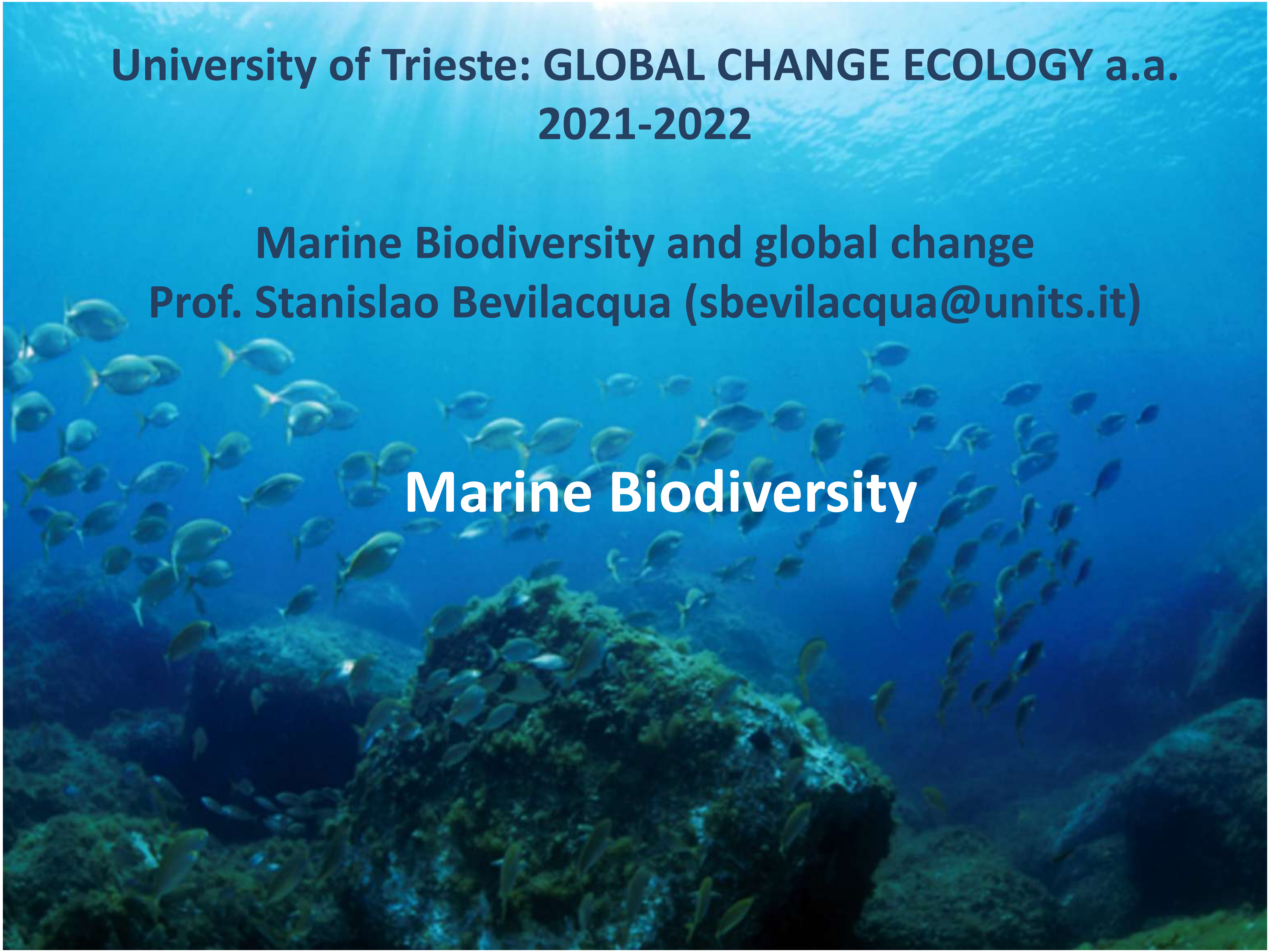


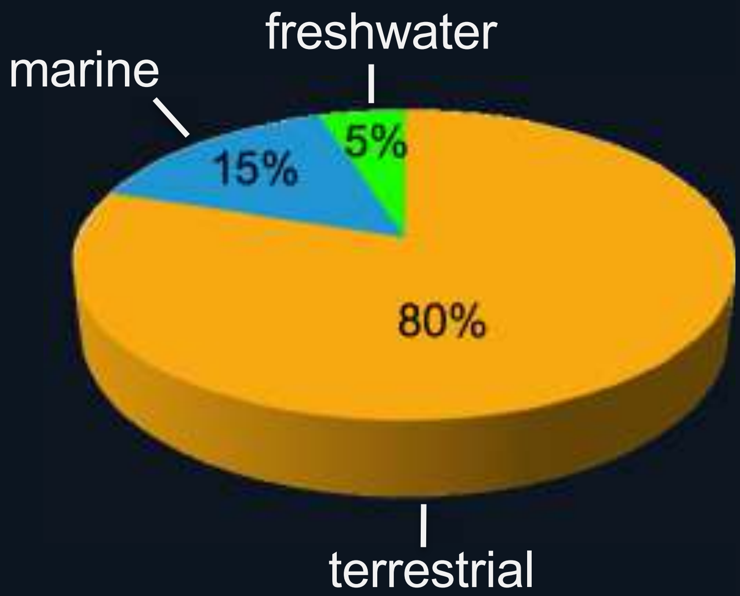
University of Trieste: GLOBAL CHANGE ECOLOGY a.a. 2021-2022

Marine Biodiversity and global change

Prof. Stanislao Bevilacqua (sbevilacqua@units.it)

Marine Biodiversity

Marine biodiversity



~34 animal phyla, 80% is marine or mostly marine

~almost all of them are benthic or have benthic taxa

(…and don’t forget most of algae)

~1,500,000 known species on Earth

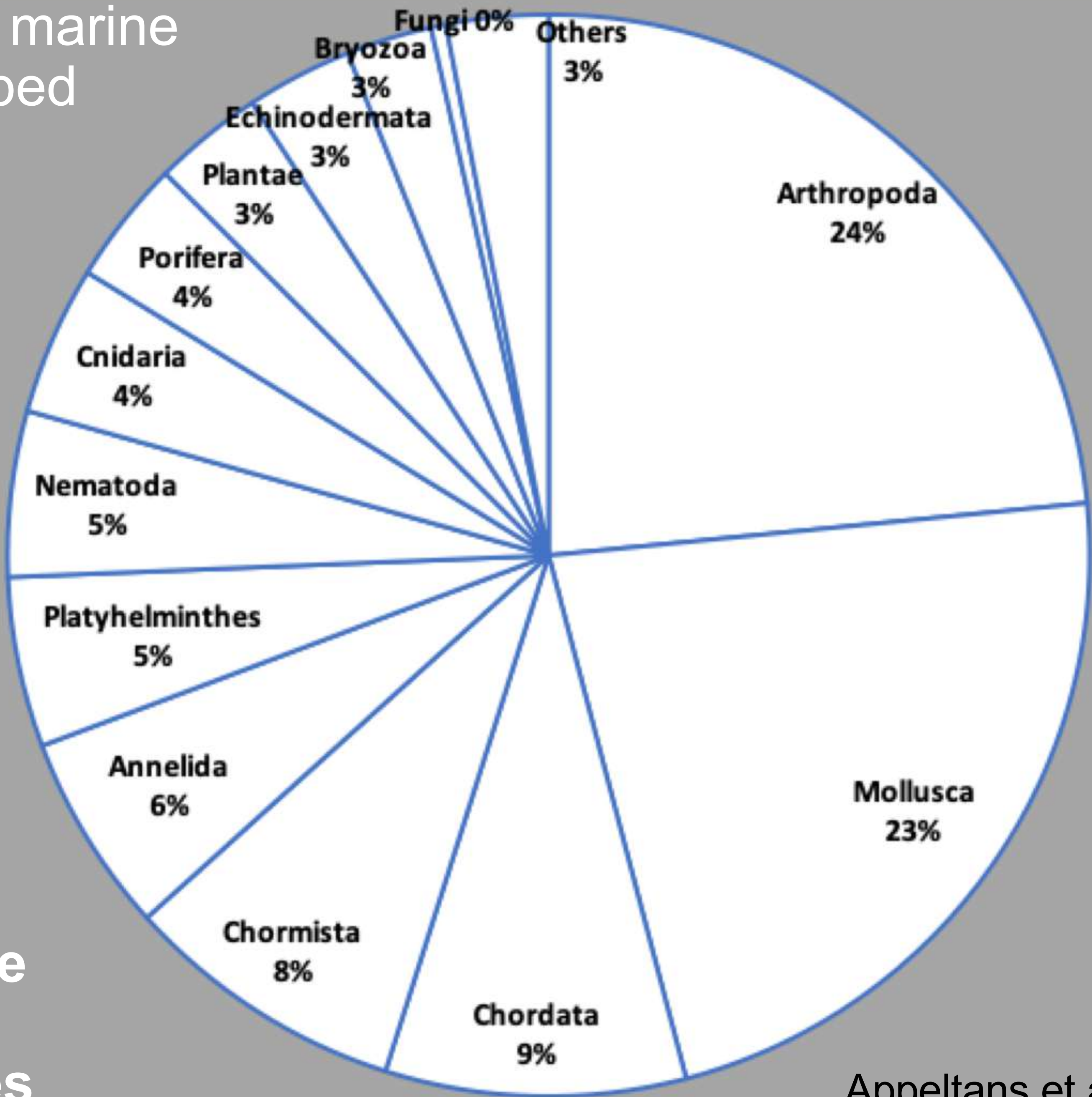
~240,000 are marine, ~85% of them are benthic

How many species

About 240,000 marine species described

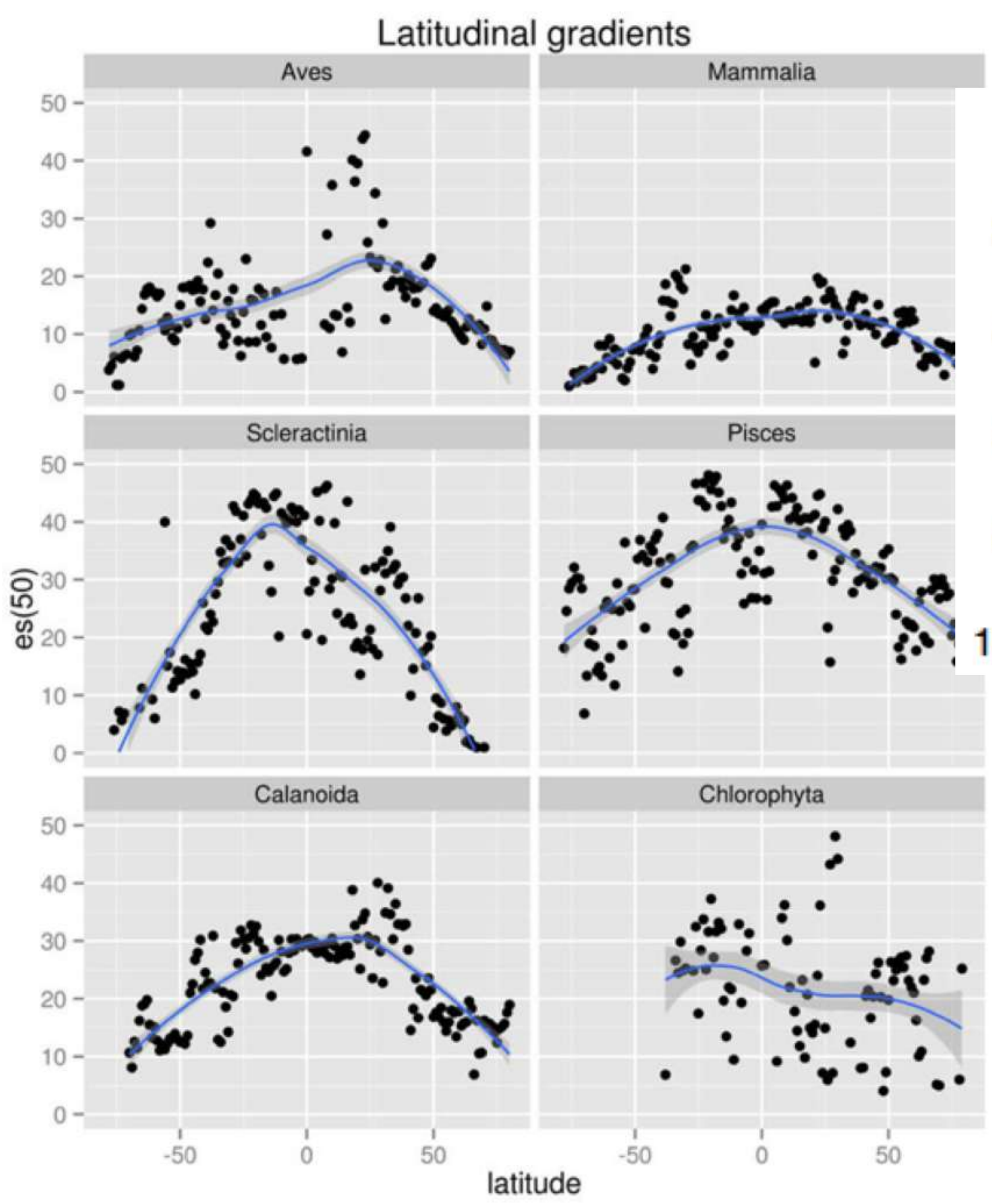
58,000-72,000 marine species sampled but still not described

