

Chapter 3 LIFE IN WATER

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Chapter Concepts

- The hydrologic cycle exchanges water among reservoirs
- The biology of aquatic environments corresponds broadly to variations in physical factors such as light, temperature, and water movements, and to chemical factors such as salinity and oxygen

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The Hydrologic Cycle

- 71% of earth's surface is covered by water:
 - ✓ 97% Oceans
 - ✓ 2% Polar Ice Caps and Glaciers
 - ✓ 1% Freshwater in lakes, streams, ground

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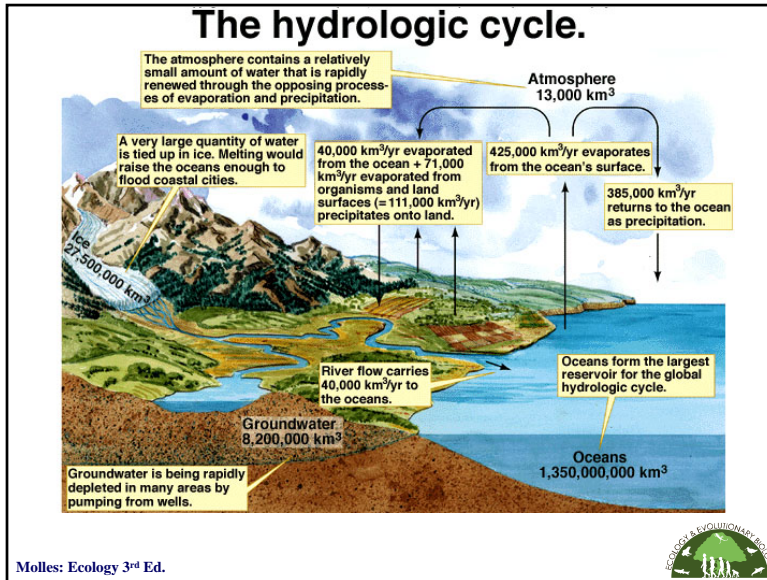


The Hydrologic Cycle

- Heat
- Evaporation
- Clouds
- Precipitation
 - ✓ Evaporation
 - ✓ Consumed by organisms
 - ✓ Groundwater
 - ✓ Surface water
 - Rivers, Ponds, Streams >> Ocean

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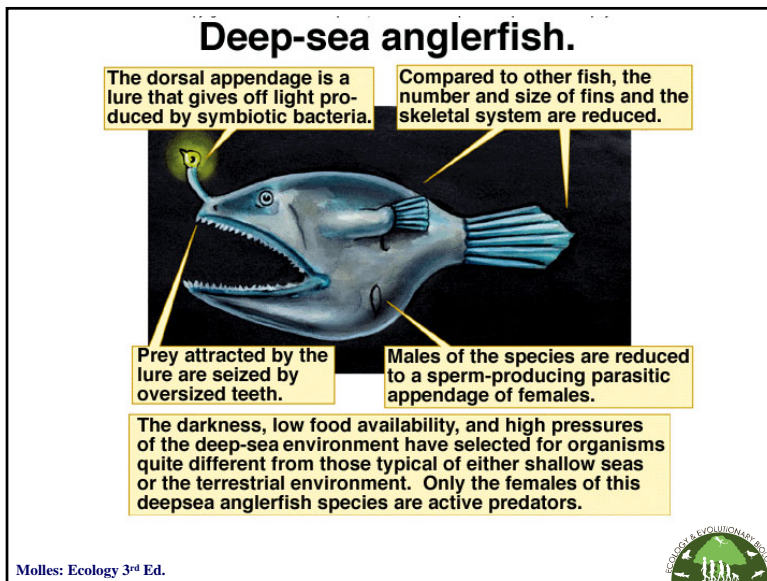


Natural History of Aquatic Environments: Deep Blue Sea

- Three major basins:

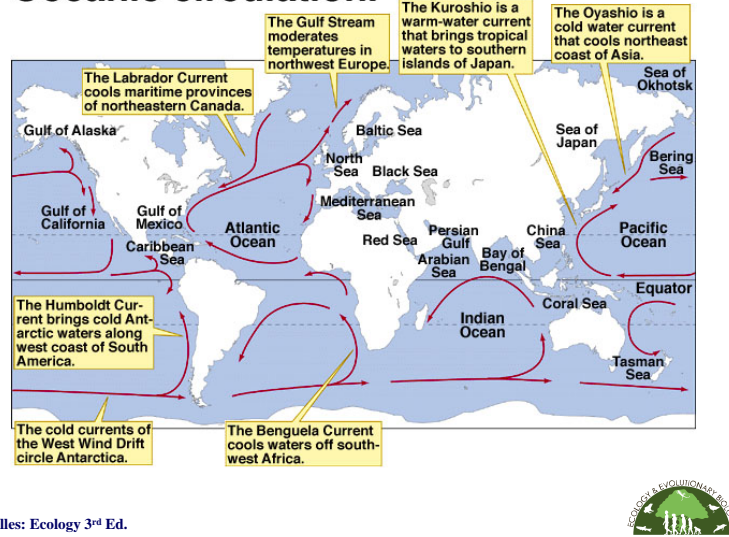
	Total Area	Depth
● Pacific	180 million km ²	4,000m ²
● Atlantic	106 million km ²	3,900m ²
● Indian	75 million km ²	3,900m ²

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- ### Deep Blue Sea
- Littoral (intertidal zone) – Shallow shoreline
 - Neritic – Coast to margin (200 m) of continental shelf
 - ✓ Epipelagic zone (surface-200 m)
 - ✓ Mesopelagic zone (200-1000 m)
 - ✓ Bathypelagic zone (1000-4000 m)
 - ✓ Abyssal zone (4000-6000 m)
 - ✓ Hdal zone
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Oceanic circulation.



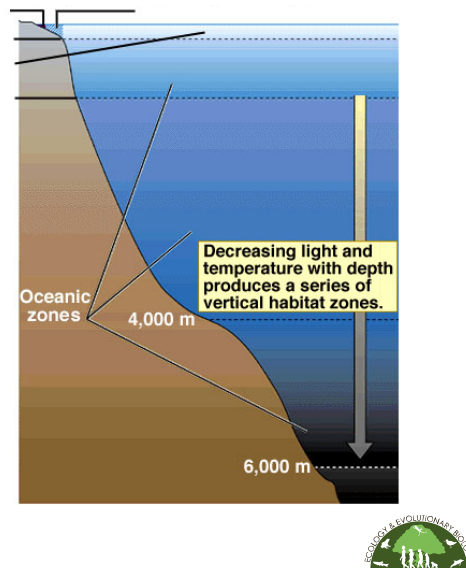
Deep Blue Sea

- **Oceanic Zone:** Areas beyond continental shelf
 - ✓ Epipelagic 0 - 200m
 - ✓ Mesopelagic 200 – 1,000m
 - ✓ Bathypelagic 1,000 – 4,000m
 - ✓ Abyssal 4,000 – 6,000m
 - ✓ Hadal 6,000m +
- **Benthic:** Habitat on bottom of ocean
- **Pelagic:** Habitat off the bottom of the ocean

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Light
Temperature
Circulation
Salinity
Organism

Structure of the oceans.



Deep Blue Sea

- Approximately 80% of solar energy striking the ocean is absorbed in first 10m
 - ✓ **Very little, if any penetrates past 600m**
- Sunlight increases velocity of water (temp.)
 - ✓ **Rapid motion decreases density, thus warm water floats on top of cooler water**
- **Thermocline** – Layer of water through which temp. changes rapidly with depth

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Deep Blue Sea

- Salinity: Amount of dissolved salt in water
 - ✓ Open ocean 34g/kg water
 - Lowest salinity occurs near equator where precipitation exceeds evaporation
 - Highest salinity occurs in subtropics where evaporation exceeds precipitation
- Oxygen: Typically concentration is highest near ocean surface, and decreases with depth. Minimum usually < 1,000m

