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

- 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
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

For every 500,000 units of energy received...

10,000 units of radiant energy is converted to tropic level 1 (phytoplankton) biomass

1000 units become tropic level 2 (zooplankton) biomass

100 units become tropic level 3 biomass

1 unit becomes tropic level 5 (human) biomass

10 units become tropic level 4 biomass
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
End of Chapter 14
Deep Sea Life

- Deep-sea creatures are specially adapted to a dark, cold, high-pressure environment, where little food is available. They tend to have:
  - *Large, light-sensitive eyes* (or they may not need eyes, and are blind)
  - *Disproportionately large jaws or teeth* as compared to their body size
  - *Red or black color*
  - Some creatures can even glow in the dark (bioluminescence), and are equipped with "headlights" or "fishing lures."
  - Bacteria are signaled to “glow on command”
Angler Fish

• Live in deep water over 3000 feet below sea level
• They are called anglers, because they can dangle a glowing lure in front of their mouths full of sharp teeth
• Most anglers are small, but one species of deep sea angler grows to 4 feet long
• The female is much larger than the male
• The male literally attaches itself to the female for life
Fangtooth
Loosejaw
Gulper Eel
Card 5

Monsters of the Deep

Giant Squid

All-Seeing: At a diameter of 15 inches, this creature's eyes are the largest known in the natural world. They allow the squid to see in the total darkness of deep seas.

Big Reach: In order to catch prey at a distance, the squid's two feeding tentacles stretch out up to 35 ft. They have club-like ends that can snatch fish.

Ancient legends told of mammoth sea monsters attacking ships. The giant squid is likely the source for these stories. This beast has eyes as big as volleyballs and ten tentacles covered with rows of powerful suckers that latch on with a deadly grip. Dwelling deep in the ocean, the giant squid is still shrouded in mystery today. No one has ever seen it in its natural habitat.

Creature Features

Species: Architeuthis harveyi

Size: Length up to 60 ft.; Weight up to 1 ton

Body Parts: 10 tentacles, bullet-shaped head, huge eyes, sharp beak

Habitat: All the world's oceans at depths of 700 to more than 3,000 ft.

Prey: Fish, crustaceans and other squid
Giant Squid
Video still frame of live giant squid
Colossal Squid
Giant Squid vs. Colossal Squid

- Giant squid is faster, more aggressive, has round suckers with toothed rings on its tentacles and arms.
- Colossal squid is heavier, slower moving, and is an ambush hunter that waits for prey to come near; has swiveling hooks on its tentacles and non-swiveling hooks on its arms.
- Giant squid is more common and is more widespread.
- Colossal squid is found only in the Southern Ocean.
- Sperm whales eat them both.
Giant Squid:
toothed suckers on arms and tentacles
Colossal Squid: non-swiveling arm hooks
Sperm Whale, the largest toothed whale

- 40 feet long, 39 to 65 tons
- Conical teeth only in lower jaw (sockets in upper jaw)
- Huge head holds oily fluid that amplifies its sonar cannon
Sperm whale dives deep to hunt its favorite food - giant squid or colossal squid, using sonar, while holding its breath for up to an hour.
Giant Pacific Octopus

(shallow water)
Dumbo Octopus
(deep water)
Hydrothermal Vent Communities
Chemosynthesis: Earth’s most ancient ecosystem
Giant red tube worms
Giant vent clam
John Martin: Iron Hypothesis

- “With half a ship load of iron...I could give you an ice age'' (John Martin, 1988)
- In the 1980’s, oceanographer John Martin, proposed that iron added to regions of the ocean that are otherwise rich in nutrients but poor in chlorophyll (so-called high-nutrient, low-chlorophyll, or HNLC, regions) can stimulate the growth of phytoplankton. This discovery is considered one of the most significant oceanographic discoveries in the past 50 years*. Thanks to Martin's iron hypothesis, scientists now know iron supply to the oceans was a key factor controlling climate over many glacial, interglacial cycles.
John Martin’s iron fertilization was tested posthumously in 1995
How We Found the Giant Squid

A specialist in bioluminescence, marine biologist Dr. Edith Widder helps design and invent new submersible instruments and equipment to study bioluminescence and enable unobtrusive observation of deep-sea environments. Her innovative tools for exploration have produced footage of rare and wonderful bioluminescent displays and never-before-seen denizens of the deep, including, most recently, the first video ever recorded of the giant squid, Architeuthis, in its natural habitat.

TED Talks Video: How We Found the Giant Squid
Underwater Astonishments

Marine geologist David Gallo shows jaw-dropping footage of amazing sea creatures, including a color-shifting cuttlefish, a perfectly camouflaged octopus, and a Times Square's worth of neon light displays from fish who live in the blackest depths of the ocean. This short talk celebrates the pioneering work of ocean explorers like Edith Widder and Roger Hanlon.

TED Talk: Underwater Astonishments