Zoogeography

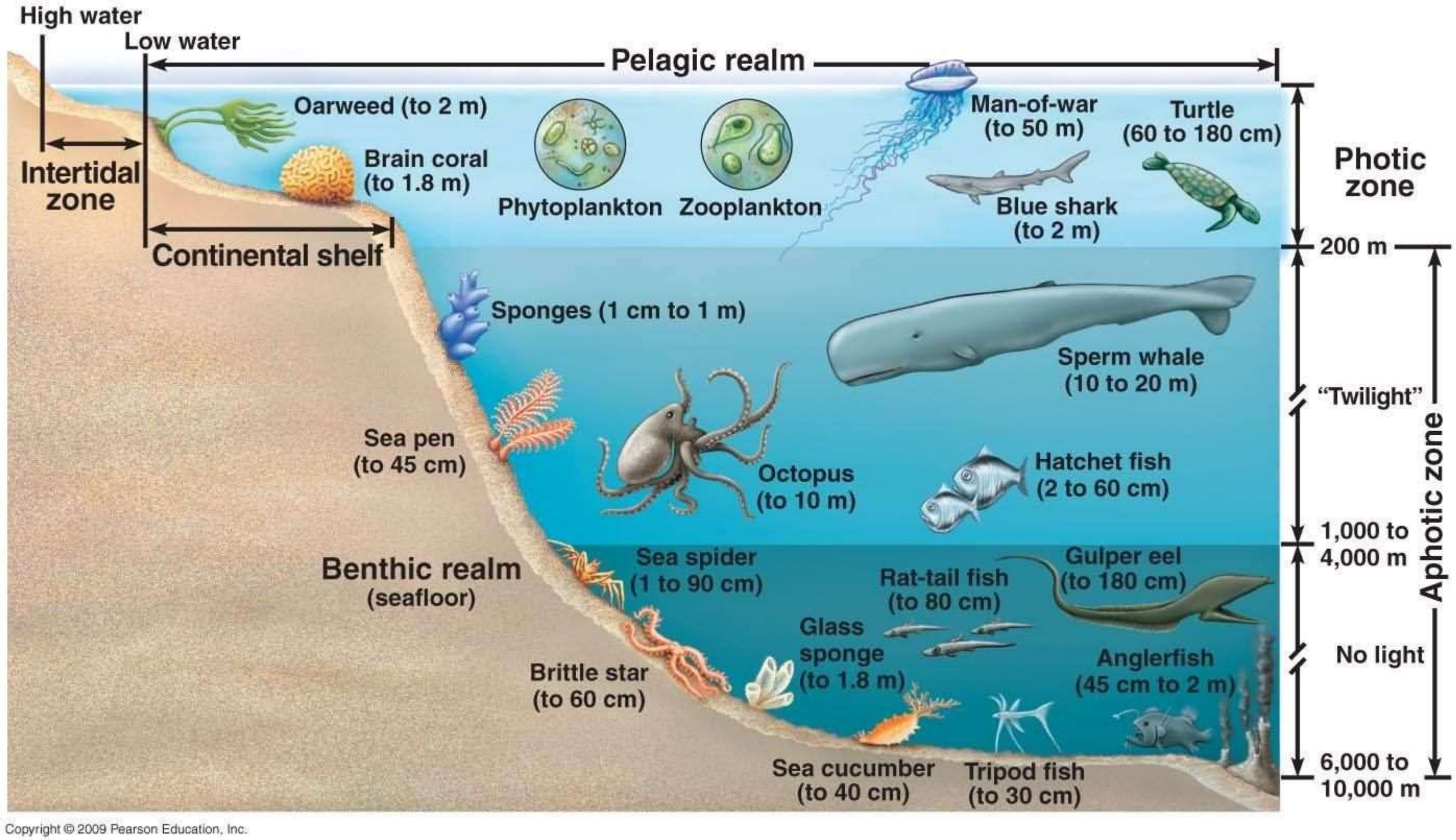
Lesson 6

Marine ecosystems

https://www.youtube.com/watch?v=9FqwhW0B3tY

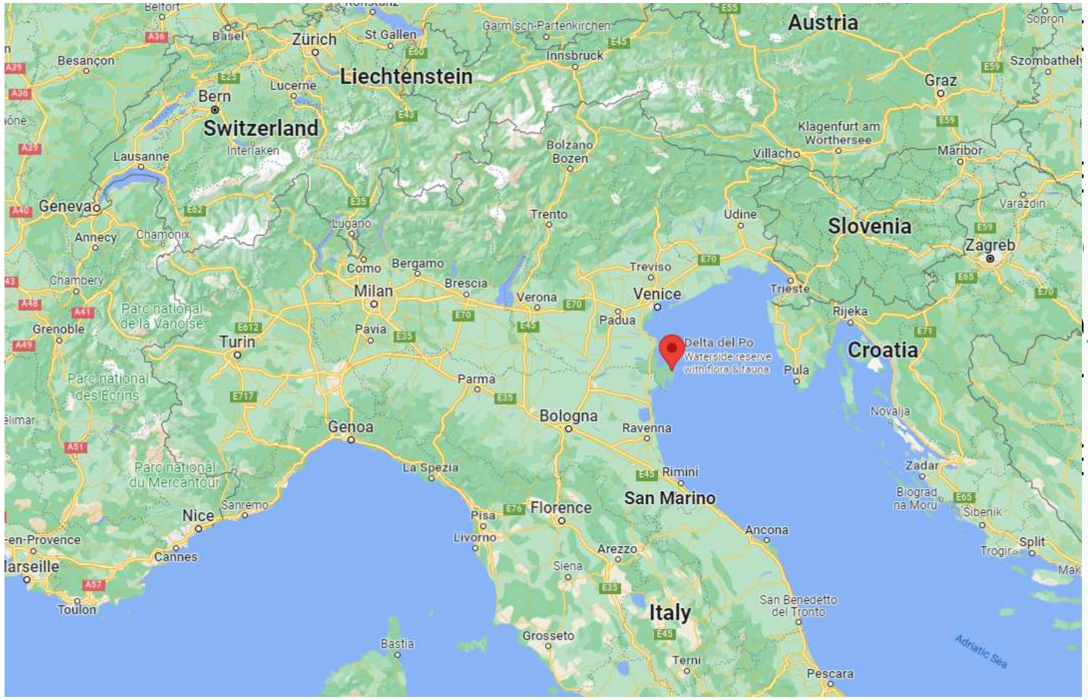
Several broad categories, although there is some disagreement, are:

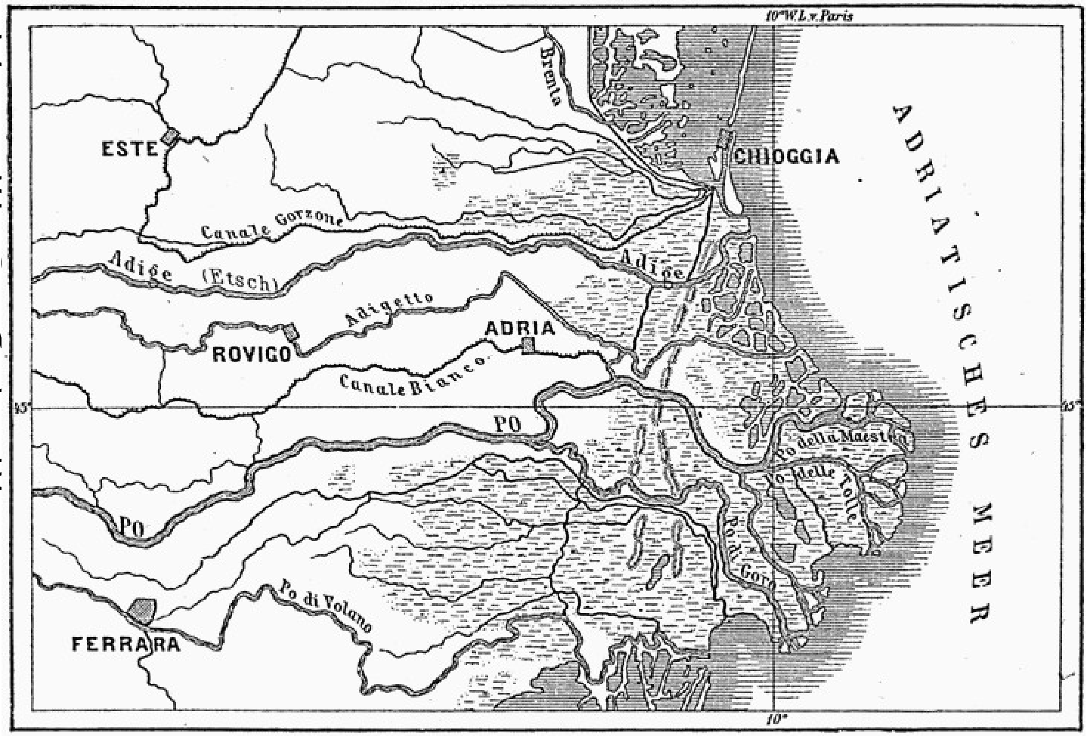
1- estuaries,
2- salt marshes,
3- mangrove forests,
4- coral reefs,
5- the open ocean, and
6- the deep-sea ocean



Estuary

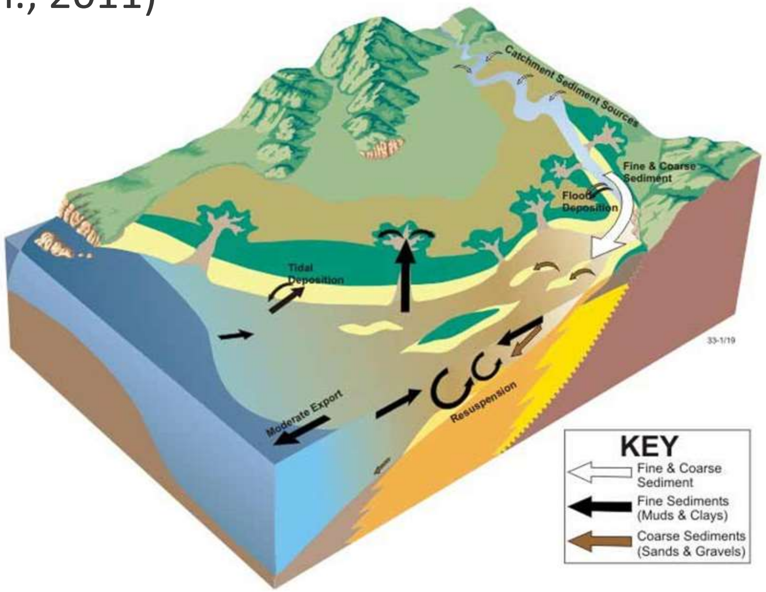
semi-enclosed body of water which has an open connection with the sea and in which sea water is measurably diluted with fresh water derived from land drainage (e.g. rivers) (Pritchard, 1967)



