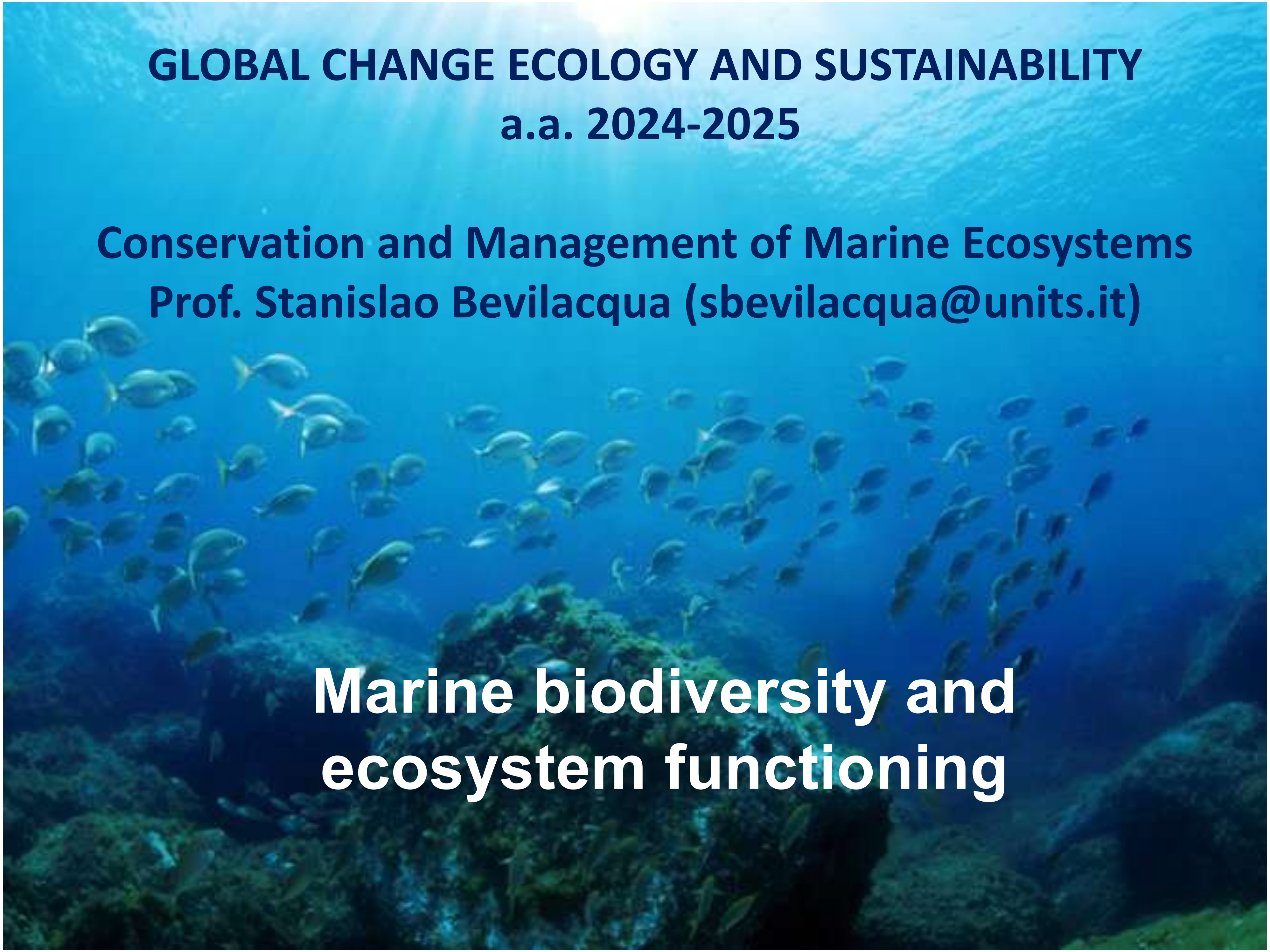


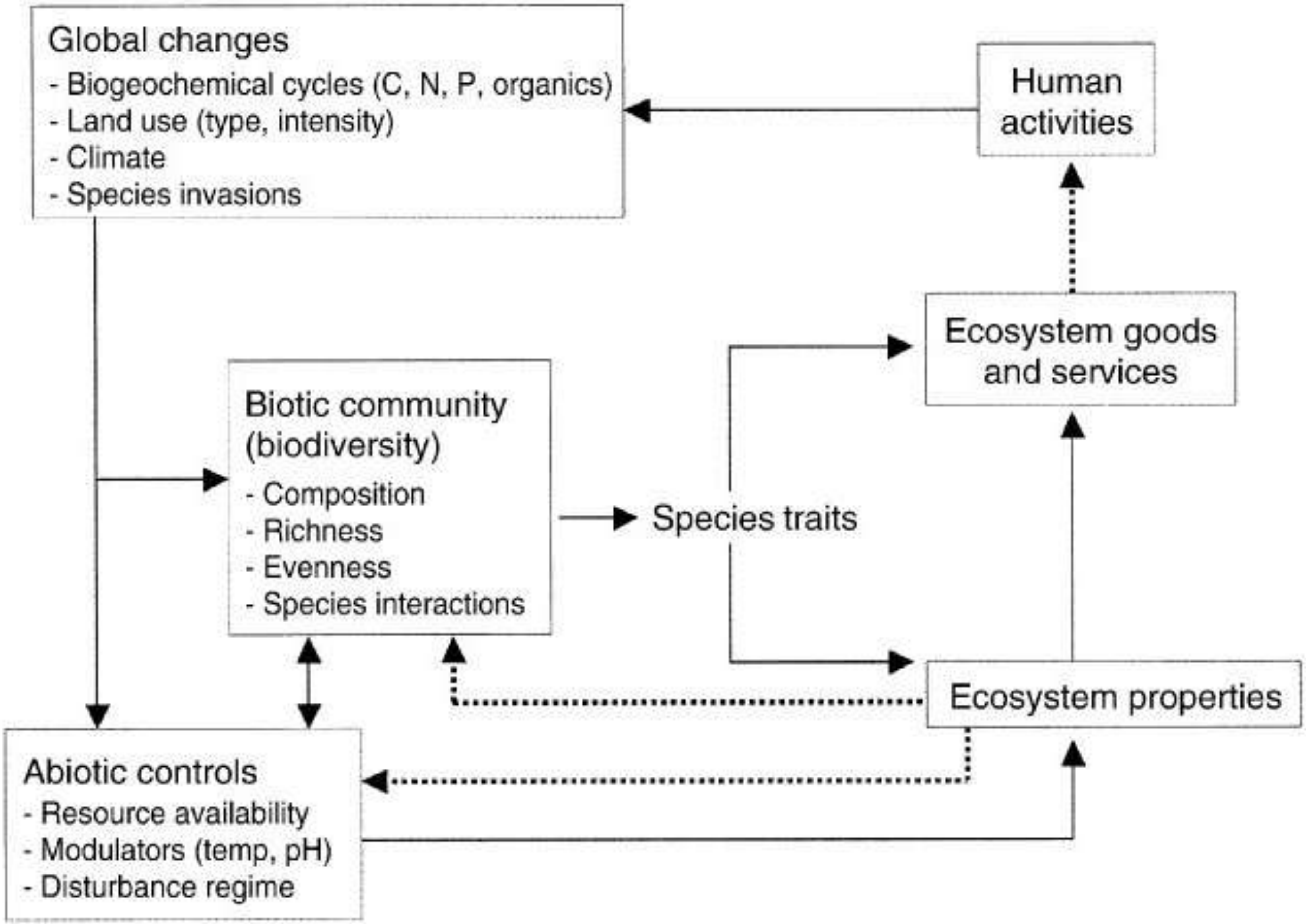
GLOBAL CHANGE ECOLOGY AND SUSTAINABILITY
a.a. 2024-2025

Conservation and Management of Marine Ecosystems

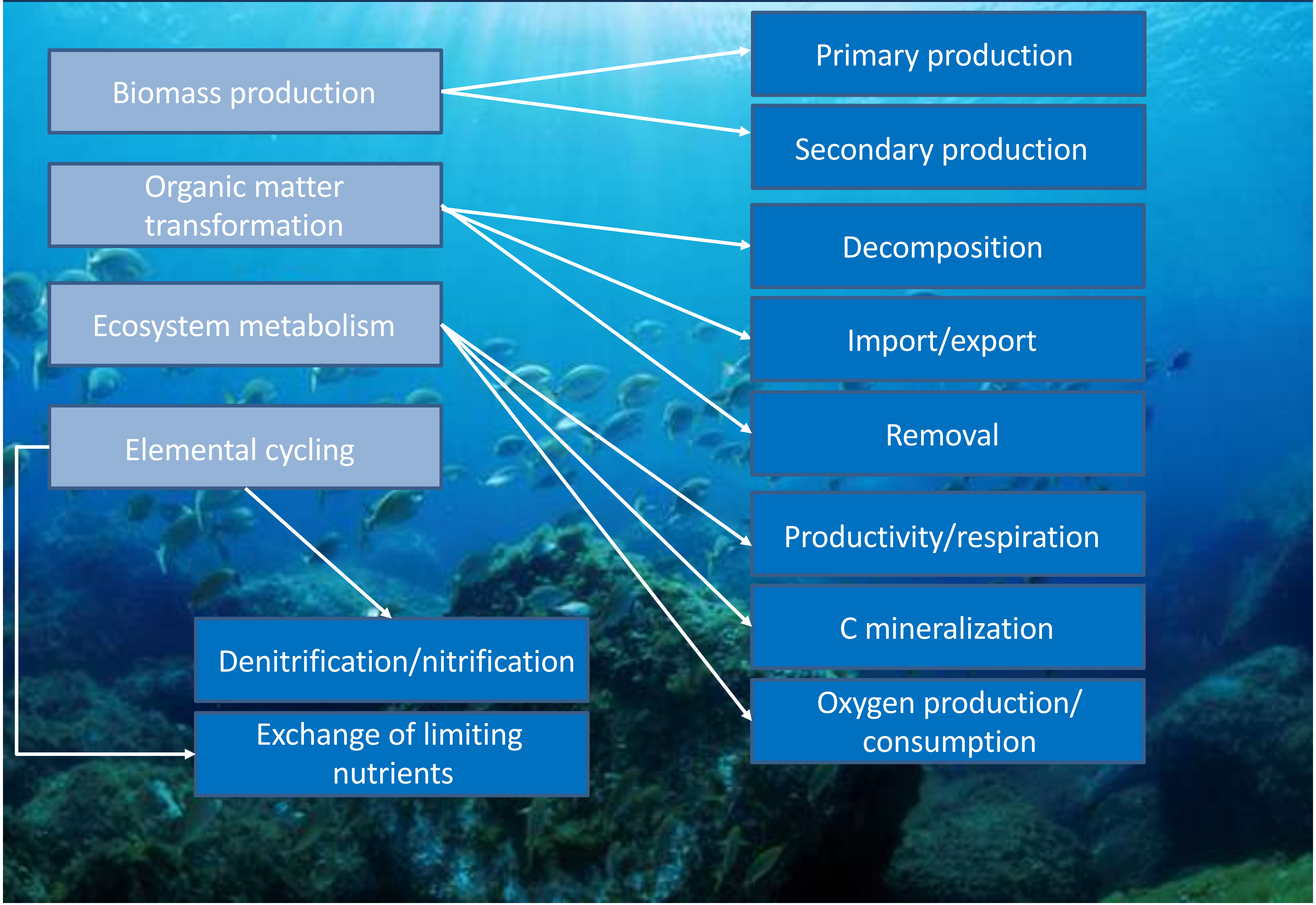
Prof. Stanislao Bevilacqua (sbevilacqua@units.it)

