ENVE203
Environmental Engineering Ecology
(Dec 03, 2012)

Elif Soyer

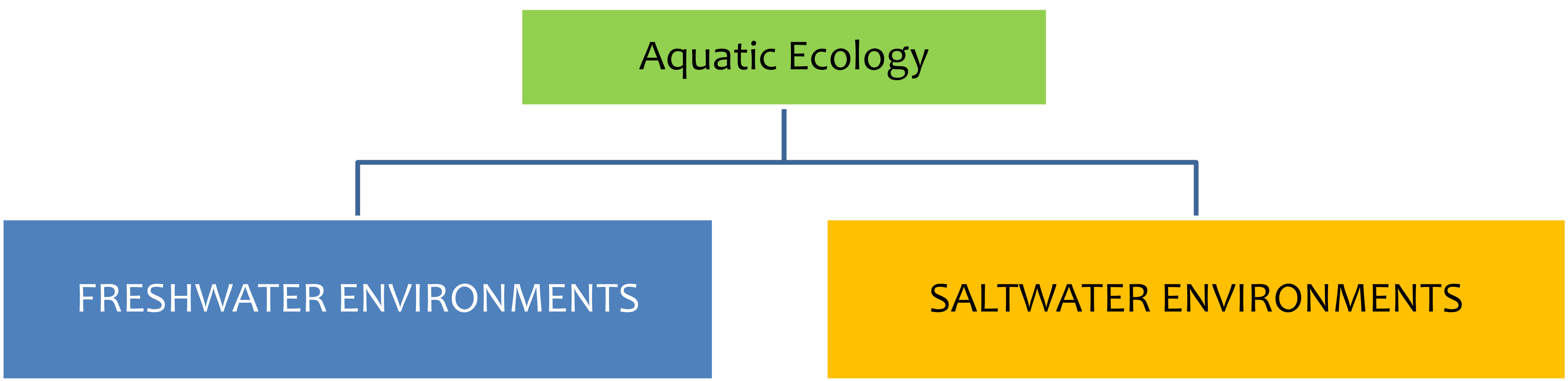
‘Aquatic Ecosystems’

Aquatic Ecosystems

Aquatic life zones differ from terrestrial biomes

Temperature is less important in watery environments because the water itself tends to moderate temperature

The most fundamental division



FRESHWATER ECOSYSTEMS

<u>flowing-water ecosystems</u>

Rivers

Streams

<u>standing-water ecosystems</u>

Lakes

Ponds

<u>freshwater wetlands</u>

Marshes

Swamps

Freshwater ecosystems occupy a relatively small portion of Earth's surface ~ 2 %

- Freshwater ecosystems have an important role in hydrologic cycle:

Assisting in recycling precipitation that flows as surface runoff to the ocean

- Large bodies of fresh water moderate daily and seasonal temperature fluctuations on nearby land
- Freshwater habitats provide homes for many species

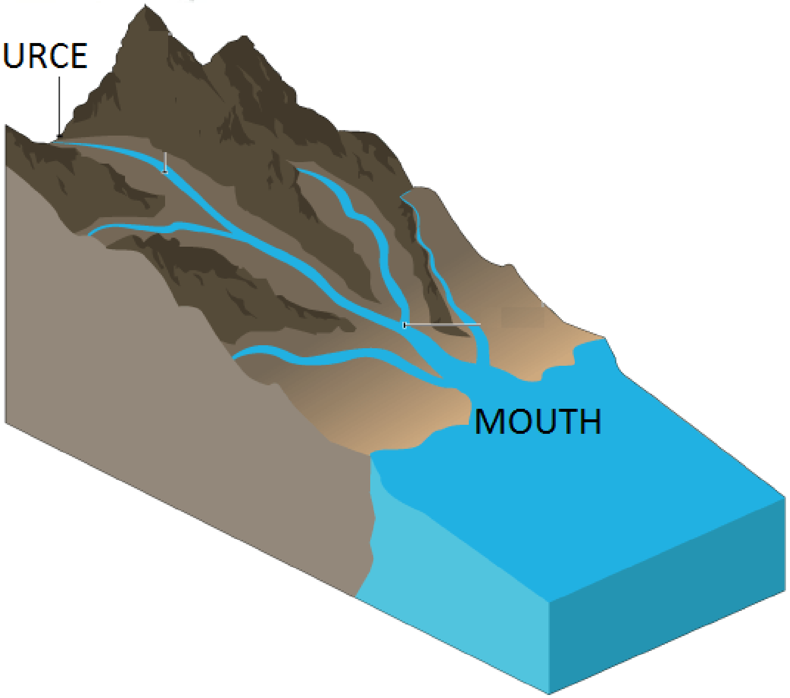
Rivers & Streams: Flowing-Water Ecosystems

Flowing-Water Ecosystems:

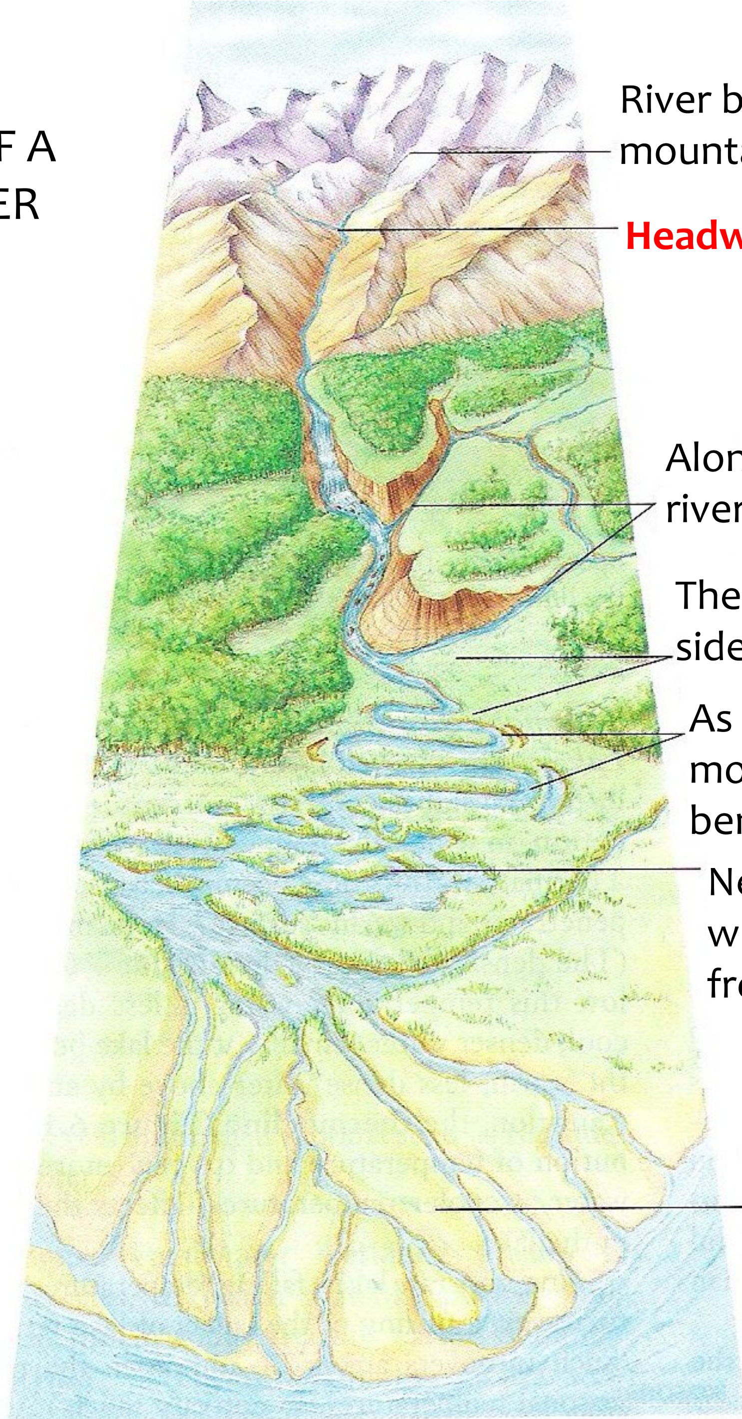
A freshwater ecosystem such as a river or stream in which the water flows in a current

Its nature changes greatly between

- The source (where it begins)
- The mouth (where it empties into another body of water)



FEATURES OF A TYPICAL RIVER



River begins at a **source**, often high in the mountains & fed by melting snows & glaciers

Headwater streams flows downstream rapidly

Along the way, smaller **tributaries** feed into the river, adding to its flow

The **floodplain** is the relatively flat area on either side of the river that is subject to flooding

As the river's course levels out, the river flows more slowly & winds from side to side, forming bends called **meanders**

Near the ocean, the river may form a **salt marsh** where fresh water from the river and salt water from the ocean mix

The **delta** is a fertile, low-lying plain at the river's **mouth** that forms from sediments deposited by the slow-moving river as it empties into the ocean