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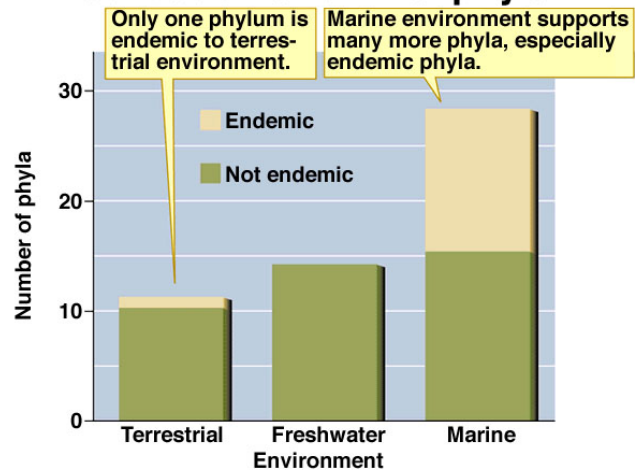
Deep Blue Sea

- Photosynthetic organisms are limited to upper epipelagic zone (euphotic zone)
 - ✓ Phytoplankton and zooplankton
 - ✓ Due to size, oceans contribute 1/4 of total photosynthesis in the biosphere
- Chemosynthesis occurs near undersea hot springs

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Distribution of animal phyla.



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Deep Blue Sea

- For most of human history, vastness of oceans has acted as a buffer against human intrusion
- New Human-induced threats:
 - ✓ Overharvesting
 - ✓ Dumping

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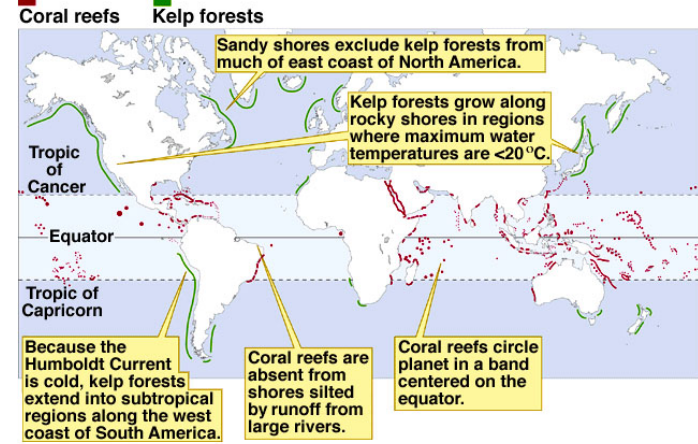
Life in Shallow Marine Waters

- Reef Categories:
 - ✓ Fringing Reefs: hug shore of continents
 - ✓ Barrier Reefs: stands between open sea and lagoon
 - ✓ Coral Atolls: Coral inlets built up from submerged ocean island
- Kelp Beds
 - ✓ Structure similar to terrestrial forests
 - Canopy at water's surface

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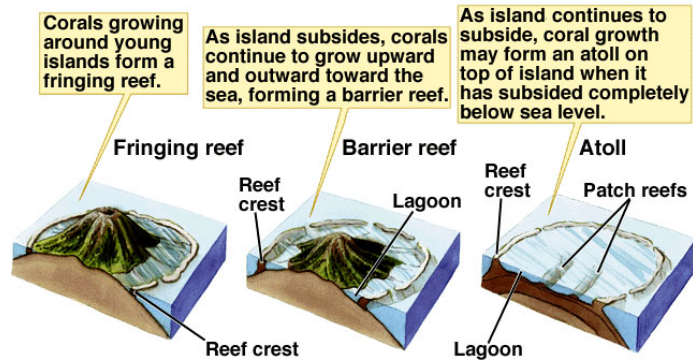
Distribution of kelp forests and coral reefs.



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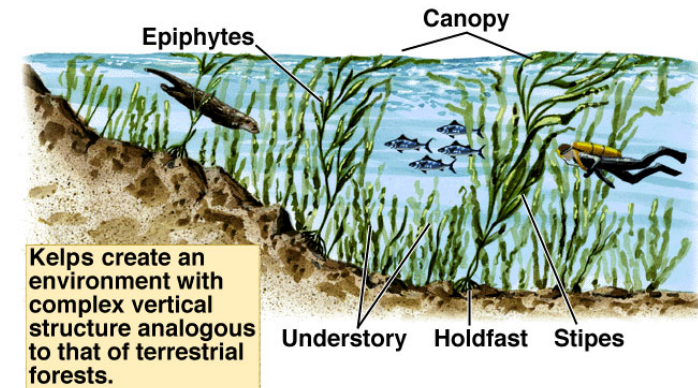
Types of coral reefs.



