GLOBAL CHANGE ECOLOGY AND SUSTAINABILITY
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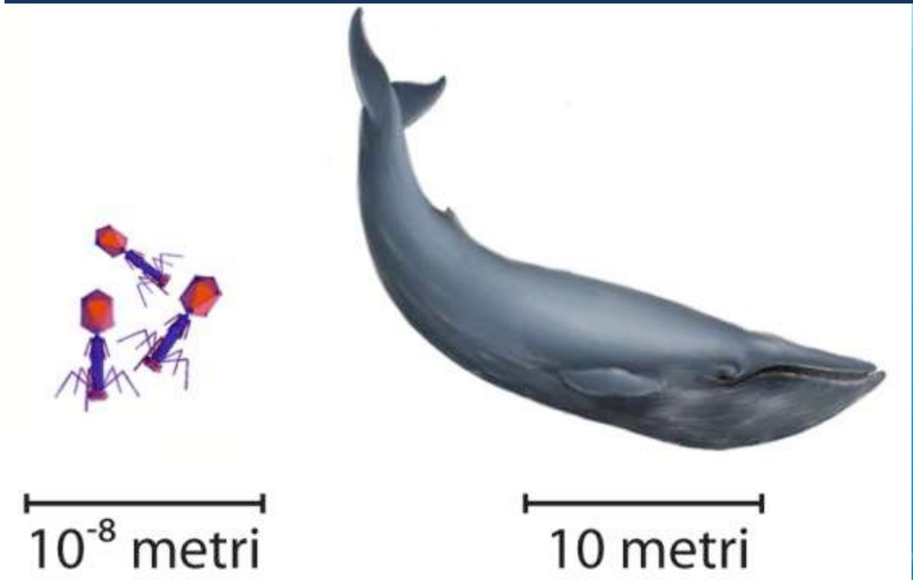
Conservation and Management of Marine Ecosystems

Prof. Stanislao Bevilacqua (sbevilacqua@units.it)

Adaptations

Size

Marine organisms range from virus (<100 nm) to whales (>30 m), and from <1 fg (= 10^{-15} g) to >100 tons

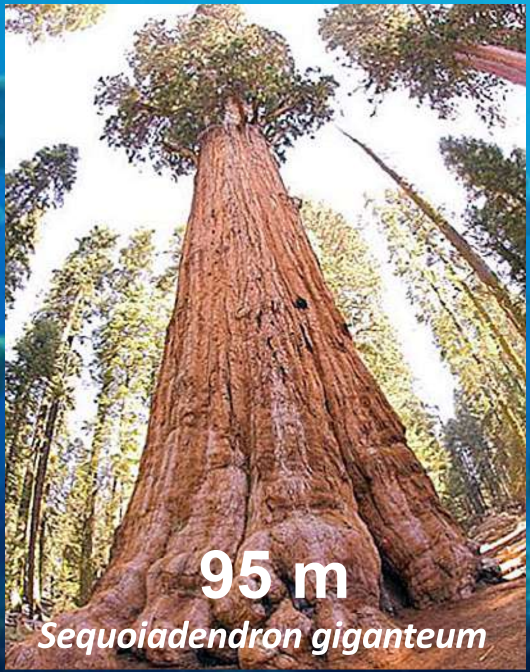


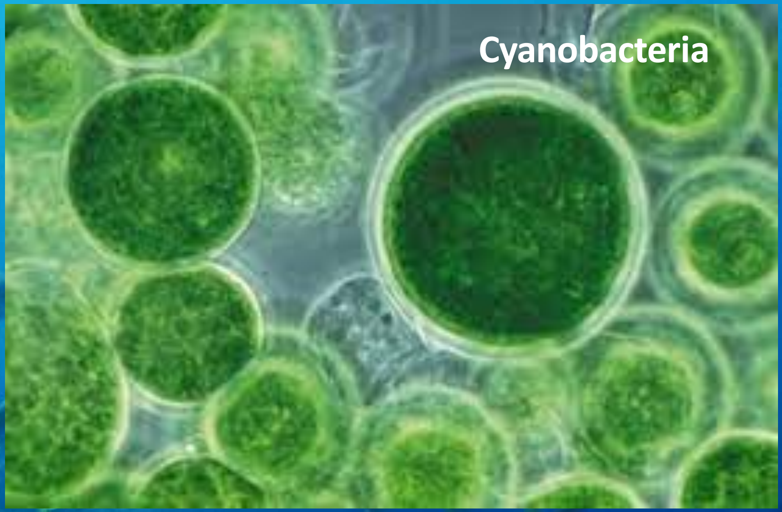
3.5 m
7 tons

This has many reasons, such as the higher efficiency in energy trasfer through the trophic levels and buoyancy.

Size

Primary producers in the ocean are smaller than on land. Most of them are small phytoplanktonic species, whereas macroalgae and seagrass are only a small component of primary producers.



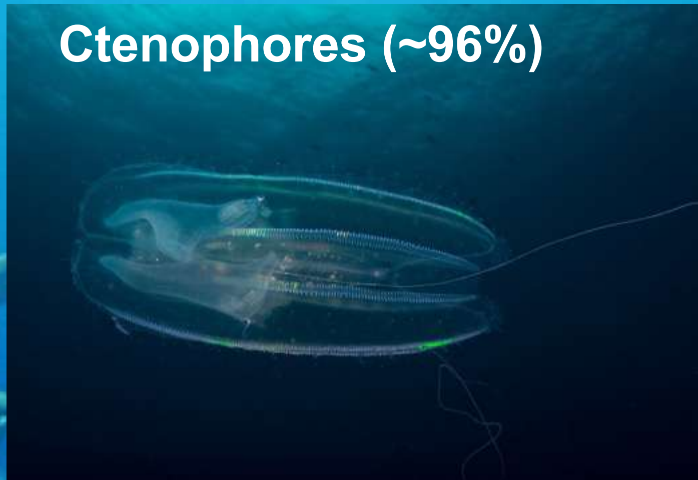


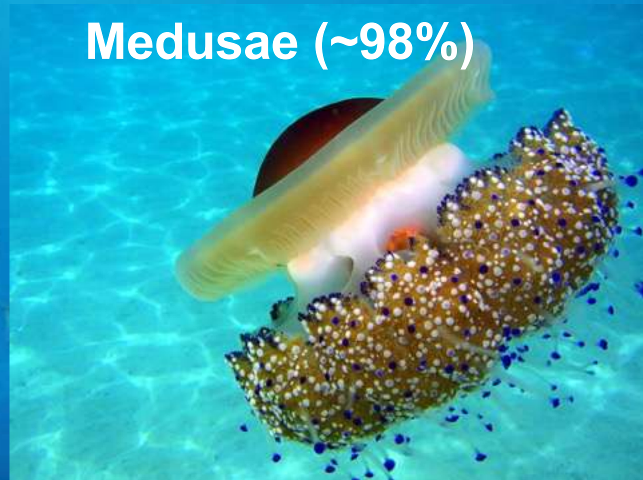
1 µm

Small size in marine organisms allows increasing the surface/volume ratio of their bodies, increasing the resistance to sink and the efficiency of exchanges of gases, metabolites, and/or nutrients with the environment

Tissue density

Sea water density generally ranges between 1.020 and 1.040 g cm^{-3} , with lower values at the surface (generally warmer) and near the coast (freshwater inputs) and higher at higher depth.



