEAN
Antarctic Bottom Water
DEEP COLD CURRENT
ANTARCTICA


Causes of Ocean Currents Resulting in the Global Conveyor Belt
Wind and Weather
Density (Temperature and Salinity)
Global Conveyor Belt
Tides
Topography and Bathymetry


Conveyor Belt
Sun
CORE
northern branch
southern branch



A more realistic model of world ocean circulation, emphasizing the role of the Southern Ocean.



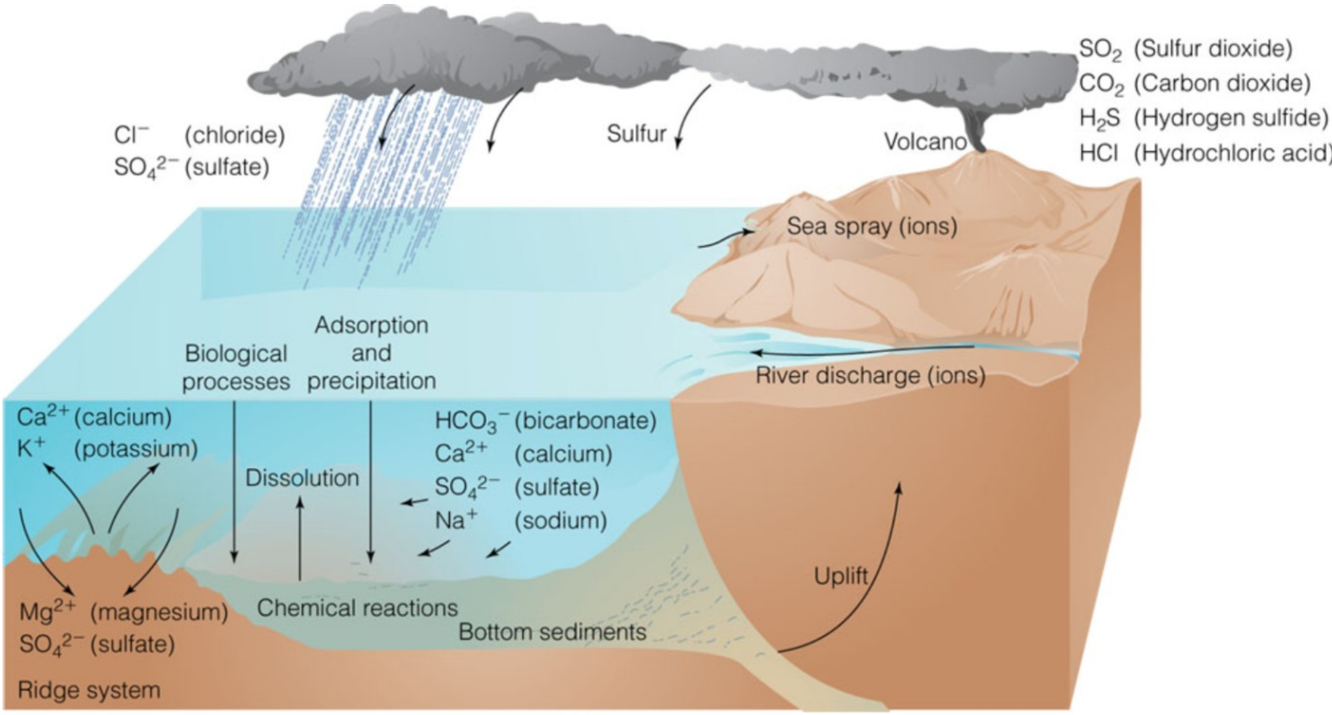
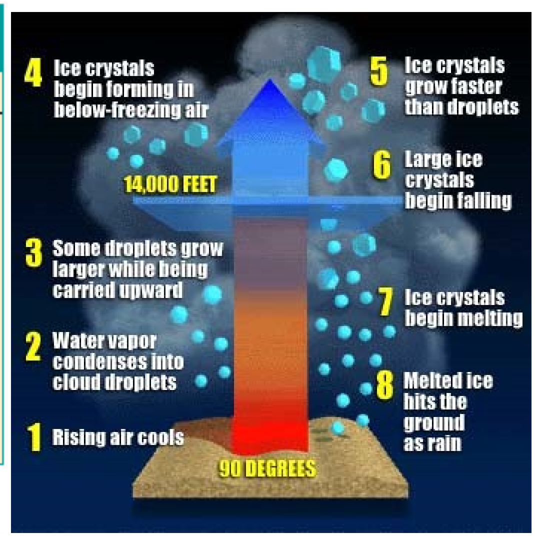
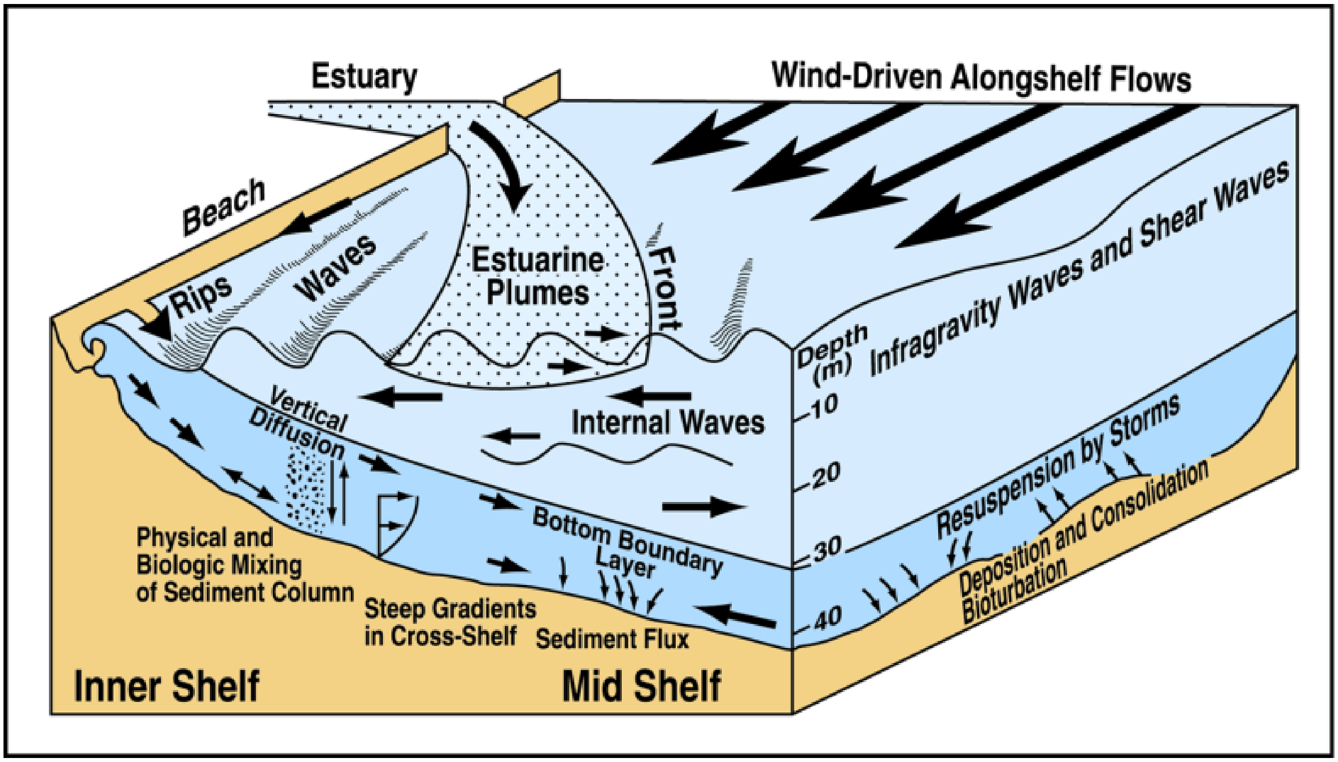