Marine biodiversity and ecosystem functioning

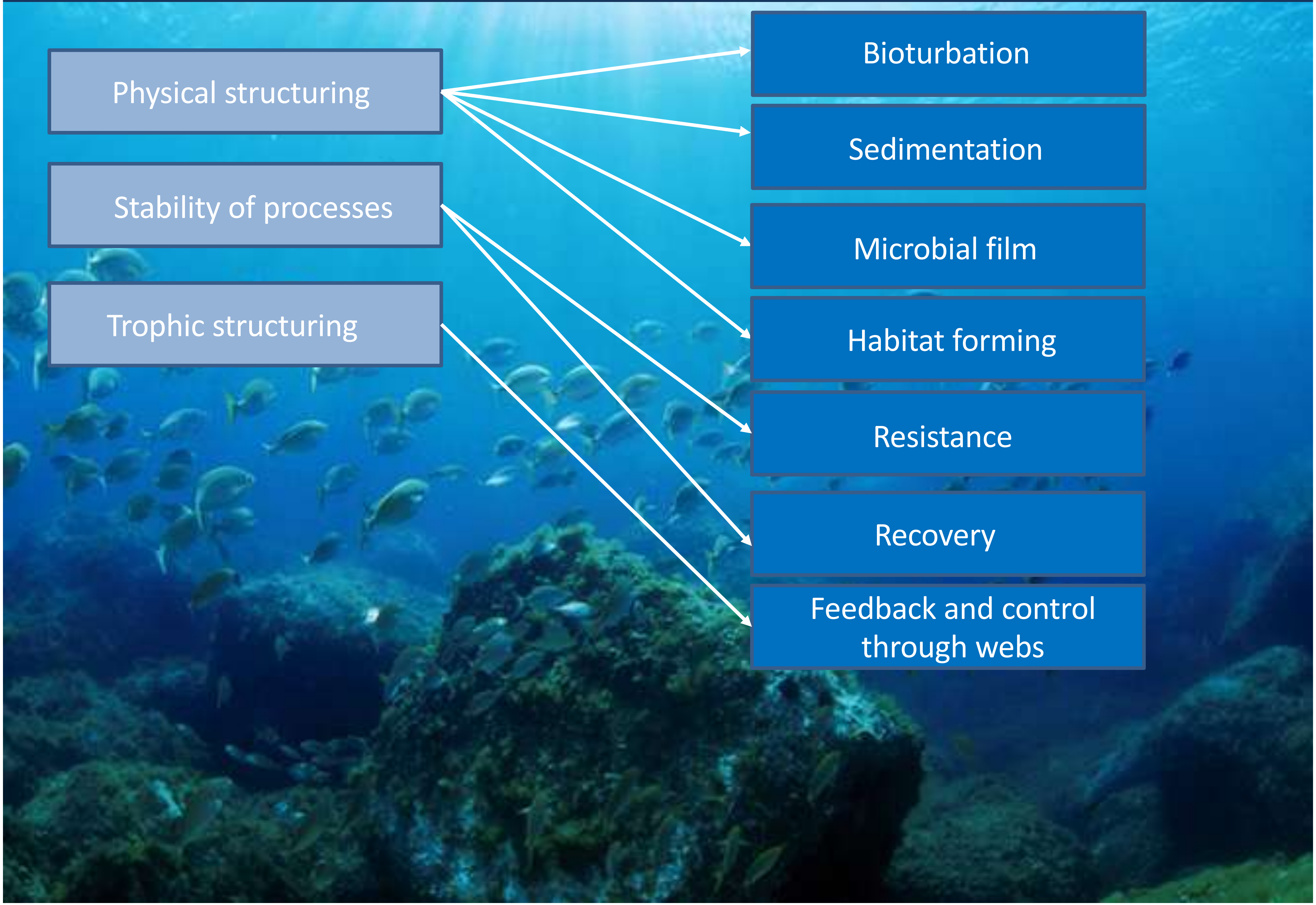
Ecosystem functions: mechanisms



Ecosystem functions



Ecosystem functions



Functional traits, functional roles

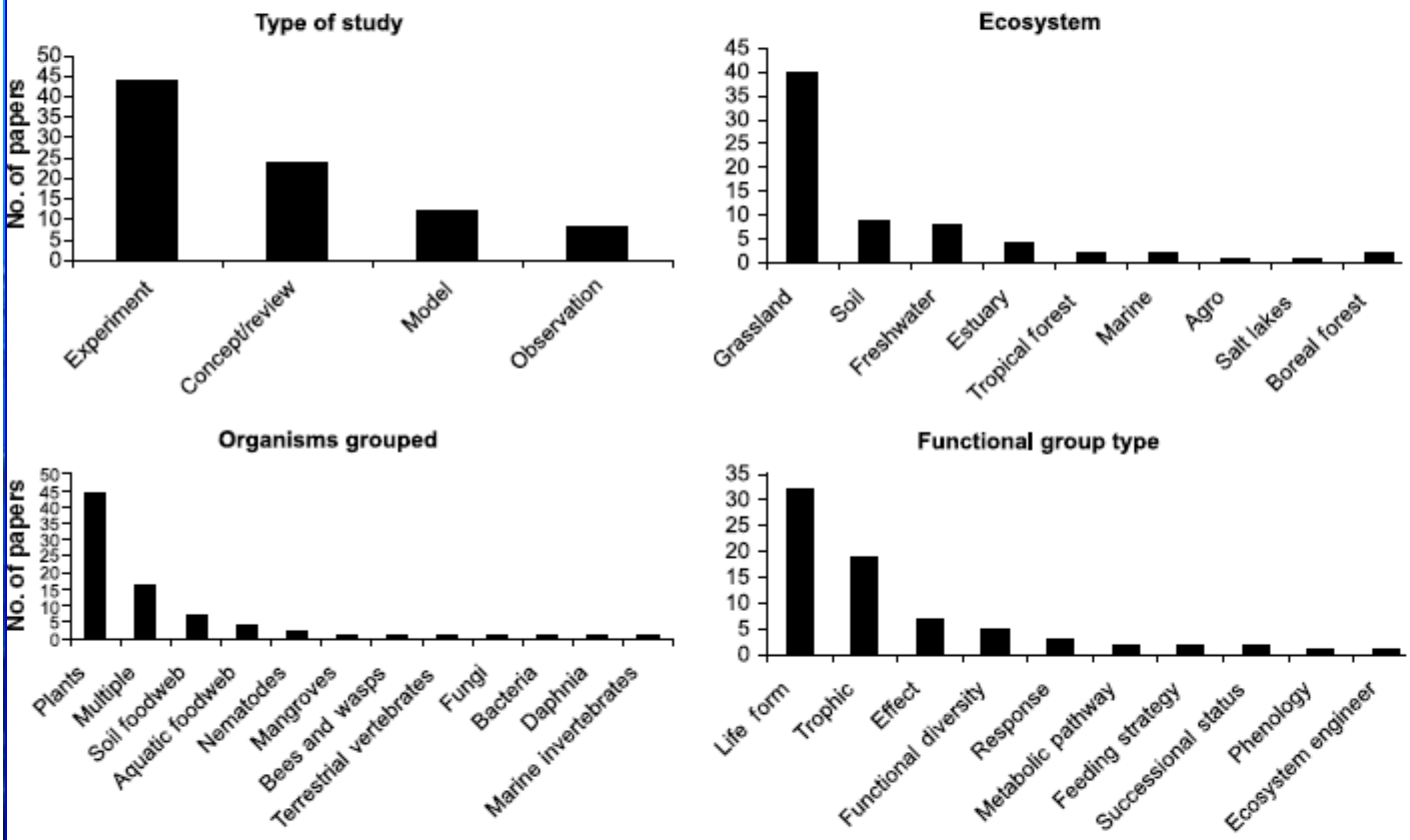
- Ecosystem functioning depends on the interplay between environmental processes and biological components. This last part is regulated by species features (phenotype, behaviour, life cycles, biochemical pathways, trophic role and all others traits identifying species).

- All functions are mediated by species abundance, so that the magnitude of related functional processes may be proportional to abundance. However, for some species, important processes may be exerted even at low abundance (ex. keystone predators)

- Functional traits may vary among individuals, and also depending on the life stage, or environmental or geographic contingencies.

