Aquatic biomes

• Aquatic biomes
  – occupy largest part of biosphere
  – two major categories of aquatic biomes
    • Freshwater
      – salt concentration of <1%
    • Marine
      – salt concentration of ~ 3%
      – many exhibit pronounced vertical stratification

Aquatic biomes

• vertical stratification
  – based on physical and chemical variables, such as
    • light
    • temperature

Aquatic biomes

• vertical stratification
  – light
    • is absorbed by organisms and the water
      – intensity decreases rapidly with depth
    • ecologists distinguish between 2 zones based on light penetration
      – photic zone
        » zone through which light penetrates
        » light is sufficient for photosynthesis
      – aphotic zone (profundal)
        » very little light can penetrate
        » insufficient for photosynthesis

Aquatic biomes

• vertical stratification
  – temperature
    • light-penetrated layer
      – warmed by heat energy from sunlight
• **thermocline**
  – narrow stratum of rapid temperature change
  – separates a more uniformly warm upper layer from more uniformly cold deeper waters

• **deep waters**
  – beyond penetration of light
  – are uniformly cold

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**Aquatic biomes**

• **vertical stratification**
  – **benthic zone**
    • bottom of any aquatic biome
    – the substrate, made up of
      » sand
      » organic and inorganic sediments
    • contains **detritus**
      – dead organic matter
    • occupied by communities of organisms collectively called **benthos**
      – for whom a major source of food is detritus
        » rains down from waters of photic zone

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**Major aquatic biomes**

• **Freshwater biomes**
• **Marine biomes**

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**Major aquatic biomes**

• **Freshwater biomes**
• **Marine biomes**

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**Freshwater biomes**

• **Freshwater biomes**
  • salt concentration of <1%
  • closely linked to soils and biotic components of terrestrial biomes through which they pass
  • characteristics are influenced by
    – patterns and speed of water flow
    – climate of area in which its located

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**Freshwater biomes**

• **Freshwater biomes**
  • two categories
    • **standing** (lentic) bodies of water
- lakes
- ponds
- inland wetlands
• **moving** (lotic) bodies of water
  - rivers
  - streams

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**Freshwater biomes**

- **Freshwater biomes**
  - two categories
    - **standing** (lentic) bodies of water
      - lakes
      - ponds
      - inland wetlands
    - **moving** (lotic) bodies of water
      - rivers
      - streams

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**Freshwater biomes**

- Freshwater biomes
  - lakes
    - large, natural bodies of standing fresh water
    - formed when precipitation, runoff, groundwater seepage fills depressions in earth’s surface
      - depressions can be formed by
        » glaciation (Great Lakes, NA)
        » crustal displacement (Lake Nyasa, East Africa)
        » volcanic activity (Crater Lake, Oregon)
    - large lakes may have many of same characteristics as oceans

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**Freshwater biomes**

- Freshwater biomes
  - lakes
    - consist of 4 zones, defined by depth and distance from shore
      - littoral zone
      - limnetic zone
      - profundal zone
      - benthic zone

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**Freshwater biomes**

- Freshwater biomes
- lakes
  - littoral zone
    - shallow, well-lit, close to shore.
    - rooted and floating plants flourish
  - limnetic zone
    - well-lit, open surface water, farther from shore, extending to depth penetrated by light
    - occupied by phytoplankton, zooplankton, higher animals
    - produces food and oxygen that supports most of lake’s consumers

**Freshwater biomes**

- Freshwater biomes
  - lakes
    - profundal zone
      - consists of deep, aphotic regions
      - too dark for photosynthesis
      - oxygen levels are low
      - inhabited by fish adapted to cool dark waters
    - benthic zone
      - bottom of lake
      - inhabited by organisms that can tolerate cool temperatures and low oxygen levels

**Freshwater biomes**

- Freshwater biomes
  - lakes
    - productivity
      - determined by several factors
        » temperature
        » depth
        » nutrient content
        » dissolved oxygen content

**Freshwater biomes**

- Freshwater biomes
  - lakes
    - dissolved oxygen content
      - aquatic organisms must have molecule oxygen (O₂)
      - enters water from
        » air
        » released as result of photosynthesis
        » mixing from wave action
determines types of organisms that can inhabit a lake

