On the assessment of functional diversity in coastal nurseries: the Bay of Biscay case study

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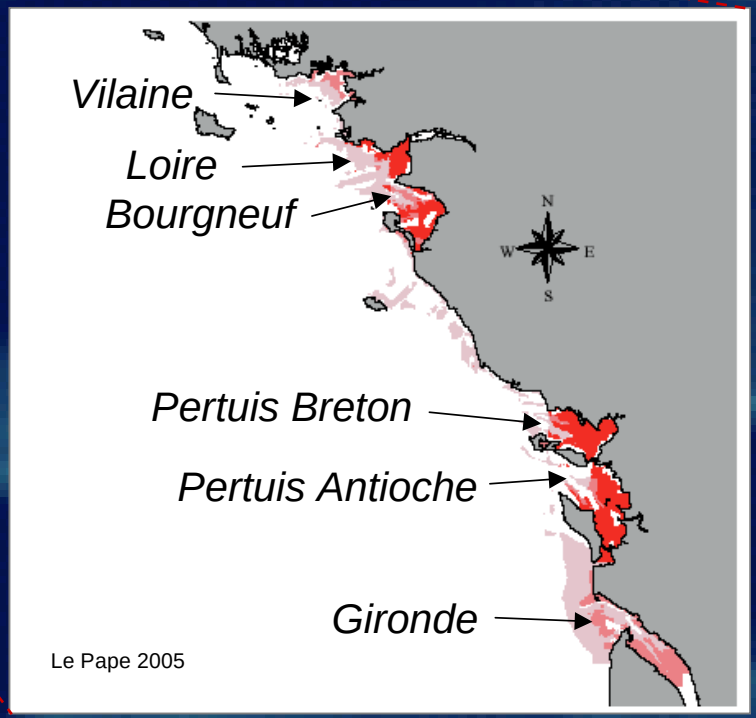
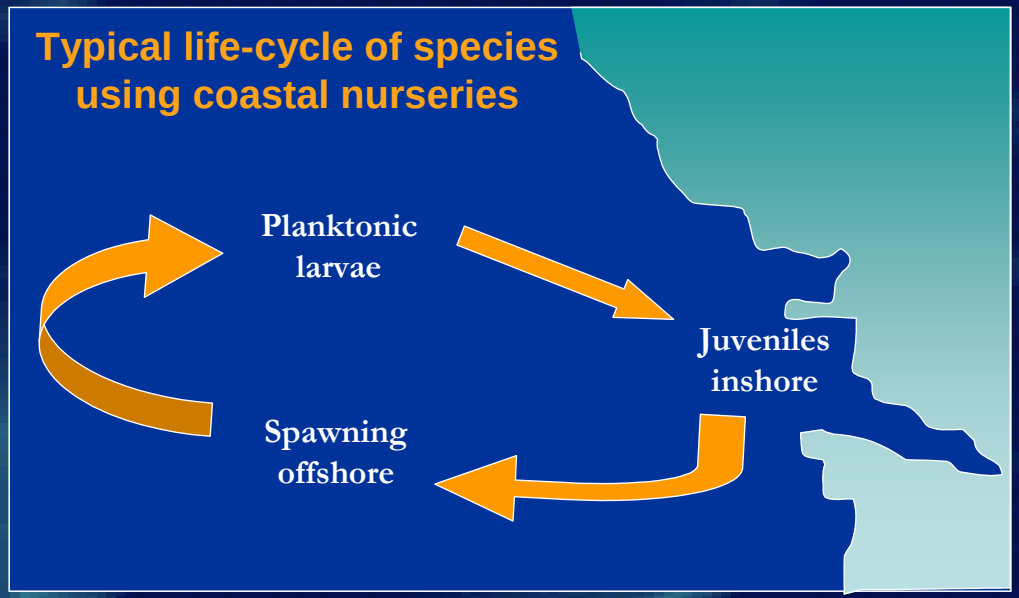
Bay of Biscay

Diverse and highly productive habitats: Estuaries, bays, exposed coasts

Coastal habitats: Numerous studies (e.g. flatfish recruitment)



Coastal nursery habitats



Important ecological functions:
Nursery habitats for many commercial fish stocks:

Flatfish (common sole, wedge sole, plaice, flounder), sea bass, whiting, pouting…

Loss of habitat quality and quantity
Change in biodiversity
↓
Community structure
Changes in resource use patterns between species
↓
Ecosystem processes
Functional relationships

Functional approach : Why ?

