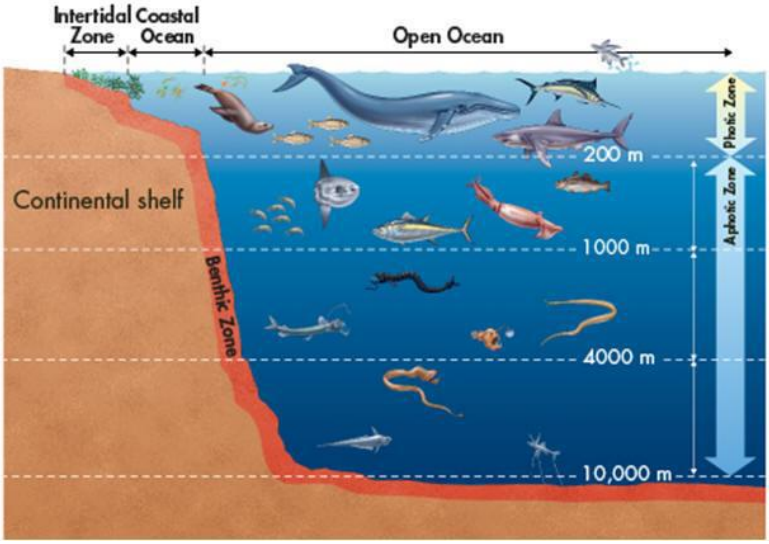
L1C Life in the Aquatic Environment (TW)

Our Water Planet

- 71% of Earth's surface is water ⇒ 300x more space for life than land and freshwater combined
- Deepest ~11,000m, average 3,800m
- Oceans formed ~4.4-3.5bya (lot of time for life to evolve since)
- More phyla in sea than on land and in freshwater (most are undescribed!)
- Almost all bodies of water contain a wide variety of communities governed by abiotic and biotic factors (e.g. light, salinity, nutrients and oxygen)



Life in the Sea

- Appears harsh to us
- BUT life evolved in the seawater (we think due to):
  - Most water on Earth is in the oceans
  - Many phyla of animals live in saltwater, fewer live in freshwater

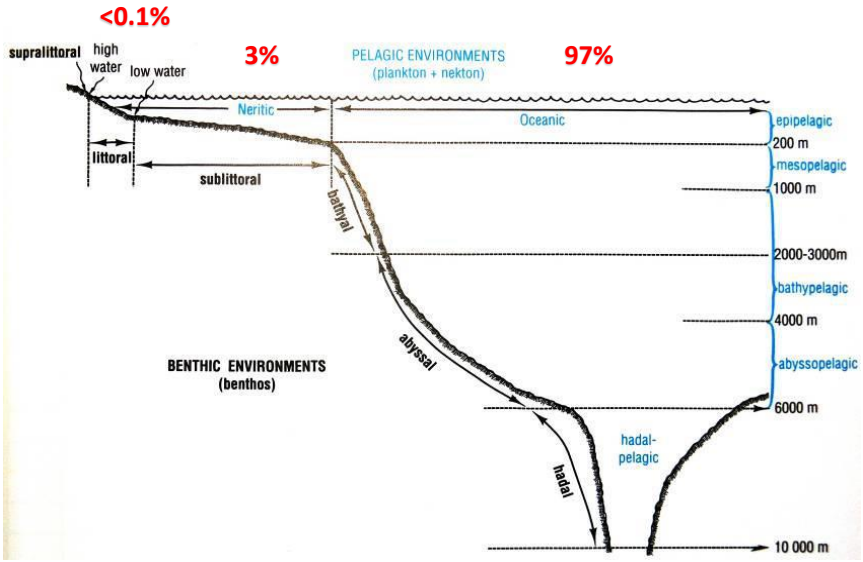
Favourable Attributes of Seawater

- Seawater is denser than air – marine species buoyed up by water = don't need large skeletons for support
- Energy saving - Floating and swimming requires little energy
- Temperatures stability - doesn't vary much in the ocean

