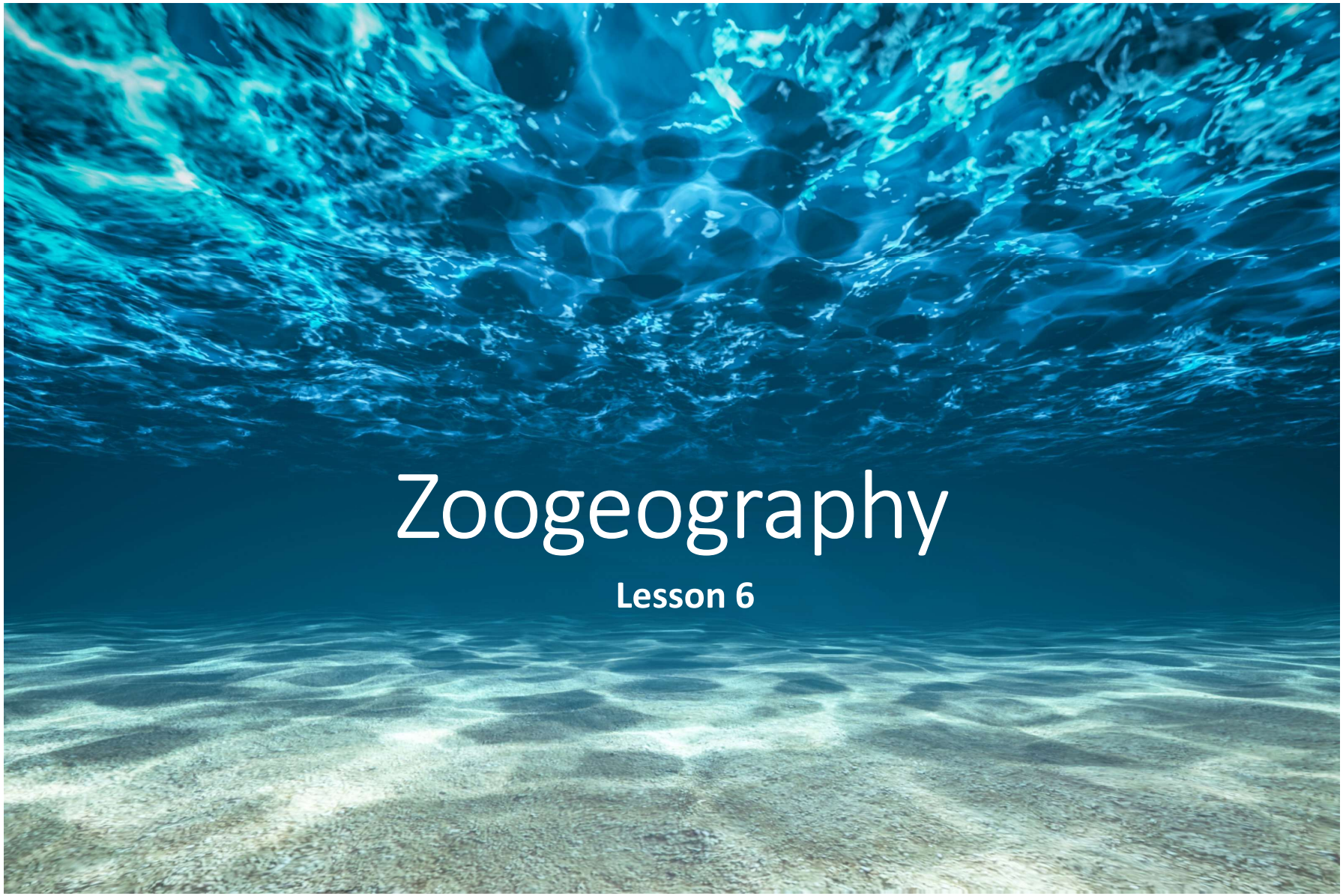
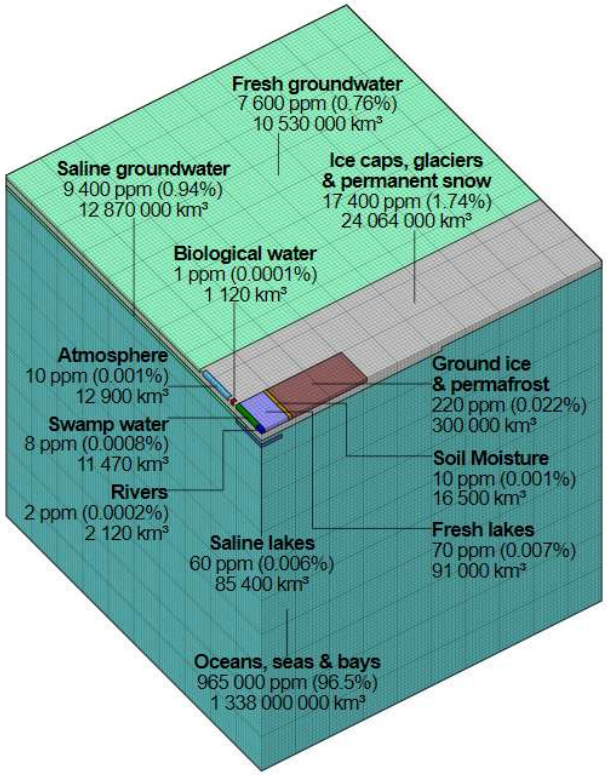


Zoogeography

Lesson 6

Freshwater environments

- lakes,
- ponds,
- bogs,
- wetlands,
- rivers,
- streams,
- springs, and
- hyporheic zone
- groundwater



Distribution (by volume) of water on Earth: Visualization of the distribution (by volume) of water on Earth. Each tiny cube (such as the one representing biological water) corresponds to approximately 1000 km³ of water, with a mass of about 1 trillion tonnes (200000 times that of the Great Pyramid of Giza). The entire block comprises 1 million tiny cubes.

Some keywords…

- Fresh water creates a hypotonic environment for aquatic organisms.
- Most aquatic organisms have a limited ability to regulate their osmotic balance and therefore can only live within a narrow range of salinity.

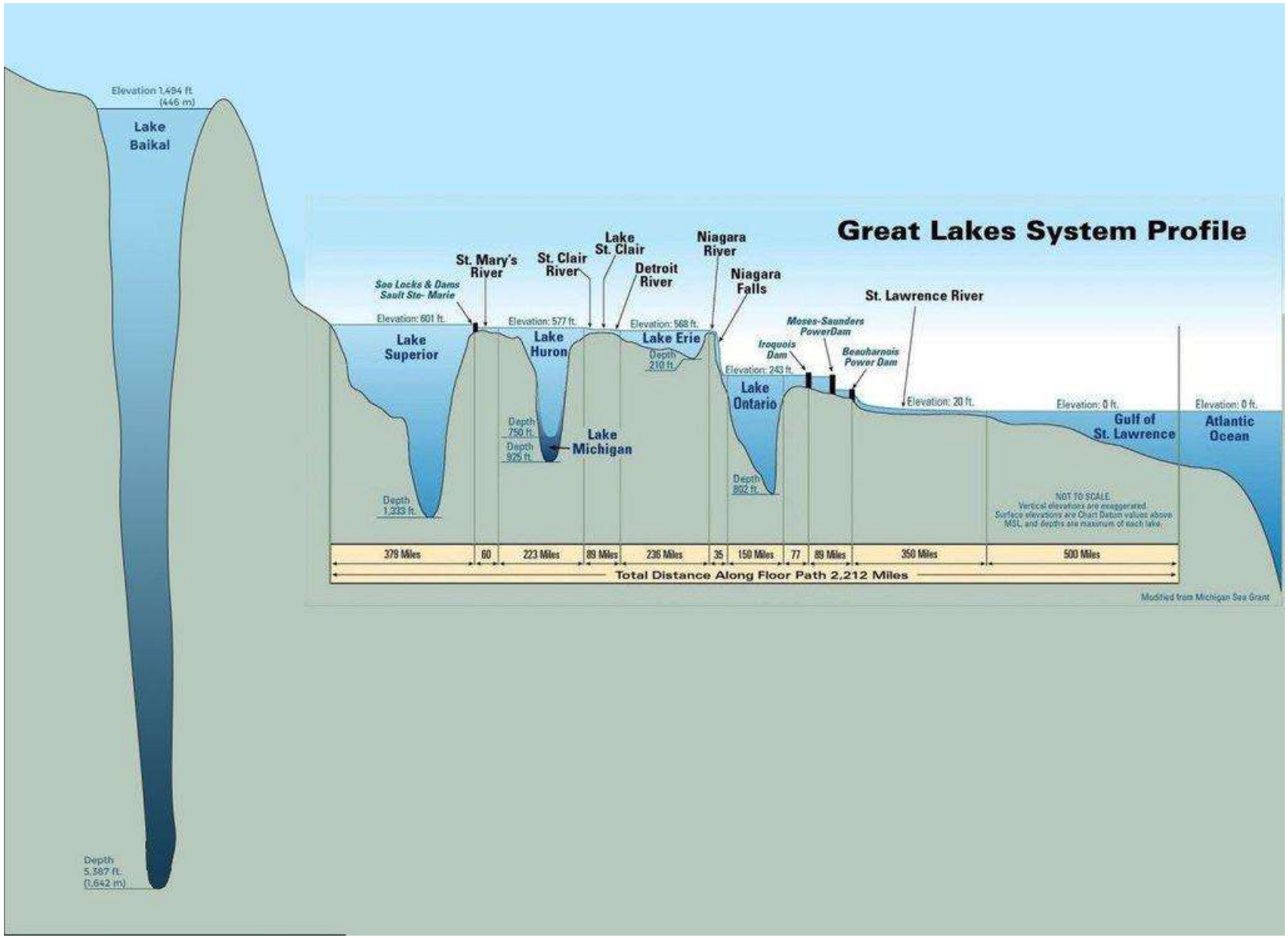
Osmotic balance: Osmoregulation is the active regulation of the osmotic pressure of an organism's fluids to maintain the homeostasis of the organism's water content; that is, it keeps the organism's fluids from becoming too diluted or too concentrated.

Lakes

- The greatest part of the lakes is relatively young; many lakes were formed in basins left over after the retreat of glaciers some 50,000 years ago.

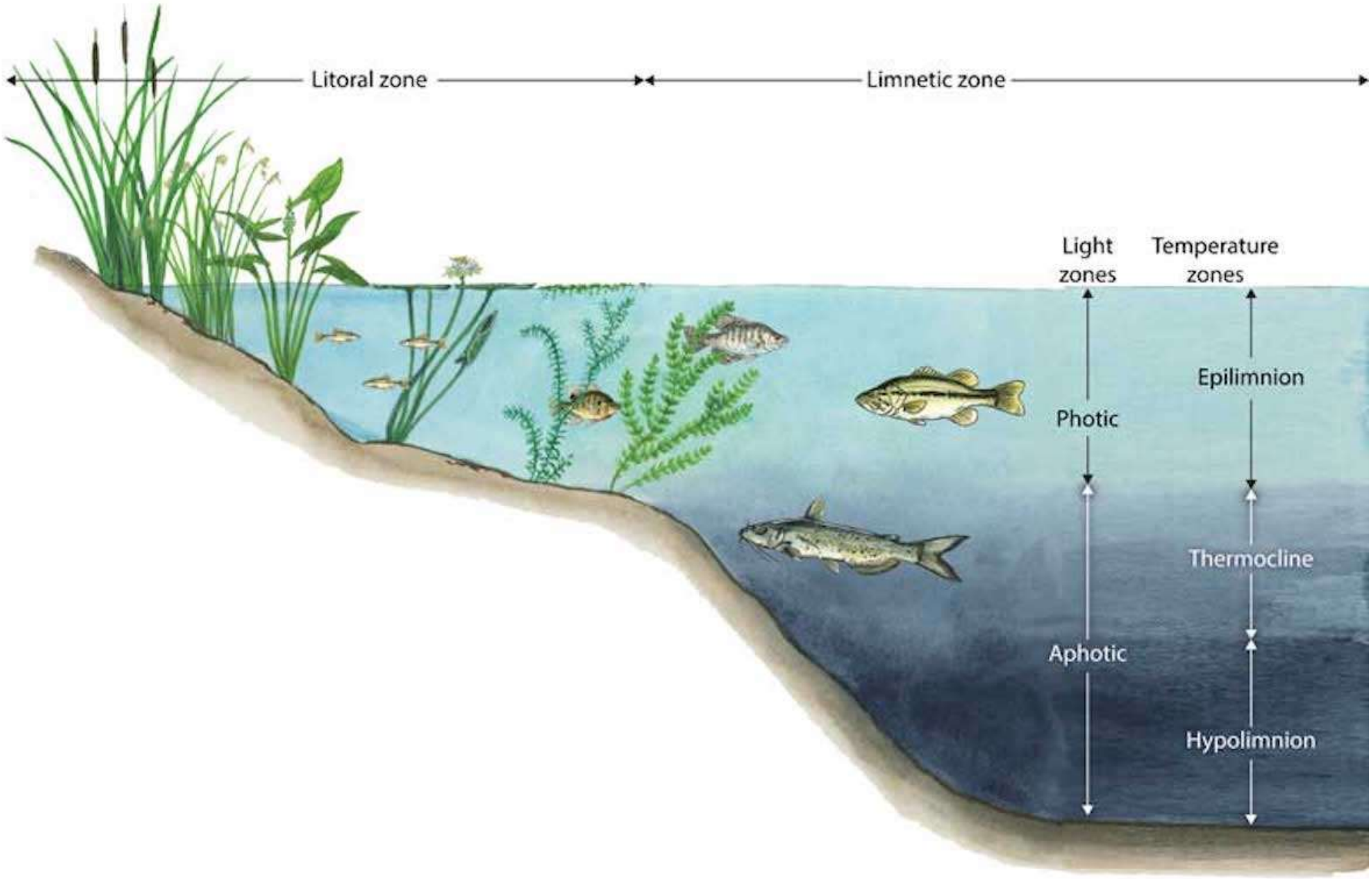
- The oldest are the tectonic lakes that date back to the Tertiary era and whose age is estimated at hundreds of millions of years.

- Hutchinson (1976) classified lakes into 76 different types, but due to the wide variability among lakes, this classification does not meet the expectations of more demanding limnologists.


Elevation 1,494 ft.
(446 m)
Lake
Baikal
Depth
5,387 ft.
(1,642 m)
Great Lakes System Profile
Soo Locks & Dams
Sault Ste- Marie
St. Mary's
River
St. Clair
River
Lake
St. Clair
Detroit
River
Niagara
River
Niagara
Falls
St. Lawrence River
Moses-Saunders
PowerDam
Iroquois
Dam
Beauharnois
Power Dam
Elevation: 601 ft.
Elevation: 577 ft.
Elevation: 568 ft.
Elevation: 243 ft.
Elevation: 20 ft.
Elevation: 0 ft.
Elevation: 0 ft.
Lake
Superior
Lake
Huron
Lake Erie
Depth
210 ft.
Lake
Ontario
Depth
790 ft.
Depth
925 ft.
Lake
Michigan
Depth
1,333 ft.
Depth
802 ft.
Gulf of
St. Lawrence
Atlantic
Ocean
NOT TO SCALE
Vertical elevations are exaggerated.
Surface elevations are Chart Datum values above
MSL and depths are maximum of each lake.
379 Miles
60
223 Miles
89 Miles
236 Miles
35
150 Miles
77
89 Miles
350 Miles
500 Miles
Total Distance Along Floor Path 2,212 Miles
Modified from Michigan Sea Grant

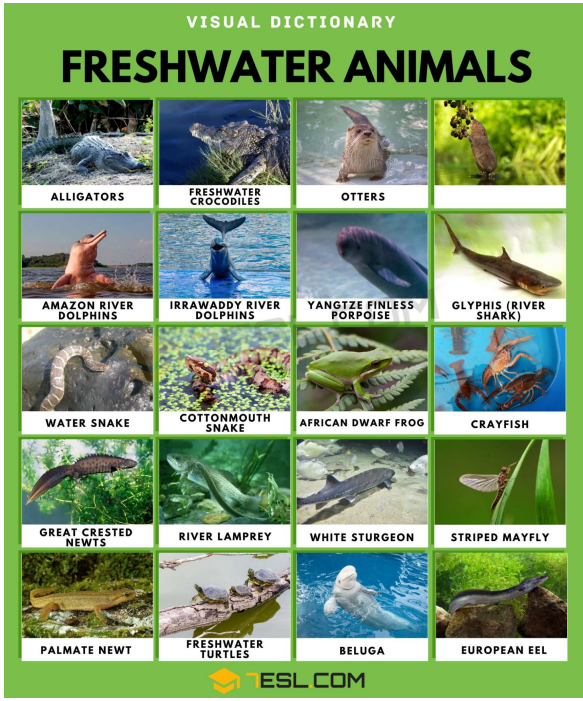
Origin and classification of lakes

- lakes of tectonic origin
- lakes of volcanic origin
- lakes of glacial origin
- Dissolution lakes: originating from soluble rocks such as limestone
- fluvial or lowland lakes:
- Coastal lakes: formed by deposited material that is deposited by currents and tides in long strips parallel to the coastline
- Landslide lakes: lakes generated by landslides falling on a glacier
- Accidental or artificial lakes


Litoral zone
Limnetic zone
Light zones
Temperature zones
Photic
Aphotic
Epilimnion
Thermocline
Hypolimnion

Life in lakes

- **Low biodiversity**
- Crustacenas: low number of decapods, whereas copepods and cladocers well represented
- Insects
- Amphibians (frogs and salamanders): not present in the marine environment
- Reptiles (crocodiles, alligators and caimans), turtles and snakes
- Fish (fewer in number than in the sea)
- Mammals (otters and beaver)



Dinoflagellates

Cladocers

Rotifers

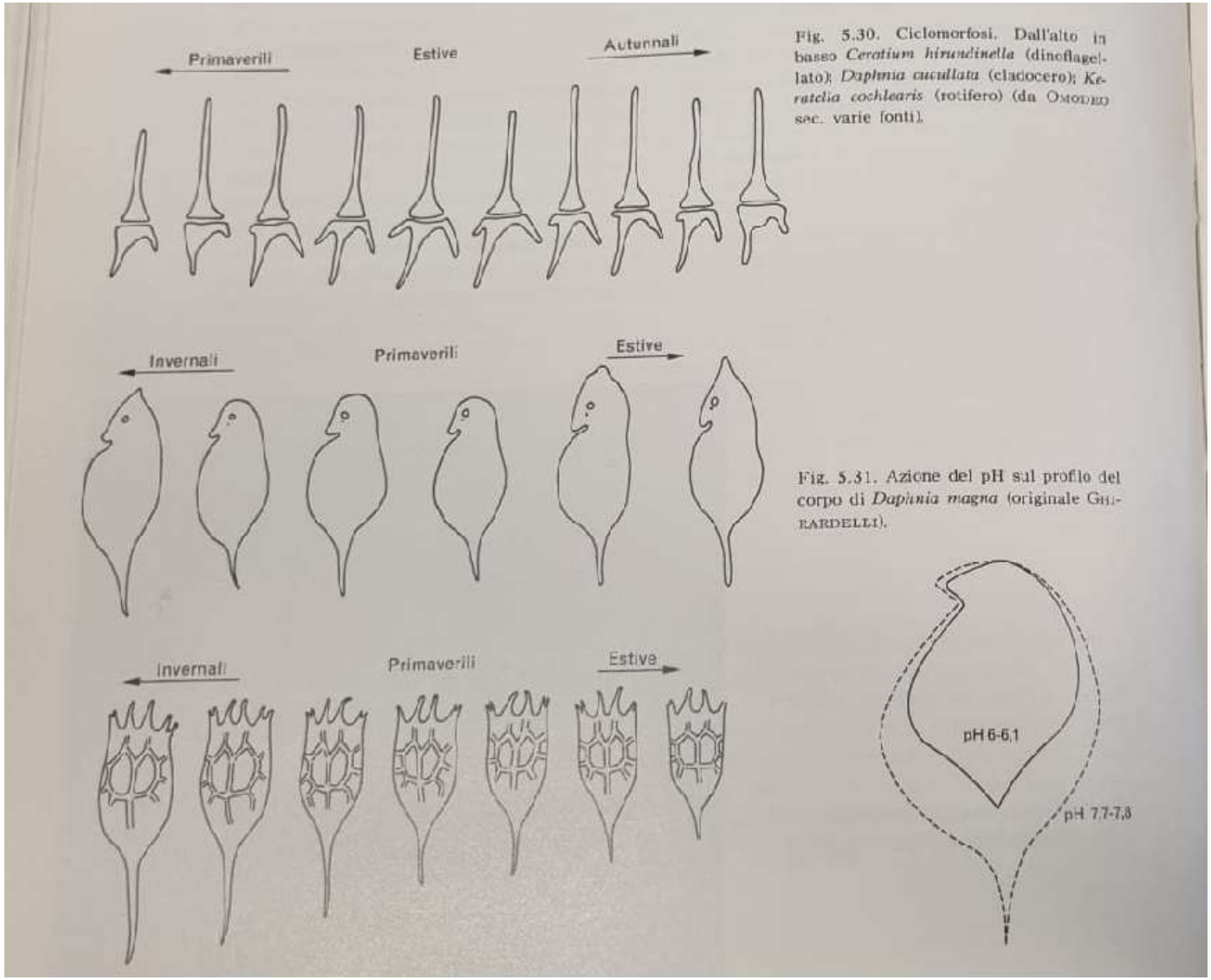
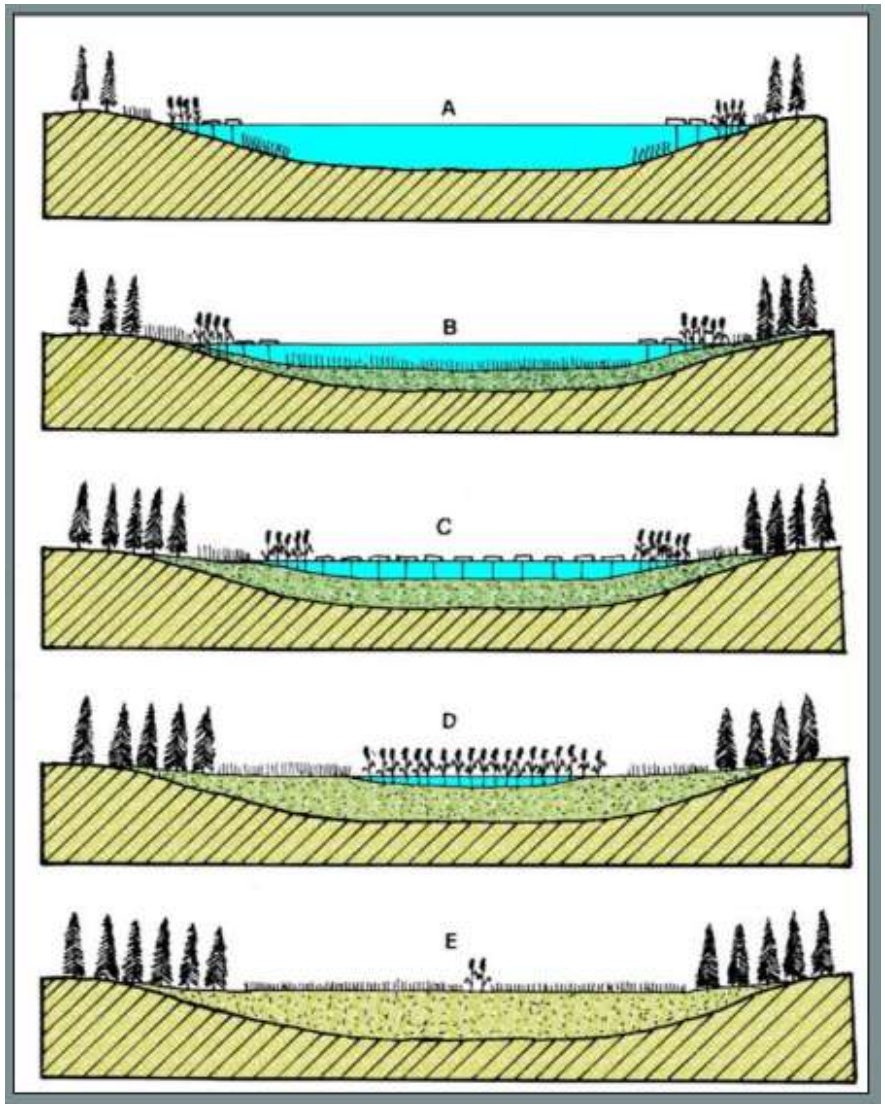


Fig. 5.30. Ciclomorfosi. Dall'alto in basso *Ceratium hirundinella* (dinoflagellato); *Daphnia cucullata* (cladocero); *Keratella cochlearis* (rotifero) (da OMODEO sec. varie fonti).

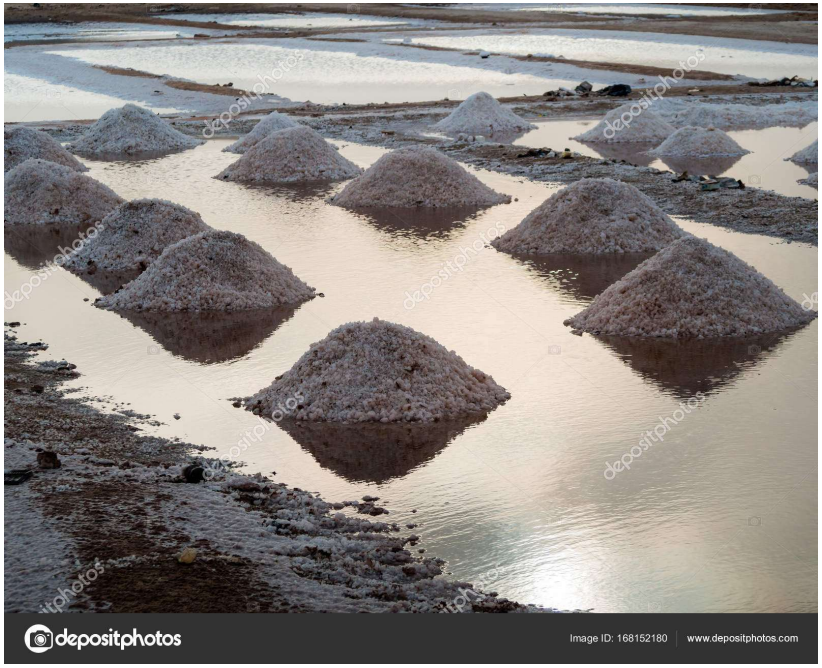
Fig. 5.31. Azione del pH sul profilo del corpo di *Daphnia magna* (originale GHIRARDELLI).

La vita nelle Acque, E. Ghirardelli, UTET


A
B
C
D
E

Osmotically Peculiar Environments

Lakes, pond and salt pools



Urmia Lake (Kazakistan e Uzbekistan), by Nasa Earth Observatory

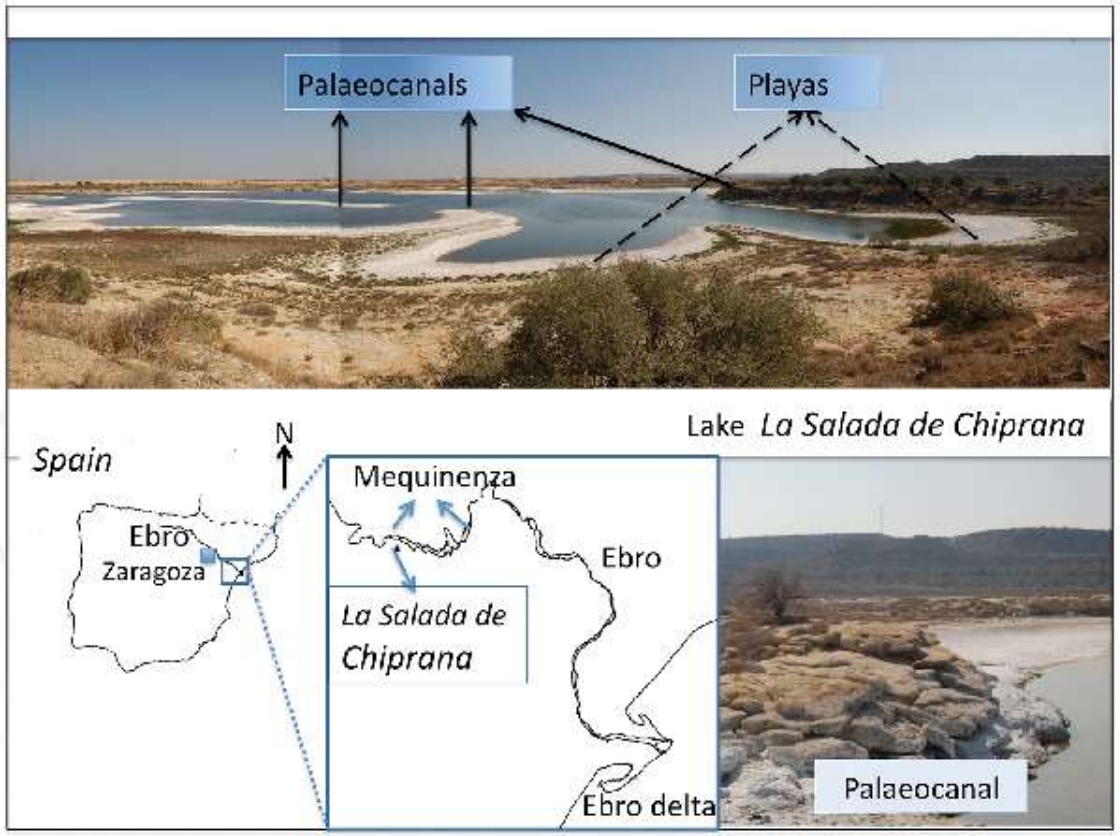
Osmotically Peculiar Environments

Table 13.1 Distribution of water sources on Earth.

Source	% of total water	Volume ($km^3 \times 10^6$)	Renewal time (vol/vol added $time^{-1}$)
Oceans	97.2	1350	300–11,000 years
Saline lakes	0.008	0.1	1–4 years
Fresh water (total)	2.8	37	
Glaciers and ice caps	2.15	29	12,000 years
Aquifers/ground water	0.62	8.2	60–300 years
Soil water	0.005	0.07	–
Lakes	0.009	0.12	1–100 years
Rivers	0.0001	0.001	2–10 days
Atmospheric water	0.001	0.013	~7 days
Water in biota	0.0001	0.001	–

Any freshwater lake without outlets tends to become salty = **Lake Endoreic** and may even dry up completely, forming salt plains or ponds.

Lagoon waters have a composition similar to seawater, but in water bodies that become salty due to evaporative phenomena (e.g. in warm seasons), the ionic composition may vary considerably = **Atalassic (not sea-like) salt lakes**

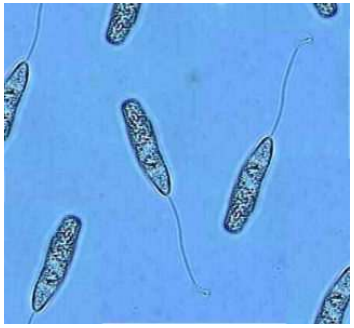
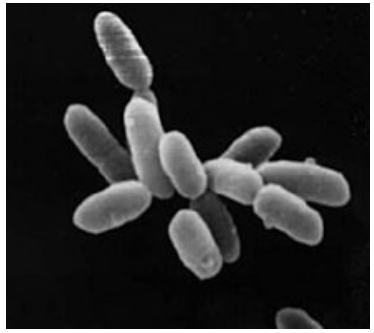


Lake (location)	Osmotic concentration (mOsm)	Ionic concentrations (mM)						Salinity (ppt)
		Na	K	Mg	Ca	Cl	SO_4	
Great Salt Lake (USA)	~6000	3000	90	230	9	3100	150	210
Mono Lake (USA)	~2000							70
Dead Sea (Middle East)	6200–6500							226
Lake Koombekine (Australia)	~7500	4070	17	110	32	1670	72	263

The salinity of some lakes can be 6-8 times higher than seawater

Biota nei laghi salati

- ↓ level of biodiversity (in extreme cases dominance of 1 or a few species of cyanobacteria, flagellates or halobacteria)

- …but where the water is reasonably persistent...

- 140 ppt salinity and high temperatures

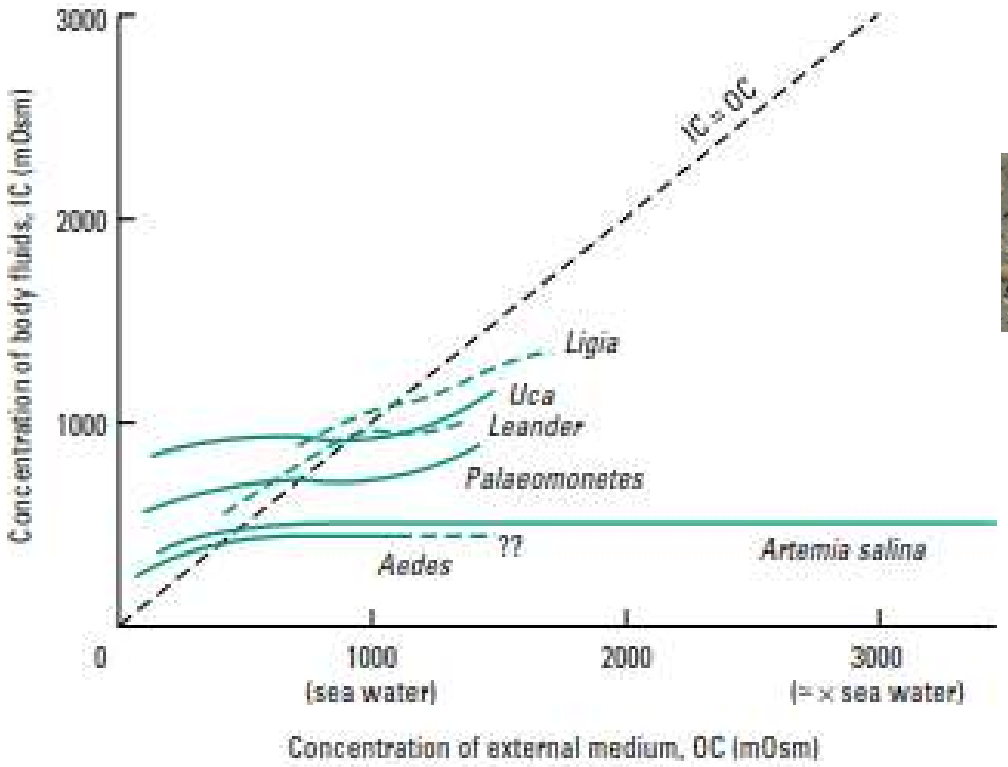
Ephydra (Dipteran)

Cyprinodon elegans

Cyprinodon pecosensis

Ephydrella (Dipteran)

All crustaceans and insects are excellent osmoregulators



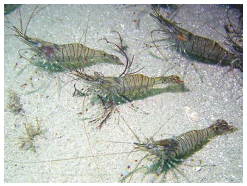
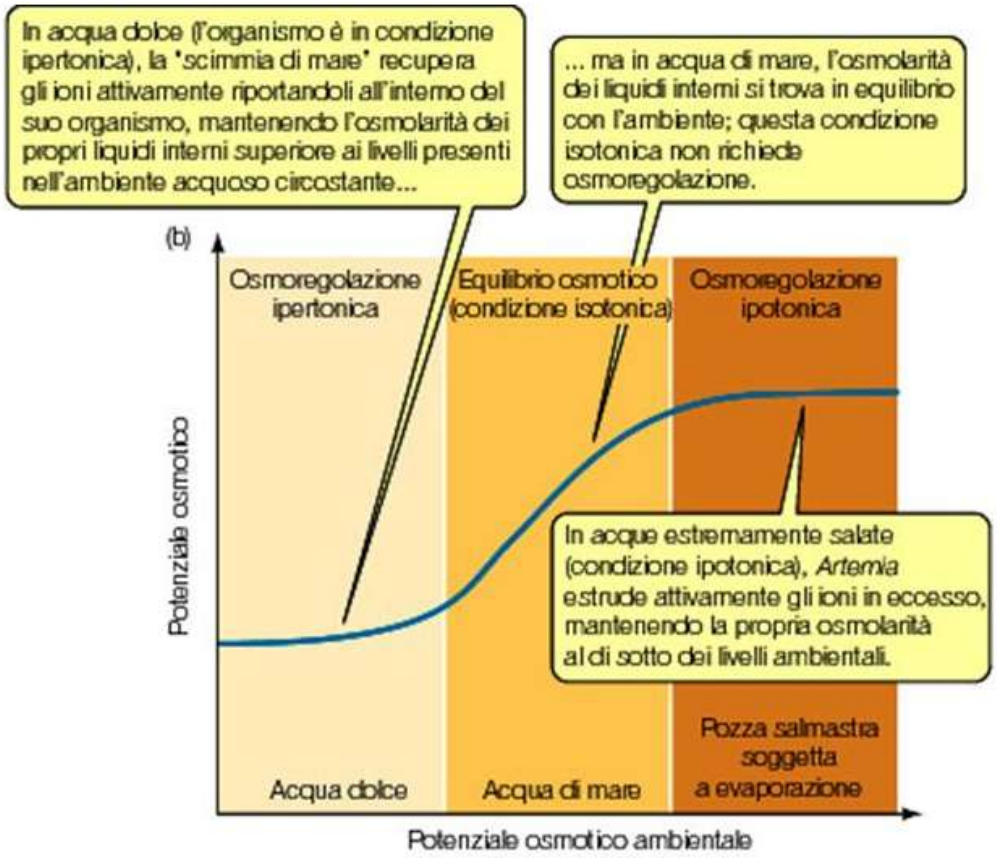


Fig. 14.6 The patterns of hypo-hyper-regulating in various brine-dwelling animals, comparing internal and external media.

L'Artemia salina è un campione in osmoregolazione

(a) *Artemia* sp.



In mosquito larvae of the genus Aedes, hyporegulation is achieved by drinking up to 1/3 of the body mass - 20 kg of water for a 60 kg person - per day with hyperosmotic excretion from the **anal papillae protruding from the rectum**

ELSEVIER

Limnologica - Ecology and Management of Inland Waters

Volume 41, Issue 2, May 2011, Pages 96-106

Size of anal papillae in chironomids: Does it indicate their salinity stress?

Ben J. Kefford [a], Kasturi Reddy-Lopata [b], Colin Clay [b], Tarah Hagen [b], Orsolya Parkanyi [c], Dayanthi Nugegoda [b]

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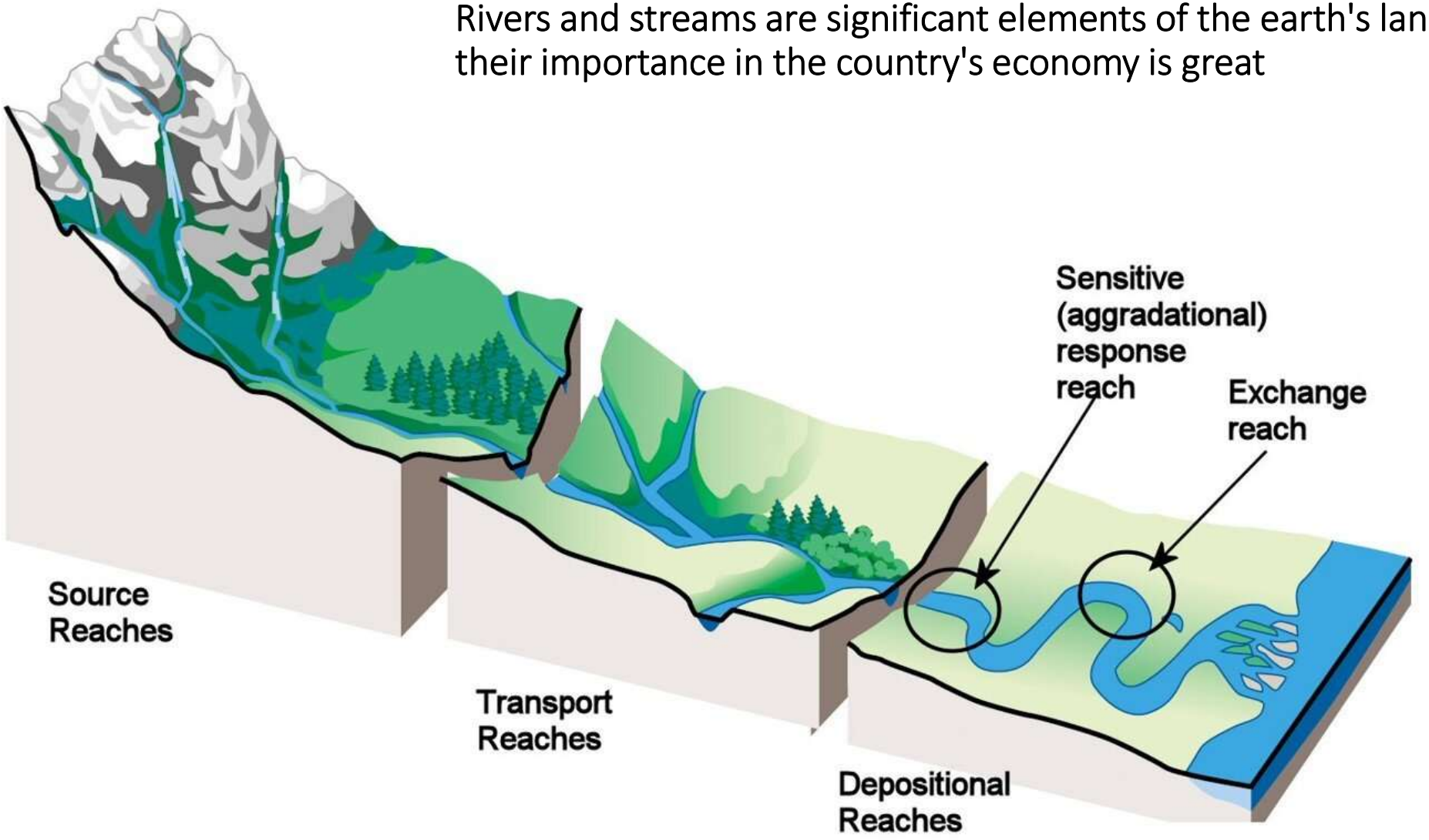
Rivers and streams are significant elements of the earth's landscape, their importance in the country's economy is great



Running waters are among the most “active” modifying agents of the earth's crust with their erosive action, transporting and depositing eroded material

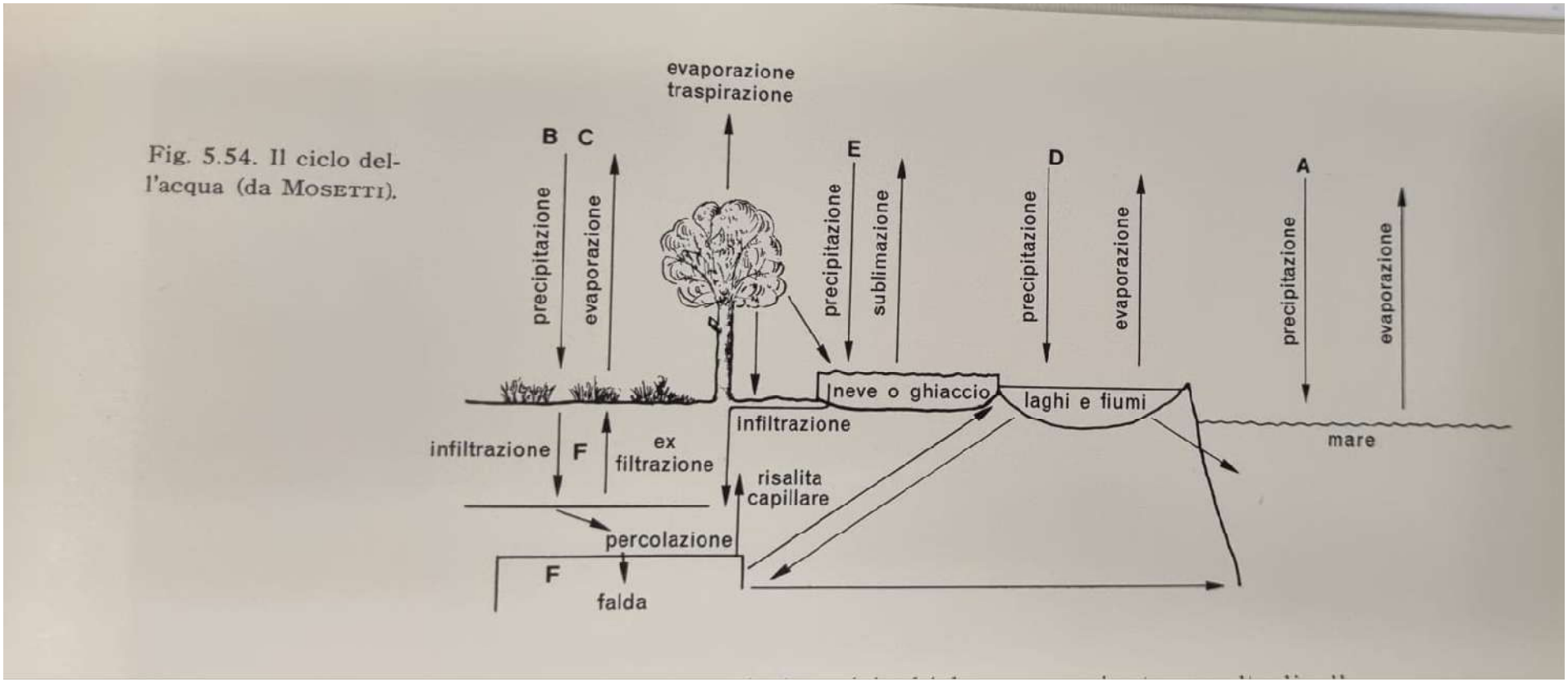


Fig. 5.54. Il ciclo dell'acqua (da MOSETTI).

for all the reasons mentioned below each river is its own environment

- part of the water that feeds the rivers comes from precipitation that has infiltrated at different depths in the ground and reaches the rivers enriched with substances collected during their course

- the characteristics of a body of water also depend on the **transpiration** that takes place through the vegetation cover and removes water from the soil

- Vegetation provides a large organic fraction and creates microenvironments (fallen leaves deposited on the bottom) for various animal species (e.g. *Gammarus*) together with dead body animals

Rivers classification

It is difficult to classify rivers, Pennak (1971) proposed a classification based on 13 parameters, each comprising 4-6 categories.

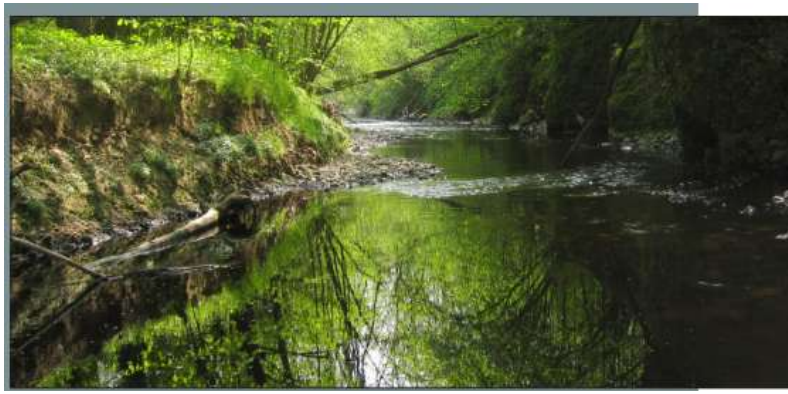
Their combinations make it possible to define more than 180 million watercourses

- Lotic bodies are not suitable for plancton
- Turbidity hampers light penetration and suspended mineral particles settle on the surface of the respiratory organs, altering or preventing gas exchange

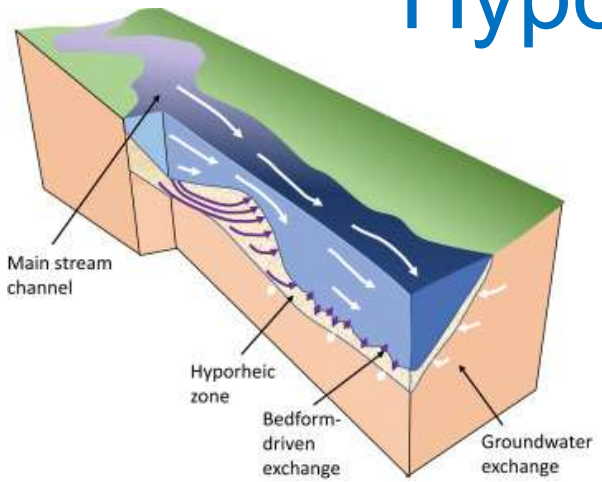
- Rheophilic organisms > in lotic waters
- dorso-ventrally flattened morphologies

(insect larvae, adult ispodos, gobids)

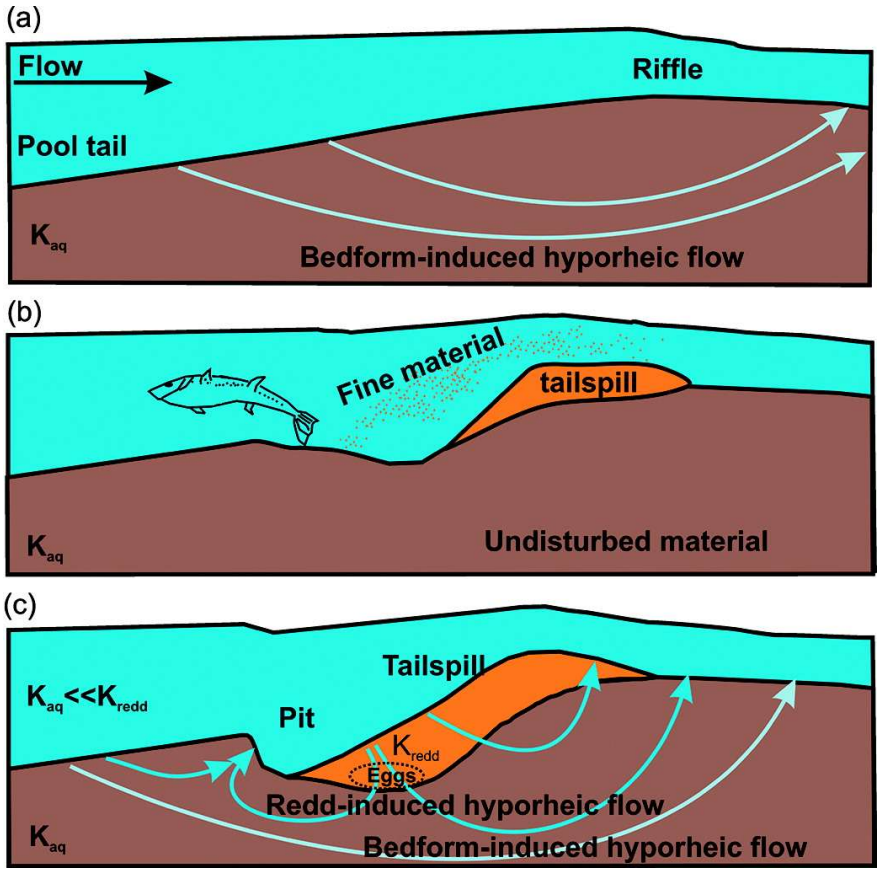
- animals living in flowing water often have eggs with abundant reserve material, which are attached to a substrate or carried by the mother (i.e. Decapod)
- Limnophilic organisms > in lentic waters



Hyporheic zone

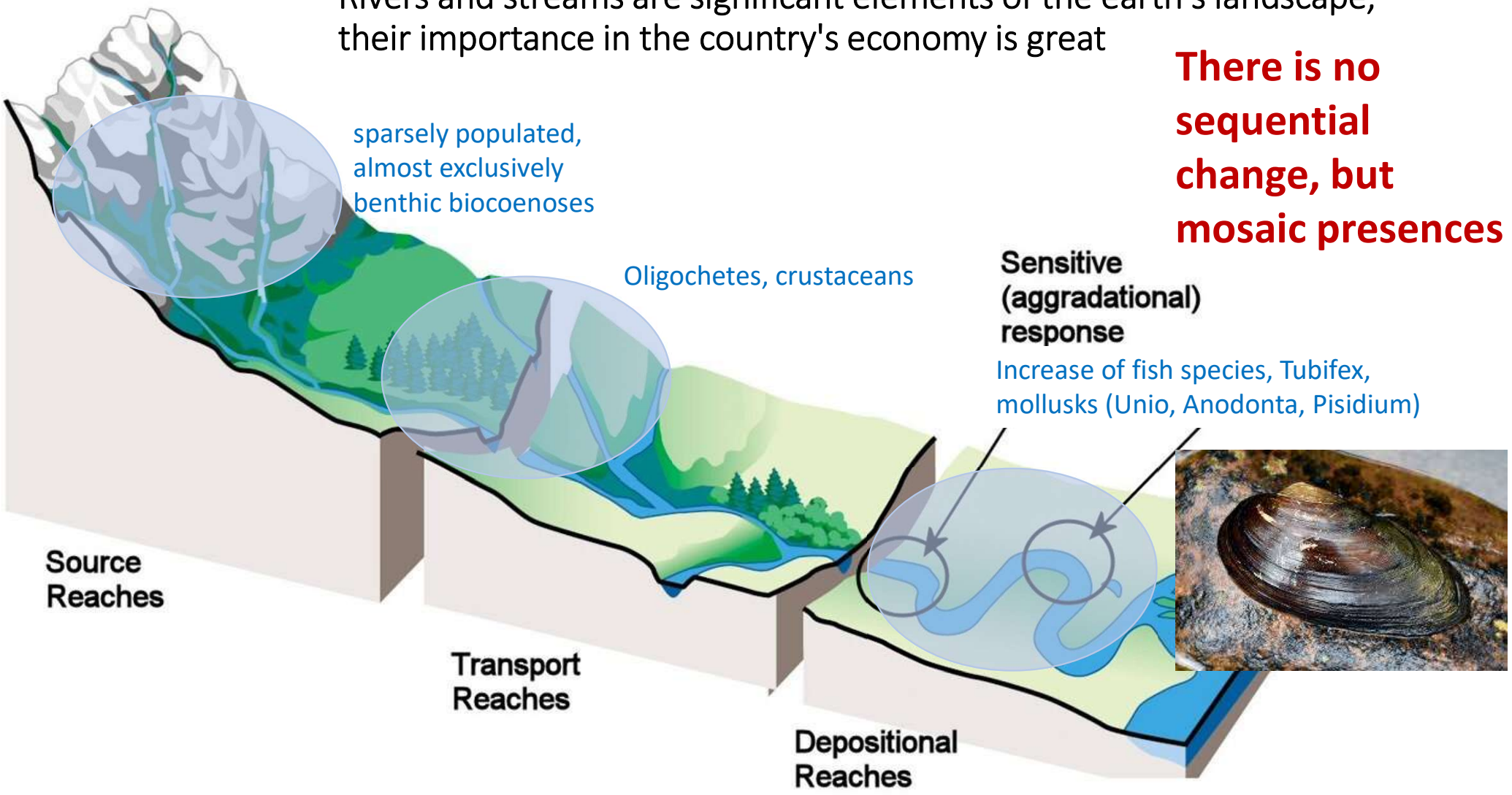


- The **hyporheic zone** was **first studied by biologists** because of its function in carrying oxygen-rich stream waters to salmonid embry os incubating in streambed nests called redds (Stuart, 1954)

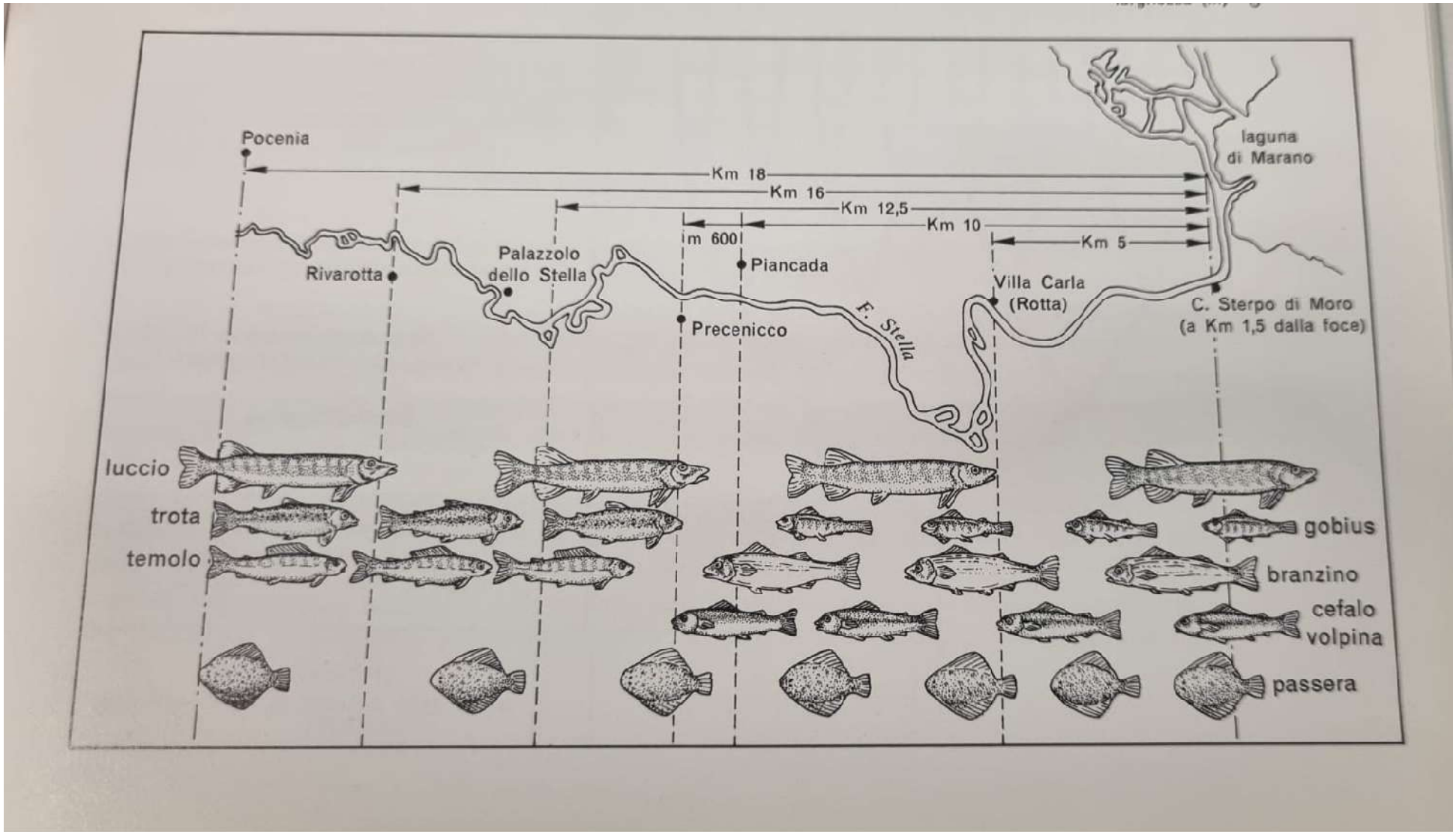


Rivers and streams are significant elements of the earth's landscape, their importance in the country's economy is great

There is no sequential change, but mosaic presences



Ichthyofauna of the lower Stella river (FVG)



- In river fauna: documented decrease and disappearance of fish species (Ghetti, 1974)

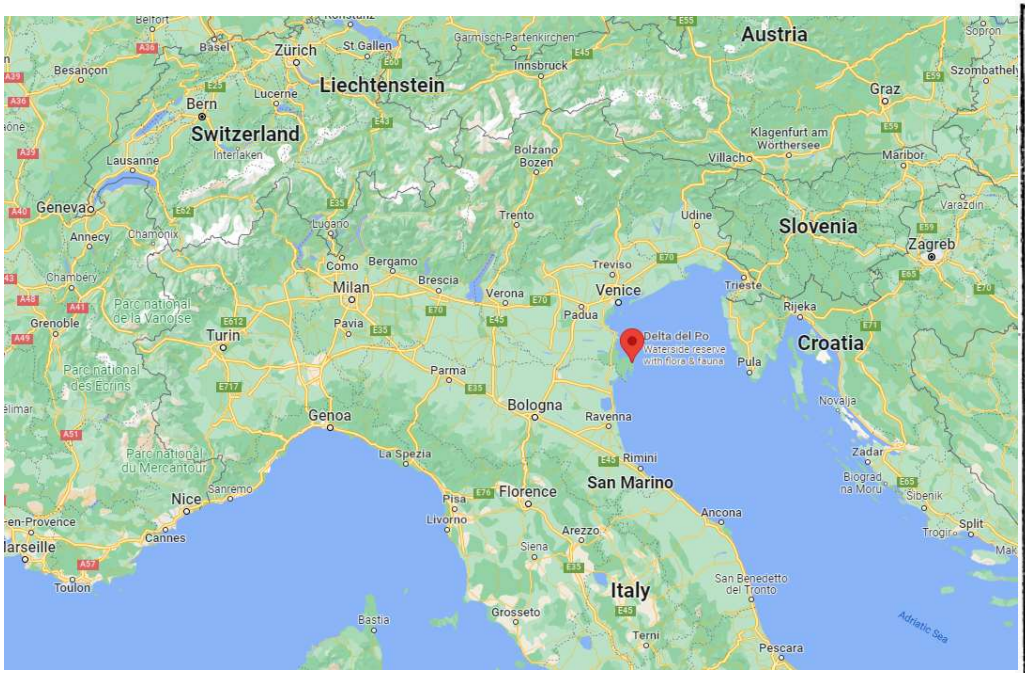
Pollution (direct and indirect effects), fishing activity (only on selected species), introduction of allochthonous species

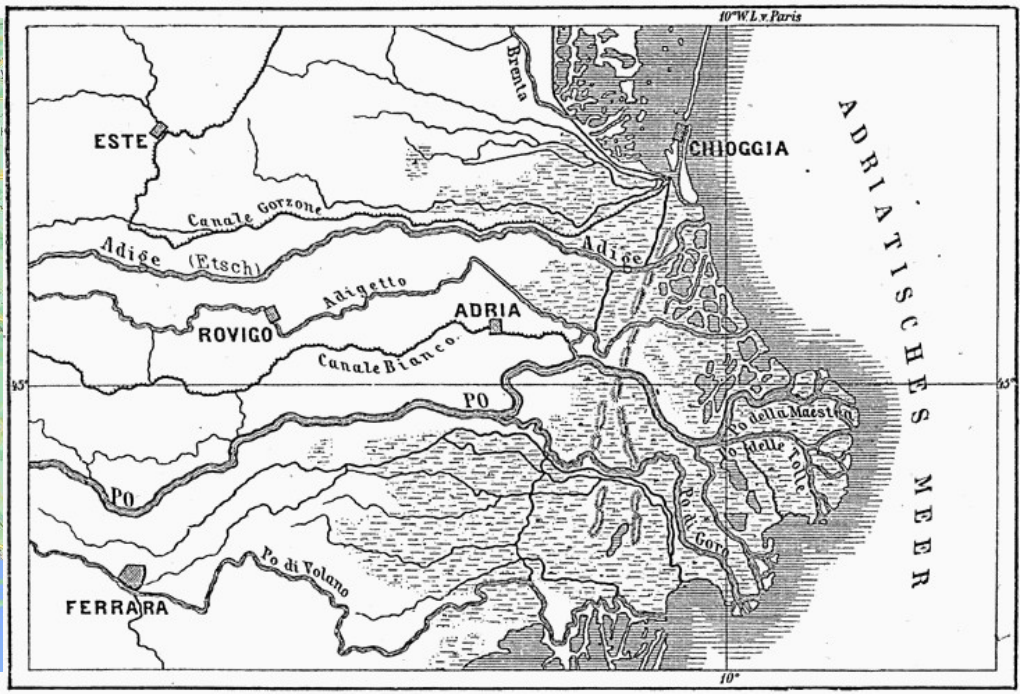
Disappearance due to overfishing of immature specimens/restricted diet/poor ability to acclimatise to new conditions

Fish restocking must be rethought

Estuary

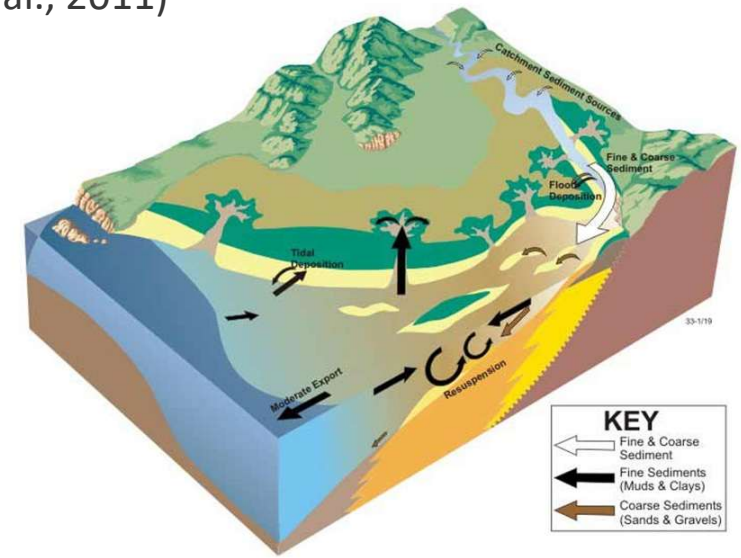
semi-enclosed body of water which has an open connection with the sea and in which sea water is measurably diluted with fresh water derived from land drainage (e.g. rivers) (Pritchard, 1967)



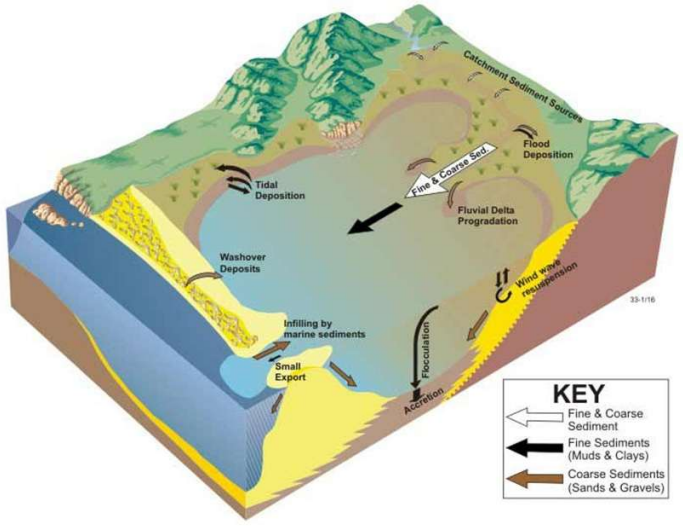


Classification of estuarine ecosystems

- Based on geomorphology (e.g. coastal plain estuaries, fjords and lagoons)
- Based on water circulation patterns (e.g. salt wedge and different stages of mixing) (Bowden, 1967)
- Others are relative to the importance of waves and tides, or the large-scale morphology (see Dürr et al., 2011)



tide dominated sediment transport



wave dominated sediment transport

System description

- Estuaries are very dynamic and transitory systems, influenced by what happens at their landward as well as their seaward end.
- Being a transitional area, estuaries are rich in gradients of processes and environmental factors:
  - between the **hydromorphological dynamics** of the river and of the sea
  - between **fresh river water and saline water**
  - between **river sediment and marine sediment.**

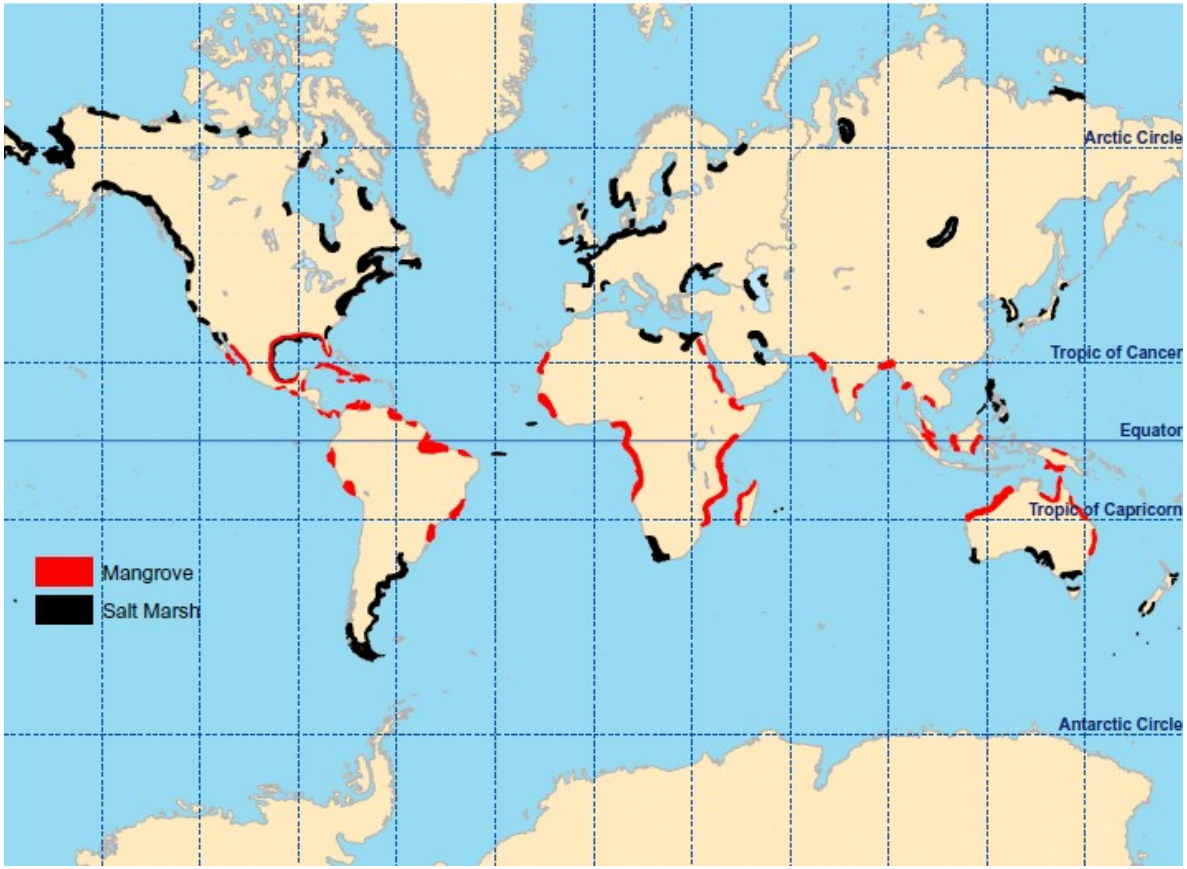
Ecology

- Besides food, the estuarine environment also provides breeding-, resting-, nursery grounds. In fact, migratory birds rest and feed in estuarine habitats, which makes estuaries important stop-overs along bird migration routes.
- Estuaries also provide **billions of larvae of zooplankton** to coastal waters.
- Multiple **commercially important sea fish and crustaceans** use estuaries as **nurseries** during their juvenile stage. Thus, estuarine habitats are critical to the survival of many marine species.
- Estuarine communities have a relatively **low species diversity** compared to those in fresh or fully saline conditions. This is due to the presence of high-amplitude and partly unpredictable stresses, such as salinity conditions, osmotic stress, hydrodynamic stress, which select a limited set of adapted species.

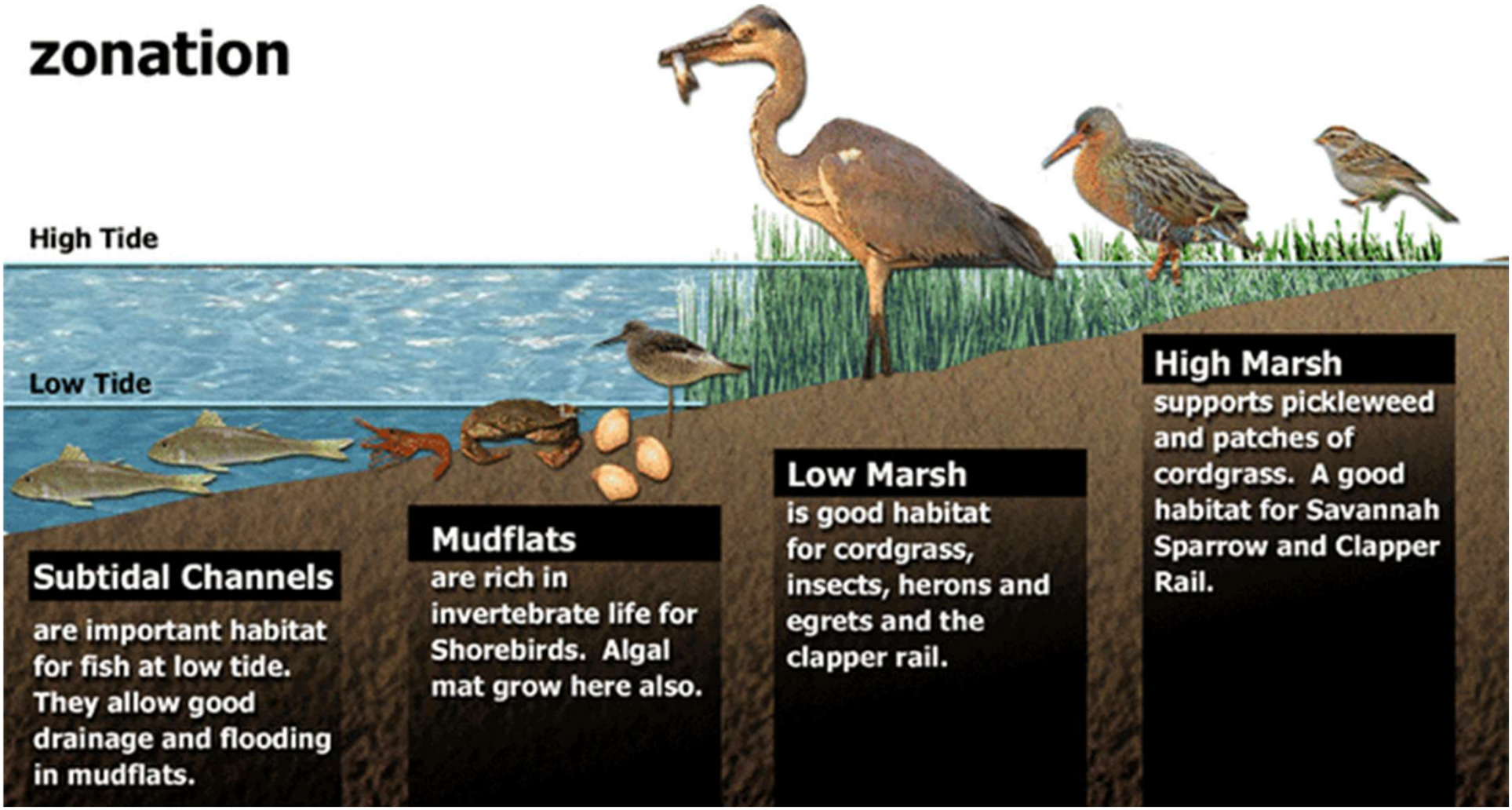
- The biota responsible for changes in the geomorphology and biogeochemistry of soft substrates are termed '**ecosystem engineers**' (Jones *et al.*, 1997).
- They can be divided into **two main functional groups**, namely '**biostabilizers'**, causing increased sediment stability and a reduced erosion potential, and '**biodestabilizers**', doing the opposite (Paterson & Black, 1999; Reise, 2002; Widdows & Brinsley, 2002; Bouma *et al.*, 2008; Montserrat *et al.*, 2008).
- **Stabilizing key species** of tidal flats are for example microphytobenthos, sea grasses and mussel beds. Benthic macrofauna may have both stabilizing and destabilizing effects.

Salt marshes

- Salt marshes occur where oceans meet land.
- These places are **rich in nutrients** from sediment brought in by the ocean.
- Marshes are regularly flooded by high tides, making the surrounding **ground wet and salty**.
- As a result, the **soil is low in oxygen** and filled with decomposing matter.
- These ecosystems are dominated by **low-growing shrubs and grasses**.



zonation


High Tide
Low Tide
Subtidal Channels
are important habitat for fish at low tide. They allow good drainage and flooding in mudflats.
Mudflats
are rich in invertebrate life for Shorebirds. Algal mat grow here also.
Low Marsh
is good habitat for cordgrass, insects, herons and egrets and the clapper rail.
High Marsh
supports pickleweed and patches of cordgrass. A good habitat for Savannah Sparrow and Clapper Rail.

Mangrove forest

- Mangrove forests are found in tropical areas.
  These ecosystems frequently flood with ocean water, submerging the roots of mangrove trees.
- The root systems of mangroves filter out salt and sit above ground to access oxygen. These trees provide a home for a variety of species.
- Animals, such as fish, crabs, shrimp, reptiles, and amphibians, live among the mangrove's roots while its canopy provides a nesting site for birds.

i.e. key animals in mangroves

- Crabs are the most abundant and important larger invertebrate in mangroves. When building their burrows, crabs improve the penetration of ground water, water from high tides and freshwater runoff
- Crabs are vital to the recycling of nutrients, in particular nitrogen. Many crabs eat large amounts of fallen mangrove litter while other species eat algae and detritus.
- The presence of crabs in these ecosystems has been shown to improve the growth of mangrove plants, and also increases the biomass and diversity of other organisms.

Threats

- Deforestation for fuel & timber accounts for the ongoing loss of approximately 26% of existing mangroves (Valiela *et al*. 2001).
- However, we cannot rely on reforestation to prevent mangrove loss. These fragile and rare ecosystems are being lost at such a tremendous rate that mangrove experts predict that without changes to current practices, mangroves will be functionally extinct in **less than a century** (Duke *et al.* 2007).
- A world without mangroves means a world without most fisheries, without bioshields from storms, and without many bird and other species. The loss of mangroves as a unique habitat would directly **jeopardize more than a billion of the world's human population.**