

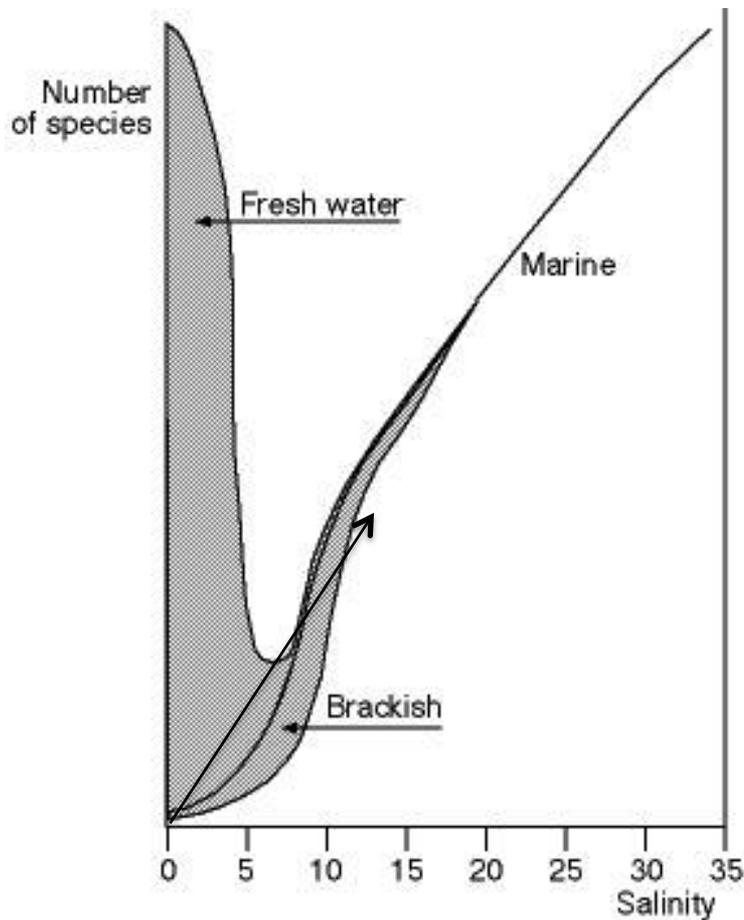
Biodiversity components in lagoons: drivers, patterns, mechanisms and impacts

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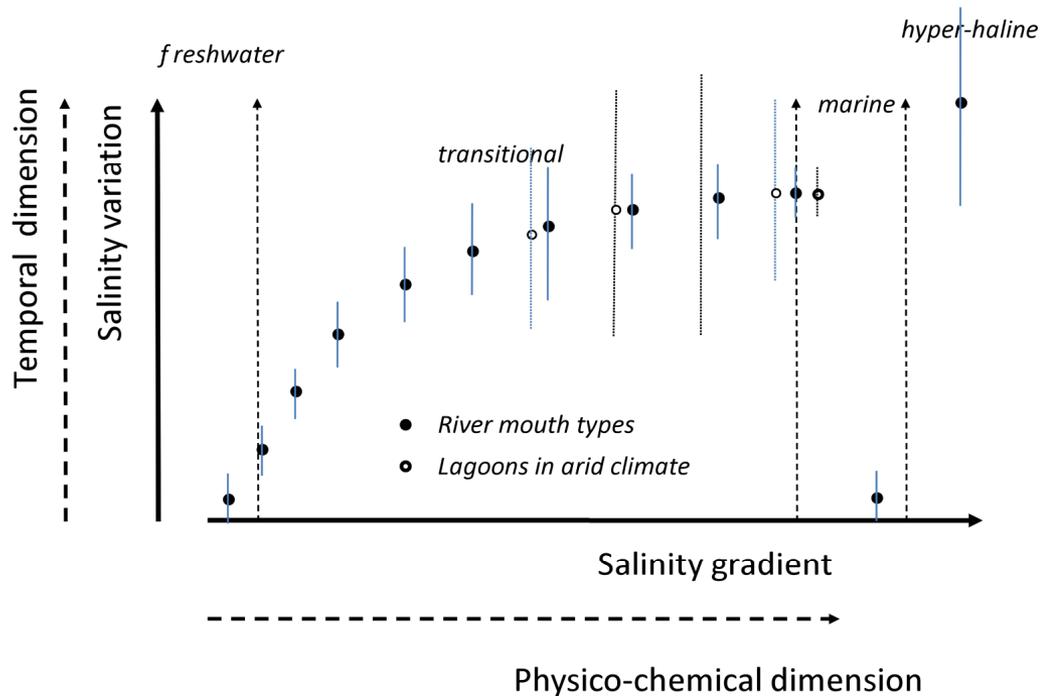
BIODIVERSITY PARADOXES IN LAGOONS



How do we need to look at the Remane diagram?

- ➔ Cutting sections at salinity thresholds?
- ➔ Cutting sections across the salinity gradient? and where?
- ➔ Adding a time scale?

BIODIVERSITY PARADOXES IN LAGOONS



How do we need to look at the Remane diagram?

➡ Is mono-dimensional variability limiting biodiversity;

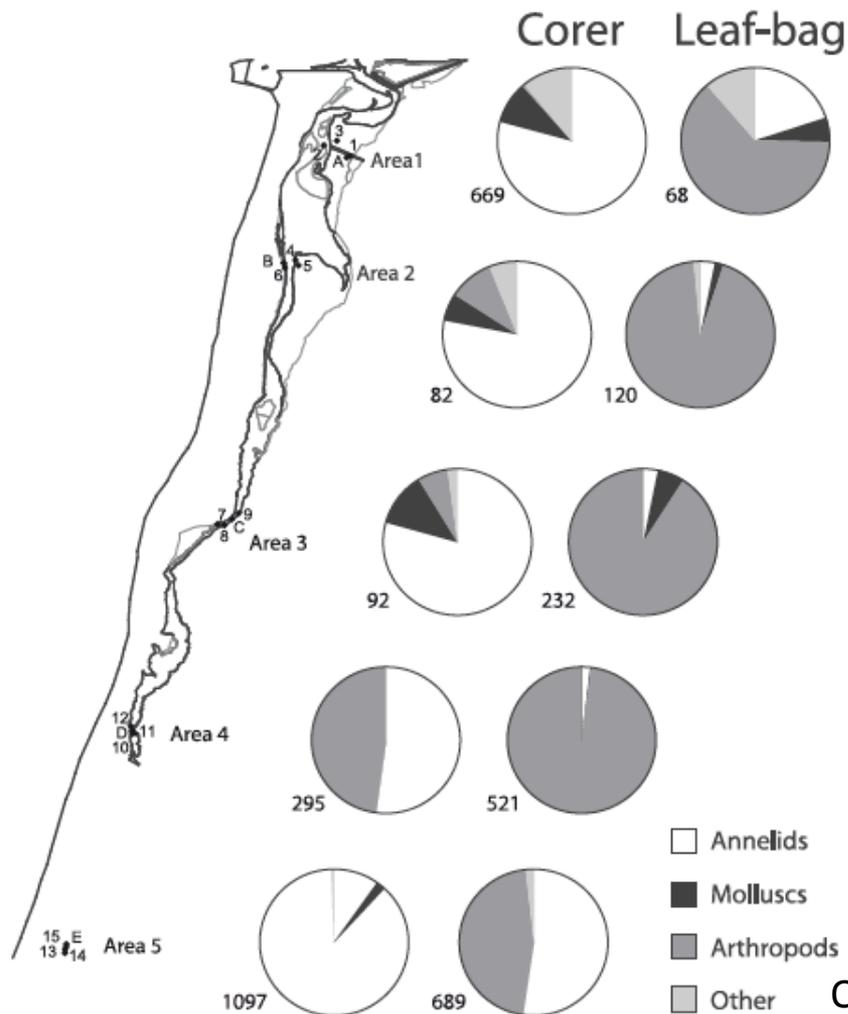
➡ Is mono-dimensional variability enhancing biodiversity?

➡ Are physical stresses limiting biodiversity? or just selecting species? or species traits? or....

Basset et al., 2011, ECSS submitted

BIODIVERSITY PARADOXES IN LAGOONS

V. Quintino et al. / *Estuarine, Coastal and Shelf Science* xxx (2011) 1–12



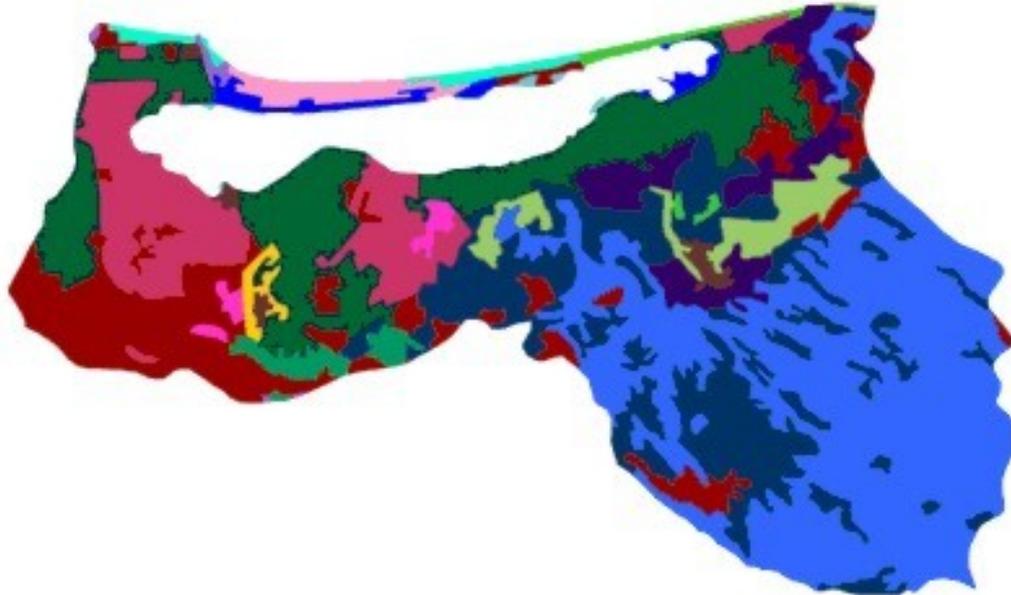
Quintino et al., 2011, ECSS online

BIODIVERSITY PARADOXES IN LAGOONS

Area 1	Area 2	Area 3	Area 4	Area 5
Taxa	Taxa	Taxa	Taxa	Taxa
Mediomastus fragilis	Mediomastus fragilis	Hediste diversicolor	Streblopsio shrubsoli	Chironomidae
Phoronida	Capitella spp.	Streblopsio shrubsoli	Corophium multisetosus	Oligochaeta
Aphelochaeta marioni	Oligochaeta	Capitella spp.	Oligochaeta	Curbicula fluminea
Angulus tenuis	Aphelochaeta marioni	Scrobicularia plana	Cyatura carinata	Cladocera

Modified from: Quintino et al., 2011, ECSS online

BIODIVERSITY PARADOXES IN LAGOONS



How do we need to look at the Remane diagram?

