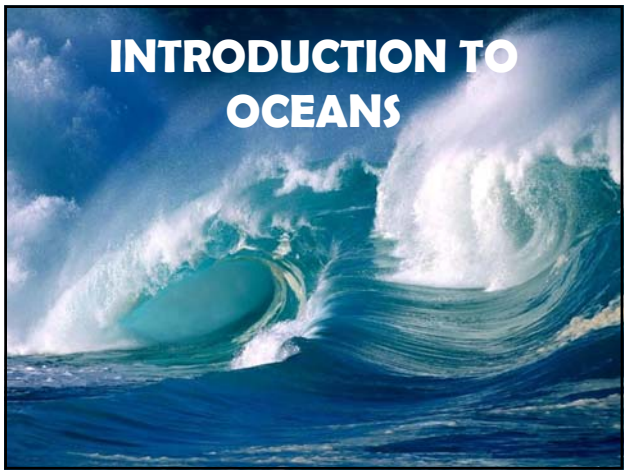
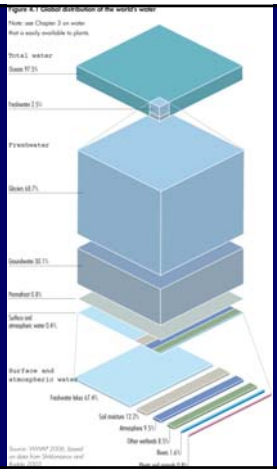



**THE OCEANS**

**97.5 % of global water too salty to drink!**

Energy cost of desalination:
2.5 – 7 kWh/m$^3$



**Physical Oceanography**

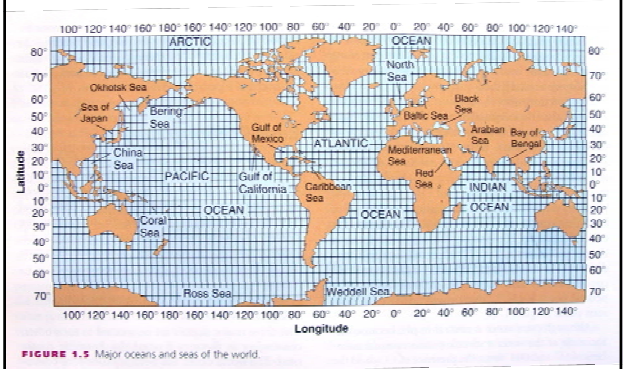



FIGURE 1.5 Major oceans and seas of the world.

Source: Nybakken, J.W. 2000. Marine Biology: An Ecological Approach. Benjamin Cummings.

**Also see Fig. 2.1**

## Ocean Geomorphology

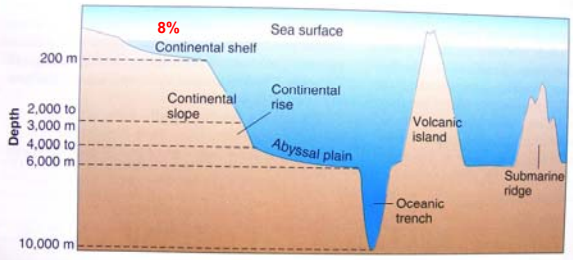



**FIGURE 1.6** Diagrammatic cross section of an ocean basin, showing the various geographic features. (Not to scale; large vertical exaggeration.)

*Source: Nybakken, J.W. 2000. Marine Biology: An Ecological Approach. Benjamin Cummings.*