Rivers & Streams: Flowing-Water Ecosystems

Headwater streams: Small streams that are sources of a river

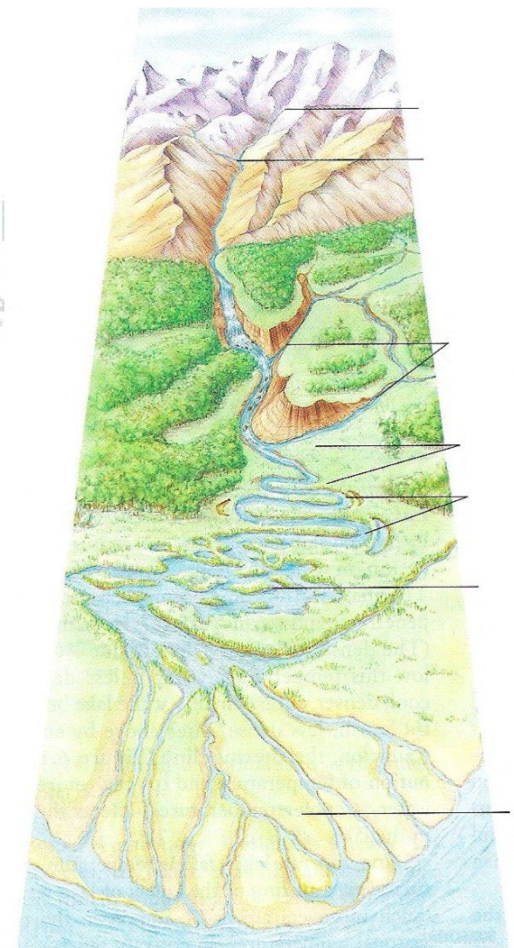
- Usually shallow
- Cool
- Swiftly, flowing
- Highly oxygenated

Rivers downstream from the headwaters

- Wider & deeper
- Cloudy (containing suspended solids)
- Not as cool
- Not as slower flowing
- Less oxygenated

Rivers & Streams: Flowing-Water Ecosystems

Various environmental conditions in a river system → Many different habitats



River continuum concept

The concept of a river system as a single ecosystem with a gradient in physical features from headwaters to mouth

Rivers & Streams: Flowing-Water Ecosystems

Adaptations of the inhabitants

In streams with fast currents
e.g. larvae of blackflies
with hooks or suckers to attach
themselves to rocks not to sweep away

e.g. immature water-penny beetles
Flattened bodies to slip under or between
rocks

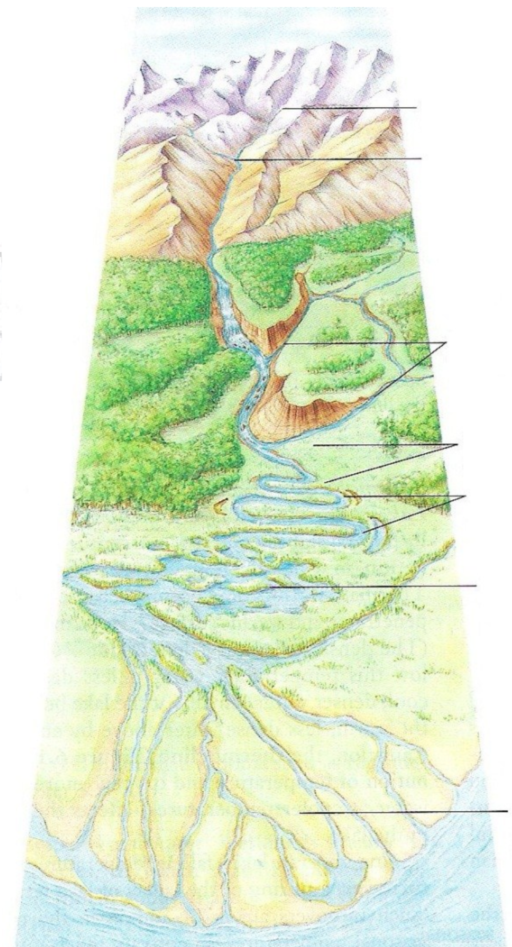
Streamlined and muscular enough to
swim in the current
e.g. fish

Rivers & Streams: Flowing-Water Ecosystems

Freshwater ecosystems depend on the land for much of their energy

<u>Headwater streams</u>
Almost all of the energy input comes from detritus e.g. dead leaves

<u>Downstream</u>
Rivers contain more producers, less dependent on detritus as a source of energy



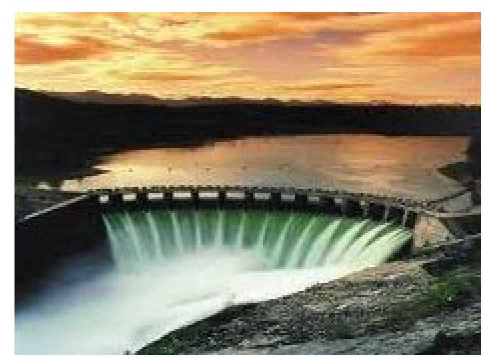
Rivers & Streams: Flowing-Water Ecosystems

Human activities

Pollution changes the physical environment

- threatens wildlife habitat
- adverse affects on our water supply

- A dam causes water to back up, flooding large areas of land and forming a reservoir
  Changes in terrestrial habitat



FRESHWATER ECOSYSTEMS

<u>flowing-water ecosystems</u>

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<u>standing-water ecosystems</u>

Lakes

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<u>freshwater wetlands</u>

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Swamps

Lakes & Ponds: Standing-Water Ecosystems

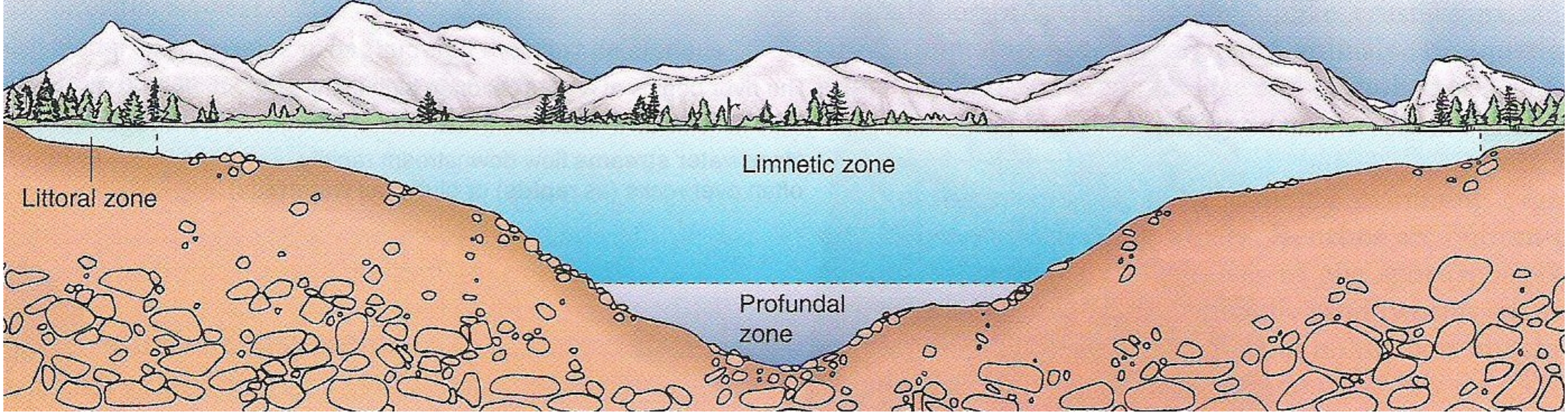
<u>Standing-Water Ecosystems</u>:

A body of freshwater that is surrounded by land and that does not flow

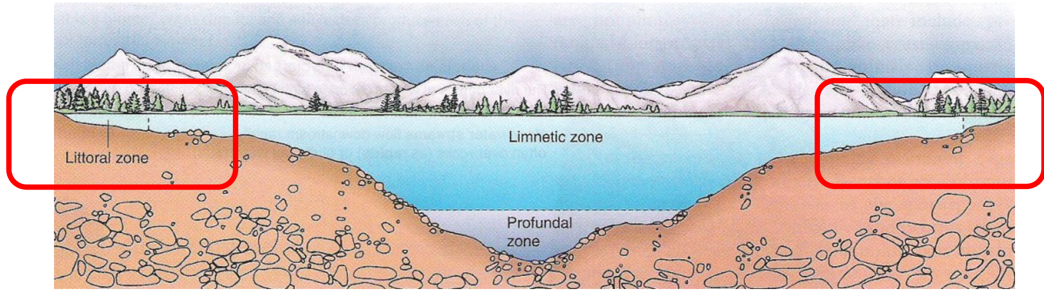
Zonation characterizes the standing-water ecosystems