➔ Most of what we do in the watershed affect components of the Remane diagram; or...

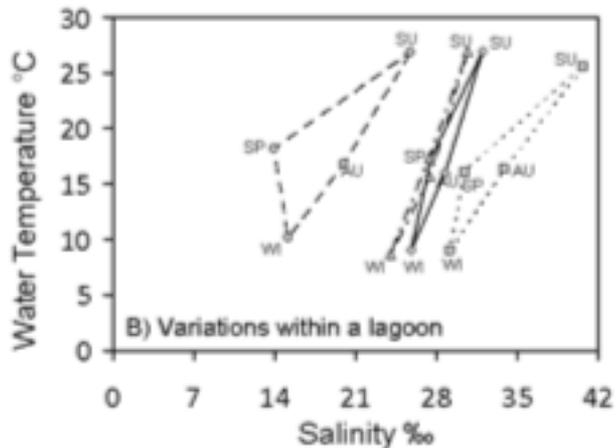
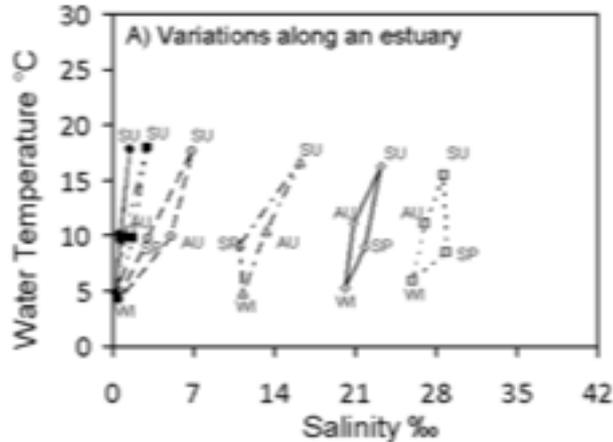
➔ The position of the Remane diagram along its vertical axis

DRIVERS OF BIODIVERSITY IN LAGOONS

THE ECOTONE APPROACH

TWs are multi-dimensionale ecotones with distinct peculiarities, in terms of:

- surface area, which can be much larger than in structural terrestrial ecotones;
- subsidies of energy, both hydraulic and food energy, driving ecosystem processes;
- boundaries, being variable through time;
- gradients of environmental conditions or niche dimensions, posing high physical pressures to potential colonisers; and
- species turnover, which is faster that in structural terrestrial ecotones.



DRIVERS OF BIODIVERSITY IN LAGOONS

Transitional Waters as Ecotone Ecosystems:

- ✓ 1° order - Freshwater-marine ecotone; or
- ✓ 2° order - Freshwater – lagoon - marine ecotones
- ✓ 2° order - Land-water ecotone
- ✓ 2° order - Sediment – water ecotone

characteristics	Ecotone order				Hydraulics	
	1 st	2 nd A	2 nd B	2 nd C	force	scale
Tidally dominated at the seaward part; salinity notably reduced by freshwater river inputs; riverine dominance inward					↑	↔
Land freshwater seepage or markedly seasonal riverine inputs; limited tidal influence; stratified; long narrow, glacially-eroded sea inlet, step sided, sill at mouth					↑	↔
Limited exchange with the sea through a restricted mouth(s); separated from sea by sand or shingle banks, bars, coral, etc., shallow area, tidal range ≤ 50cm					↑	↔
As above but with tidal range ≥ 50cm					↑	↔
Drowned river valley, some freshwater inputs; limited seawater exchange					↑	↔
Glacially carved embayment, sea inlet, smaller than fjord; limited freshwater inputs					↑	↔
River outlet as well-defined physiographic coastal feature					↑	↔
Low energy, characteristically shaped, sediment dominated, river mouth area; estuary outflow					↑	↔
Outflow of estuary or lagoon, notably diluted salinity and hence differing biota than surrounding coast					↑	↔
longitudinal salinity gradient water - land (terrestrial/sediments) brackish - freshwater brackish - marine	relative importance					
	<div style="display: flex; justify-content: space-between; width: 100%;"> </div>					
	<div style="display: flex; justify-content: space-between; width: 100%;"> low medium high </div>					

DRIVERS OF BIODIVERSITY IN LAGOONS

Ecotone mediated Drivers of

- 1st order F-M → hydraulic connectivity
- 2nd order F-B-M → biotic connectivity
- physiography
- sedimentation patterns
- spatial dimensions
- salinity gradient
- physical gradient
- chemical gradient

- 2nd order L-W → OM connectivity
- biotic connectivity
- OM gradient
- chemical gradient

- 2nd order S-W → functional connectivity
- process rate gradient
- chemical gradient

Ecosystem properties and Biodiversity

- Openness
- Exergy
- Resilience
- Vigour
- Parsimony

PATTERNS OF BIODIVERSITY IN LAGOONS

NULL/NEUTRAL PLANE

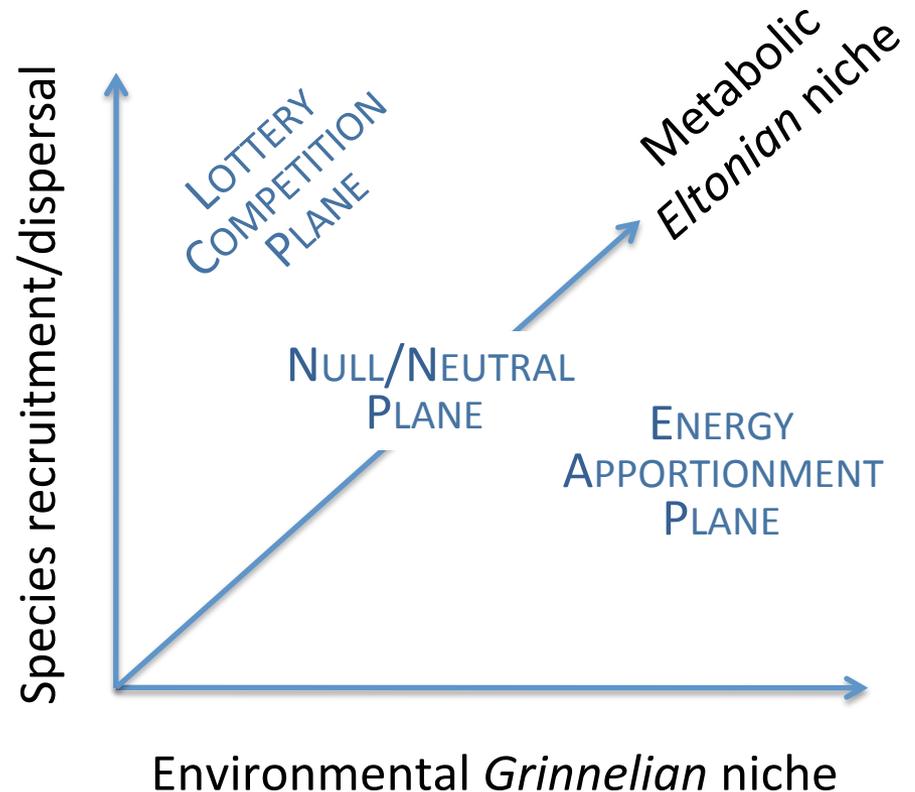
Environmental selective,
Resource unlimited,
Stochastic colonisation

ENERGY APPORTIONMENT PLANE

Environmental selective,
Resource limited,
Deterministic colonisation

LOTTERY COMPETITION PLANE

Fluctuating resource limitation
Stochastic colonisation /
Deterministic selection