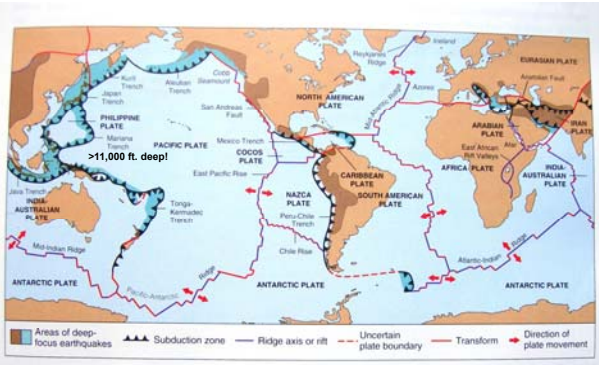


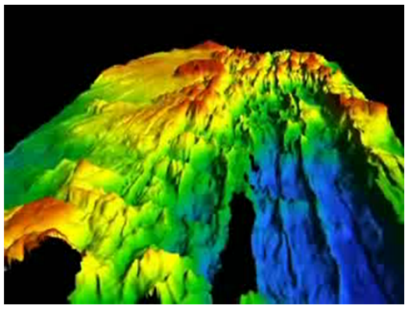

**FIGURE 1.7** Location and boundaries of the Earth's plates, midocean ridges, and trenches. Arrows indicate the direction of plate movement. (*Scientific American*, Vol. 226, No. 5, May 1972, pp. 56–57. Reproduced with permission from the Estate of Mary and Dan Todd.)

**Review Section 2.2**
**Castro & Huber 2016**

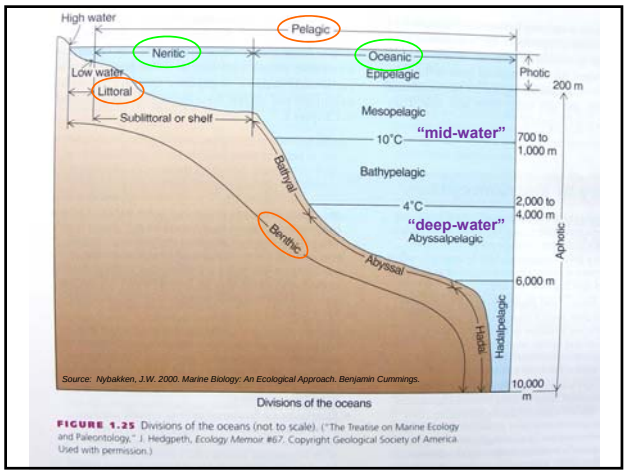
*Source: Nybakken, J.W. 2000. Marine Biology: An Ecological Approach. Benjamin Cummings.*

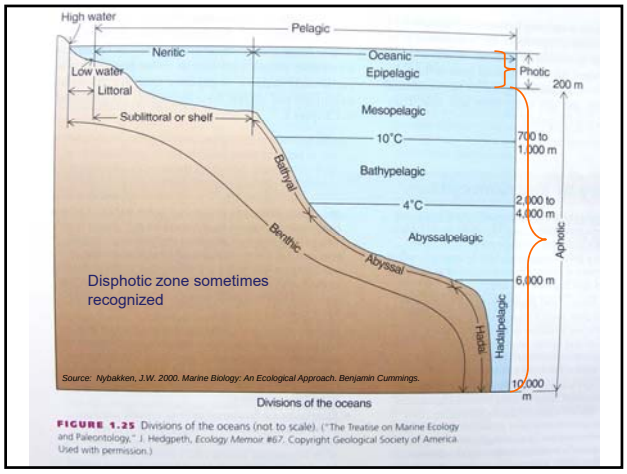
## Mapping the Ocean Floor

**Multibeam sonar**

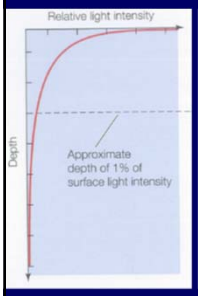


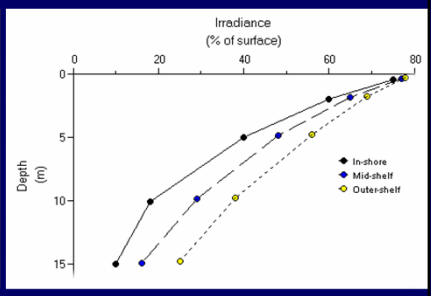
**Review Sec. 1.1; See Figs. 2.6, 2.21. 2.22**




