The removal of forage species hinder the robustness of a marine food web

Testing food web robustness against taxa's sensitivity in an exploited fishing ground

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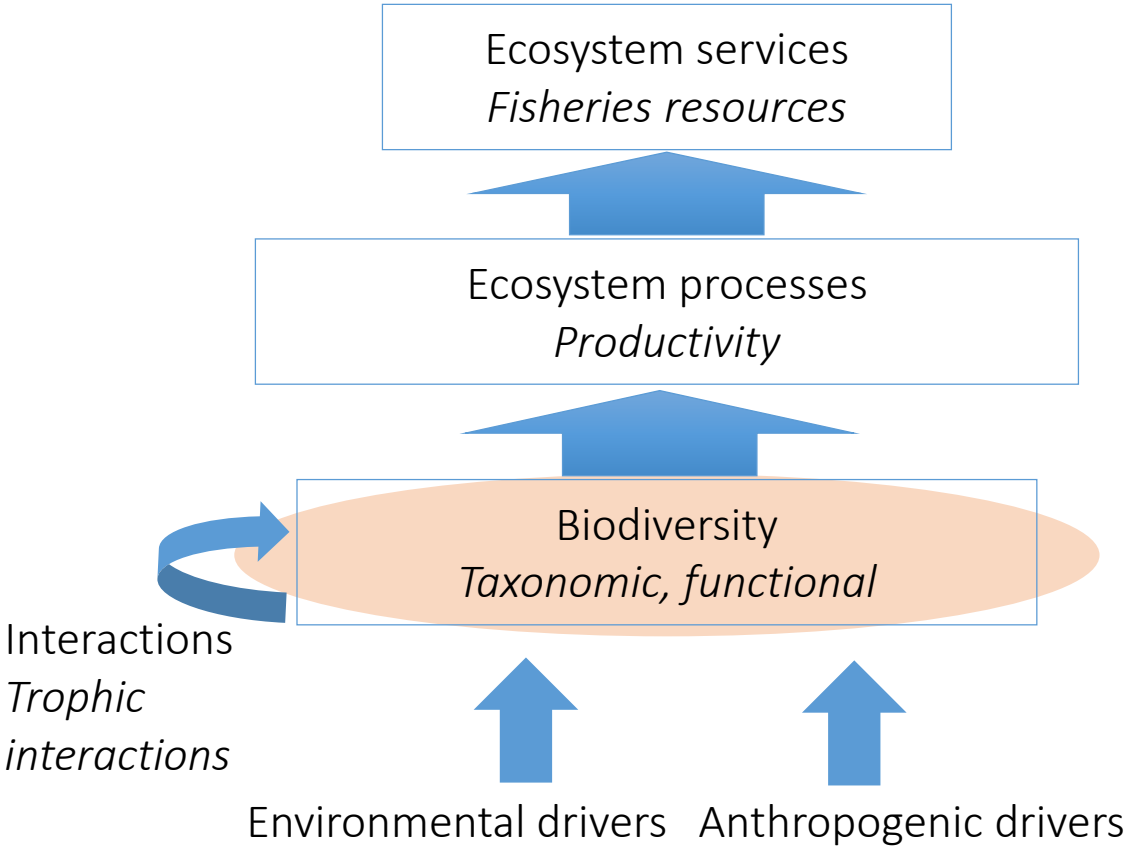
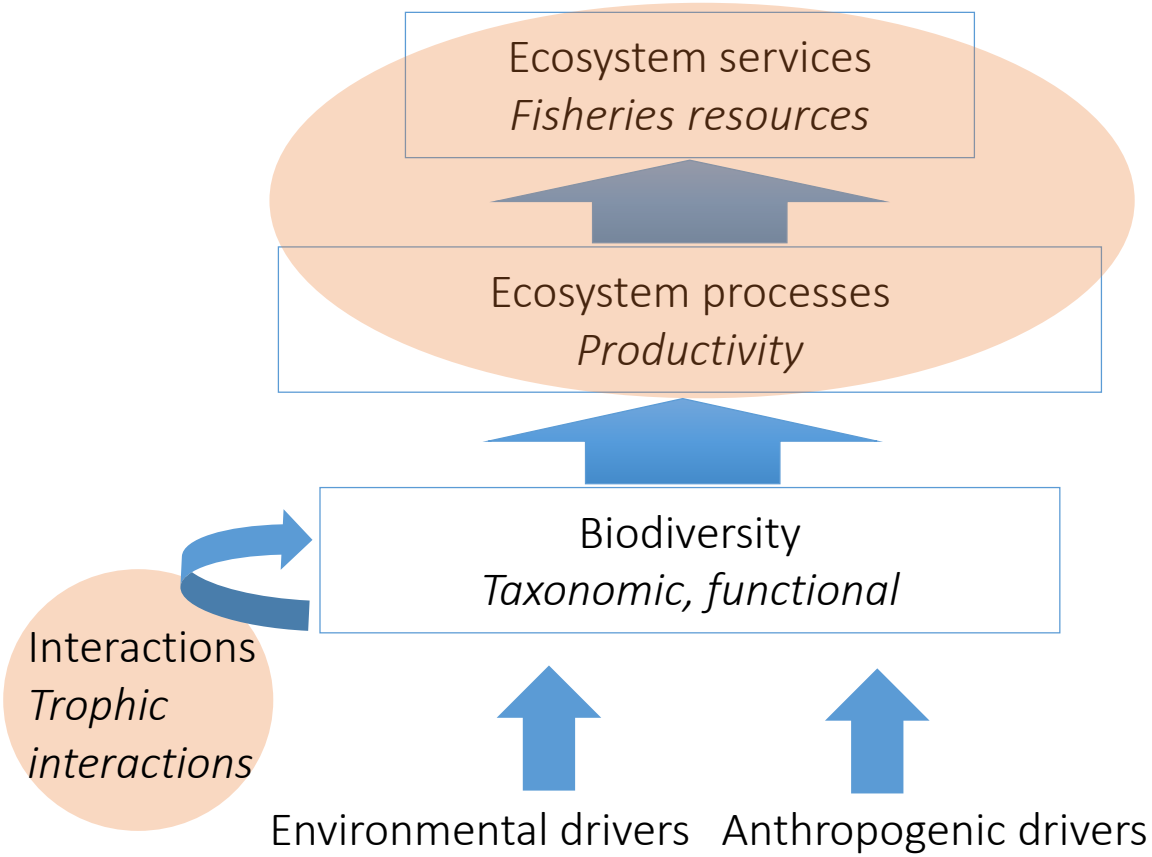
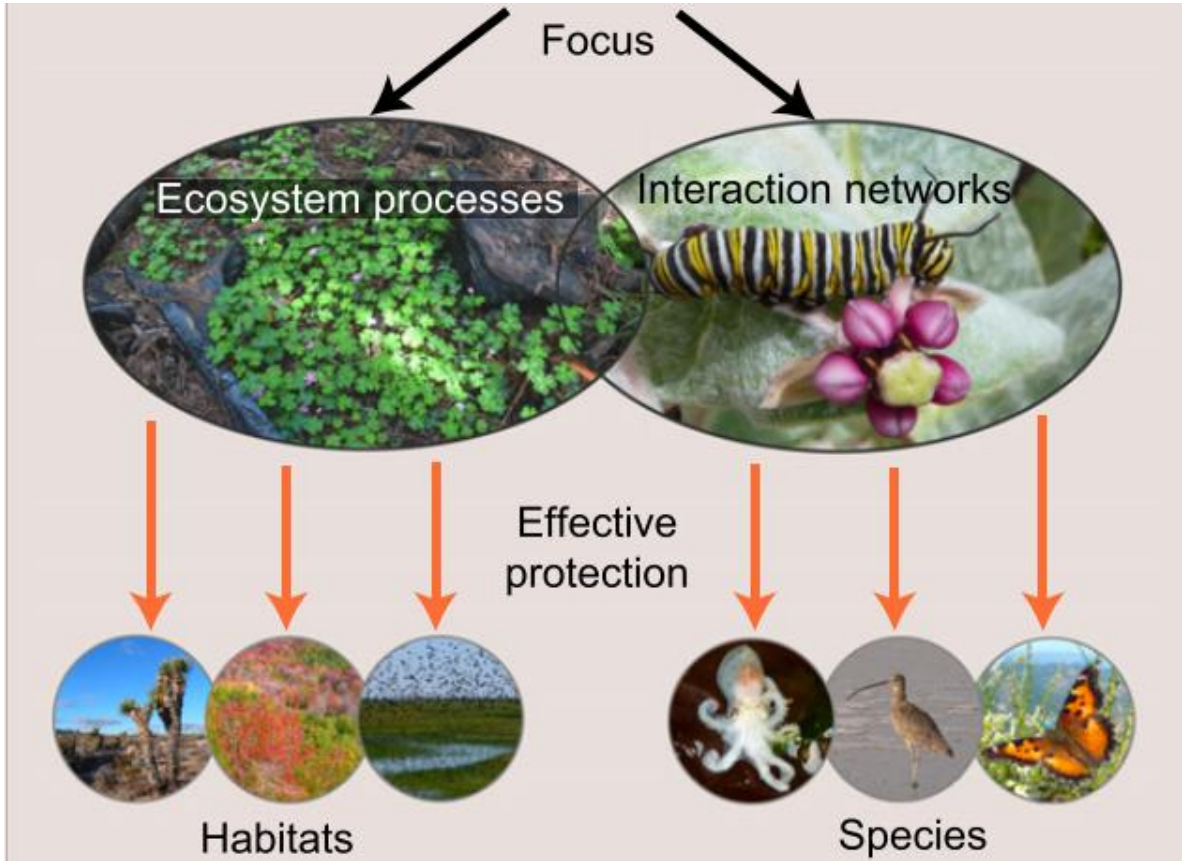
Historical conservation focus