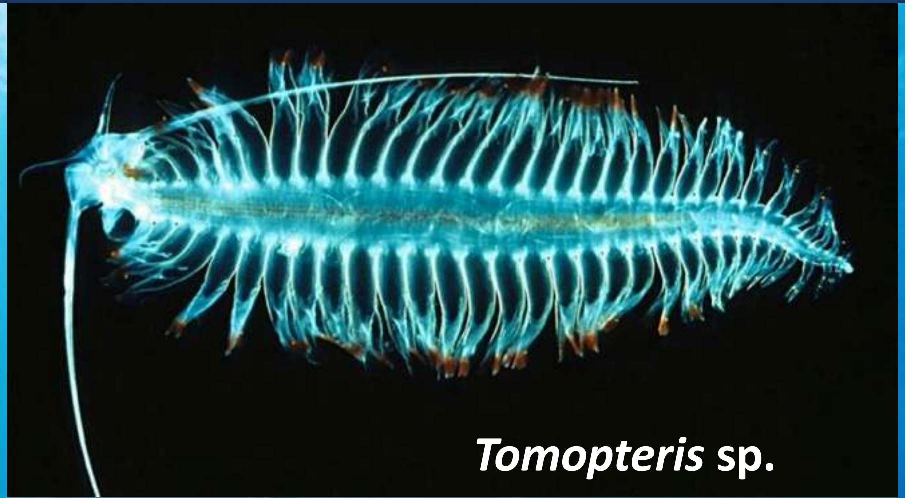


Cytoplasmatic density in animals ranges between 1.03 and 1.10 g cm^{-3}.
Many marine organisms have low density of their biomass, close to that of sea water, to facilitate bouyancy.

Fish tissues 1.07 g cm^{-3}
Zooplancton 1.05-1.15 g cm^{-3}

Body shape

Most of planktonic species, but also fish, have body appendices or other structures that increase buoyancy

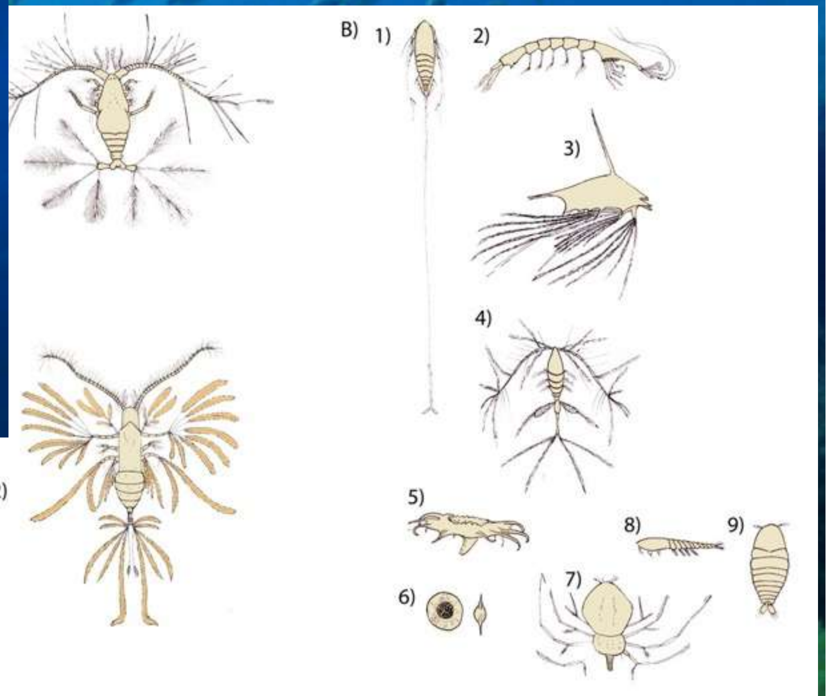


Tomopteris sp.

Glaucus atlanticus

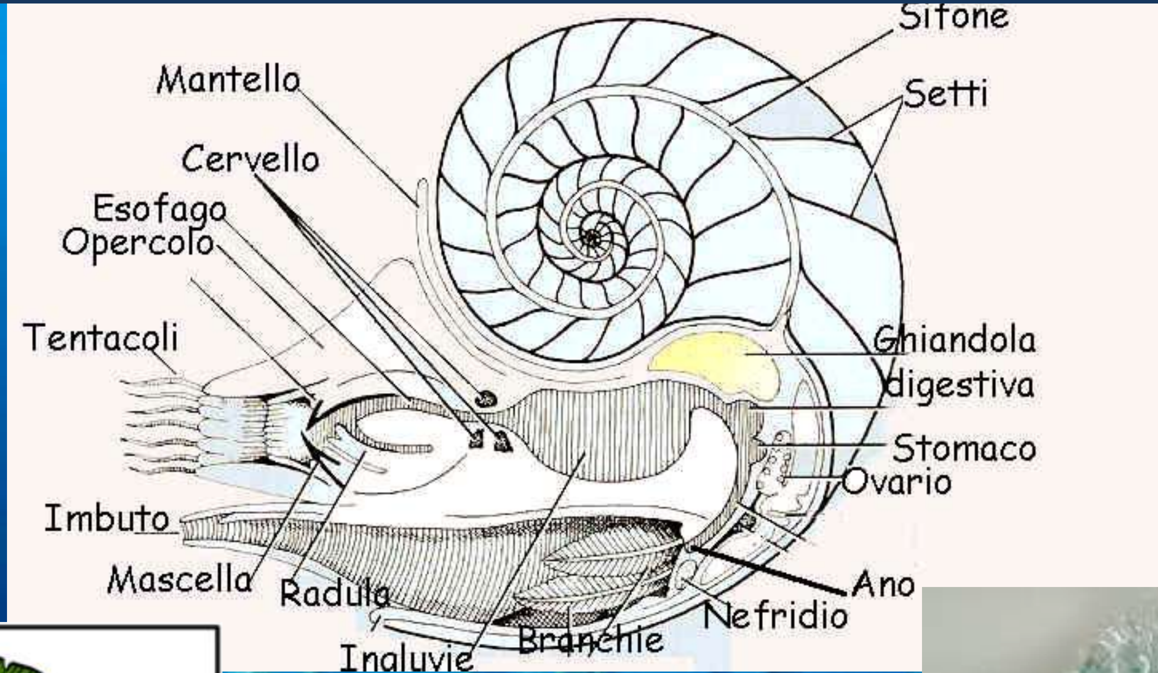
Manta birostris

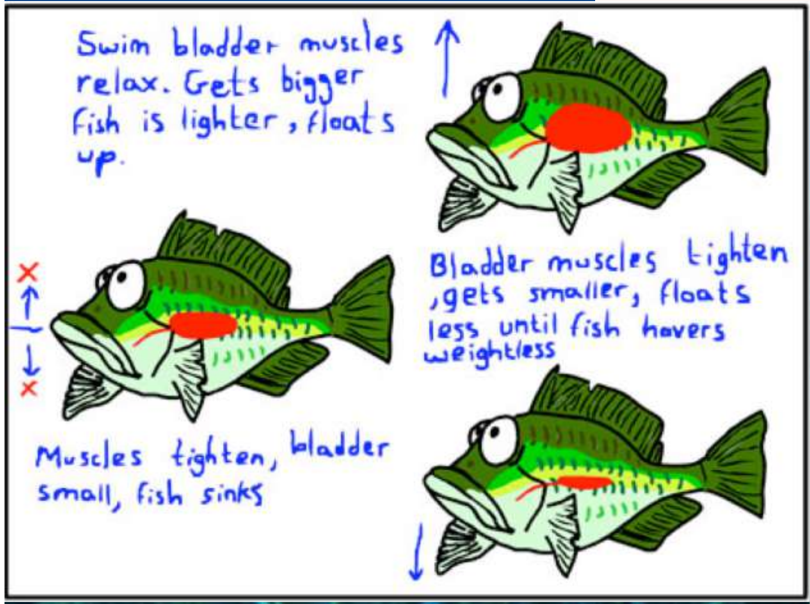
Rhyzostoma pulmo

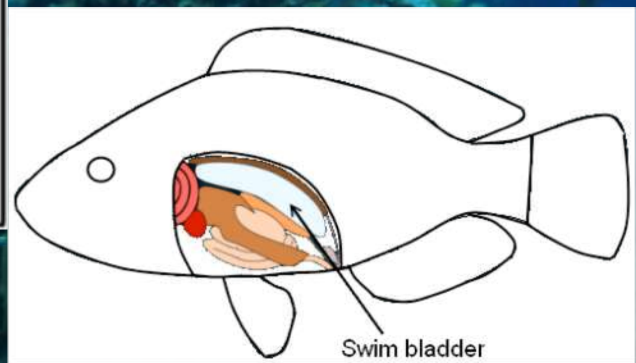


Gas tanks

Nautilus spp.