All these factors complicate our understanding of functioning. In the marine realm, moreover, the limited knowledge of species, and particularly of invertebrates, further hampers our ability to study how species affect functioning of marine systems.

Limited studies in the marine environment



Redundancy (?)

Are all species unique in term of their contribution to the overal functioning? Or are there “replicated” functions (redundancy)?

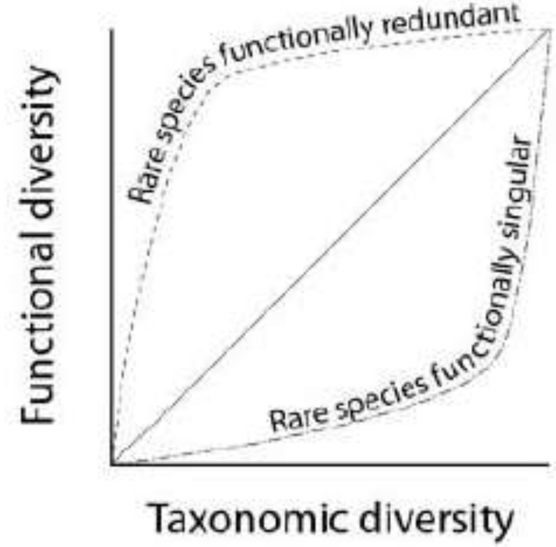
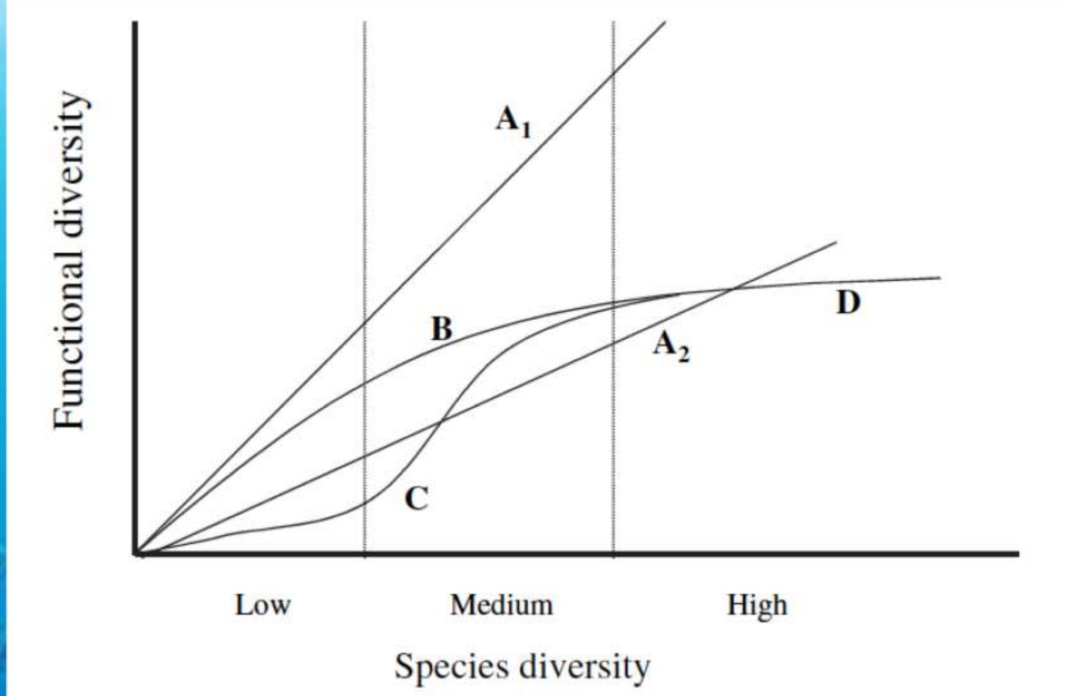
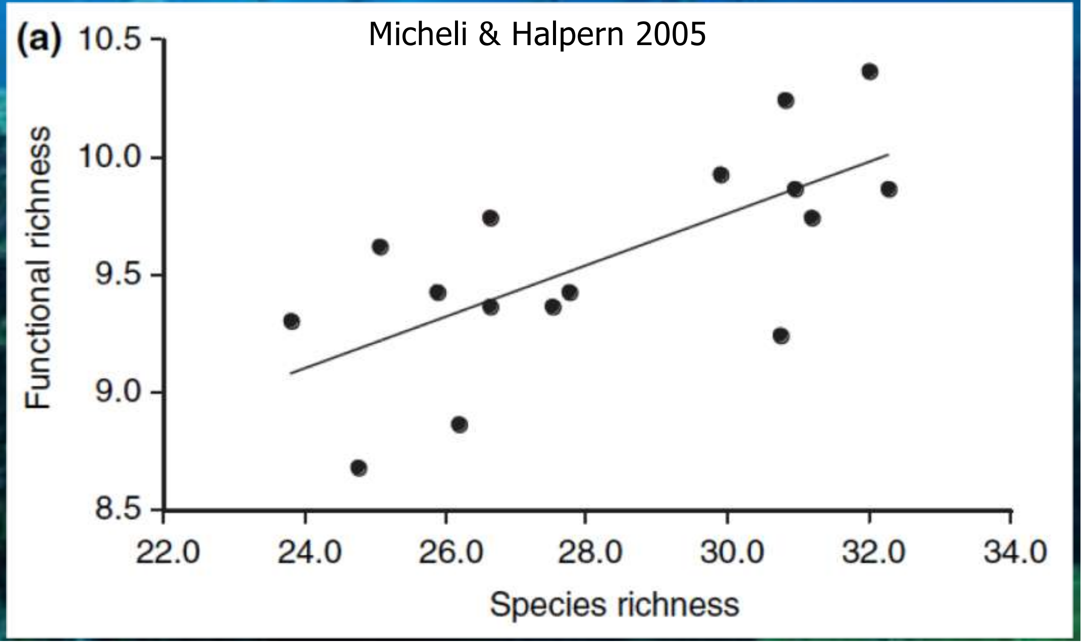


Figure 2 The relationship between taxonomic and functional diversity. Three possible relationships are shown. The top (dashed) line shows the relationship when rare species are functionally redundant. The middle, straight line (continuous) shows the relationship when every species contributes to functioning and is equally abundant. The third relationship (bottom, dash-dot) shows the relationship when rare species carry unique functional traits.

However, redundancy strongly depends on the approach used to group species, or to define traits





Biodiversity and ecosystem functions

- **Facilitation**

Facilitative interactions among species could lead to increases in ecosystem pools or process rates as species or functional richness increase. Such facilitation could occur if certain species alleviate harsh environmental conditions or provide a critical resource for other species (improve functioning and enhance biodiversity)

- **Complementarity**

Complementarity results from reduced interspecific competition through niche partitioning. If species use different resources, or the same resources but at different times or different points in space, more of the total available resources are expected to be used by the community

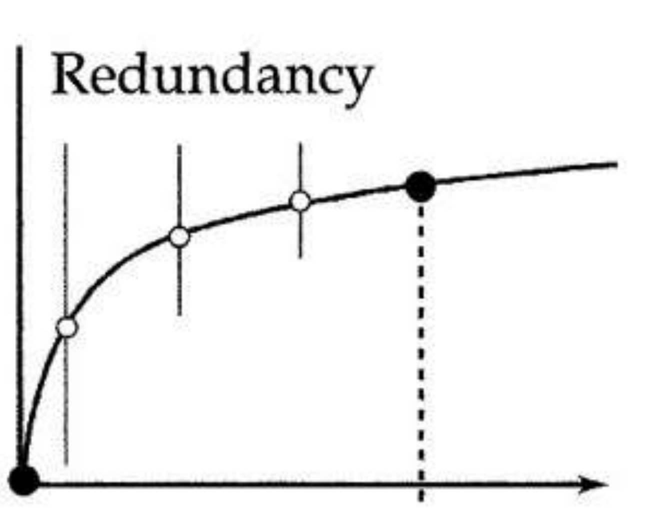
- **Sampling effect**

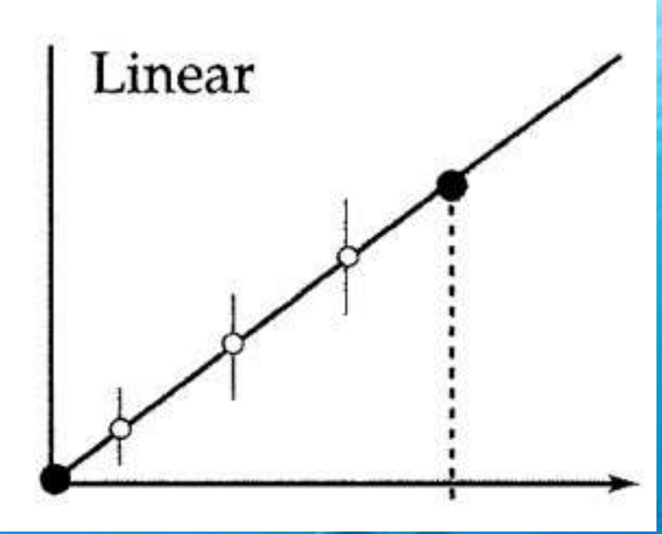
Increased probability of including species that best perform at a given condition

- **Portfolio effect on stability**

Portfolio effects derive from statistical averaging across the dynamics of system components. Increased ability to face perturbation, or compensating functional loss avoiding collapse.