A large lake has 3 zones

- Littoral zone
- Limnetic zone
- Profundal

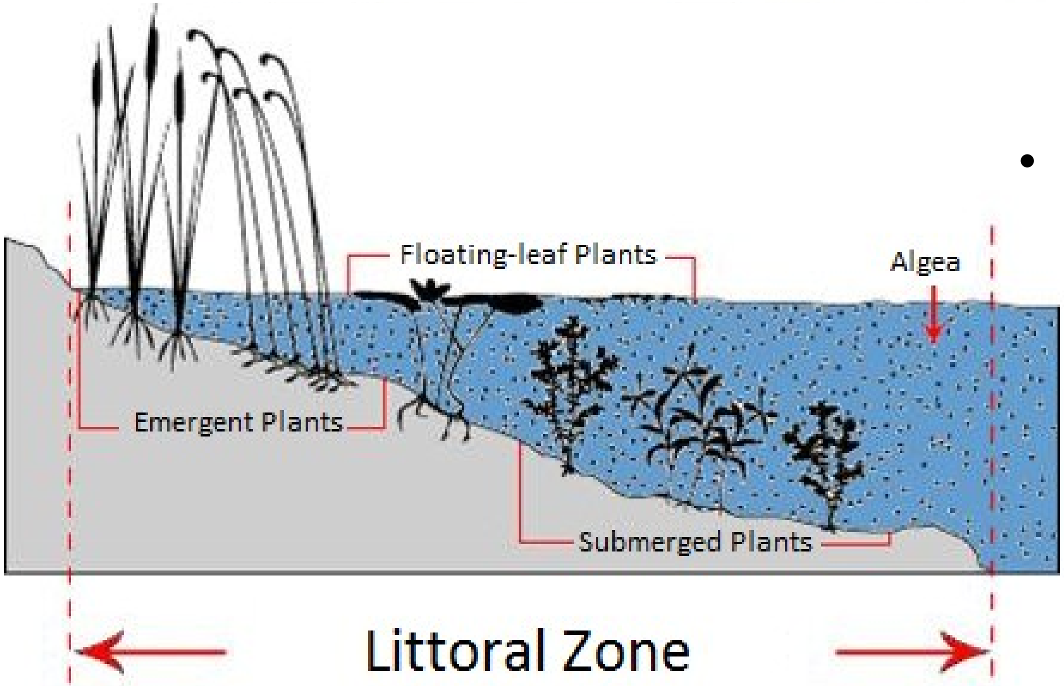


Lakes & Ponds: Standing-Water Ecosystems



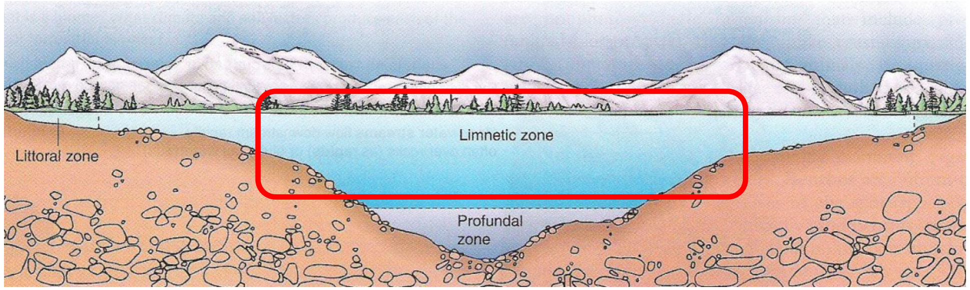
LITTORAL ZONE

- A shallow-water area along the shore of a lake or pond
- Light reaches the bottom
- Emergent vegetation, e.g. deeper-dwelling aquatic plants and algae



- Most productive section of the lake (greatests photosynthesis), it receives nutrient inputs from the surrounding land
- Animals: frogs, turtles, worms, crayfish & other crustaceans, insect larvae, many fishes

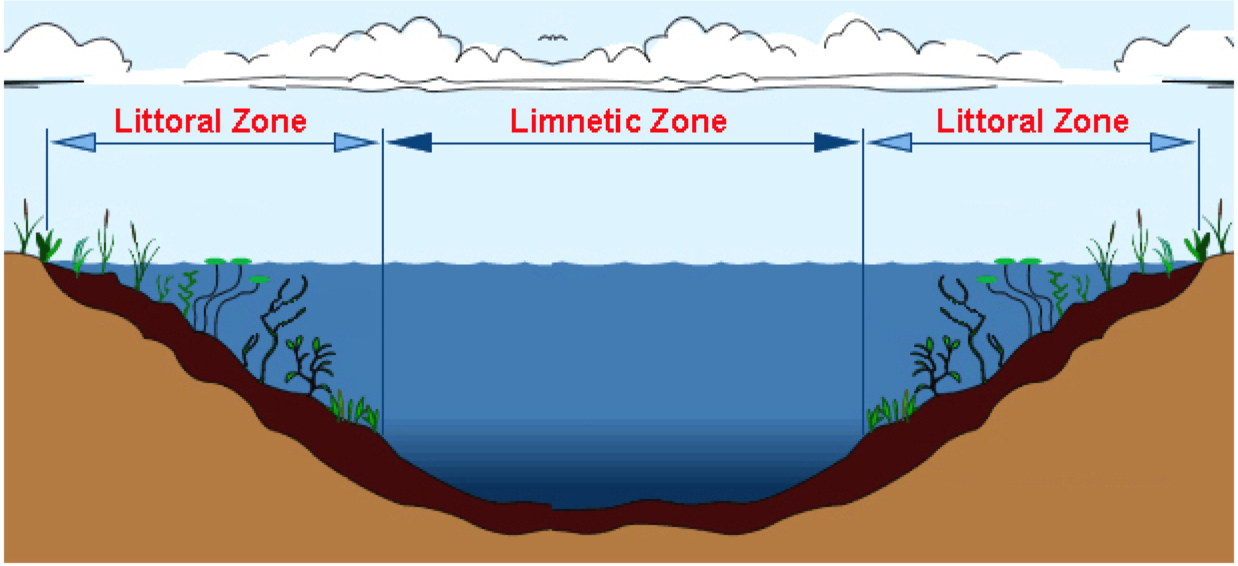
Lakes & Ponds: Standing-Water Ecosystems



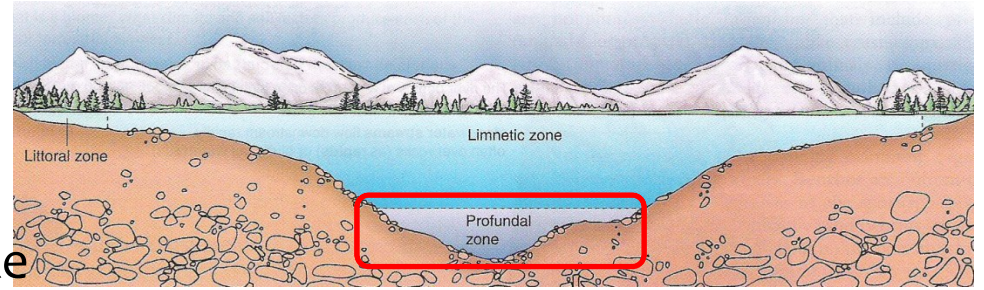
LIMNETIC ZONE

Open water beyond the littoral zone (away from the shore)

- Main organisms: microscopic phytoplankton & zooplankton
- Larger fishes (they may go to the littoral zone to feed and reproduce)
- Less vegetation grows (because of its depth)



Lakes & Ponds: Standing-Water Ecosystems



PROFUNDAL ZONE

The deepest zone
Beneath the limnetic zone of a large lake
(not exists in smaller lakes & ponds)

- Light does not penetrate to this depth: no plants and algae
- Food drifts into this zone from littoral & limnetic zones
- Bacteria decompose dead organisms & other organic material, using up oxygen, relasing nutrient minerals
- There are no producers in this zone to use/recycle these nutrient minerals
- Profundal zone: mineral-rich & anaerobic (without O_2)

Human Effects on Lake & Ponds

Eutrophication: Nutrient enrichment of a body of water with inorganic plant and algal nutrients like nitrates and phosphates

Although eutrophication is a natural process, human activities often accelerate it.

Increseased levels of nutrients

Runoff of agricultural fertilizers

Discharge of treated or untreated sewage

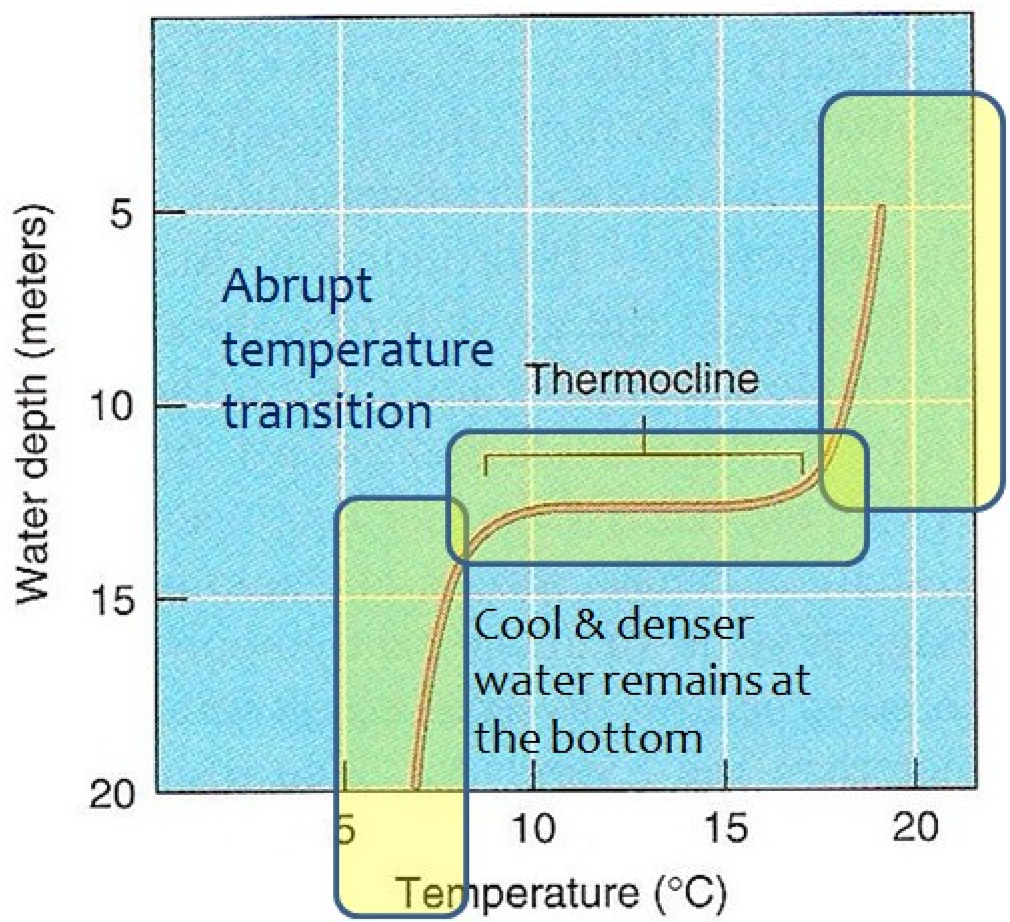
Soil erosion

EUTROPHICATION → Number & kinds of aquatic organisms living in the lake *change*

Thermal Stratification & Turnover in Temperate Lakes

Thermal stratification:

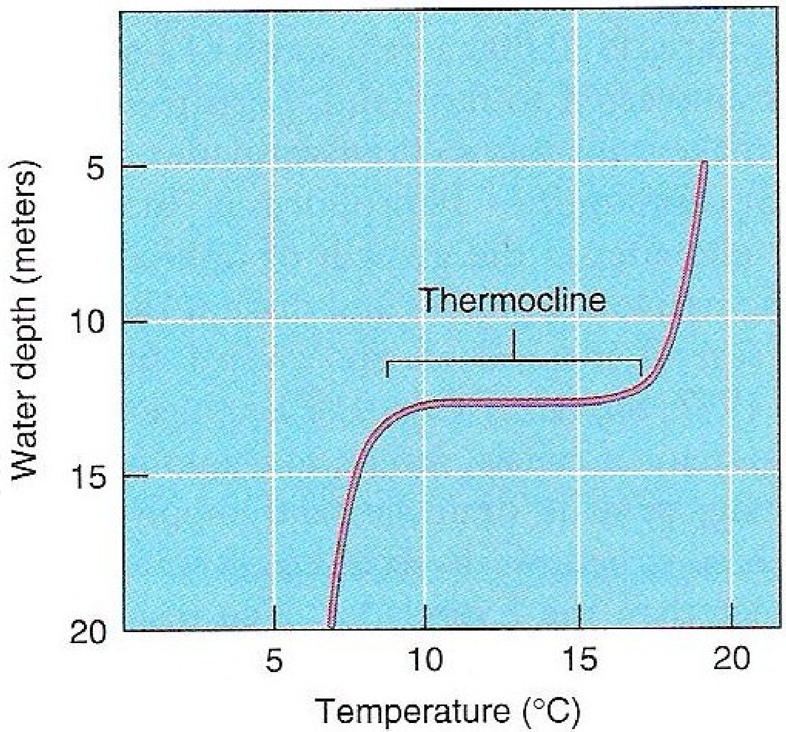
- The marked layering of large temperate lakes caused by how far light penetrates
- Temperature changes sharply with depth



Summer sunlight penetrates & warms surface waters, making them less dense

Thermal Stratification & Turnover in Temperate Lakes

Thermal stratification



More oxygen dissolves in water at cooler temperatures

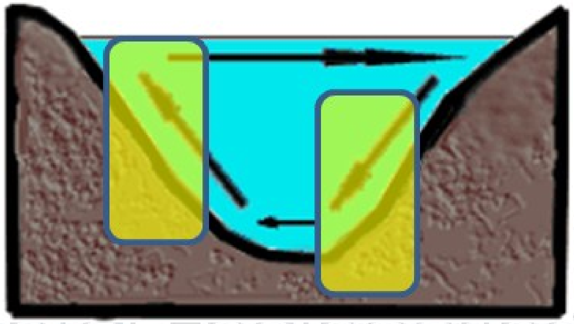
seasonal distribution of temperature & oxygen

affects

distribution of fish in the lake

FALL TURNOVER

Reason: decreasing temperatures in autumn



Warmer water rises to the surface, where it cools and sinks

Surface water cools

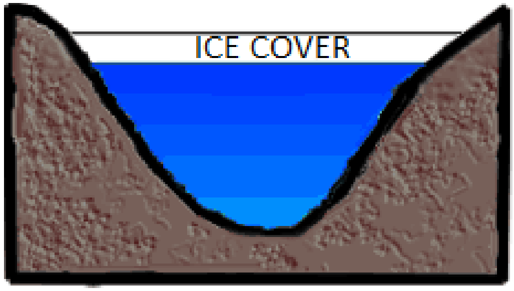
Its density increases

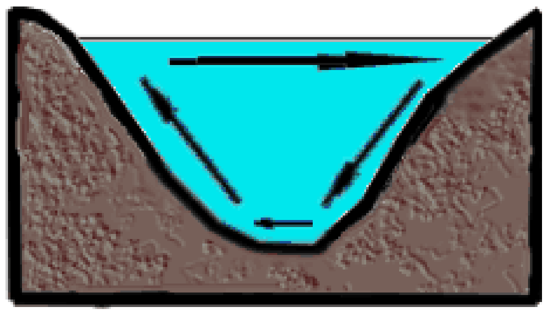
It displaces the less dense, warmer, mineral-rich water beneath

This process, *cooling & sinking* continues until the lake reaches a uniform temperature throughout

SPRING TURNOVER

Occurs as ice melts & the surface water reaches 4 ºC



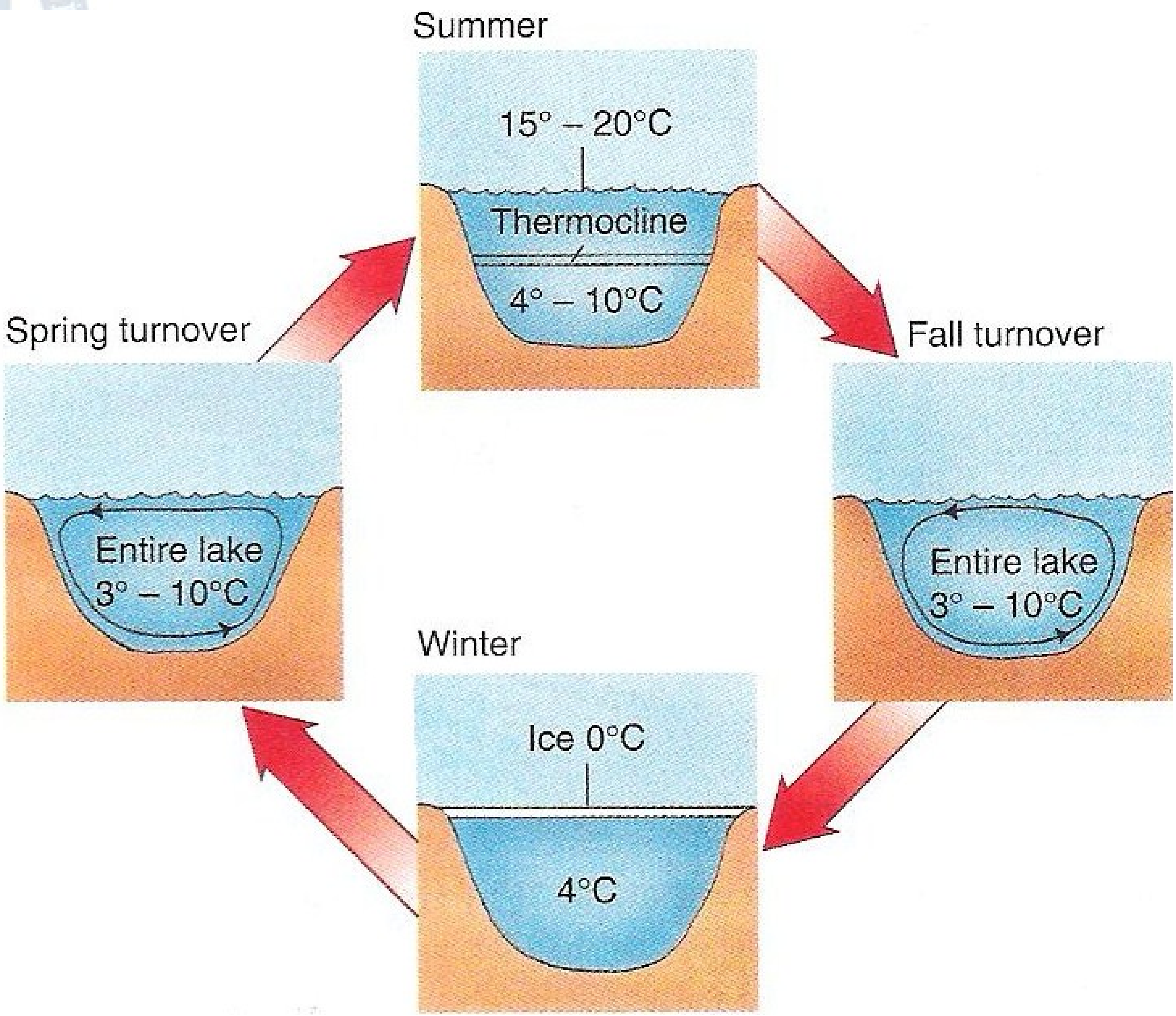


Surface water sinks to the bottom

Bottom water returns to the surface

As summer arrives thermal stratification occurs again

Fall & Spring Turnovers



Fall & Spring Turnovers

Deeper, nutrient-rich water mixing Surface, nutrient-poor water

- Essential nutrient minerals are brought to the surface,
- Oxygenated water to the bottom

ALGAL BLOOMS

- During fall & spring
- Population explosions of algae & cyanobacteria
- Temporary
- Sudden presence of large amounts of nutrient minerals in surface

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Marshes & Swamps: Freshwater Wetlands

Freshwater Wetland:

Land that shallow freshwater covers for at least part of the year & that has a characteristic soil & water-tolerant vegetation

Marshes

Grasslike plants dominate

Swamps

Woody trees or shrubs dominate

Marshes & Swamps: Freshwater Wetlands

Wetland soils
- Waterlogged (filled/saturated with water)
- Anaerobic

for variable periods

Most of them rich in accumulated organic materials (anaerobic conditions discourage decomposition)

Wetland plants
Highly productive & provide enough food to support a variety of organisms