Table 7.3 Approximate Residence Times for Constituents of Seawater

Constituent	Residence Time (years)
Chloride (Cl^-)	100,000,000
Sodium (Na^+)	68,000,000
Magnesium (Mg^{2+})	13,000,000
Potassium (K^+)	12,000,000
Sulfate (SO_4^{2-})	11,000,000
Calcium (Ca^{2+})	1,000,000
Carbonate (CO_3^{2-})	110,000
Silicon (Si)	20,000
Water (H_2O)	4,100
Manganese (Mn)	1,300
Aluminum (Al)	600
Iron (Fe)	200

Sources: Data from Broecker and Peng, 1982; Bruland, 1983; Riley and Skirrow, 1975.



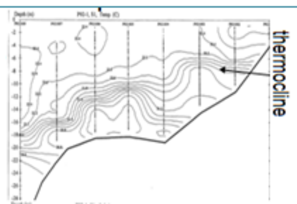
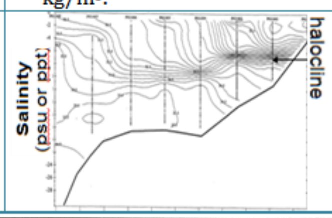
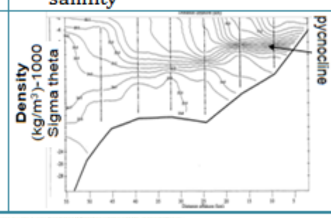
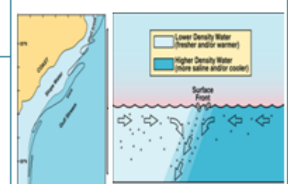

Estuary
Wind-Driven Alongshelf Flows
Beach
Rips
Waves
Estuarine Plumes
Front
Infragravity Waves and Shear Waves
Depth (m)
10
20
30
40
Vertical Diffusion
Internal Waves
Physical and Biologic Mixing of Sediment Column
Bottom Boundary Layer
Resuspension by Storms
Deposition and Consolidation
Bioturbation
Steep Gradients in Cross-Shelf Sediment Flux
Inner Shelf
Mid Shelf

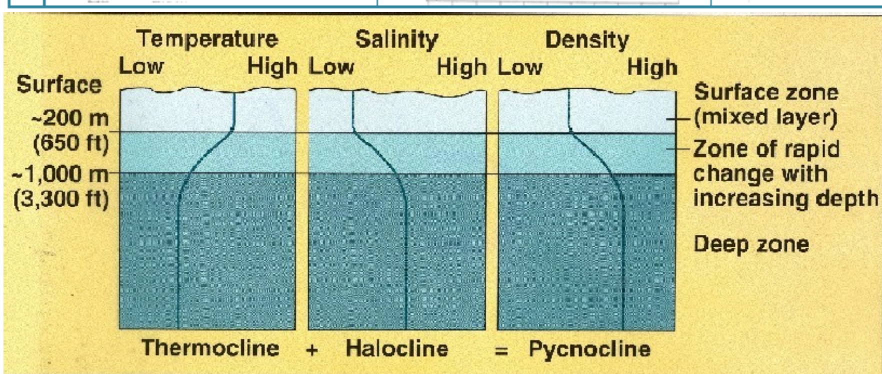
Descriptive Oceanography

Describe the **Seasonal changes** in **circulation on LA/TX continental shelf**

- During the winter the water on the shelf is cooler → denser → sinking → mixing.
- The winds are also stronger during the winter → mixing
- Thus in the winter the water is less stratified than it is during the summer

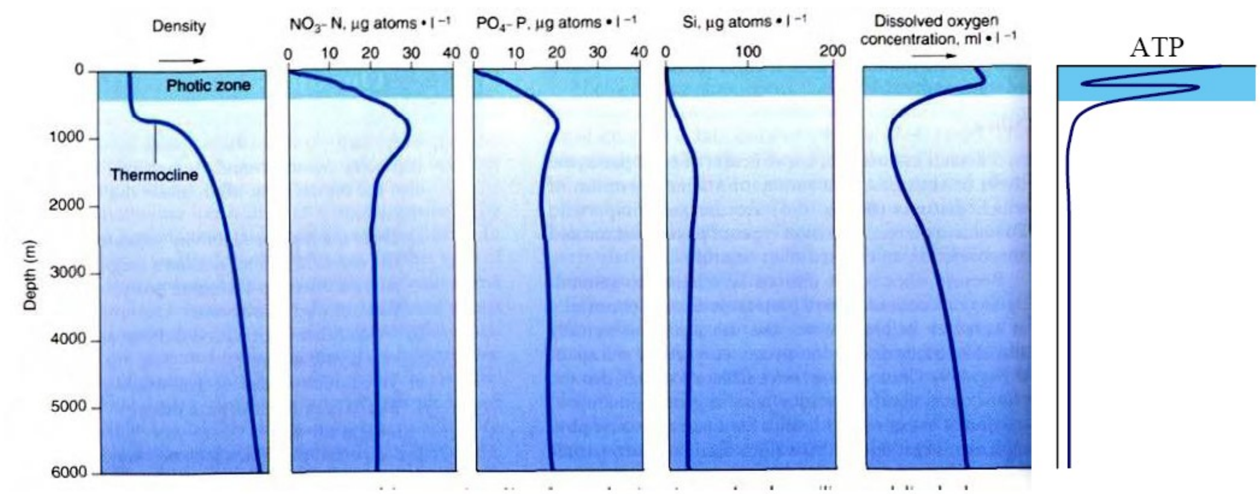
What are **thermocline, halocline, pycnocline**? Are they important on Louisiana shelf? How could they affect SST?

