Composition of seawater

- Seawater consists of about 3.5% (by weight) dissolved minerals
- Salinity
  - Total amount of solid material dissolved in water
  - Typically expressed in parts-per-thousand (‰)
  - Average salinity is 35‰
  - Major constituent is sodium chloride
Relative proportions of water and dissolved components in seawater.

Figure 14.1

- Water: 965 grams
- Salt: 35 g
- Seawater Salinity = 35%
- Dissolved components:
  - Cl\(^-\): 55.0%
  - Na\(^+\): 30.6%
  - Minor constituents: 0.7%
    - Ca\(^2+\): 1.2%
    - Mg\(^{2+}\): 3.7%
    - K\(^+\): 1.1%
    - SO\(_4^{2-}\): 7.7%
    - Sr\(^{2+}\), Br\(^-\), C
Composition of seawater

- Sources of sea salts
  - Chemical weathering of rocks
  - Outgassing – gases from volcanic eruptions

- Processes affecting seawater salinity
  - Variations in salinity are a consequence of changes in the water content of the solution
Composition of seawater

❖ Processes affecting seawater salinity
  • Processes that decrease salinity (add water)
    • Precipitation
    • Runoff from land
    • Icebergs melting
    • Sea ice melting
  • Processes that increase salinity (remove water)
    • Evaporation
    • Formation of sea ice
Composition of seawater

Processes affecting seawater salinity

• Surface salinity in the open ocean ranges from 33‰ to 38‰
Ocean temperature

- Surface water temperature varies with the amount of solar radiation received
  - Lower surface temperatures are found in high-latitude regions
  - Higher temperatures found in low-latitude regions
Ocean temperature

Temperature variation with depth

- Low-latitudes
  - High temperature at the surface
  - Rapid decrease in temperature with depth
    (thermocline)
- High-latitudes
  - Cooler surface temperatures
  - No rapid change in temperature with depth
Variations in ocean water temperature with depth

Figure 14.4
Ocean temperature

- Ocean temperature over time
  - The unique thermal properties of seawater make it resistant to temperature changes
  - Global warming could eventually influence ocean temperatures
Variations in the ocean’s surface temperature and salinity with latitude

Figure 14.3
Ocean density

- Density is mass per unit volume - how heavy something is for its size
- Determines the water’s vertical position in the ocean
- Factors affecting seawater density
  - Salinity
  - Temperature - the greatest influence
Ocean density

Variations with depth

- Low-latitudes
  - Low density at the surface
  - Density increases rapidly with depth (pycnocline) because of colder water

- High-latitudes
  - High-density (cold) water at the surface
  - Little change in density with depth
Variations in ocean water density with depth

Figure 14.5
Ocean density

Ocean layering

- Layered according to density
- Three-layered structure
  - Surface mixed zone
    - Sun-warmed zone
    - Zone of mixing
  - Shallow (300 meters)
Ocean density

Ocean layering

- Three-layered structure
  - Transition zone
    - Between surface layer and deep zone
    - Thermocline and pycnocline
  - Deep zone
    - Sunlight never reaches this zone
    - Temperatures are just a few degrees above freezing
    - Constant high-density water
Layering in the ocean

Figure 14.6
Ocean life

- Marine environment is inhabited by a wide variety of organisms
- Most organisms live within the sunlight surface waters (photosynthesis)
- Classification of marine organisms
  - Plankton
    - Floaters
    - Algae (phytoplankton)
Ocean life

Classification of marine organisms

• Plankton
  • Animals (zooplankton)
  • Bacteria
  • Most of Earth’s biomass

• Nekton
  • All animals capable of moving independently of the ocean currents
  • They are unable to move throughout the breath of the ocean
Ocean life

Classification of marine organisms

• Benthos
  • Bottom dwellers
  • A great number of species exist on the shallow coastal floor
  • Most live in perpetual darkness in deep water
Ocean life

Marine life zones

- Several factors are used to divide the ocean into distinct marine life zones
  - Availability of light
    - Photic (light) zone
      - Upper part of ocean
      - Sunlit
      - Euphotic zone is near the surface where the light is strong
Ocean life

Marine life zones

• Several factors are used to divide the ocean into distinct marine life zones
  • Availability of light
    • Aphotic (without light) zone
      • Deep ocean
      • No sunlight
Ocean life