PATTERNS OF BIODIVERSITY IN LAGOONS

NULL/NEUTRAL PLANE

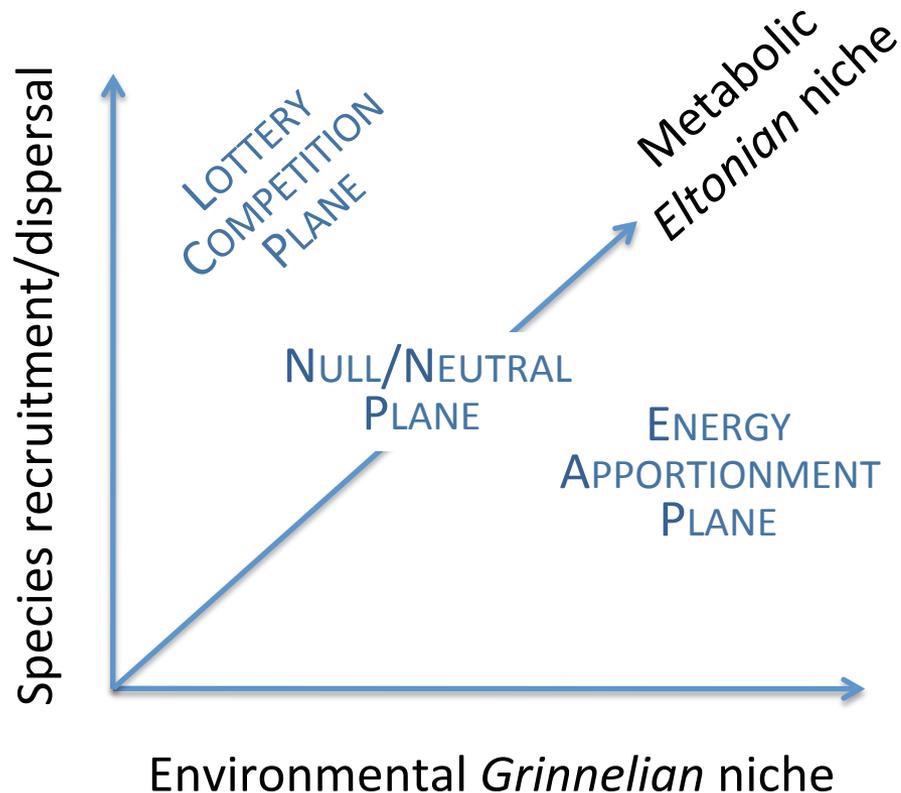
High species diversity,
Grinnelian community types
High similarity within type

ENERGY APPORTIONMENT PLANE

Low species diversity,
Eltonian community type,
High similarity within type

LOTTERY COMPETITION PLANE

High species diversity
High taxonomic redundancy
Low taxonomic similarity



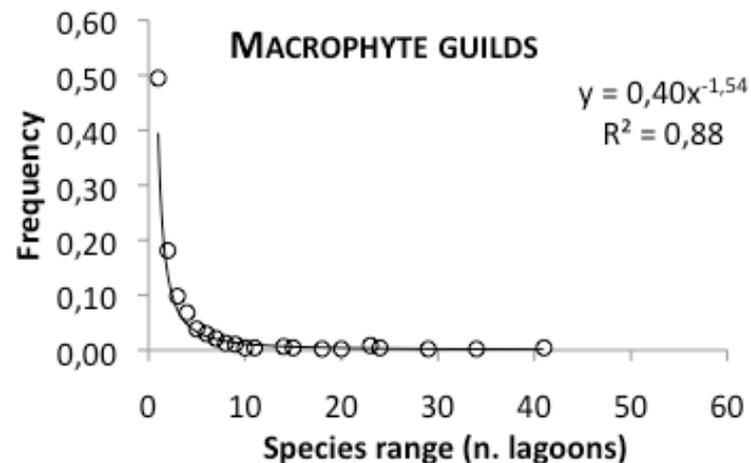
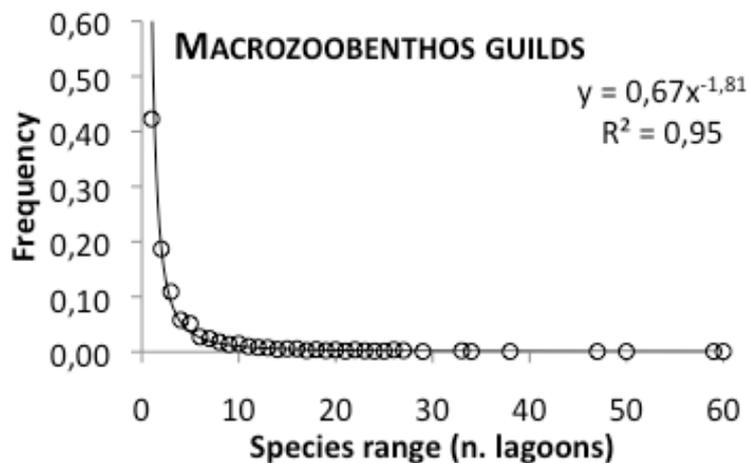
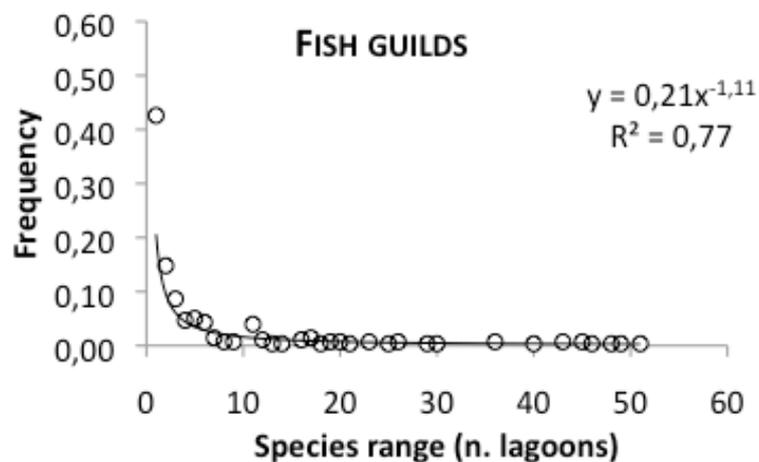
PATTERNS OF BIODIVERSITY IN LAGOONS

- ➔ Species distribution
- ➔ Taxonomic composition
- ➔ Taxonomic richness
- ➔ Species diversity
- ➔ Trait distribution
- ➔ Morpho-Functional diversity

SPECIES DISTRIBUTION

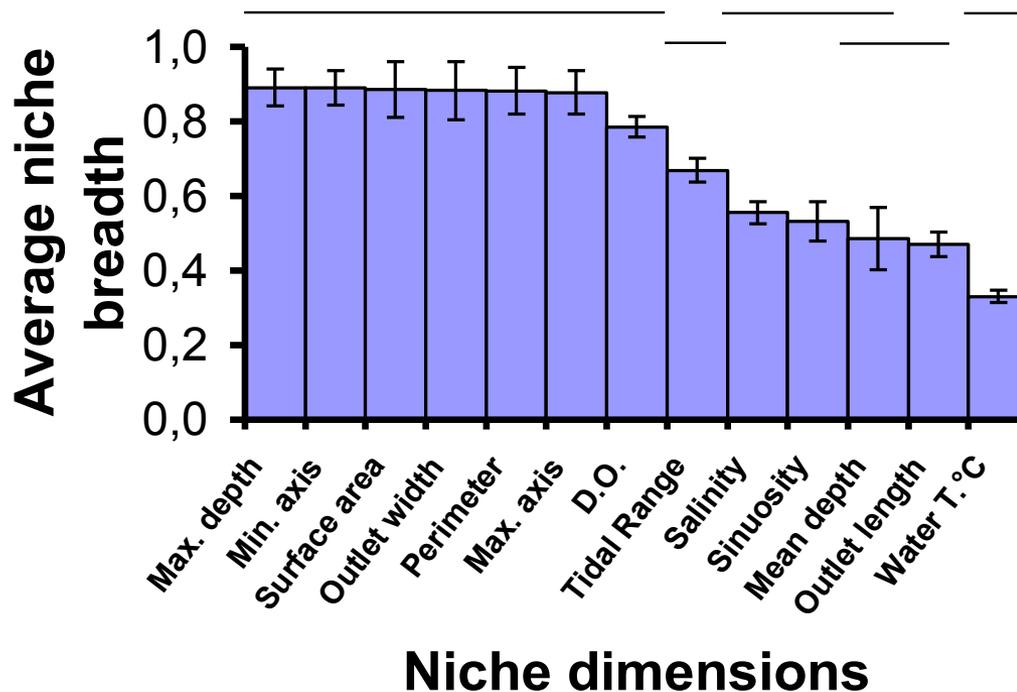
Species ranges are very narrow.....

PATTERNS OF BIODIVERSITY IN LAGOONS



PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES DISTRIBUTION



.....while species niche breadths are on average wide...

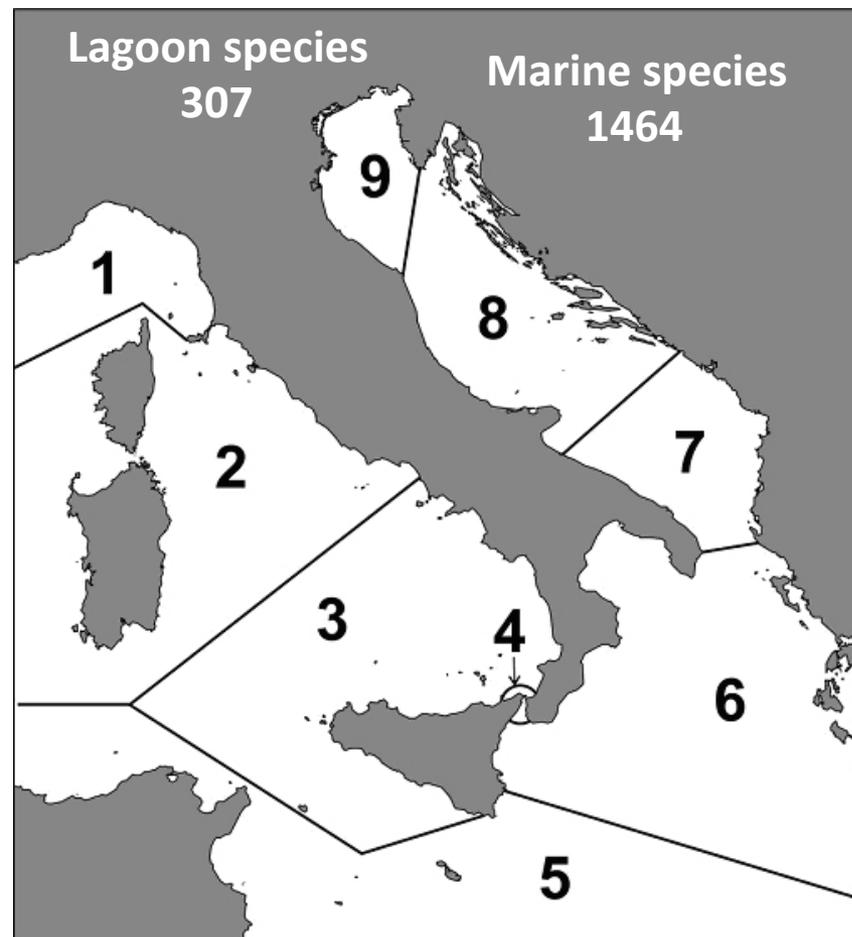
PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES DISTRIBUTION

86.64% of the lagoon molluscs species are likely to have a marine origin.

