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# Biological Conservation & Marine Protected Areas (MPAs)


**Mytilene ~ 2018**

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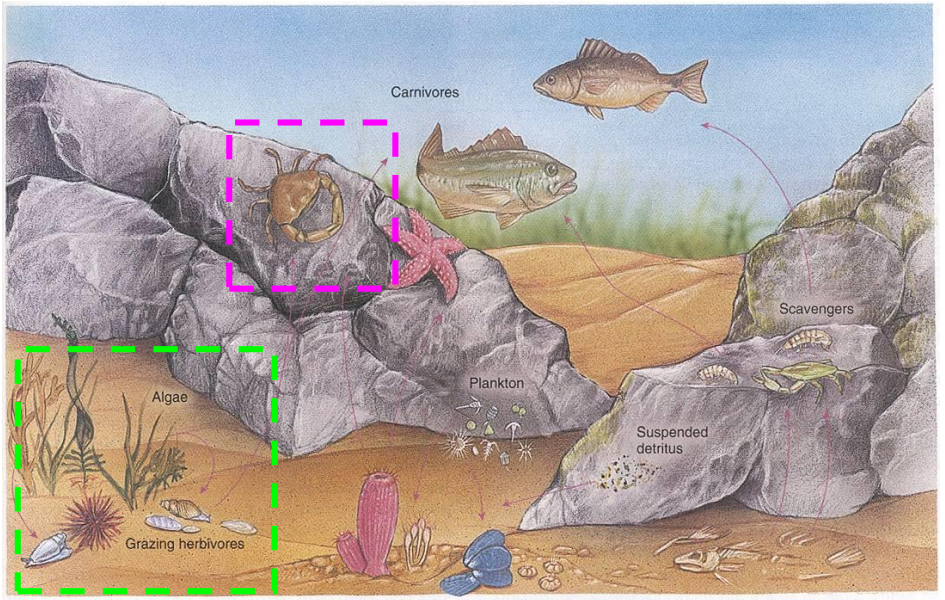
# • Measuring biodiversity

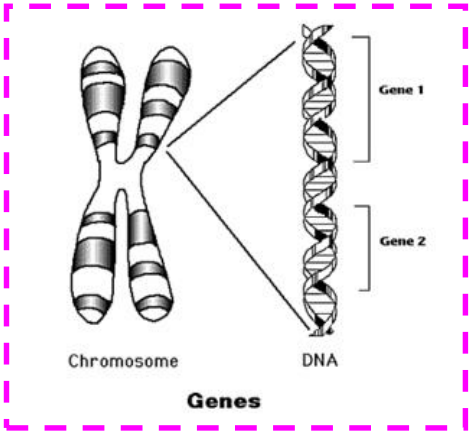
**Biodiversity is defined at three levels:**

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

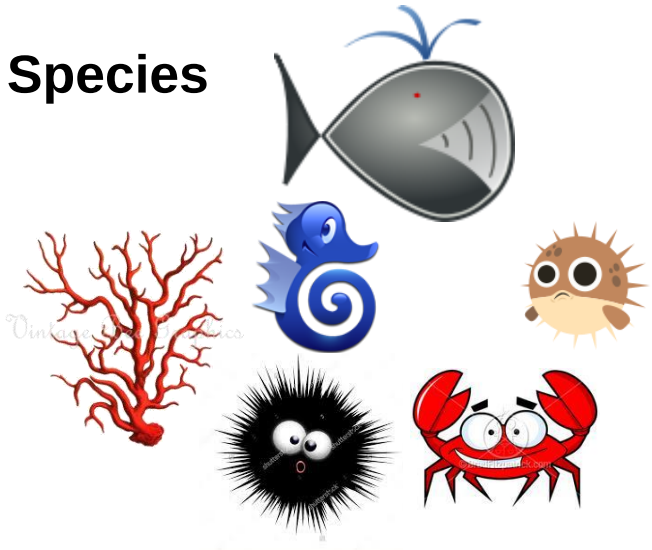
- ***Species diversity***
  The number of species found within a specific habitat type, community, ecosystem, or area.

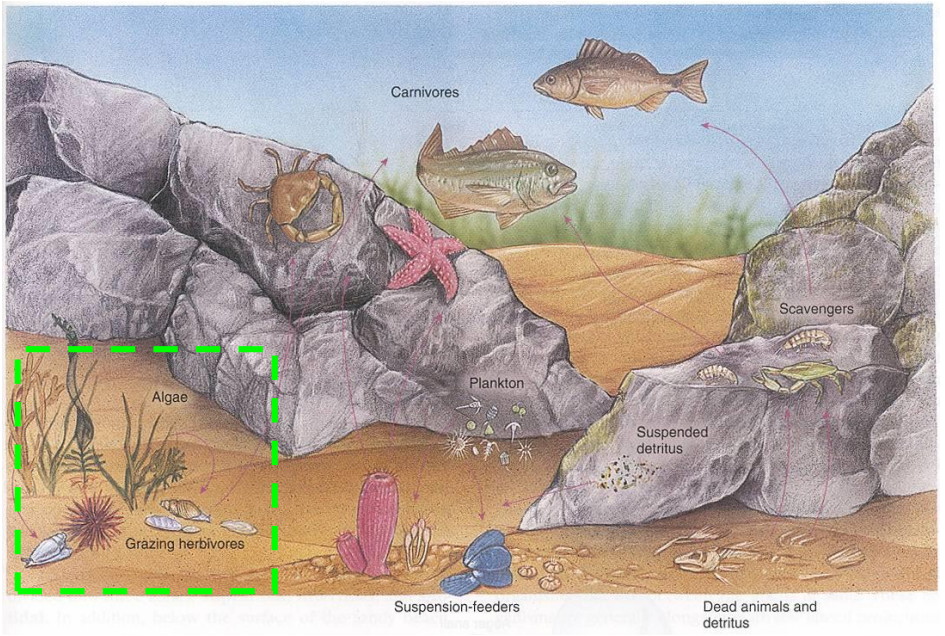
- **Genetic diversity**
  The diversity of genes found within a species population [important for the survival of a species]



# • Species diverity




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

# • Definition of a species

**What is a species?**

The Ellyfly?

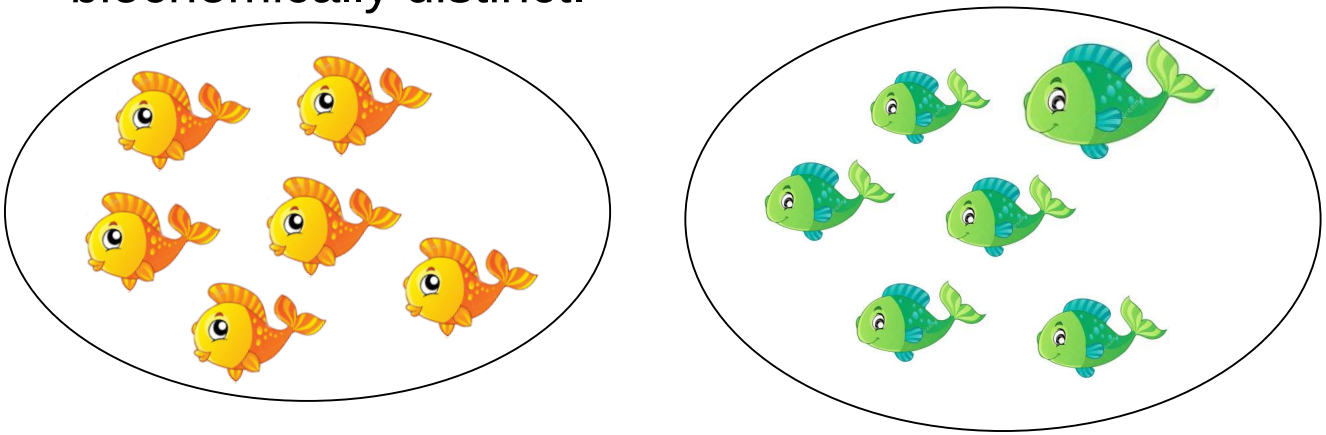

Ligers & Tigons?

ligerfacts.com

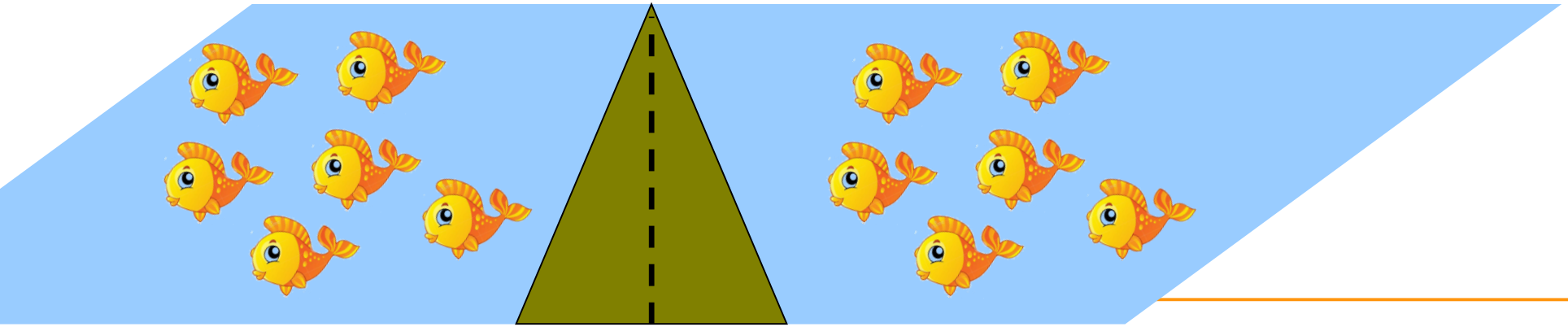
# • Definition of a species

**What is a Species?**

**Morphological definition:** a group of individuals which is morphologically, physically, or biochemically distinct.



**Biological definition:** a group of individuals that can naturally reproduce offsprings (even if they are found in different geographic areas), while they do not reproduce with other groups of individuals.