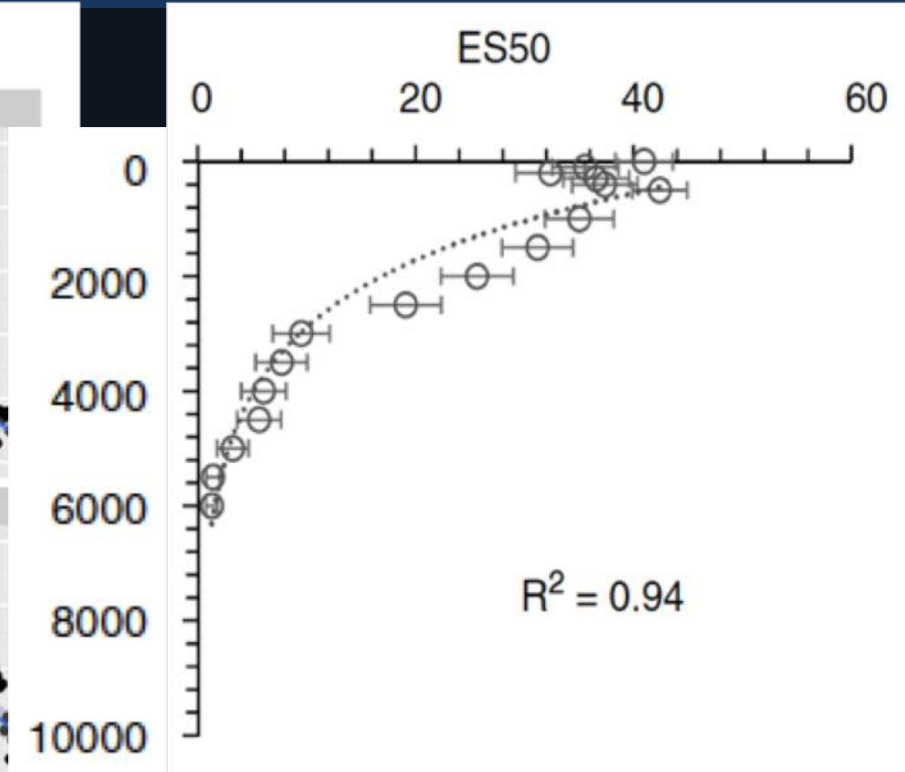
There could be 0.7-1.0 million marine species



Appeltans et al. 2012

Patterns





Marine biodiversity peaks at tropical latitude (Snelgrove et al. 2016) and at shallower depths
(Costello & Chaudhary 2017)

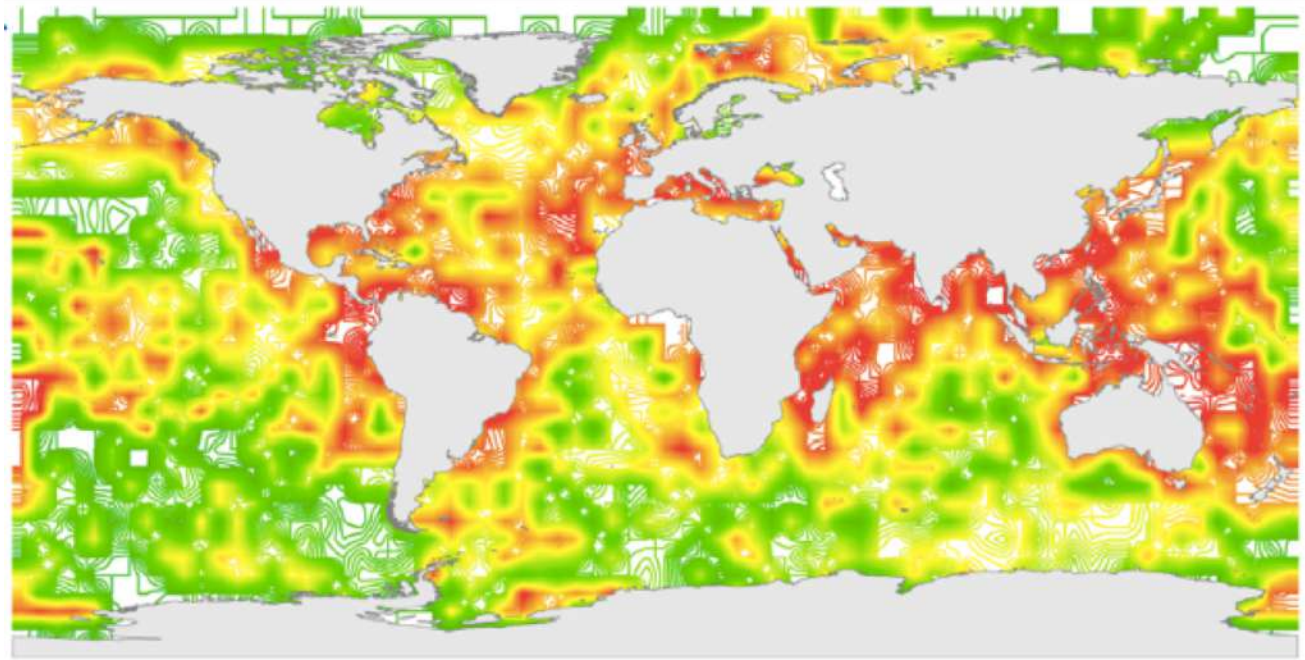
Factors affecting biodiversity

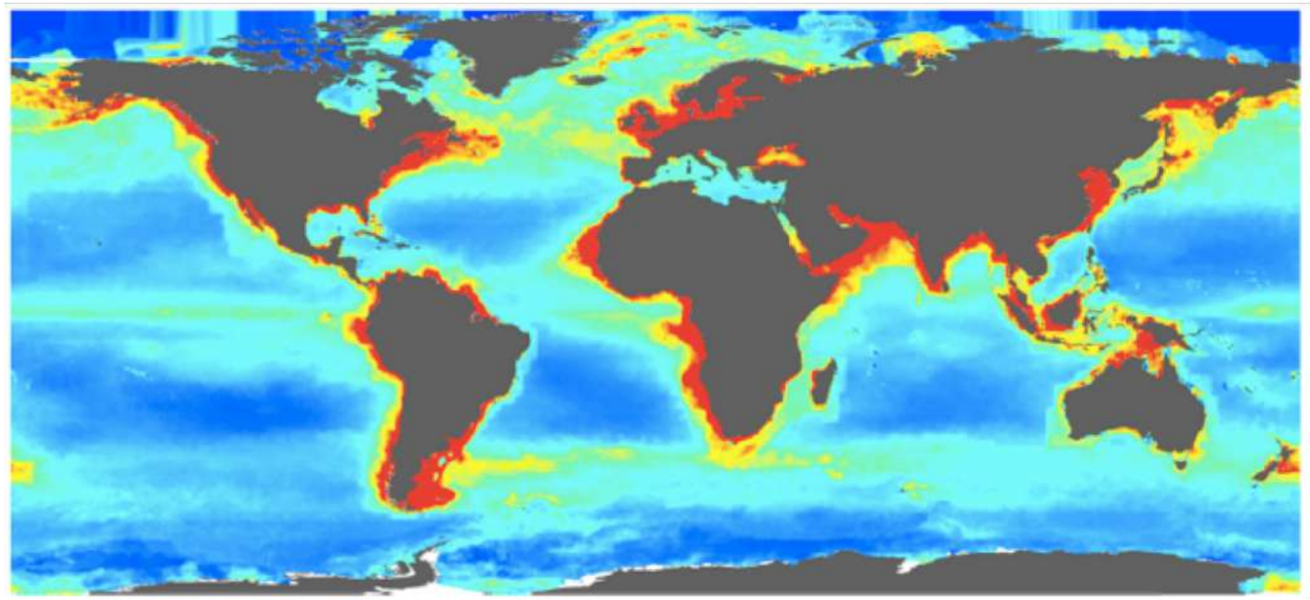
- Geographic factors (latitude, depth)
- Productivity, climatic factors, history
- Predation, competition
- Disturbance, isolation, heterogeneity

The intermediate disturbance hypothesis (Connell 1978). Small-infrequent or large-frequent disturbance could reduce diversity, which is maximum at intermedite levels of disturbance

Stability-Time Hypothesis (Sanders 1968). This model says that physical instability in an environment prevents the establishment of diverse communities. However, if physically stable conditions persist for a long period of time, speciation and immigration will cause species diversity to increase gradually.

Productivity

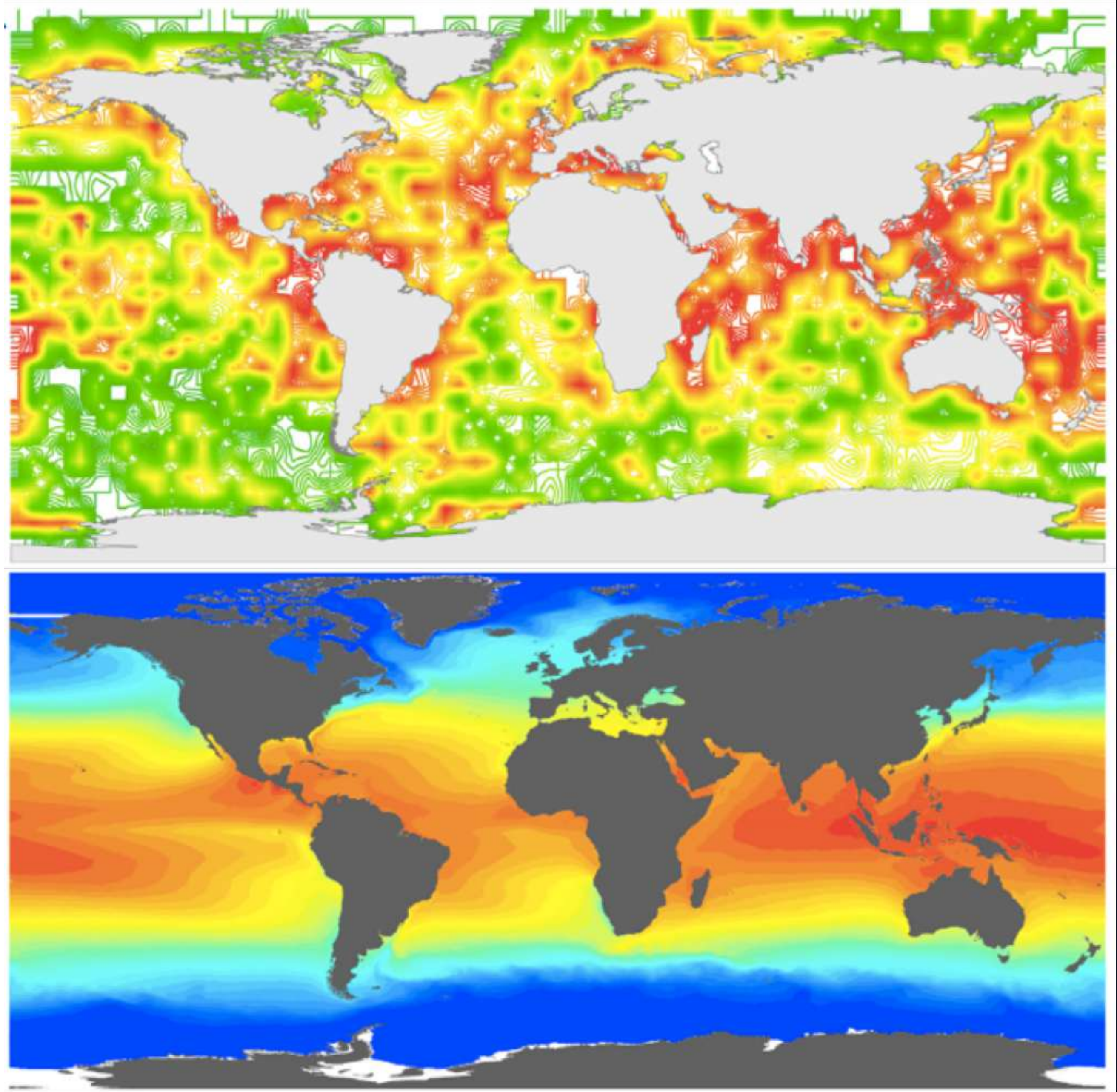




Productivity and high energy flow could sustain higher number of species with respect to less productive areas

(maps from Costello & Chaudhary 2017)