Models of BEF relationships

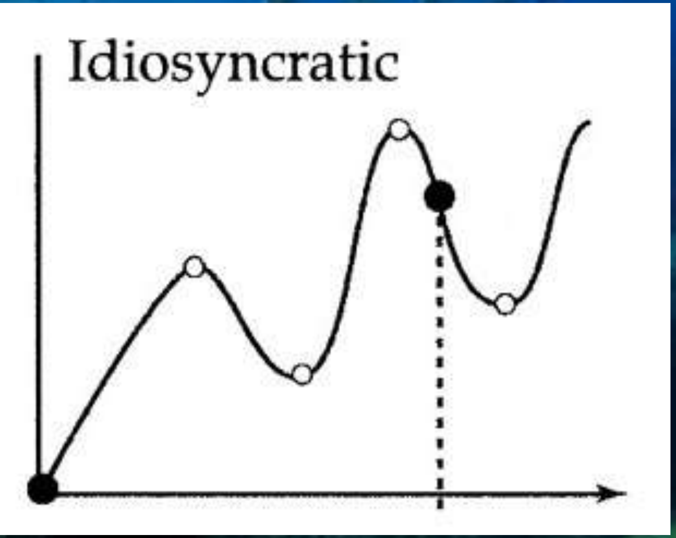




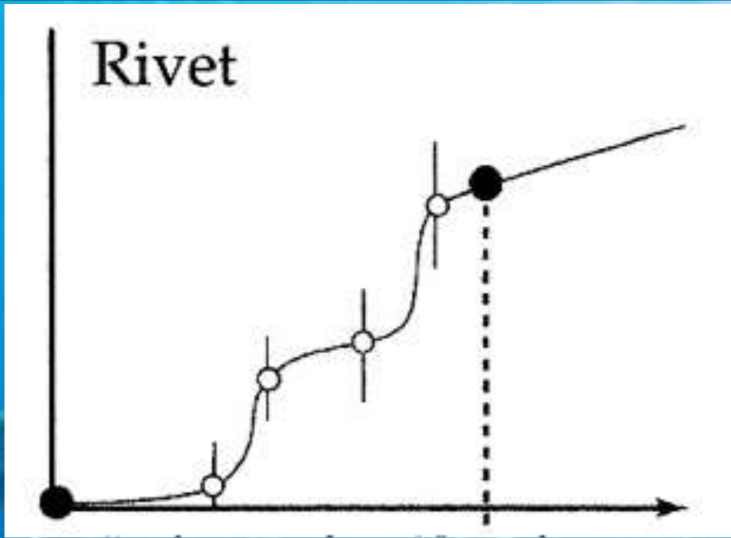
Species are primarily singular: loss or addition of species causes detectable changes in ecosystem process rates, i.e. species make unique contributions to ecosystem functioning.

Species are primarily redundant: loss of species is compensated for by other species with a similar function. Conversely, the addition of such species adds nothing new to the system.

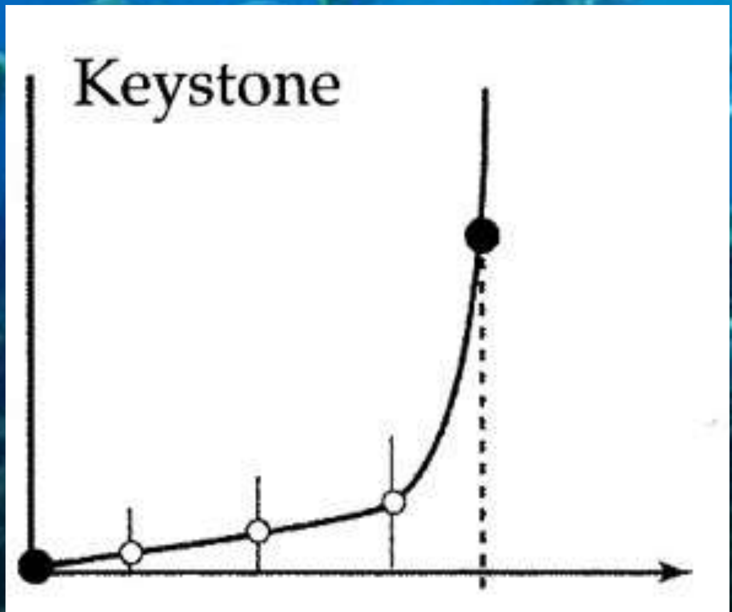
Species impacts are context-dependent and therefore idiosyncratic: the impact of loss or addition of species depends on environmental conditions and the species, and its interaction with the others (Lawton 1994)



Models of BEF relationships

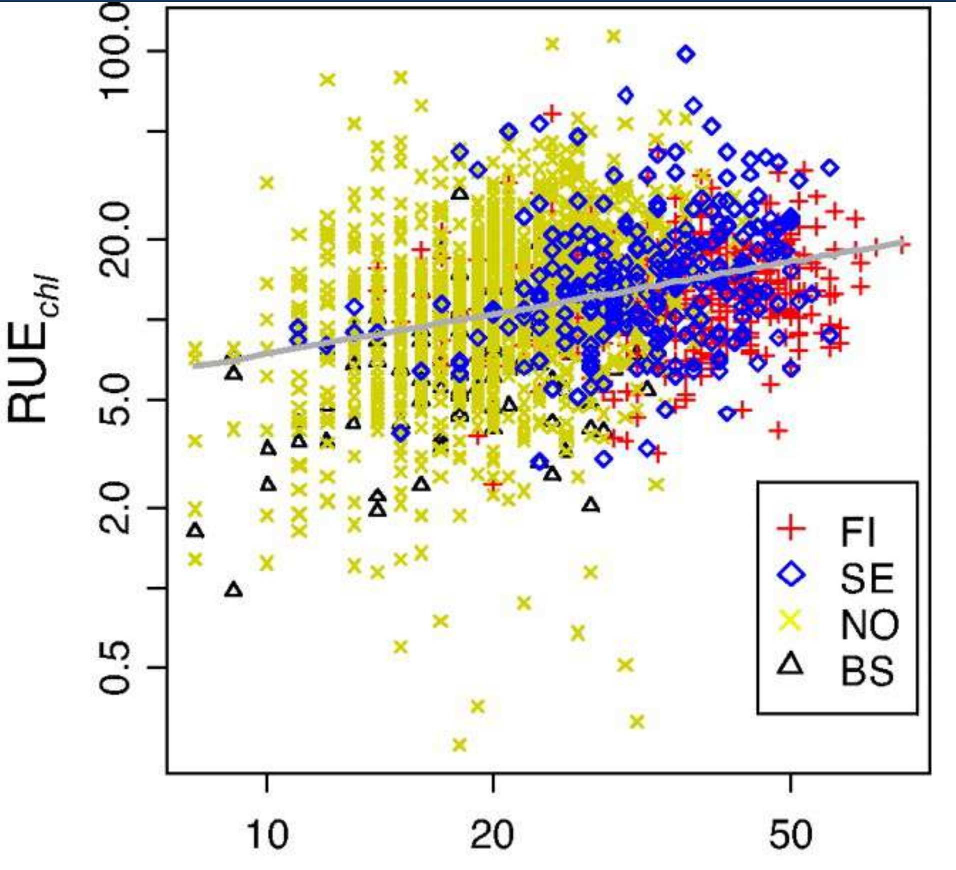


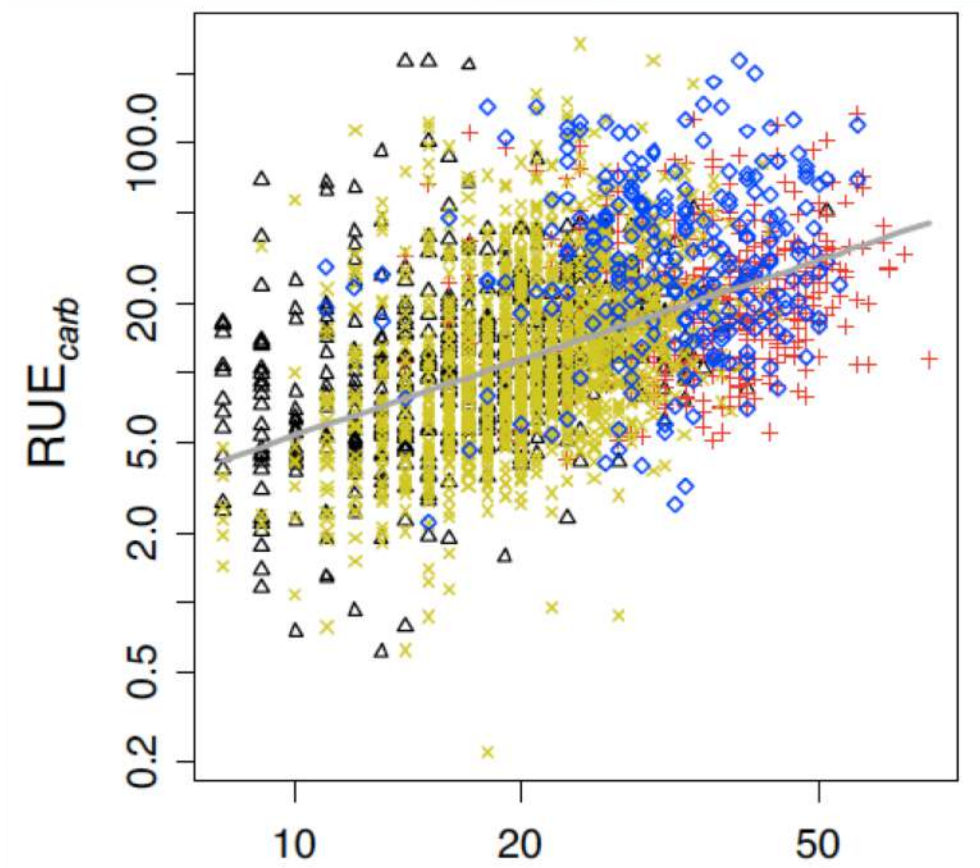
Loss of species could or could not have an impact on ecosystem processes. Species loss can be compensated for by other species with a similar function (redundancy). However, when all species with the same role are removed this causes a change in the system (Ehrlich & Ehrlich, 1981)



Some species is more important than others in causing changes in ecosystem processes, exerting a keystone role

Diversity and primary productivity





Diversity predicts stability and resource use efficiency in natural phytoplankton communities