21 Freshwater biomes

• Freshwater biomes
  – lakes
    • dissolved oxygen content
      – decomposition of organic matter by bacteria and fungi requires oxygen (as they perform respiration)
    • biochemical oxygen demand (BOD)
      » amount of oxygen used by decomposers to break down a specific amount of organic matter
      » greater amount of organic matter (or influx of nutrients) increases BOD and decreases amount of O₂ available in water

22 Freshwater biomes

• Freshwater biomes
  – lakes
    • often classified according to their production of organic matter
      – three general categories
        » oligotrophic
        » eutrophic
        » mesotrophic

23 Freshwater biomes

• Freshwater biomes
  – lakes
    • oligotrophic
      – deep
      – cold
      – small surface area relative to depth
      – nutrient-poor
      – phytoplankton are sparse, not very productive
      – don’t contain much life
      – waters often very clear
      – sediments low in decomposable organic matter
      – example: Lake Baikal, Siberia
Freshwater biomes

- Freshwater biomes
  - lakes
    - eutrophic
      - shallow
      - warm
      - large surface area relative to depth
      - nutrient-rich
      - phytoplankton more plentiful and productive
      - waters often murky
      - high organic matter content in benthos
        » leads to high decomposition rates and potentially low oxygen

- Freshwater biomes
  - lakes
    - mesotrophic
      - moderate nutrient content
      - moderate amount of phytoplankton, reasonably productive.

- Freshwater biomes
  - lakes
    - eutrophication
      - process in which some oligotrophic lakes become eutrophic
      » occurs over long periods of time
      » lakes pass from oligotrophic to mesotrophic to eutrophic
      » occurs as runoff brings in nutrients and silt
      » pollution from fertilizers can cause explosions in algae population and cause a
decrease in oxygen content
Freshwater biomes

• Freshwater biomes
  – two categories
    • standing (lentic) bodies of water
      – lakes
      – ponds
      – inland wetlands
    • moving (lotic) bodies of water
      – rivers
      – streams

Freshwater biomes

• Freshwater biomes
  – wetlands
    • an area covered with water at some point in year that supports aquatic plants
      – range from periodically flooded regions to soil that is permanently saturated
        » conditions favor specially adapted plants called hydrophytes
    • can be freshwater or saltwater

Freshwater biomes

• Freshwater biomes
  – wetlands
    • many types, including
      – marshes
        » usually covered with water year-round
        » dominant plants are emergent (stems and leaves extending above surface
      – swamps
        » dominated by woody plants
      – bogs
        » dominated by sphagnum mosses
      – seasonal pools

Freshwater biomes

• Freshwater biomes
  – wetlands
    • generally develop in three topographic situations
      – basin wetlands
      – riverine wetlands
Freshwater biomes

- **Freshwater biomes**
  - **wetlands**
    - **basin wetlands**
      - develop in shallow basins
        » ranging from upland depressions to filled-in lakes and ponds
    - **riverine wetlands**
      - develop along shallow, periodically flooded banks of rivers and streams
    - **fringe wetlands**
      - occur along coasts of large lakes and seas
      - water flows back and forth due to changing lake levels or tidal action

Freshwater biomes

- **Freshwater biomes**
  - **wetlands**
    - are among richest biomes
      - contain diverse communities
    - provide important services
      - water-storage basins
        » help reduce intensity of flooding
        » improve water quality by filtering pollutants
    - frequently destroyed or degraded by human activity
      - filled for agriculture and development
    - now protected in many areas

Freshwater biomes

- **Freshwater biomes**
  - two categories
    - **standing** (lentic) bodies of water
      - lakes
      - ponds
      - inland wetlands
    - **moving** (lotic) bodies of water
      - rivers
      - streams
• Freshwater biomes
  – rivers and streams
    • bodies of water moving continuously in one direction
    • downward flow of surface water and groundwater from mountain highland to sea can be separated into
      – three zones
        » source zone
        » transition zone
        » floodplain zone

Freshwater biomes

• Freshwater biomes
  – rivers and streams
    • source zone
      – contains headwaters (headwater streams)
        » often begins as springs or snowmelt
        » cold
        » clear
        » carries little sediment
        » contains relatively few nutrients
        » channels usually narrow
        » current is swift
        » substrate is rocky