- Wetlands are valued as a wildlife habitat
- Provide natural food control because they are holding areas for excess water
- Groundwater recharging areas (to help cleanse water by trapping & holding pollutants in the flooded soil) → *ECOSYSTEM SERVICES*

Estuaries: Where Fresh Water & Salt Water Meet

Estuary:

A coastal body of water, partly surrounded by land, with access to open ocean & a large supply of fresh water from a river

Several ecosystems may occur where the ocean meets the land:

- A rocky shore
- A sandy beach
- A tidal estuary

- Water levels in an estuary rise & fall with the tides
- Salinity fluctuates with
    - Tidal cycles
    - The time of year
    - Precipitation

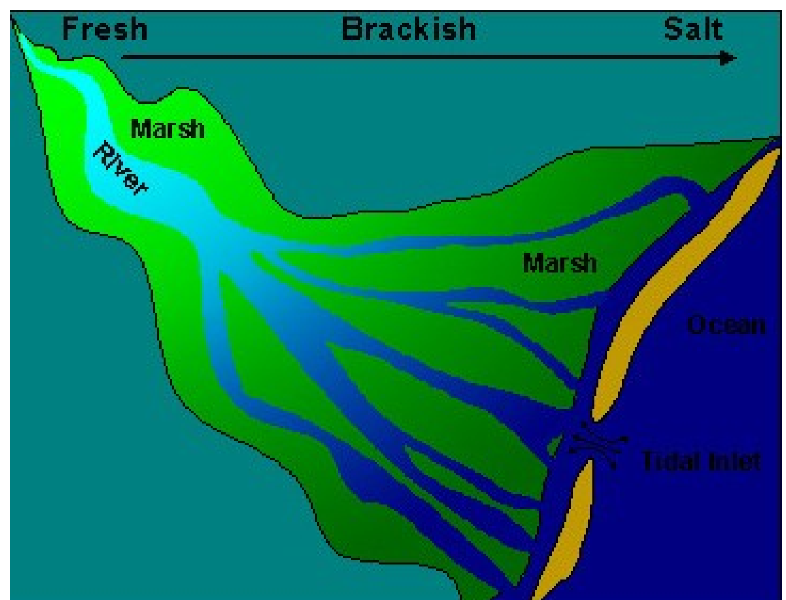
Estuaries: Where Fresh Water & Salt Water Meet

Unsalty freshwater at the river entrance

Salty ocean water at the mouth of the estuary

Estuarine organisms must tolerate the significant daily, seasonal & annual variations in

- *Temperature*
- *Salinity*
- *Depth of light penetration*



Estuaries: Where Fresh Water & Salt Water Meet

Estuaries are among the most fertile ecosystems in the world
A much greater productivity than either the adjacent ocean or the fresh water upriver

High productivity is brought about by 4 factors:

(1) Nutrients are transported from the land into rivers & creeks that flow into the estuary
(2) Tidal action promotes a rapid circulation of nutrients & helps remove waste products
(3) A high level of light penetrates the shallow water
(4) Presence of many plants provides an extensive photosynthetic carpet & mechanically traps detritus, forming the base of a detritus food web

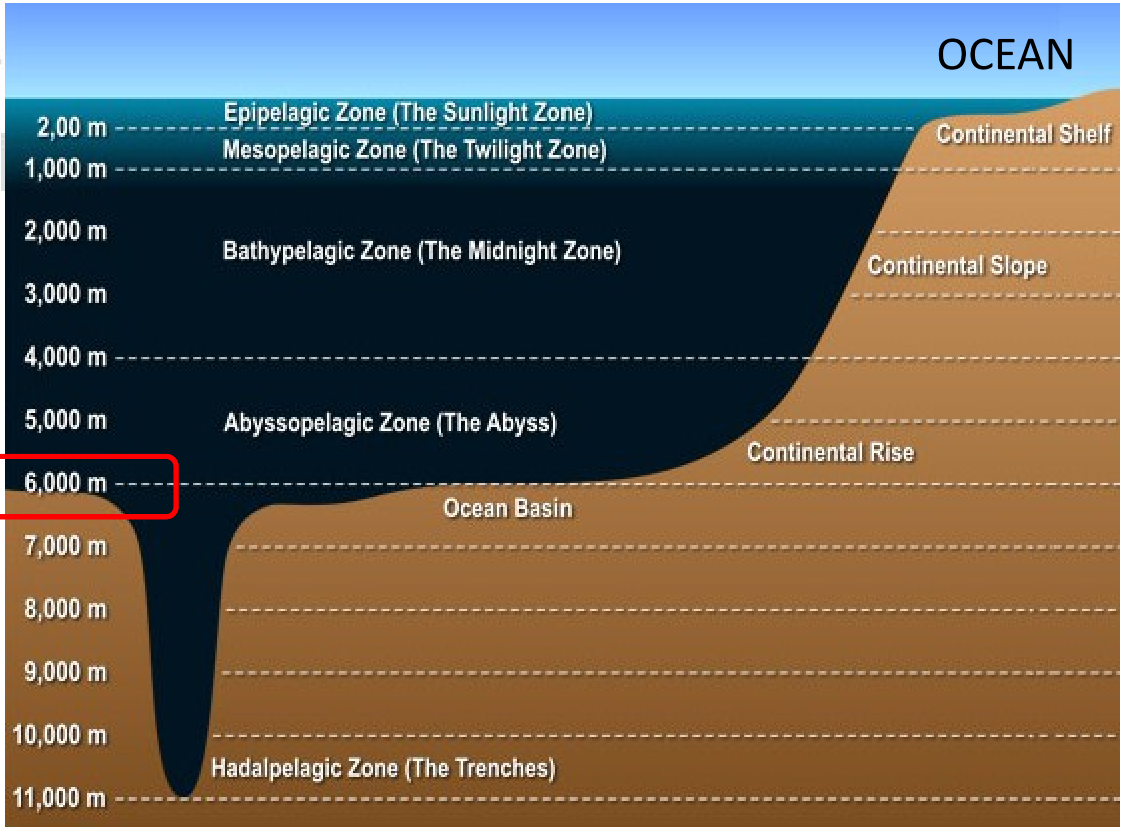
Many species spend their larval stages in estuaries among the protective tangle of decaying plants

American eels spawn in the ocean, but they inhabit freshwater, estuaries, and brackish habitats for most of their lives

MARINE ECOSYSTEMS

Although lakes and the ocean are comparable in many ways, there are many physical differences

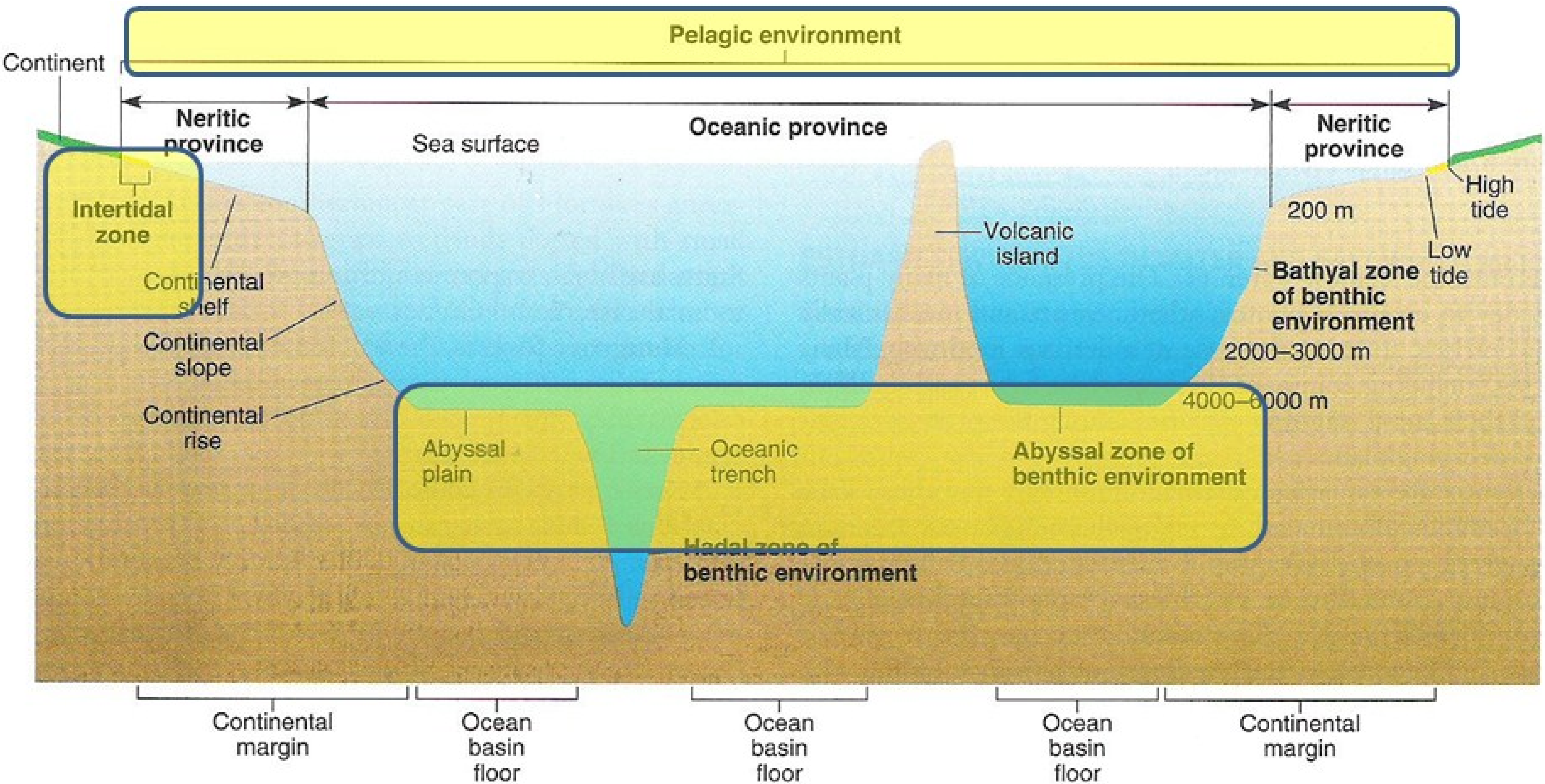
The depths of even the deepest lakes do not approach those of the ocean trenches, with areas that extend more than 6 km below the sunlit surface



MARINE ECOSYSTEMS

Marine environment is subdivided into several life zones:

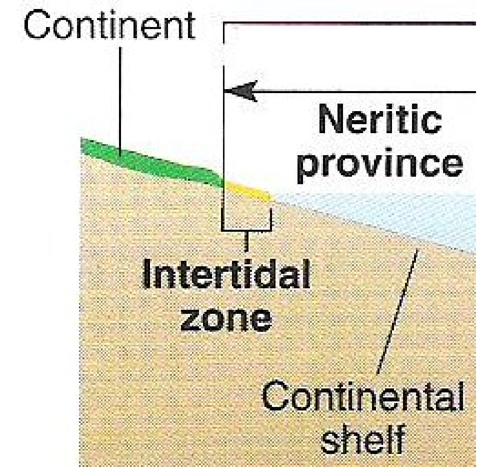
- Intertidal zone
- Benthic environment
- Pelagic environment

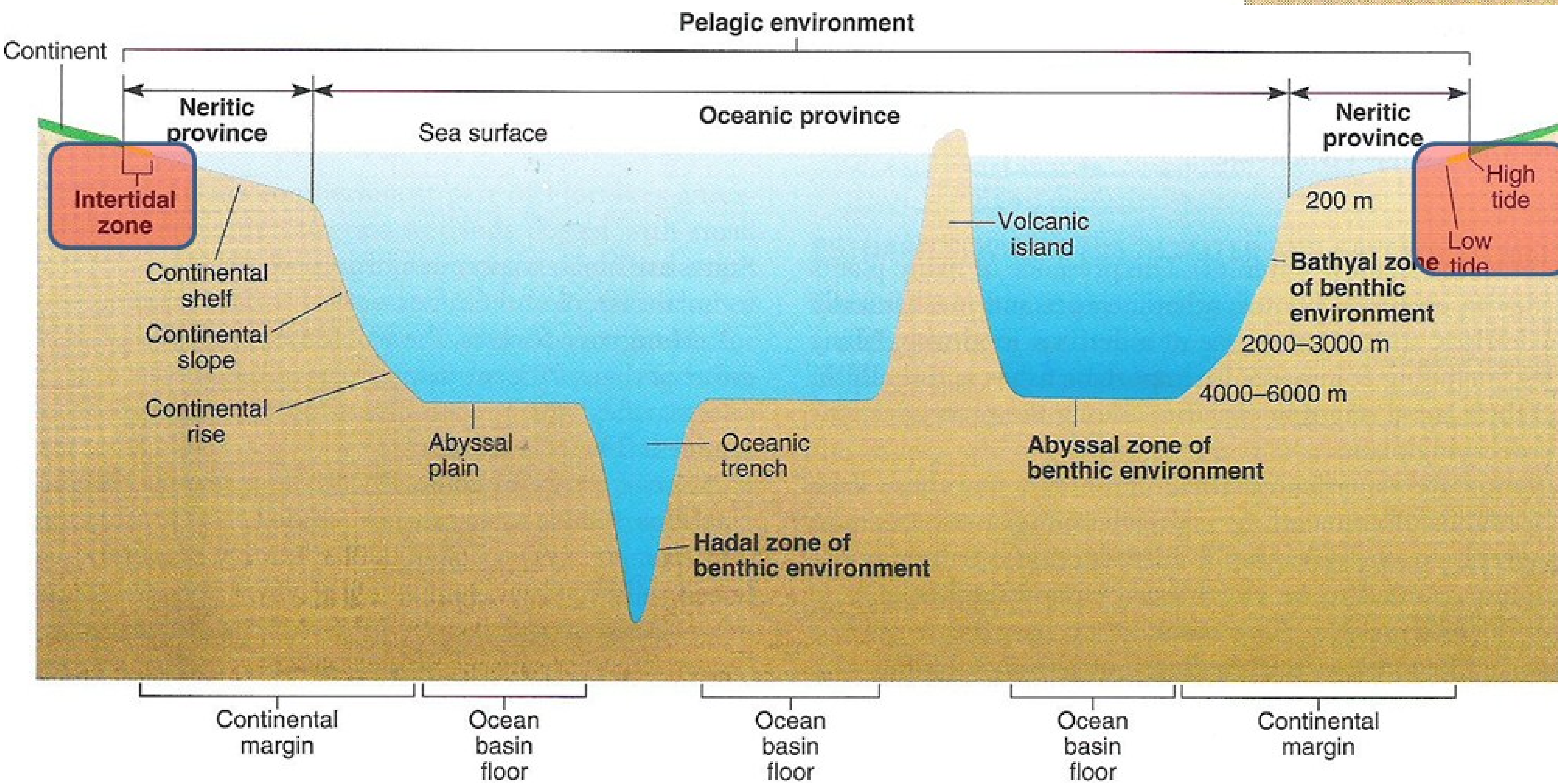


MARINE ECOSYSTEMS

Intertidal zone

Organisms live along the shore between high and low tides



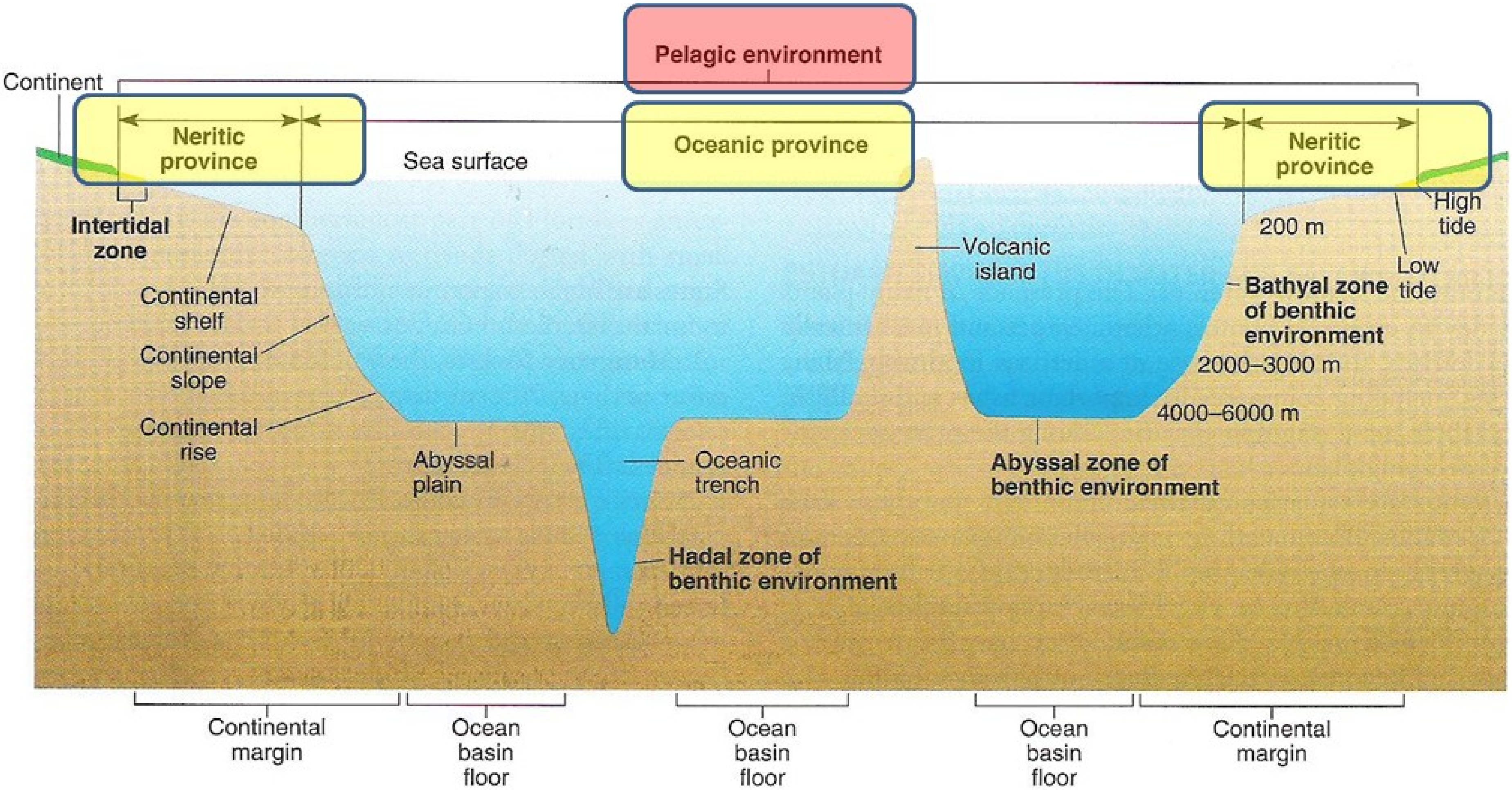


MARINE ECOSYSTEMS

Pelagic environment
Organisms live in the water

Neritic province
Shallow waters close to shore (overlies the ocean floor from the shoreline to a depth of 200 m

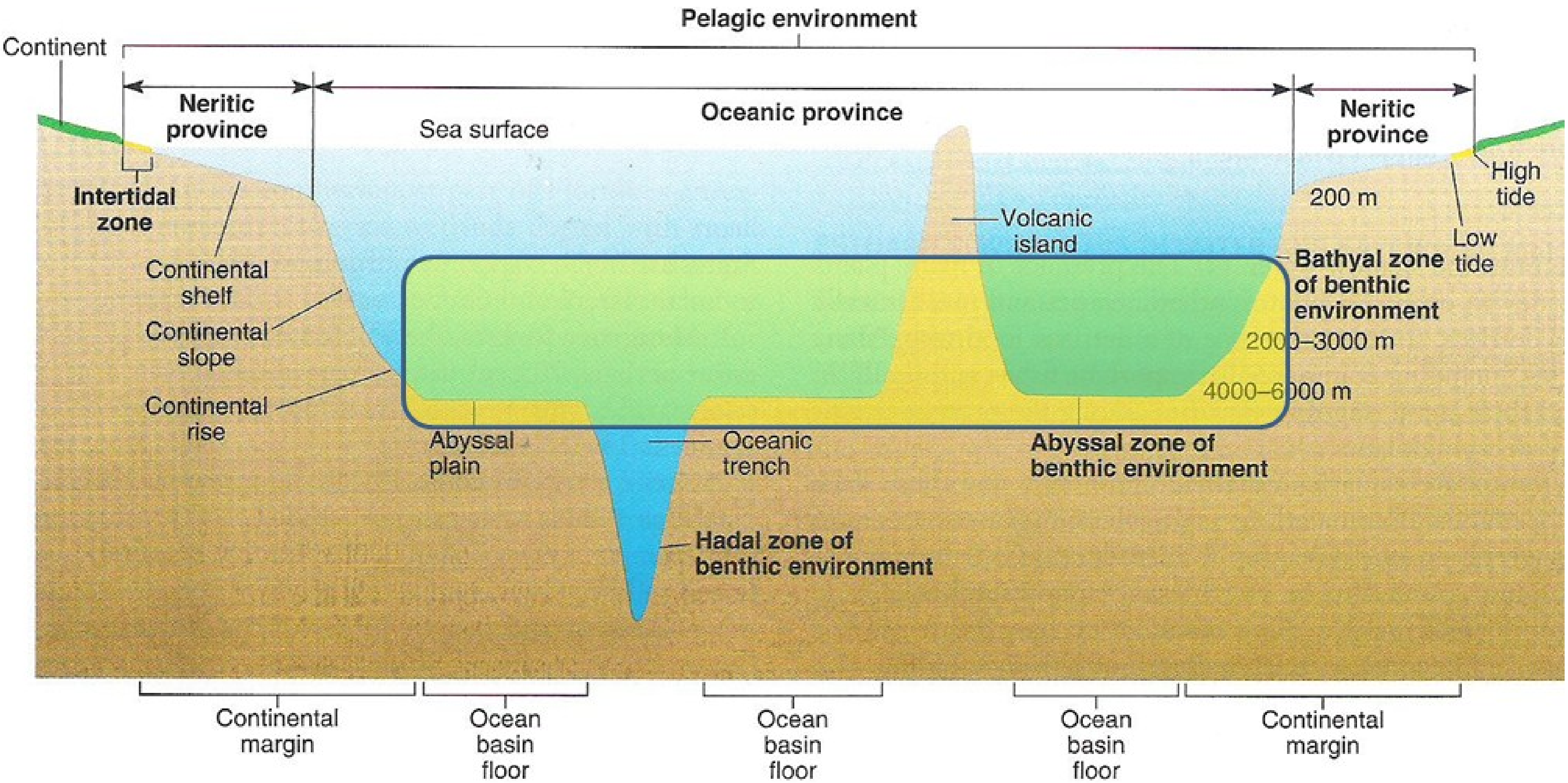
Oceanic province
Overlies the ocean floor at depths > 200 m



MARINE ECOSYSTEMS

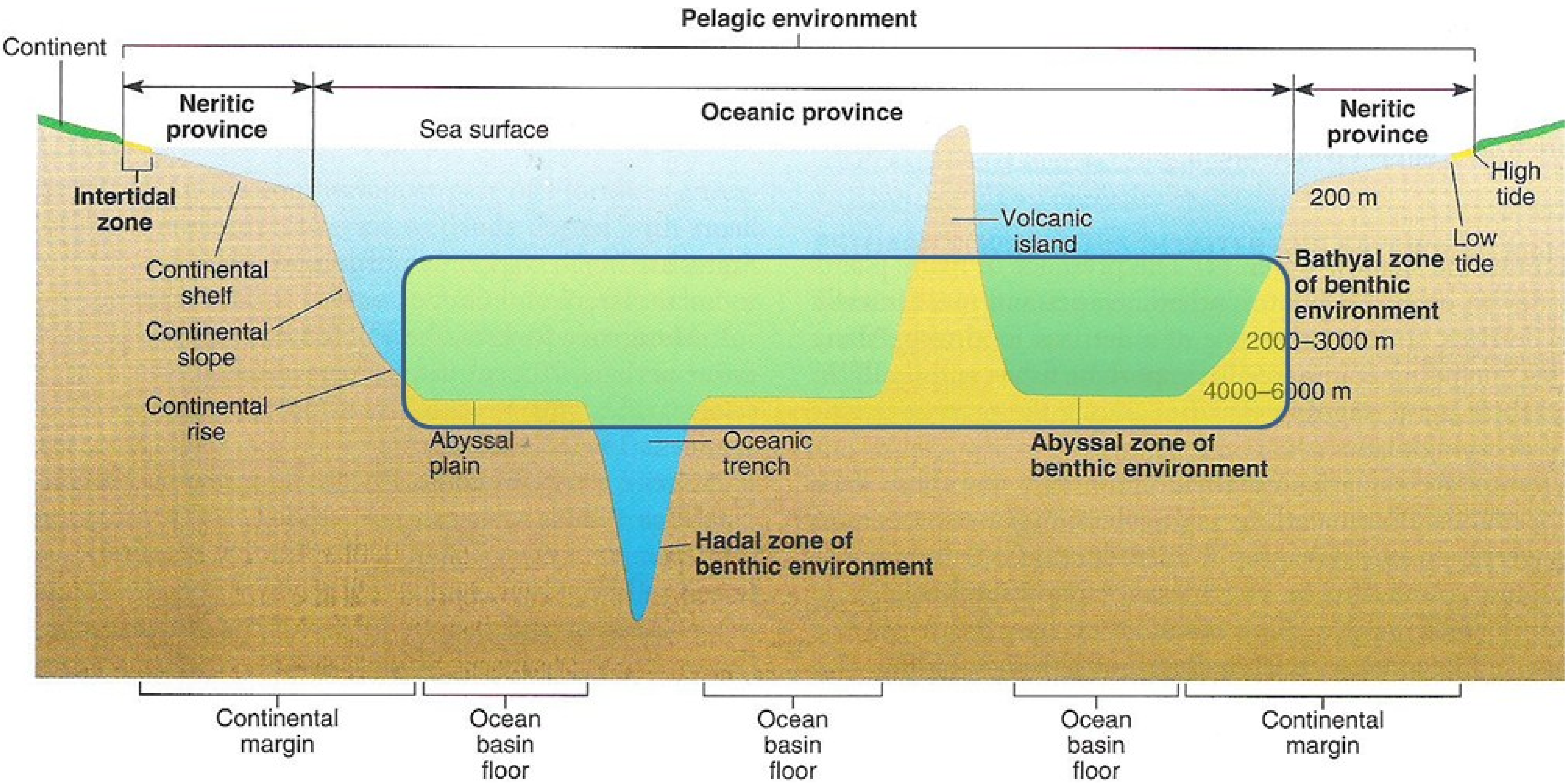
Benthic environment

- Ocean floor, which extends from the intertidal zone to the deep ocean trenches
- Organisms live on or under the seafloor



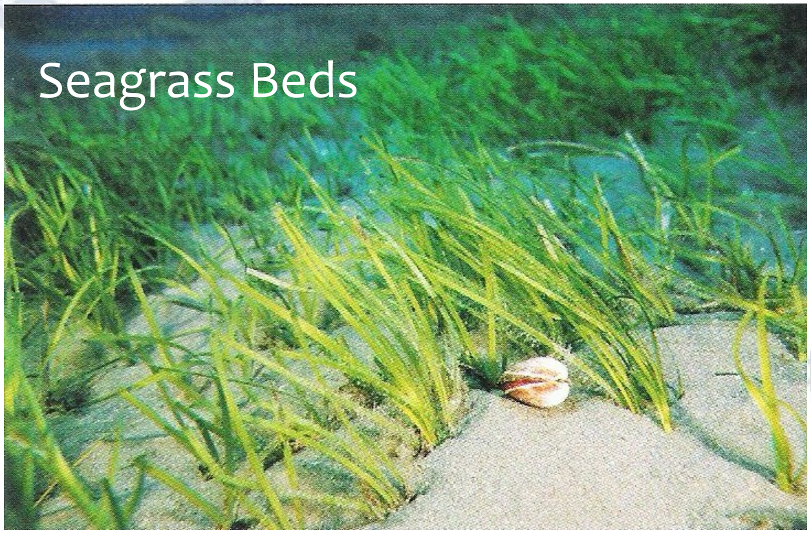
MARINE ECOSYSTEMS

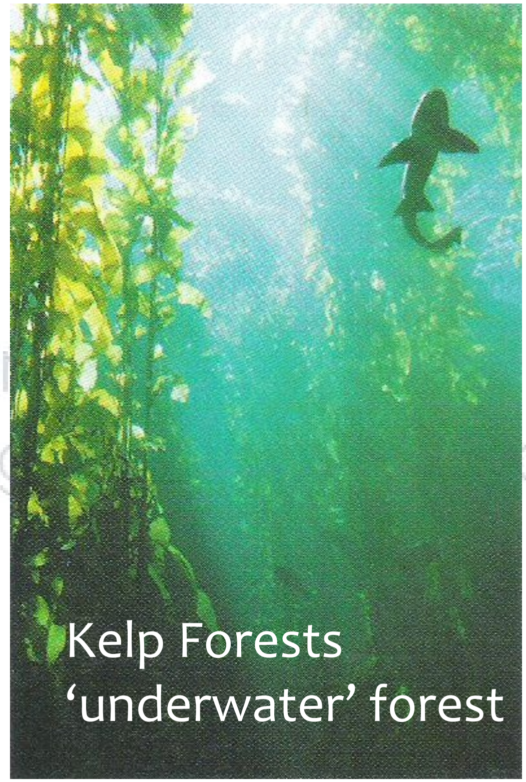
Benthic environment
Sediments (mostly sand & mud)
Many animals, e.g., worms & clams burrow
Bacteria > 500 m below the ocean floor at several sites



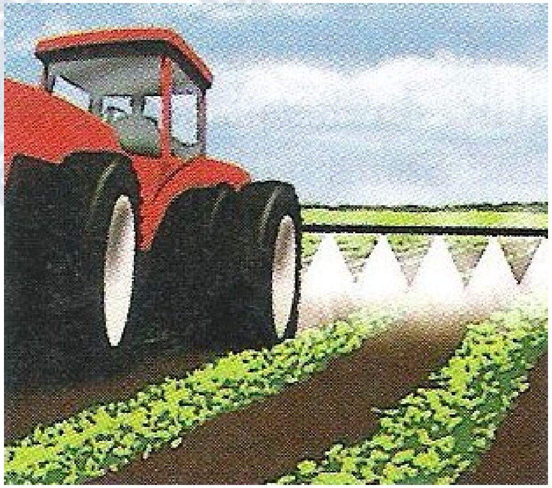
MARINE ECOSYSTEMS

Benthic environment



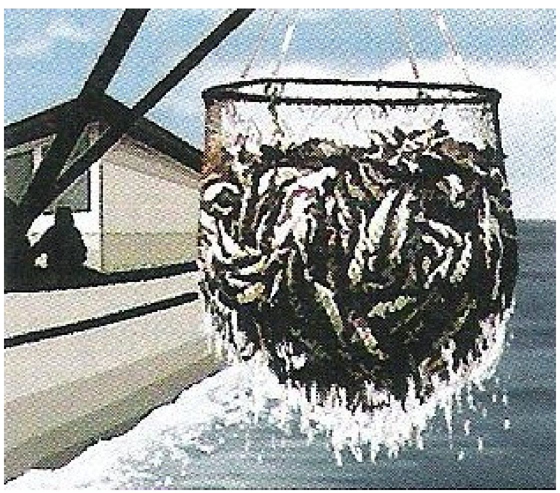


Human Impacts on the Ocean



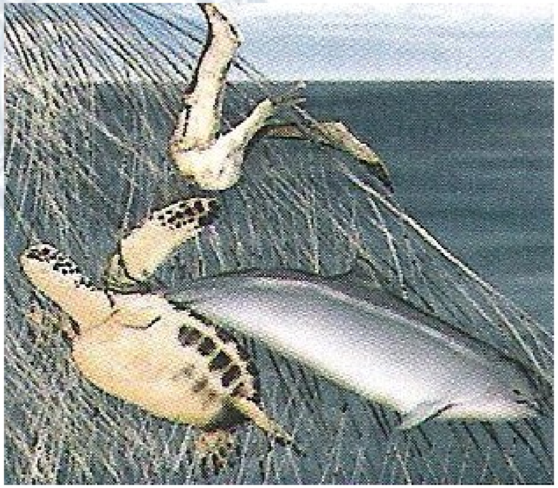
Nonpoint Source Pollution
(runoff from land)
Example: Agricultural runoff pollutes water (fertilizers, pesticides, and livestock wastes)

Invasive Species
Example: Release of ships' ballast water, which contains foreign crabs, mussels, worms & fishes

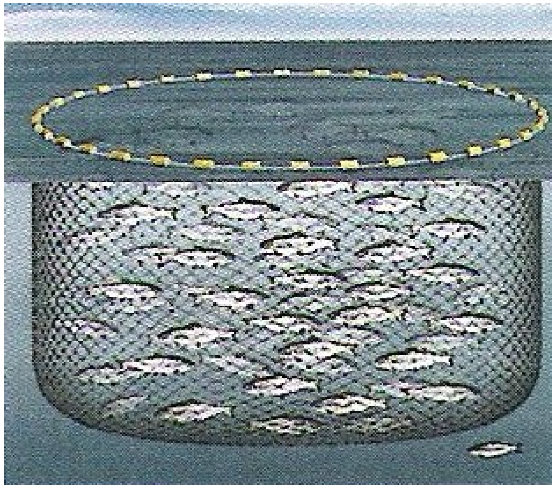


Overfishing
Example: The populations of many commercial fish species are severely depleted

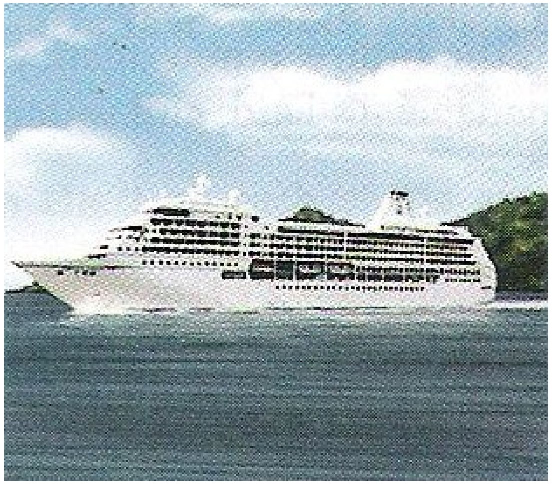
Human Impacts on the Ocean



Bycatch
Example: Fisherman unintentionally kill dolphins, sea turtles, and seabirds

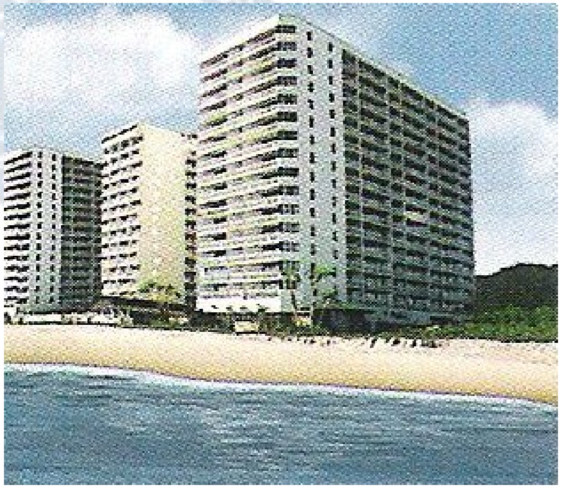


Aquaculture
Example: Produces wastes that pollute ocean water & harm marine organisms; requires wild fish to feed farmed fish

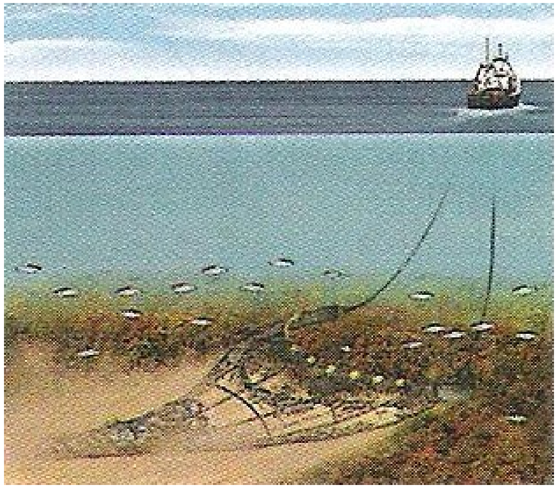


Point Source Pollution
Example: Passenge cruise ships dump sewage, shower & sink water, & oily water

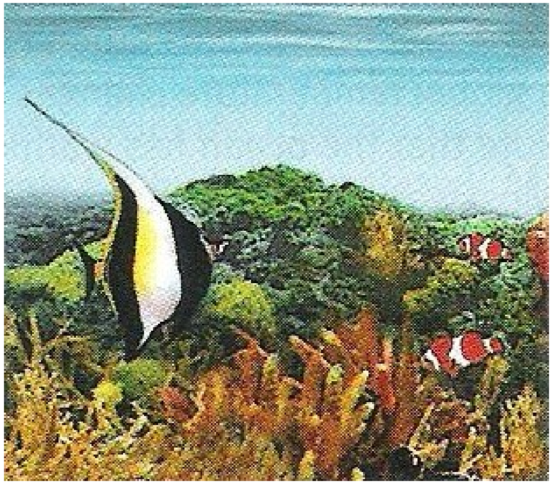
Human Impacts on the Ocean



Coastal Development
Example: Developers destroy important coastal habitat, such as salt marshes & swamps



Habitat Destruction
Example: Trawl nets destroy habitat (fishing equipment pulled along the ocean floor)



Climate Change
Example: Coral reefs are particularly vulnerable to increasing temperatures & ocean acidification