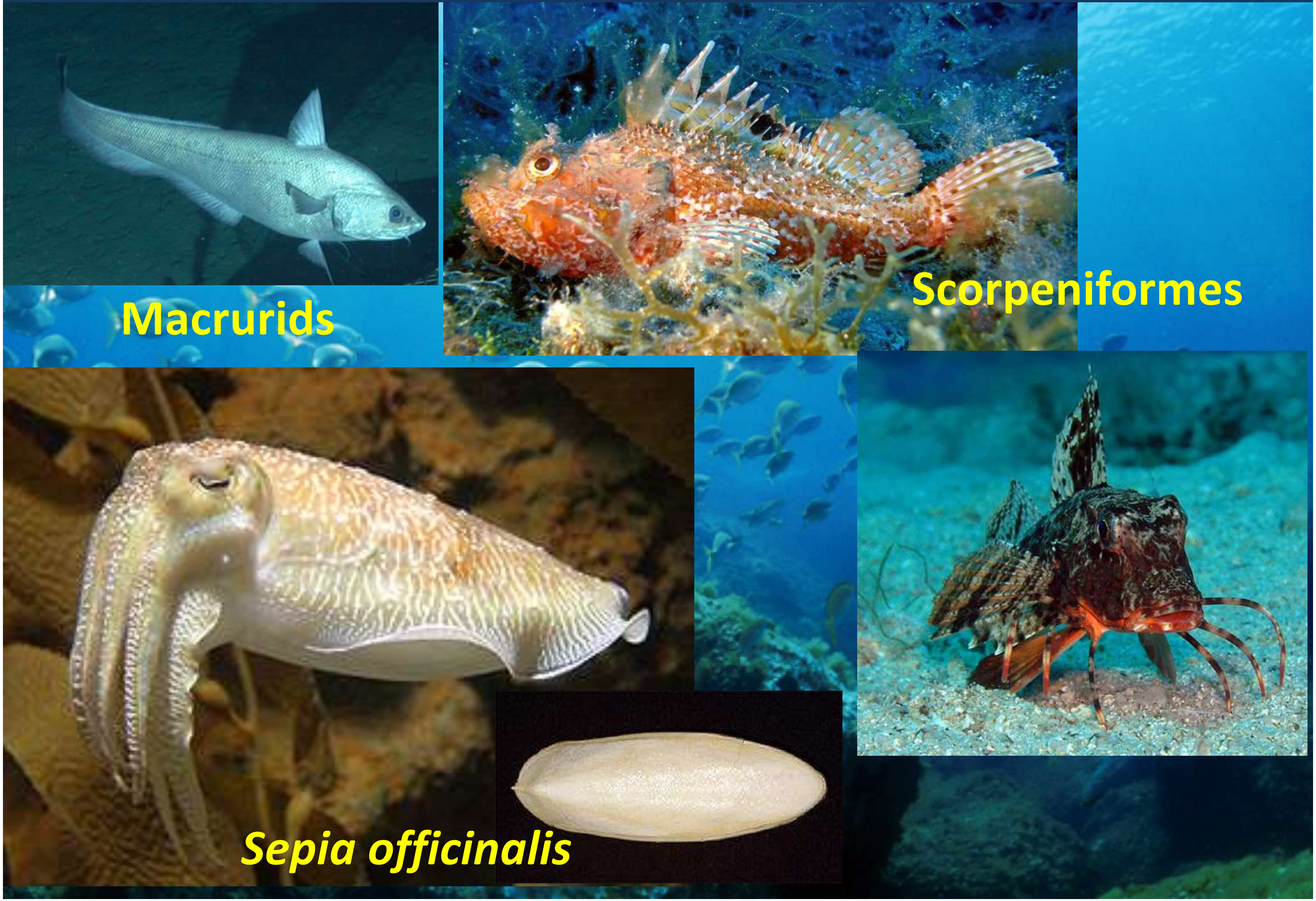






Physalia physalis

Other adaptations

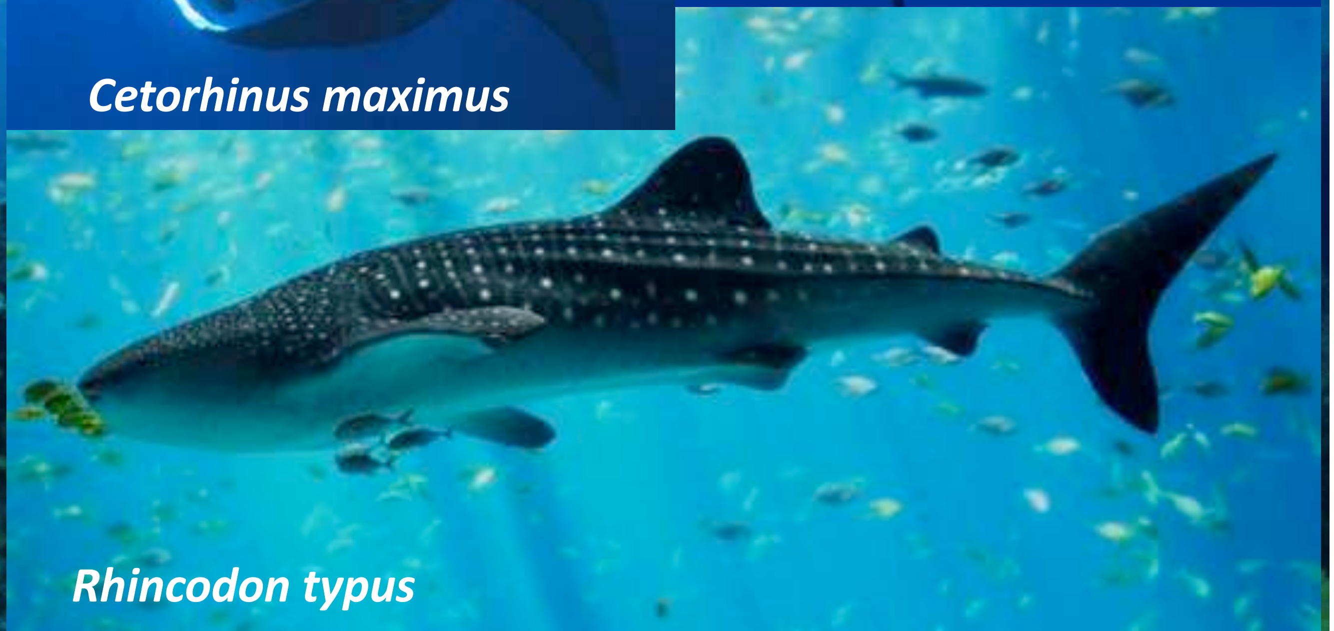


Fats and oils

In many marine organisms, buoyancy is ensured by lipids, which have lower density than sea water, and are accumulated in their body (cytoplasm, tissues) to decrease density (and as energy reserves). Sharks do not have a swim bladder, and use the liver for buoyancy. This organ in sharks has a high content of lipids and could account for the 20-30% of the total body weight.