73% occur in both lagoon and marine ecosystems and 13.64 have congeners in the marine ecosystem

Lagoons do not seem to be too selective for marine molluscs: 18.2% of marine species occur in lagoons

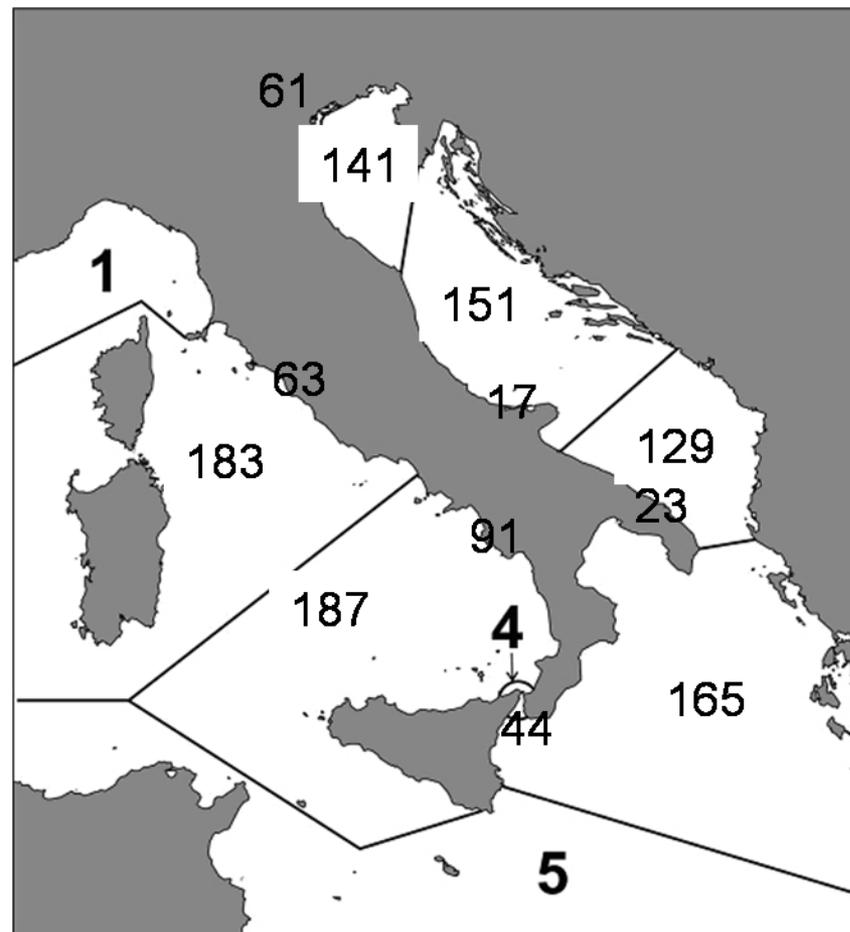


SPECIES DISTRIBUTION

Molluscs show biogeographic distribution patterns:

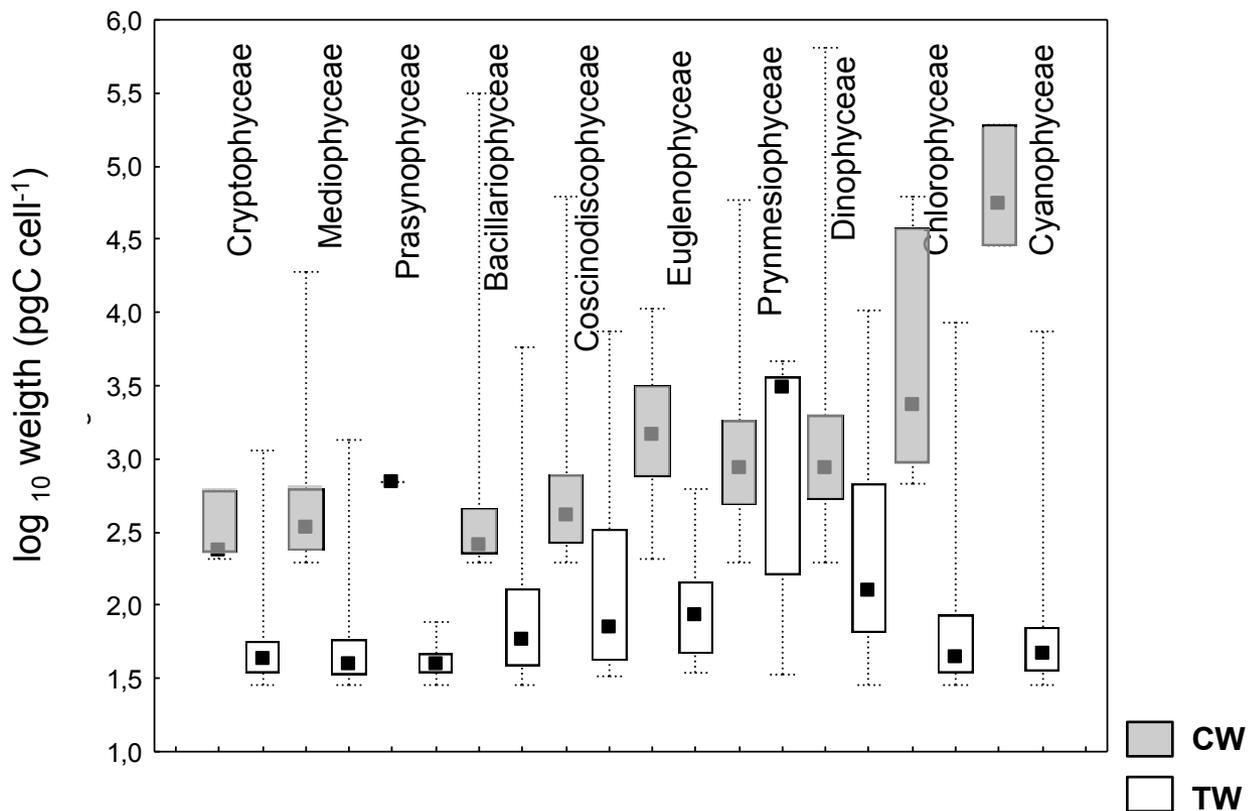
1. Tyrrenian lagoons have a disproportionately high number of mollusc taxa when compared to lagoon surface;
2. Tyrrenian lagoons seems more subjected to marine dispersal (almost 100% of mollusc species from the neighbouring sea sector)

PATTERNS OF BIODIVERSITY IN LAGOONS



PATTERNS OF BIODIVERSITY IN LAGOONS

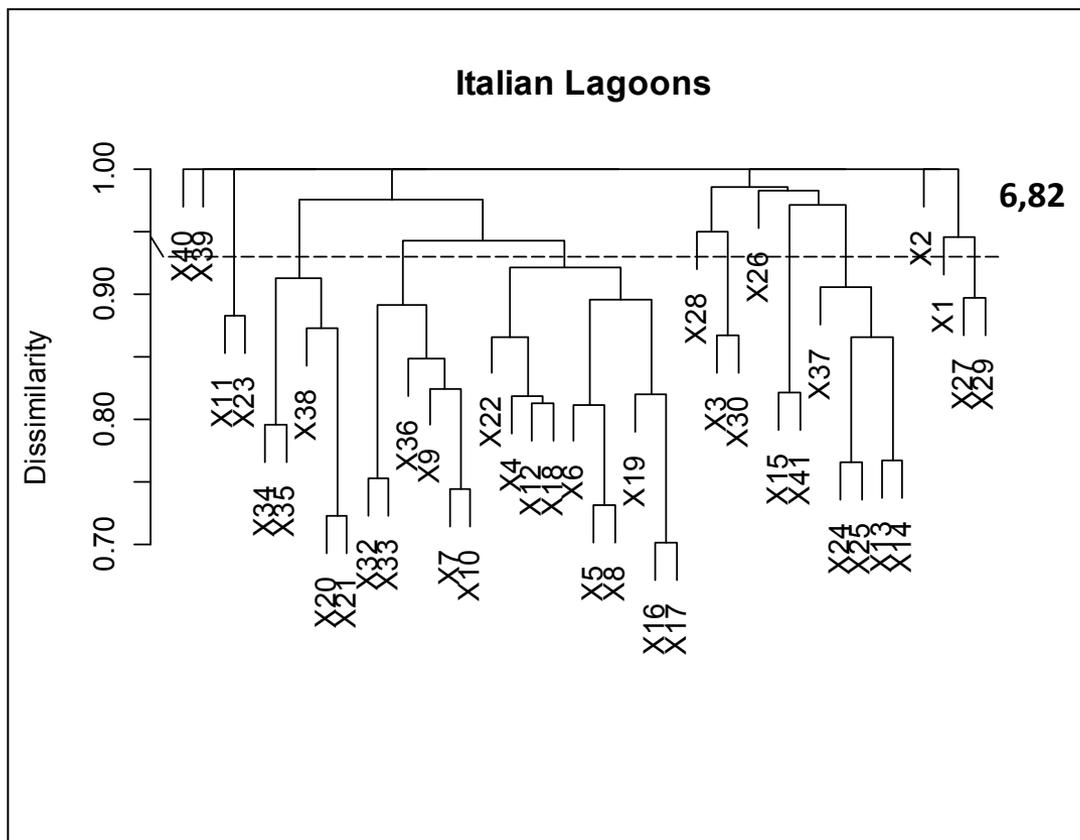
...while most species are marine, their traits are exposed to directional selection in lagoon ecosystems