Identify indicators of anthropogenic pressures on coastal communities using functional approach (e.g. functional diversity)

- Simplify species-rich communities and thus allow the transferability of habitat models among ecosystems (Angermeier and Winston 1998)
- Groups of traits form operational units that respond to environmental changes in a more predictable way than individual species (Austen et al. 1994)
- Analytical way (first approach) of assessing the groups traits relevant to ecosystem functioning

Functional diversity : Which DF measure ?

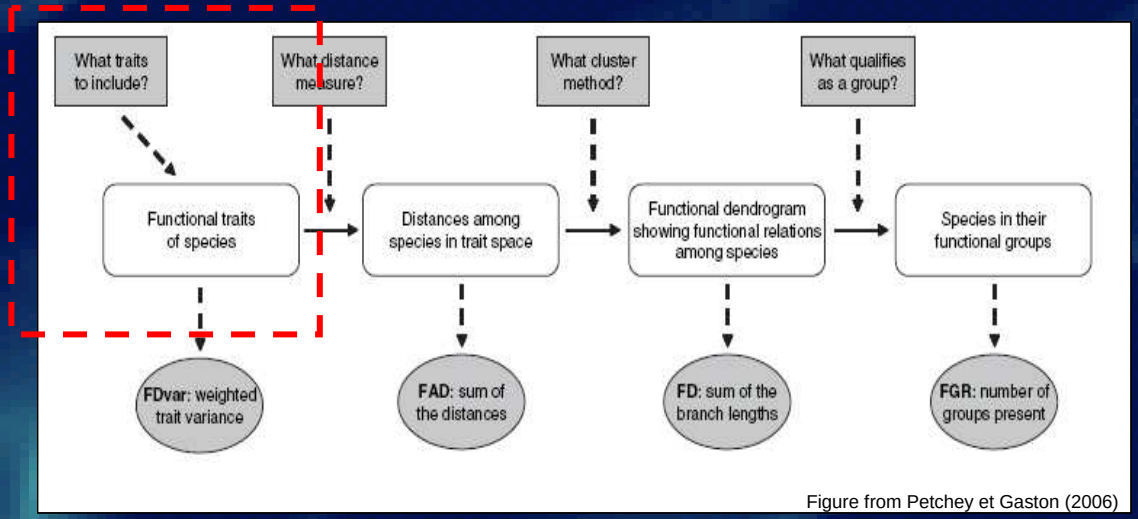


Figure from Petchey et Gaston (2006)

Common question: Which traits should be included ?

Effect traits

All traits important for the function of interest

Response traits

All traits associated with the forcing of interest (e.g. fishing impact)

Main goals

Verify if we can detect anthropogenic pressures on coastal communities and if functional diversity is a good indicator of bottom perturbation by trawls and dredges

Questions

1) What are the important groups of traits structuring the nursery communities? … Which traits are correlated with bottom trawl/dredge activities ?

2) Do they vary among nurseries ?

3) Do the measures of functional diversity display among-nursery variation ?

Sampling procedure

Sampling in 2000-2003 (September)

Six bays/estuaries

3 m beam trawl (n=176 hauls)

Depth range : 3 to 37 m

Biological data (45 species)

Fish (25), molluscs (9), arthropods (5), echinoderms (3), annelids (3)

List of species

Species included in the analyses		
Acanthocardia echinata	***Dicologlossa cuneata***	*Phrynorhombus norvegicus*
Alloteuthis	***Gobius niger***	***Platichthys flesus***
Amphiura brachiata	*Hippocampus hippocampus*	***Pleuronectes platessa***
Amphiura filiformis	*Liocarcinus*	***Pomatoschistus minutus***
Aphrodita aculeata	***Loligo vulgaris***	*Psammechinus miliaris*
Arnoglossus laterna	***Merlangius merlangus***	***Raja clavata***
Asterias rubens	***Merluccius merluccius***	*Scyliorhinus canicula*
Buglossidium luteum	***Mullus surmuletus***	***Sepia officinalis***
Callionymus lyra	*Necora puber*	***Solea solea***
Carcinus maenas	*Ophiura ophiura*	***Sparus auratus***
Cerastoderma edule	*Owenia fusiformis*	*Spondyliosoma cantharus*
Chelidonichthys gurnardus	*Paguridae*	*Trachurus trachurus*
Chelidonichthys lucernus	***Palaemon serratus***	***Trisopterus luscus***
Ciliata mustela	*Pectinaria koreni*	***Trisopterus minutus***
Crangon crangon	*Philine aperta*	*Turritella communis*
Dicentrarchus labrax		

