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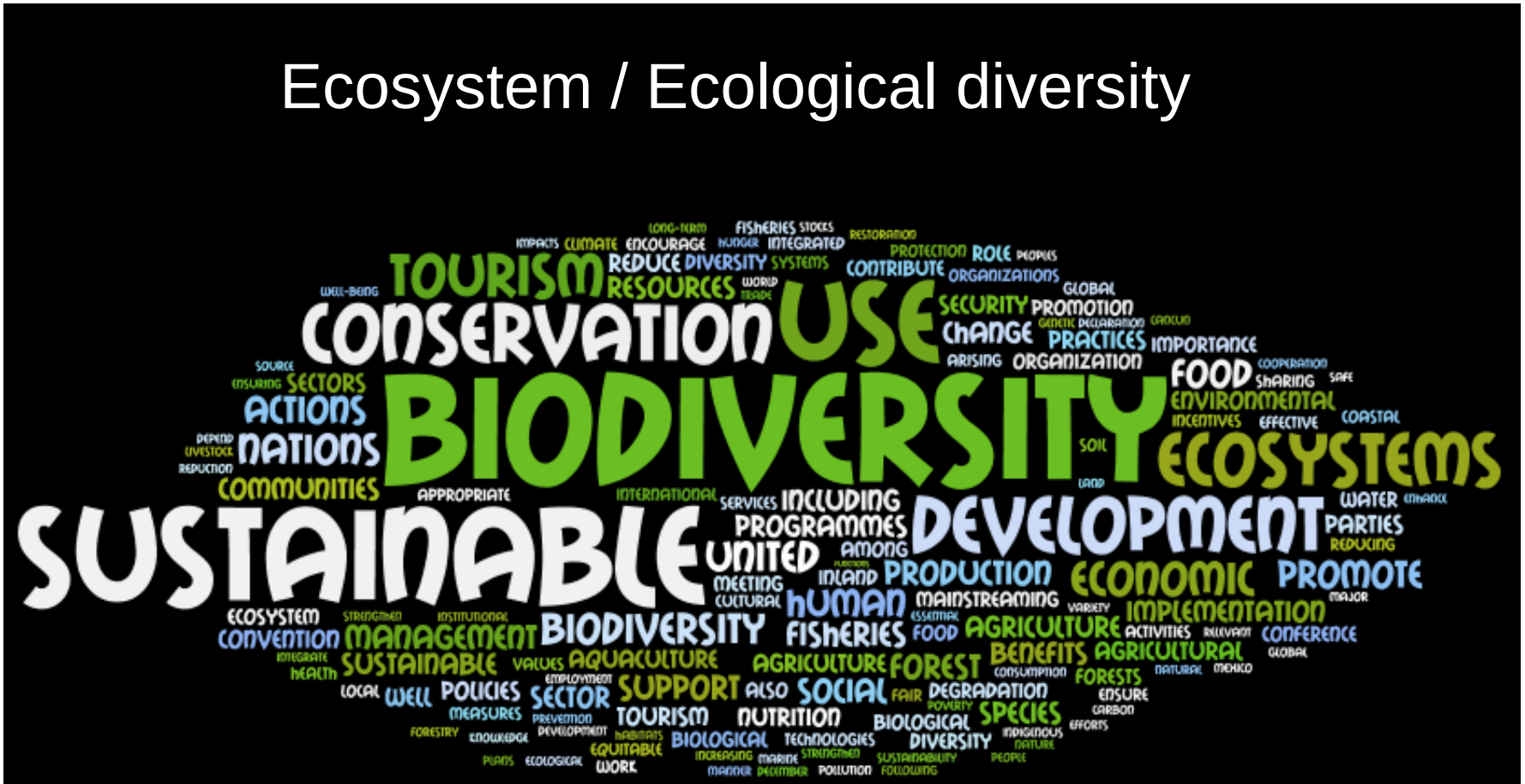
Biological Conservation & Marine Protected Areas (MPAs)

Ecosystem / Ecological diversity



Ecosystem goods & services
Value of Biodiversity

Mytilene ~ 2018

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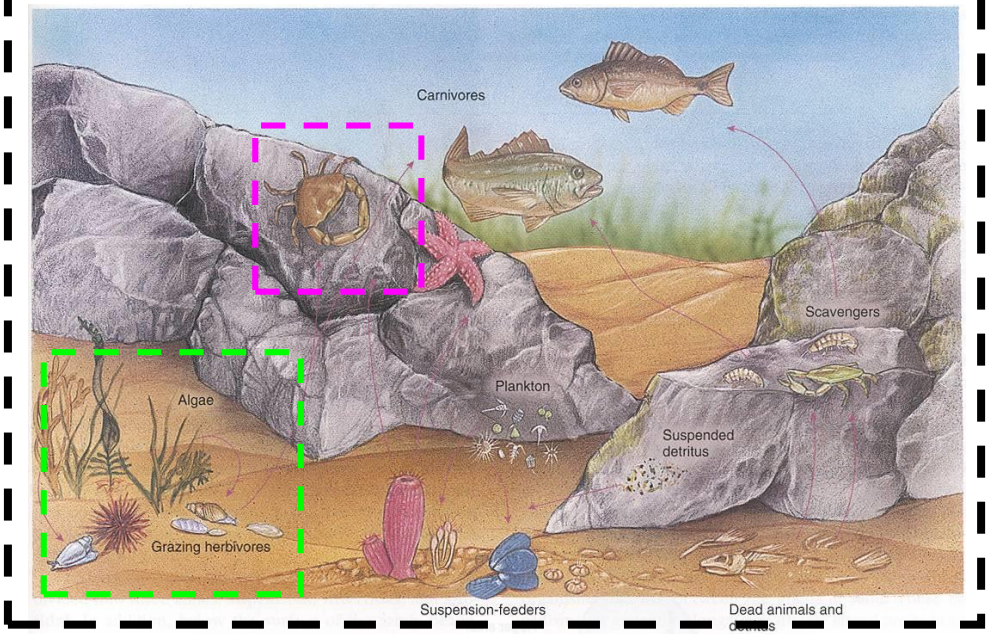
• Measuring biodiversity

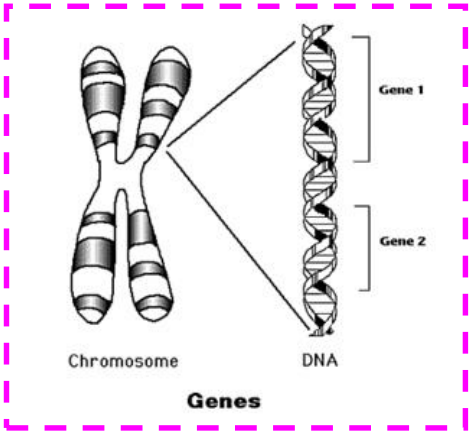
Biodiversity is defined at three levels:

- ***Ecosystem / Ecological diversity***
  Including the number of marine ecosystems, habitat types, or communities, found across the seascape of an entire region.



- ***Species diversity***
  The number of species found within a specific habitat type, community, ecosystem, or area.

- **Genetic diversity**
  The diversity of genes found within a species population [important for the survival of a species]

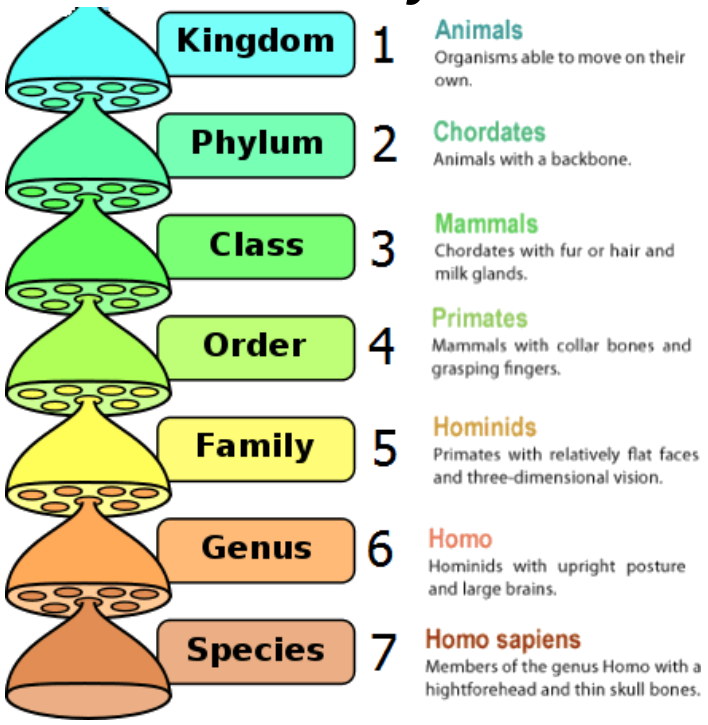


• Measuring biodiversity

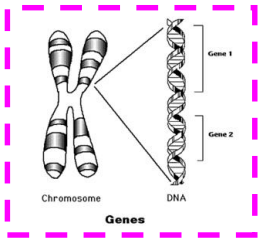
Elements of biodiversity – the ones most commonly used.

(Heywood & Baste, 1995;)

- ***Species / organismal diversity***
  - Kingdoms
  - Phyla
  - Families
  - Genera
  - Species
  - Subspecies
  - Populations
  - Individuals



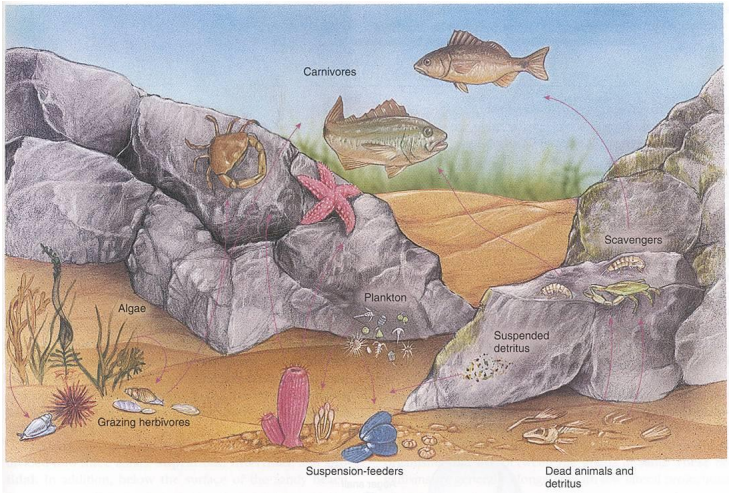
- ***Genetic diversity***
  - Populations
  - Individuals
  - Chromosomes
  - Genes
  - Alleles



- ***Ecosystem / Ecological diversity***
  - Biogeographic realms
  - Biomes
  - Provinces
  - Ecoregions
  - Ecosystems
  - Habitats
  - Communities

• Ecosystem / Ecological / Landscape diversity

- ***Ecosystem / Ecological diversity***
  Biogeographic realms
  Biomes
  Provinces
  Ecoregions
  Ecosystems
  Habitats
  Communities



Pros:

Important biodiversity dimension, not captured by genetic or species diversity.