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Kelp forest structure.



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Life in Shallow Marine Waters

- Reefs and Kelp Beds both grow in surface waters with sufficient light for photosynthesis
 - ✓ Both limited by temperature
- Currents deliver oxygen and nutrients, and remove waste products
 - ✓ Biological productivity may depend on flushing action
- Reefs and Kelp Beds among most productive and diverse ecosystems

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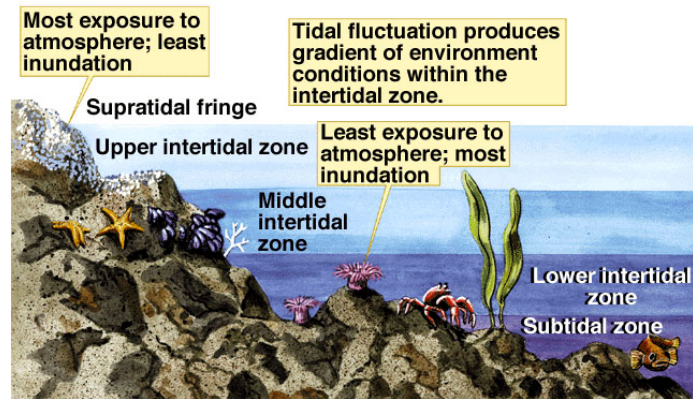
Marine Shores (Intertidal)

- Intertidal Zone can be divided vertically:
 - ✓ Supratidal Fringe: Covered by high tide
 - ✓ Upper Intertidal: Covered only during highest tides
 - ✓ Lower Intertidal: Uncovered during lowest tides
 - ✓ Subtidal: Covered by water even during lowest tides

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Intertidal zonation.



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Marine Shores

- Two most important water movements affecting distribution and abundance of intertidal organisms are waves and tides
 - ✓ Semidiurnal Tides: 2 periods of low and high tides daily
 - ✓ Diurnal Tides: Single low and high tide each day

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Marine Shores

- Inhabitants of intertidal zone are adapted to amphibious existence
 - ✓ Differential tolerances to periodicity of air exposure leads to zonation of species
- Due to increased accessibility, intertidal zones are experiencing increasing human exploitation

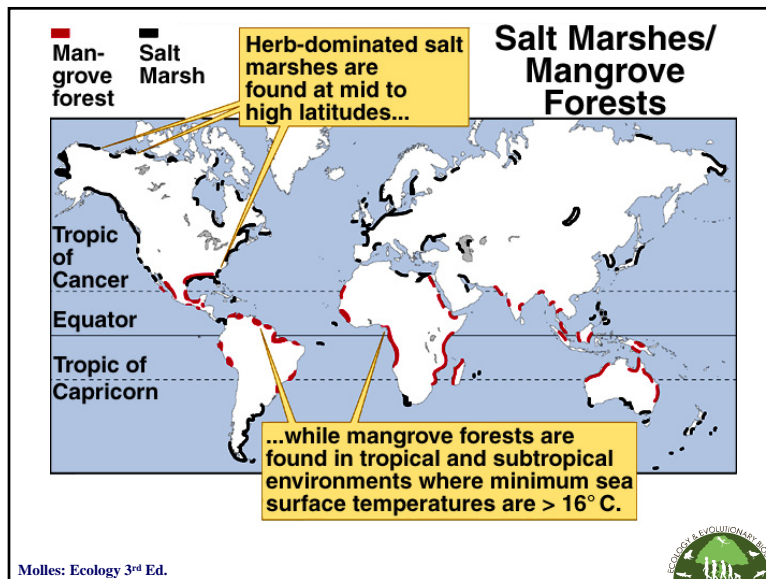
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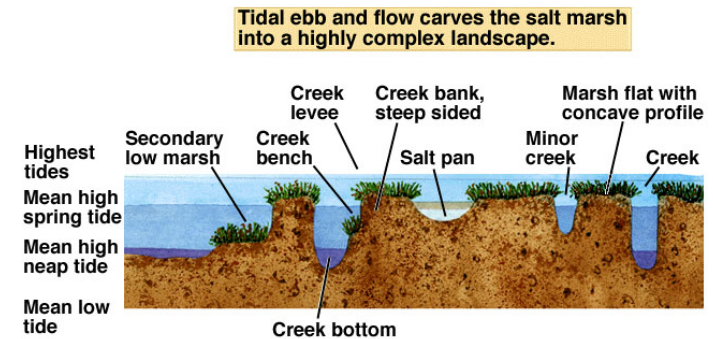
Estuaries, Salt Marshes, and Mangrove Forests