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Functional traits

Feeding, reproductive, ecological guilds, biogeo, substrate, commercial

Environmental variables

Temperature, bathymetry, substrate, pressure index

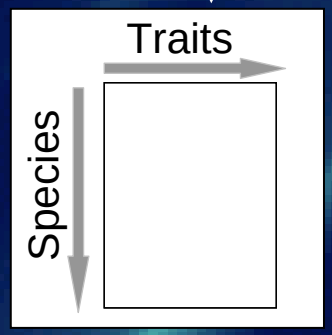
Methodological framework
Part I: Selection of functional traits

List of natural and anthropogenic stresses

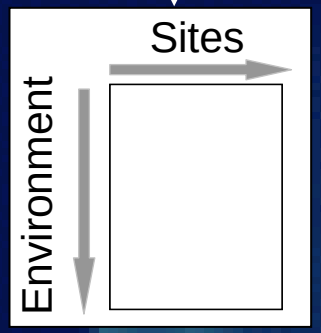
Matrix species-functional traits

Matrix of environmental forcing

Literature
Database
Experts



X 6
nurseries



Sampling
Calculated

List of species functional traits

Functional category	Attribute	Code
Feeding guilds	Phytoplankton	PL
	Zooplankton	ZP
	Invertebrate (mollusc, crustacean)	IS
	Fish	FS
	Plants	VS
	Deposit feeder	DSS
	Plankton + Deposit feeder	PD
	Detritivore	DS
	Omnivore	OM
Reproductive guild	Pelagic eggs	Op
	Eggs guarded	Og
	Eggs protected (shed, pouch, case)	Os
Ecological guild	Marine migrant	MA
	Marine seasonal migrant	MS
	Marine juvenile migrant	MJ
	Estuarine resident	ER
	Catadromous	CAT
Mobility	Swimmer	SR
	Crawler	CR
	Burrower	BR
	Permanent attachment	PA

+ Substrate pref
+ Commercial
+ Biogeography

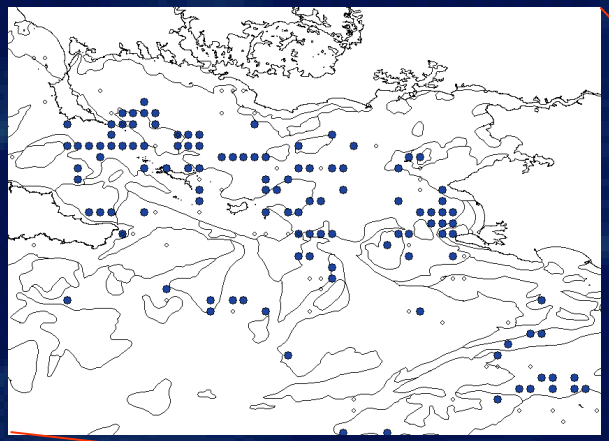
Functional trait

Substrate preference
Reproductive guild
Vertical distribution
Tolerance to anoxia

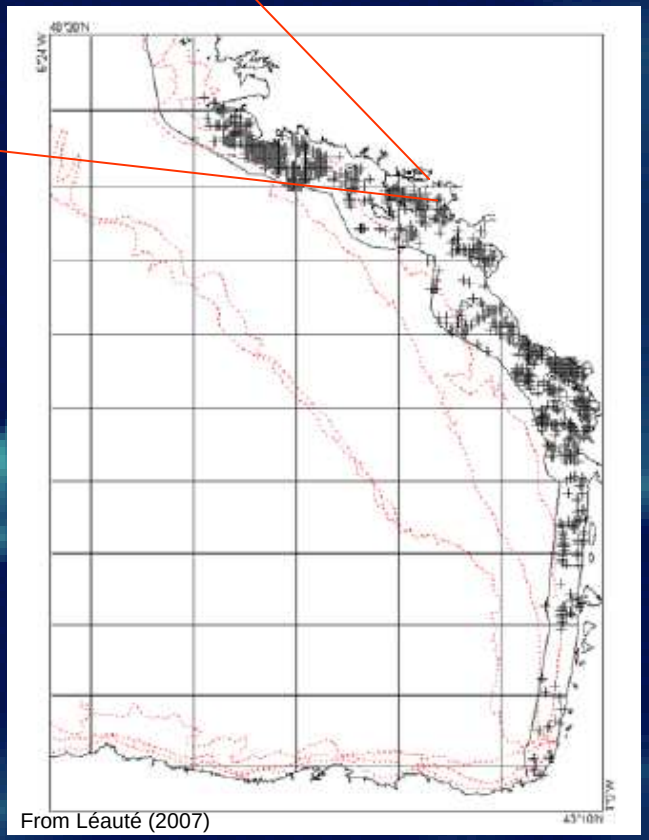
Body size
Vertical distribution
Feeding guild
Life-history strategy
Commercial (for bycatches)