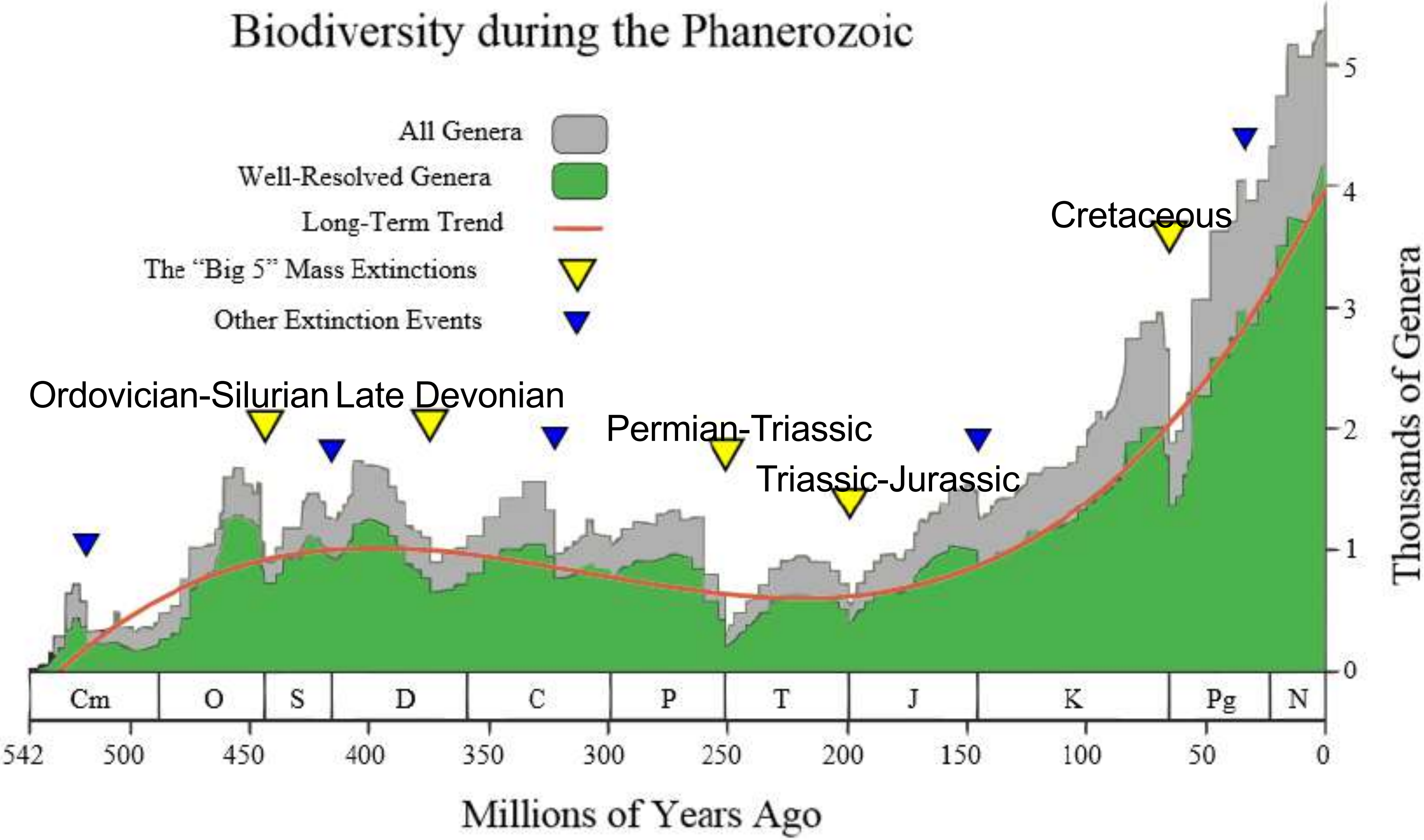
Temperature



(maps from Costello & Chaudhary 2017)

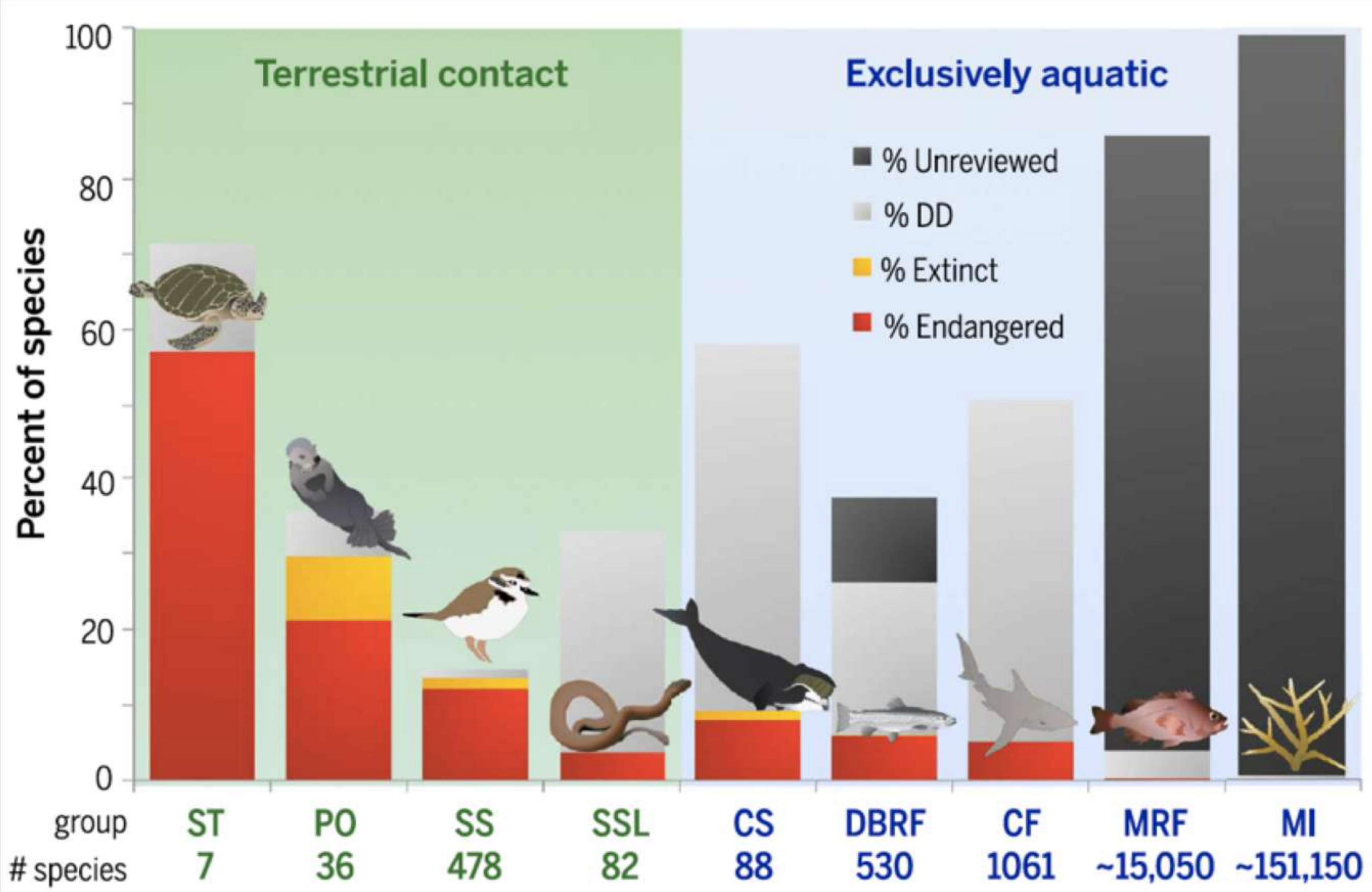
Rates of genetic divergence and speciation are both governed by metabolic rate and therefore show the same exponential temperature dependence. So, higher temperature increases speciation rates (Allen et al. 2006)

Biodiversity in the last eon



5 big mass extinctions. Biodiversity is increasing

Modern extinction risk



McCauley et al. 2015

Threat from defaunation is portrayed for different groups of marine fauna as chronicled by the IUCN Red List. Threat categories include "extinct" (orange), "endangered" (red; IUCN categories "critically endangered" + "endangered"), "data deficient" (light gray), and "unreviewed" (dark gray).

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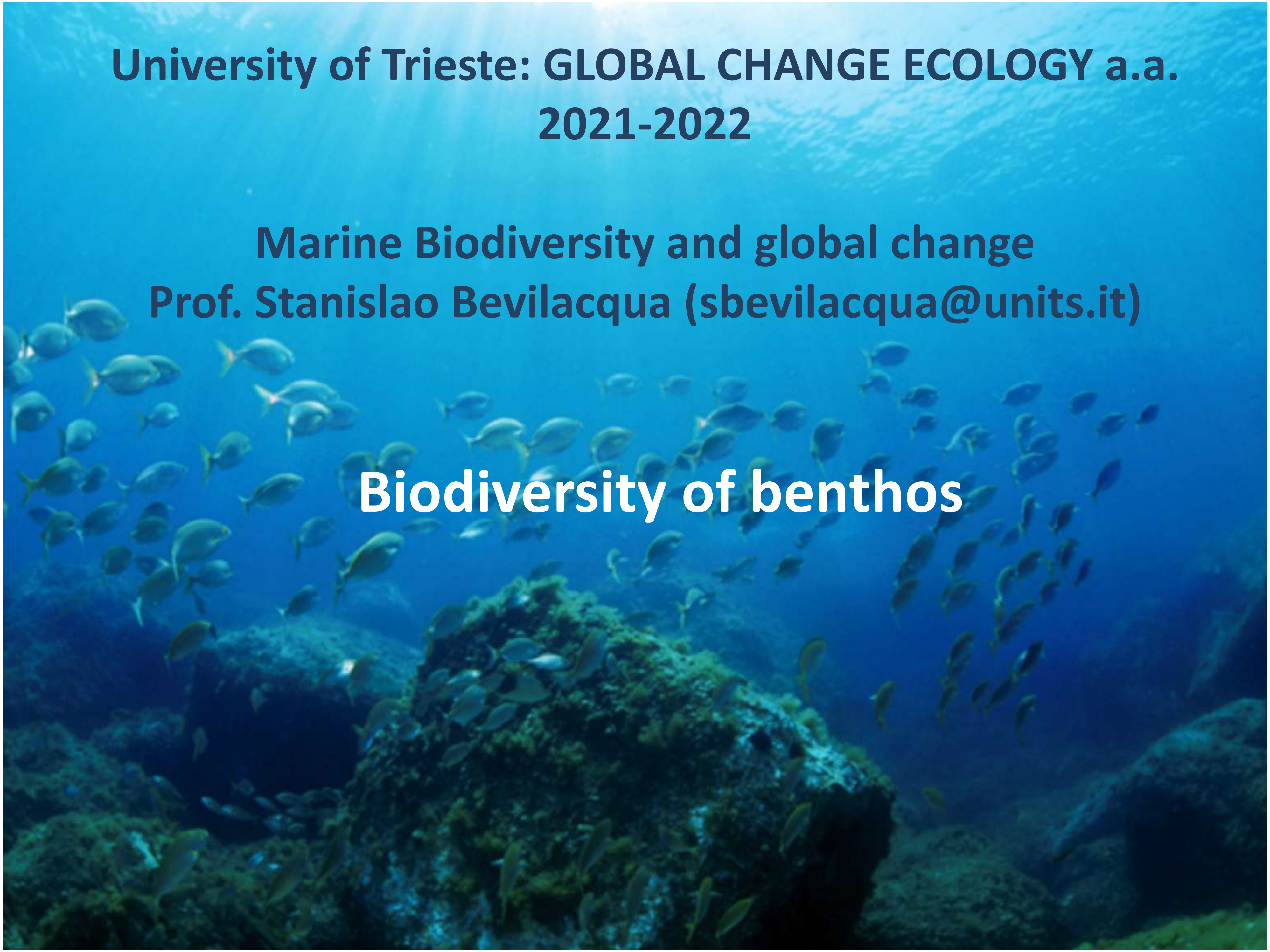
Marine Biodiversity and global change

Prof. Stanislao Bevilacqua (sbevilacqua@units.it)

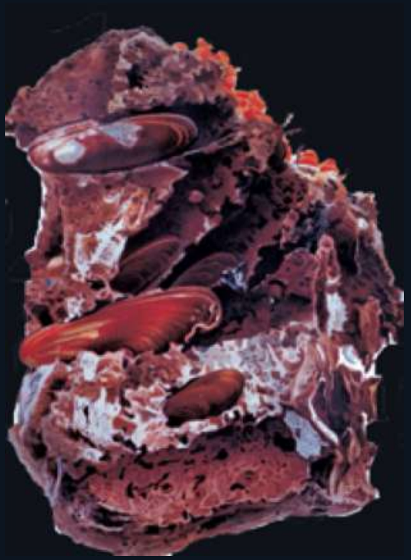
Biodiversity of benthos



The diversity of marine benthos

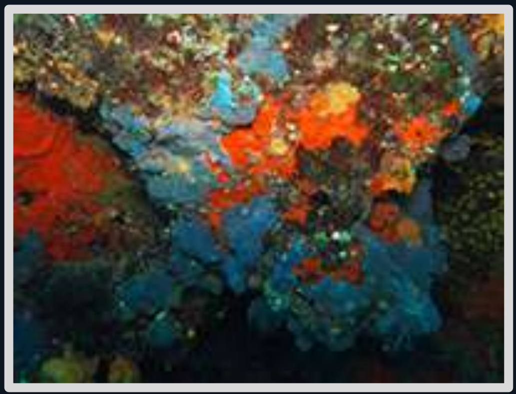
Benthos

All organisms living on or near the bottom, and in the substratum



Modular:
Consisting of replicated units, none of them indispensable for the survival of the whole organism