Cetorhinus maximus

Carcharodon carcharias



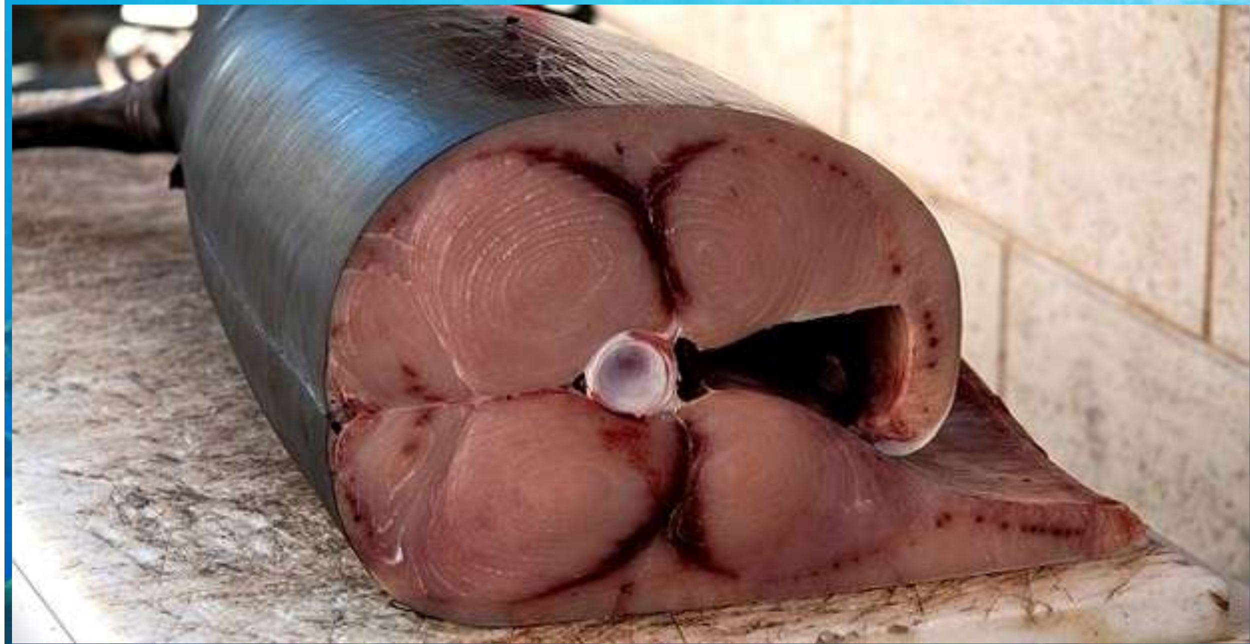
Rhincodon typus

Movement and body shape

Pelagic fish have streamlined shapes, adapted for cruise swimming. Arrow-like for predators that need strong acceleration.

Demersal fish have compressed/flat shapes, adapted to move near the bottom and/or within crevices

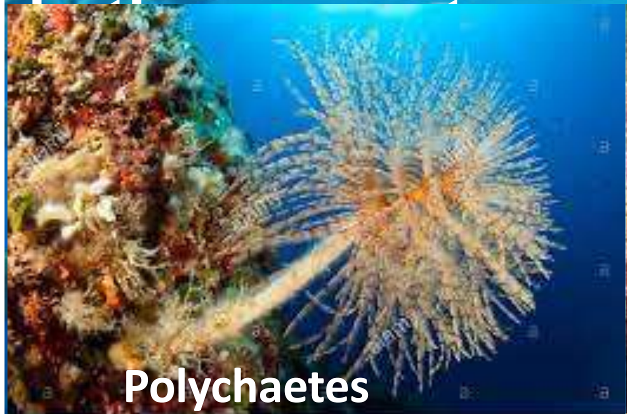
Movement and muscles

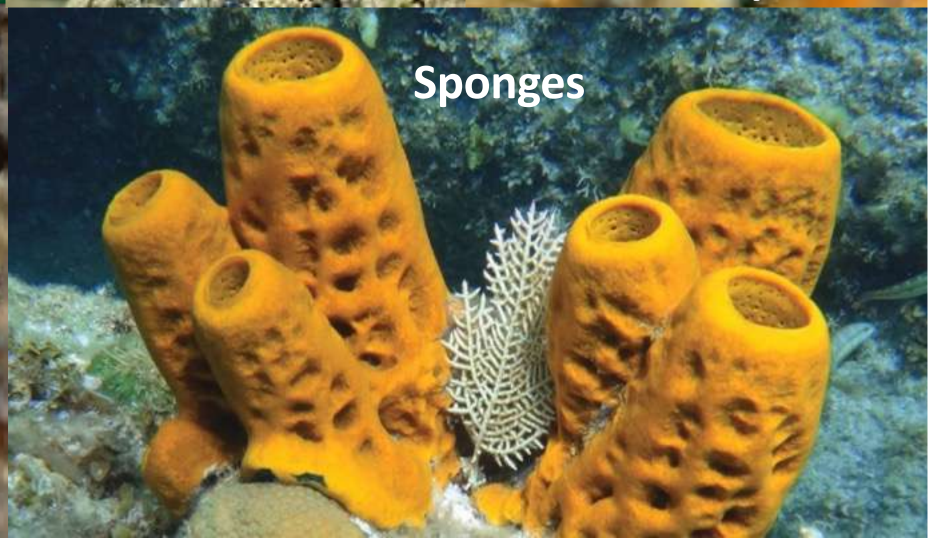


The body shape is related to the movement pattern. This also have implications for the muscle type. In animals adapted to prolonged swimming patterns (like tuna), muscle mass is mostly red (high content of mioglobin, with high blood supply, and high mitochondrial volume). In contrast, in animals specialized to rapid attack or to move in complex seascapes, white muscle is dominant (low content of mioglobin, with low blood supply, and low mitochondrial volume). This last muscle type is particularly efficient in anaerobic conditions, thus for quick and short movements

Sessile animals

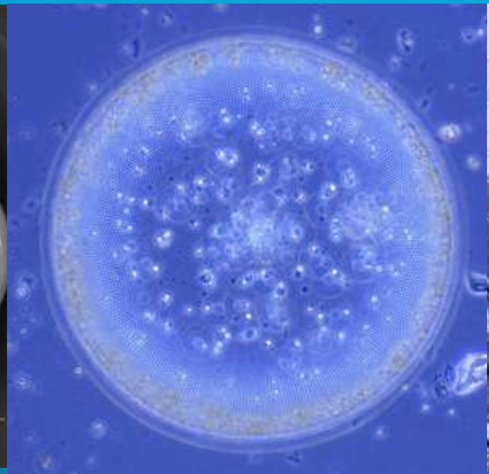
Many marine animals are sessile, and live attached to the substrates, like plants. They feed on suspended particles, plankton or even larger preys. This is possible due to the trasport of organic matter