Ecological guild
Feeding guild
Reproductive guild
Mobility

Estimation of fishing impact



Coastal fisheries surveys



From Léauté (2007)

Fishing fleet surveys

Monthly from 11/2000 to 11/2001

Inside the 12 miles

Census of fishing boat (+ type of fisheries)

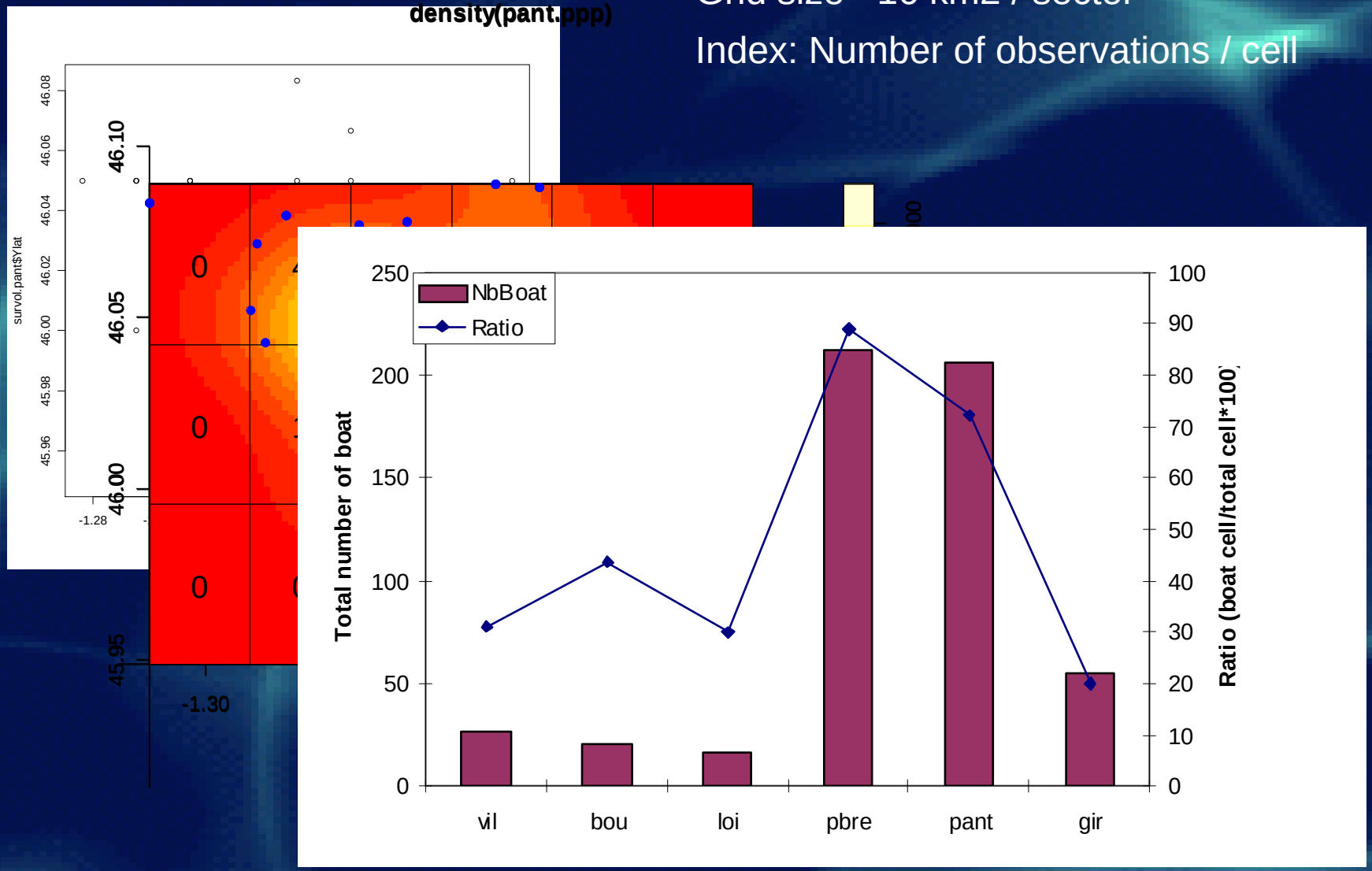
- Bottom trawls and dredges
- Others (gillnets, potters, longlines)