Easily perceived

Useful units for conservation and management,

Cons:

Not easily distinguishable – boundaries are not clear (e.g. definition of habitats)

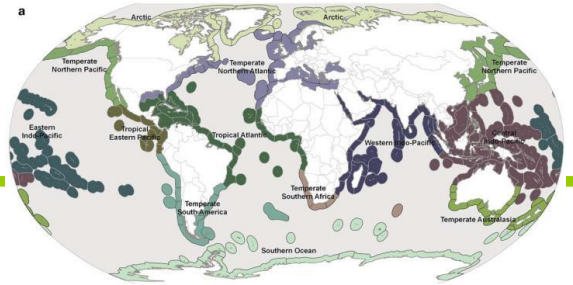
Include biotic and abiotic components, while *bio*diversity refers to only biotic components:

Biodiversity = Variety of life.

• Ecosystem / Ecological / Landscape diversity

- ***Ecosystem / Ecological diversity***
  - Biogeographic realms
  - Biomes (14 terrestrial)
  - Provinces
  - Ecoregions
  - Ecosystems
  - Habitats
  - Communities

→ Large areas of different spatial scales which are distinguished by unique species assemblages, ecosystems, and abiotic conditions.



Biogeographic realms:

Terrestrial ~ 8 (Australasia, Antarctic, Afrotropic, Indo-Malaya, Nearctic, Neotropic, Oeania and Palearctic; *Olson et al. 2001*)

Marine ~ 12 (Arctic, Temperate Northern Atlantic, Temperate Northern Pacific, Tropical Atlantic, Western Indo-Pacific, Central Indo-Pacific, Temperate South America, Temperate southern Africa, Temperate Australasia, southern Ocean; *Spaldin et al. 2007-BioScience*)

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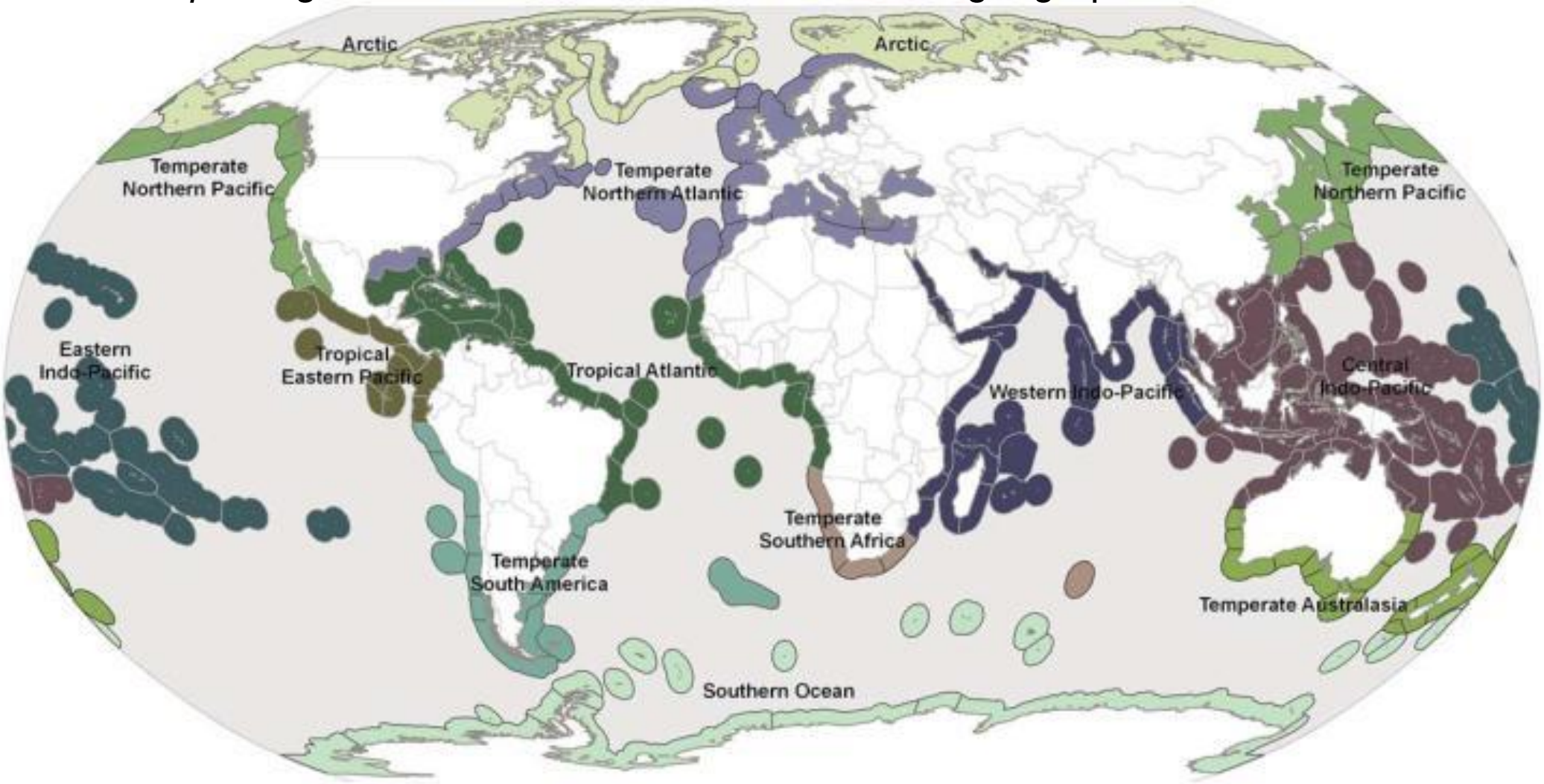
- Ecosystem / Ecological / Landscape diversity

Spalding et al. 2007 – BioScience: Marine biogeographic realms



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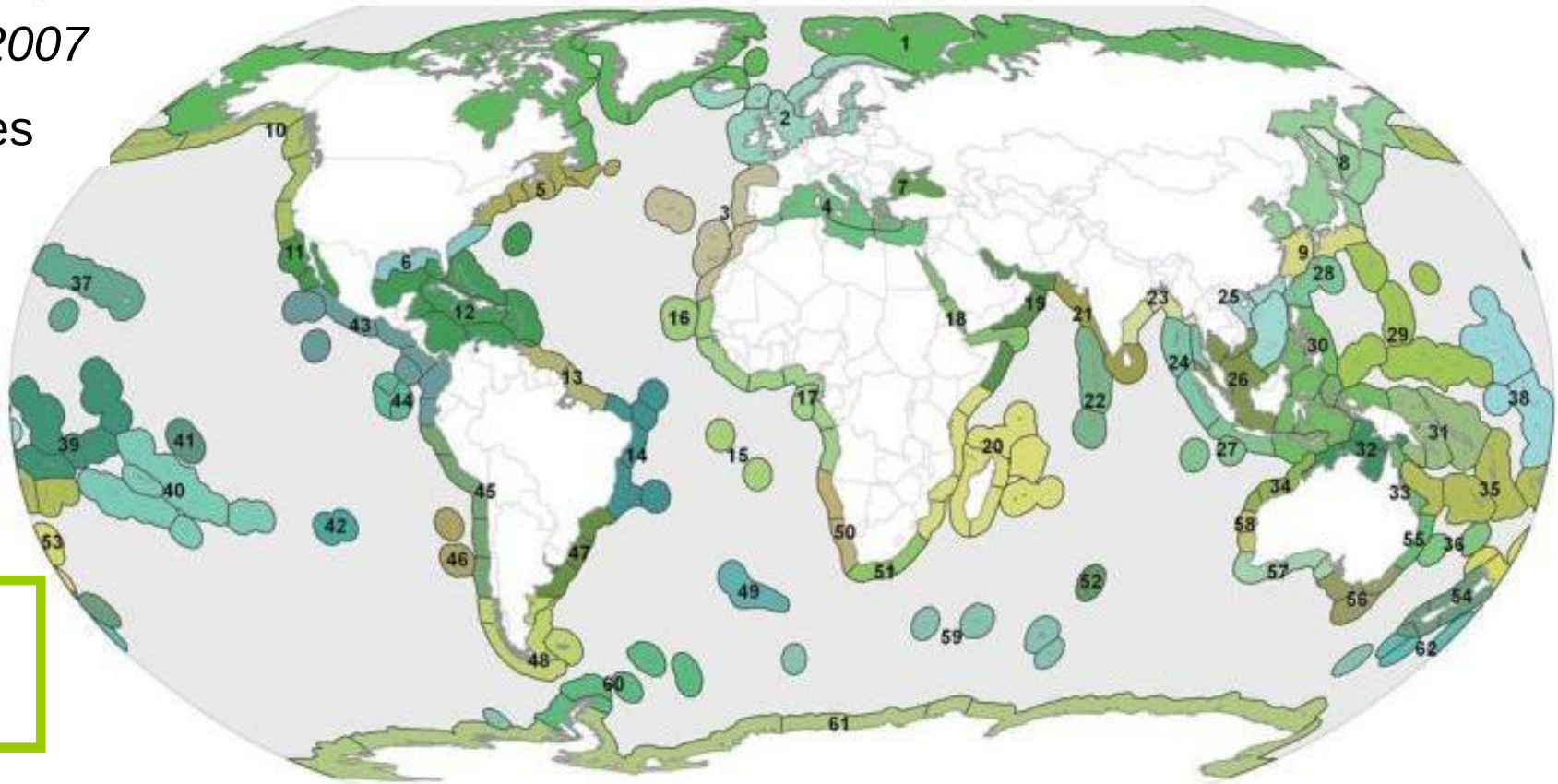
Spalding et al. 2007

Marine Provinces



Provinces:

Marine - 62

Ecoregions:

Terrestrial - 867 (Olson et al. 2001)

Freshwater - 426 (Abell et al. 2008)

Marine coastal & shelf (up to 200 m isobath) - 232 (*Spalding et al. 2007*)

e.g. Marine realm: Temperate Northern Atlantic, Province: Mediterranean, Ecoregion: Aegean Sea (ecoregion)