PATTERNS OF BIODIVERSITY IN LAGOONS

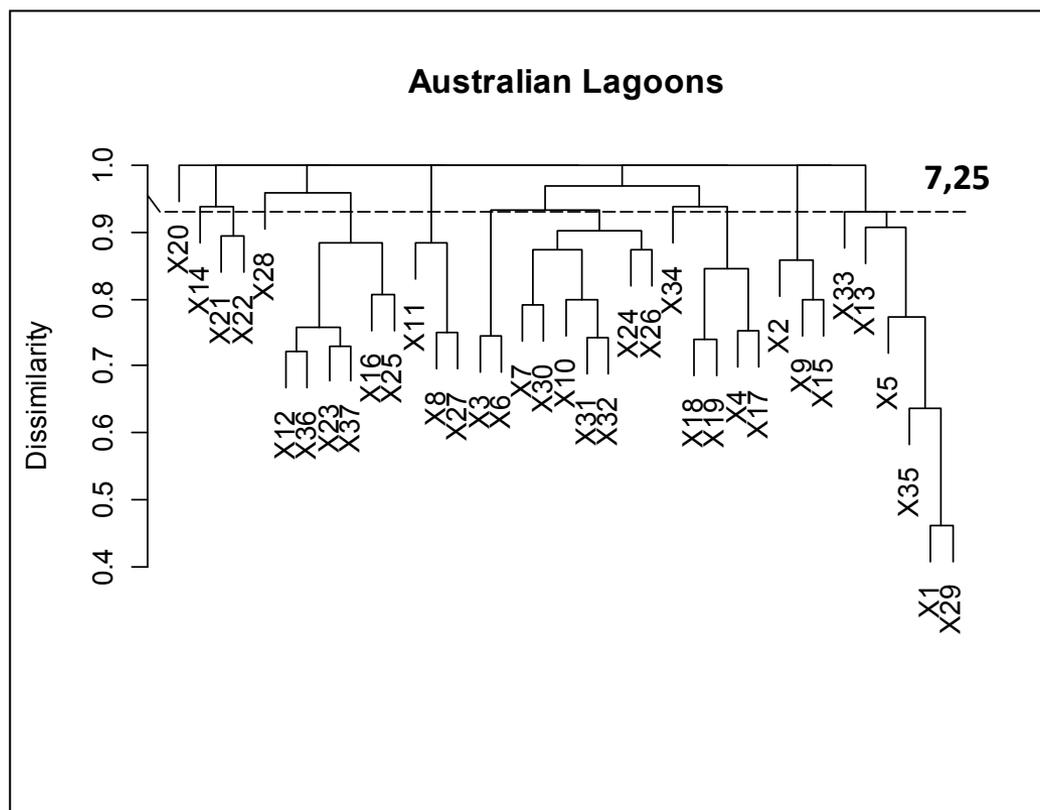
SPECIES COMPOSITION

Taxonomic similarity among lagoons is very low



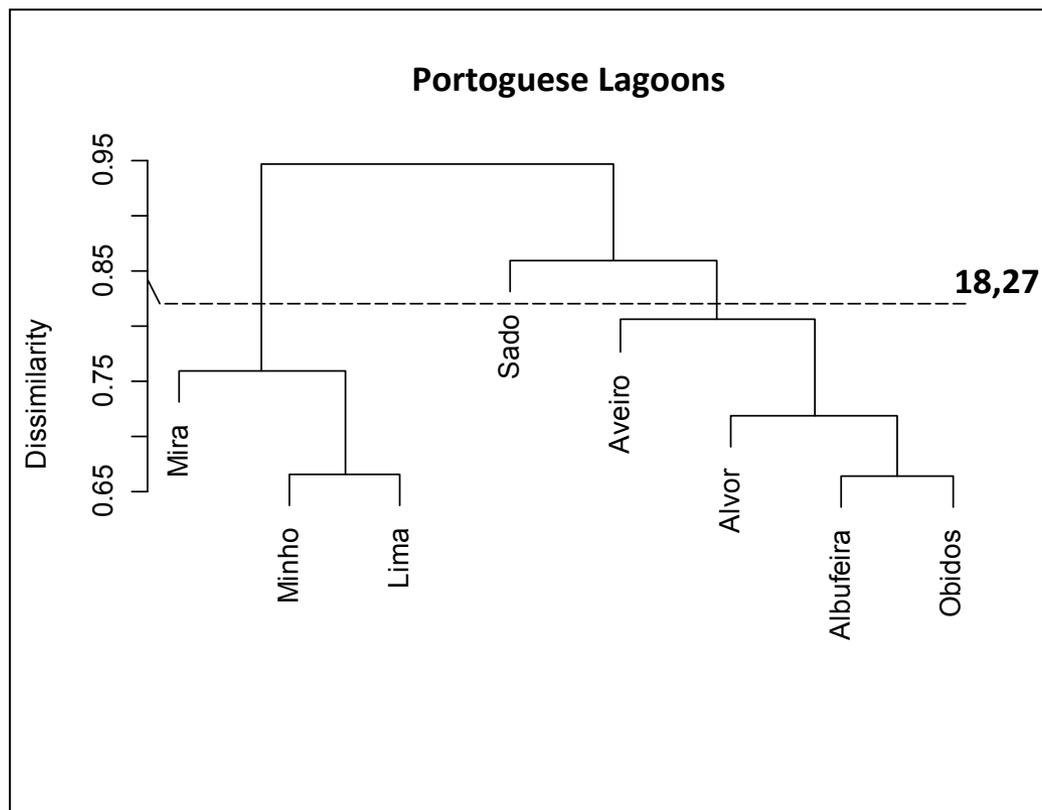
PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES COMPOSITION



PATTERNS OF BIODIVERSITY IN LAGOONS

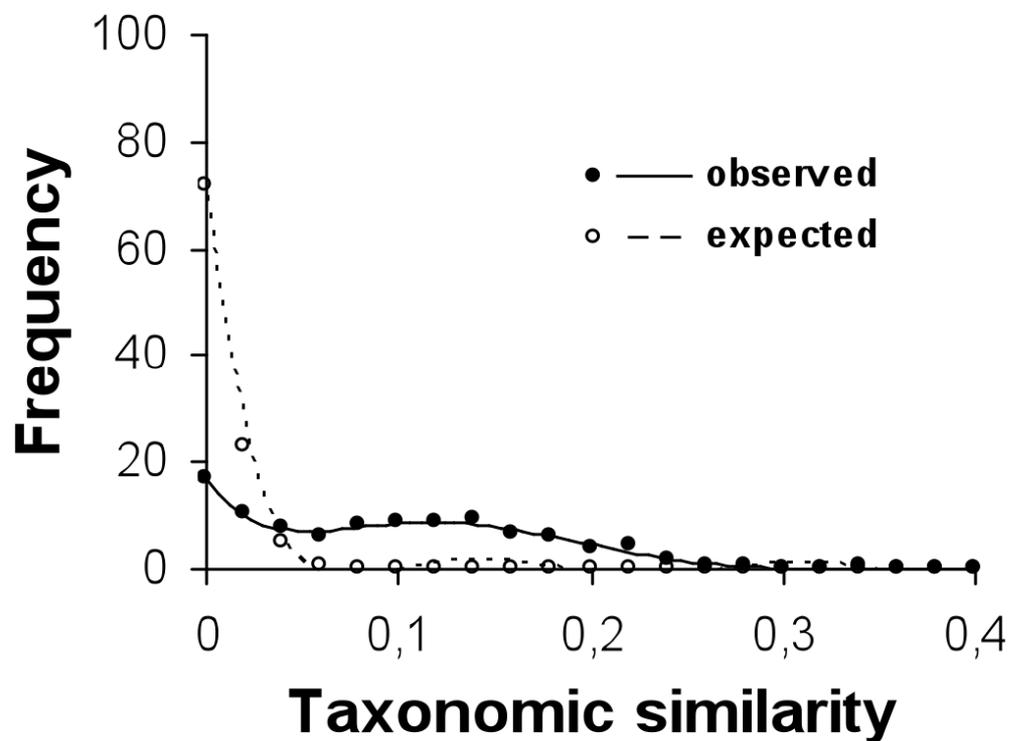
SPECIES COMPOSITION



PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES COMPOSITION

but it is higher than expected according to null modeling...