- Estuaries: found where rivers meet the sea
- Salt Marshes and Mangrove Forests are concentrated along low-lying coasts
 - ✓ All are driven by ocean tides and river flow
 - Transports organisms, nutrients, oxygen, and removes waste
 - ✓ Extremely vulnerable to human intrusion

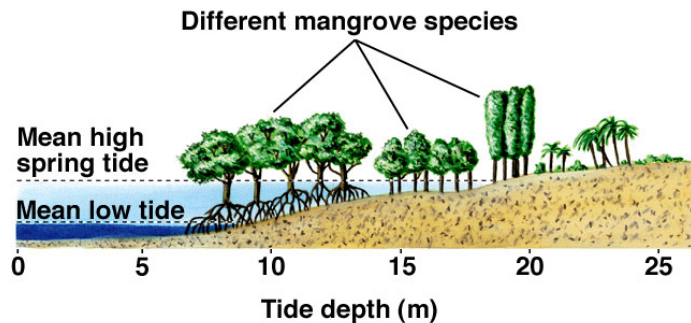
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Salt marsh channels.



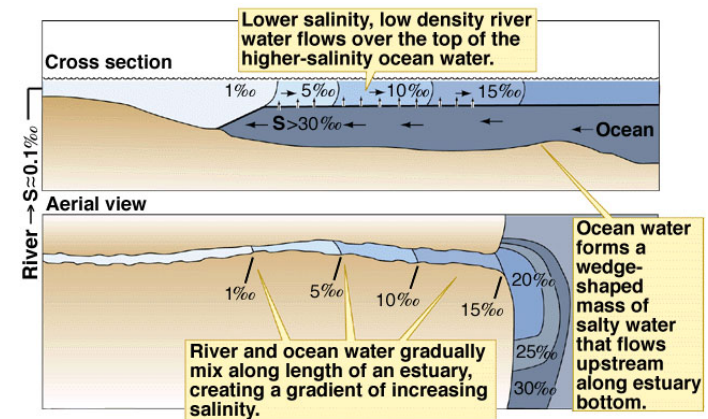
Tidal level and mangrove distributions.



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Structure of a salt wedge estuary.



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Rivers and Streams

- Rivers and Streams can be divided along three dimensions:
 - ✓ Length: pools, runs, riffles, rapids
 - ✓ Width: wetted / active channels
 - ✓ Vertical: water surface, column
 - Benthic
 - Hyporheic Zone: Trans. between surface water and groundwater.
 - Phreatic Zone: Beneath Hyporheic

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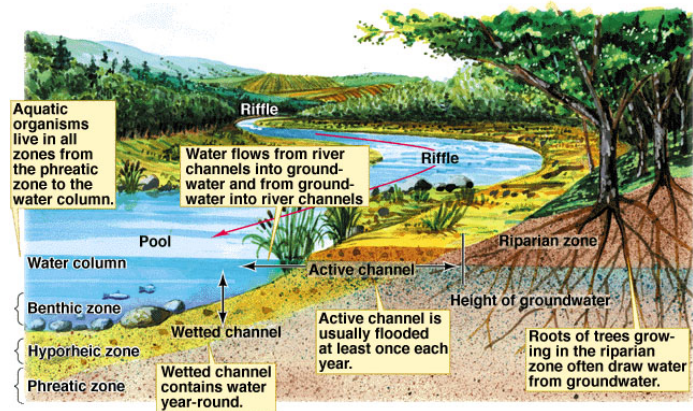
Major rivers.



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The three dimensions of stream structure.