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# • Definition of a species

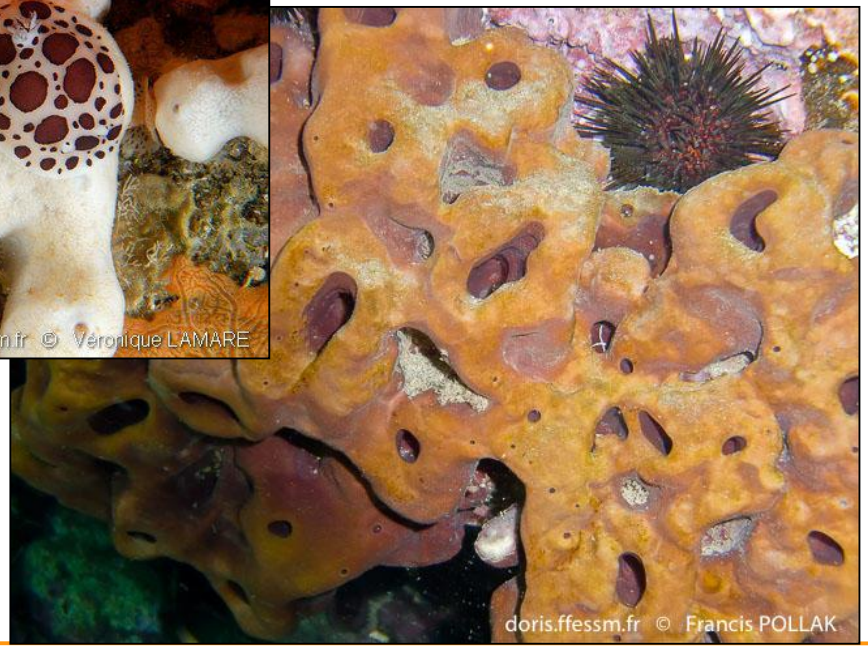
**It is important to accurately define a species.**

**However…**

• One species may present differences in their morphology in response to different environmental conditions.

*Petrosia ficiformis*





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# • Definition of a species

•There are species which look similar but belong to different species

*Aplysina cavernicola*


*Aplysina aerophoba*


www.marinespecies.org

WoRMS World Register of Marine Species

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# • Definition of a species

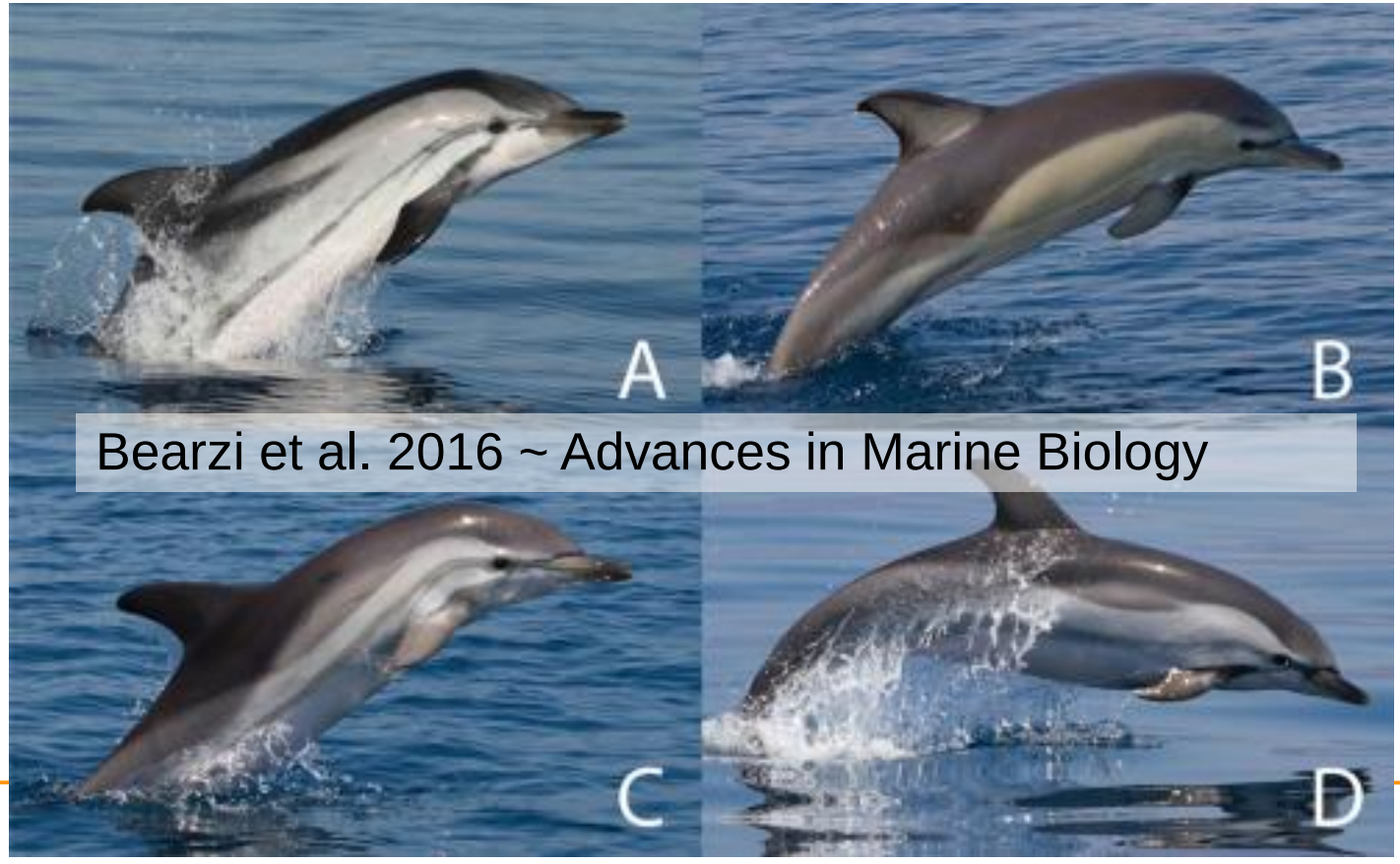
• **Hybrids** (particularly common in plants): when individuals of different but related species reproduce and produce offsprings that share characteristics of both species.

~ Sometimes hybrids are better adjusted to local environment than parent species and create a new species

**Example:** Dolphin abundance in the Gulf of Corinth

Short-beaked common dolphins (*Delphinus delphis*) = **22** individuals

Striped dolphins (*Stenella coeruleoalba*) = **1324** individuals




Bearzi et al. 2016 ~ Advances in Marine Biology

Dolphins with intermediate pigmentation (possibly striped/common dolphin hybrids) = **55** individuals

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# • Definition of a species

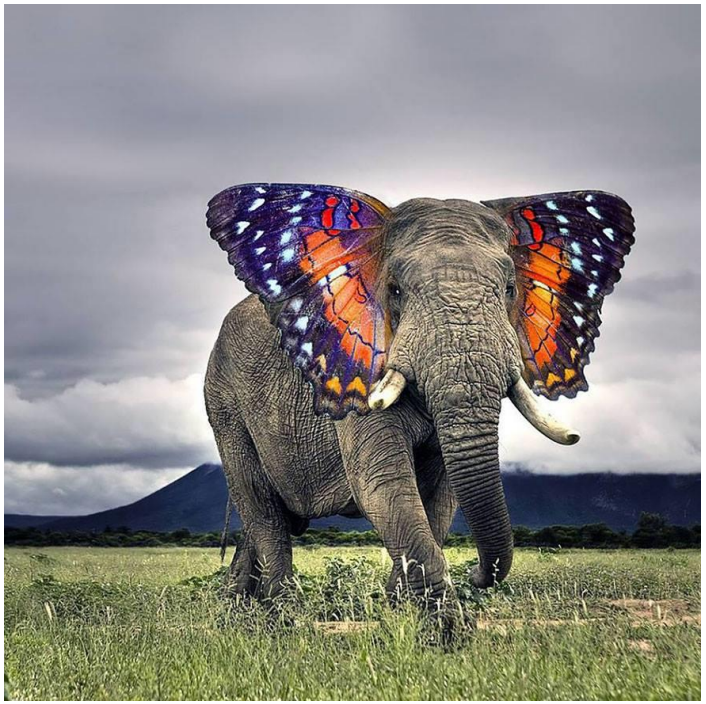
**When a species is not clearly defined…**

~ in terms of morphological variability

~ in terms of taxonomic confusion

**…then there is a problem of what to protect**

**…and there is a delay in protection efforts and the adoption of adequate laws**



# • Measuring species diversity

**Need for a quantitative measure of species diversity at various geographical (spatial) scales.**

**Ecologists have developed three main indices.**

**α-diversity or species richness:** the mean number of species found in a particular habitat or ecosystem within a given region.