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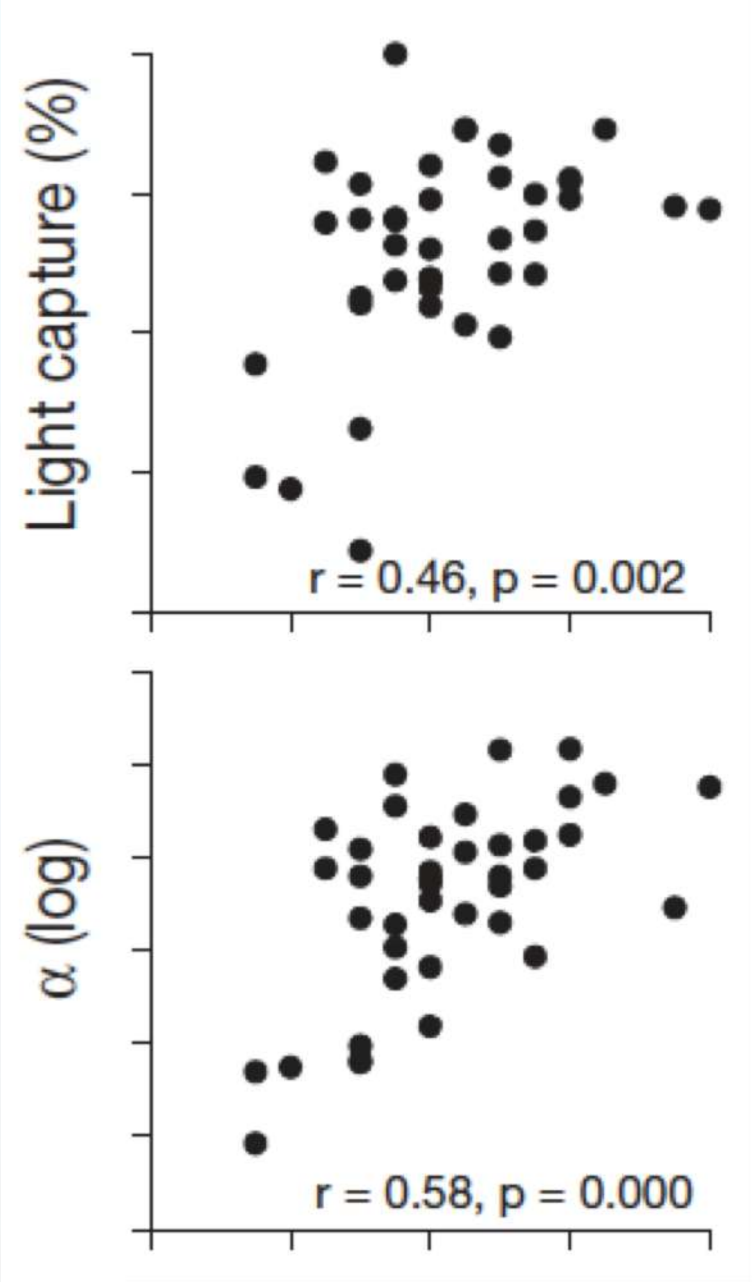
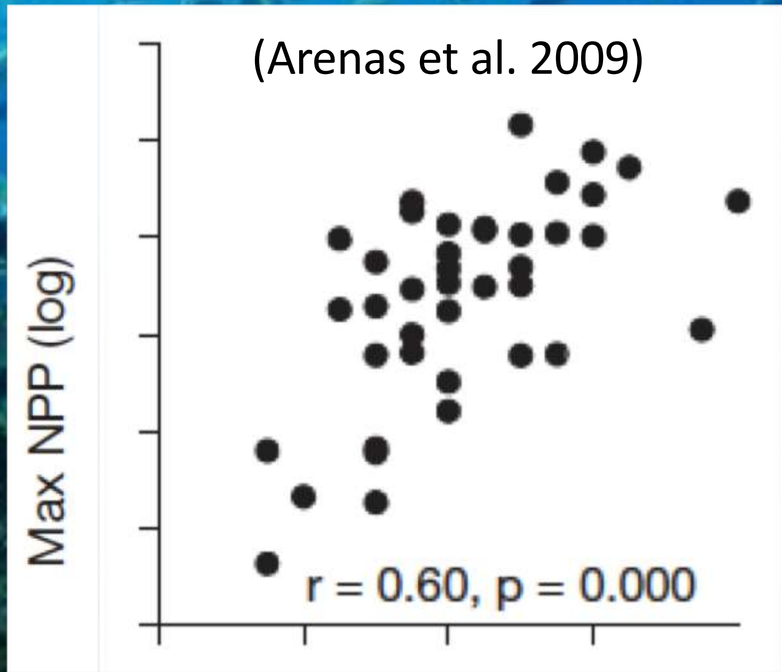
Diversity and primary productivity

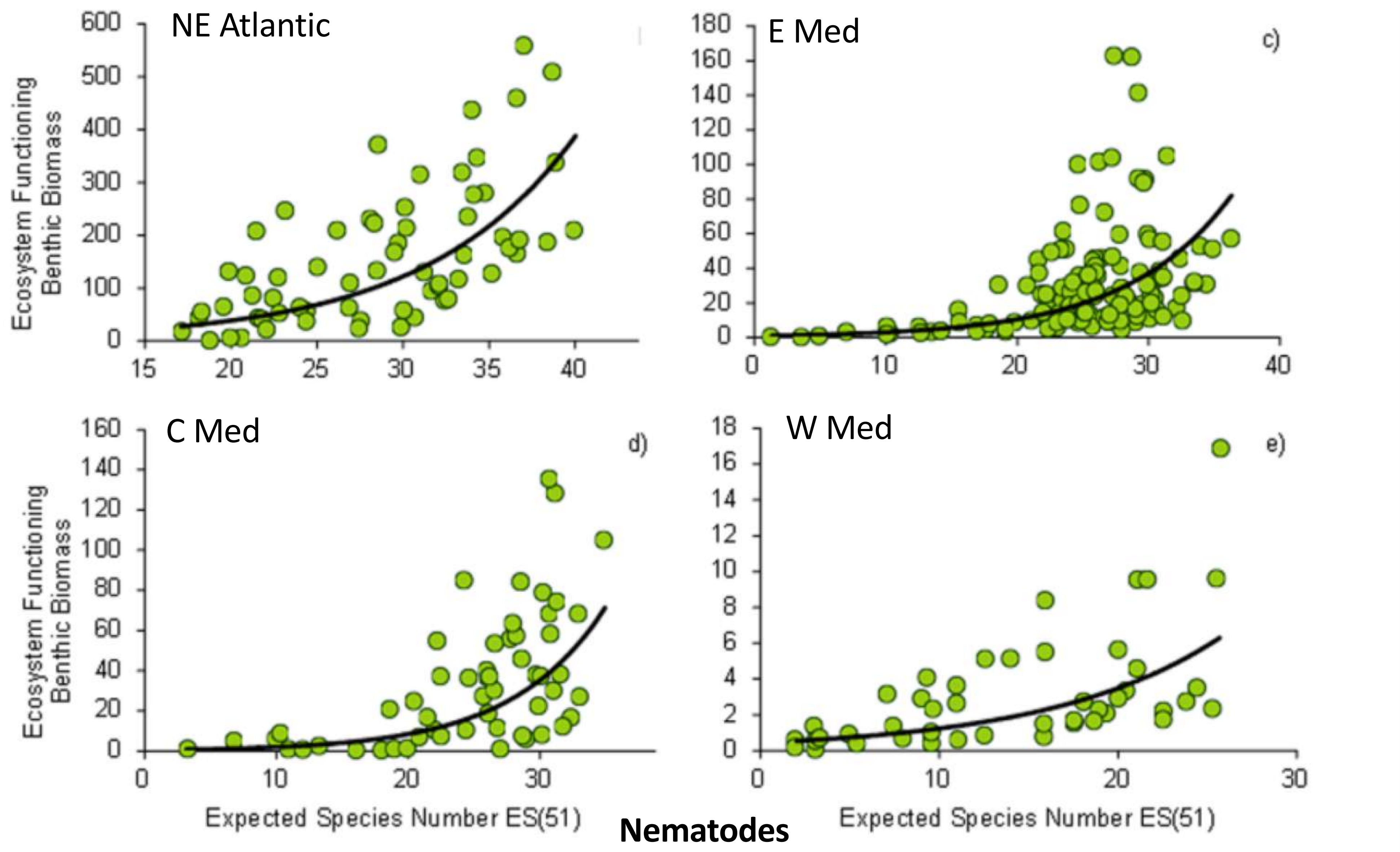


Positive relationships between species richness and light capture, photosynthetic efficiency and maximum net primary production in intertidal macroalgal assemblages