Individual:
Unitary organisms



Sessile:
Attached to the substratum

Sedentary:
Tend to remain in the same place but are able to move

Vagile:
Motile organisms

The diversity of marine benthos

Algae and plants







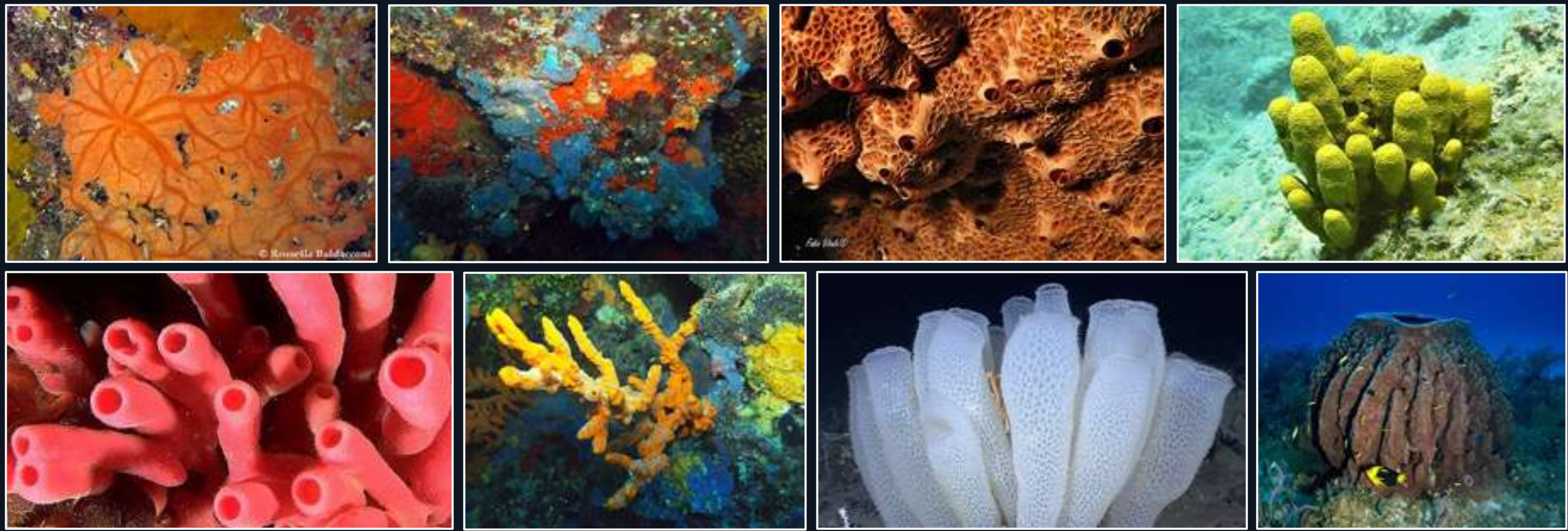

Autotrophic organisms – Sessile – Habitat formers

Primary producers, the basis of food webs in marine environments; O_2 production and CO_2 sequestration through photosynthesis and carbonate fixation

Important commercial targets

The diversity of marine benthos

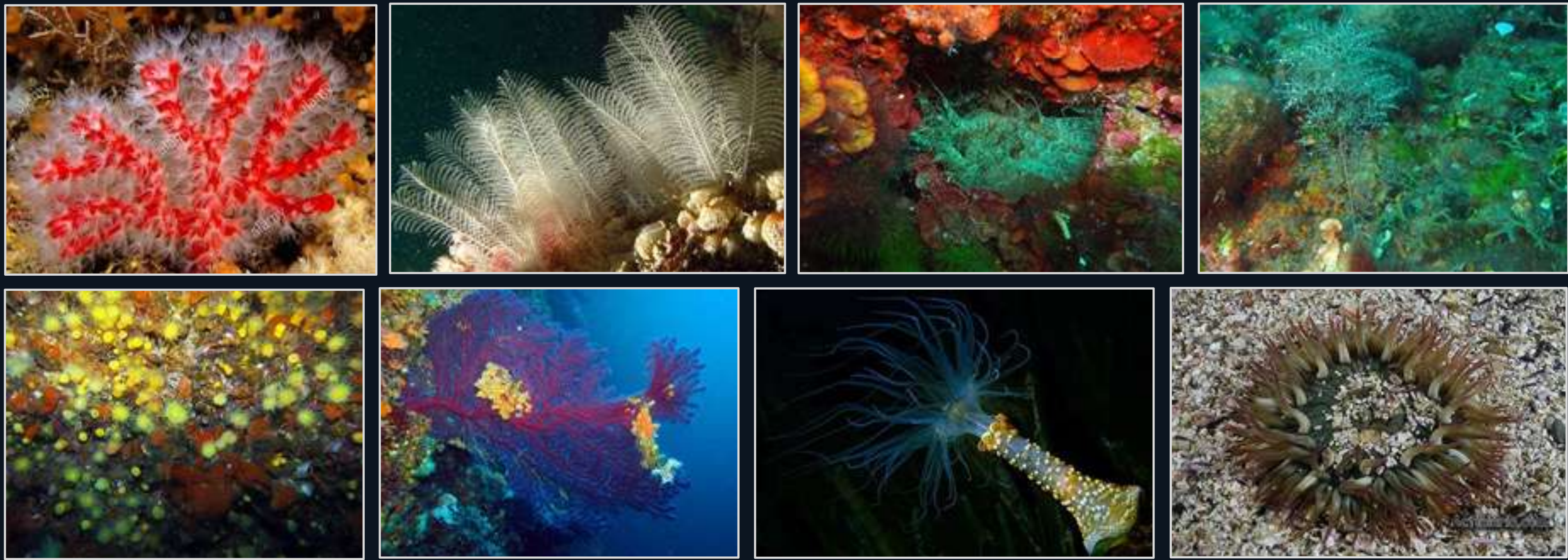
Porifera (sponges)



Sessile – Colonial
Sexual and asexual reproduction
Filter feeders
Potential role in N cycle
Eroders (boring sponges)

The diversity of marine benthos

Cnidaria (hydroids, anthozoans, medusae)



Sessile or sedentary – Colonial or individual (solitary actinians)
Sexual and asexual reproduction
Carnivorous, predators, filter feeders
Habitat formers (ex. coral reefs, forests of sea fans)
Can have planktonic stage (medusa)

The diversity of marine benthos

Annelida (ragworms)

Sessile, sedentary, vagile – Individual
Sexual reproduction
Wide range of feeding strategies: predators, filter feeders, omnivores, detritivores, scavengers. Habitat formers (ex. *Sabellaria* reefs), bioturbation. Some economic importance

The diversity of marine benthos

Mollusca (shellfish, sea slugs, snails, cephalopods)

Sessile, sedentary, vagile – Individual; Sexual reproduction
Wide range of feeding strategies: herbivores, predators, filter feeders, omnivores, detritivores, scavengers
Habitat formers (ex. vermetid and oyster reefs, mussel beds), bioturbation; carbonate fixation; Important commercial targets

The diversity of marine benthos

Arthropoda (crustaceans and sea spiders)



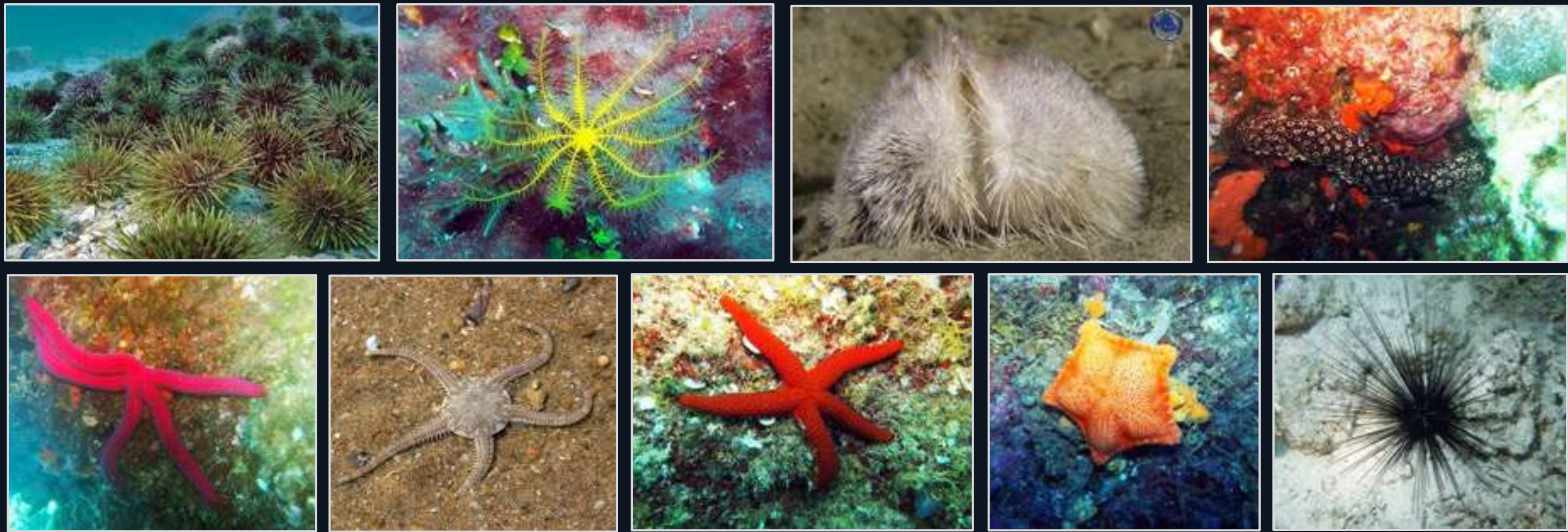





Vagile, sedentary, sessile (barnacles) – Individual
Sexual reproduction
Wide range of feeding strategies: predators, filter feeders, omnivores, detritivores, scavengers, grazers
Important commercial targets

The diversity of marine benthos

Echinodermata (sea urchins, stars, cucumbers)



Vagile – Individual
Sexual reproduction – High regenerative potential
Wide range of feeding strategies: predators, filter feeders, detritivores, grazers; Key-stone predators and grazers, bioturbation. Important commercial targets

The diversity of marine benthos

Ectoprocta (bryozoans)

Sessile – colonial

Sexual and asexual reproduction

Filter feeders. Contribute to habitat 3-D structure (es. in coralligenous outcrops)

The diversity of marine benthos

Tunicata (ascidians)

Sessile – colonial or individual
Sexual and asexual reproduction
Filter feeders. Economic relevance (fouling)

The diversity of marine benthos

Fish

Vagile – individual
Sexual reproduction
Predators, grazers, herbivores, scavengers, omnivores
Important commercial targets
Key-stone predators and grazers

The diversity of marine benthos

Nemertea (ribbon worms)

Vagile – individual
Sexual and asexual reproduction (fragmentation)
Predators

Pogonophora (beard worms)

Sessile, sedentary – individual
Sexual reproduction. Filter feeders, chemosymbiotic
Important for uptake DOM in deep-sea

Priapulida (penis worms)

Sedentary – individual
Sexual reproduction
Predators

Phoronida

Sedentary, sessile – individual (but gregarious colonies)
Sexual reproduction
Filter feeders

The diversity of marine benthos

Brachiopoda (lamp shells)

Sedentary – individual
Sexual reproduction
Filter feeders

Echiura (spoon worms)

Sedentary – individual
Sexual reproduction
Detritivores

Sipuncula (peanut worms)

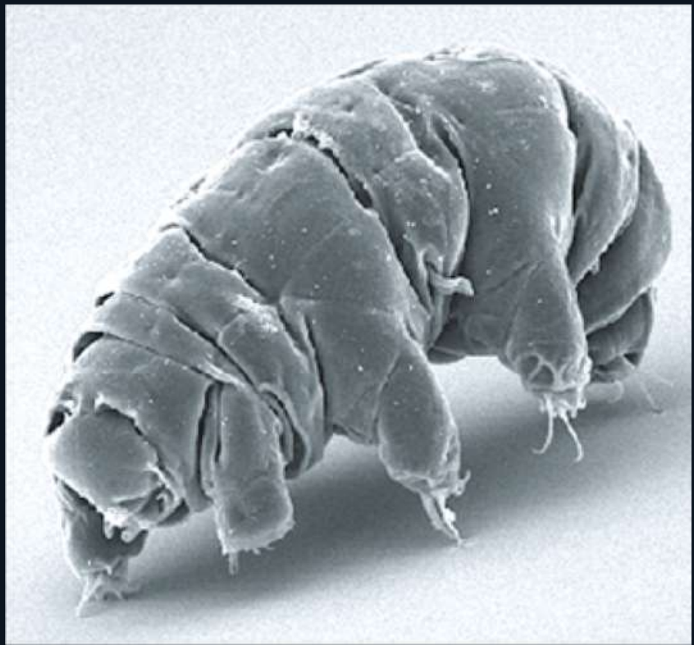
Sedentary – individual. Sexual reproduction (but some asexual). Detritivores. Detritus recycling. Bioturbation. Some economic importance