**γ-diversity:** the total number of unique species found in a wider geographic area, encompassing several habitats or ecosystems.
• Also used to show differences between different habitats within a region.

**β-diversity = γ-diversity / α-diversity:** relates α and γ diversity by representing the number of shared / unshared species between different habitats within a region.
• e.g. if two different rocky reefs have similar species, β-diversity is low;
if two different rocky reefs have different species. β-diversity is high.

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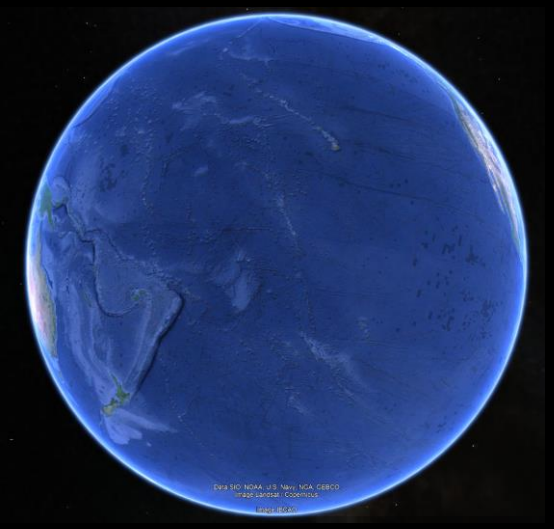
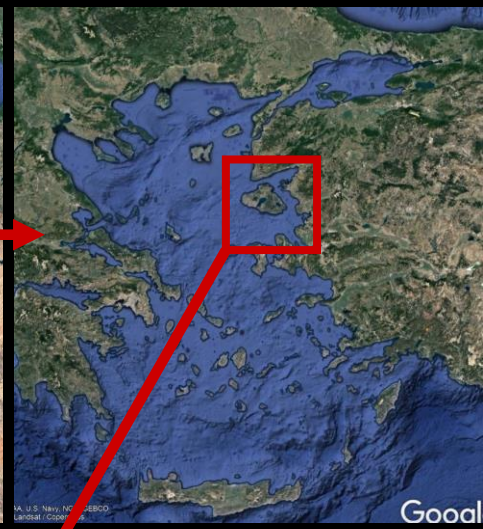
# Measuring species diversity

## The importance of spatial scale [χωρική κλίμακα]



When estimating biodiversity it is important to define the scale we are referring to.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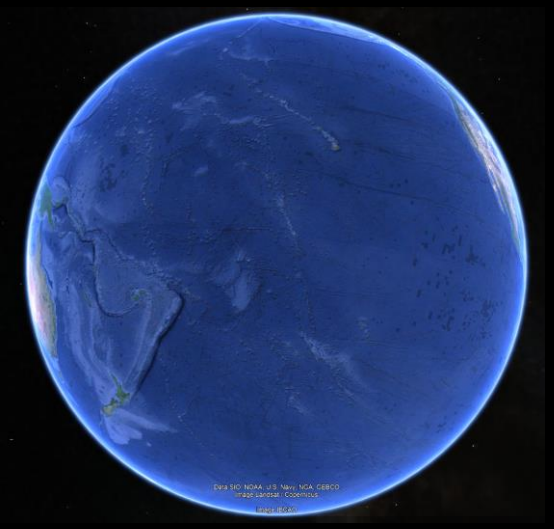
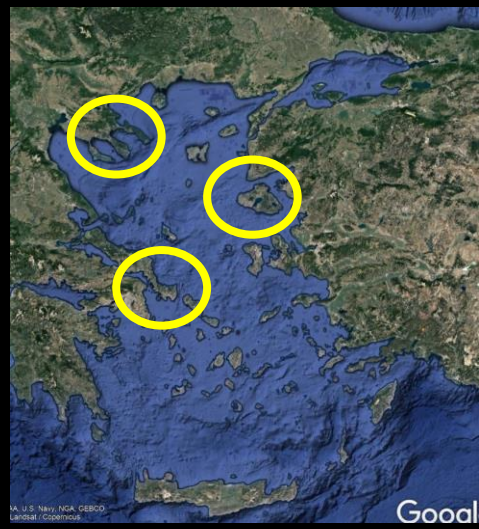
# Measuring species diversity

## The importance of spatial scale [χωρική κλίμακα]





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# Measuring species diversity

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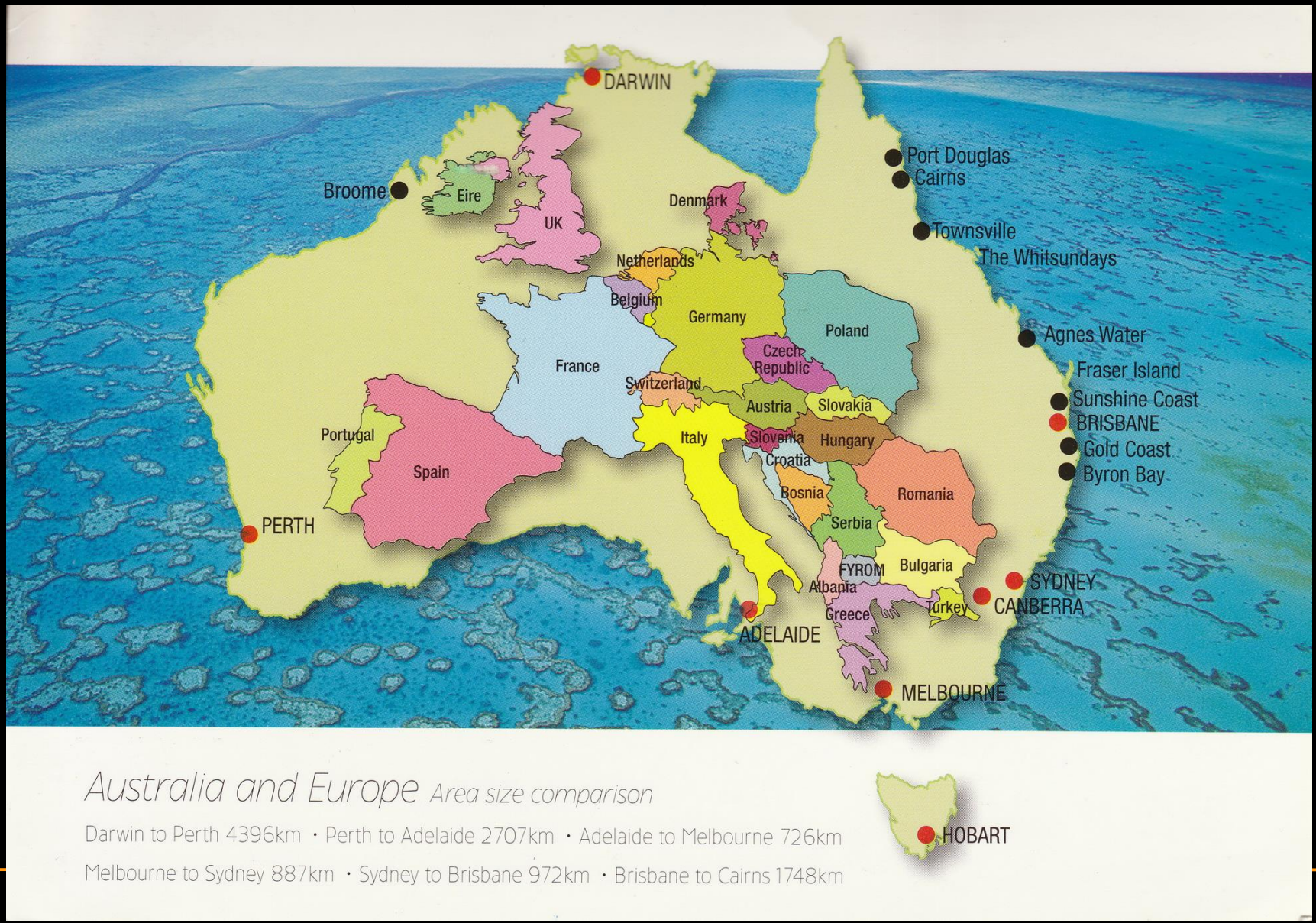
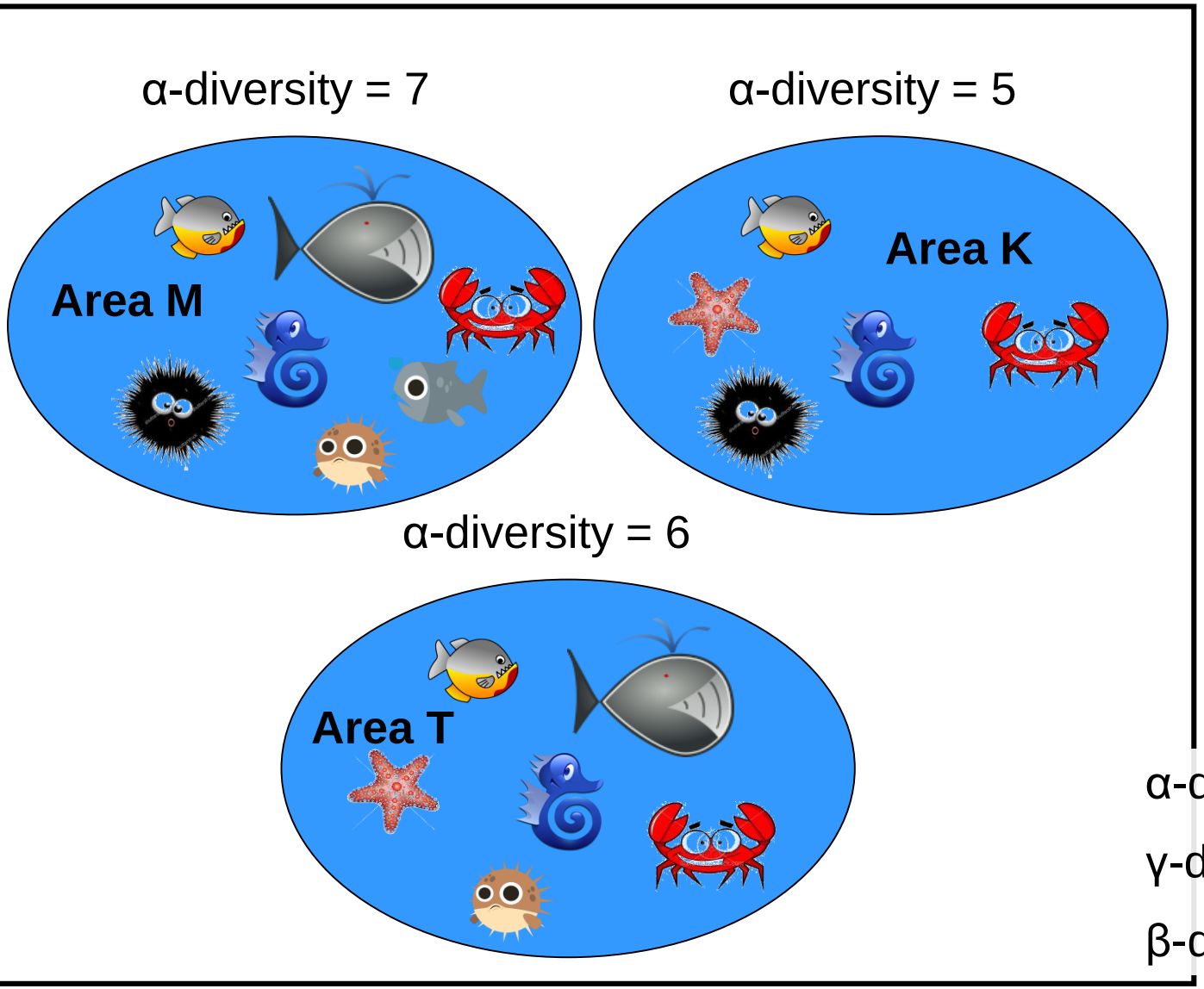


# • Measuring species diversity




α-diversity = M+K+T/3= 6

γ-diversity = 7

β-diversity = γ/α = 1.2

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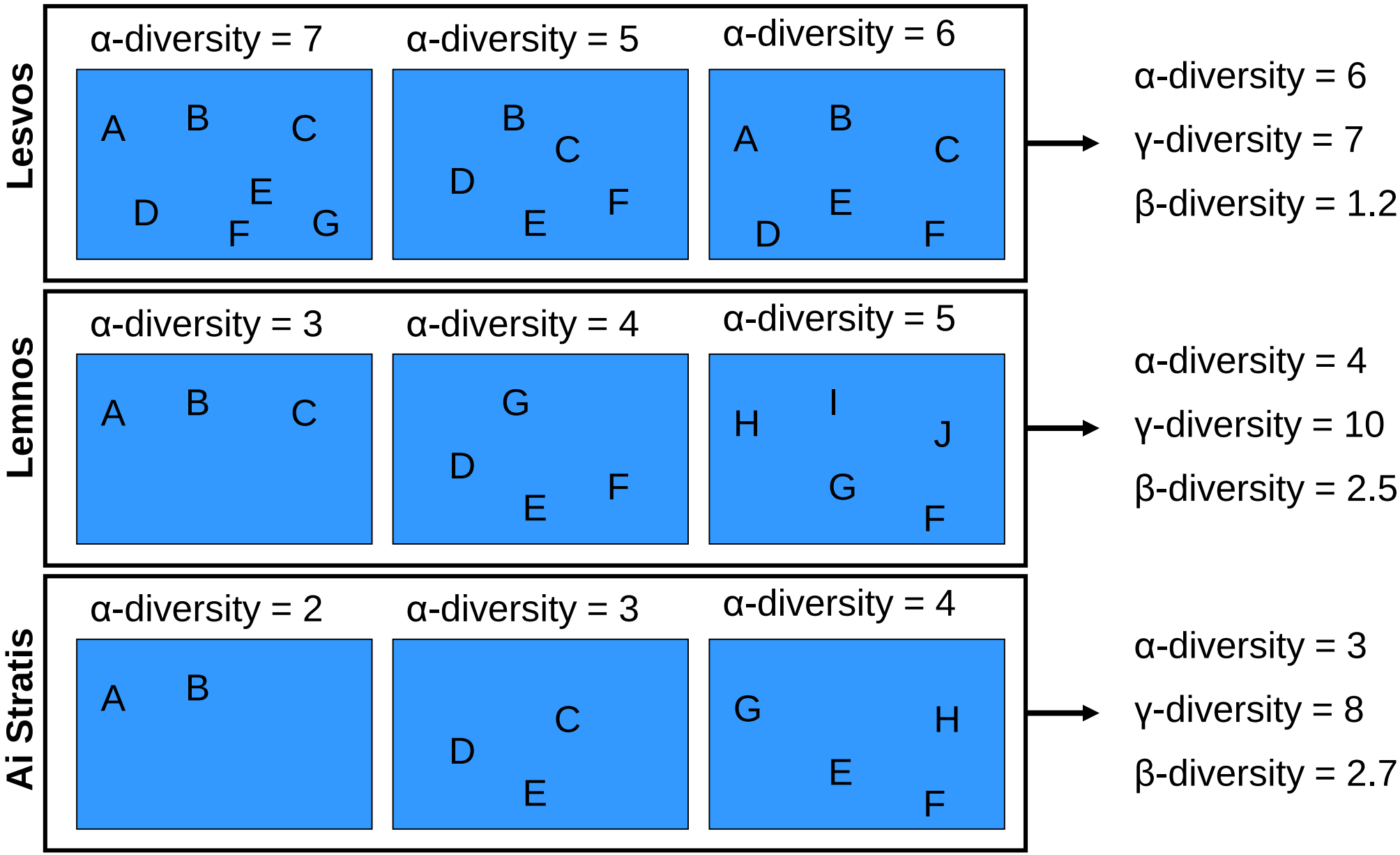
3 islands. Each island has 3 candidate marine sites for protection. Find **a)** the site with the highest species richness, **b)** the island with the highest species richness, **c)** the island with highest spatial uniqueness in species composition.



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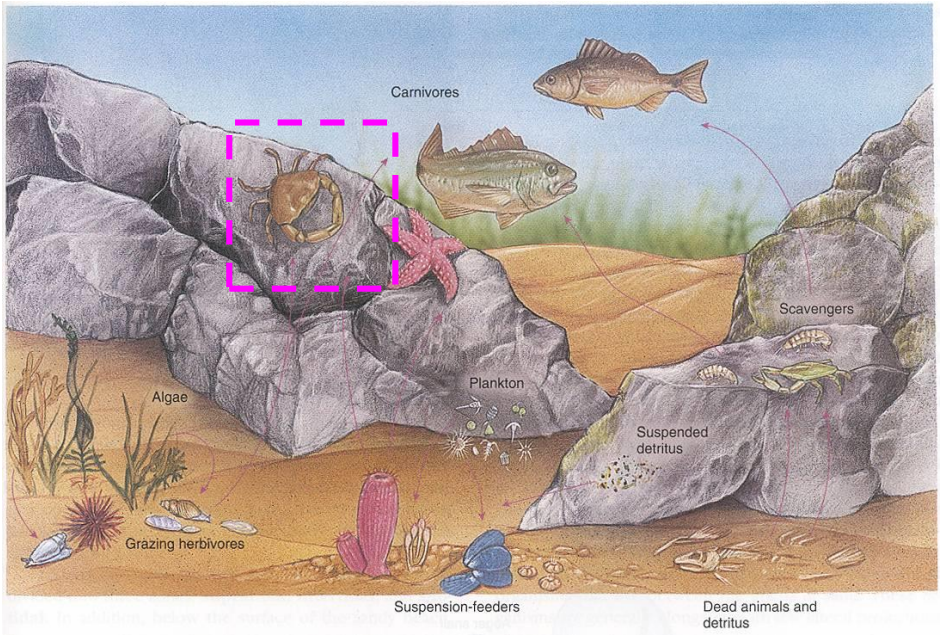
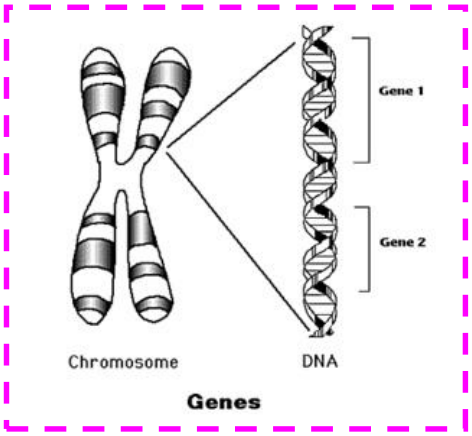
# • Genetic diversity

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



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# • Genetic diversity

**Genetic diversity** is the diversity of genes found within a species.

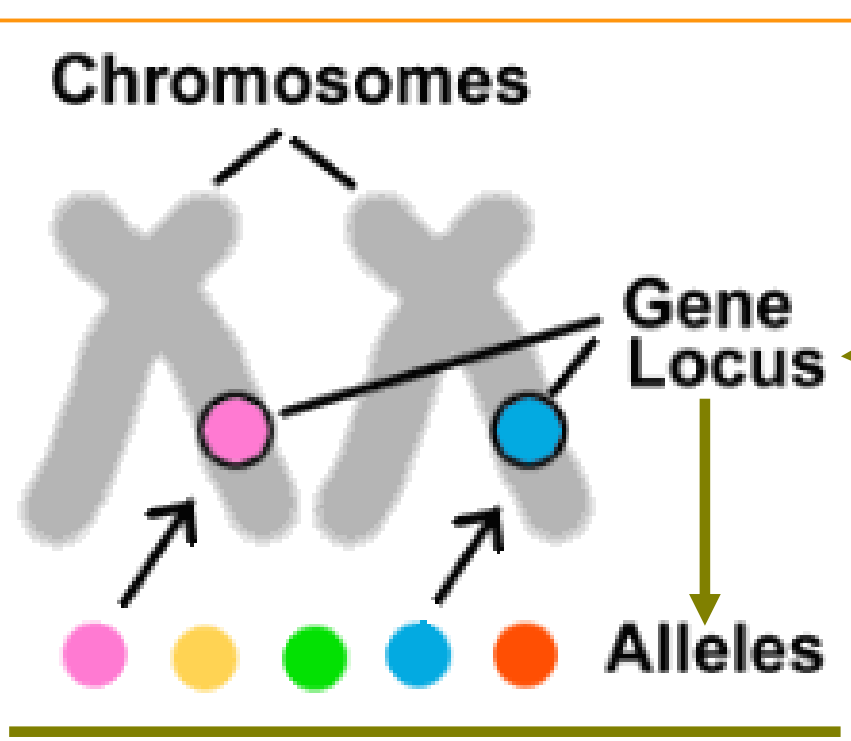
• It is the result of the recombination of genes and alleles during the reproduction process.

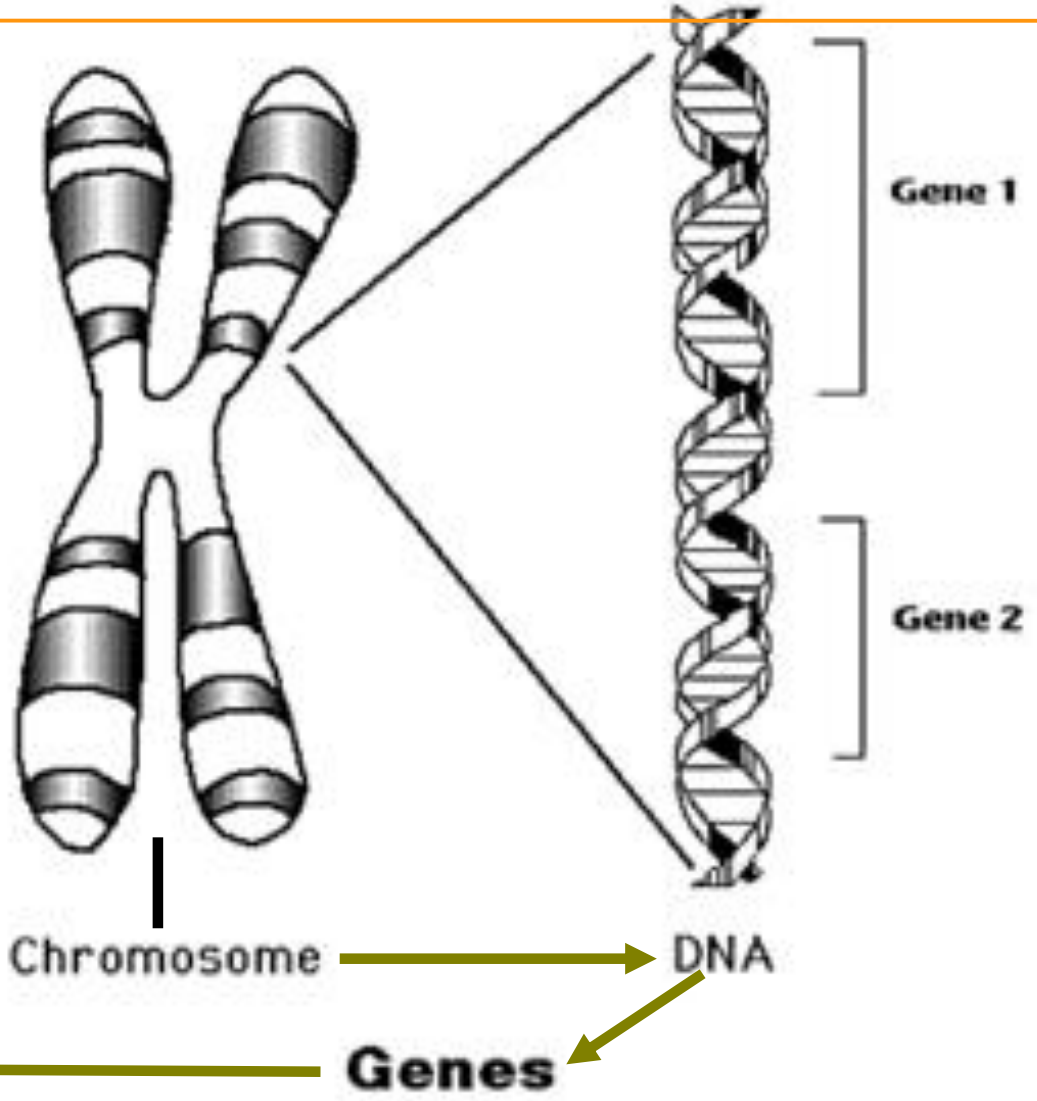
• Genetic diversity exists both at the individual level and at the population level.

**Population** is a group of individuals found within a specific area which can reproduce offsprings.

• A species may have more than one populations (sub-populations) which have several genetic differences. But the individuals of the same population may also present genetic differences.

# • Genetic diversity




**Genes** [γονίδια]
• The functional units of DNA

**Alleles** [αλληλόμορφα]
• Different versions of a gene [γονίδιο].
• Allele diversity is responsible for differences in growth and physiology of an individual, and affect its adaptability (ability to survive and reproduce).

# • Genetic diversity

**Mutations** [μεταλλάξεις]

Different alleles are created by mutations.

~ A mutation is a change in the DNA sequence (structure), either due to a mistake when DNA is copied or as a result of environmental factors.

~ Mutations are a source of diversity.

**Genotype** is the specific combination of alleles witin an individual.

The **phenotype** is the expression of the genotype in the morphological, physical, anatomical and biochemical characters of the individual.

**Gene pool** is the sum of genes and alleles within a population or a species.

# • Measuring biodiversity

**Biodiversity is defined at three levels:**

- ***Ecosystem diversity***

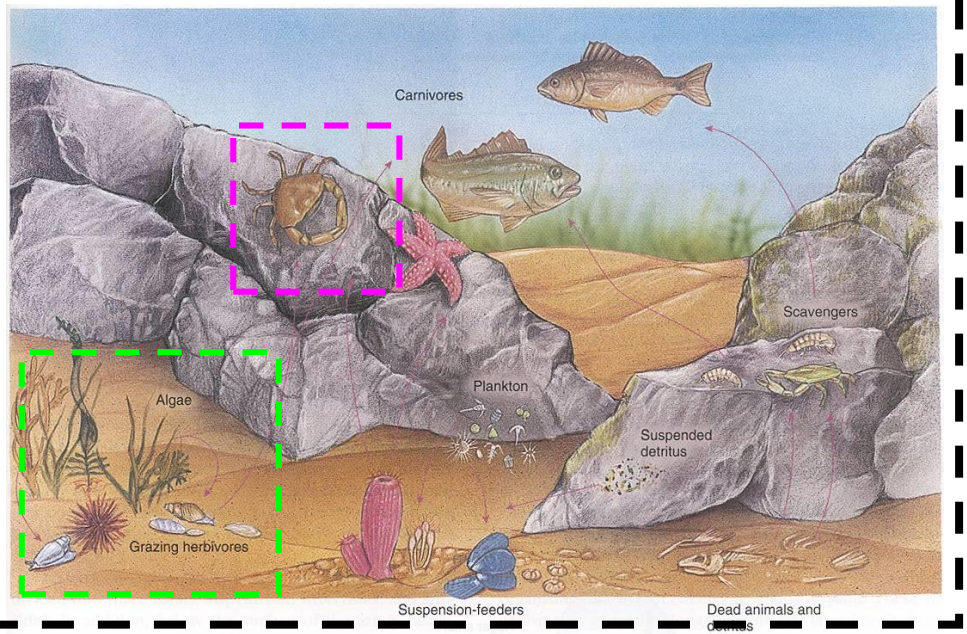
Next Lecture

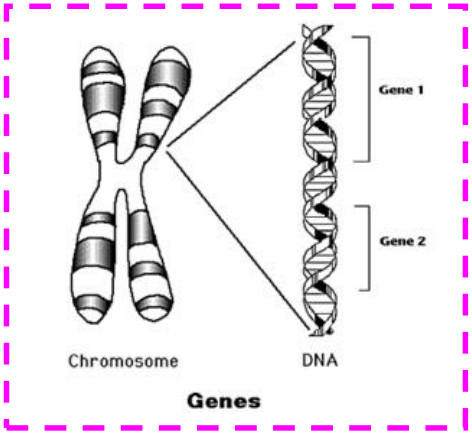
- ***Species diversity***

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]



# • Conservation Biology – Targets & objectives

***Conservation biology – Specific Aims***

- Halt / stop (σταματάω) biodiversity loss
- Reduce extinction risk (ρίσκο ή πιθανότητα ρίσκου)
- Maintain / conserve (διατηρώ) ecosystem health
- Restore (αποκαθιστώ) ecosystem health

**Problem**: Limited time / resources, conflicting interests

To achieve effective conservation we need to set specific **conservation targets & criteria**

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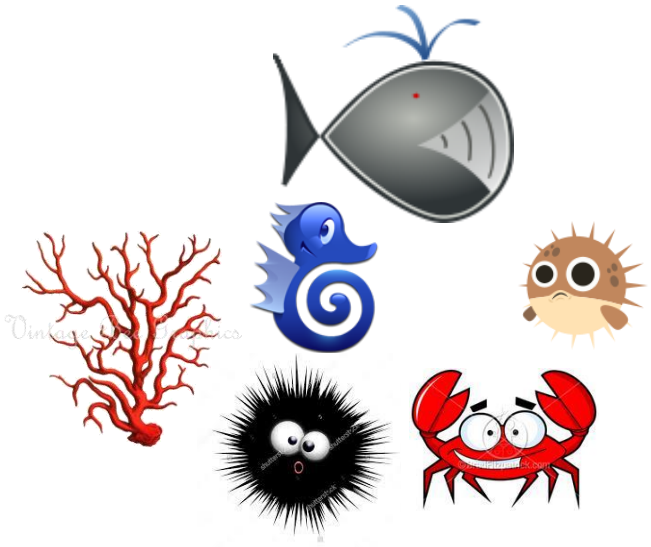


# Using species as the main criterion of conservation

• Using species as the main criterion of conservation

**Endemic** (Ενδημικά)

**Indigenous** (Αυτόχθονα)



**Allochthonus** (Αλλόχθονα)

**Invasives** (Εισβολικά)


# • Using species as the main criterion of conservation

**Ecosystem engineers** (μηχανικοί του οικοσυστήματος)

• Species that create, modify and maintain habitats (or microhabitats) by causing physical state changes in biotic and abiotic materials, and by modulating availability of resources to other species.

Affect the distribution and abundance of a large number of plants and animals, and significantly modify biodiversity.

• Using species as the main criterion of conservation

**Ecosystem engineers** (μηχανικοί του οικοσυστήματος)

~ **Allogenic (Αλλογενείς) engineers** – change the environment via mechanical activity

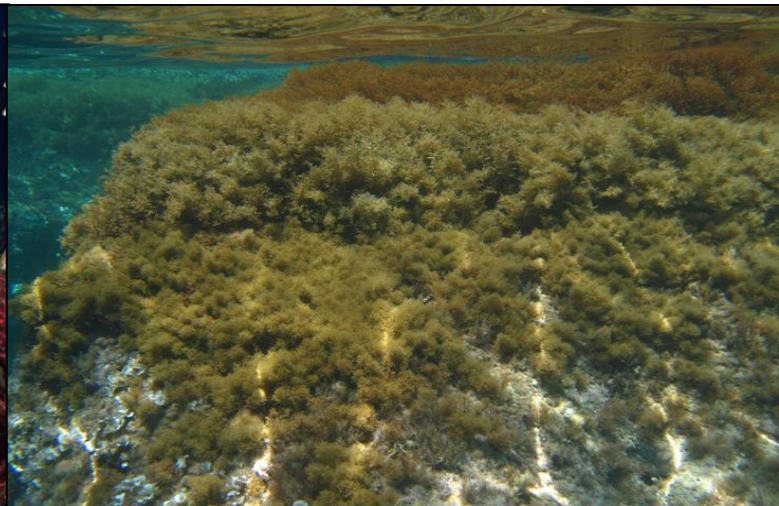
Examples: *Lithophaga lithophaga,* polychaetes, beavers, ants, woodpeckers.

Best known example: *Homo sapiens!*

~ **Autogenic (Αυτογενείς) engineers** or **Foundation species (Ιδρυτικά είδη)** – change the environment via their own physical structure

Examples: trees, corals, kelps, *Cystozeira* spp.





# • Using species as the main criterion of conservation

**Keystone species** (Θεμελιώδες είδος)

• A species which has a disproportionately (δυσανάλογο) **large effect on its environment relative to its abundance** (αφθονία).

• Play a critical role in **maintaining the structure** of an ecological community

• **Affect the numbers** of other organisms in the ecosystem

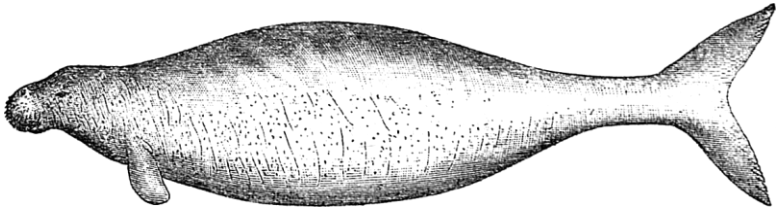
•They are commonly predators

•The loss of such a species results to a collapse in ecosystem function, as well as the loss of coexisting species.