From Harvey et al. 2017

Future conservation focus





From Harvey et al. 2017

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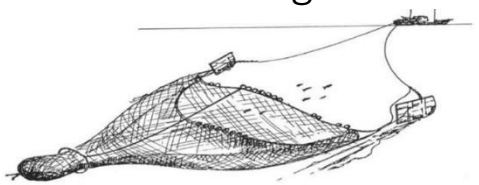
Ecosystem services
Fisheries resources

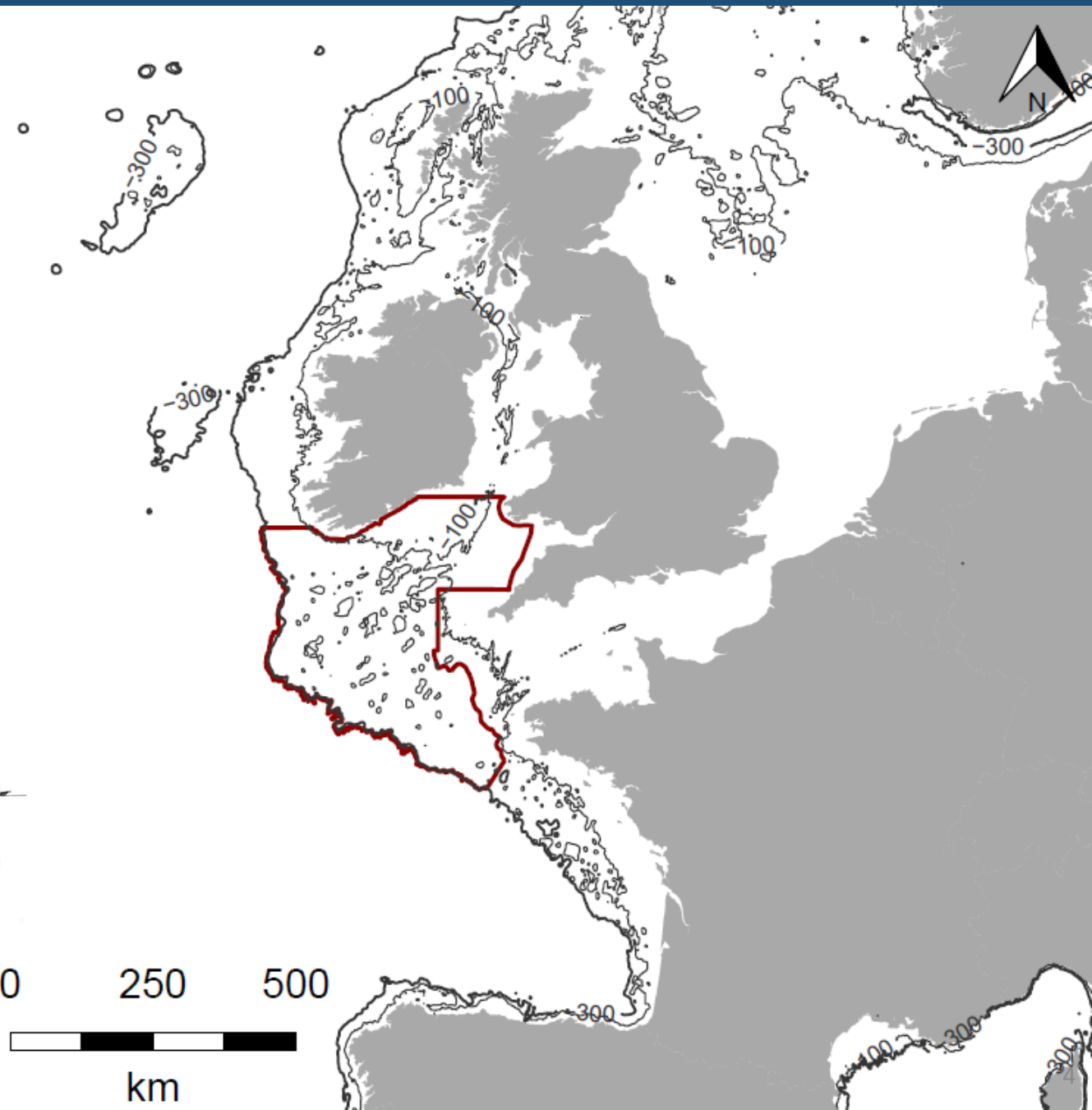
Ecosystem processes