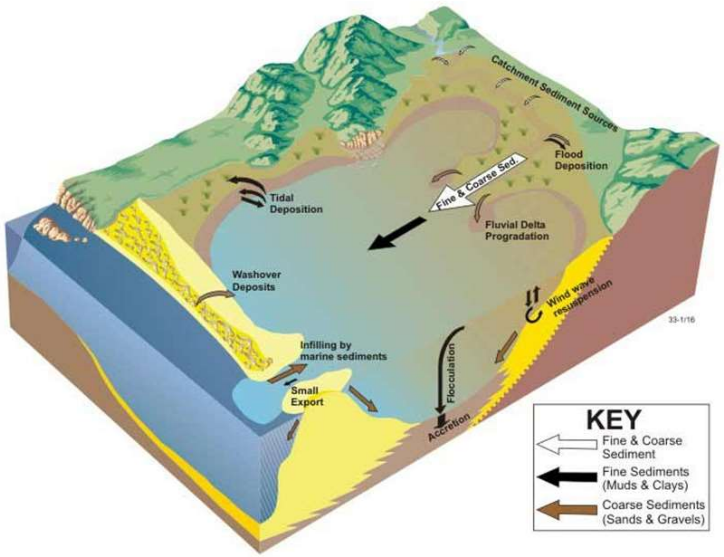


Classification of estuarine ecosystems

- 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.**

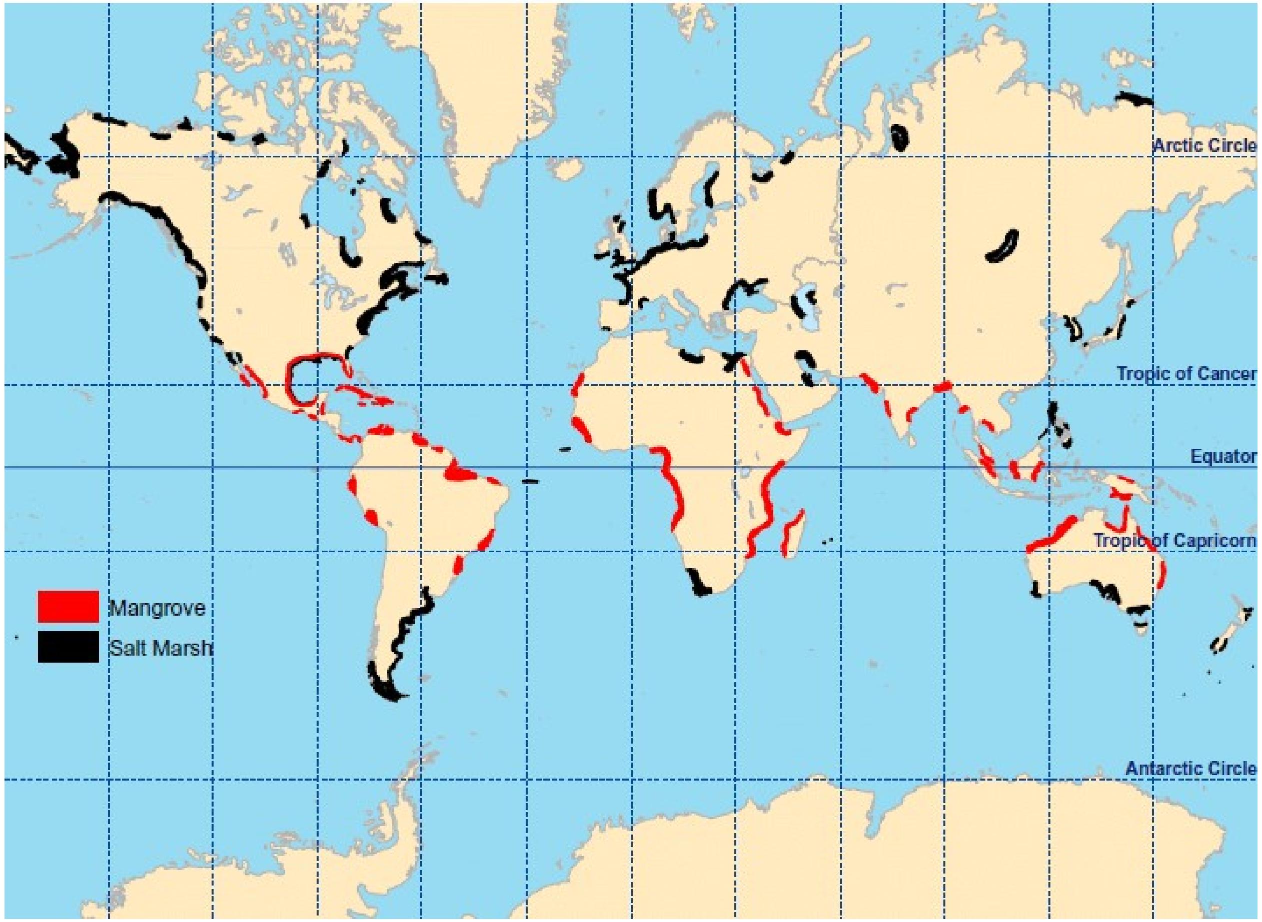
Ecology

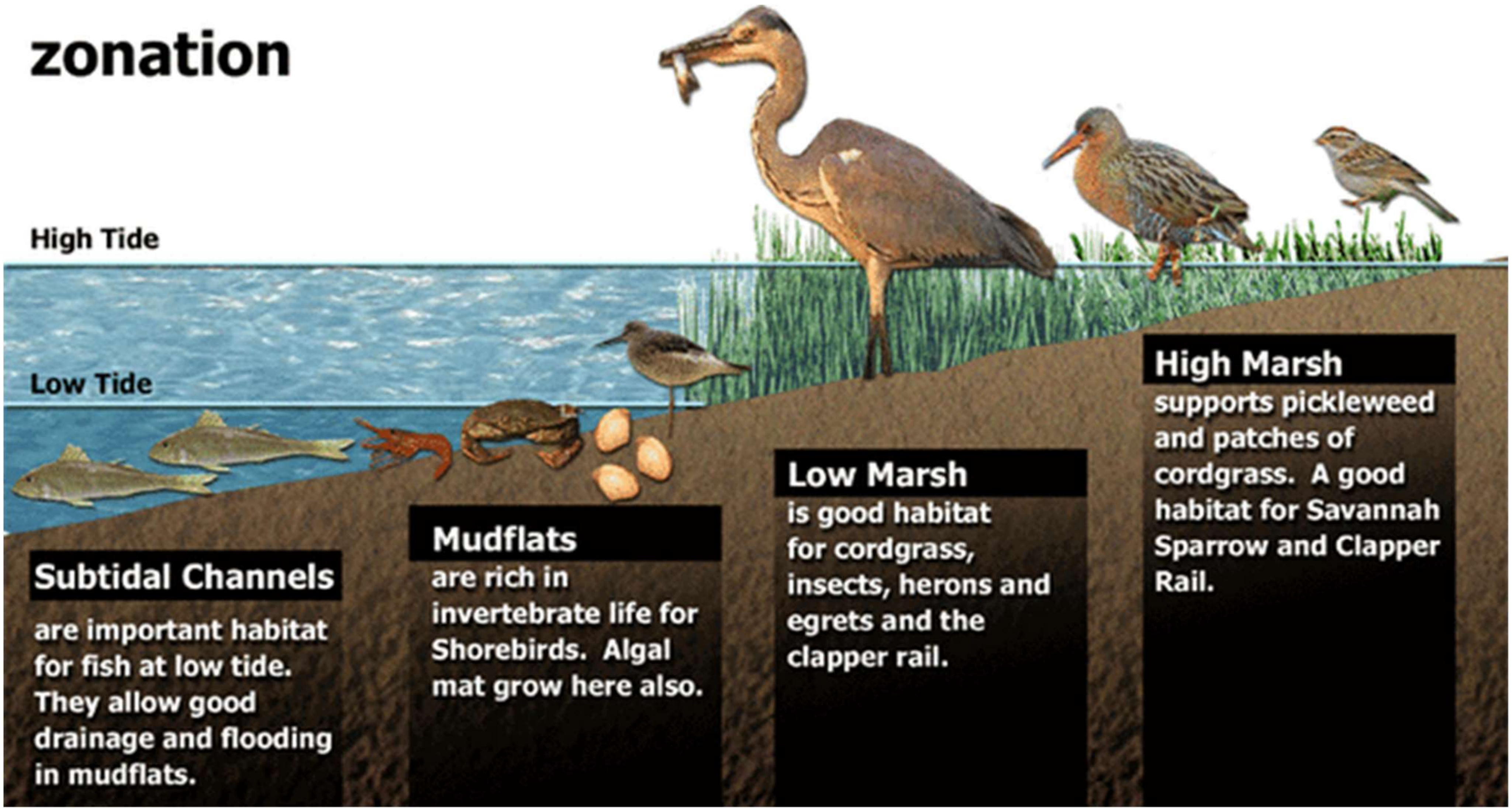
- Besides food, the estuarine environment also provides breeding-, resting-, nursery grounds. In fact, migratory birds rest and feed in estuarine habitats, which makes estuaries important stop-overs along bird migration routes.
- Estuaries also provide **billions of larvae of zooplankton** to coastal 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

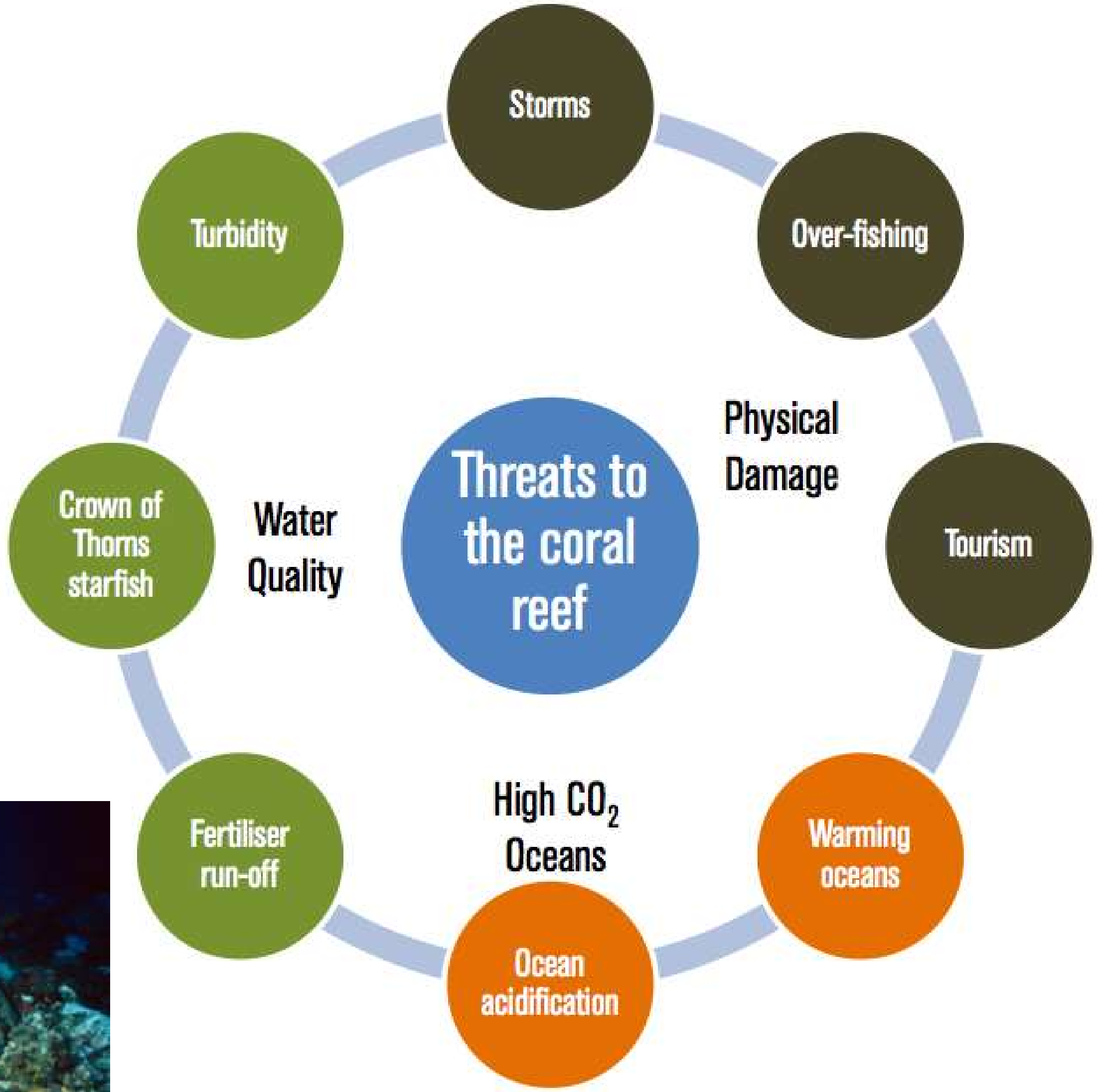
- Deforestation for fuel & timber accounts for the ongoing loss of approximately 26% of existing mangroves (Valiela *et al*. 2001).
- However, we cannot rely on reforestation to prevent mangrove loss. These fragile and rare ecosystems are being lost at such a tremendous rate that mangrove experts predict 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.**

Coral reef

- A bit farther out into the tropical sea are coral reefs, euphotic-zone ecosystems built from the exoskeleton secreted by coral polyps. These exoskeletons form complex structures that shelter many different organisms.
- Coral reefs are extremely diverse ecosystems that host sponges, crustaceans, mollusks, fish, turtles, sharks, dolphins, and many more creatures. By some counts, **coral reefs can account for a quarter of all ocean species**.

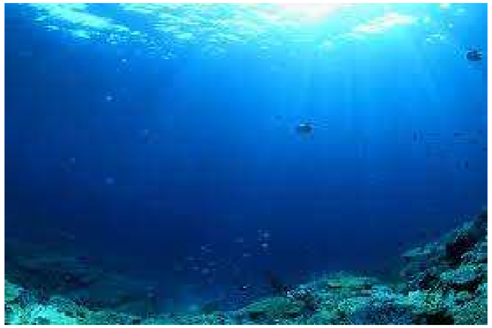


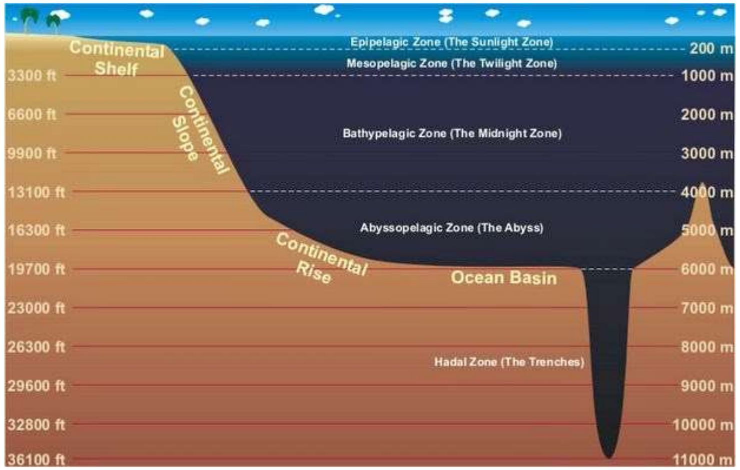
Coral reef threats



The open ocean

- Beyond the coral reefs lies the open ocean.
- At the surface of the ocean, the **euphotic zone**,
  the ecosystem receives plenty of light and oxygen, is fairly warm, and supports many photosynthetic organisms. Many of the organisms that we associate with marine ecosystems, such as whales, dolphins, octopi, and sharks, live in the open ocean.





- https://www.bioexplorer.net/ocean-animal-adaptations.html/
- Camouflage: To survive in the well-lit, exposed habitat of the open ocean, many types of animals have evolved a form of camouflage called countershading (e.g. sharks, rays, dolphins, and whales). These animals are darker on their top side and lighter on their under side (e.g. great white shark, Fig. 7). This makes them more difficult to spot from above (they blend in with the darker deep water below them), or from below (they blend in with the clearer shallow water above them).
- https://manoa.hawaii.edu/sealearning/survival-of-the-fittest#:~:text=To%20survive%20in%20the%20well,7).

The deep-sea

- As the depth of the ocean increases, it gets darker, colder, and with less available oxygen. Organisms living in deep-sea ecosystems within the dysphotic and aphotic zones have unusual adaptations that help them survive in these challenging environments. Some organisms have extremely large mouths that allow them to catch whatever nutrients fall from shallower ocean depths. Others have adapted to get their energy via chemosynthesis of chemicals from hydrothermal vents.

Yeti crabs, *Kiwa hirsuta*, were discovered relatively recently, in 2015, during the expedition to the deep-sea hydrothermal vents

- These crabs can be found at the bottom of the sea, around hydrothermal vents in the Pacific, and close to Antarctica. Yeti crabs are yellowish-white in color, with prominent front pincers.
- All of their appendages are covered in long hair called setae, and the hair layer is incredibly thick on the front pincers.
- The scientists have observed that the crabs occasionally sit at the vents' openings, waving their hairy pincers above them.
- It was also established that the hair contains a large number of bacteria. It is supposed that the crabs support these bacterial colonies, providing them with nutrients emitted by the vents, and these bacteria are used as a supplemental food source.

The Pacific blackdragon is a deep-water fish. It has an elongated body with a long fin along the upper part of the body.

- It has a large head with prominent, sharp, and curved teeth.
- This fish is a predator.
- Unlike anglerfish that bait the potential prey, the blackdragon prefers to wait in an ambush. Unfortunately, this strategy can be problematic even in the deep sea.
- Though this species lives on the levels where there is no natural light, multiple species have bioluminescence.
- This means that there is enough light for potential prey to see their predators. The black dragons have an ingenious solution to this problem.
- Like many sea species, these fish have the black pigment-melanin. Melanin is stored in unique structures called melanosomes.
- In Pacific blackdragons, these melanosomes are very tightly packed, which is usually quite rare.
- Due to this melanosomes organization, the Pacific Blackdragons can absorb bioluminescent light almost wholly, dissolving into the darkness – and attacking their prey entirely unexpectedly.

Bio(zoo)geography Today

- Ecologists began with the study of **living species** or subspecies, and with the factors that control, or alter, their patterns of distribution today.
- This was because they were working at a scale of detail, both in geographical terms and in taxonomic terms, that could not be perceived in the historical record.
- Only in the study of the comparatively **recent past**, such as the **Ice Ages**, could the **biogeographer** be **confident of the ecological preferences of the organisms under study**, because they were closely related to those alive today.
    - Fossil sufficiently detailed for taxonomy
    - Environmental changes sufficiently detailed

- The development of techniques of analysis of the details of the **molecular structure** of their genes provided an enormous quantity of data on the molecular characteristics of the organisms.

- At the same time, as it became **easier and cheaper to obtain this data**, the number of organisms whose molecular characteristics had been analysed rapidly increased

- Species: most are clearly defined by their (common):
    - Appereance
    - Structure
    - Physiology
    - Behaviour

+Great deal of variation within species:

Size,

Colour,

Feeding preferences

Mate choice

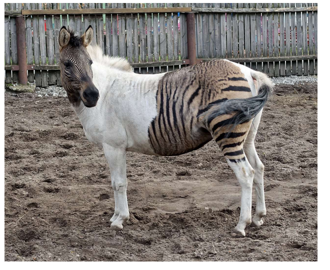
Species normally restrict their breeding to individuals of the same species, but this is not always the case, and one cannot define a species on this basis.

Hybridization

Organisms that have intermediate characteristics.


Mule


Hinny


Hebras


Zorse


Zonkey

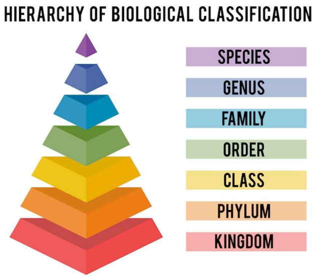
	Horse ♀	Donkey ♀	Zebra ♀
Horse ♂	Horse (*E. ferus*)	Hinny	Many terms incl. "hebra"
Donkey ♂	Mule	Donkey (*E. africanus*)	Many terms incl. "donkra"
Zebra ♂	Many terms incl. "zorse"	Many terms incl. "zonkey"	Zebra (3 species)

Taxonomy

- Science of classifying organisms → most ancient of biological disciplines

- 1953: discovery of DNA structure→ determination of features of form and physiology

- Species can be grouped



- structural features alone have proved misleading, and taxonomists rely increasingly on genetic studies to understand relationships in the natural world.

Species and subspecies

- Some species, for example, exist in a number of different forms that are sufficiently stable to be termed **subspecies** → often have different distribution patterns (termed **polytypic species**).
- less variable species that exists in just one form – called a **monotypic species**.
- Increasing use of **genetic analyses** highlights the complex relationships within species, and such complexity is reflected in distribution patterns.

i.e. Herring gull (*Larus argentatus*)

- Example of polytypic species, 12 subspecies spread around the entire Northern Hemisphere.
- Genetic studies revealed a complex relationships among subspecies

European herring gull, which was given the name *Larus argentatus argentatus* is almost indistinguishable in its plumage from the American herring gull (*Larus argentatus smithsonianus*).

molecular studies on their DNA indicated that they were not as closely related as had been supposed.

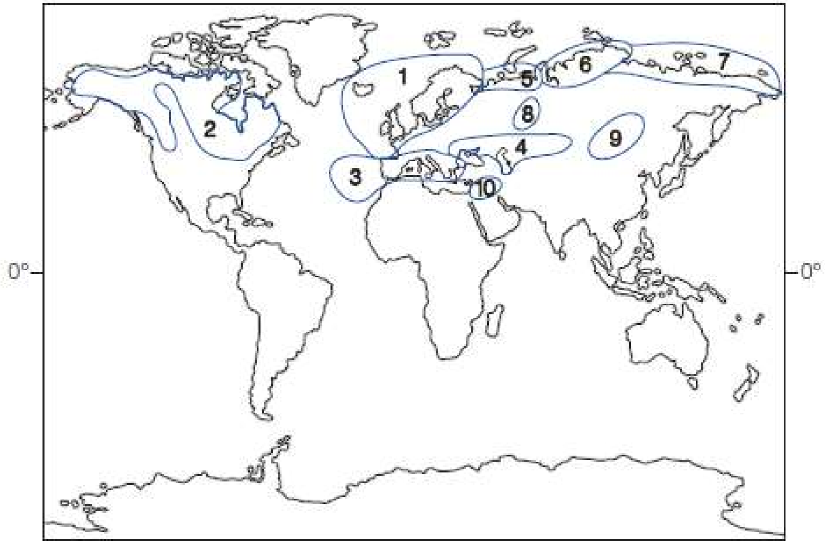


Figure 2.1 Approximate breeding distributions of various taxa within the herring gull complex [2,3]: (1) European herring gull (*Larus argentatus*); (2) American herring gull (*L. smithsonianus*); (3) yellow-legged gull (*L. michahellis*); (4) Caspian gull (*L. cachinnans*); (5) Heuglin's gull (*L. heuglini*); (6) Taymyr gull (*L. taimyrensis*); (7) Vega gull (*L. vegae*); (8) steppe gull (*L. barabensis*); (9) Mongolian gull (*L. mongolicus*); (10) Armenian gull (*L. armenicus*). There is still considerable dispute among taxonomists regarding the precise status of these taxa. 5, 6 and 7 may be subspecies of 1; and 8 and 9 may be subspecies of 4.

Evolution is still occurring in this gull complex as an ancestral species is splitting into new and separate forms, and then sometimes merging once more

Larus argentatus michahellis

- Occuring around Mediterranean coasts
- **Yellow-legged gulls** are spreading northward along the west coast of Europe, and the **Caspian gull** is spreading north from the Black Sea area in eastern Europe and **meeting** up with the European herring gull **in Poland**.

- For the biogeographer, it means that mapping the distribution of organisms and explaining such patterns that emerge are far from simple tasks (impossible for gulls of Northern Russia, to date)

Larus cachinnans

Cline and clinal variation

- Def. gradual change in genetics and form along a gradient.

- The chimpanzee (*Pan troglodytes*), for example, has 4 extant subspecies, all found in central and west Africa.

1- *Pan troglodites troglodites* **(nominate subspecies)**
2- *Pan troglodytes vellerosus*
3- *Pan troglodytes verus* (isolated from other taxa)
4- *Pan troglodytes schweinfurthii*

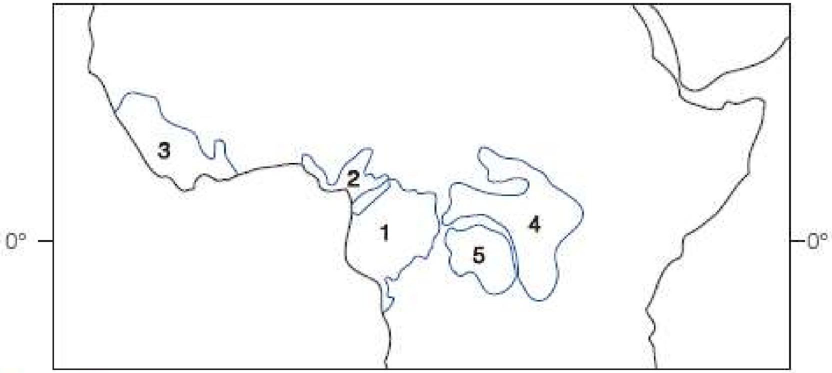


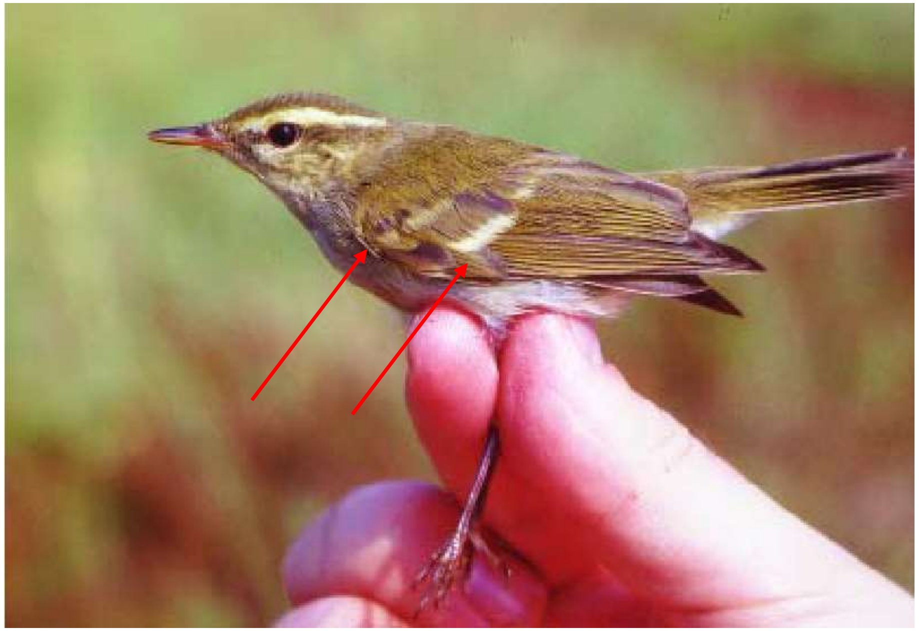
Figure 2.2 Distribution patterns of chimpanzee subspecies and bonobo in Central and West Africa: (1–4) the subspecies of chimpanzee, *Pan troglodytes*; (5) the bonobo or pygmy chimpanzee, *Pan paniscus*. More specifically: (1) the nominate *Pan troglodytes troglodytes*; (2) *Pan troglodytes vellerosus*; (3) *Pan troglodytes verus*; (4) *Pan troglodytes schweinfurthii*. The bonobo is found south of the River Congo and is hence separated from other chimpanzees by a formidable barrier to movement.

Ring species

greenish warbler
(*Phylloscopus trochilloides*)

- Sometimes a species may form a circle around a barrier

Phylloscopus trochilloides viridanus



Phylloscopus trochilloides plumbeitarsus

Where the two subspecies overlap in their range, they fail to interbreed, so subspeciation has reached a point where the two are regarded by some taxonomists as separate species.

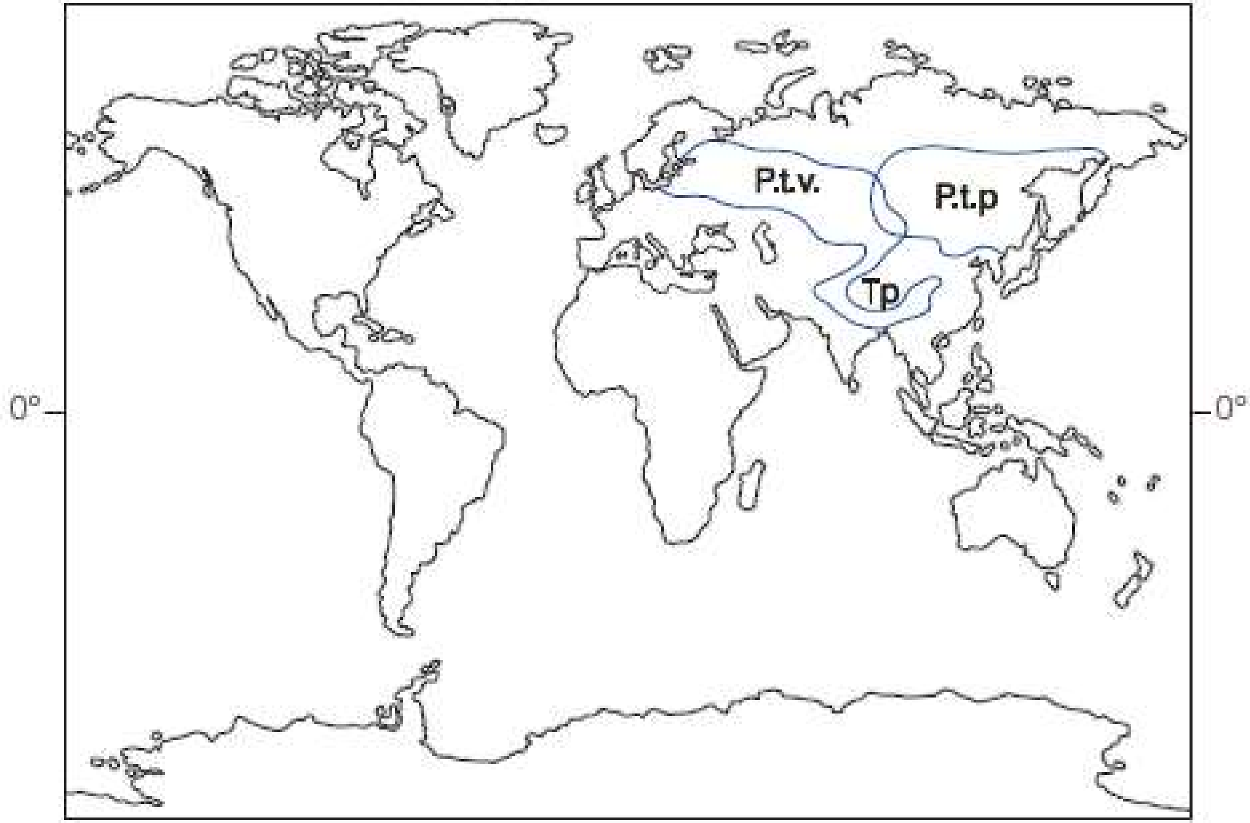


Figure 2.3 Breeding distributions of the greenish warbler (*Phylloscopus trochilloides*) in Asia. P.t.p. is the two-barred form of the greenish warbler, *Phylloscopus trochilloides plumbeitarsus*. P.t.v. is the single-barred form of the greenish warbler, *Phylloscopus trochilloides viridanus*. Between them, they form a ring around the harsh environment of the Tibetan Plateau (Tp). This is a rare example of an avian ring species. A further example of this process is shown in Plate 3.

Range and microhabitat

- Distribution and range (the area within which the species is found)

→careful about the spatial scale we are considering

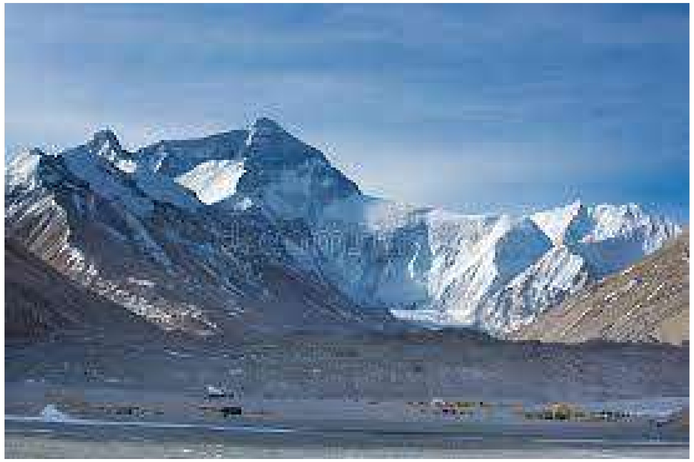
1) Two species may be widespread within a given area, and yet occupy different types of habitats (such as woodland or grassland).
2) Species may occupy different microhabitats, such as forest canopies or forest floors (e.g. kiwi and fantail in New Zealand)

scale, in both horizontal and vertical dimensions, is an important consideration when studying distribution patterns

Limits of Distribution

- *physical barriers* prevent the spread of an organism. High mountain chains, expanses of water or areas of arid desert may confine a species to one particular region

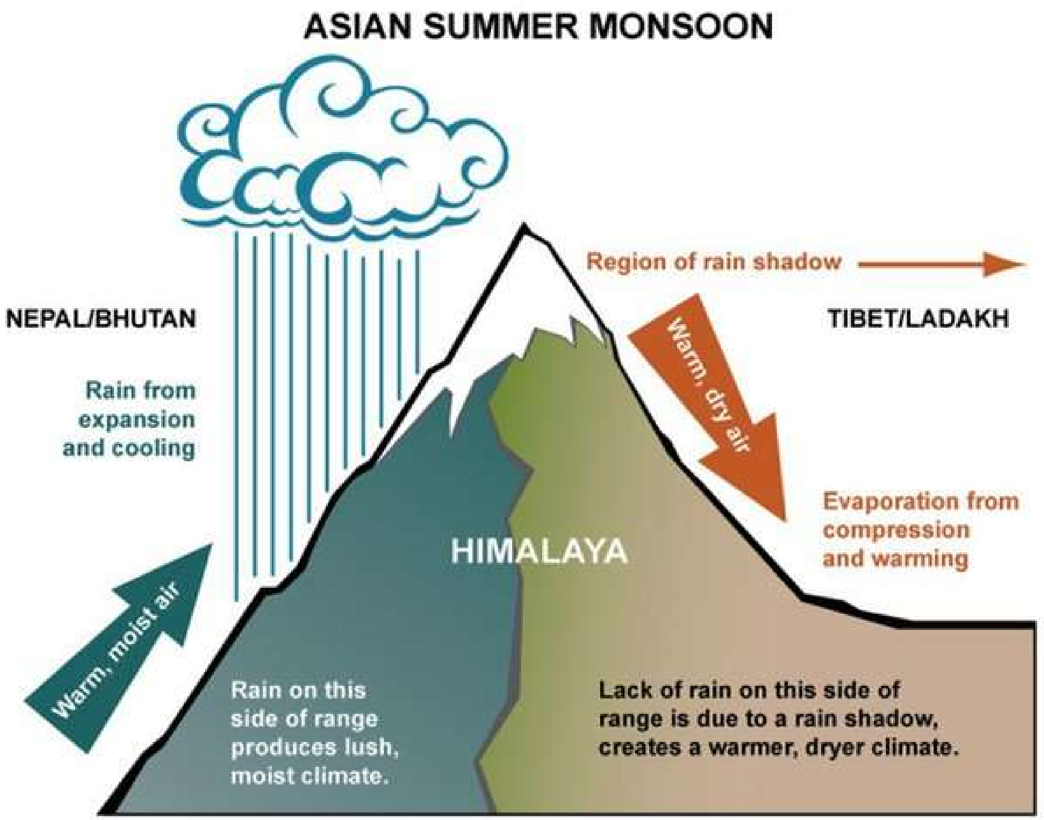
(i.e. The Himalayan mountain chain is a formidable barrier to most animals, but the barheaded goose (*Anser indicus*) is able to migrate over the Himalayas)



Climatic barriers

- Frost can prove fatal to many tropical plants because the formation of ice within the cells of the plant, followed by melting, disrupts the cell membranes and results in death.

- Drought can similarly cause problems of desiccation in many plants and animals that have limited capacity for water conservation.

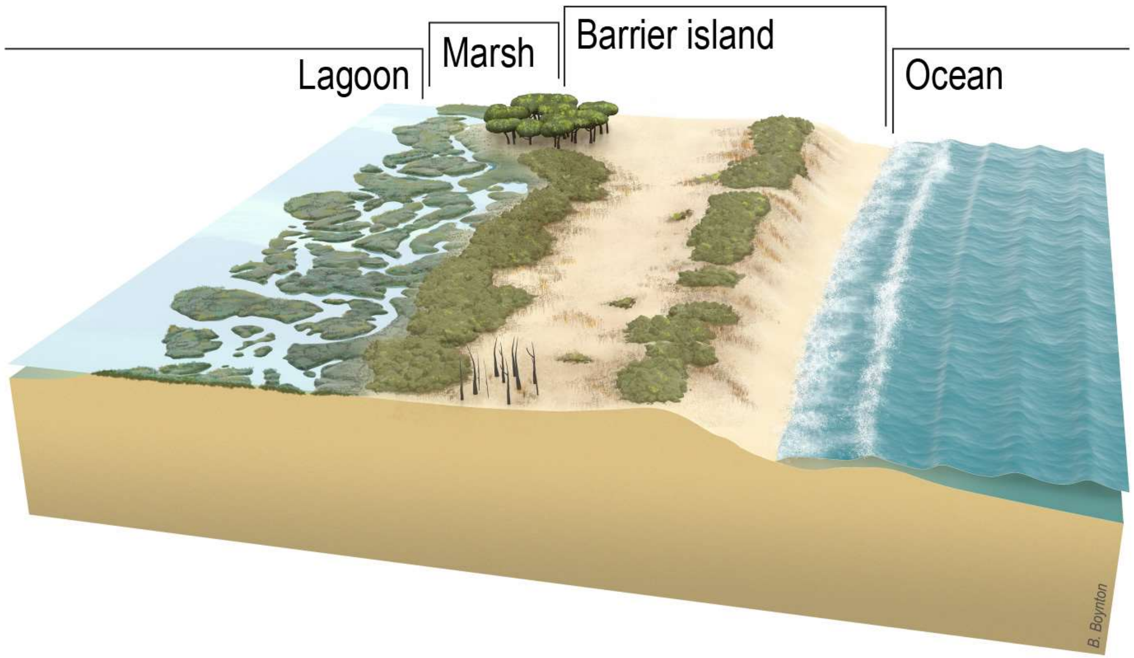


Geological barriers

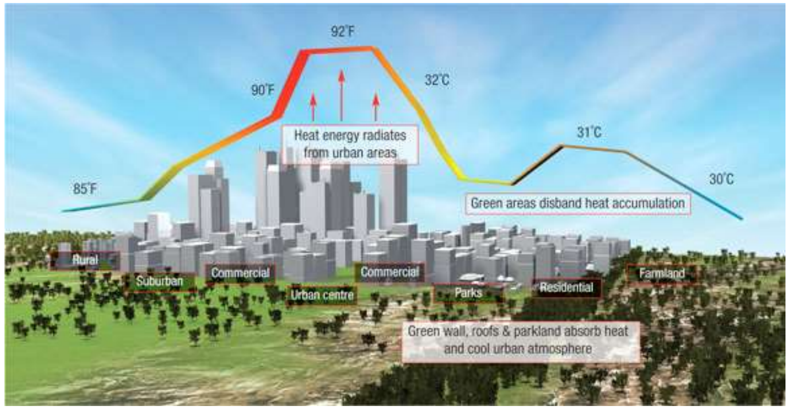
- Geology, and its effect on soil chemistry and structure, is often limiting for plants and for soil-inhabiting invertebrate animals and microbes.
- Overcoming such geological barriers demands effective dispersal strategies, either by aerial transport in the case of some fruits, seeds and very small animals like spiders, or by hitching a ride with more mobile organisms, as adhering to fur or feather.

Nature of the habitat

- A forest species may be deterred from crossing an area of grassland; or a marsh organism may fail to travel across dry habitats to reach the next area of wetland



Nature of the habitat



- Distribution patterns may derives from habitat mosaics. (i.e. regions highly modified by human activity).
- At a lower level of scale, organisms may occupy different microhabitats that are subjected to small-scale variations in physical conditions, or microclimate.

Microclimate is a term that covers temperature, humidity and light variations on a very small scale.

i.e. Animals may be restricted in their microhabitats because of limitations in their resistance to desiccation or temperature variation, but also in their dependence on food availability.

Biological barriers

- It occurs when an organism is subjected to increased predation, parasitism, disease or competition from more robust species if it were to move beyond specific area limits.

i.e. The northern subspecies of the spotted owl (*Strix occidentalis caurina*) has become endangered because of the fragmentation of the forests of the Pacific northwest of North America. Its main problem is that of predation when crossing open areas from one forest fragment to another.

Historical factors

- barriers that confine species to a limited area. Changes in the pattern of land masses over the surface of the Earth have resulted in the creation of physical barriers, sometimes between closely related taxa.

Po river delta

Chance

- <u>Stochastic event</u>: The arrival of a wind-borne insect or a seed at a particular point in space cannot be predicted with certainty, and the first arrival may well be at an advantage over those arriving later.
- Some plants and animals are confined in their distribution, sometimes (although not always) within the areas in which they evolved; these are said to be **endemic** to that region.
- Their confinement may be due to physical barriers to dispersal, as in the case of many island faunas and floras (termed **palaeoendemics**)
- They have only recently evolved and have not yet had time to spread from their centres of origin (**neoendemics**)