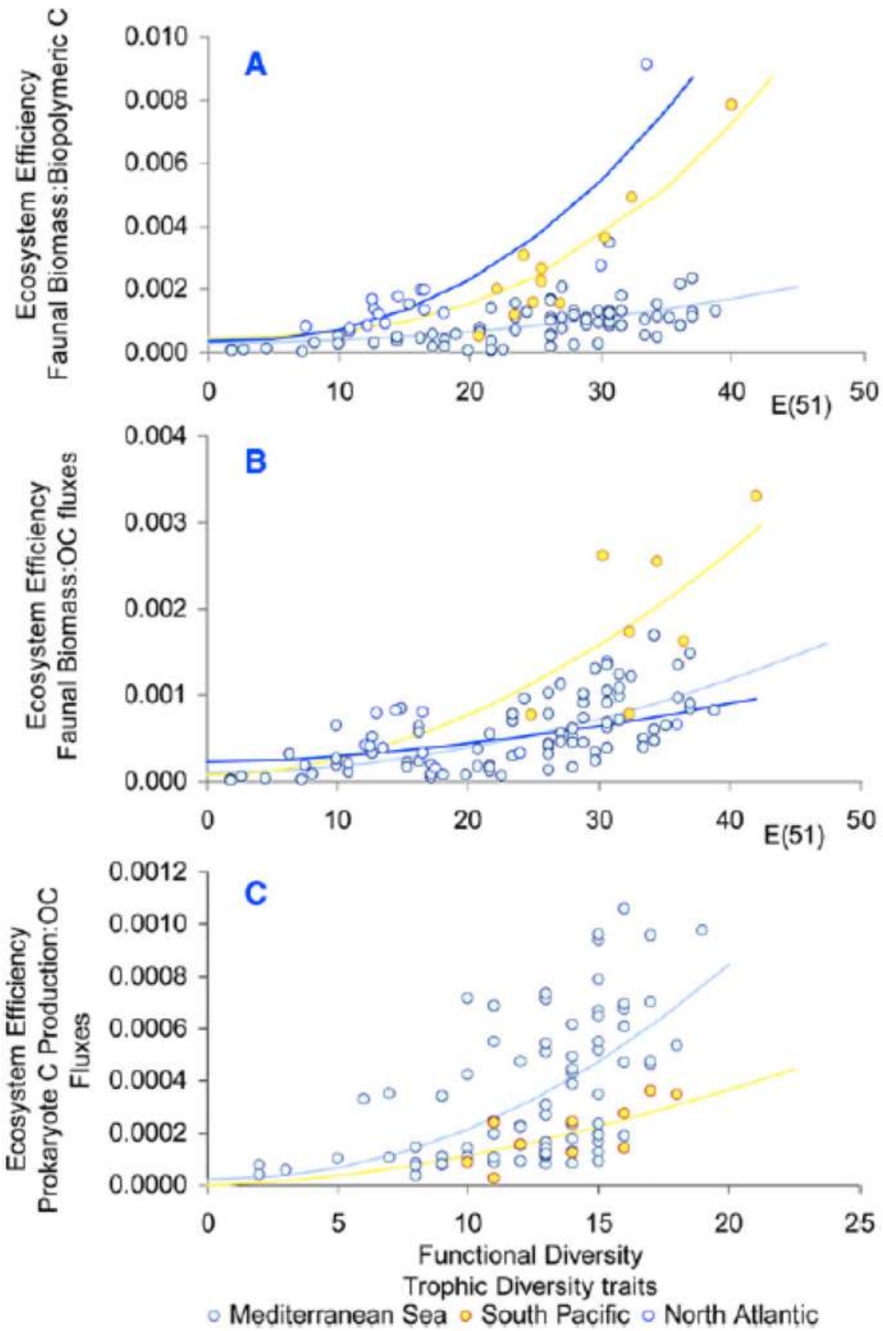
(Arenas et al. 2009)

Diversity and secondary productivity



Narayanaswamy et al. 2013

Diversity and carbon flux



Danovaro et al. 2008

Deep-sea ecosystem functioning is exponentially related to deep-sea biodiversity and that ecosystem efficiency is also exponentially linked to functional diversity. These results suggest that a higher biodiversity supports higher rates of ecosystem processes and an increased efficiency with which these processes are performed. The exponential relationships presented here, being consistent across a wide range of deep-sea ecosystems, suggest that mutually positive functional interactions (ecological facilitation) can be common in the largest biome of our biosphere.

A) Faunal biomass/biopolymeric C (detritus) in sediments vs FD

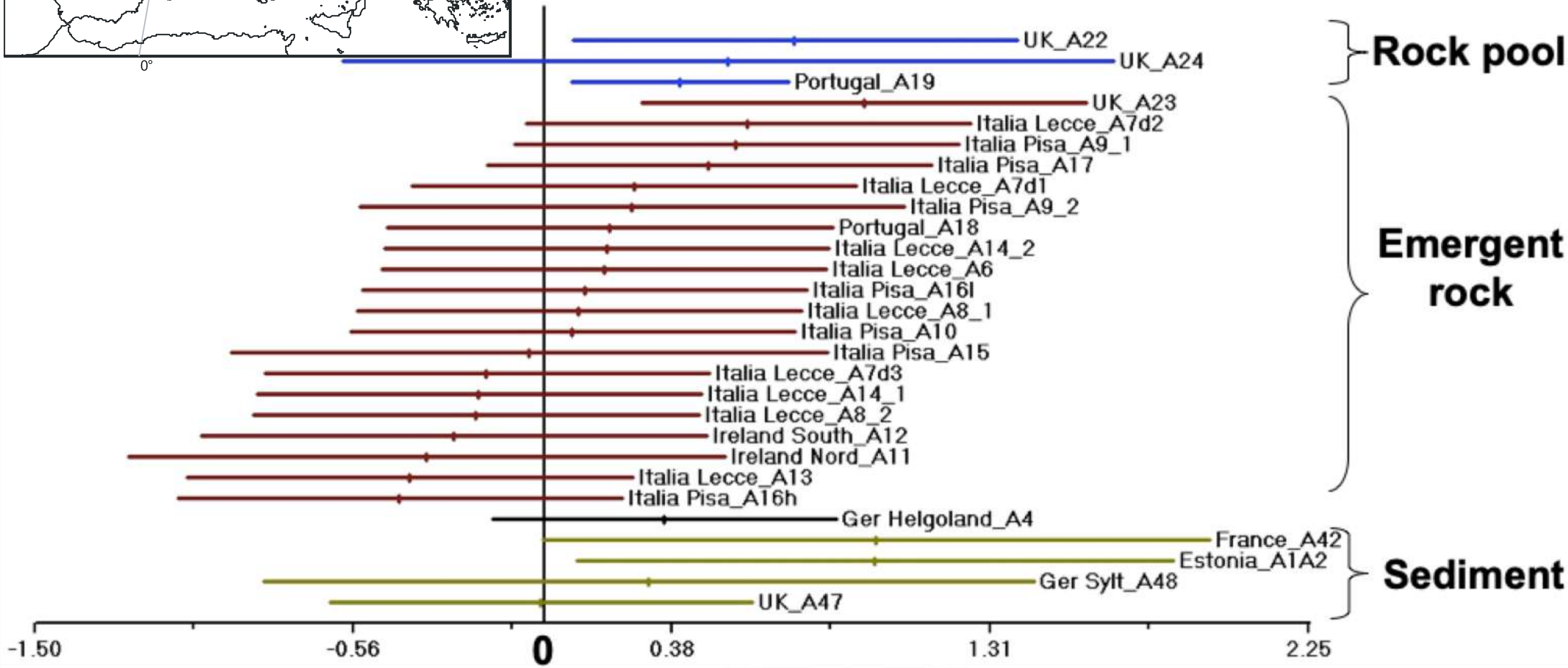
B) Faunal biomass/organic C flux (increase C in sediments) vs FD

C) Bacterial C production/organic C flux vs FD

Diversity and stability

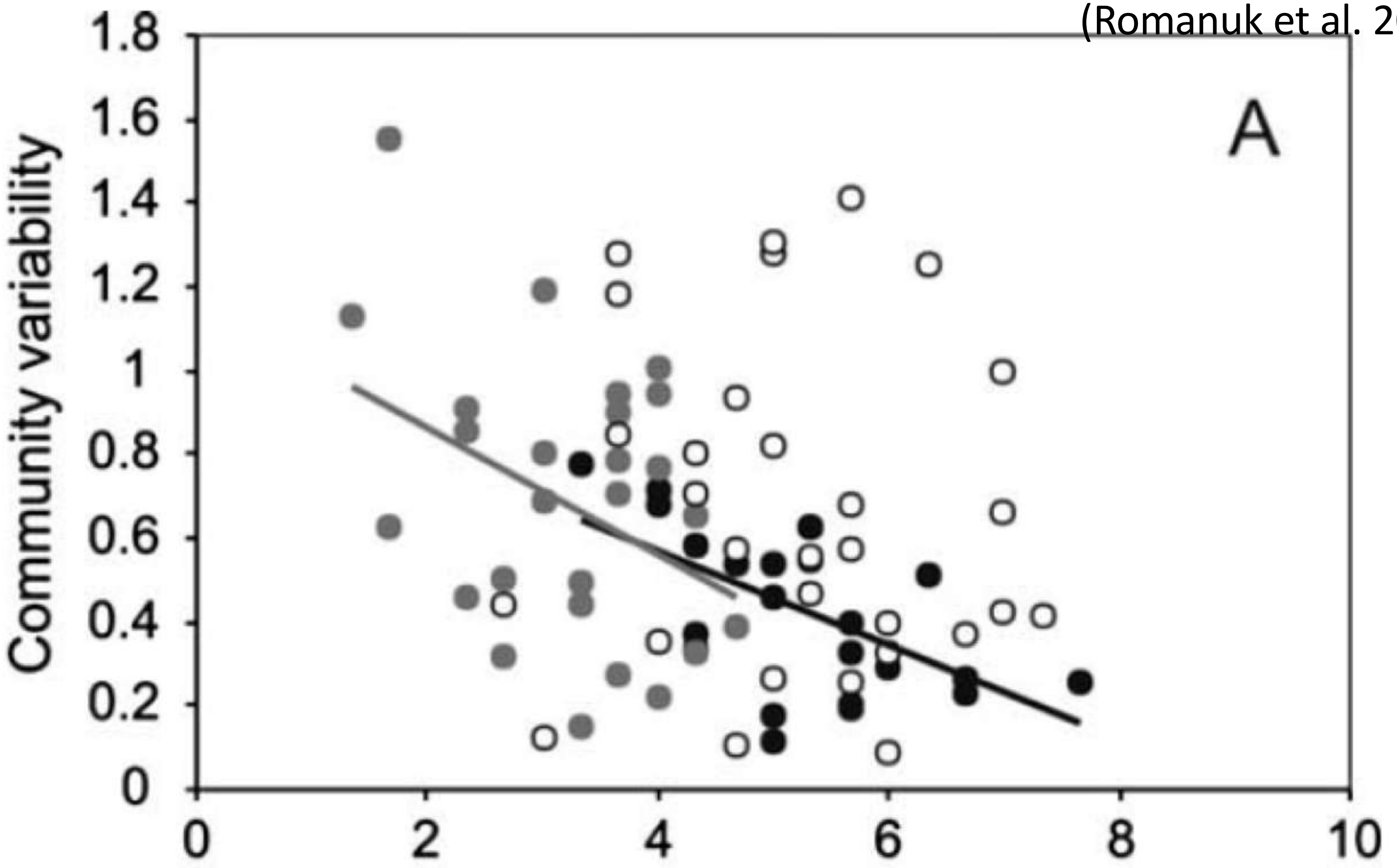
Negative or positive, or no correlation between species richness and temporal variability in benthic assemblages