Productivity

Biodiversity
Taxonomic, functional

Interactions
Trophic interactions

Fishing

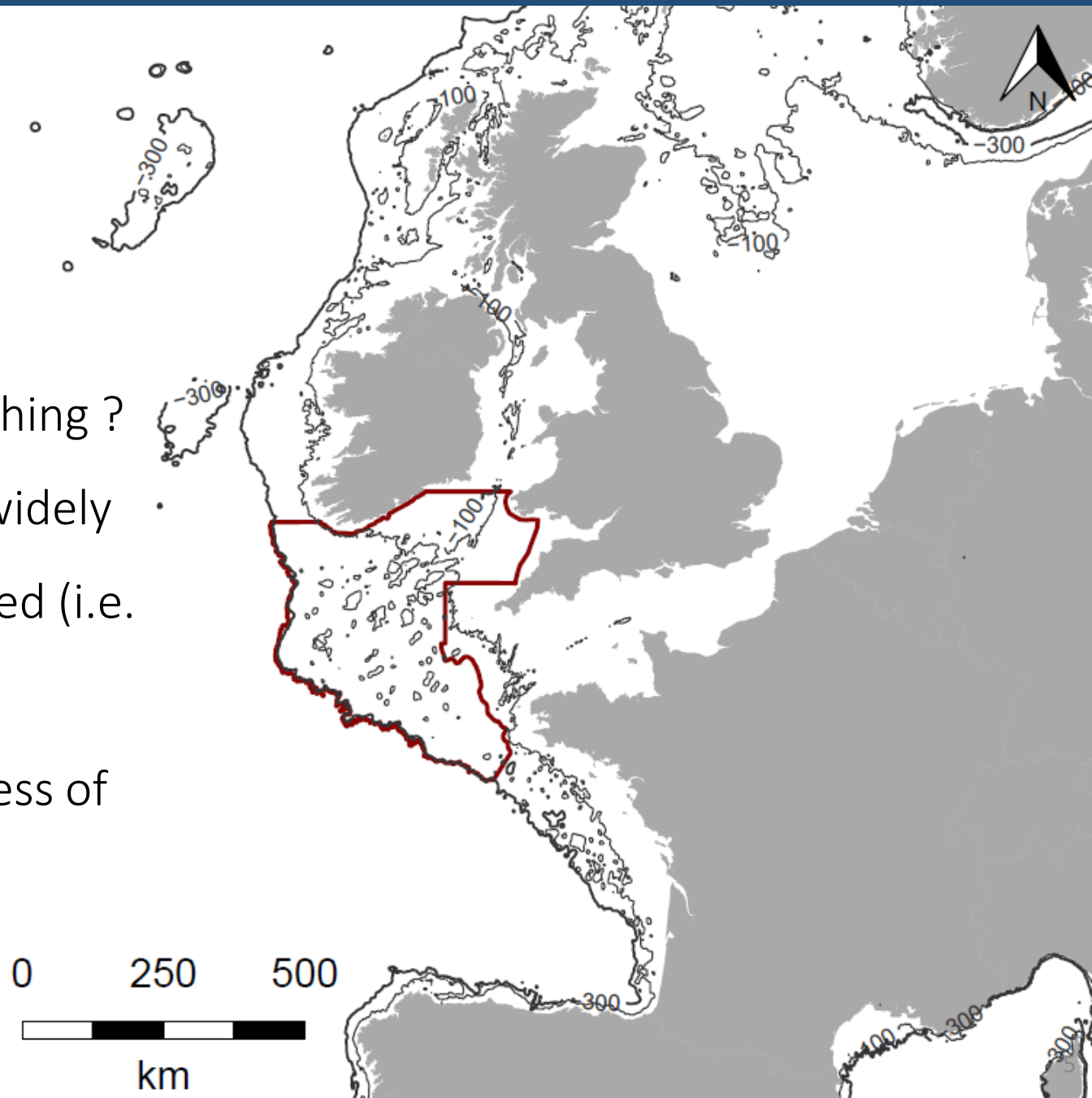




→ Use of sensitivity index

We investigated the implication of the sensitivity of species
to the robustness of the trophic network