PATTERNS OF BIODIVERSITY IN LAGOONS

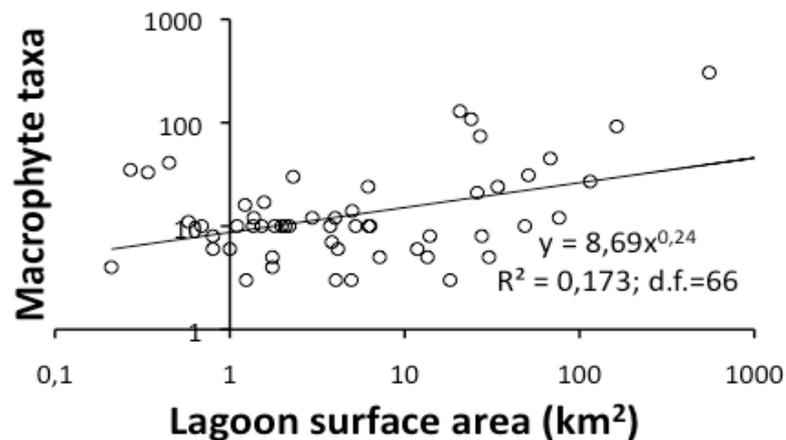
IMPLICATIONS - NOTE¹

From the species distribution/composition

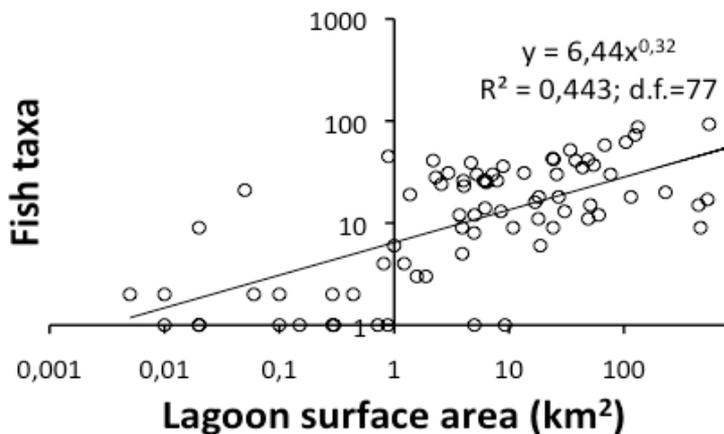
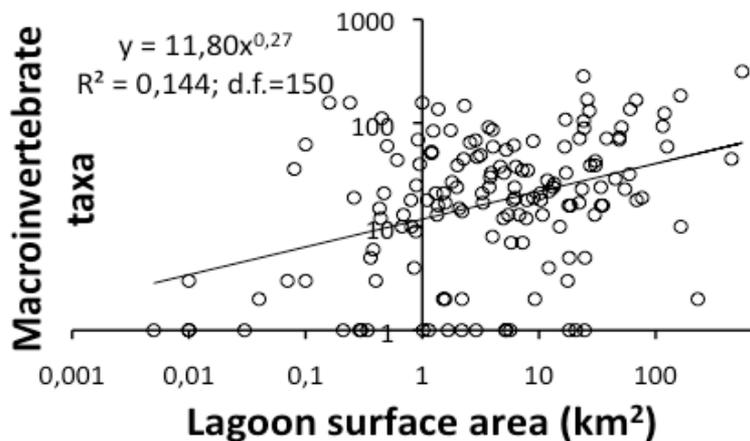
1. There is a strong stochastic component affecting both species distribution and species composition of lagoons;
2. There is a very high redundancy among species;
3. Evidences of deterministic components occur;
4. Management and conservation of biodiversity requires a large scale generally trans-national approach

PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES RICHNESS (SARs)

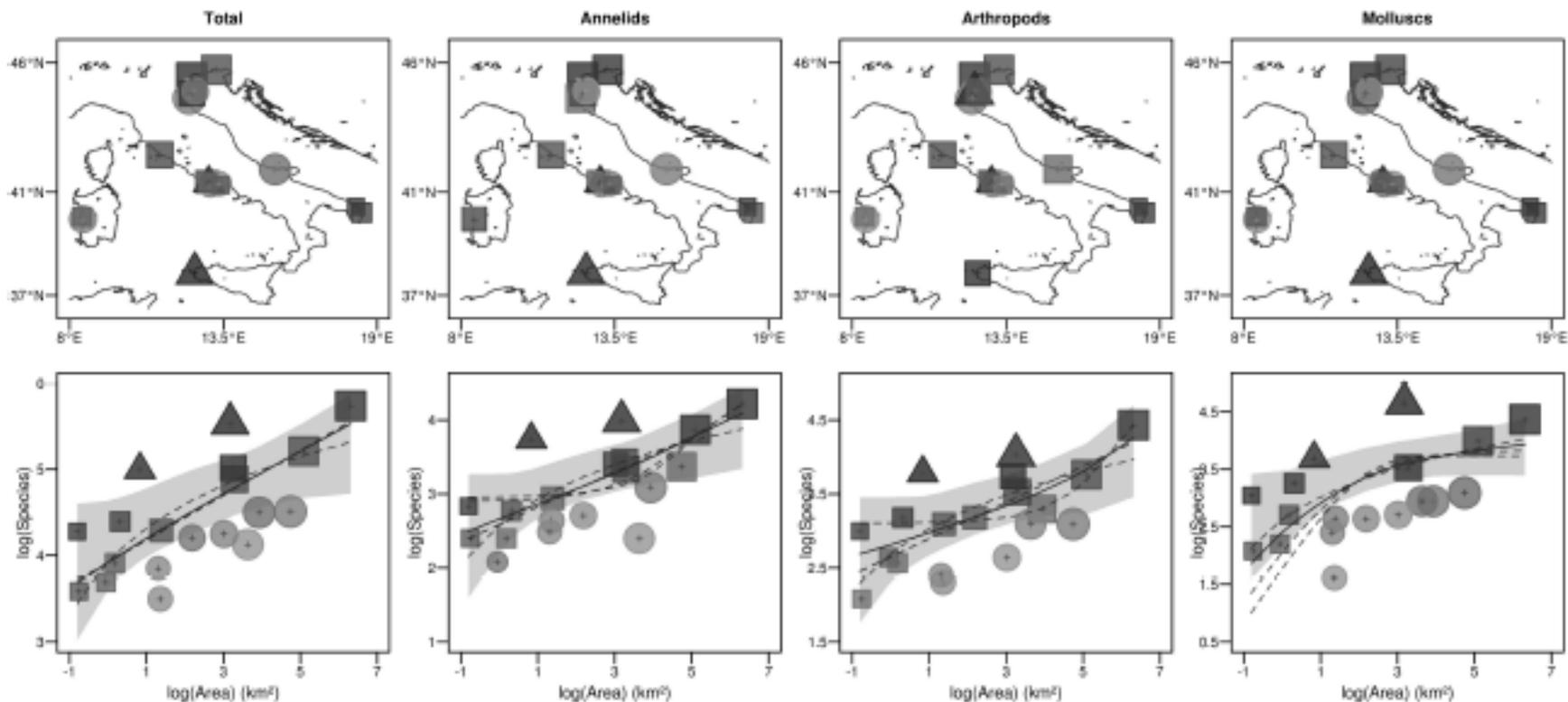


- ✓ Species area relationships are consistently found in lagoons;
- ✓ SARs slopes are generally higher for continental islands.



PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES RICHNESS (SARs)

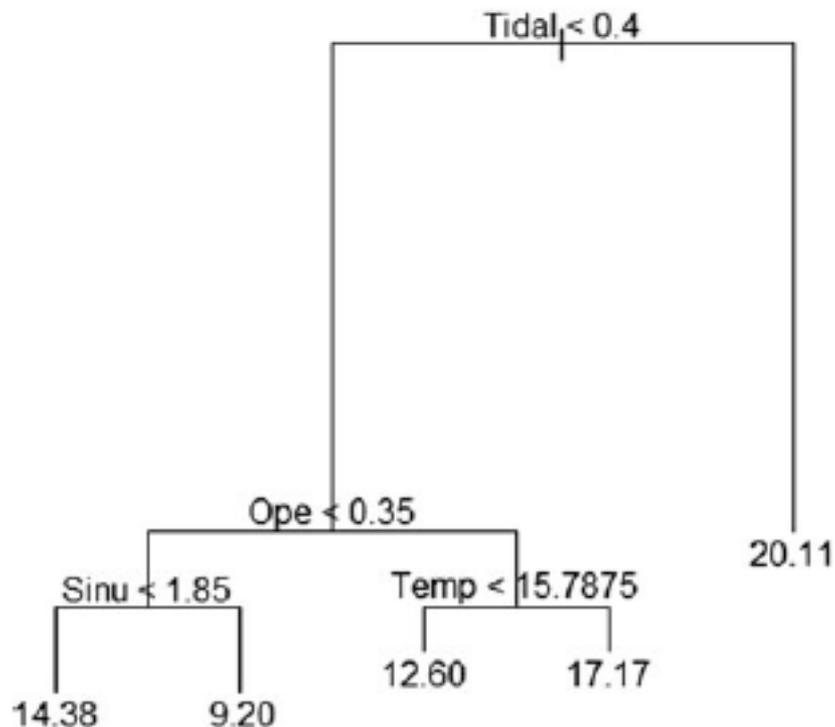


Guilhaumon et al., 2011 ECSS *in press*

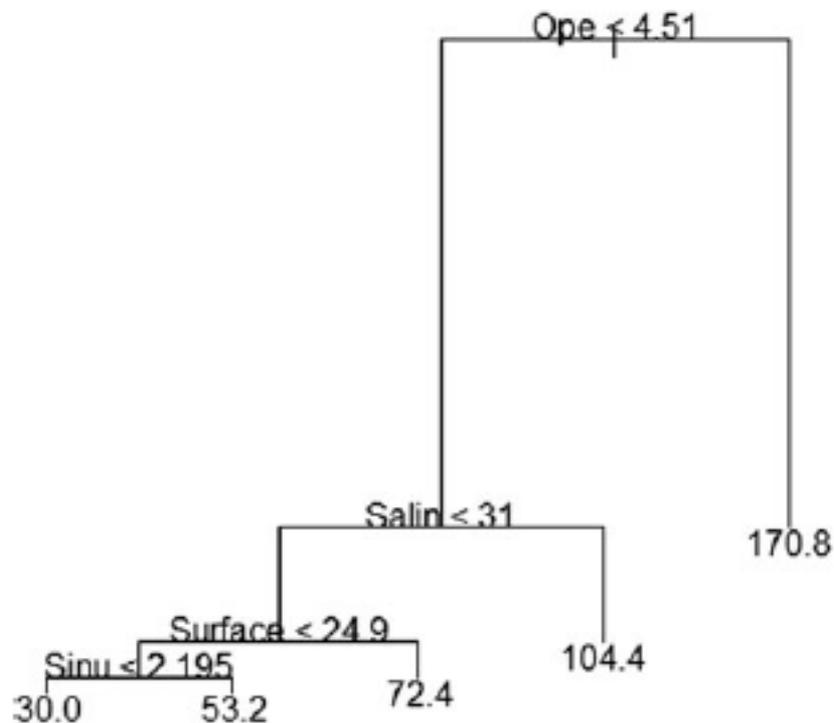
PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES RICHNESS DETERMINANTS

CaD Database



ITA Database



Explained Variance 60.0%

PATTERNS OF BIODIVERSITY IN LAGOONS

In 176 BC, Lucius Murena cut the channel connecting the lagoon to the sea.