Defense

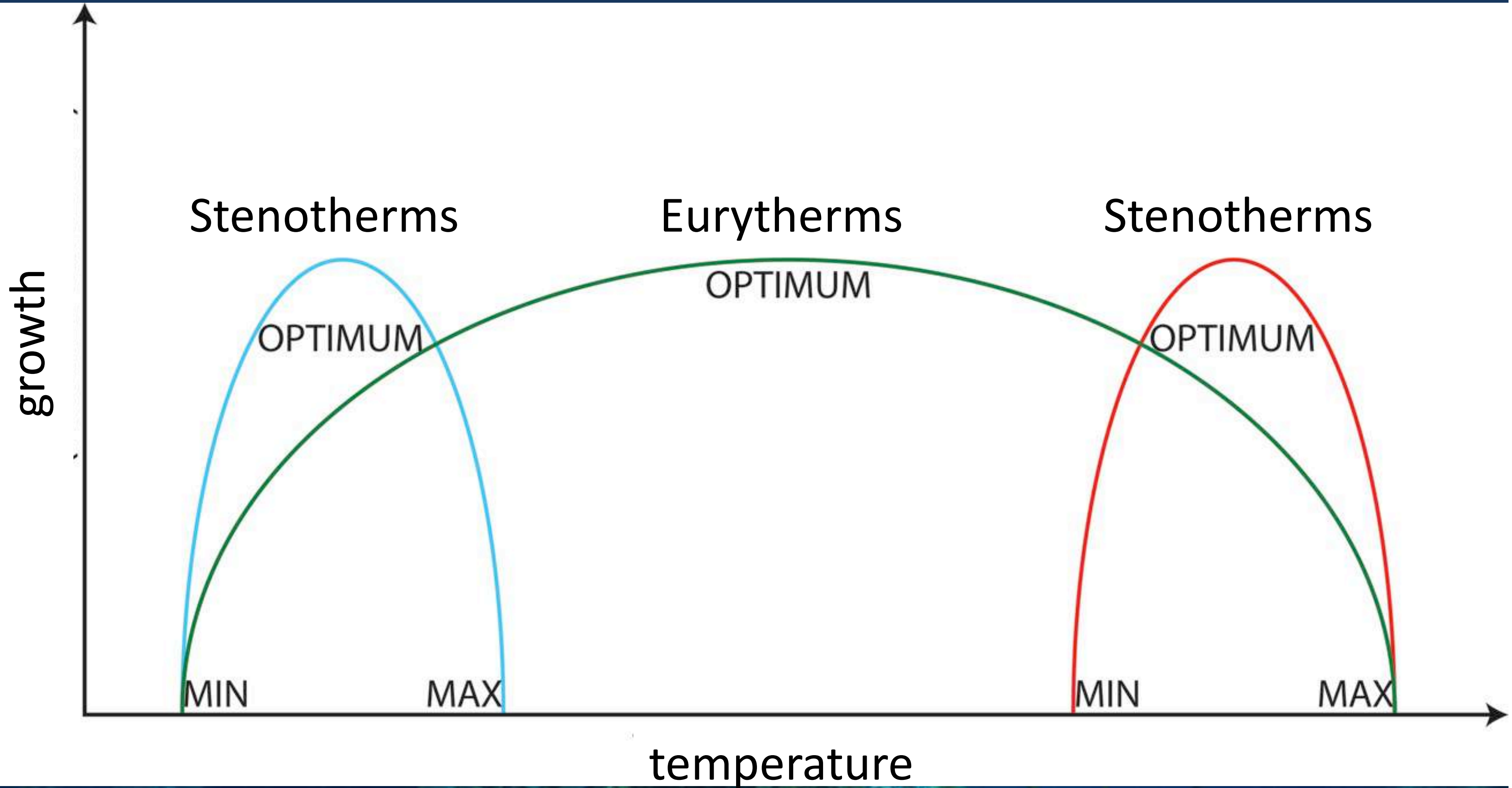
Hard structures are developed to protect against predators, physical disturbance, and to sustain the soft bodies. Structures could be external, or within the bodies. Silicates and carbonates are the most widespread inorganic compounds building these structures.




Vagile and sedentary animals could be toxic, poisonous, mimetic or simply having endobenthic habits

Temperature range

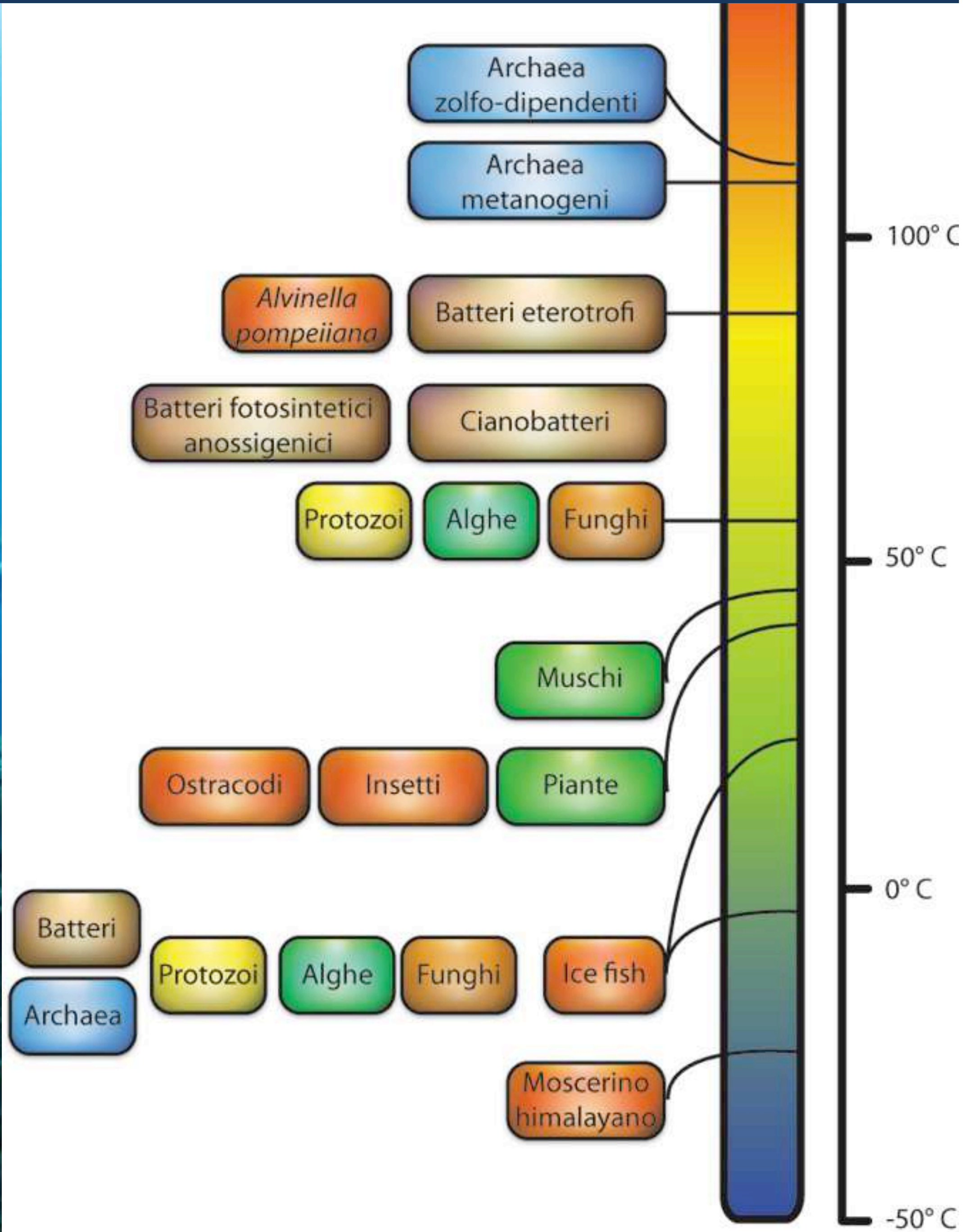


Species have a range of tolerance as far as environmental conditions (and even resources). This range is comprised between two extremes, a minimum and a maximum value which include the optimal interval (*optimum*) where the species can survive and thrive.

Temperature range

Above 60° C and below -20° C, temperature conditions are prohibitive for the the continuity of life. For high temperatures, problems depends on proteins denaturation, metabolic disruption and dehydratation. At very low temperatures, instead, metabolism could be too slow to allow the normal functioning of organisms. Also, water within cells and tissues represents a problem due to the formation of ice crystals.

Some organisms have adaptations to resist to very low or very high temperatures.some bacteria could resist to temperature >100° C near hydrothermal vents, some fungi instead could live at -50° C in antarctic ice.
Also particular animals could live at high temperature, like the polychaetes *Alvinella pompeiana,* whereas tardigrads could survive at temeperature close to 0° K.