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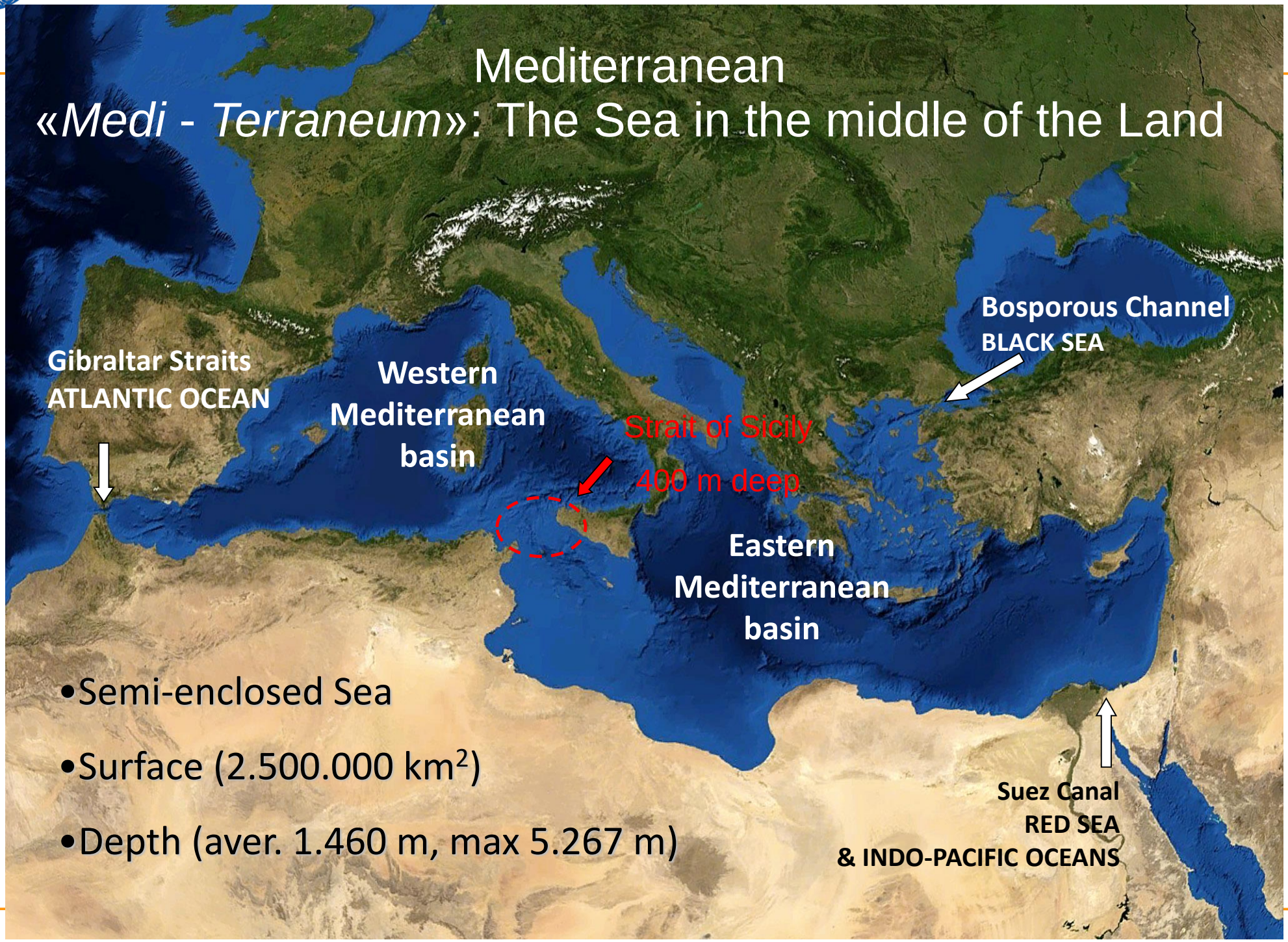
Mediterranean
«*Medi - Terraneum*»: The Sea in the middle of the Land



- Semi-enclosed Sea
- Surface (2.500.000 km^2)
- Depth (aver. 1.460 m, max 5.267 m)

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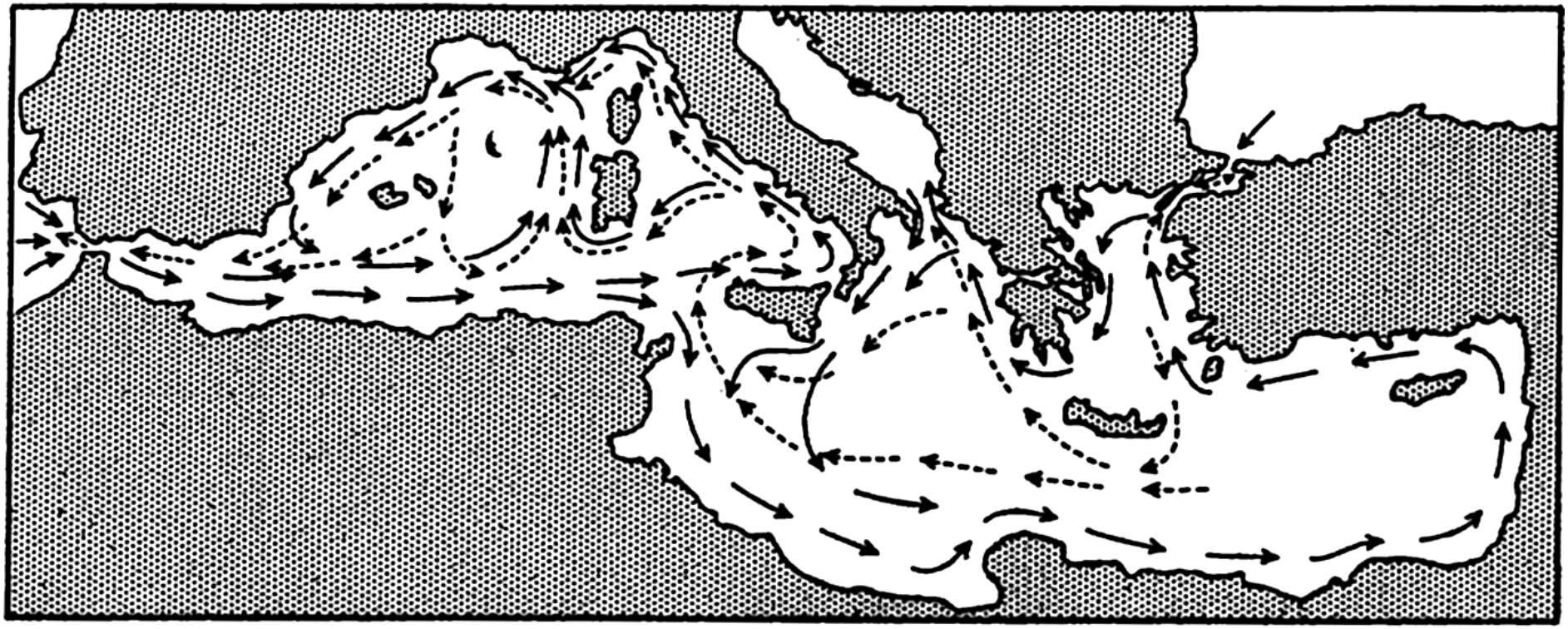
Simplified scheme of Mediterranean circulation



- Atlantic cool, low-salinity water enter through Gibraltar, and flow east-wards / north-wards
- Gradually the water becomes saltier and sinks in the Eastern Mediterranean
- Returns west-wards and exits through Gibraltar

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Mediterranean marine species ~ 17.000

Biogeographical origin
(βιογεωγραφική προέλευση)

Temperate (από εύκρατο κλίμα) Atlantic - Mediterranean
Cosmopolitan (βρίσκεται παγκοσμίως)
Endemics:
- Neo-endemics (νέο-ενδημικά) – 20.000 y BP
- Paleo-endemics (πάλεο-ενδημικά) – 220 my BP

Subtropical (υπό-τροπικά) Atlantic
Boreal (από βόρειες περιοχές) Atlantic
Red Sea migrants / Lessepsian migrants
Eastern Atlantic migrants

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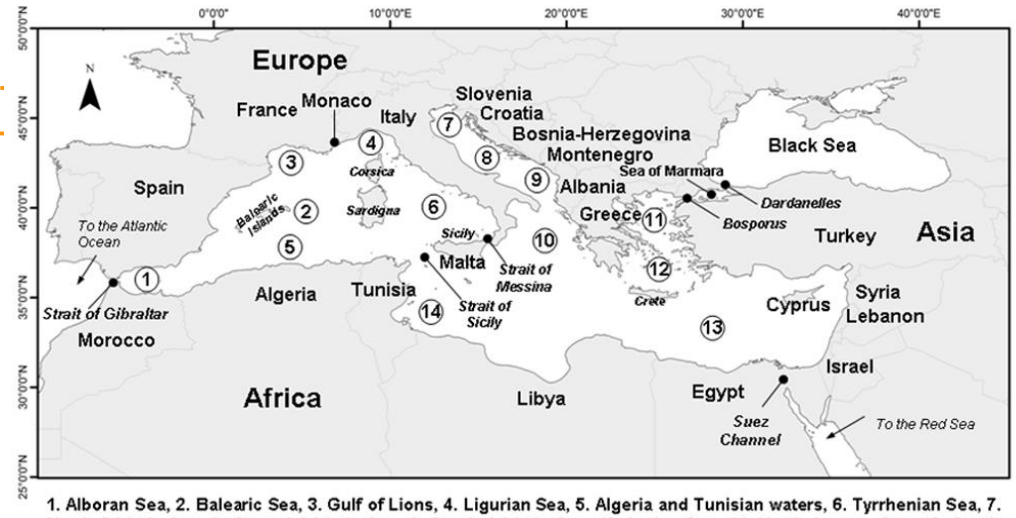
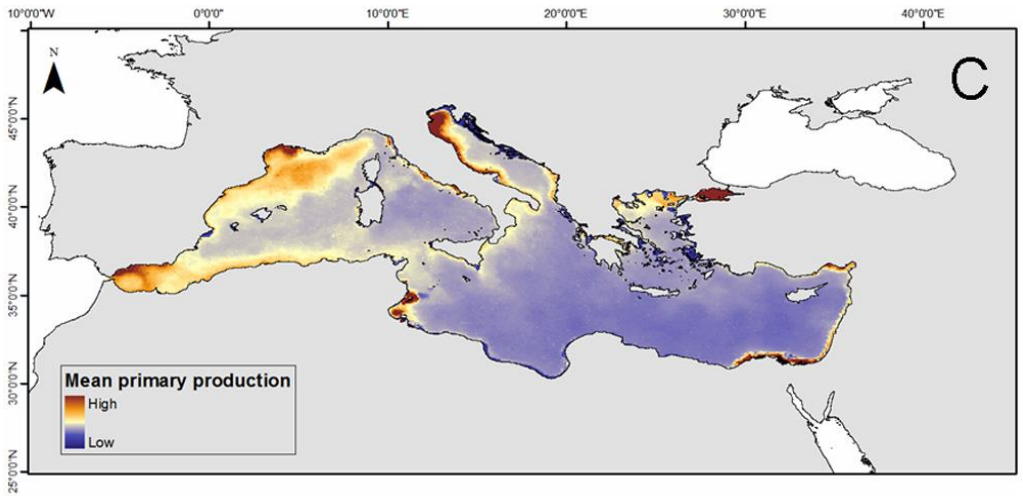
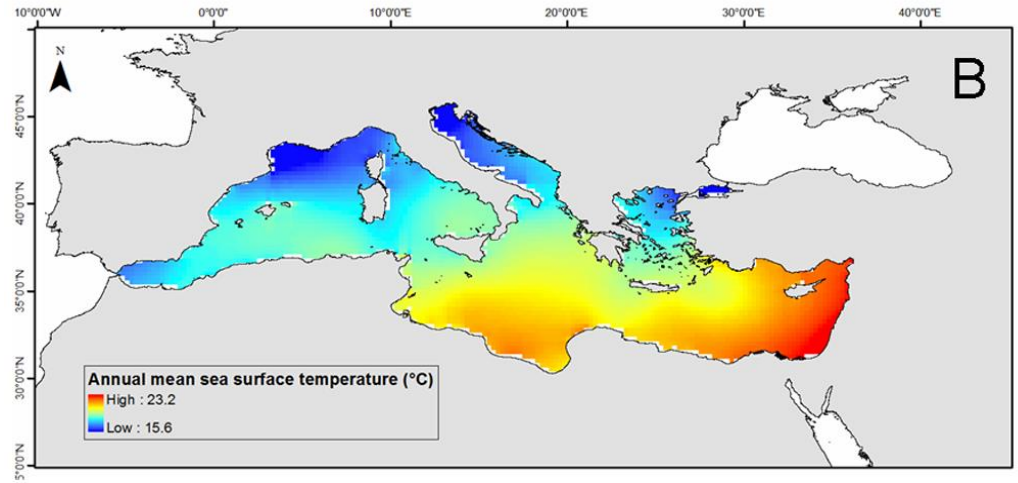
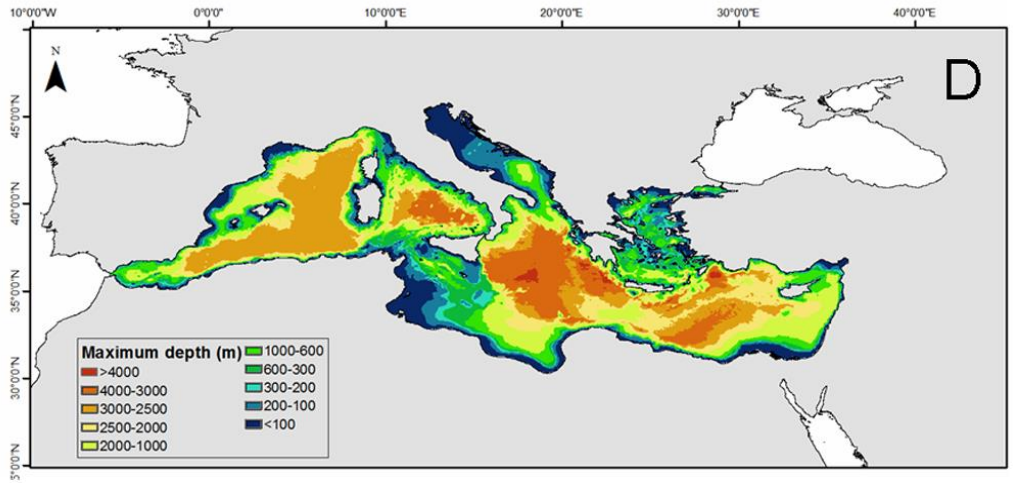


1. Alboran Sea, 2. Balearic Sea, 3. Gulf of Lions, 4. Ligurian Sea, 5. Algeria and Tunisian waters, 6. Tyrrhenian Sea, 7. North Adriatic Sea, 8. Central Adriatic Sea, 9. South Adriatic Sea, 10. Ionian Sea, 11. North Aegean Sea, 12. South Aegean Sea, 13. Levant Sea, 14. Gulf of Gabès.







- 7 Different Eco-regions (A)
- Temperature increase from N to S and from W to the E (B)
- Decrease of Primary Productivity from N to S and from W to the E (C)
- A large part with Open and Deep Seas (D)

• Ecosystem / Ecological / Landscape diversity

- ***Ecosystem / Ecological diversity***
  Biogeographic realms
  Biomes (14 terrestrial)
  Provinces
  Ecoregions
  Ecosystems
  Habitats
  Communities

→ Units of smaller geographical scale

Community [Κοινότητα / Βιοκοινότητα]

The sum of species within a given area, along with their interactions

Ecosystem [Οικοσύστημα]

All communities + physical / chemical environmental parameters + their interactions within a specific area.

Habitat [Ενδιαίτημα]

……

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Habitat (οικότοπος) - Definition

The space (χώρος), resources (πόροι), and conditions (συνθήκες) a species requires to complete its life cycle (κύκλος ζωής).

[definition by: Convention on Biological diversity – UNEP/CBD/COP/11/INF/19/2012]

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Habitat (οικότοπος)

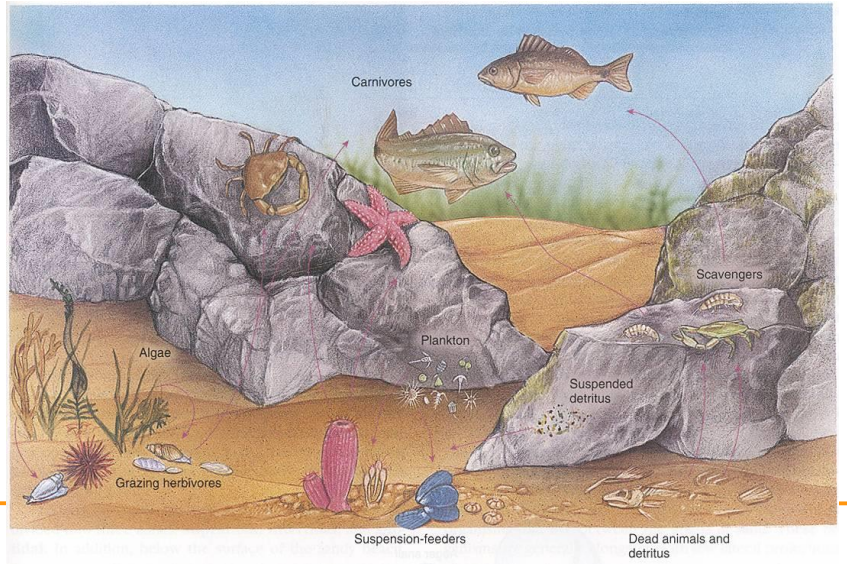
Defined by:

a) Physical / abiotic characteristics

- Substratum (rocky / sediment / artificial / grain size)
- Light intensity & depth (Light & depth *zones**)
- Turbulence & sedimentation
- Exposure to waves / currents (Hydrodynamism)

b) Biotic characteristics

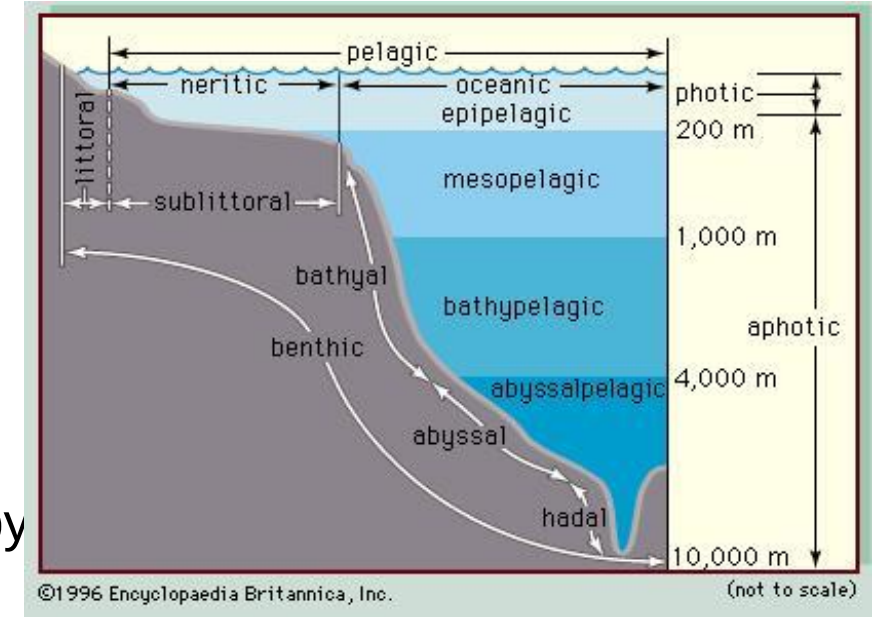
- Habitat forming species
- Dominant species
- Species interactions (inter & intra)



Marine habitats

Light & depth zones:

Divided into benthic & pelagic



Benthic

Littoral

- **Supralittoral** (υπερπαραλιακή)
  – never submerged, influenced by sea spray & wave splash
- **Mediolittoral** (μεσοπαραλιακή)
  – slight & periodic submergence, depending on tides

Sublittoral

- **Infralittoral** (υποπαραλιακή)
  – always submerged, usually down to 40 m. Determined by light penetration & presence of sea-grasses or photophilous algae.
- **Circalittoral** (περιπαραλιακή)
  – From the lower limit of the infralittoral usually down to 200 m.

- **Bathyal** – below 200 m.

Depend on water clarity, so may change from one region to the other

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Mediterranean marine habitats

*** Priority Habitats (Natura 2000):**
habitat types in danger of disappearance and whose natural range mainly falls within the territory of the European Union.

Marine & Coastal Habitat types included in the Annex I of the Habitats Directive 92/43/EEC

1110 – Sandbanks slightly covered by sea water all the time (αμμοσύρσεις που καλύπτονται διαρκώς από θαλάσσιο νερό)
1120* – Posidonia beds (*Posidonia oceanica*) (Λιβάδια Ποσειδωνίας)
1130 – Estuaries (Εκβολές ποταμών)
1140 – Mudflats and sandflats not covered by seawter at low tide (Λασπώδεις και αμμώδεις επίπεδες εκτάσεις που αποκαλύπτονται κατά την άμπτωτη)
1150* – Coastal lagoons (Λιμνοθάλασσες)
1160 – Large shallow inlets & bays (Αβαθείς κολπίσκοι και κόλποι)
1170 – Reefs (Ύφαλοι)
1180 – Submarine structures made by leaking gases (Υποθαλάσσιοι σχηματισμοί από διαφυγές υγρών & αερίων)
8330 – Submerged or partially submerged sea caves (Βυθισμένα ή ήμι-βυθισμένα Θαλάσσια σπήλαια)

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1110 – Sandbanks slightly covered by water all the time

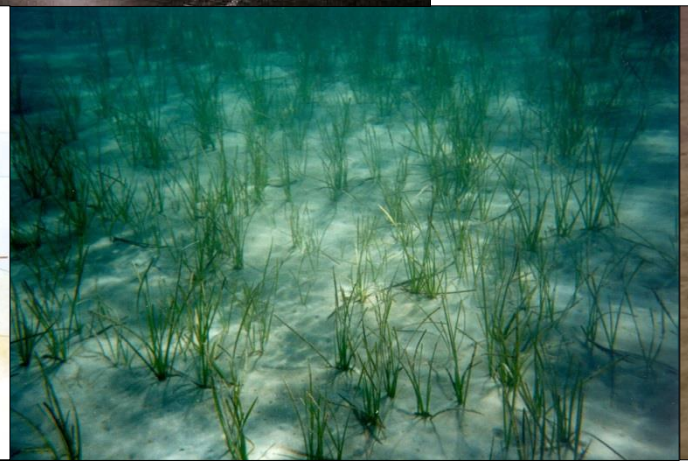
Definition: Elevated, elongated, rounded or irregular topographic features, permanently submerged and surrounded by deeper water.

Soft substrate communities

Cymodosea nodosa beds

Invertebrates of sandy sublittoral (e.g. polychaetes)

Important feeding, resting, nursery grounds for sea birds, fish, or marine mammals



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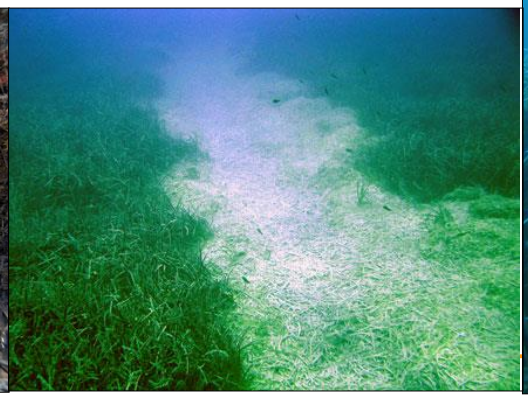
1120* – Posidonia beds

Posidonia oceanica

- Priority habitat type (0.5 – 30 m)
- Traps & stabilizes sediment
- Weaken water movement (up to 70%) – coastal protection
- Primary production is large
- Much of this primary production is exported to other ecosystems
- Hosts approx. 400 plant species & >2000 animal species
- Complex & rich food web





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1130 – Estuaries

Where rivers meet the sea.

Definition: River estuaries are coastal inlets with a substantial freshwater influence.

Mixing of fresh & sea water, often leads to extensive intertidal sand and mud flats.

Species: *Zostera noltii* beds (plants), soft-substrate invertebrate taxa, birds.

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1140 Mudflats and sandflats not covered by seawter at low tide

Not typical of the Mediterranean, which presents short-range tides

Rich in invertebrates, important for birds.

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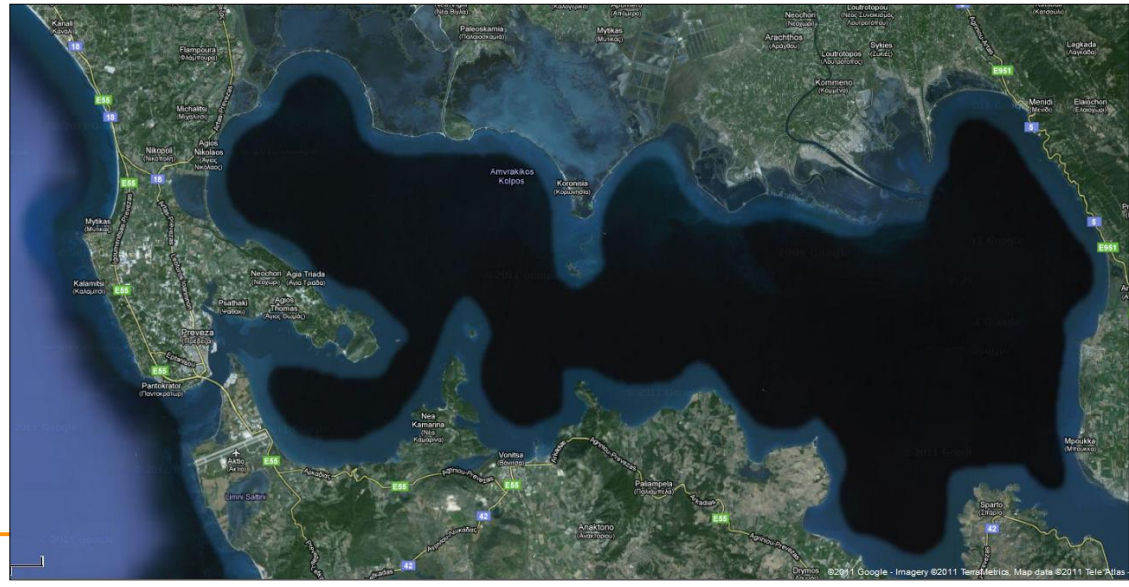
1150* – Coastal lagoons

Definition: Expanses of shallow coastal salt water, wholly or partially separated from the sea by sand or rocks. Salinity may vary according to rainfall (the addition of freshwater) or temporary flooding of the sea in winter.

Characteristics: Important for invertebrate communities, fish, and birds. High economical interest (fisheries and salt-works)



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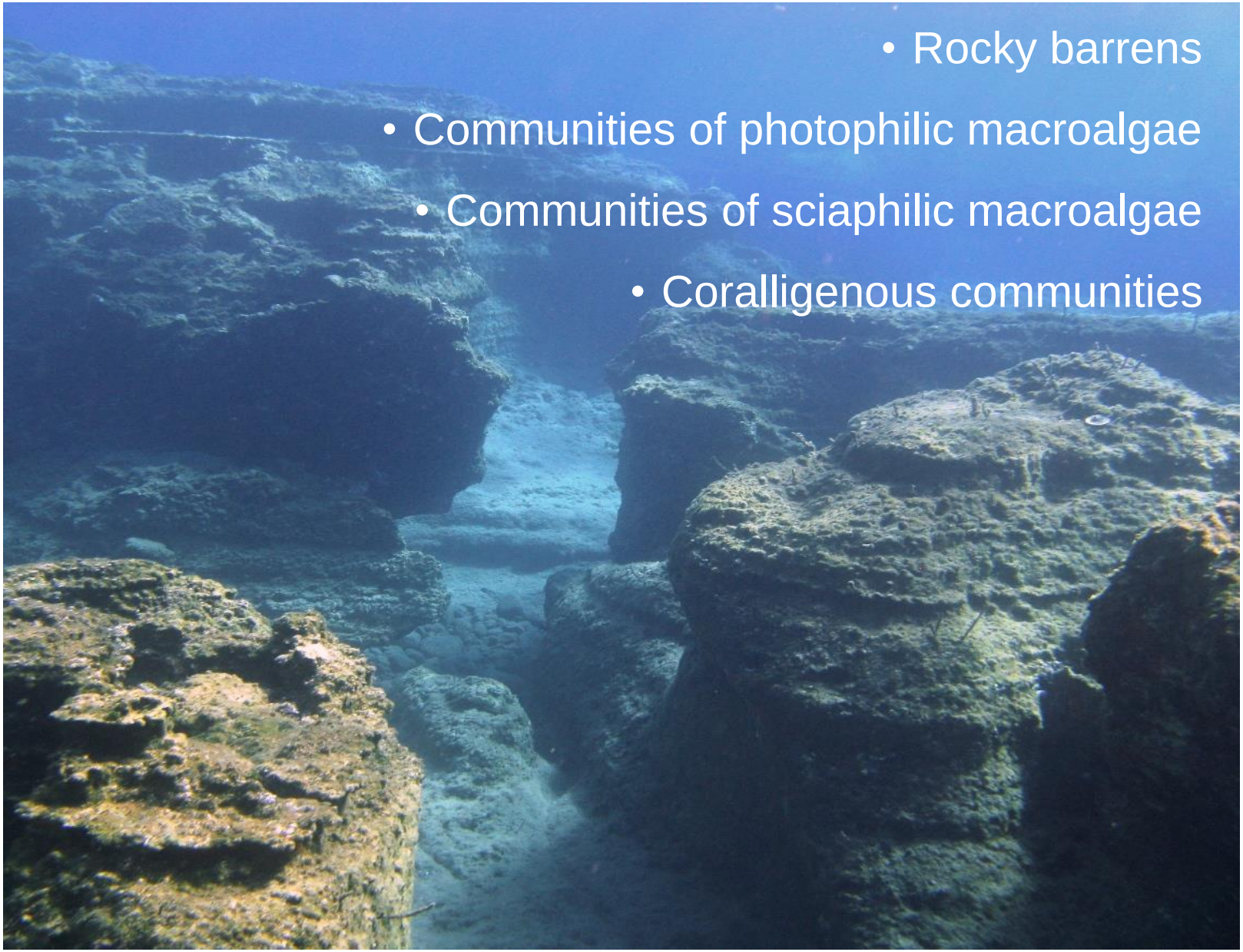
1170 – Reefs



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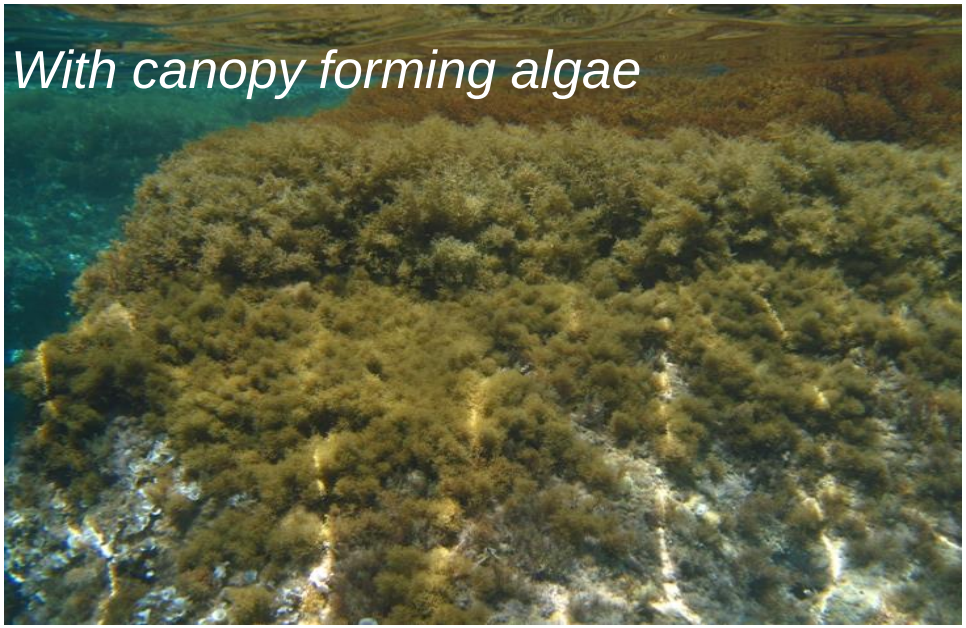
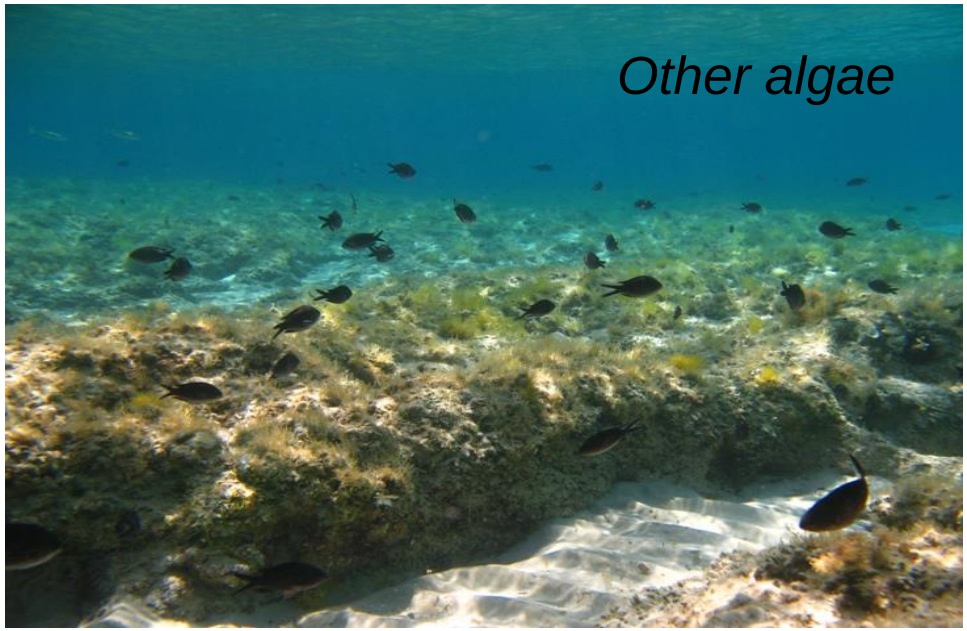
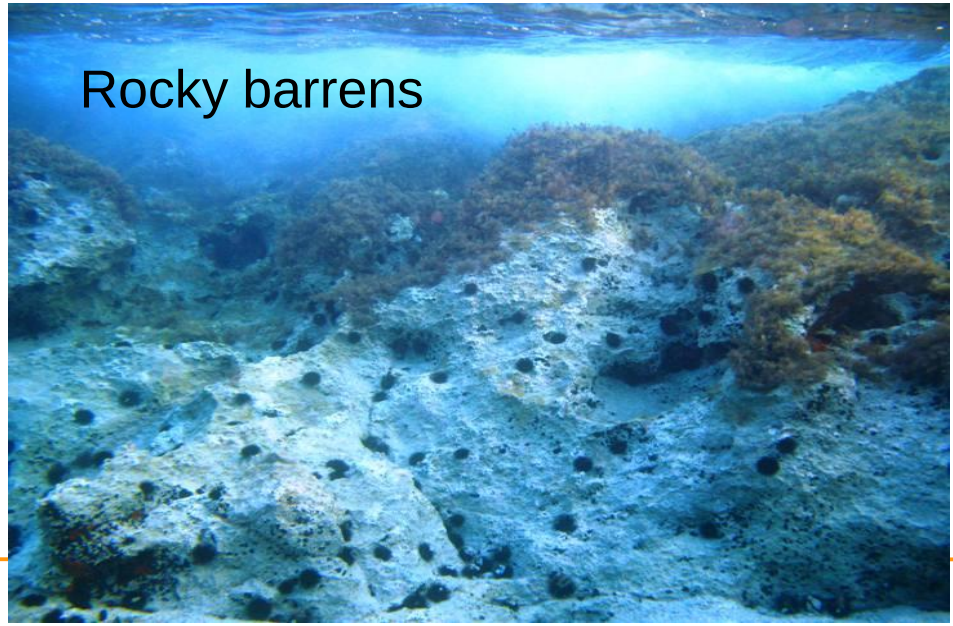
1170 – Reefs





Communities of photophylous macroalgae



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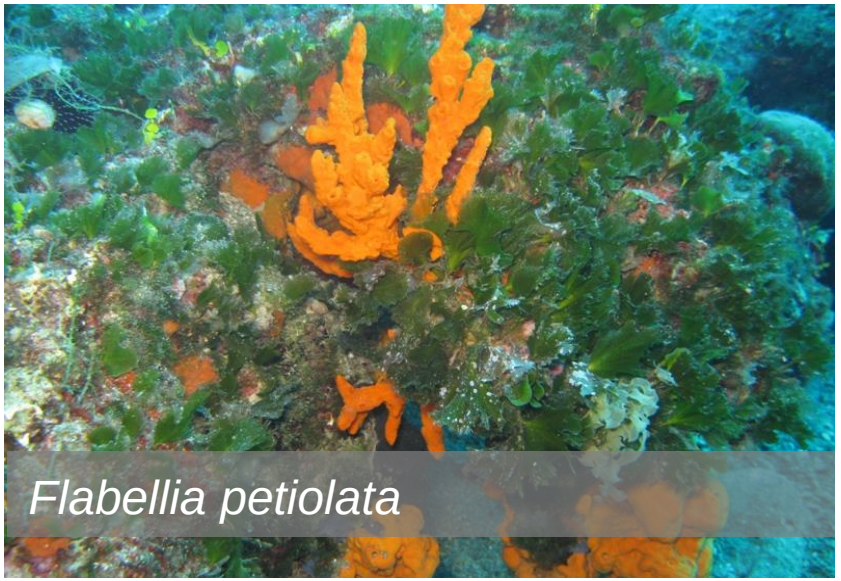
1170 – Reefs


Peyssonnelia rubra


Flabellia petiolata

Communities of sciaphilous macroalgae


Pre-coralligenous


Halimeda tuna

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1170 – Reefs

Coralligenous formations

(Ballesteros, 2003)

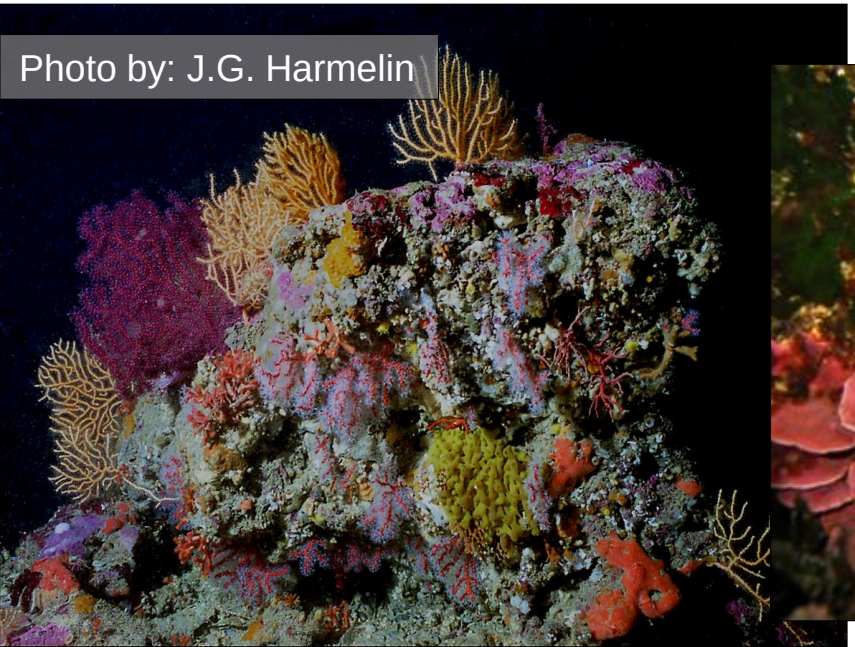

Photo by: J.G. Harmelin

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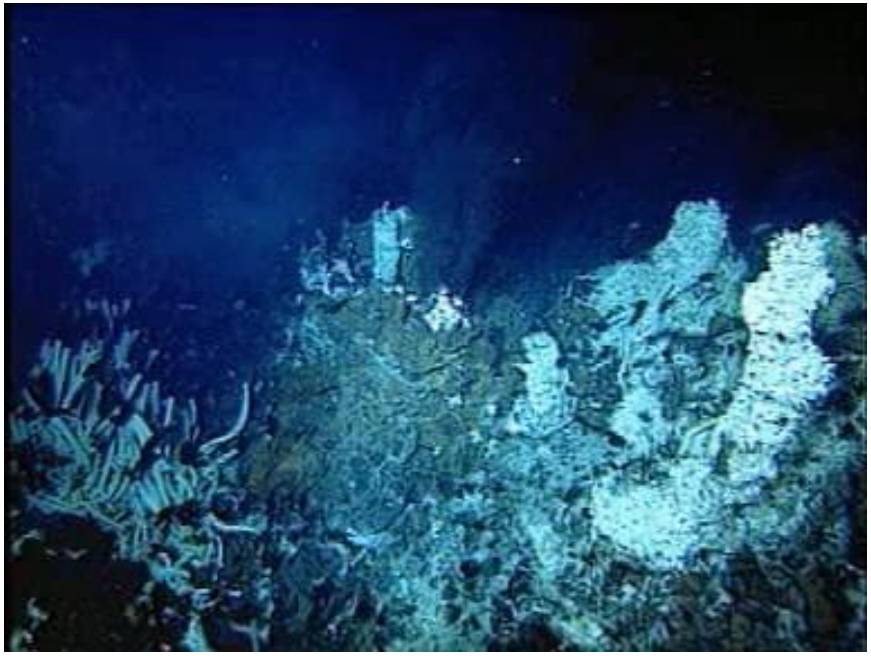
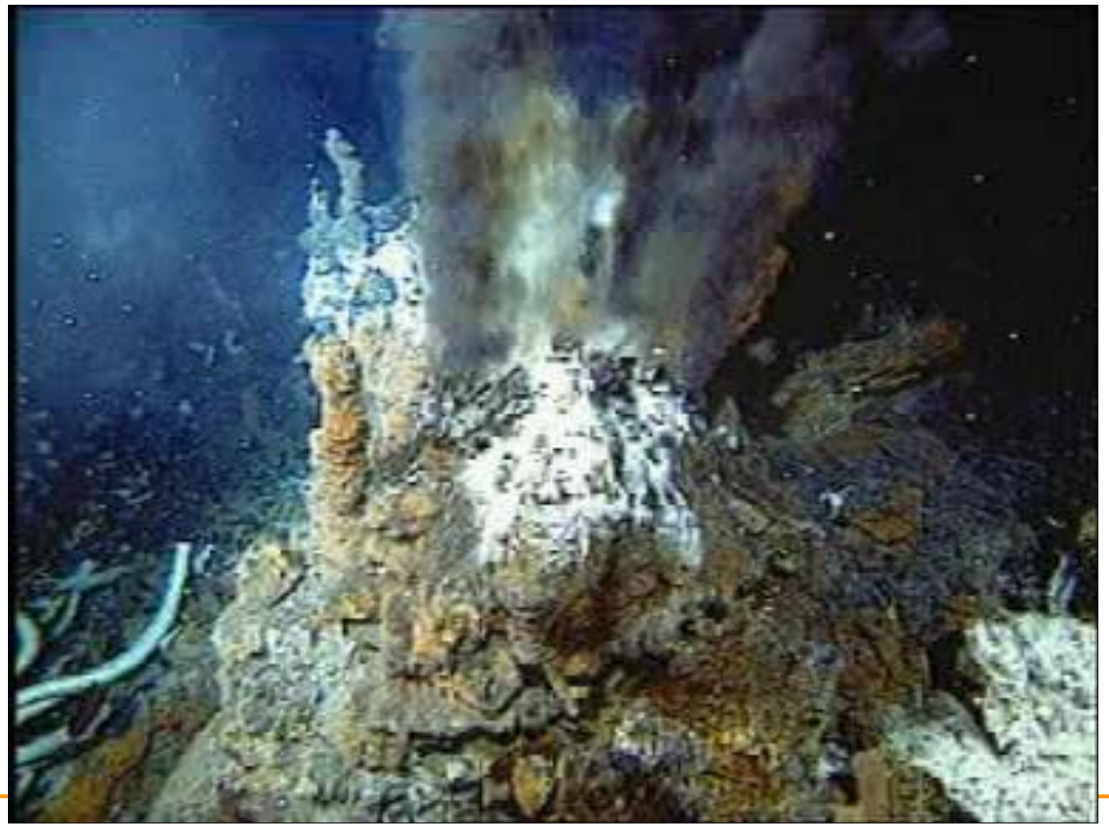
1180 – Submarine structures made by leaking gases

Definition: Sandstone slab or pavements (αμμώδεις πλάκες), and pillars (κολώνες) up to 4 m high, formed by the aggregation of carbonate cement (ανθρακικό συγκολλητικό υλικό) resulting from microbial oxidation of gas emissions, mainly methane. Gas vents (οπή / σχισμή / καμινάδα) are interspersed (διάσπαρτες) across these structures, and intermittently (περιοδικά) release gas. **Characteristics:** Little is known about their biota. Usually occur in deep waters of volcanic areas.





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1180 – Marine caves

Communities of dark caves & tunnels

Communities of semi-dark caves

Coralligenous or precoralligenous communities of cave entrances

• Importance of biodiversity

Importance of species/organismal diversity:

Every organism performs several functions within an ecosystem. These functions range from decomposition to keeping populations of herbivores under control. Species interactions play a major role in maintaining ecosystem balance.

Importance of genetic diversity:

High genetic diversity ensures better survival of species. The more genetic diversity the greater the chances of survival of a population under changing environmental conditions.

Importance of ecosystem / ecological / landscape diversity:

Includes the large variety of different ecosystems on Earth, each having its own interlinked species, niches, trophic levels, energy flow, food chains.

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• Why is it important to protect biodiversity?

From an anthropocentric perspective
all three levels of biodiversity are vital for the **welfare of humans**

Biodiversity of natural systems

↓

Maintain **complex interactions** between organisms and their environment

↓

Ensure **health & resilience** of natural systems

↓

Enhance natural **ecosystem functions**

↓

Provide multiple **Goods & Services**

• **Examples of Goods & Services**

Food

Tourism

Raw materials

Medicine

Climate regulation

Protection from natural hazards

Pest control

Biodiversity provides multiple social, economical, cultural & health benefits

• Look at the environment as a whole

Case study: The yellow stone park

How wolves changed the rivers (documentary): https://www.youtube.com/watch?v=ysa5OBhXz-Q

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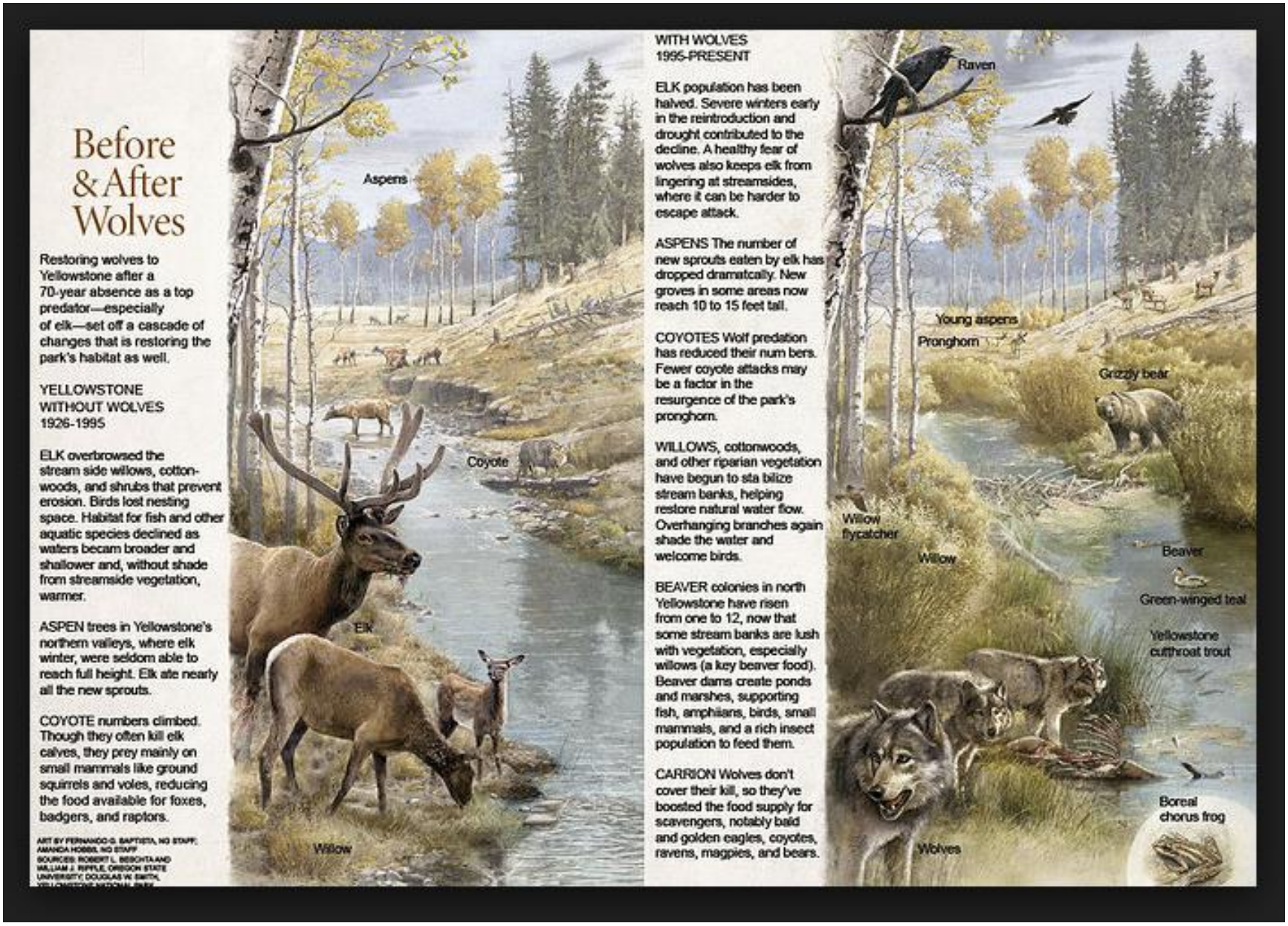
• Look at the environment as a whole

Case study: The yellow stone park



• Look at the environment as a whole

Case study: The yellow stone park

What happened?

1926 – 1995: 70 years without wolves

Dear population expanded in the absence of predators

Consumed a large part of the vegetation

1995: wolves re-introduced (επαναφορά)

wolves started killing dears & coyotes

behavior of the dears **changed** – avoidance behavior (συμπεριφορά αποφυγής)

habitats **re-generated**, plants started **re-growing**

birds increased, beavers (κάστορες) increased and created additional habitats

in the absence of coyotes – other small mammal populations

bear populations grew – because of more berries

Eventually **wolves changed the behavior of rivers** – less erosion, narrower channels, more pools were formed.

• Look at the environment as a whole

Case study: The yellow stone park

DOCUMENTARY

What do we learn from this?

Provide an example of a keystone species…

Give an example of an ecosystem engineer…

What happened?

• Ecological role of biodiversity

All species participate in numerous ecological processes that occur within and between ecosystems. Each species has a specific role.

Some examples:

• Ecological role of biodiversity

1. **Production of energy and food :** Plants and algae are directly or indirectly related with food production.

   ~ Directly as **primary producers:** plants, phytoplankton and algae are the only medium which can convert solar energy into chemical energy. This energy in turn is used by all the living organisms in the biosphere. they are the main source of food.

   ~ Indirectly: energy is then transferred through trophic chains in the form of food from one organism to the other. **Consumers:** All the other animals which are directly or indirectly take plants as their food resources are consumers. All the herbivores and carnivores are called consumers.

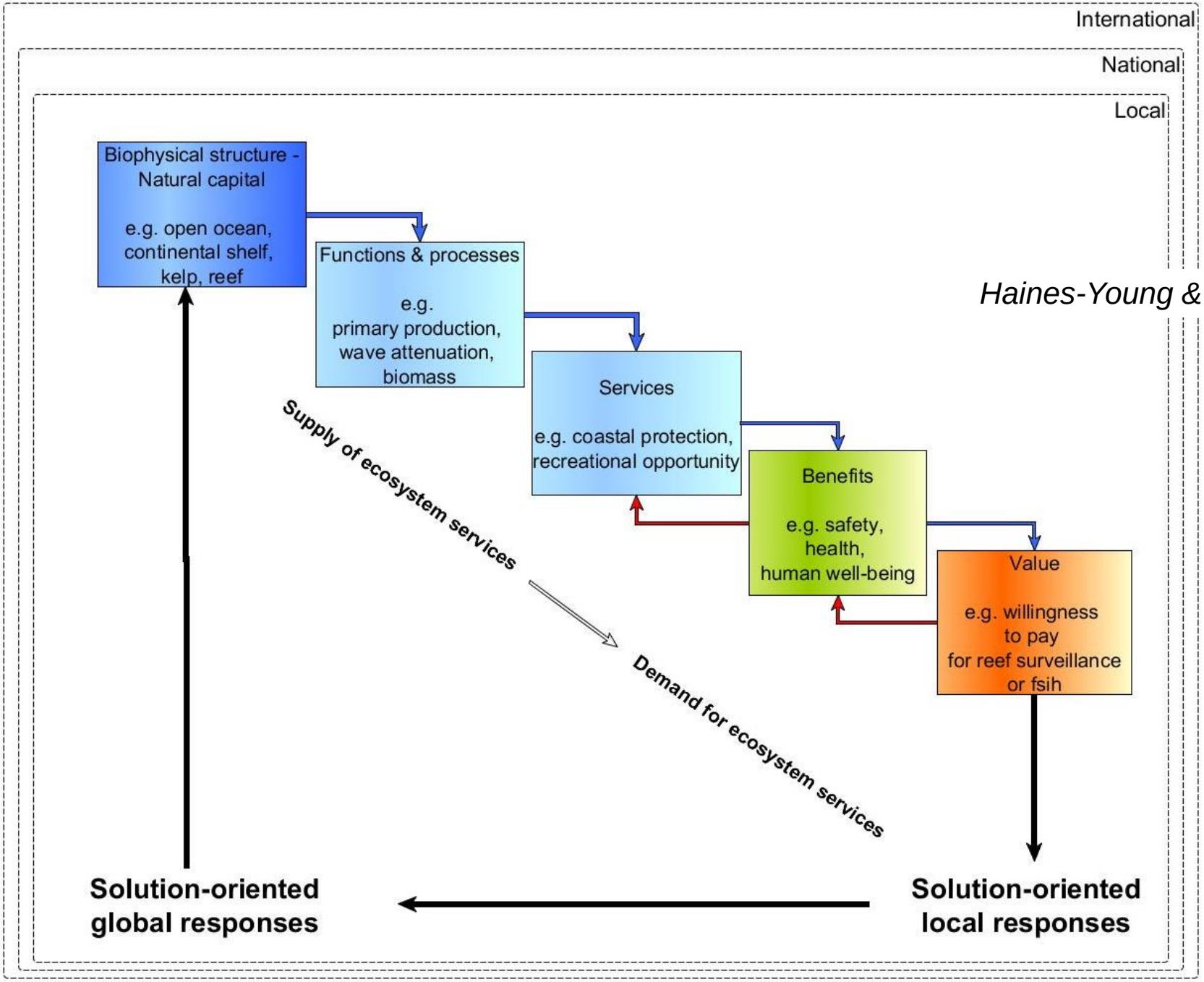
2. **Cycling of water and nutrients:** Mostly done by plants, animals and microbes, but non-living (abiotic) components like air, water (currents, upwellings) and solar energy also play some role.

3. **Soil generation and reduction of erosion:** Living organisms both plants and animals help in the formation of soil and biogenic substrates. Abiotic factors help in this process.

• Ecological role of biodiversity

4. **Decomposers and decomposition:** Several organisms decompose the dead plant and animal organic mater and help in the recycling of materials. This process is known as decomposition and the organisms are called decomposers.
5. **Climatic stability:** Plants and algae play an important role in climatic stability e.g. forests, through the process of respiration, the storage of CO_2 and the production of rain. Marine algae also play an important role as a CO_2 sink (δεξαμενή).
6. **Reduction in pollution:** Several plants and organisms have the capacity to breakdown pollutants. Natural way to control pollution.
7. **Reduction in natural disturbances / calamities** e.g. drought, flood, tsunamis. These natural disasters often result to the loss or destruction of biodiversity. Rich biodiversity lessens the occurrence of natural disasters, while healthy ecosystems have the ability to recover faster (are more resilient – ανθεκτικός, ευπροσάρμοστος).

• Ecosystem goods & services



Haines-Young & Potschin, 2010

• Biodiversity value

A fundamental challenge of conservation biologists is to ensure that all economic costs and benefits are understood and considered when making decisions that impact biodiversity.

• Biodiversity value

Categories of biodiversity values

Direct Values: direct use of biodiversity for the benefit of humans.