Examples:
**sea otters** (βίδρα/ενιδρύδα) that prey on sea urchins

# • Using species as the main criterion of conservation

**Example:** The case study of the **extinction of the Steller's sea cow** (*Hydrodamalis gigas*) through its interaction with sea otters, sea urchins, and kelp.

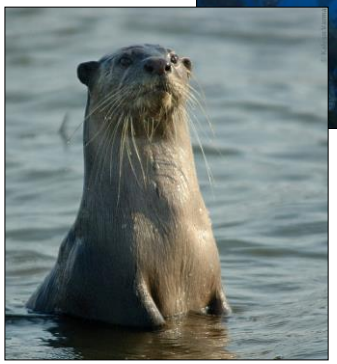


***The background***

- Kelp beds grow and form nurseries in shallow waters for other animals (e.g. sea cows)
- Sea urchins feed on kelps
- Sea otters feed on sea urchins

***The story***

- The rapid decline of sea otters due to overhunting, led to increase of sea urchin populations.
- Sea urchins grazed unrestricted on the kelp beds and the ecosystem collapsed.
- Sea urchins destroyed the shallow water kelp communities that supported the Steller's sea cow's diet and hastened their dissappearance.



Which is the keystone species here & why?

Answer: The sea otter

• Using species as the main criterion of conservation

**Critical link species** (Συνδετικά είδη)

• Species which play an important role in supporting a network of species by functioning as:
  ~ Pollinators (επικονιαστές)
  ~ Nutrient circulators (κυκλοφορία θρεπτικών)
• Nutrients in the sea are usually circulated through
  ~ currents, upwelling

**Darwin's paradox**

**OR**

**The coral reef paradox**

• Using species as the main criterion of conservation

**Darwin's paradox OR the coral reef paradox:**
"Thriving in a marine desert"

One of the **most productive & diverse** systems of the world occurs in some of the **most oligotrophic areas of the world**. How is this possible?

The sponge loop:

- Sponges are filter-feeders
- Intake – DOM dissolved organic matter
- Export – POM (i.e. sponge cells as detritus)
- Sponges provide food for reef fauna

# • Using species as the main criterion of conservation

**Indicator Species** (Είδη δείκτες):

• A species that is very sensitive to environmental change

• **Indicator species** have a narrow set of ecological requirements [στενό φάσμα οικολογικών απαιτήσεων]

• They are affected almost immediately by **change** (αλλαγή) in the surrounding environment, and can give **early warning** (προειδοποίηση) that a habitat is under stress

• Change that is hard to observe, e.g. water pollution, or climate change first become apparent in indicator species

• Therefore, they are useful targets for observing the health of an ecosystem.

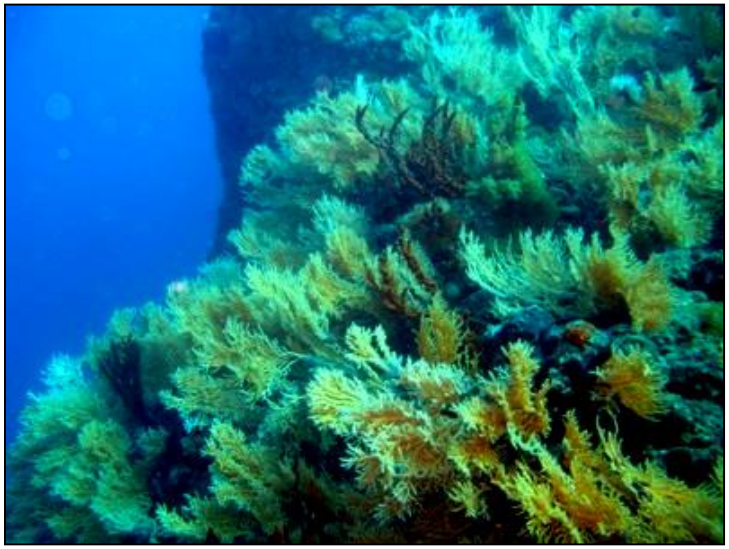
It is generally recommended that **multiple indicators** should be monitored for effective conservation

- Using species as the main criterion of conservation

## Cabrera Island 2000-2007



## Lesvos Island 2010-2013



• Using species as the main criterion of conservation

**Umbrella species** (Είδη ομπρέλα):

• An umbrella species is an organism whose protection indirectly results to the protection of many other species found in the community or habitat

The Panther is an Umbrella Species; when we protect the Panther, we protect all our neighbors! Credit: Steve Carboi

**Characteristics**:

• Wide-ranging species

• Home range usually covers multiple habitat types & ecosystems

• Equally or more sensitive to habitat changes to other species included in the habitat

Examples:
lions, tigers, panthers, whales, dolphins, sea turtles

**Conservation-related term**

Importance to conservation practices:

Used for making conservation-related decisions

Used for the selection of the location & minimum size of conservation areas

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# • Using species as the main criterion of conservation

**Flagship species** (Είδη-σημαία)

or **Charismatic species** (Χαρισματικά είδη)

• Species that have the ability to capture the imagination of the public

- Beautiful & popular
- Serve as symbols
- Stimulate conservation awareness & action
- Induce people to support conservation actions & donate funds




Examples: …..

Bengal tiger

Giant panda

Monk seal

Sea Turtles

RAC/SPA

# • IUCN categories

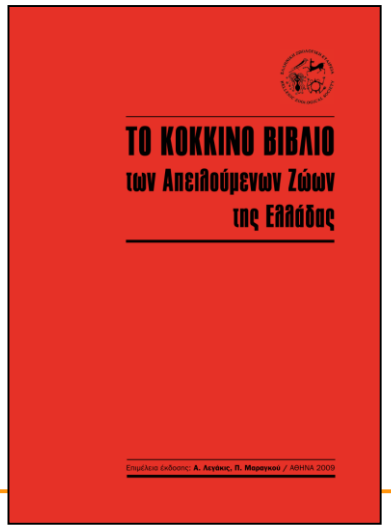
• The **International Union for the Conservation of Nature (IUCN)** developed a system to classify species according to their extinction risk.

• **An international conservation tool & a global index of biodiversity**

Specific aims of IUCN classification system:

- Provide specific guidelines that allow
  a) Consistent application by different people
  b) Ability to evaluate different factors that affect the **risk of extinction**
  c) Facilitate comparisons across different taxa

• Updates on the status of species conservation through its **Red List & Red Books**

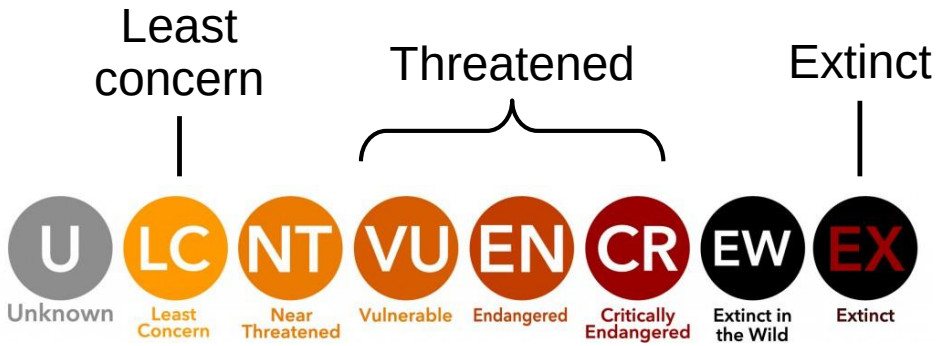




IUCN RED LIST

**www.iucnredlist.org**

# • IUCN categories

**(EX) Extinct** – No known individuals remaining.
**(EW) Extinct in the wild** – Known only to survive in captivity, or as a naturalized population outside its historic range.
**(CR) Critically endangered (CR)** – Extremely high risk of extinction in the wild
**(EN) Endangered** – High risk of extinction in the wild
**(VU) Vulnerable** – High risk of endangerment in the wild
**(NT) Near threatened** – Likely to become endangered in the near future
**(LC) Least concern** – Lowest risk. Does not qualify for a more at-risk category. Widespread and abundant taxa are included in this category
**(DD)** Data deficient – More data is needed !!! (Attention….Why?)




IUCN RED LIST©
www.iucnredlist.org

# • IUCN criteria

Main criteria: ……

- **Geographic range** & countries of occurrence:
  - ~ characterization based on native / allochthonous, threatened / extinct

- **Population size** & population trend:
  - ~ population increasing or decreasing, number of mature individuals, population connectivity

- **Habitat & Ecology**
  - ~ habitat requirements & reproductive rate (ρυθμός αναπαραγωγής)

- **Threats**
  - ~ natural or anthropogenic

- **Conservation actions**


• Using species as the main criterion of conservation

**Taxonomic groups that do not receive the same degree of social attention** or attract funds as the vertebrates. These include:

**Fungi** (μύκητες & λιχίνες) - As mycorrhizal symbionts, decomposers and recyclers, fungi are essential for sustainability of forests.