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Rivers and Streams

- Light Considerations:
 - ✓ How much light shines on the surface
 - ✓ How far light penetrates the water column
- Turbidity:
 - ✓ Erosion from land
 - ✓ Suspended bottom sediments

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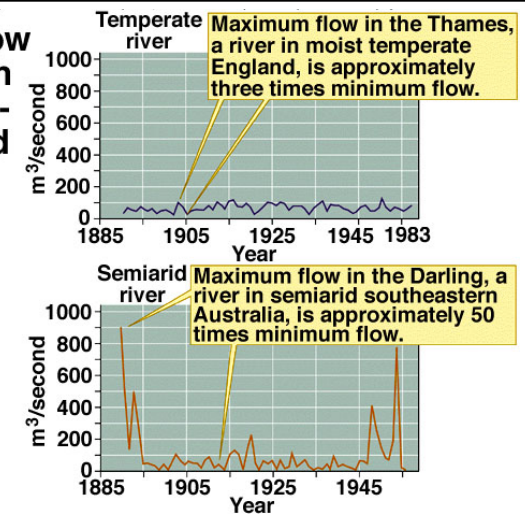
Rivers and Streams

- Temperature:
 - ✓ Closely tracks air temp.
- Dissolved Salts:
 - ✓ Reflects history of leaching in the basin
- Oxygen:
 - ✓ Inversely correlated with temp.
 - Usually not limiting factor in river systems
- Human Influence:
 - ✓ Long and intense
 - Transportation, Irrigation, Waste Disposal

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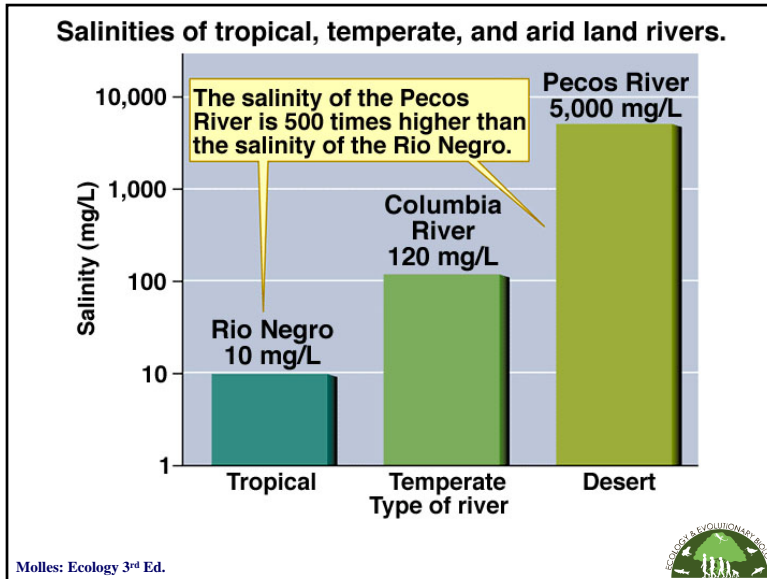


Annual flow of rivers in moist temperate and semiarid climates.



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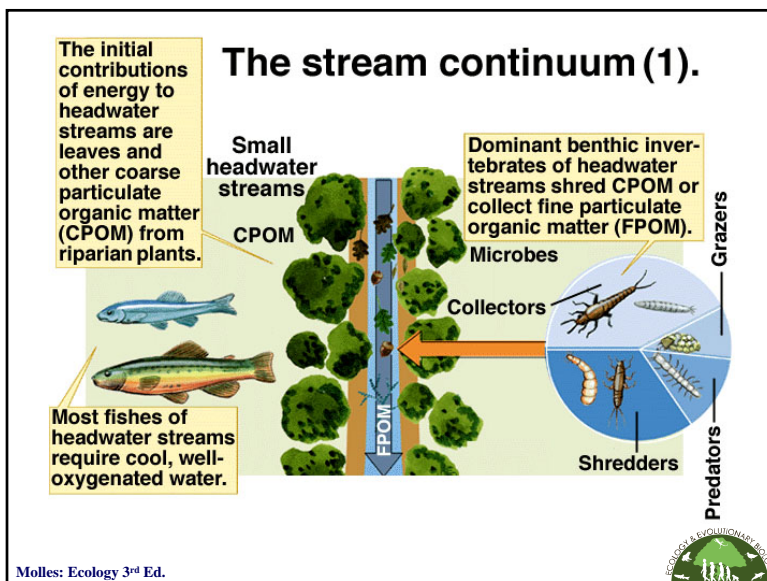