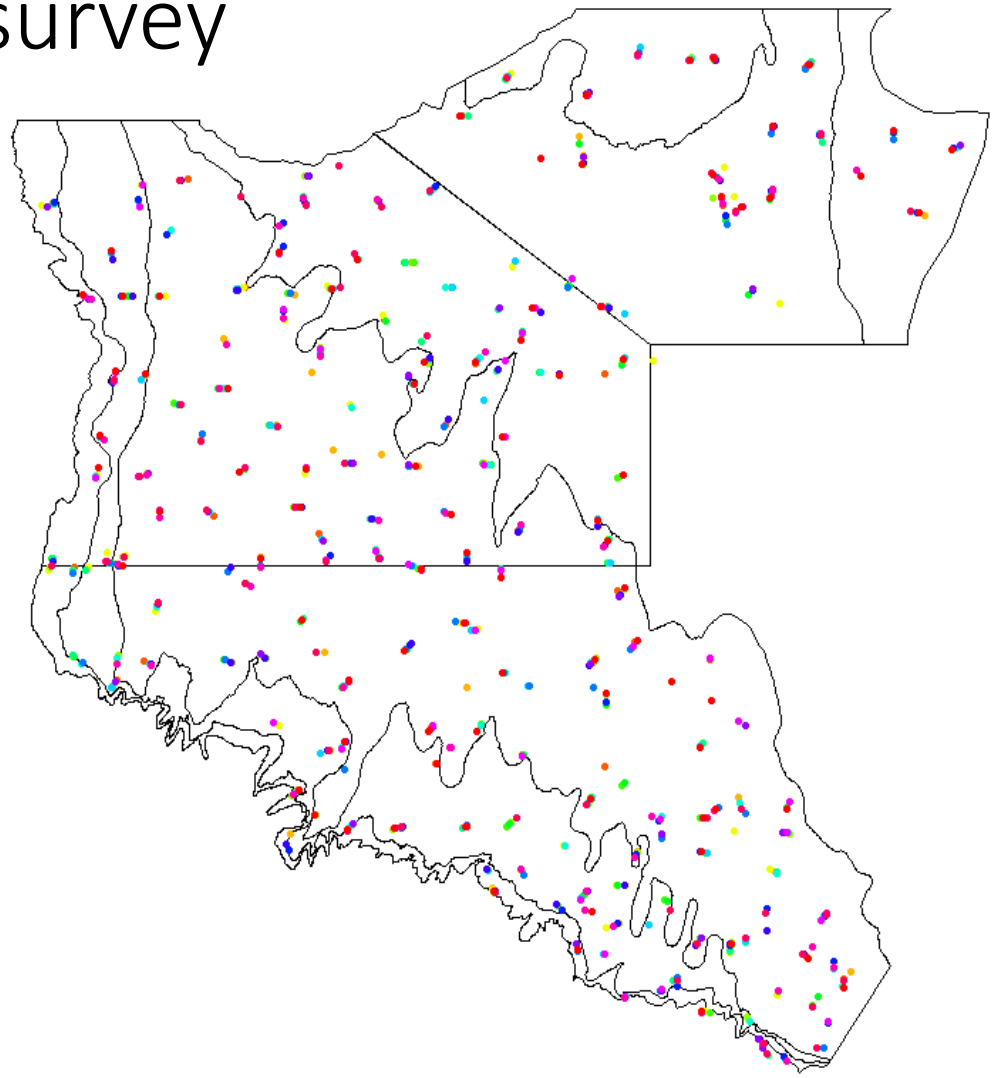
1. What are the more sensitive species to fishing ?
2. Which species are susceptible to lead to widely spreading effects in the food web if affected (i.e. the most central) ?
3. Which species lead to the lowest robustness of the network ?