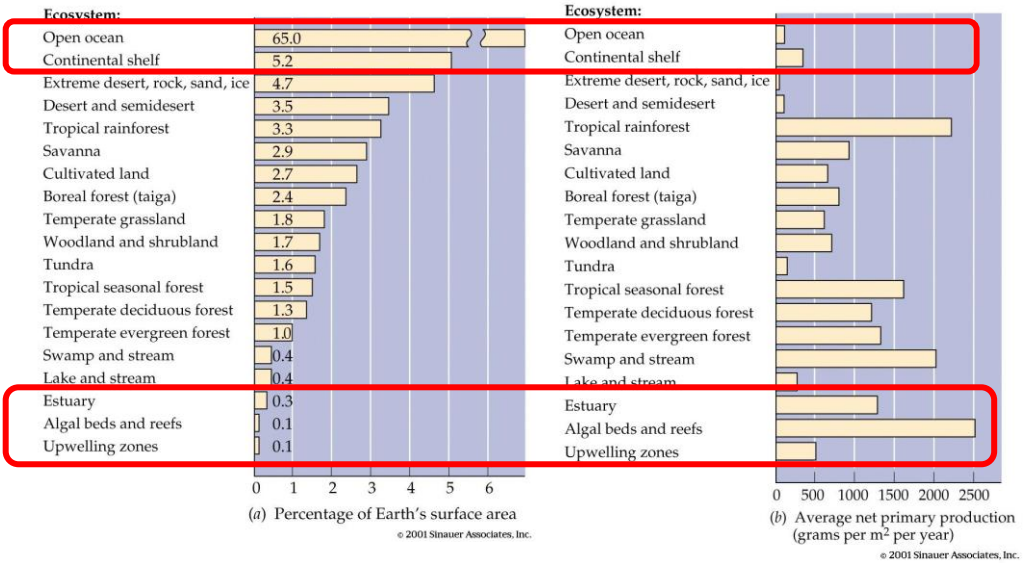
Unfavourable Attributes of Seawater

- Light penetration limits - Plant growth is limited to upper waters ⇒ limits primary production
- Nutrient limitations - Plant growth is limited by essential nutrients:
  - Decaying matter sinks to seafloor (not in the same place as light)
  - Needs water movement (upwelling) to return it
- Hydrostatic pressure increases with depth → creates vertical zonation
- Geographic barriers set by physical (e.g. temp) and chemical (e.g. salinity) difference in seawater (creates zonation)

The Marine Environment Zones



Area (% of Earth) Productivity (per area)

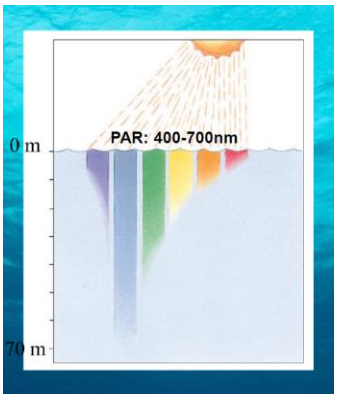


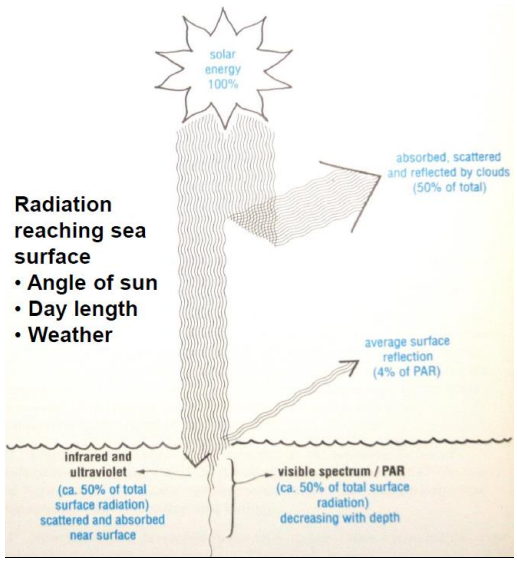
Main Abiotic Factors Governing Marine Life

- Light
- Temperature
- Salinity
- Water movement
- Nutrients
- Depth (hydrostatic pressure)
- Chemical composition (CO_3^{2-}, pH, O_2, SO_4^{2-}, …)