(Cusson et al. 2014)



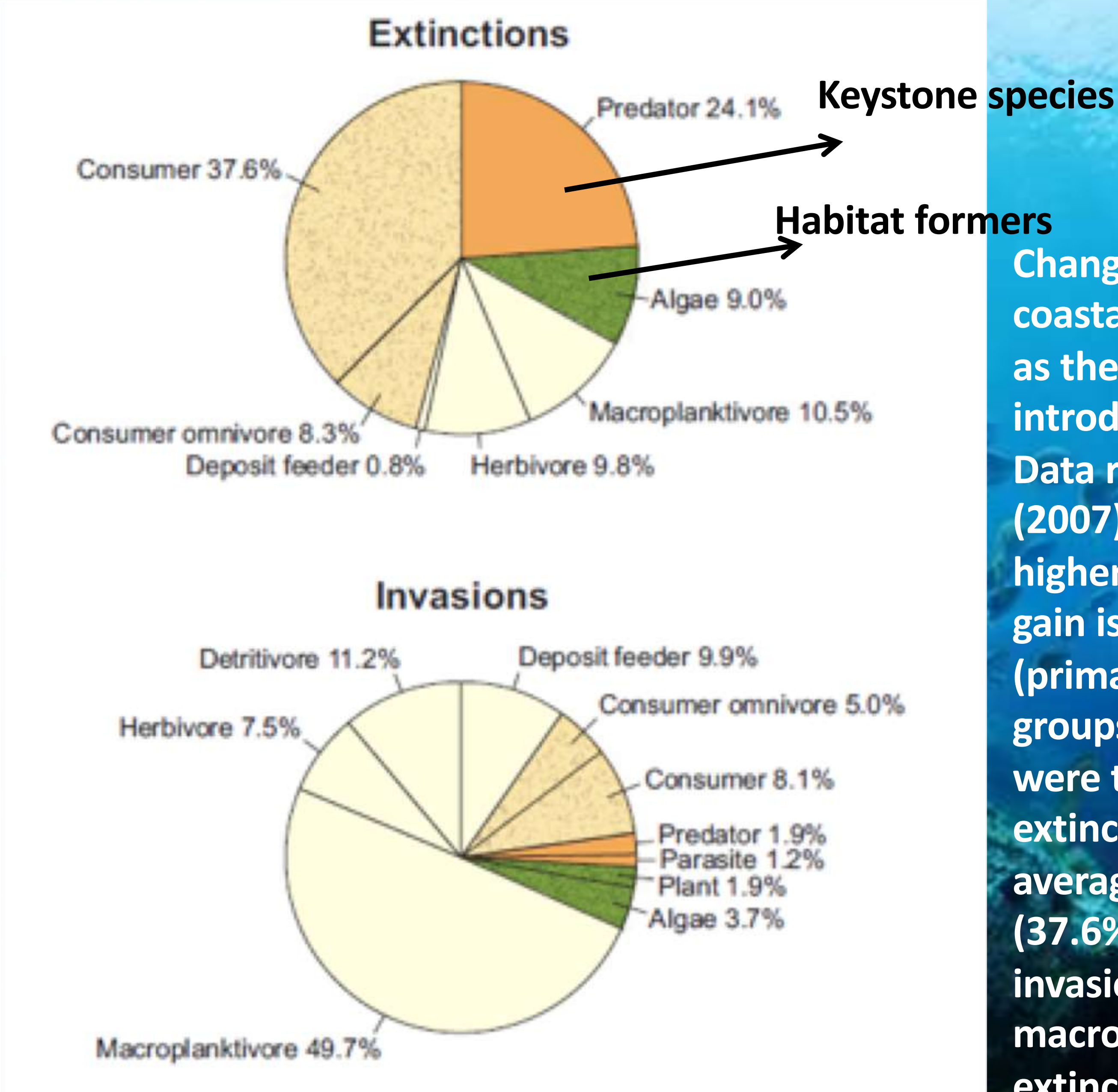
Diversity and stability

(Romanuk et al. 2009)



Effect of species richness on community variability for laboratory microcosms (black circles), artificial rock pools (grey circles) and natural pools (open circles).

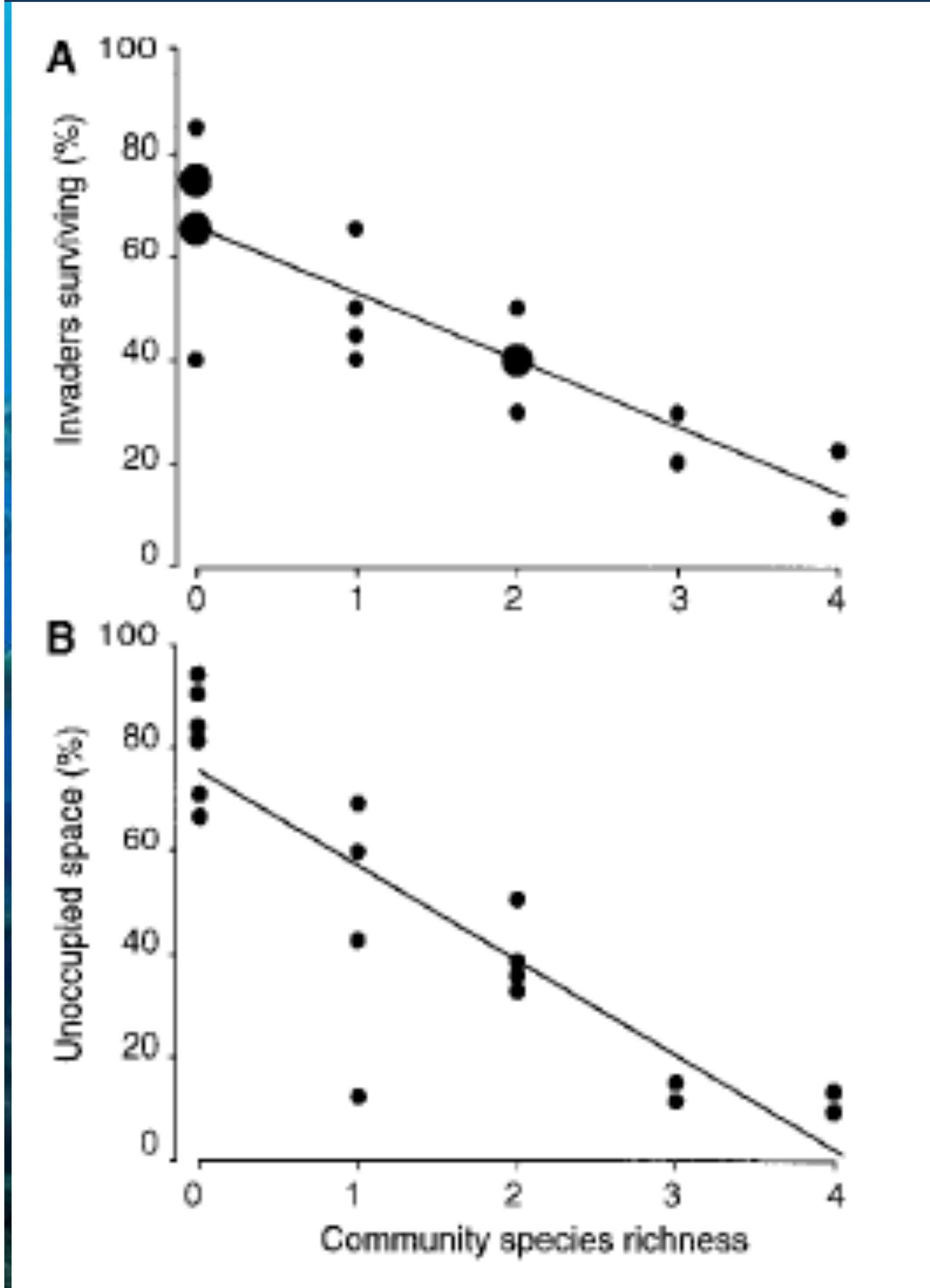
Diversity and invasion

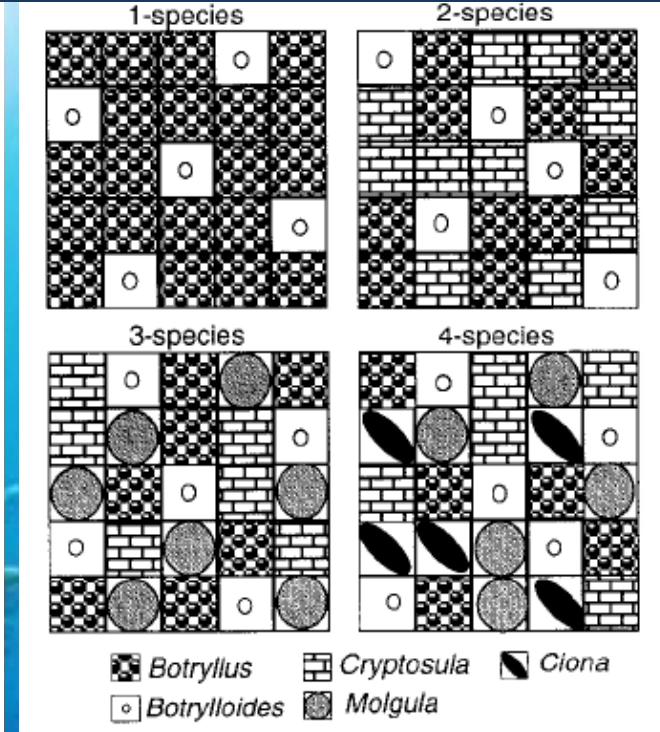


Changing patterns of trophic skew in coastal/estuarine marine ecosystems as the combined result of species introductions and local extinctions. Data replotted from Byrnes et al. (2007). Species loss is biased toward higher trophic levels, whereas species gain is biased toward lower levels (primary consumers). The functional groups most responsible for this skew were top predators (24.1% of extinctions but 6.1% of invasions on average), secondary consumers (37.6% of extinctions but 8.1% of invasions), and suspension feeding macroplanktivores (10.5% of extinctions but 44.6% of invasions).