Biomass data – from EVHOE survey

Part of the European international bottom trawl survey. Standardized sampling since 1997

Megabenthic and demersal species
(fish, cephalopods, crustaceans, bivalves)



Trophic data – from EVHOE survey and professional boats

Isotopic measurements

- 69 megabenthic and demersal species

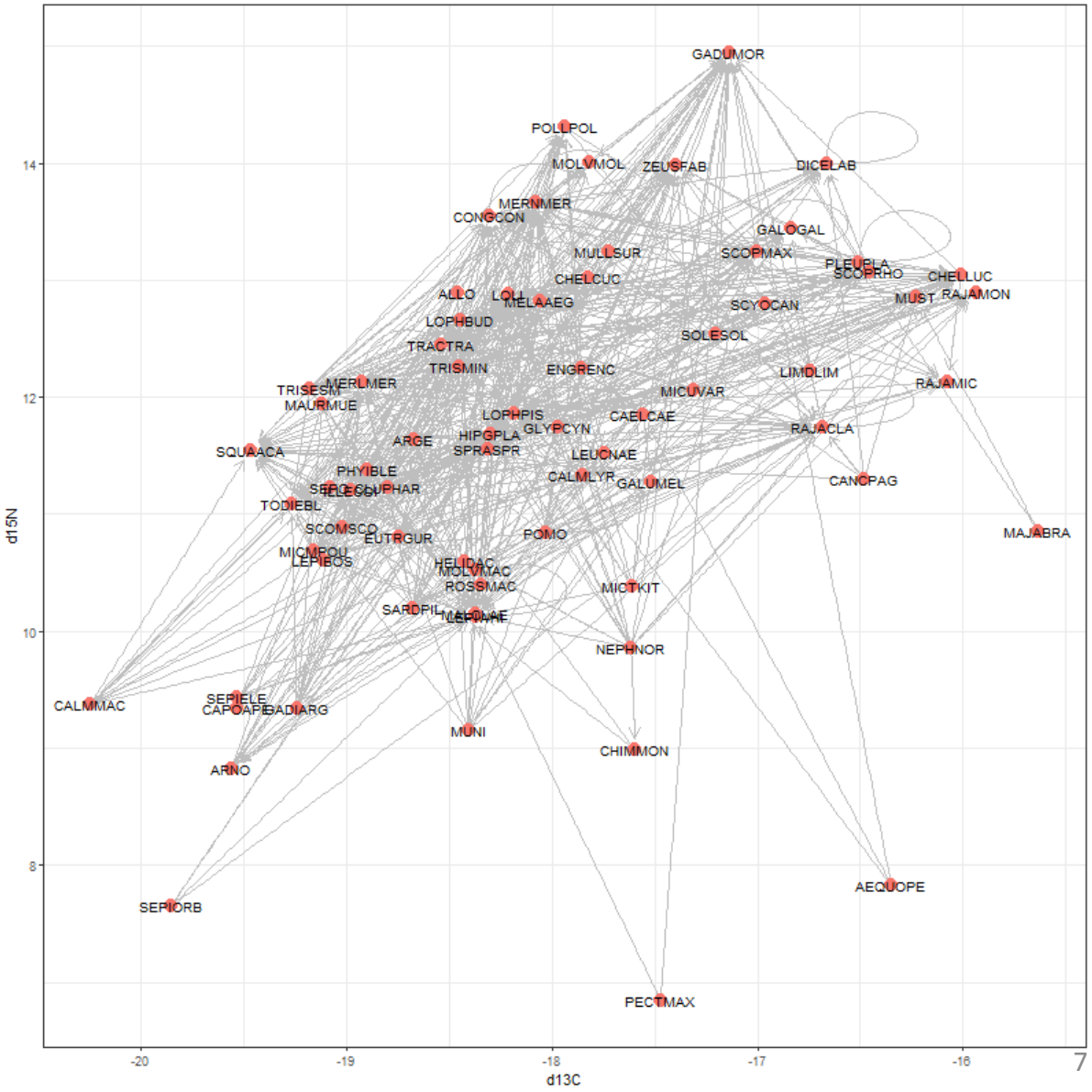
➔Values of $\delta^{15}N$ and $\delta^{13}C$