Light: Solar Radiation

- Light → plants → conversion to organic matter
- Light → water → heat → temperature regimes
- Light penetration controls max depth distribution of plants and some animals (e.g. deepest seaweed = 268m)



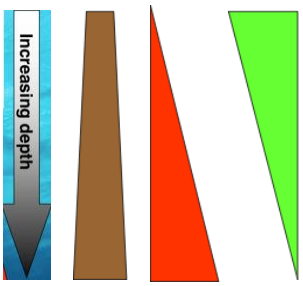


Ecological Zones defined by Light Penetration

- Euphotic zone: sufficient light to support plants
- Dis-photic zone: fish and some invertebrates can see, not enough light for positive net photosynthesis
- Aphotic zone: sunlight not detected by any biological system. No plant life ⇒ spatially removed from initial link in the food chain.

#Depth of these zones varies depending on light reaching the surface, clarity of the water and the angle of the sun.

Algal Distribution: with light and depth

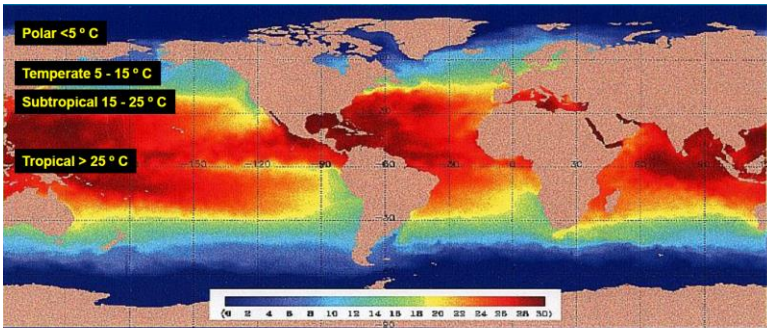


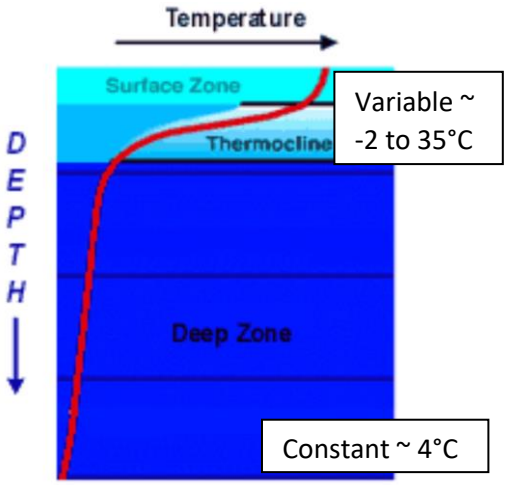
- Some algae have adapted photosynthetic responses:
  - Algal form and growth rates
  - Pigment concentration
- Therefore, as a 'rule of thumb' there are more green seaweeds in shallow waters, redder in deep waters and brown extending with depth.
- Non-photosynthetic responses:
  - Photo-tropism (taxis)
  - Reproduction cues (e.g. day length, blue light)

Primary contributor(s) to light attenuation in different aquatic environments

Temperature affecting marine biology

- Controls rates at which chemical reactions and biological processes take place
- Temperature and salinity combine to determine density of water
- Temperature partly determines [dissolved gasses]
- Isotherms (lines of equal temperature) set distribution boundaries for species and communities