Stachowicz et al. (2007)

Diversity and invasion



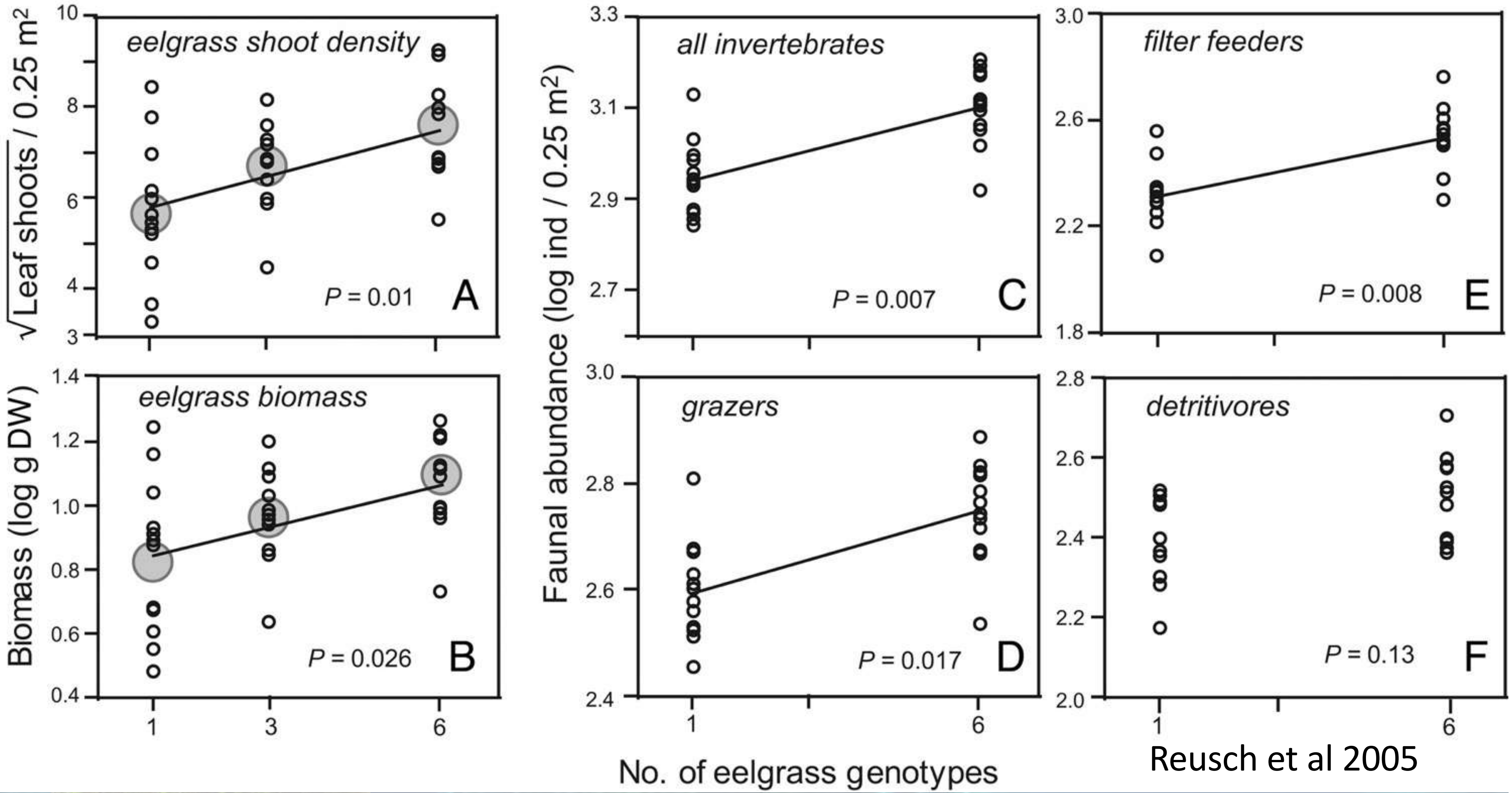


The exotic ascidian *Botrylloides diegensis*

Stachowicz et al. (1999)

Increased species richness significantly decreased invasion success, apparently because species-rich communities more completely and efficiently use available space, the limiting resource in this system.

Diversity and climate change



Reusch et al 2005

The seagrass <u>*Zostera marina*</u> (dominant macrophyte species of shallow sedimentary shorelines in the northern hemisphere)

Ecosystem recovery after <u>climatic extremes</u> enhanced by genotypic diversity

Summary of evidence

Response	Positive	Negative	No effect
Stability, disturbance, resistance, or resilience[b]	9	1	0
Plant biomass or production	7	0	6
Decomposition	0	0	2
Associated species diversity	0	0	3
Associated species abundance	2	0	1
Resource use[b]	6	0	3
Resource regeneration[c]	4	4	9
Invader abundance or survival	0	6	1
Invader settlement	2	0	1
Secondary production	6	0	1

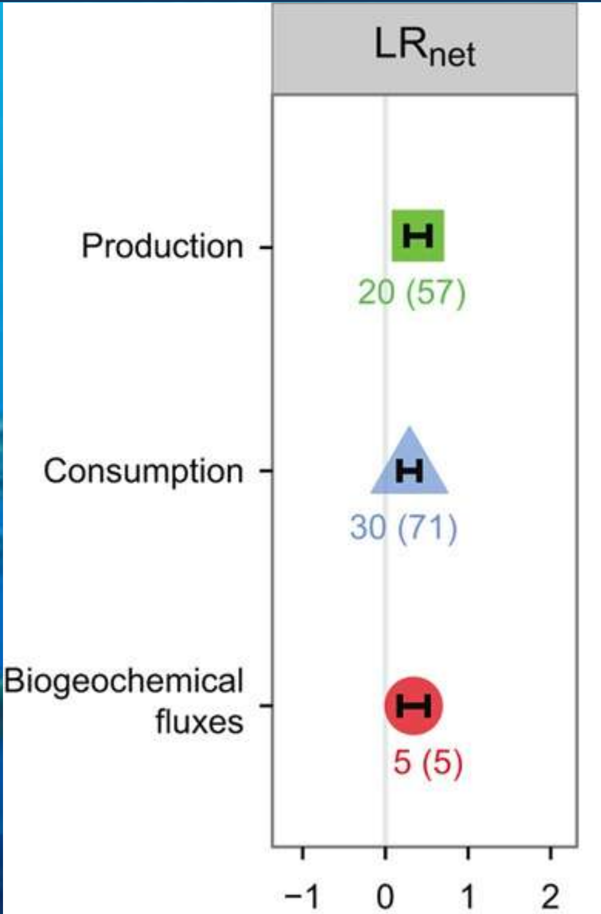
Manipulation of species richness within single trophic levels

Taxon manipulated	Response	Positive	Negative	No effect
Algal prey	Consumer growth	6	0	0
	Consumer survival	5	0	2
	Consumer reproduction	5	0	3
	Integrated production or population growth	6	0	1
Consumer	Prey biomass	3	8	4
Predator	Plant biomass (two trophic levels away)	3	2	1

Manipulation of species richness within a trophic level and effects on other trophic levels

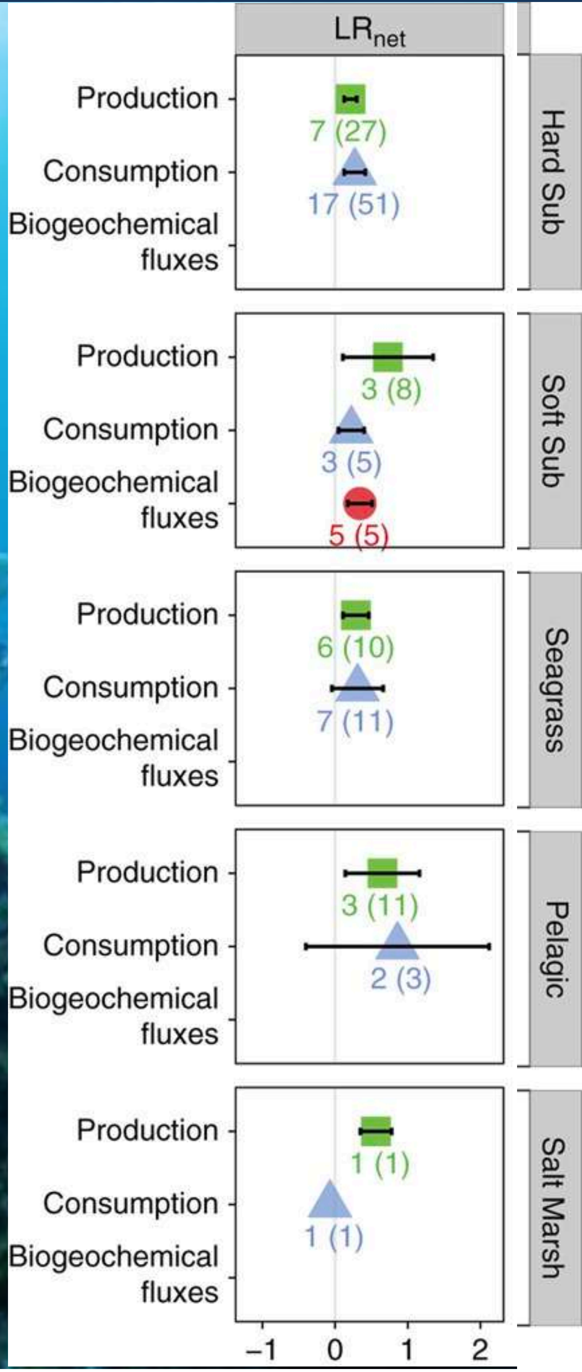
Stachowicz et al. (2007)

Summary of evidence



Meta-analysis of available studies comparing multispecies and average monospecific systems suggest a positive effect of biodiversity on production, consumption and cycles

Gamfeldt et al. (2015)



This pattern is common to different marine ecosystems