Rivers and Streams

- **Nutrient Levels**
 - ✓ **Oligotrophic:** low biological production, although often well oxygenated
 - ✓ **Eutrophic:** high biological production, but may be depleted of oxygen
- **Human Populations** have had profound, usually negative effect
 - ✓ **Municipal and Agricultural run-off**
 - ✓ **Exotic Species – Zebra Mussels**

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Lakes

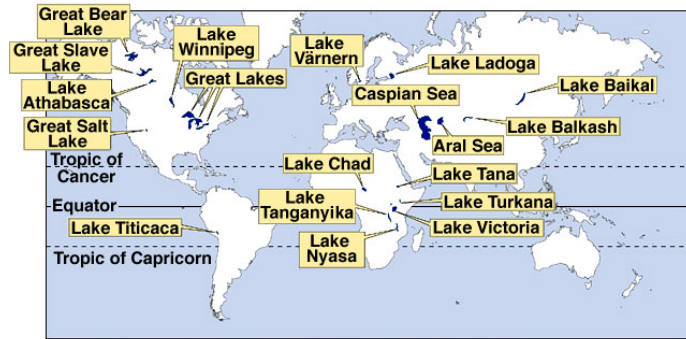
- **Most of the world's freshwater** resides in a few large lakes
 - ✓ **Great Lakes** contain 20% of freshwater in the world

Structure:

- ✓ **Littoral Zone:** Shallows
- ✓ **Limnetic Zone:** Open lake

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Distributions of some major lakes.



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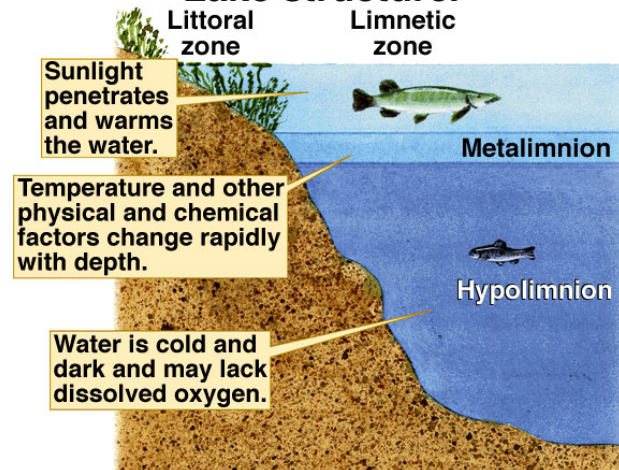
Lakes

- Vertical Distribution:
 - ✓ Epilimnion: warm surface layers
 - ✓ Metalimnion: (Thermocline) – temp changes substantially with depth
 - ✓ Hypolimnion: – cold dark waters
- Color:
 - ✓ Depends on light absorption and bio. activity
- Stratification:
 - ✓ Become thermally stratified as they warm

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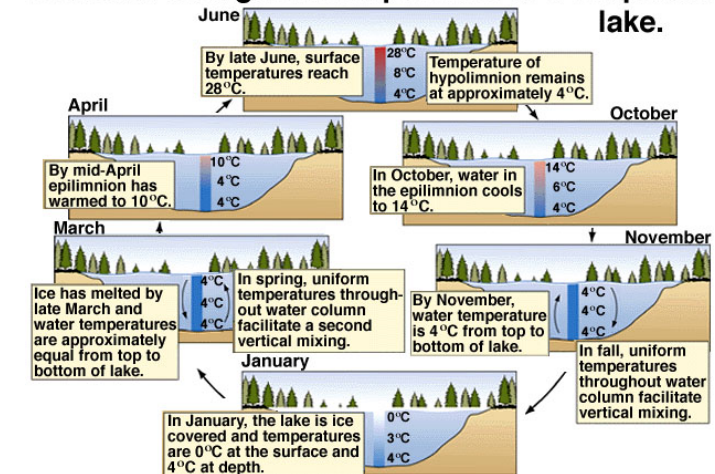
Lake structure.



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Seasonal changes in temperature in a temperate lake.



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Oligotrophic and eutrophic lakes.