L.(ucius) **FABERIUS C** - (ai) **F** - (ilius) **POM**(ptina[tribu]) **MURENA**
AUGUR IIII (quattuor) **VIR AED**(ilis)
AQUA(am) **QUAE FLUEBAT EX LACU**
CONLEGIT ET SALIENTEM IN LACU(m) **REDEGIT**
D(e) **S**(ua) **P**(ecunia) **F**(aciundum) **C**(uravit)

from G.C. Carrada files

PATTERNS OF BIODIVERSITY IN LAGOONS

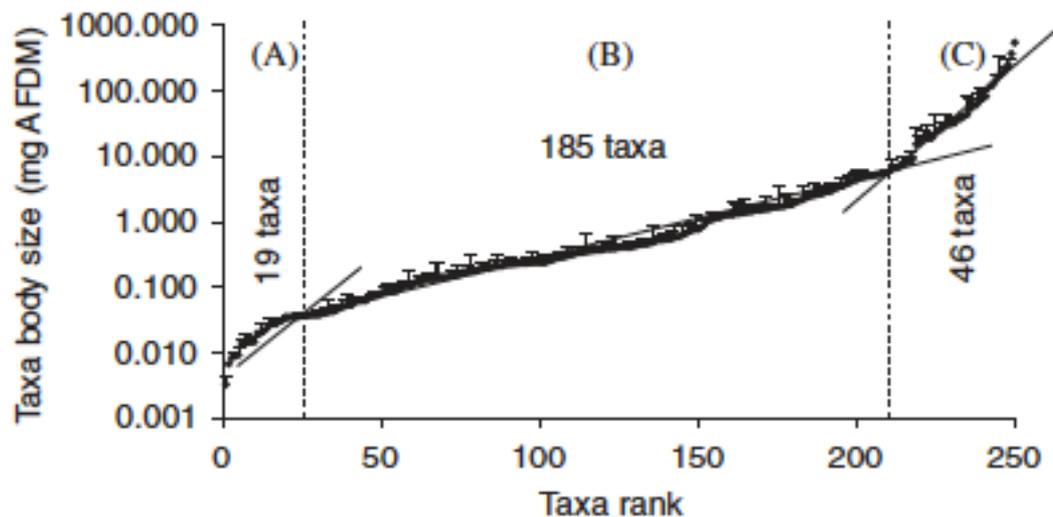
IMPLICATIONS – NOTE²

From species area relationships

1. There is a strong deterministic component affecting species richness of lagoons;
2. This component is relatively independent of the habitat sampling strategy and functional traits of species;
3. SARs are mainly driven by *Openness* associated parameters as well as by *Exergy* and *Vigour*;
4. Management and conservation of species richness have a long tradition but do not necessarily positive impacts on all guilds.

PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES TRAITS – BODY SIZE



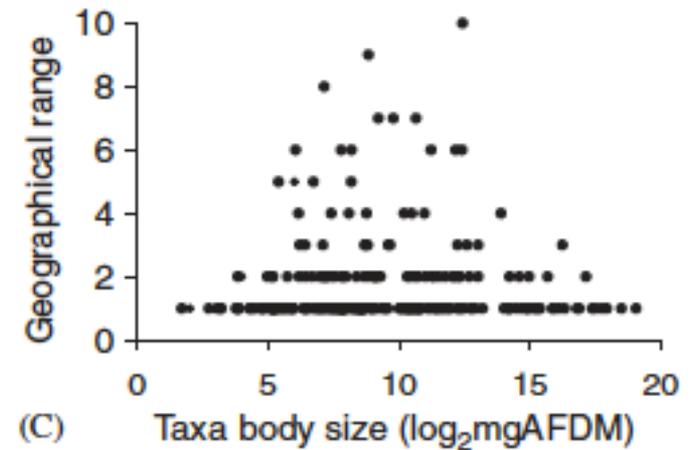
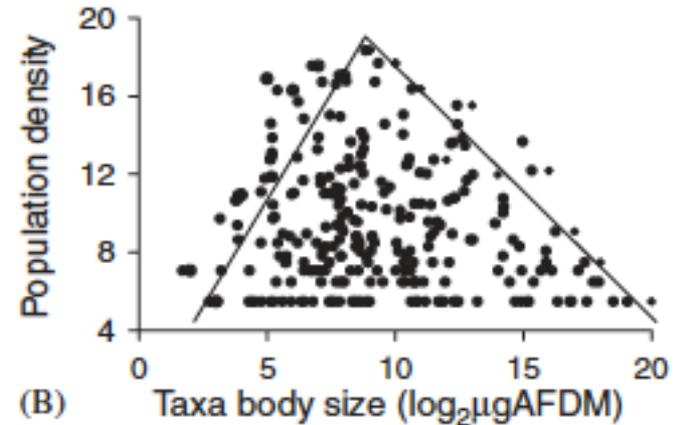
Basset et al., 2008 Aquatic Conservation

SPECIES TRAITS – BODY SIZE

Macroinvertebrate guild size spectra show a deterministic selective component:

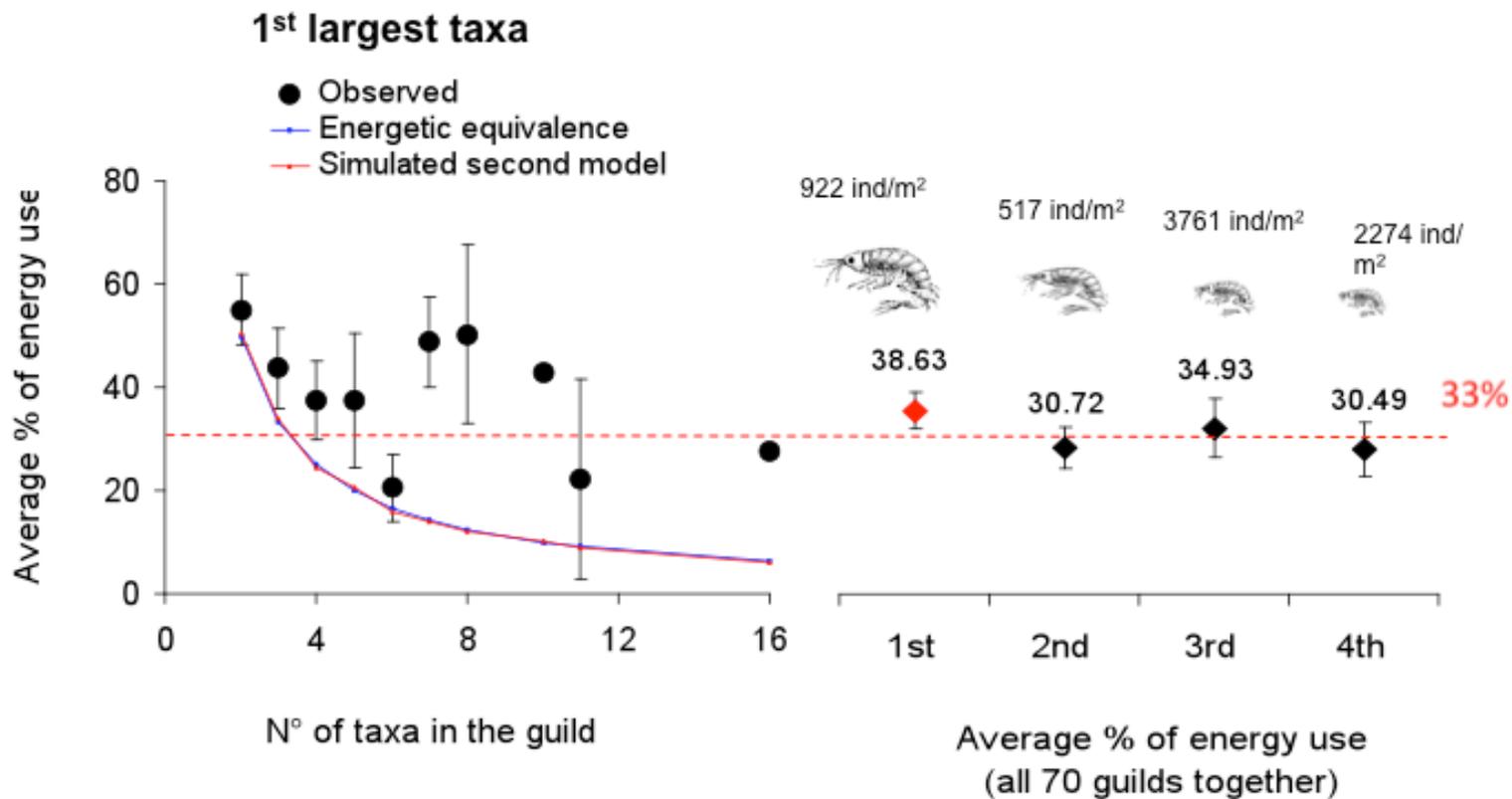
- Size-richness, size-abundance, size-energy and size-range distributions are all triangular;
- All distributions peak at a body size values close to 0.5 mg, AFDW;
- Sizes between 0.1mg and 0.5mg seem to be 'optimal' macroinvertebrate's sizes