**Invertebrates** (ασπόνδυλα) & particularly insects (έντομα) - The value of insects in the biosphere is enormous because they outnumber all other living groups in measure of species richness However: in their majority they are conceived as aesthetically 'unpleasant' creatures.

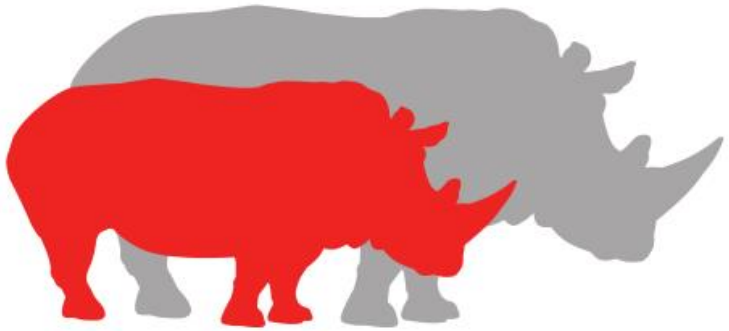
**Plants** create habitats that support the vast majority of biodiversity. The greatest bulk of biomass on land is found in plants which provide important food source.

• Using species as the main criterion of conservation

Nature's backbone

## Vertebrates

61%



Assessment Goal 61,635
Species Assessed 39,727 (2015)
Described Species 64,788

**Assessed versus described species**

An estimated 99% of all organisms are

## Invertebrates

1.2%

Assessment Goal 45,344
Species Assessed 17,408 (2015)
Described Species 1,359,365

The Earth's lungs

## Plants

6.5%

Assessment Goal 38,521
Species Assessed 20,185 (2015)
Described Species 310,129

The most under-researched and under-funded

## Fungi and other species groups

0.01%

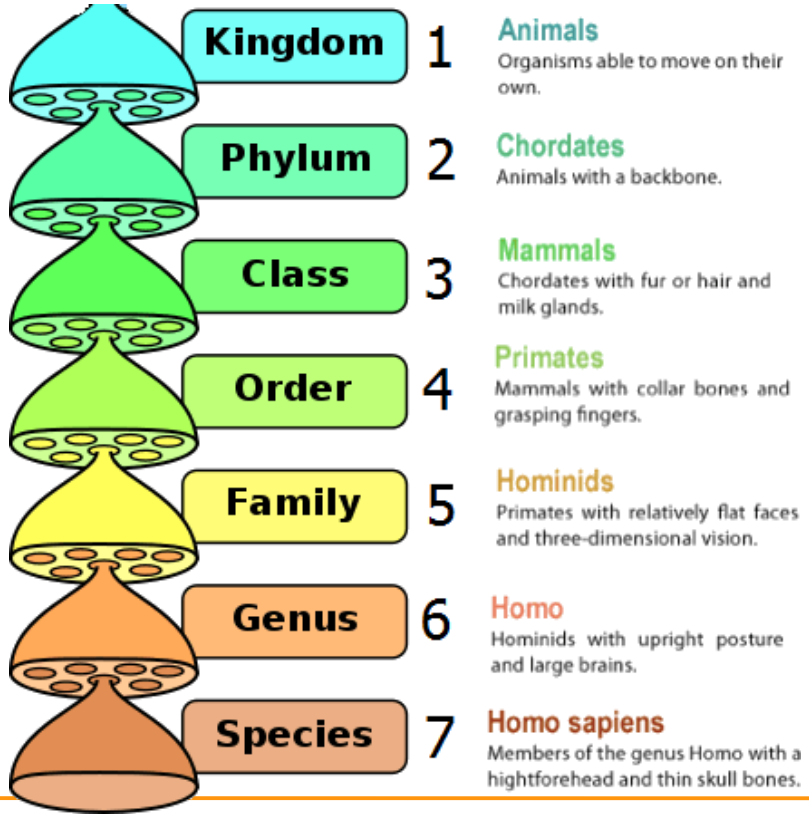
Assessment Goal 14,500
Species Assessed 20 (2015)
Described Species 165,305

• Using species as the main criterion of conservation

## How many species are there in the world?

*"Knowing how many plants and animals there are on the planet is absolutely fundamental."*

*"Without this knowledge, we cannot even begin to answer questions such as **how much diversity we can lose while still maintaining the ecosystem services that humanity depends upon**."* - Bob May, Oxford University, UK - May RM (2011) PLoS Biol 9(8): e1001130




**Taxonomic classification of life**

**Mora C, Tittensor DP, Adl S, Simpson AGB, Worm B (2011) How Many Species Are There on Earth and in the Ocean? PLoS Biol 9(8): e1001127.**

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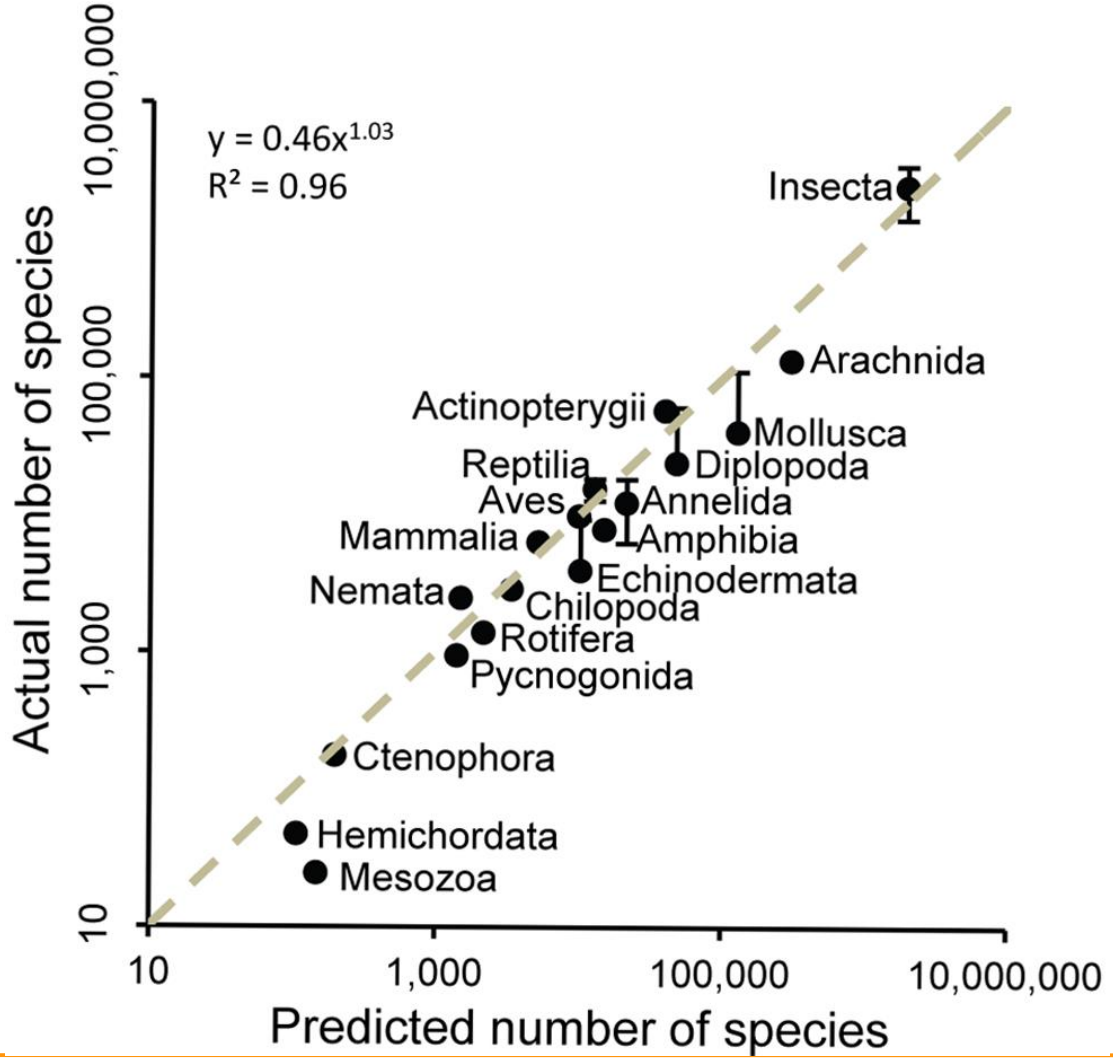


~ After 250 years of taxonomic classification **more than 1.2 million species** have been catalogued in a central database.

**Prediction:**

~ 8.7 million eukaryotic species exist globally (±1.3 million SE).

~Out of which, 2.2 million (±0.8 million SE) are **marine**.

**Number of species not described yet:**

~ 86% of species on Earth

~ 91% of species at Sea


See you next week…