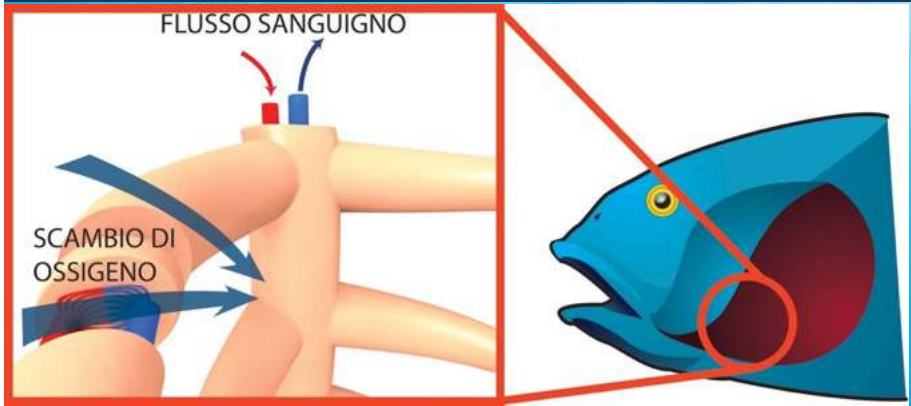


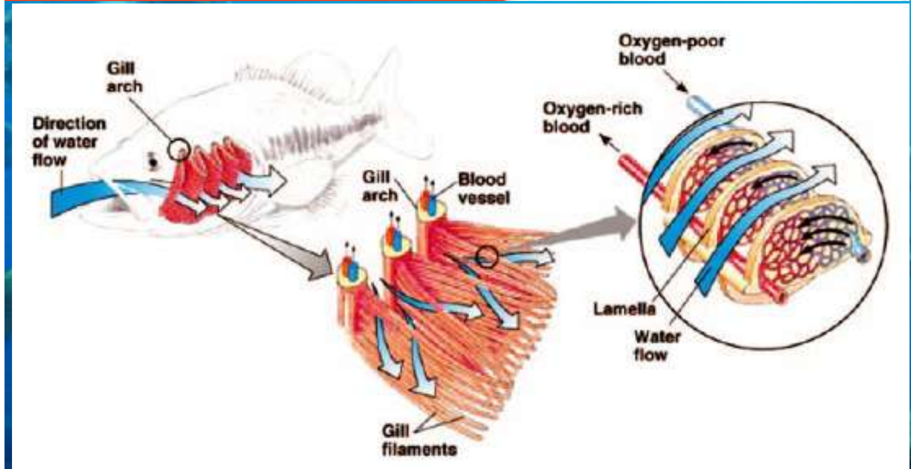
Adaptation to extremely low temperature

Fish of the order Notothenioidea dominate in the Antarctic waters. They have low hemoglobin and limited erythrocytes to increase the blood flow, increased heart size and diameter of veins, and increased vascularization of the skin. In some species, both hemoglobin and blood cells are absent.

These characteristics, coupled with low metabolism, contrast the tendency of higher blood viscosity due to low temperature, and compensate the low number of erythrocytes and low content of hemoglobin facilitating oxygen exchange from the environment and transport to tissues. They also have Anti Freezing Glicoproteins that prevent body fluid to freezing.

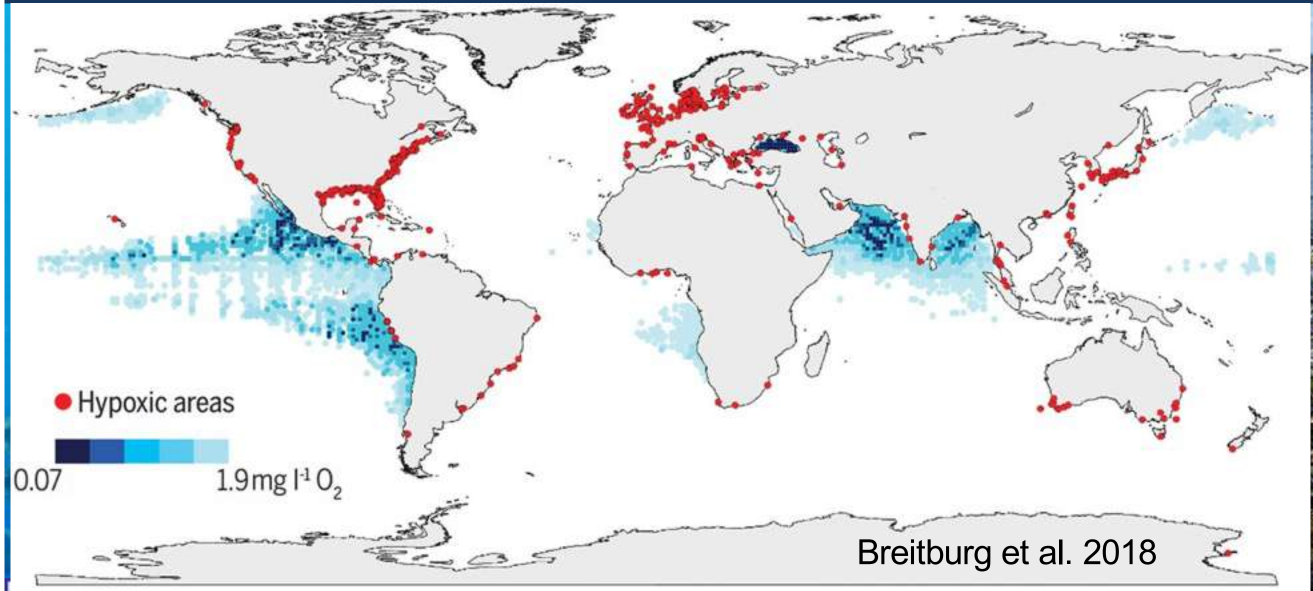
Oxygen

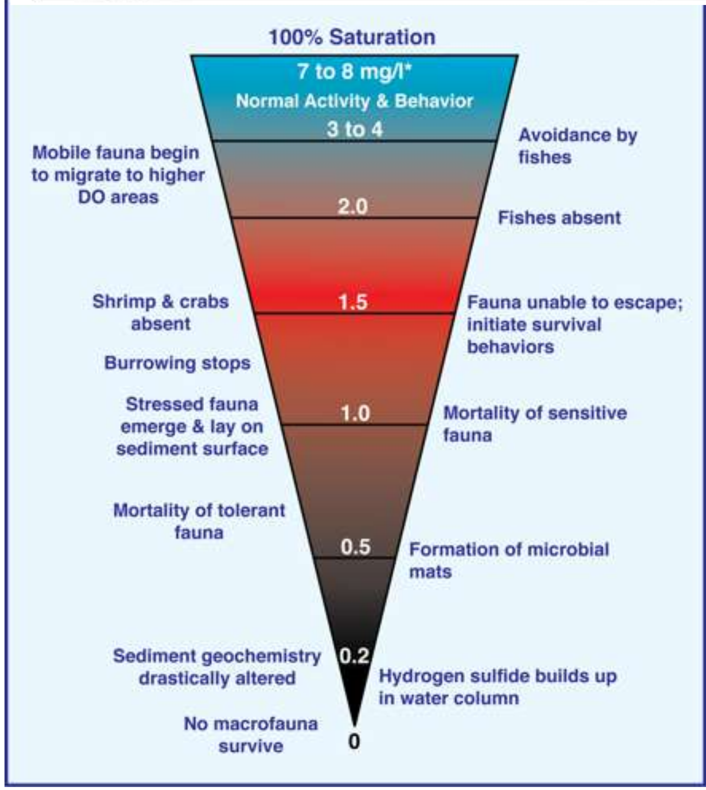




Dissolved oxygen in sea water (normally between 5-10 ml/l) comes from photosynthetic activities and diffusion from the atmosphere. Its concentration depends on temperature and salinity (higher T and salinity, lower oxygen).
Marine organisms absorb oxygen in different ways, through skin and external tissues, digestive organs or have specific structures (e.g. gills)