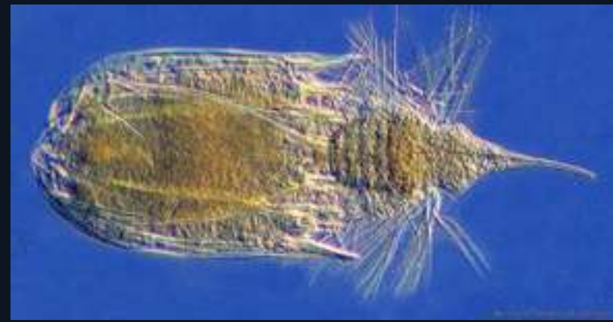
Platyhelminthes (flat worms)

Sedentary – individual
Sexual reproduction, high regeneration potential
Predators

The diversity of marine benthos

Meiofauna



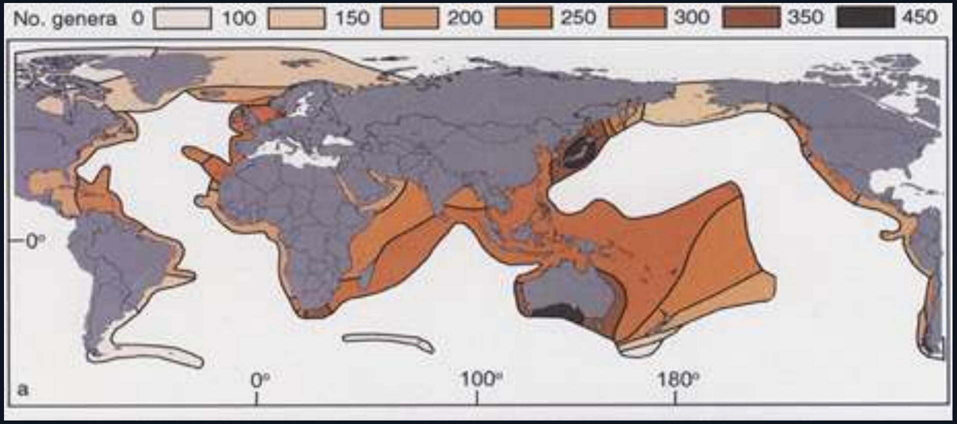



Vagile – individual
Sexual reproduction
Predators, grazers, herbivores, omnivores
Potential effects on resting stages of plankton

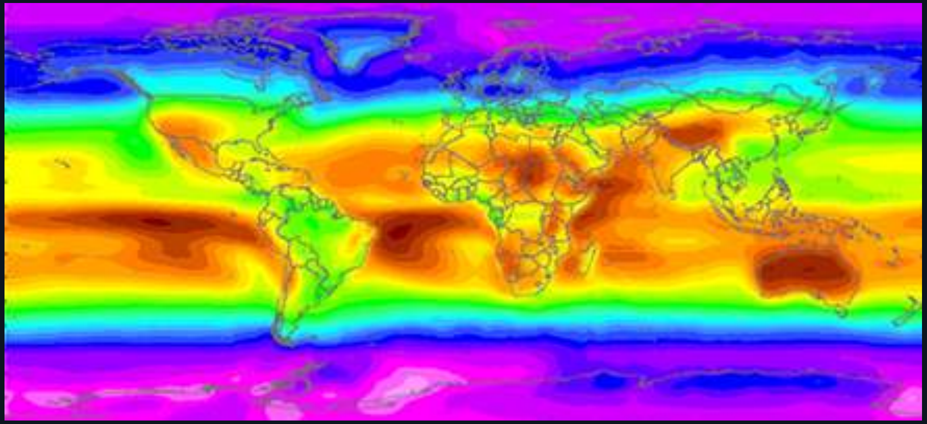
Distribution, factors and processes

Sea temperature and solar radiation influence the distribution of benthic organisms, especially algae and corals and the associated fauna. Shifts in distribution (climate change), mass mortalities, bleaching

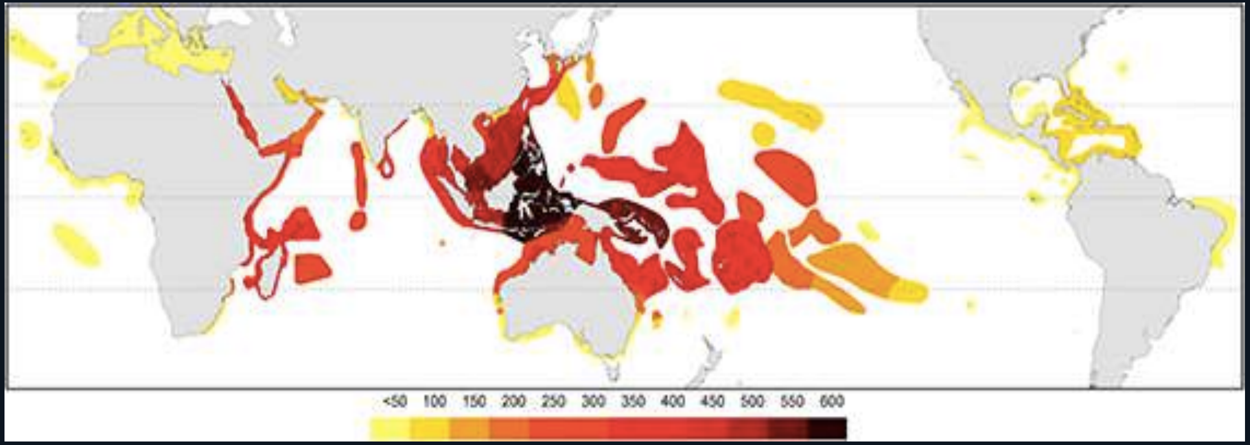
Global distribution of macroalgal genera



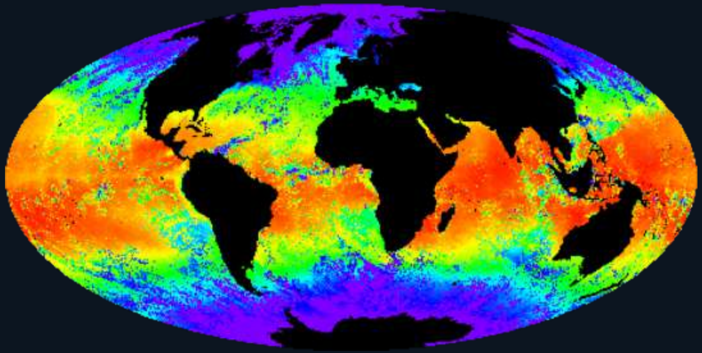
Solar radiation



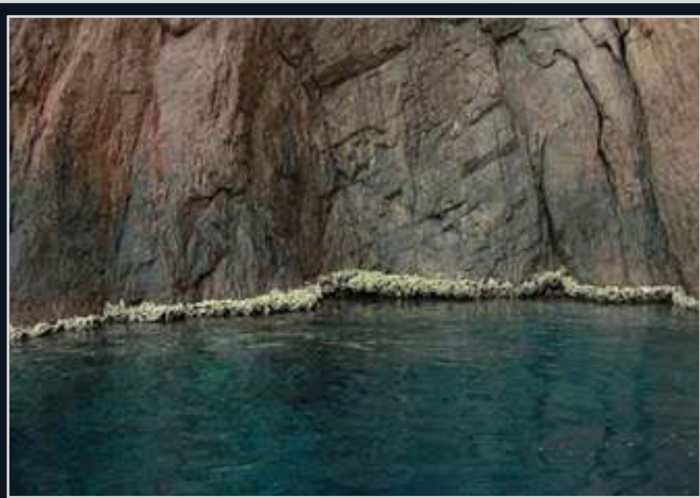
Global distribution of coral species



Surface temperature



Main benthic habitats



Rock pools
Oyster fields
Beaches
***Cystoseira* fringe**
Trottoir

Intertidal

Harsh environmental conditions: variations in temperature, salinity, desiccation, hydrodynamism

Zonation

Economic relevance

The basic unit of benthic zonation by Pérès and Picard (1964) is the zone defined as:

The vertical space of marine benthic domain where ecological conditions, in dependence of sea level, are generally constant or change regularly between two extremes representing the boundaries of the zone. Assemblages at the boundaries reflect transitions between zones, and have mixed features (ecotones). The width of transitional areas depends on the strength of environmental gradients.

Zonation is mostly under the control of ABIOTIC factors, which can be ascribed to two categories: climatic and edafic factors

Climatic factors

Factors determining the presence of a given zone in a specific geographic area

- **Solar radiation and associated factors (light intensity and penetration, temperature)**
- **Humidity considering evaporation, spray, tides, and waves**
- **Pressure, especially for deeper zones**

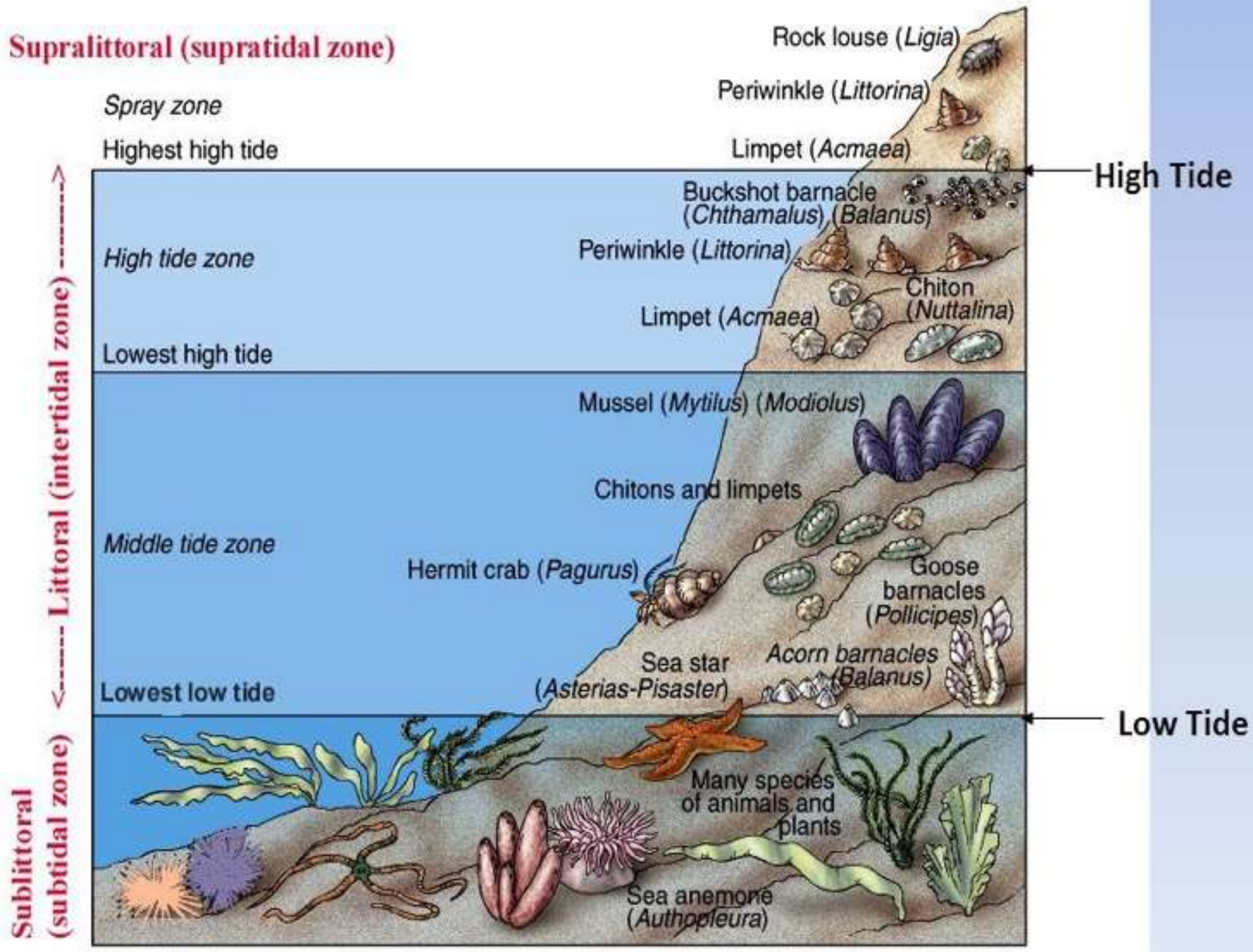
Edafic factors instead determine the presence of different biocenosis in a given zone

Edafic factors

Factors acting at local scale on the substrate that interact with climatic factors

- **currents on the bottom, very high (or very low) surface hydrodinamisms;**
- **Morphology and geological features of the coast (shoreline and submerged coastal profile);**
- **Freshwater inputs;**
- **Turbidity and sedimentation**
- **Water circulation (e.g., upwelling);**
- **Human disturbance**