Geographical positions

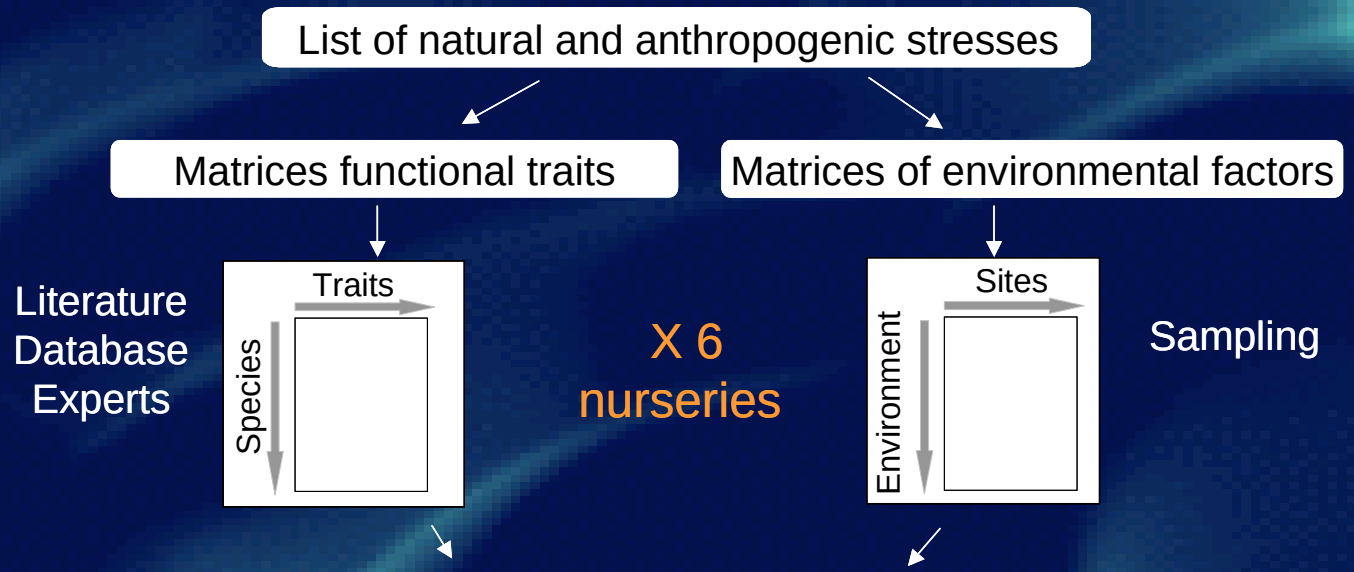
Spatially-based index of bottom perturbation