Oxygen



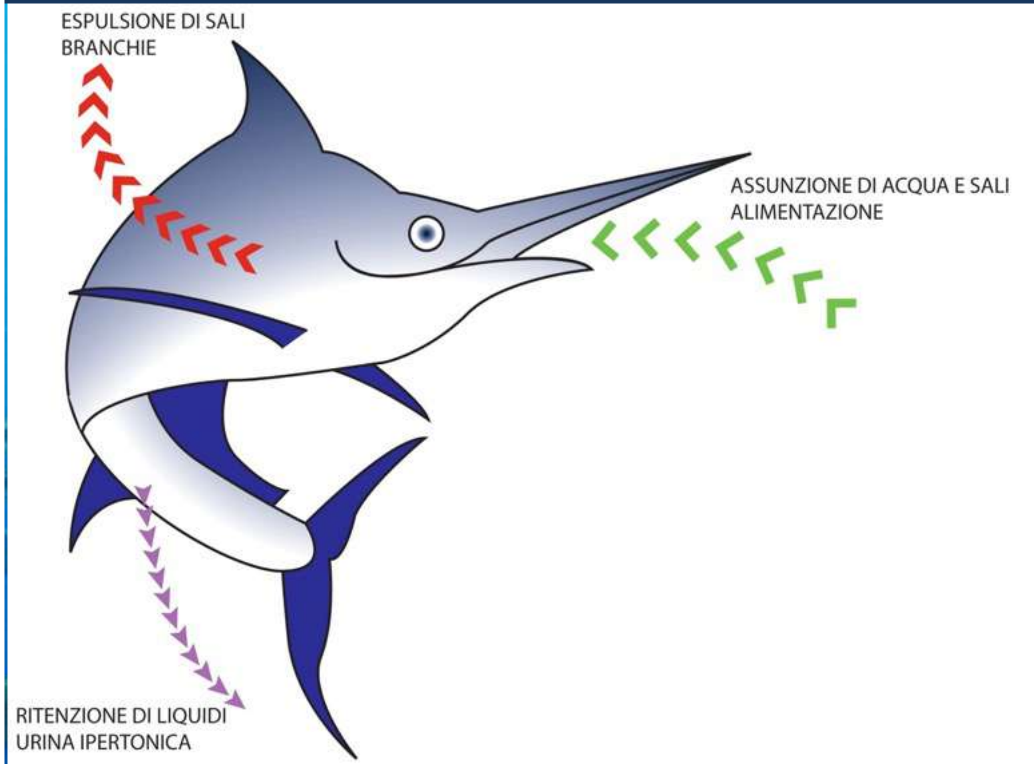


Levels of DO below 2 mg/l could cause drastic changes to marine environments and, consequently, to marine life.

Due to increasing temperature, altered circulation, increasing nutrient load, coastal but also pelagic areas all over the world's oceans are becoming hypoxic or completely anoxic (dead zones)

Air exposure

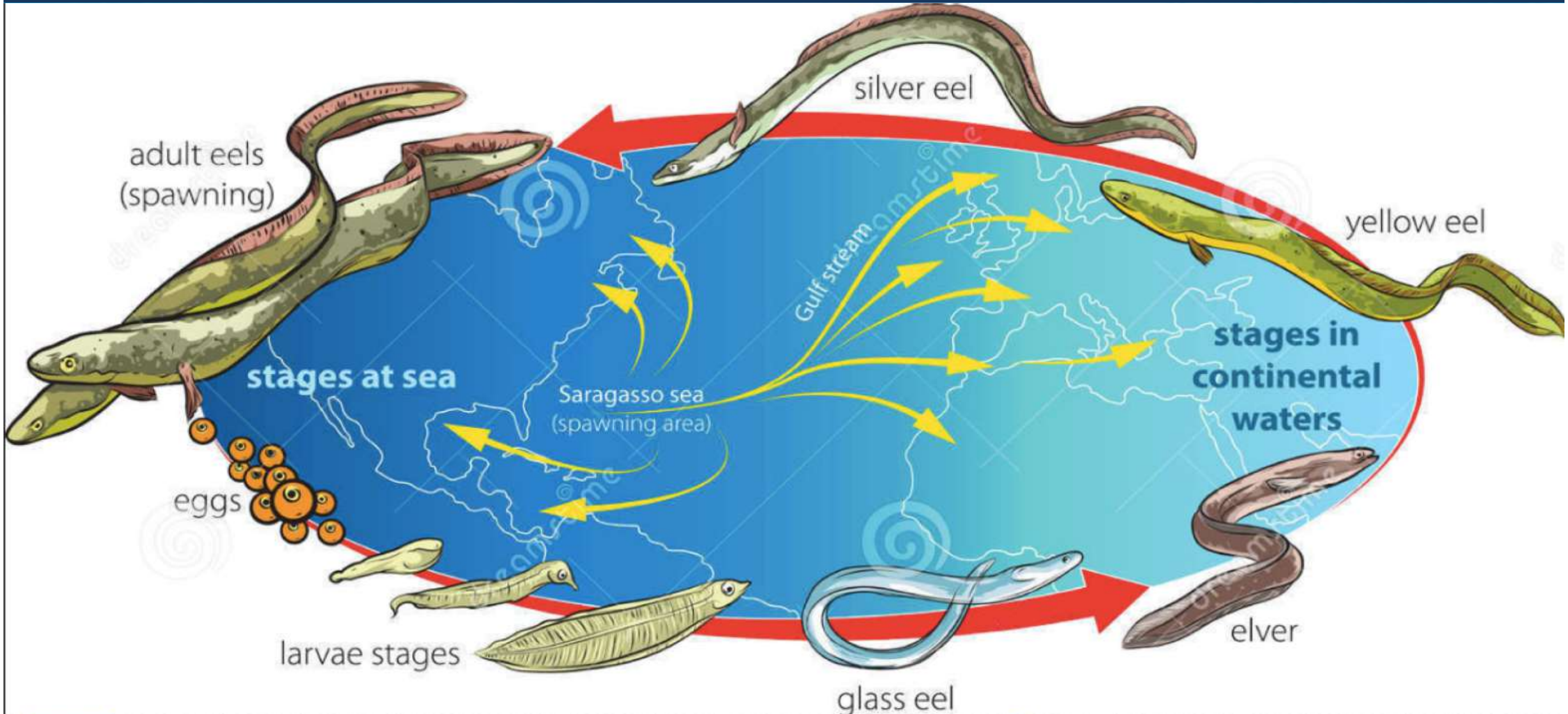
Osmoregulation



Teleosts have hypotonic blood. To maintain osmosis ingest water and salts (also from food) and excrete salts from gills and hypertonic urine.
Sharks increase urea concentration in their blood to approximate isotonic conditions and excrete salts through the rectal gland.
Marine mammals avoid sea water ingestion (water is taken with food), and excrete hypertonic urine.
Other marine vertebrates also excrete salts through specific glands near the eyes or the nose cavity (reptiles and seabirds)

Many marine organisms are isotonic or hypertonic with respect to sea water, and maintain salt concentration in their fluids through active transport of salts, low permeability of teguments to water.
Osmolyte production (e.g., urea, glycerol) in hypotonic organisms.

Catadromous and anadromous species



Life cycle of the European eel (*Anguilla anguilla*): from fertilized eggs to the zygote, who through several larval stages becomes a small transparent eel (glass eel). Then, the individual grows and start to produce pigments until the juvenile stage. It migrate in continental freshwaters or brackish waters and increase in size until the adult stage (yellow eel). It becomes a silver eel to return to the sea for reproduction. **(catadromous species)**

Anadromous species

Salmons do exactly the opposite (anadromous species)

Salmo salar

Diadromous species

Megalops

Carcharinus leuca

Summary of main land-sea differences

Biodiversity and evolutionary history

Space dimensionality, connectivity and environmental variability

Organisms do not invest much of their biomass to form structures (skeletal and cellulose) to oppose the force of gravity

Important biochemical differences:
Carbohydrates for terrestrial organisms (structural molecules for support and protection) - Proteins for marine organisms (complex organic molecules, muscles) – buoyancy

Amount of organic matter produced is higher in terrestrial environment

Transfer efficiency is higher in the marine environment -> more trophic levels:
active biomass in producers – reduced energy loss for movement and temperature regulation