Zonation



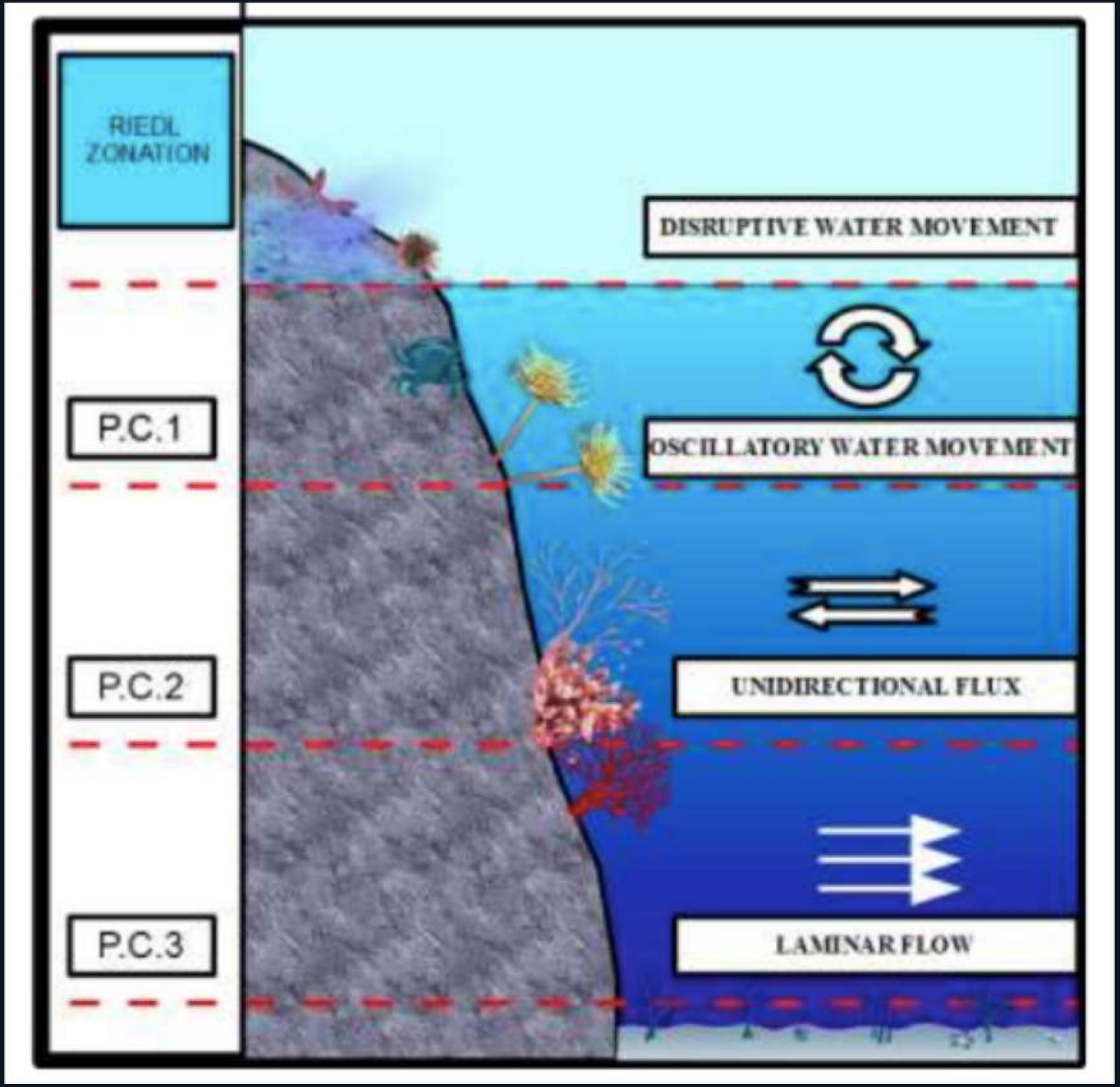
Intertidal and subtidal (tides)

Supralittoral
Mediolittoral
Infralittoral
Circalittoral
(light and vegetation)

Riedl's model of zonation

Instead of light, as dominant factor, here it is the hydrodinamism the driving force of distribution

- Zone of disruptive movements
- Zone of multidimensional movements
- Critical depth 1: oscillatory, orbital movements (10-15m)
- Critical depth 2: unidimensional movements (40m)
- Critical depth 3: laminar movements (until 200 m, continental shelf)



Supralittoral (spray) zone

Occasionally sprayed by wave action – organisms require high humidity but are able to tolerate desiccation and prolonged emersion, high temperature and solar radiation. Its extension depends on coastal morphology and wave regimes

Insects, isopods, barnacles, molluscs, diatoms and cyanobacteria.

Midlittoral zone (intertidal)


Harsh environmental conditions: variations in temperature, salinity, desiccation, hydrodynamism

Varying zonation



Rock pools
Oyster fields
Beaches
***Cystoseira* fringe**
Trottoir

Infralittoral zone: rocky bottoms

From the lowest tide level until the depth limit for seagrasses, or generally of photophilic algae. Its extension depends on water turbidity, which influence light penetration. 15-20 m northern basins, 40-50 m in the Mediterranean Sea, until 70-80 m tropical waters.

Edafic factors such as hydrodinamism, sedimentation, subtrate type determine the biocenosis

Main benthic habitats

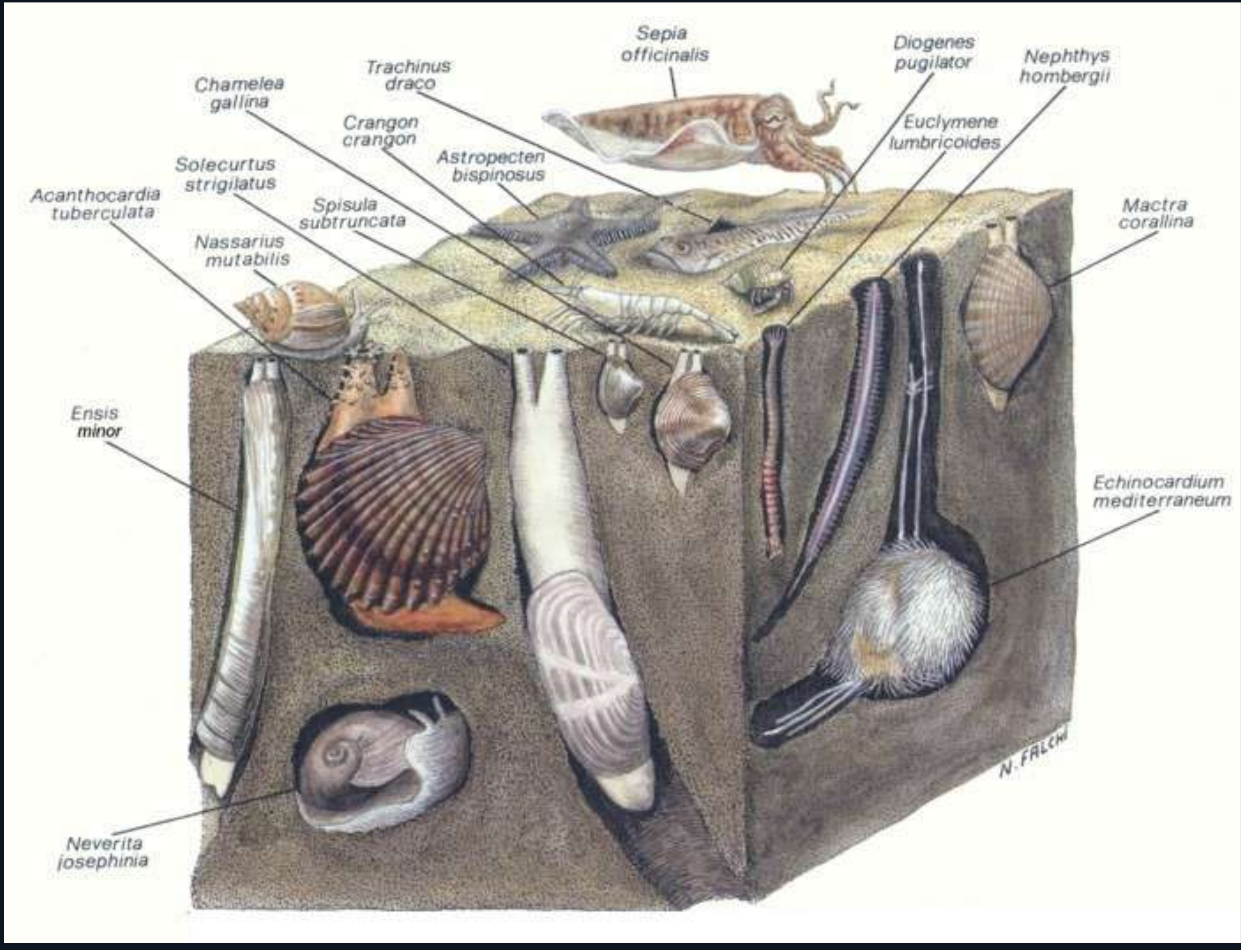
Subtidal soft bottoms

Dominance of individual organisms; grain size, oxygen and organic matter, hydrodynamism. High economic and ecological relevance; geochemical flows, retention of pollutants

Sands / Detritic / Mud flats

Transitional water systems

Infralittoral zone: soft bottoms

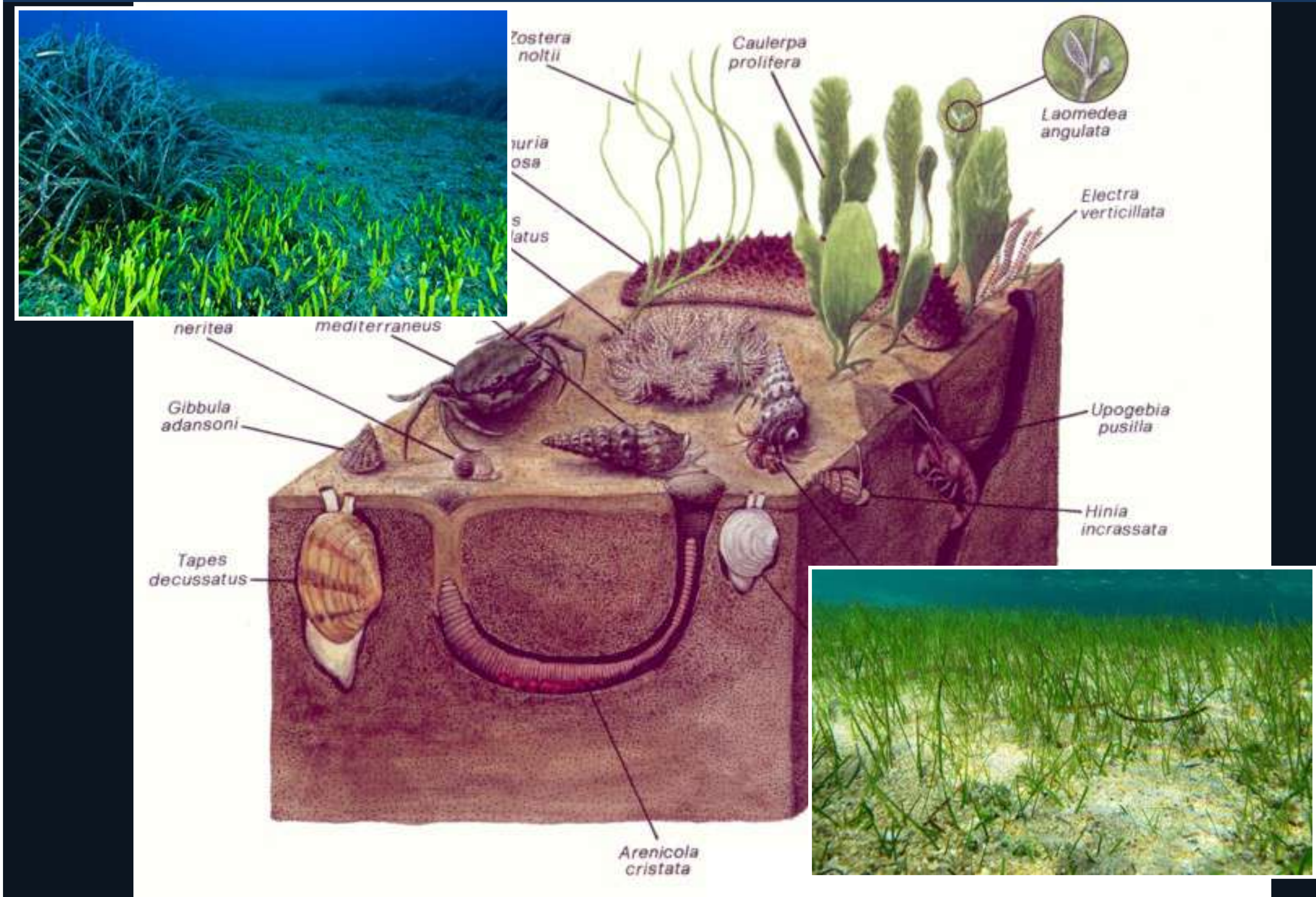


Main benthic habitats

Seagrass beds

Priority habitat – Ecological and economic relevance (primary production, oxygen production, nursery, CO_2 sequestration, food provision, stabilization of sediments, coastal defence. High biodiversity (the most diverse habitat in the Mediterranean)