- Consumptive use value: the value of nature products which are consumed directly without passing through a market. [Firewood, game of hunt, medicines]

- Productive use value: the value of nature products which are consumed directly after passing through the market. [Fish bought from a market have a productive use value].
  - Can also be referred to as Economical value: e.g. food, medicine, raw material, employment

• Biodiversity value

Categories of biodiversity values

Indirect Values or Non-Consumptive Values: we do not physically use a plant or animal, but its existence keep the ecosystem healthy.

Healthy ecosystems provide several goods and services to provide to humans.

- Ecological value: Every species has a unique role in ecosystems. Through its role it helps maintain ecological balance.

  ~Ecosystem productivity: e.g. the destruction of a forest for production of wood will result to an increase of floods, and the erosion of land.

  ~Waste management:

  ~Climate regulation: e.g. forests and calcareous organisms in the sea (algae or corals) absorb greenhouse gases like CO_2. This helps reduce global warming.

  ~Species interactions: e.g. fish – sea urchins – algae interactions.

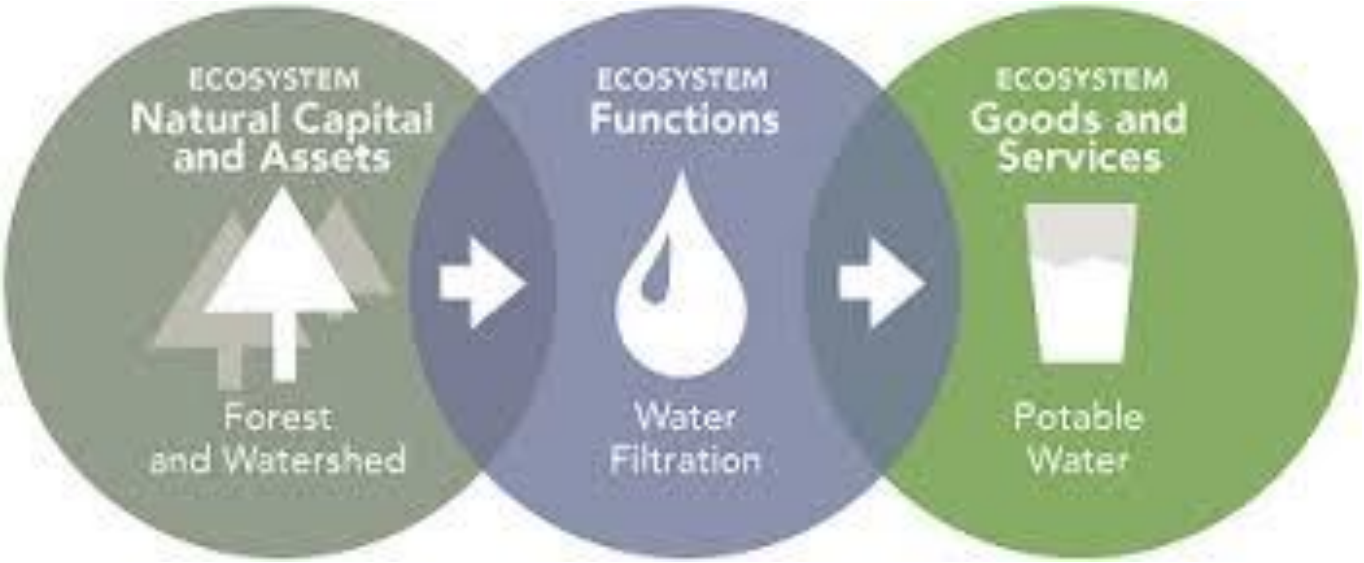
  ~Environmental indices: mussels (filter feeders) accumulate toxic waste in their tissues like heavy metals, PCBs and pesticides. They can provide information about the level of pollutants within water.

• Biodiversity value

Indirect Values or Non-Consumptive Values: (continue…)

- Social value: importance to the survival of local societies
- Scientific or Educational value: nature is great subject of research (medicine, evolution, societies)
- Future use value: refers to undiscovered plants/animals and the goods they may potentially have to offer, or to the new ways in which we could use organisms we already know (e.g. biofuel, new medicinal substances).
- Value of Existence: understanding the value of nature for its own being, and feeling obliged to pass it on to next generations.
- Aesthetic value: the beauty of the world. Also important for leisure, pleasure and toursim.
- Ethical and Moral value
- Cultural and Spiritual value

• Ecosystem goods & services



Φυσικό κεφάλαιο / Περιουσιακό στοιχείο

Οικοσυστημικές λειτουργίες

Οικοσυστημικά αγαθά & υπηρεσίες

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• Ecosystem goods & services – some examples

Service	Ecosystem service providers/ trophic level	Functional units	Spatial scale
Aesthetic, cultural	All biodiversity	Populations, species, communities, ecosystems	Local-global
Ecosystem goods	Diverse species	Populations, species, communities, ecosystems	Local-global
UV protection	Biogeochemical cycles, micro-organisms, plants	Biogeochemical cycles, functional groups	Global
Purification of air	Micro-organisms, plants	Biogeochemical cycles, populations, species, functional groups	Regional-global
Flood mitigation	Vegetation	Communities, habitats	Local-regional
Drought mitigation	Vegetation	Communities, habitats	Local-regional

Millenium Ecosystem Assessment, 2003

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• Ecosystem goods & services – some examples

Climate stability	Vegetation	Communities, habitats	Local-global
Pollination	Insects, birds, mammals	Populations, species, functional groups	Local
Pest control	Invertebrate parasitoids and predators and vertebrate predators	Populations, species, functional groups	Local
Purification of water	Vegetation, soil micro-organisms, aquatic micro-organisms, aquatic invertebrates	Populations, species, functional groups, communities, habitats	Local-regional
Detoxification and decomposition of wastes	Leaf litter and soil invertebrates, soil micro-organisms, aquatic micro-organisms	Populations, species, functional groups, communities, habitats	Local-regional
Soil generation and soil fertility	Leaf litter and soil invertebrates, soil micro-organisms, nitrogen-fixing plants, plant and animal production of waste products	Populations, species, functional groups	Local
Seed dispersal	Ants, birds, mammals	Populations, species, functional groups	Local

Millenium Ecosystem Assessment, 2003

• Ecosystem goods & services – main categories

Provisioning (εφοδιασμός)

• Food – e.g. fish and shell-fish

• Raw materials – e.g. seaweed, fishmeal, pharmaceuticals, natural medicine, ornamental goods.

• Photosynthesis, chemosynthesis, and primary production

• Reproduction and nursery areas

Maintenance of biodiversity (διατήρηση)

• Ecosystem function allows for the continuation and diversification of the variability among living organisms over time

Millenium Ecosystem Assessment, 2005

• Ecosystem goods & services – main categories

Regulating (ρύθμιση)

• Air quality & climate regulation – i.e. balance of the chemical composition of the atmosphere & climate regulation (sinks of CO_2)

• Water quality regulation / Bioremediation of waste – i.e. removal of waste through storage, burial, recycling. Organisms may store, bury and transform waste. Detoxification & purification processes.

• Disturbance and natural hazard prevention – e.g. seagrasses

•Nutrient cycling – storage, cycling and maintenance of nutrients by organisms. This increases productivity across all levels of the food chains.

Millenium Ecosystem Assessment, 2005

• Ecosystem goods & services – main categories

Culture (πολιτισμός)

• Cognitive benefits – e.g. education & research, provides information about the past (fossil record) and about the future; technological & medicinal advancements.

• Leisure, recreation, cultural inspiration, aesthetic appreciation, spiritual experience

• Feel good or warm glow (non-use benefits) – ensuring the availability of biodiversity & ecosystem functions for future generations.

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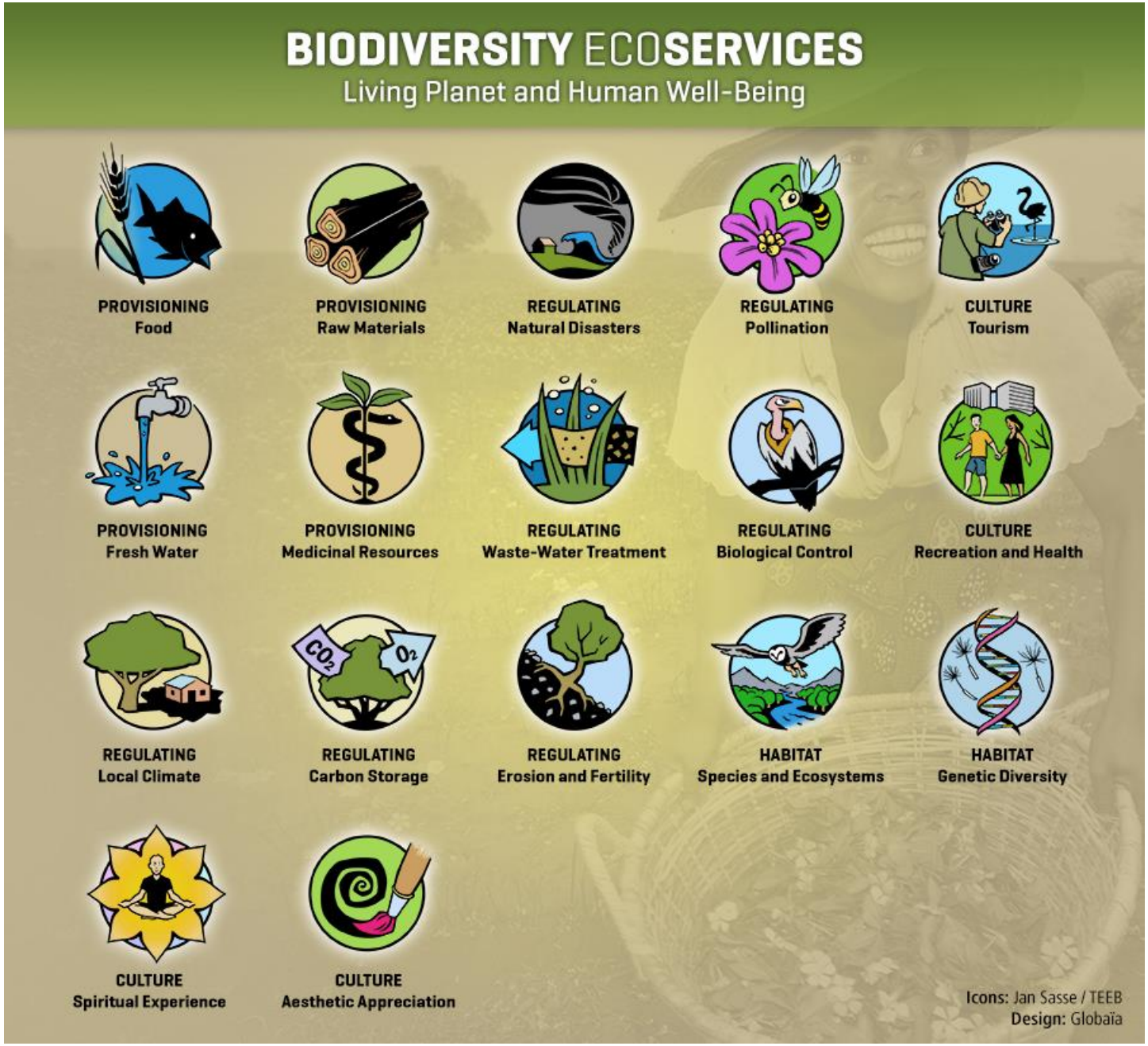
• Ecosystem goods & services – main categories



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It is important to look at the environment as a whole

(holistic approach, integrated approach)

(ολοκληρωμένη προσέγγιση)