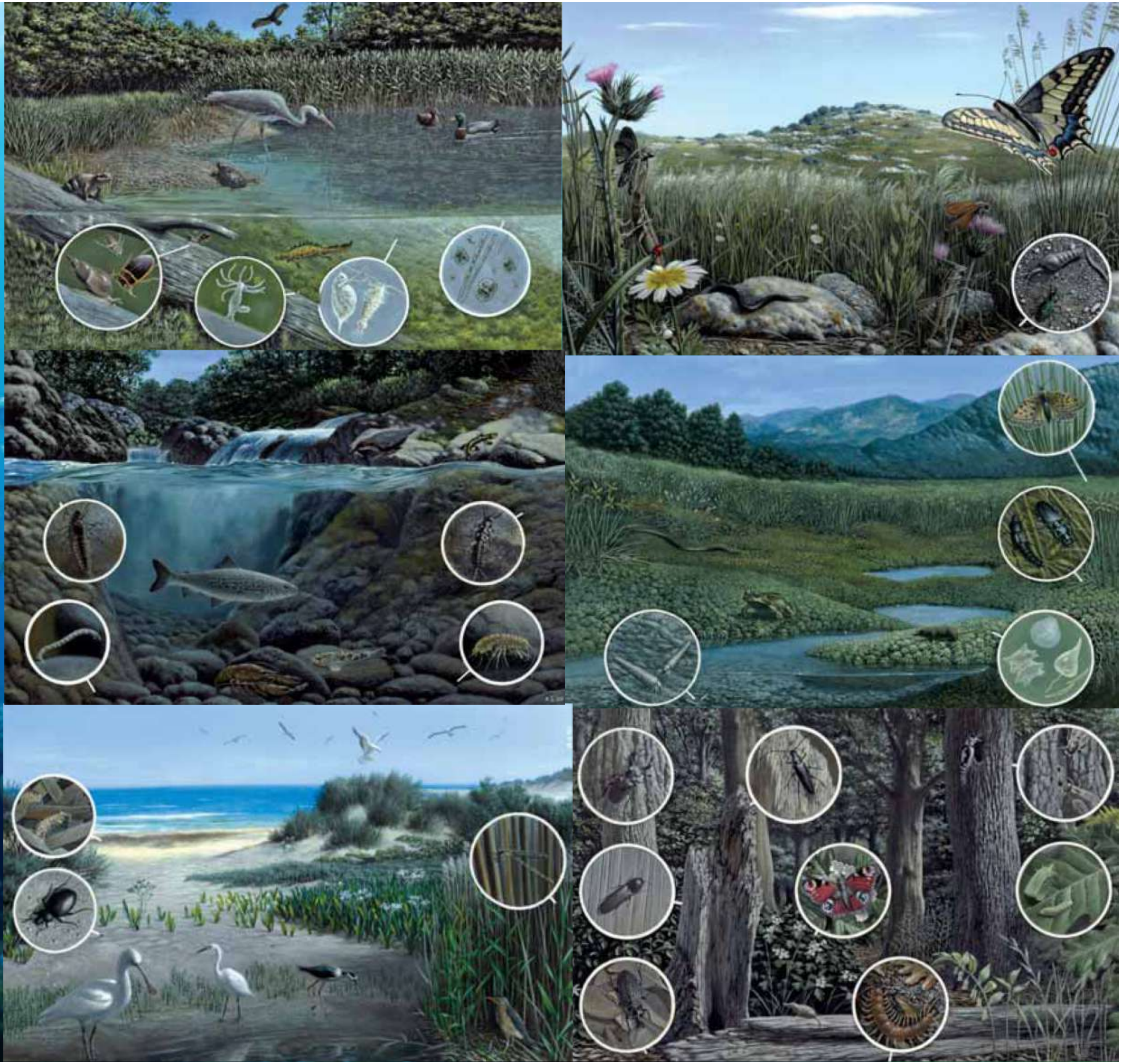
Difficulty of framing trophic groups in the marine environment:
switching to different trophic levels during the life cycle

On land

the landscape is made of plants (necromass)

plants are the structural backbone of ecosystems

animals are functional

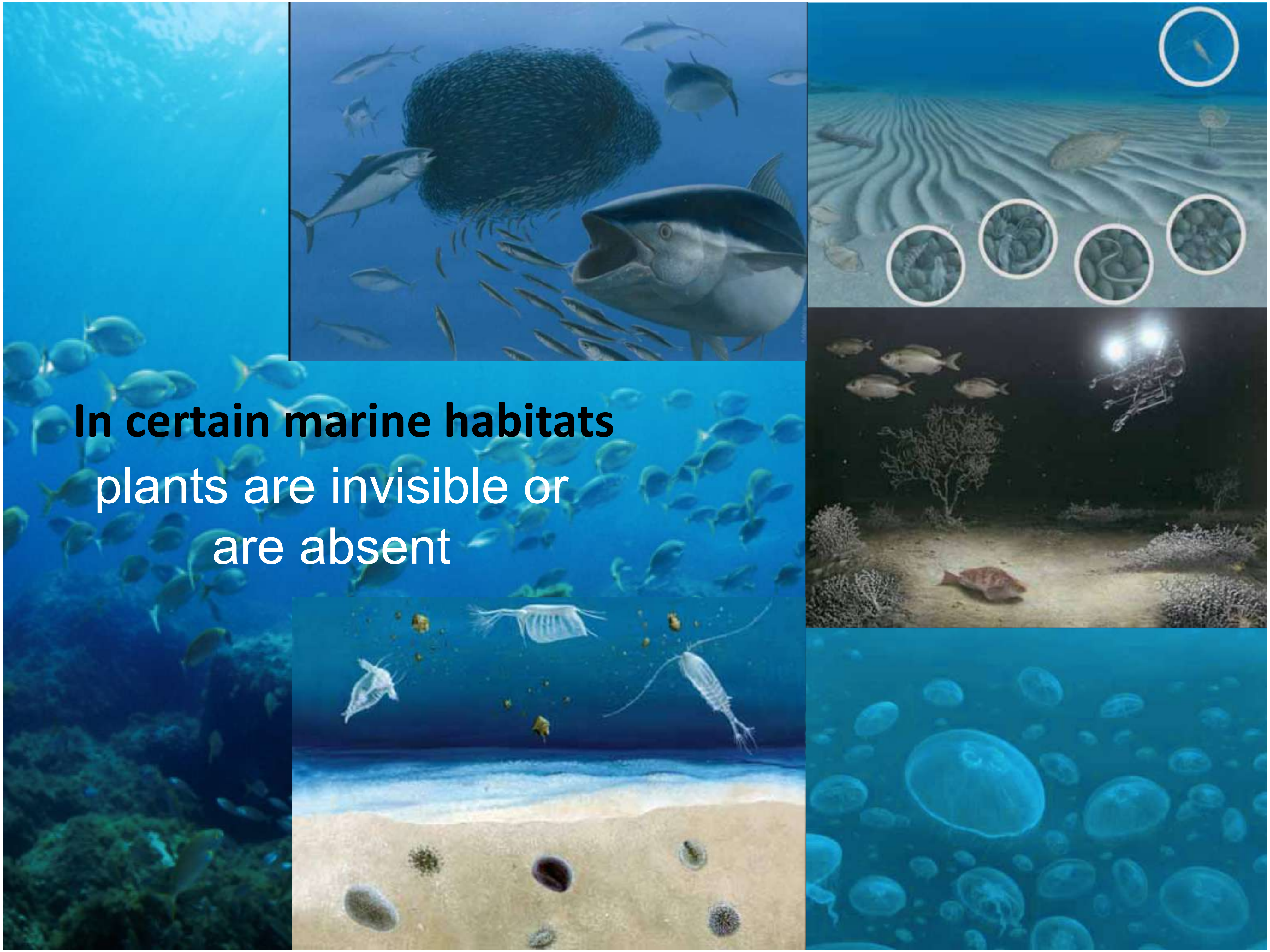


In the sea

plants make
the landscape
near the
surface

but, below the
euphotic zone,
habitats are
dominated by
animals

the land is for
botanists
the sea is for
zoologists


In certain marine habitats
plants are invisible or
are absent

On land

The majority of products derive from agriculture and farming

we are not hunters and gatherers any more

landscapes are radically altered

In the sea

seascapes are less altered

we can still be hunters and gatherers