PATTERNS OF BIODIVERSITY IN LAGOONS



PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES TRAITS – BODY SIZE

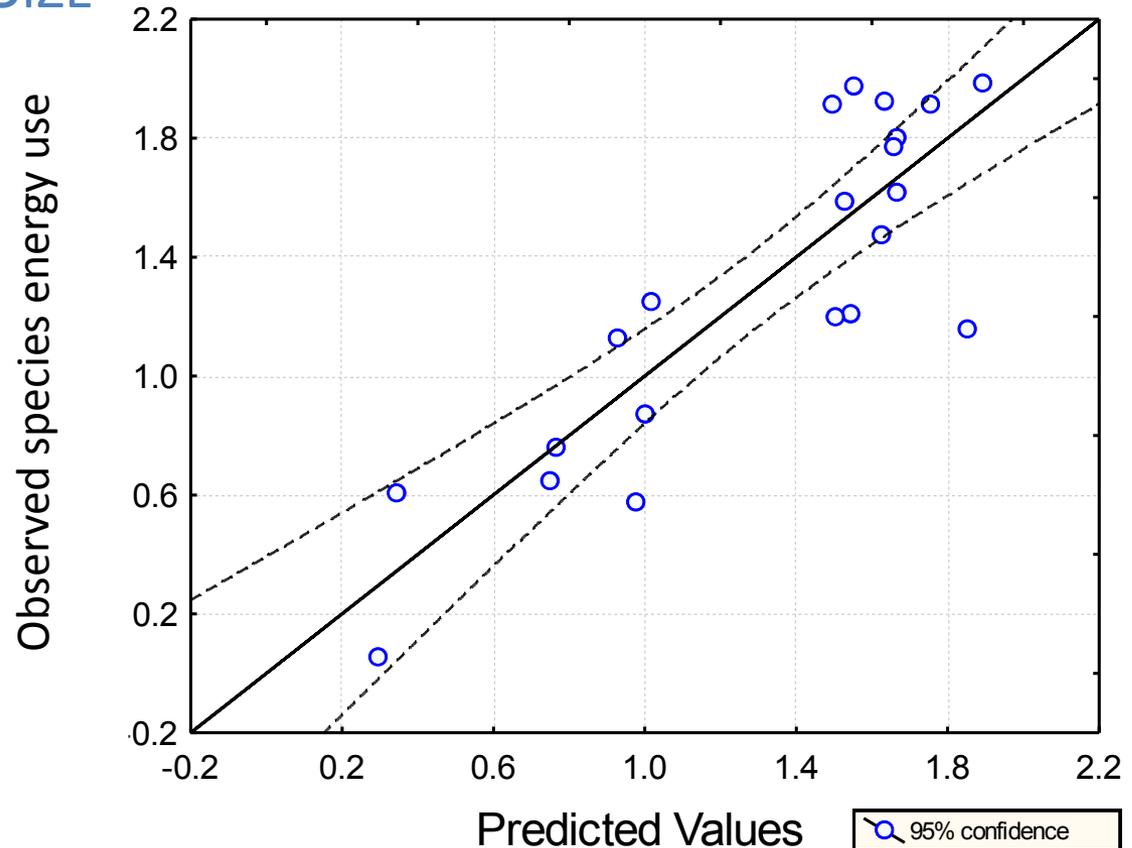


PATTERNS OF BIODIVERSITY IN LAGOONS

SPECIES TRAITS – BODY SIZE

69% of variation of energy used by the 1^o largest species is explained by three factors:

- Temperature
- Salinity
- Dissolved oxygen



PATTERNS OF BIODIVERSITY IN LAGOONS

IMPLICATIONS – NOTE³

From species morpho-functional traits

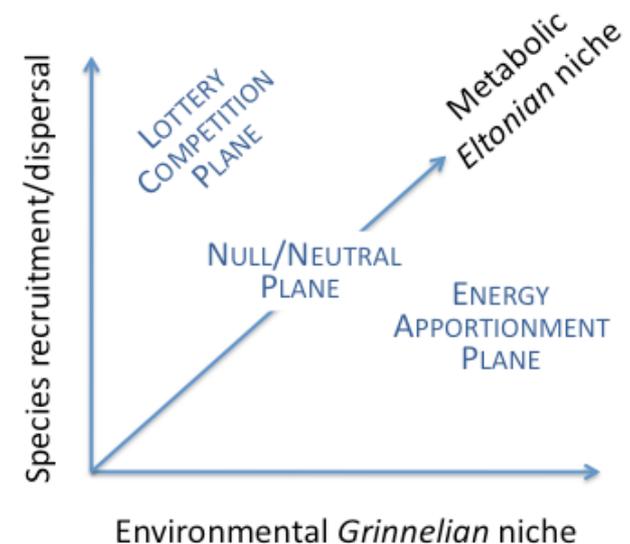
1. Macro-invertebrate in lagoons show an ‘optimal body size’;
2. Size-class redundancy is low;
3. Energy allocation among species show also a deterministic component with a suggested strong size dependent hierarchy;

MECHANISMS MAINTAINING LAGOON BIODIVERSITY

FINAL REMARKS (1 OF 4)

The ORGANISATION PLANES

1. At the taxonomic level, the NULL/NEUTRAL and the ENERGY APPORTIONMENT PLANES do not seem too relevant;
2. At the functional level, the ENERGY APPORTIONMENT PLANE seems to be the most relevant

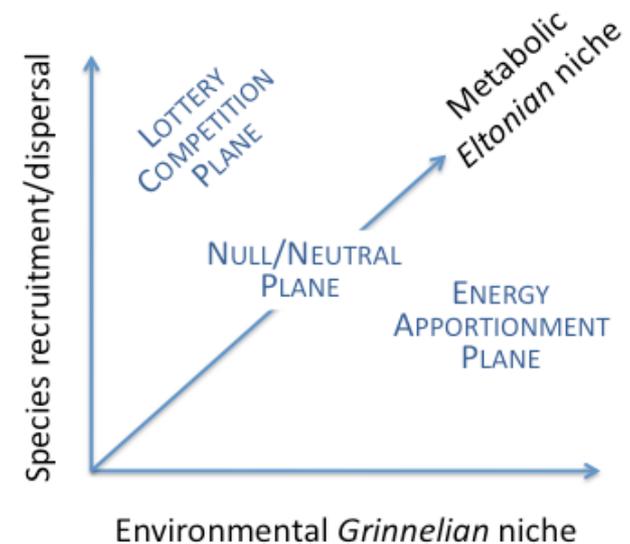


MECHANISMS MAINTAINING LAGOON BIODIVERSITY

FINAL REMARKS (2 OF 4)

The ECOSYSTEM PROPERTIES

2. Openness, exergy and resilience are key ecosystem properties:
 1. Openness ensures connectivity and patchiness;
 2. Exergy ensures resource availability and dynamics;
 3. Resilience (and redundancy) positively impact lagoon stability.

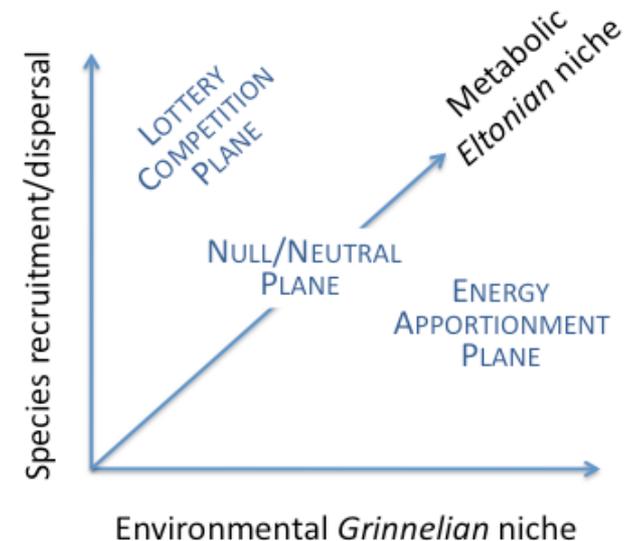


MECHANISMS MAINTAINING LAGOON BIODIVERSITY

FINAL REMARKS (3 OF 4)

ECOSYSTEM & COMMUNITY PROPERTIES IN CHANGING SCENARIOS

3. Openness, exergy and resilience are expected to be reduced :
 1. Connectivity, patchiness and resource availability are negatively impacted;
 2. Genetic, taxonomic, habitat and functional diversity are impacted;
 3. We are going towards lagoons with smaller species.



MECHANISMS MAINTAINING LAGOON BIODIVERSITY

FINAL REMARKS (4 OF 4)

The CONSERVATION ISSUE (WHAT CAN WE DO NOW)

1. Account for the proper scale(s) (and mechanisms) of biodiversity organisation in lagoons;
2. Protect openness, exergy and resilience;
3. Protect TW ecotones planning eco-efficiency of freshwater use