## Vertical Gradients - Light




**Light declines exponentially with depth**
**~90% of ocean volume has *no light***

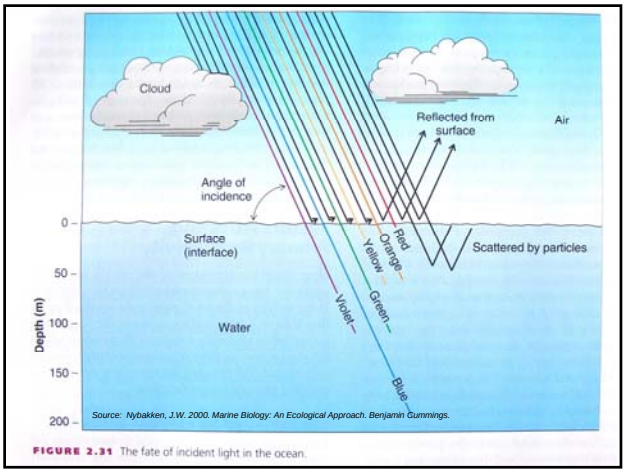



FIGURE 2.31 The fate of incident light in the ocean.

## Properties of Sea Water

**Recall properties of water!**

**Salinity = total amount of dissolved material (practical salinity units – psu)**

- **96.5% water, 3.5% dissolved substances**
- **salinity ~35 $^{o/oo}$ (parts per thousand): Range 34-37 psu**
  - ***think: where is it higher or lower?***
- **halocline = salinity gradient**

***Most processes that affect salinity occur at the surface!*** **(read pg. 55)**

## Properties of Sea Water

**Dissolved Materials (~3.5% of seawater)**

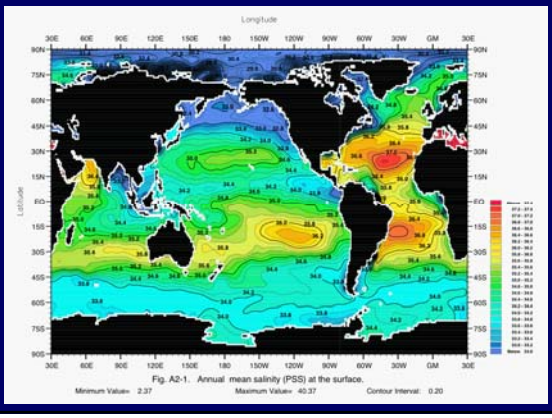
- **99.3% inorganic Salts: $Cl^-$, $Na^+$, $SO_4^{2-}$, $Mg^{2+}$, $Ca^{2+}$, $K^+$**
- **0.6% minor ions: $HCO_3^-$ (bicarbonate), trace metals**
- **<0.1% trace elements: $NO_3$, $PO_4$, $SiO_2$, Fe, Cu: limit productivity**

***Review on you own:***
***Leibig's Law of the Minimum***

Table 3.1
The Composition of Seawater of 35‰ Salinity

| Ion | Concentration ‰ | Percentage of Total Salinity |
|---|---|---|
| Chloride ($Cl^-$) | 19.345 | 55.03 |
| Sodium ($Na^+$) | 10.752 | 30.59 |
| Sulfate ($SO_4^{2-}$) | 2.701 | 7.68 |
| Magnesium ($Mg^{2+}$) | 1.295 | 3.68 |
| Calcium ($Ca^{2+}$) | 0.416 | 1.18 |
| Potassium ($K^+$) | 0.390 | 1.11 |
| Bicarbonate ($HCO_3^-$) | 0.145 | 0.41 |
| Bromide ($Br^-$) | 0.066 | 0.19 |
| Borate ($H_2BO_3^-$) | 0.027 | 0.08 |
| Strontium ($Sr^{2+}$) | 0.013 | 0.04 |
| Fluoride ($F^-$) | 0.001 | 0.003 |
| Other dissolved material | <0.001 | <0.001 |