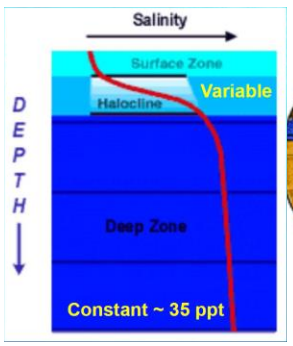


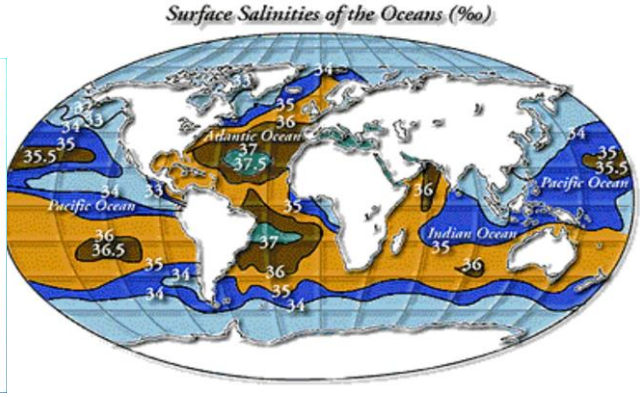


Temperature generally decreases with depth

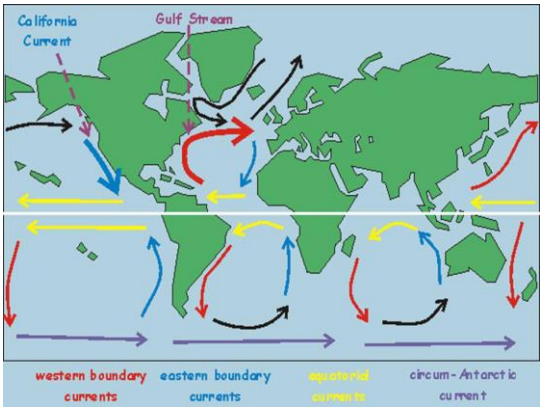
Salinity (ppt, psu)

- Maintaining osmotic balance is challenging and physiologically costly
- 34-37ish, warmer waters = more evaporation = saltier water.
- Salinity generally ⇑ with depth
- Can vary seasonally
- Open ocean = 32-38 $^{0}/_{00}$ (average is 35)
- Shallow coastal areas = 27-30 $^{0}/_{00}$
- Estuaries = 0-40 $^{0}/_{00}$
- Semi closed seas:
  - <25 $^{0}/_{00}$ (brackish, eg. Baltic sea)
  - > 40 $^{0}/_{00}$ (hypersaline, eg. Red Sea, Shark Bay)





Water Movement: Currents

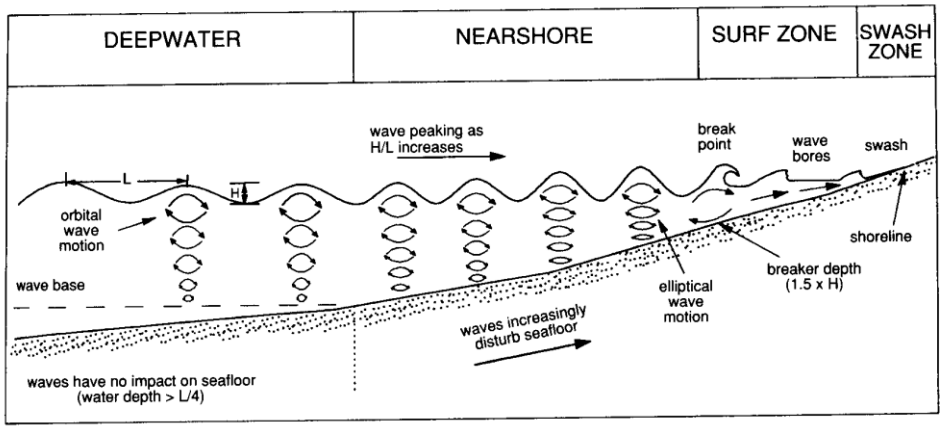


- Affected by energy from the sun, Earth's rotation and tides

1. **Energy from the Sun**: Radiation balance is positive at low latitudes and negative at high latitudes ⇒ heat redistributed to higher latitudes by wind and currents
2. **Rotation of Earth:**
   - Friction is weak between the ocean and earth
   - Coriolis Force is strong!
     - 0 at equator, highest at poles
     - Right angles to direction of motion = deflects right in NH, left in SH
3. **Tides** → gravitational pull of the moon

Water Movement: Waves

- Orbital wave motion, usually driven by wind



Surge Zone (e.g. shallow reef environment)

- Physical challenge for species due to mechanical drag of waves
- Organism adaptions including leathery and flexibility (e.g. seaweeds)

Environment-Organism Relationships

- Shape, size, colour, behaviour etc. of every organism depends on the environment in which it lives and its place in the ecosystem
- Essential strategies for all organisms include obtaining/making food, avoiding being eaten and reproduction
- Meeting those requirements dictates where organisms live (niche) and how they obtain/make food (nutrition)