	Thermocline	Halocline	Pycnocline	LA Shelf
Def.	- is a layer within a body of water or air where the temperature changes rapidly with depth	- strong vertical salinity gradient	- layer across which there is a rapid change in water density with depth.	**Shelf waters are:** • **Warmer** • **Fresher (less salty)** • **Less Dense** **Gulf Waters are:** • **Cooler** • **Saltier** • **More Dense**
Affect SST	- Without temperature profiles through the water column it wouldn't be possible to determine from SST along how deep the surface layer extends - Diurnal creates an even greater problem for interpreting SST data	- Because salinity (in concert with temperature) affects the density of seawater, it can play a role in its vertical stratification. - Increasing salinity by one kg/m³ results in an increase of seawater density of ~ 0.7 kg/m³.	- In freshwater environments such as lakes this density change is primarily caused by water temperature, while in seawater environments such as oceans the density change may be caused by changes in water temperature and/or salinity	
Figures				 **Salt Water Wedge**



What are several **causes** for **SST fronts in coastal regions**?

- Surface Fronts (thermal, optical, haline) are indicative of the following types of **converging water masses**:
  1) Near-coastal fronts: rivers, estuaries, rainfall runoff events
  2) Shelf fronts: differential cooling, typical of winter
  3) Eddy advection
  4) upwelling



Density

	density	SigmaT (σ_t)
Surface Seawater	1.030	**30**
Zooplankton	1.027	**27.2**
Ocean benthos	1.031	**31**

- The density of seawater is due to temperature and salinity
- Density Equation: $\boldsymbol{\sigma_t}$ **= (density – 1)(1000)**
- There is a density gradient & the zooplankton will sink until it reaches = density (which occurs ~1000 m)

Nitrogen & Phosphorous

- Phosphorous and Nitrogen are missing at the ocean surface, because they are limiting for photosynthesis
- Redfield Ratio: Carbon (C) : Nitrogen (N) : Phosphorous (P)
  - The general rule of thumb is 50% of the carbon goes to energy & 50% to the new cell (thus 50% of the N & P are wasted)

Oxygen

- Oxygen exists in **dissolved form** in water
  - Oxygen is either **dissolved from the atmosphere** or **created by photosynthesis**
- the Oxygen minimum is where the CO_2 max is → implies respiration by organisms
- there is **more oxygen** in **cold water** than in warm water, because the O_2 molecules are agitated by the heat

ATP

- ATP profiles in water column shows there is a functioning population past 1000m depth
- The net effect of low temperature & high pressure is to slow down the metabolic rate
  - With the exception of thermal vents, life goes extremely slowly at the bottom of the ocean, thus dumping wastes is a bad idea because they will NOT be broken down at depth

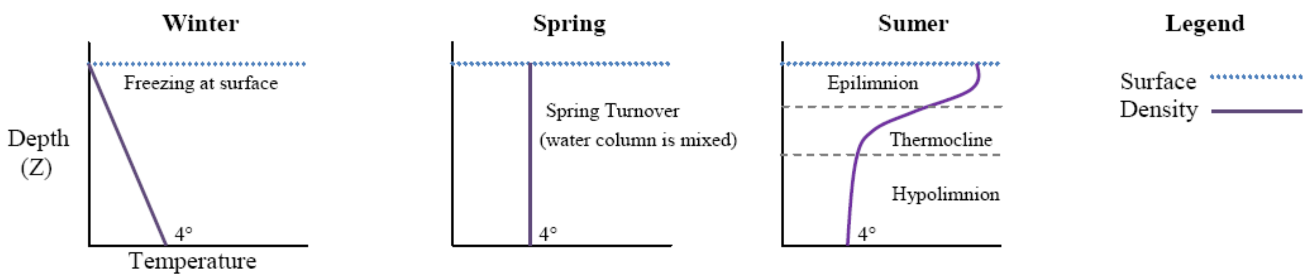
Lakes

- Although often regarded as lentic or nonflowing environments, lakes have inflows and outflows, wind-generated turbulence, and temperature-generated mixing (recall the stratification and turnover process presented in class).