## Sea Surface Salinity Map




## Properties of Sea Water

**Density** of pure water = 1 g/ml

- increases with incr. salinity
- increases with decr. temperature to freezing point -1.9°C
  - thermocline = temperature gradient
  - pycnocline = density gradient

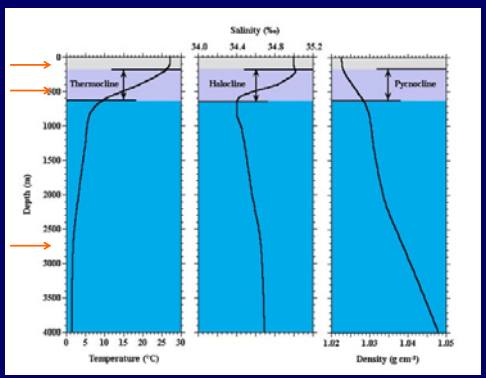
## Vertical Stratification

mixed layer

intermediate layer

deep layer

Also:
*Pressure* increases 1 atm every 10 m




See Figs. 3.22 and 3.14

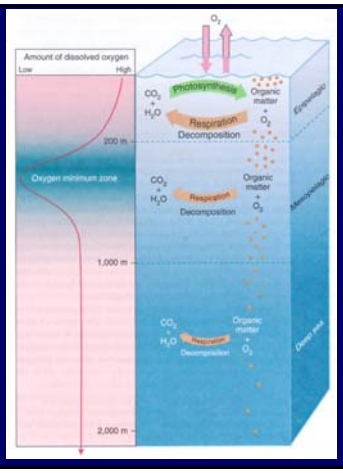
## Properties of Sea Water

Gases: solubility ↓ with ↑ temperature

- $O_2$ : less in seawater than air *0-8 ml/L vs. 210 mL/L*
- $CO_2$ : more abundant in seawater than air *0.04% vs 80% of dissolved gasses*
- inorganic carbon buffers pH (~ 7.4 - 8.4)

$CO_2 + H_2O = H_2CO_3 \Longleftrightarrow H^+ + HCO_3^- \Longleftrightarrow 2H^+ + CO_3^{2-}$

3 forms of inorganic carbon: carbonic acid, bicarbonate, carbonate
trace ~90% ~10%




**OXYGEN MINIMUM ZONE (OMZ)**

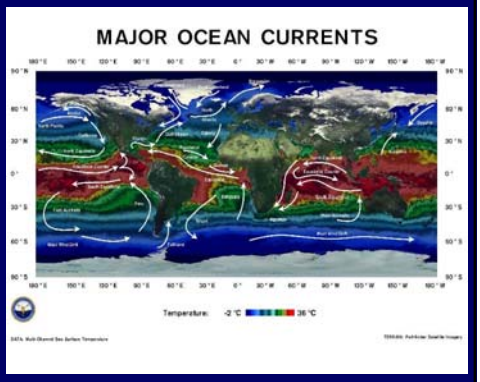
(see Castro & Huber Fig. 16.18)

## Horizontal Heterogeneity

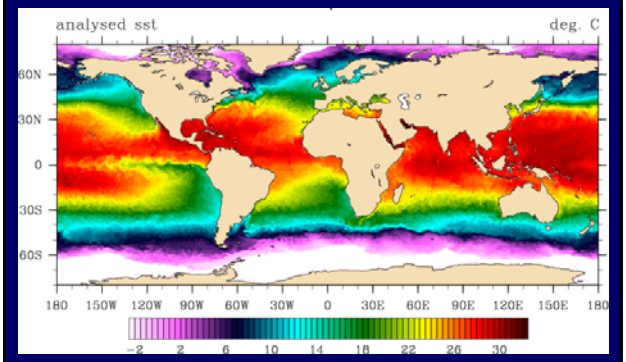
- Salinity
- Temperature
- Light

*Due to global patterns of rainfall, evaporation, and surface currents*

- Global scale
- Regional scale
- Local scale



## Sea Surface Temperature Map




## Vertical & Horizontal Heterogeneity

Gives rise to patterns of:

- Biodiversity
- Productivity