Infralittoral zone: soft bottoms

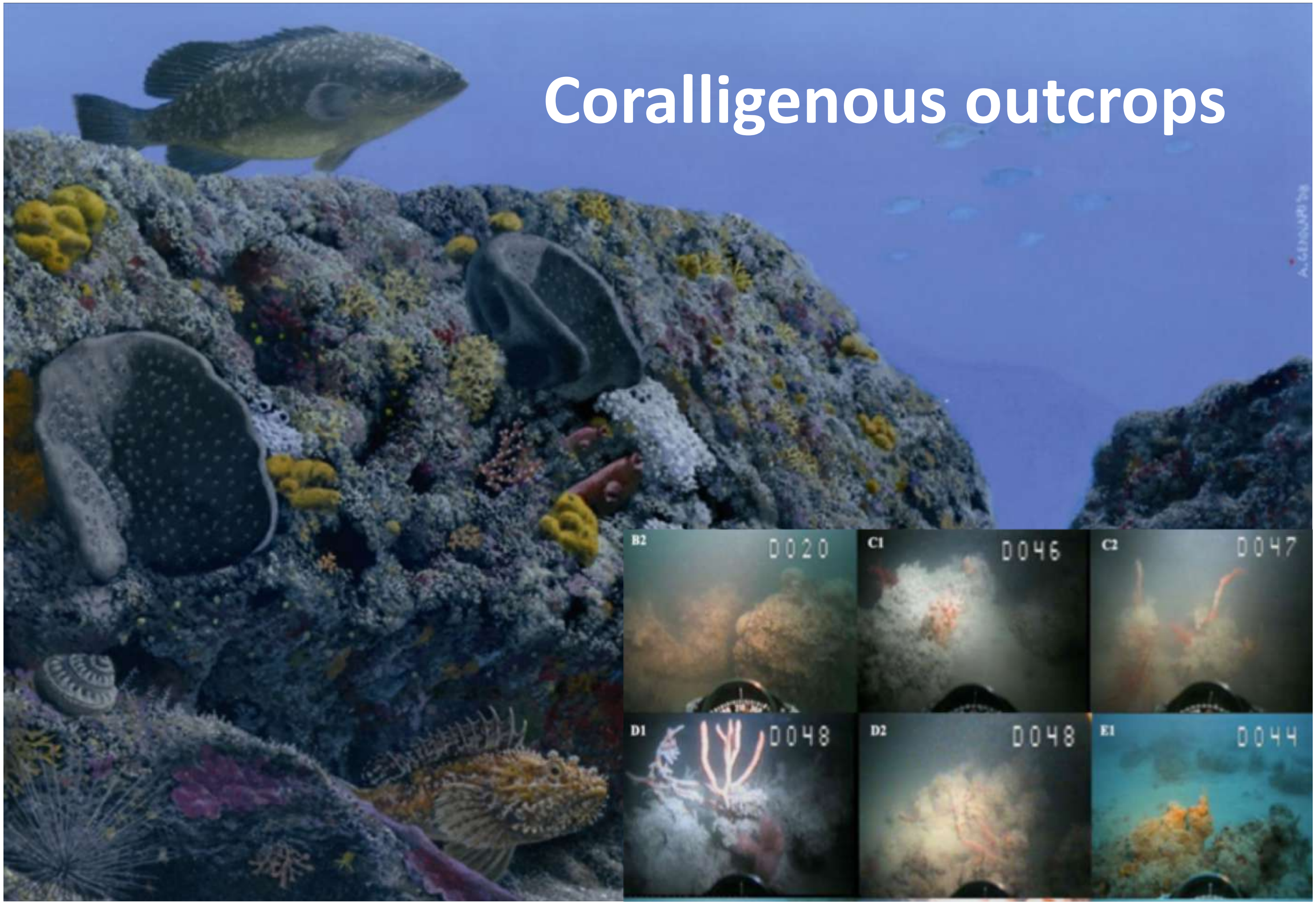


Main benthic habitats

Hard bottoms

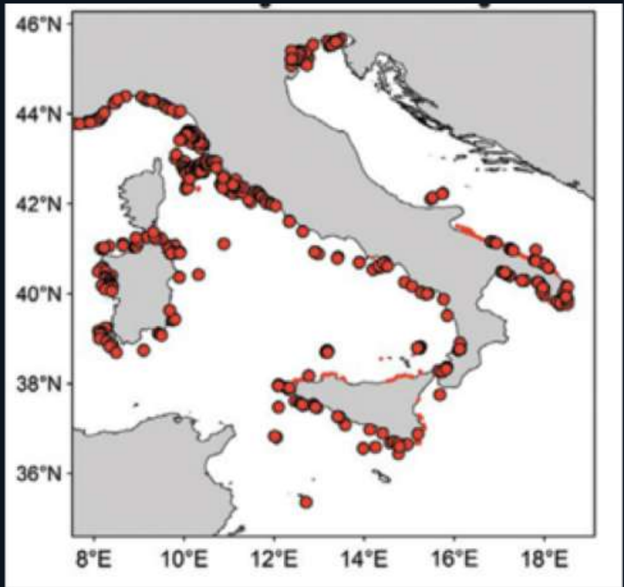
Priority habitat – Ecological and economic relevance (primary production, oxygen production, nursery, CO_2 sequestration, food provision. High biodiversity (ex. coralligenous). Dominance of sessile organisms

Circalittoral zone: hard bottoms



Circalittoral zone: hard bottoms

Trezze Tegnùe



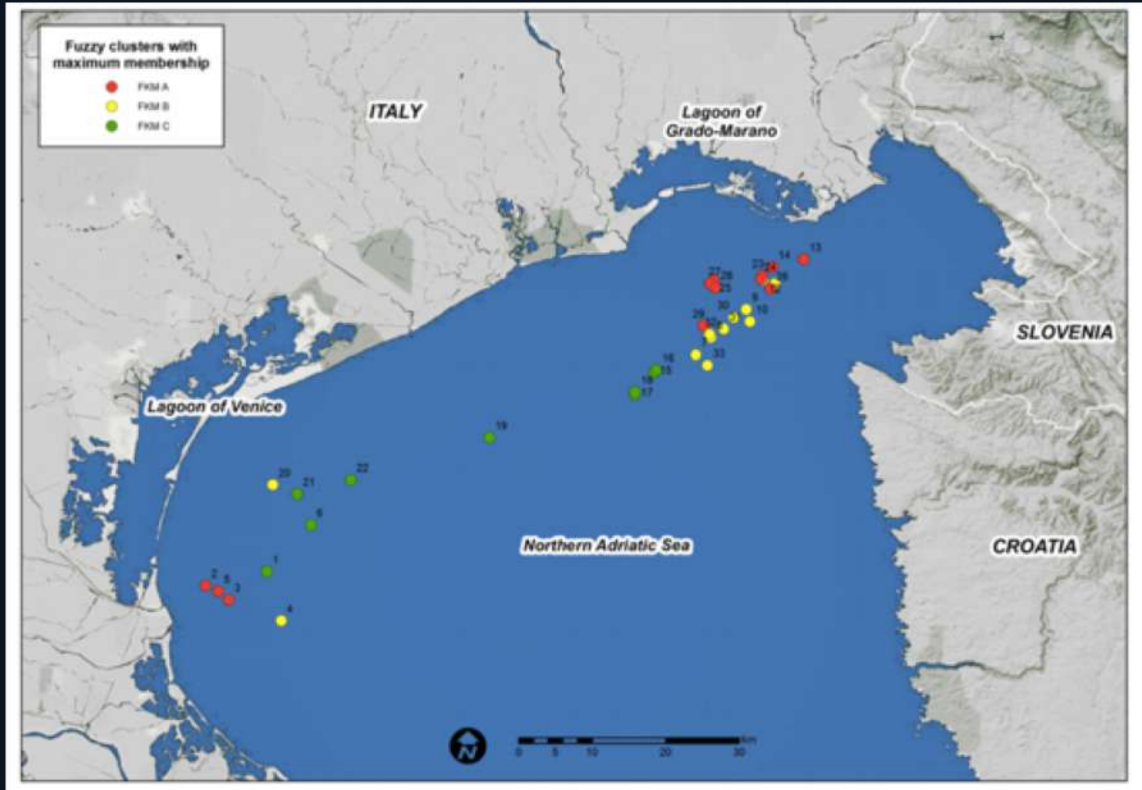
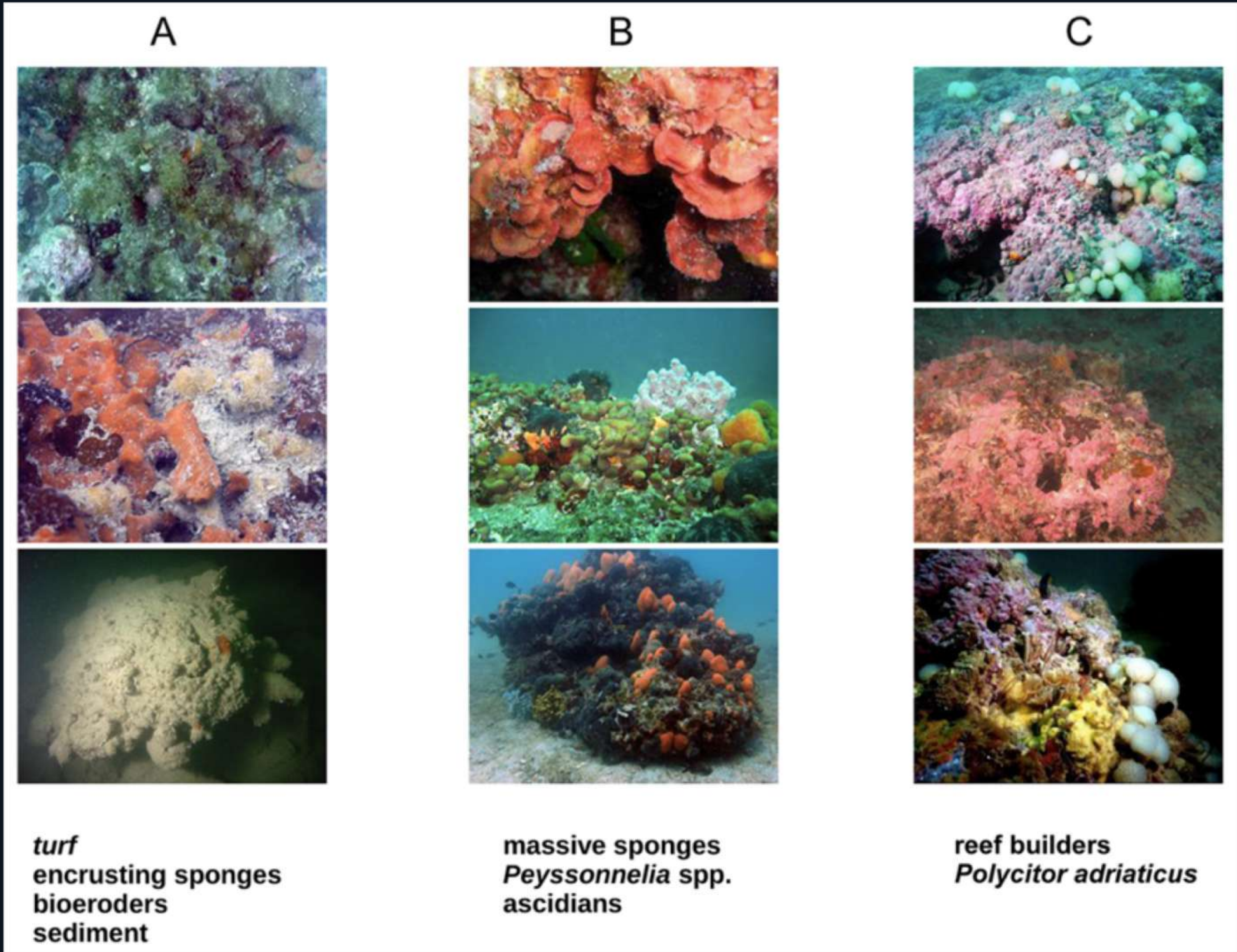


Fig 1. Occurrences of the 3 habitat typology outcrops across the northern Adriatic Sea (original copyright 2015).