● Marine life zones
  ● Several factors are used to divide the ocean into distinct marine life zones
    ● Distance from shore
      ● Intertidal zone – area where land and ocean meet and overlap
      ● Neritic zone – seaward from the low tide line, the continental shelf out to the shelf break
      ● Oceanic zone – beyond the continental shelf
Ocean life

Marine life zones

• Several factors are used to divide the ocean into distinct marine life zones
  • Water depth
    • Pelagic zone – open ocean of any depth
    • Benthic zone – includes any sea-bottom surface
    • Abyssal zone – a subdivision of the benthic zone
      • Deep
        • Extremely high water pressure
        • Low temperatures
Ocean life

Marine life zones

- Several factors are used to divide the ocean into distinct marine life zones
  - Water depth
    - Abyssal zone – a subdivision of the benthic zone
      - No sunlight
      - Sparse life
      - Food sources include decaying particles from above, large fragments falling, and hydrothermal vents
Marine life zones

Figure 14.10

[Diagram showing marine life zones with labels for Intertidal zone, Oceanic zone, Euphotic zone, Photic zone, Benthic zone, Aphotic zone, Abyssal zone, Continental shelf, Shelf break, Continental slope, Phytoplankton, Zooplankton, Limit of light penetration, Sunlight, High tide, Low tide, Neritic zone.]

Figure 14.10
Oceanic Productivity

- Related to primary productivity
  - The amount of carbon fixed by organisms through the synthesis of organic matter
  - Sources of energy
    - Photosynthesis (solar radiation)
    - Chemosynthesis (chemical reactions)
  - Influenced by
    - Availability of nutrients
    - Amount of solar radiation
Oceanic Productivity

- Related to primary productivity
  - Most abundant marine life exists where there is ample
    - Nutrients
    - Good sunlight

- Productivity in polar oceans
  - Because of nutrients rising from deeper water, high-latitude surface waters have high nutrient concentrations
Oceanic Productivity

- Productivity in polar oceans
  - Low solar energy limits photosynthetic productivity

- Productivity in tropical oceans
  - Low in the open ocean
  - Thermocline eliminates the supply of nutrients from deeper waters below
An example of productivity in polar oceans (Barents Sea)

Figure 14.11
Productivity in tropical oceans

Figure 14.12

Depth (m)

Warm, nutrient-depleted surface water

Thermocline

Cold, nutrient-rich deep water
Oceanic Productivity

Productivity in temperate oceans
- Winter
  - Low productivity
  - Days are short and sun angle is low
- Spring
  - Spring bloom of phytoplankton is quickly depleted
  - Productivity is limited
Oceanic Productivity

- Productivity in temperate oceans
  - Summer
    - Strong thermocline develops so surface nutrients are not replaced from below
    - Phytoplankton population remains relatively low
  - Fall
    - Thermocline breaks down and nutrients return to the surface
    - Short-lived fall bloom of phytoplankton

- Highest overall productivity occurs in temperate regions
Productivity in temperate oceans (Northern Hemisphere)

Figure 14.13

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Oceanic feeding relationships

- Main oceanic producers
  - Marine algae
  - Plants
  - Bacteria
  - Bacteria-like archaea

- Only a small percentage of the energy taken in at any level is passed on to the next
Oceanic feeding relationships

- Trophic levels
  - Chemical energy stored in the mass of the ocean’s algae is transferred to the animal community mostly through feeding
  - Each feeding stage is called a trophic level

- Transfer of energy between trophic levels is very inefficient (about 2%)
Ecosystem energy flow and efficiency

Figure 14.15
Oceanic feeding relationships

- Food chains and food webs
  - Food chain - a sequence of organisms through which energy is transferred
  - Food web
    - Involves feeding on a number of different animals
    - Animals that feed through a food web rather than a food chain are more likely to survive
Comparison between a food chain and a food web

**Figure 14.16**

A. Three-level food chain of Newfoundland herring

- Calanus (copepod)
- Diatoms

B. Food web of North Sea herring containing many food chains

- Calanus (copepod)
- Copepods other than Calanus
- Mollusc larvae
- Diatoms and Dinoflagellates
- Sand eels
- Arrow worms
- Amphipods
- Tunicates
- Euphausids
- Cladocerans

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End of Chapter 14