Freshwater biomes

• Freshwater biomes
  – rivers and streams
    • transition zone
      – contains wider, lower elevation streams
      – streams join to form tributaries
      – warmer
      – less clear
      – carries more sediment
      – contains more nutrients
      – channels usually wider
      – current is slower
      – substrate begins to accumulate silt

Freshwater biomes
• Freshwater biomes
  – rivers and streams
  • floodplain zone
    – tributaries join to form rivers
      » which empty into oceans at estuaries
    – warmer still
    – murky
    – carries substantially more sediment
    – contains substantially more nutrients
    – channels wider, wide mouth
    – current relatively slow
    – substrate silty from deposition of sediment

Freshwater biomes

• Freshwater biomes
  – rivers and streams
  • nutrient content
    – largely determined by the terrain & vegetation of the area through which it flows
    – input via
      » adjacent and overhanging vegetation
      » weathering of rock
      » soil erosion
      » human activities

Freshwater biomes

• Freshwater biomes
  – rivers and streams
  • estuaries
    – areas where freshwater (stream or river) merges with ocean
      » freshwater meets salt water
    – salinity varies
      » from that of fresh water to that of ocean water
      » spatially (based on location)
      » temporally (due to tidal activity)
• **Estuaries**
  – one of most productive biomes on earth due to nutrients delivered by rivers
    » major producers are salt marsh grasses, algae, phytoplankton
  – support diverse communities
  – are crucial feeding areas for many types of water fowl
  – threatened by same types of activities as wetlands

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**Major aquatic biomes**

• **Freshwater biomes**
• **Marine biomes**

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**Marine biomes**

• **Marine biomes**
  – salt concentration of ~ 3%
  – cover ~ 75% of the earth’s surface
  – have enormous impact on planet’s climate
    • evaporation of seawater provides most rainfall
    • ocean temperatures affect wind patterns, distribution of energy to land via currents
  – supply substantial portion of world’s oxygen
    • photosynthesis by marine algae & photosynthetic bacteria
  – consume huge amounts of atmospheric carbon dioxide
    • result of photosynthesis by marine algae and photosynthetic bacteria

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**Marine biomes**

• **Marine biomes**
  – communities are distributed through several zones
    • based on
      – depth of water
      – degree of light penetration
      – distance from shore
      – open water versus bottom

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**Marine biomes**

• **Marine biomes**
  – zonation in marine communities
    • 5 general zones
      – intertidal zone
      – neritic zone
      – oceanic pelagic zone
      – benthic zone
      – abyssal zone
Marine biomes
- Marine biomes
  - zonation in marine communities
    - 5 general zones
      - intertidal zone
      - neritic zone
      - oceanic pelagic zone
      - benthic zone
      - abyssal zone

Marine biomes
- Marine biomes
  - intertidal zone
    - where land meets water
    - is alternately submerged and exposed twice daily due to tides
    - communities are subjected to huge daily variations in
      - availability of saltwater
      - temperature
    - organisms are subject to mechanical forces of wave action

Marine biomes
- Marine biomes
  - intertidal zone
    - can be rocky or sandy
    - are often destroyed by pollution and human activity

Marine biomes
- Marine biomes
  - intertidal zone
    - vertical zonation
      - based on percentage of time spent submerged
        » uppermost zone
        » middle zone
        » bottom zone

Marine biomes
- Marine biomes
  - intertidal zone
    - vertical zonation
Marine biomes

• Marine biomes
  – intertidal zone
    • vertical zonation
      – middle zone
        » submerged at high tide
        » exposed at low tide
        » inhabited by array of algae, sponges, sea anemones, mollusks, crustaceans, echinoderms, small fishes

Marine biomes

• Marine biomes
  – intertidal zone
    • vertical zonation
      – bottom zone
        » exposed only during lowest tides
        » inhabited dense cover of seaweeds, diver community of invertebrates and fishes

Marine biomes

• Marine biomes
  – zonation in marine communities
    • 5 general zones
      – intertidal zone
      – neritic zone
      – oceanic pelagic zone
      – benthic zone
      – abyssal zone

Marine biomes

• Marine biomes
– neritic zone
  • beyond intertidal
  • includes shallow regions over the continental shelves
  • in warm tropical waters, this region contains
    – coral reefs

Marine biomes
• Marine biomes
  – neritic zone
    • coral reefs
      – dominated by structure of coral itself
        » formed by diverse group of cnidarians that secrete hard external skeletons made of calcium carbonate
        » cerates a substrate upon which other corals, sponges, algae grow
      – include a very diverse assortment of vertebrates and invertebrates

Marine biomes
• Marine biomes
  – neritic zone
    • coral reefs
      – very productive
        » currents and waves constantly renew nutrients
        » light penetrates to ocean floor allowing photosynthesis
      – easily degraded by
        » pollution
        » development
        » high water temperatures

Marine biomes
• Marine biomes
  – zonation in marine communities
    • 5 general zones
      – intertidal zone
      – neritic zone
      – oceanic pelagic zone
      – benthic zone
      – abyssal zone
Marine biomes

- Marine biomes
  - oceanic pelagic zone
    - extends past continental shelves, can be very deep, is the open water
    - includes most of the ocean's water.
    - water is constantly mixed by ocean currents
    - plankton live in photic zone and are producers for this biome
    - nutrient concentrations generally lower than in coastal areas
    - includes a great variety of free swimming animals (fish, large squid, sea turtles, marine mammals)

Fig. 6.19

Marine biomes

- Marine biomes
  - zonation in marine communities
    - 5 general zones
      - intertidal zone
      - neritic zone
      - oceanic pelagic zone
      - benthic zone
      - abyssal zone

Marine biomes

- Marine biomes
  - benthic zone
    - ocean bottom below neritic and oceanic pelagic zones.
    - Substrate and temperature are very important characteristics in determining community development
    - nutrients “rain” down from above in form of detritus
    - communities consist of bacteria, fungi, seaweed and filamentous algae, numerous invertebrates, and fish.

Figure 50.22  Zonation in the marine environment

Fig. 6.19
– intertidal zone
– neritic zone
– oceanic pelagic zone
– benthic zone
– abyssal zone

**Marine biomes**

- Marine biomes
  - **abyssal zone**
    - very deep benthic communities
    - organisms are adapted to
      - continuous cold.
      - high pressure
      - low to no light
      - low nutrients
    - **deep-sea hydrothermal vents** of volcanic origin found here.
      - dark, hot, oxygen-deficient environment
        » producers are chemoautotrophs

*Figure 50.23c*  Black smoker

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**Aquatic biomes**

- Primary productivity
  - in aquatic ecosystems, is limited by
    - light
    - nutrients
  - marine ecosystems
  - freshwater ecosystems

**Aquatic biomes**

- Primary productivity
  - marine ecosystems
  - light
    - is first variable to control primary production in oceans
      » since solar radiation can only penetrate to a certain depth (photic zone)
    - more than 50% of solar radiation is absorbed in first meter of water
      » even in ‘clear’ water, only 5-10% of radiation reaches depth of 20m

*Figure 50.22*  Zonation in the marine environment

*Fig. 6.19*
Primary productivity
- marine ecosystems
  - since light is primary variable limiting primary production
    - we would expect production to increase along a gradient from the poles to the equator
      » but that is not the case, there is no such gradient
      » there are parts of the ocean in tropics and subtropics that exhibit low primary production

Aquatic biomes
- Primary productivity
  - marine ecosystems
    - why are tropical and subtropical oceans less productive than we would expect?
      - due to availability of nutrients
      - nutrients more than light limit primary productivity in different geographic regions of the ocean

Aquatic biomes
- Primary productivity
  - marine ecosystems
    - nutrients
      - nitrogen and phosphorus
      » most often limit marine production
      » are examples of limiting nutrients (nutrients that must be added for production to increase)
      » concentrations are low in photic zone where photosynthesis could occur
      » often more available in deep waters where it's too dark for photosynthesis

Aquatic biomes
- freshwater ecosystems
  - limited by solar radiation and temperature
  - nutrient limitations also common
    - phosphorus is usually limiting nutrient (rather than nitrogen as in oceans)
    » hence shift in late 1970's to phosphate-free detergents
  - cultural eutrophication
    - eutrophication of lakes as a result of input of nutrients from
    » sewage and fertilizer pollution

Aquatic biomes
- aquatic primary succession
  - main concepts of terrestrial primary succession can be applied to aquatic ecosystems
  - except for oceans, over time, most aquatic ecosystems are replaced by terrestrial ecosystems
• aquatic ecosystems receive continuous input of soil particles and organic matter
• as sediment increases, water depth decreases
  – types of organisms change

The End