Grid size ~16 km2 / sector

Index: Number of observations / cell



Methodological framework
Part I: Selection of functional traits



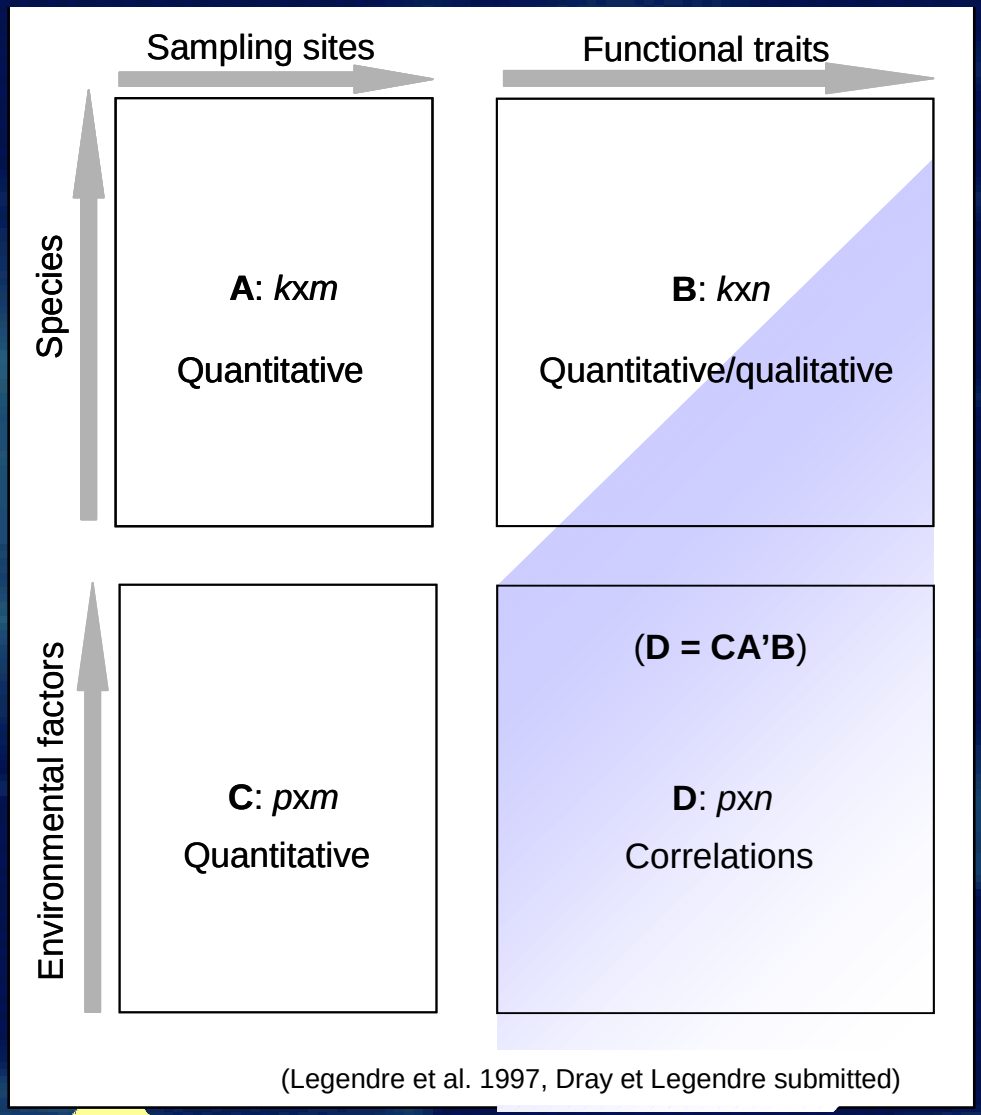
Fourth-corner analysis

Selection of functional traits structuring each nursery community

X 6
nurseries

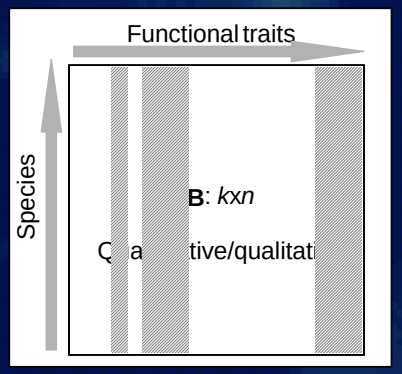
Fourth-corner analysis

Selection of functional traits structuring nursery communities

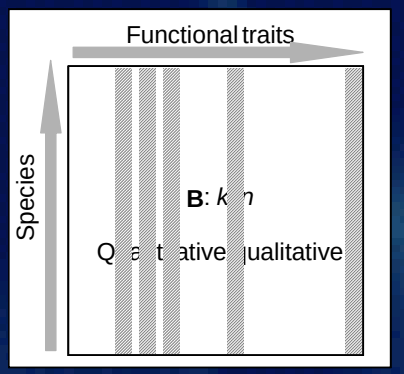


(Legendre et al. 1997, Dray et Legendre submitted)

Loire



Gironde



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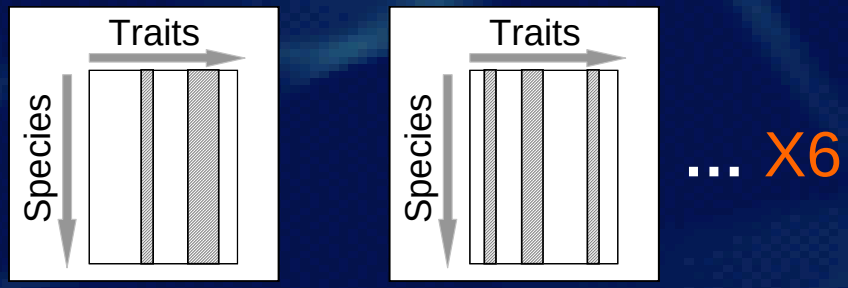
X 6 nurseries

Select functional traits displaying significant correlations with environmental factors

Methodological framework
Part II: Computation of functional diversity

New matrices of species-traits

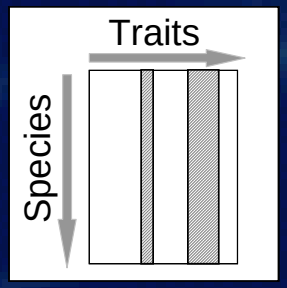


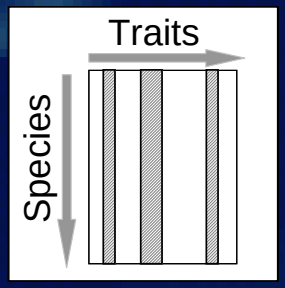
... X6

- Weight=0 if trait is not significant
- FD is weighted by the forcings and only the significant traits associated with those forcings (eg fishing impact) are influencing the DF estimate