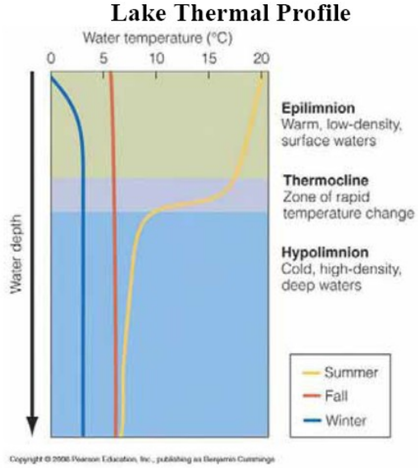
- Density increases as water freezes because of the crystal matrix formed by the freezing of water molecules
    - Due to this crystalline structure water has the same mass at 4° as it does at 0°

- Lakes undergo seasonal stratification that essentially divides the water into three zones:
    - the **epilimnion** at the surface
        - warm surface waters are much less dense, creating a stratified water column
        - high surface tension
        - high microbial abundance (~10^8)
    - the **thermocline** where there is an abrupt change in temperature and density
    - the **hypolimnion** which may become anoxic (note that the oceans have a similar thermal structure to the summer profile although the dimensions and magnitude are considerably larger)

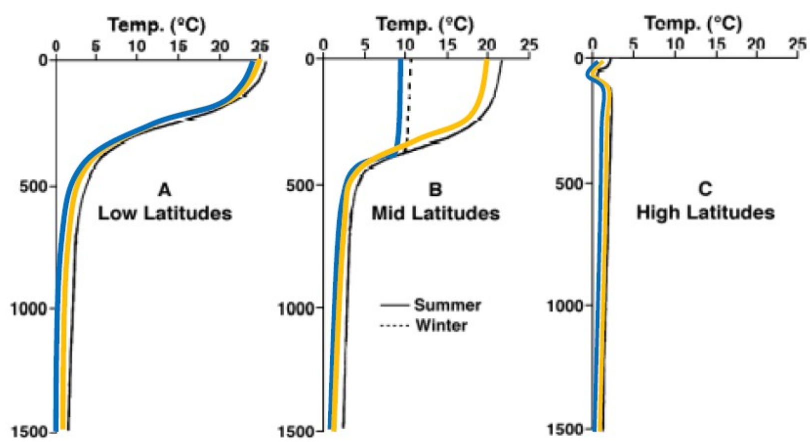
Northern Lake Seasonal Water Profile



Lake Thermal Profile



Ocean Thermal Profile



Fields and Flow Patterns

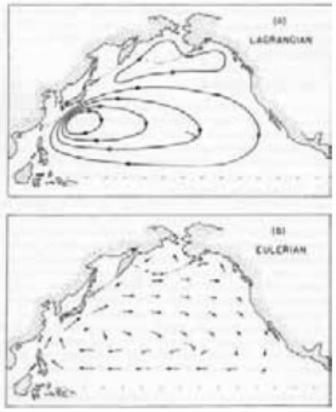
Field

- A distribution of quantity in space
- Scalar and Vector fields
- Lines of equal value (isopleths), that cannot cross or touch.
- Single value at each point.

Description of Fluid Flow

Lagrangian – Path of each fluid particle
– Drifting Buoys

Eulerian – Current value at each point
– Current Meters



Basic Physical Laws

Conservation of Mass
Conservation of Energy
Conservation of Angular Momentum

F = ma

Useful Data About the Earth and The Oceans

Size and Shape

Equatorial Radius	3963 miles	6378 km
Polar Radius	3950	6357
Average Radius	3956	6371
Equatorial Circumference	24,902	40,077

Areas of the Earth, Land, and Ocean

Land (29.2%)	57.5 x 10^6 sq. miles	149 x 10^6 sq. km
Ice sheets and glaciers	6	15.6
Oceans & Seas (70.8%)	139.4	361
Land plus continental shelf	68.5	177.4
Ocean & Seas minus continental shelf	128.4	332.6
Total Area of the Earth	196.9	510.0

Distribution of Land and Water

HEMISPHERE	LAND	OCEAN
Northern	39.3%	60.7%
Southern	19.1%	80.9%

Volume, Density, and Mass of the Earth and its Parts

	Average Thickness or Radius (km)	Volume (x 10^6 km^3) (x 10^{15} m^3)	Mean Density (x 10^3 kg/m^3)	Mass (x 10^{21} kg)	Relative Abundance (%)
Atmosphere	-	-	-	0.005	0.00008
Oceans and Seas	3.8	1370	1.03	1.41	0.023
Ice sheets & glaciers	1.6	25	0.90	0.023	0.0004
Continental crust	35	6210	2.8	17.39	0.29
Oceanic crust	8	2660	2.9	7.71	0.13
Mantle	2881	898,000	4.53	4068	68.1
Core	3473	175,500	10.72	1881	31.5
Whole Earth	6371	1,083,230	5.517	5976	