Oligotrophic lake

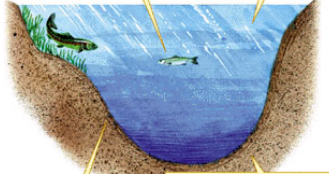
Eutrophic lake

Cool temperatures and high oxygen concentrations provide a suitable environment for fish such as trout and whitefish.

Low availability of nutrients, especially phosphorus and nitrogen, support low densities of phytoplankton and vascular aquatic plants.

Warm temperatures and low oxygen availability provide environments favoring tolerant fish such as catfish and bowfins.

High availability of nutrients, especially phosphorus and nitrogen, support high densities of phytoplankton and vascular aquatic plants.



Invertebrate species requiring high oxygen concentrations are dominant in the benthic fauna.

Steep shoreline and deep bottom reduce heating during summer and help maintain lower water temperatures.

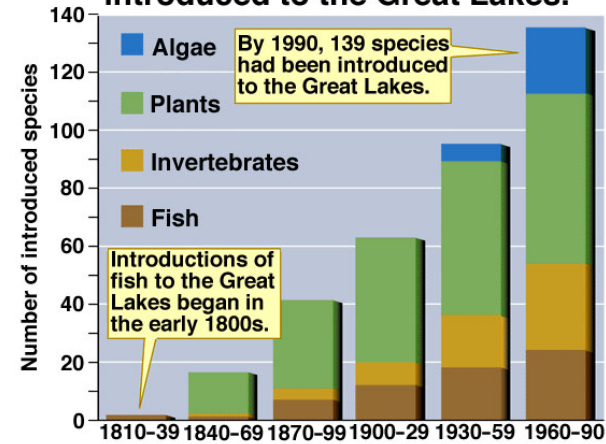
Benthic invertebrate biomass is high and dominated by species tolerant of warm temperatures and low oxygen.

Shallow bottom reduces total water volume and increases heating in summer.

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Cumulative number of species introduced to the Great Lakes.



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Calculating an Index of Biological Integrity.

Greater number of native species generally indicate higher environmental quality.

High proportions of insectivores and carnivores indicate higher environmental quality, while a high proportion of omnivores indicates lower environmental quality.

Higher proportions of diseased fish and fish showing tumors and anatomical abnormalities indicate lower environmental quality.

Higher IBI scores indicate higher environmental quality.

The researcher samples a fish community and assigns scores (S) (5 = best, 3 = moderate, 1 = worst) on the basis of several attributes:

Number and kinds of species (S_s)

Feeding biology of species (S_f)

Fish abundance (S_a)

Fish health (S_h)

The researcher adds the scores of the community on all attributes to produce an index of biological integrity (IBI):
 $IBI = S_s + S_f + S_a + S_h$

Researchers may assign several scores in each of the following categories.

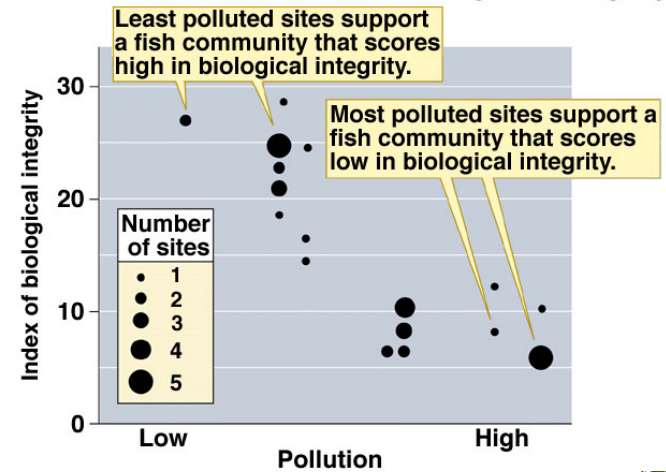
The presence of species sensitive to environmental degradation indicates high environmental quality.

Greater fish abundance indicates higher environmental quality.

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Pollution and the Index of Biological Integrity.



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Summary

- Hydrologic Cycle exchanges water among different holding areas
- Biology of aquatic organisms is largely determined by physical and chemical factors
 - ✓ Light, temp, salinity, oxygen, etc.