Methodological framework
Part II: Computation of functional diversity

New matrices of species-traits





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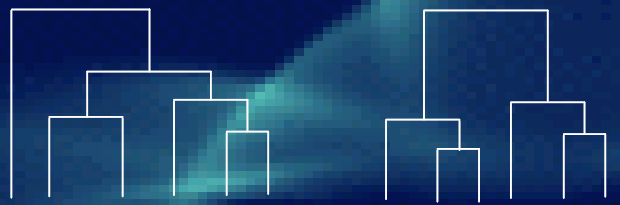
Functional Diversity

Tree-based approach

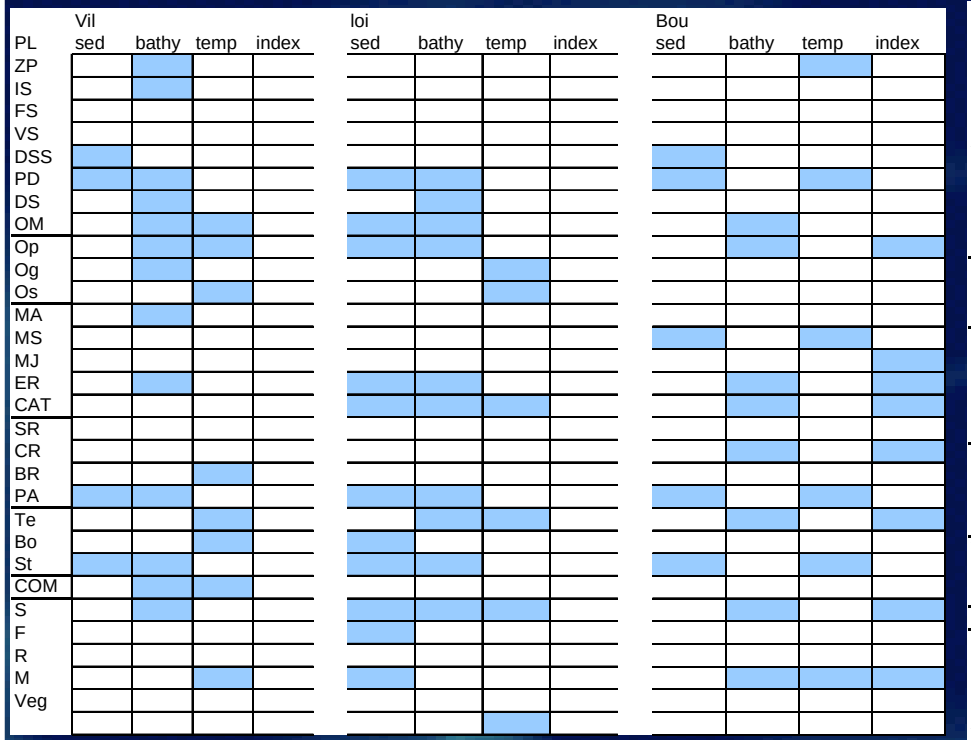
FD = branches length

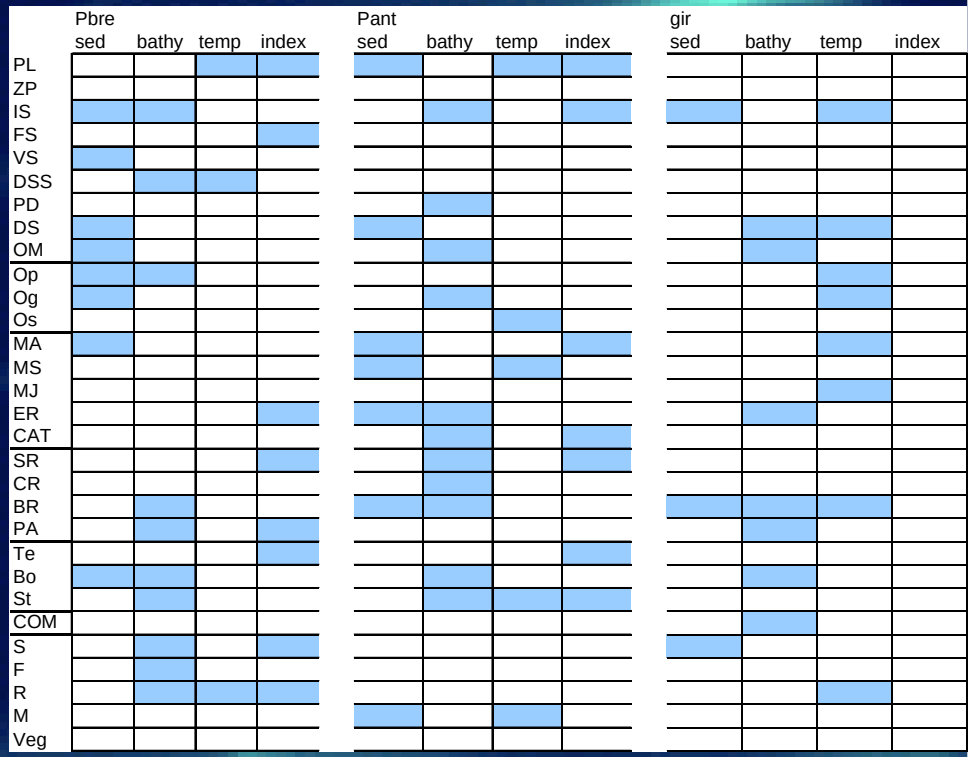


FD = 6 FD = 4

... X6

Natural variability and fishing impact





Natural variability and fishing impact

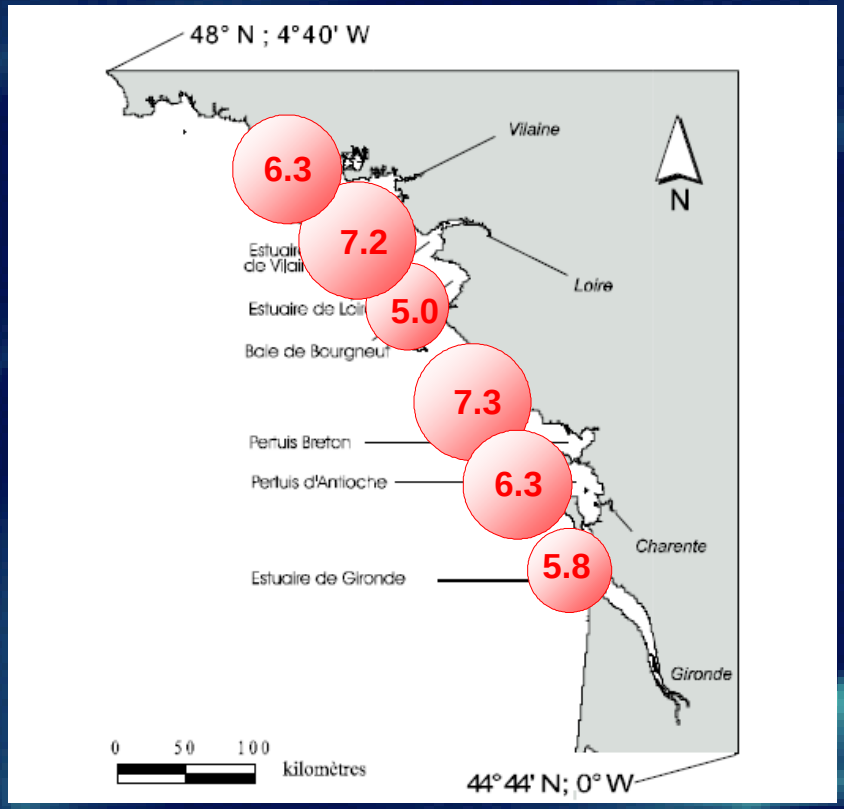
Based on PCA/Cluster analyses

Loire and Bourgneuf: Sediment and bathymetry → feeding guild (detritivores and omnivores)

Bourneuf/Antioche/Breton : Fishing index → ecological guild (juvenile migrant and estuarine resident)

Gironde: Low correlations… (burrowers)

If so, do the measures of functional diversity display among-nursery variation ?



- Small differences between nurseries

Conclusions

Methodological framework

Selection of functional traits constrained by species abundance and environmental factors

Evenness and environmental forcings (natural and/or anthropogenic)

Statistical testing of the functional traits structuring the communities

Key decision in many FD measures

Assessment of the FD using tree-based approach

Species are not treated binary (continuous measure)

Differences between nurseries

Nurseries seem structured by different factors, but similarities in nearby sectors

Bottom perturbation by bottom trawlers seems to be more important in 3 nurseries and affects mostly ecological guilds

Sector comparison