A
B
C
turf
encrusting sponges
bioeroders
sediment
massive sponges
Peyssonnelia spp.
ascidians
reef builders
Polycitor adriaticus

Circalittoral zone: hard bottoms

Main benthic habitats

Kelp forests	Coral reefs
	

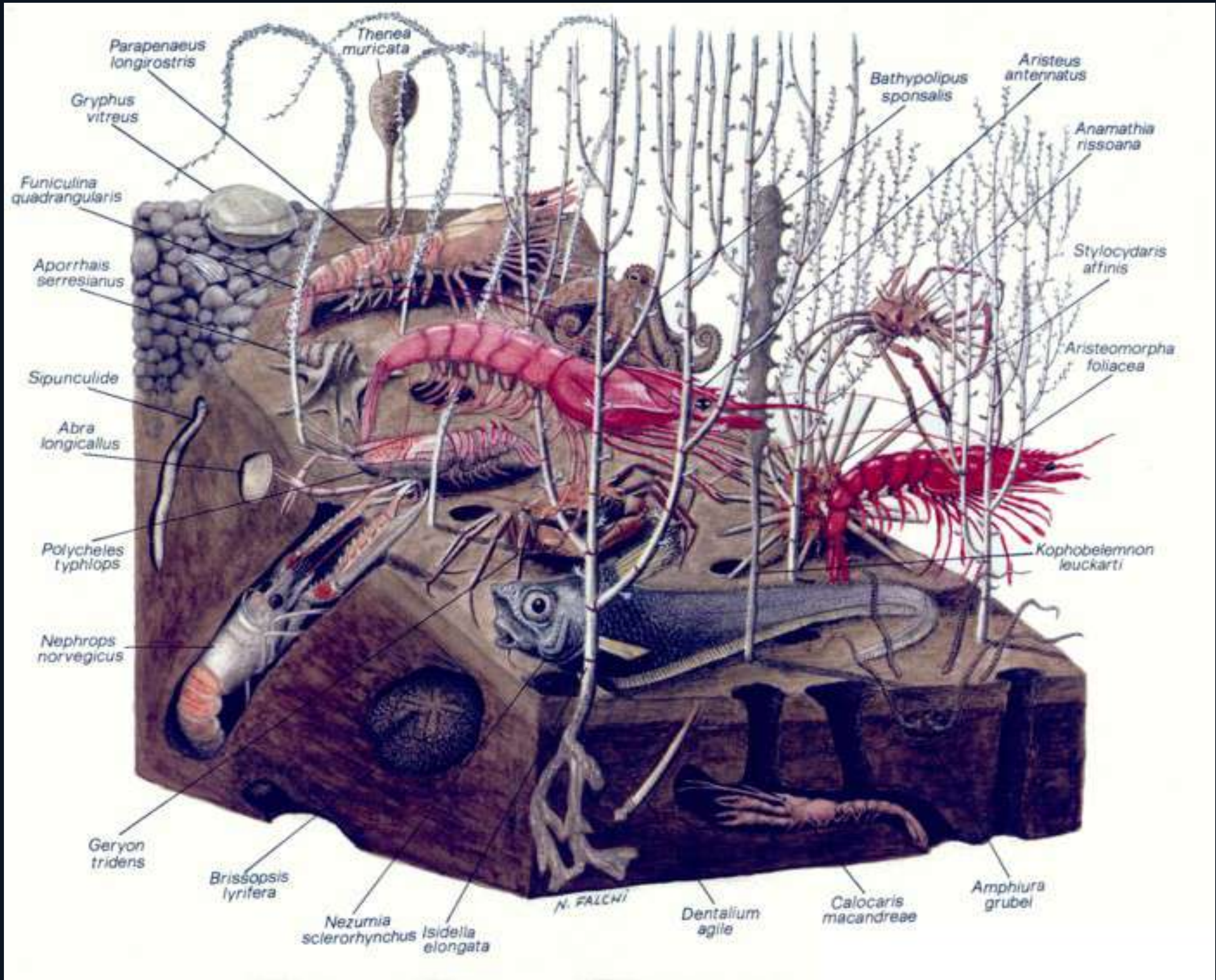
Ecological and economic relevance (primary production, oxygen production, nursery, CO_2 sequestration, food provision. Habitat formers. High biodiversity. Coral reefs are the most diverse environments in the world oceans.

Main benthic habitats

Deep sea

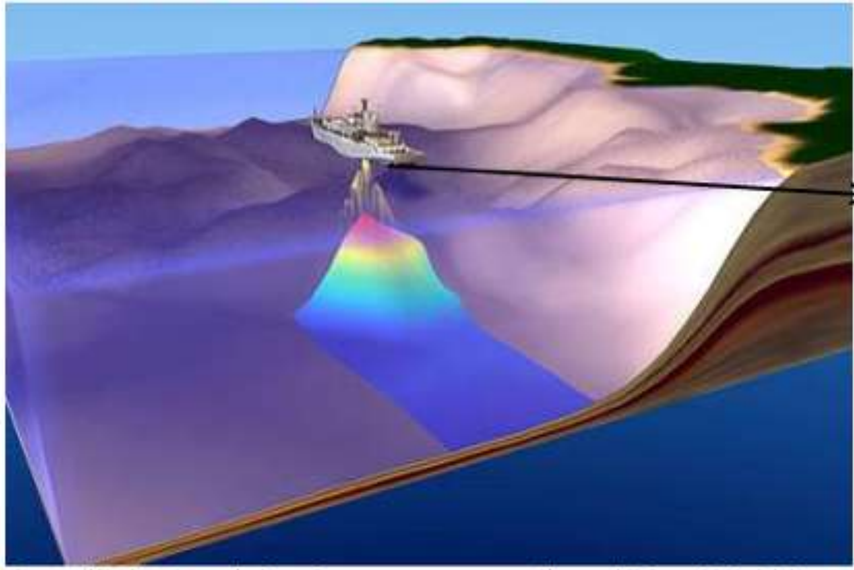
Ecological and economic relevance. Low diversity. Dependent on organic matter from above. Chemosynthesis. Hot spots of diversity (ex. hydrothermal vents, coral banks).

Bathyal, Abyssal, and Hadal zones



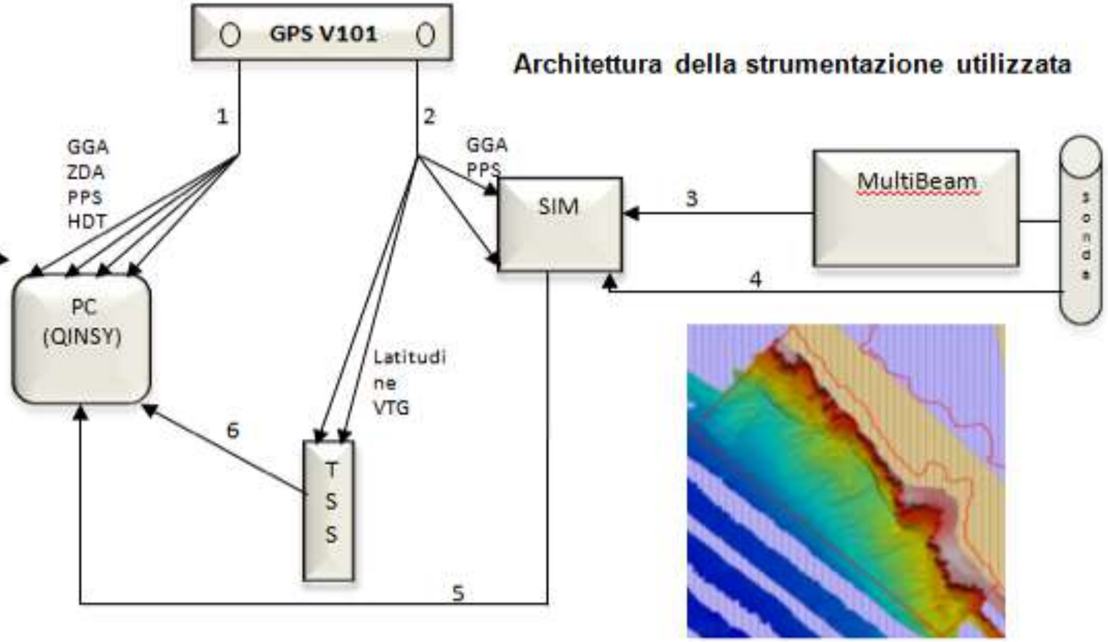
Mapping biocenosis

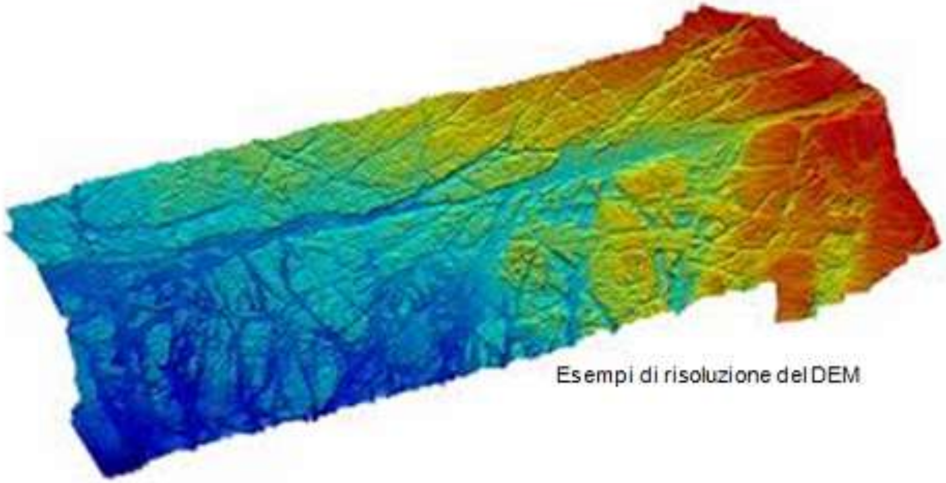
Sistema Multibeam R2 Sonic 2022



Specifiche tecniche: frequenza acustica: 170 - 450 kHz;

Architettura della strumentazione utilizzata

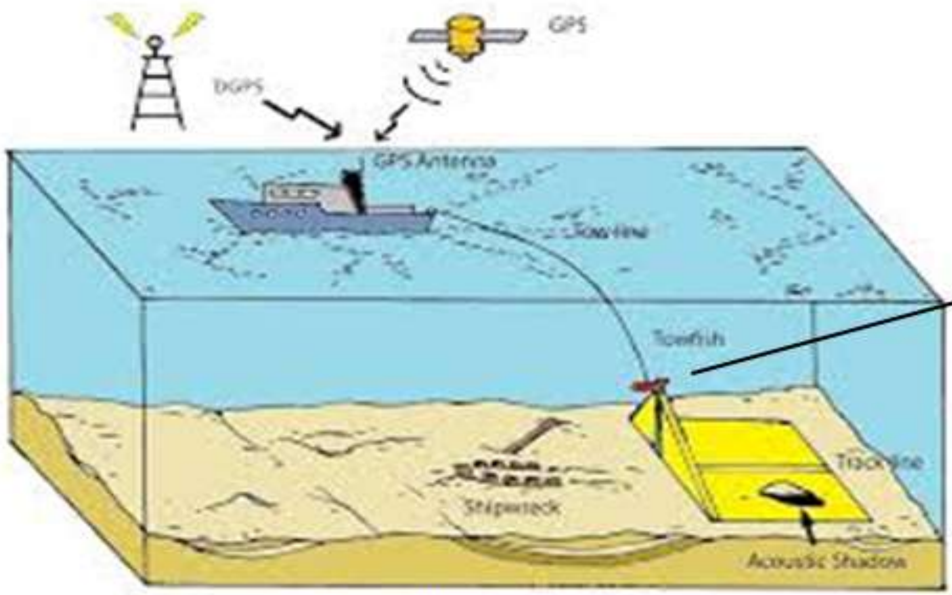




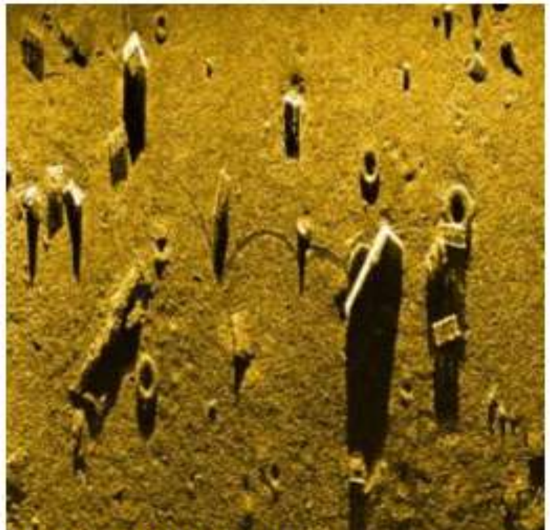
Esempi di risoluzione del DEM

Mapping biocenosis

SIDE SCAN SONAR K3900



Metodologia di acquisizione



Esempio di risoluzione

<u>Specifiche tecniche Side Scan Sonar 3900</u>: frequenza acustica: 445 - 900 KHz; beams orizzontali:0.21°; verticali 40°: 500 Watt; ingresso per GPS (Global Positioning System); range di scala 12 valori da 10 a 150 m; range massimo 150 metri a 445 KHz, 50 metri a 900 kHz; ingresso per compensatore d'onda; dimensioni: altezza 8.9 x larghezza 122; peso contenuto: 29 kg.

Mapping biocenosis

Boudouresque *et al.* 1990
Meinesz *et al.* 1983

The Regional Activity Centre for Specially Protected Areas (RAC/SPA) was established by the Contracting Parties to the Barcelona Convention and its Protocols in order to assist Mediterranean countries in implementing the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean.