1

2

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**

3

4

Aquatic biomes

- **vertical stratification**
  - based on physical and chemical variables, such as
    - light
    - temperature

5

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

6

7

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

8

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

9

Major aquatic biomes

- **Freshwater biomes**
- **Marine biomes**

10

Major aquatic biomes

- **Freshwater biomes**
- **Marine biomes**

11

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

12

Freshwater biomes

- **Freshwater biomes**
  - two categories
    - **standing** (lentic) bodies of water

- lakes
- ponds
- inland wetlands
- **moving** (lotic)bodies of water
  - rivers
  - streams

13

Freshwater biomes

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

14

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

15

Freshwater biomes

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

16

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

17 

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

18 

19 

Freshwater biomes

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

20 

Freshwater biomes

- Freshwater biomes
  - **lakes**
    - **dissolved oxygen content**
      - aquatic organisms must have molecule oxygen (O_2)
      - 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 O_2available 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

24

25

Freshwater biomes

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

26

27

Freshwater biomes

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

28

Freshwater biomes

- 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

29

30

31

Freshwater biomes

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

32

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

33

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

34

Freshwater biomes

- **Freshwater biomes**
  - **wetlands**
    - generally develop in three topographic situations
      - basin wetlands
      - riverine wetlands

- fringe wetlands

35

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

36

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

37

38

Freshwater biomes

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

39

Freshwater biomes

- **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

40

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

41

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

42

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

43

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

44

45

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)

46

Freshwater biomes

- **Freshwater biomes**
  - **rivers and streams**

- **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

47 

48 

49 

Major aquatic biomes

- **Freshwater biomes**
- **Marine biomes**

50 

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

51 

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

52 

Marine biomes

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

53 

Marine biomes

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

54 

Marine biomes

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

55 

Marine biomes

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

56 

57 

Marine biomes

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

58 

Marine biomes

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

- **uppermost zone**
  - » submerged only during highest tides
  - » have adaptations that prevent dehydration and overheating
  - » inhabited by grazing mollusks, suspension-feeding barnacles, a few algae

59

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

60

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

61

62 Fig. 6.19

63

64 Fig. 6.20b

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66

Marine biomes

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

67

Marine biomes

- Marine biomes

- **neritic zone**
  - beyond intertidal
  - includes shallow regions over the continental shelves
  - in warm tropical waters, this region contains
    - **coral reefs**

68

69

70

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

71

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

72

73

74

Marine biomes

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

75

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)

76

77 Fig. 6.19

78

79

Marine biomes

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

80

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.

81 Figure 50.22 Zonation in the marine environment

82 Fig. 6.19

83

Marine biomes

- **Marine biomes**
  - zonation in marine communities
    - 5 general zones

- intertidal zone
- neritic zone
- oceanic pelagic zone
- benthic zone
- abyssal zone

84

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

85 Figure 50.23cx Black smoker

86

87 Figure 50.22 Zonation in the marine environment

88 Fig. 6.19

89

90 Aquatic biomes

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

91 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

92 Aquatic biomes

- **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

93

94 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

95 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 its too dark for photosynthesis

96

97 Aquatic biomes

- **Primary productivity**
  - **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

98 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

99 The End