(lipid and baseline corrections)

Bibliographic data on prey-predator interactions

- From P.-Y. Hernvann's PhD work

➔ Trophic links



Aim: Sensitivity of species to fishing and implication for the stability of trophic network

How to evaluate sensitivity ?

→ Use of biological traits related to life strategy

Biological traits	Type	Levels
Max length	numeric	
Reproductive guilds	factor	Bearer, non-guarder, guarder
Longevity	numeric	
Fecundity	factor	low, medium, high, very_high
Offspring size	numeric	
Age at maturity	numeric	

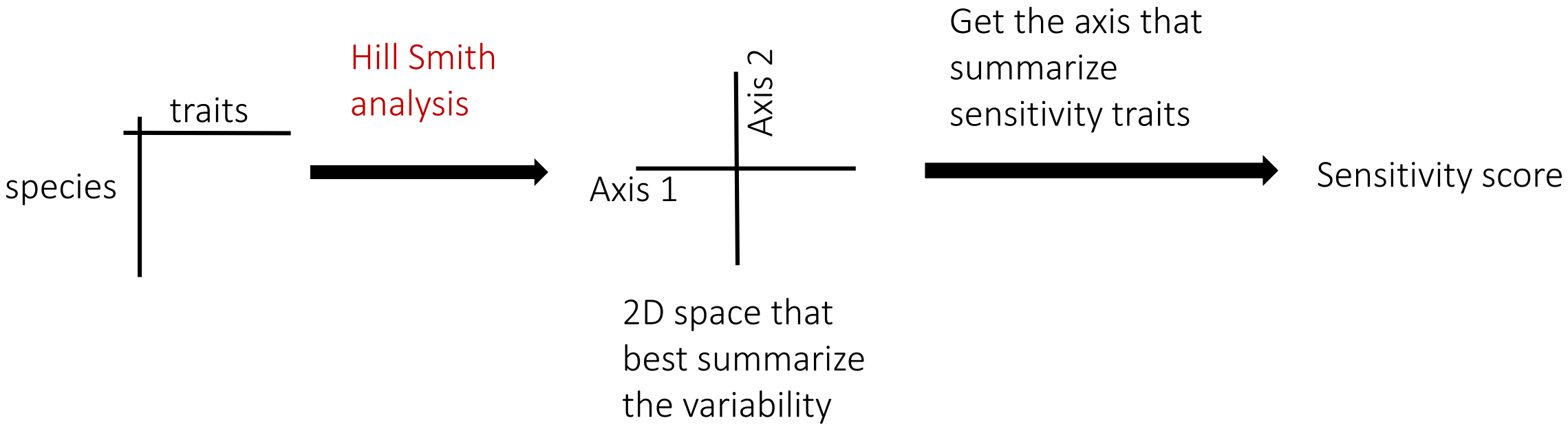
Related to fast-slow life history strategy, known to respond to fishing (Wiedmann et al. 2014)

Sensitivity of species to fishing and implication for the stability of trophic networks

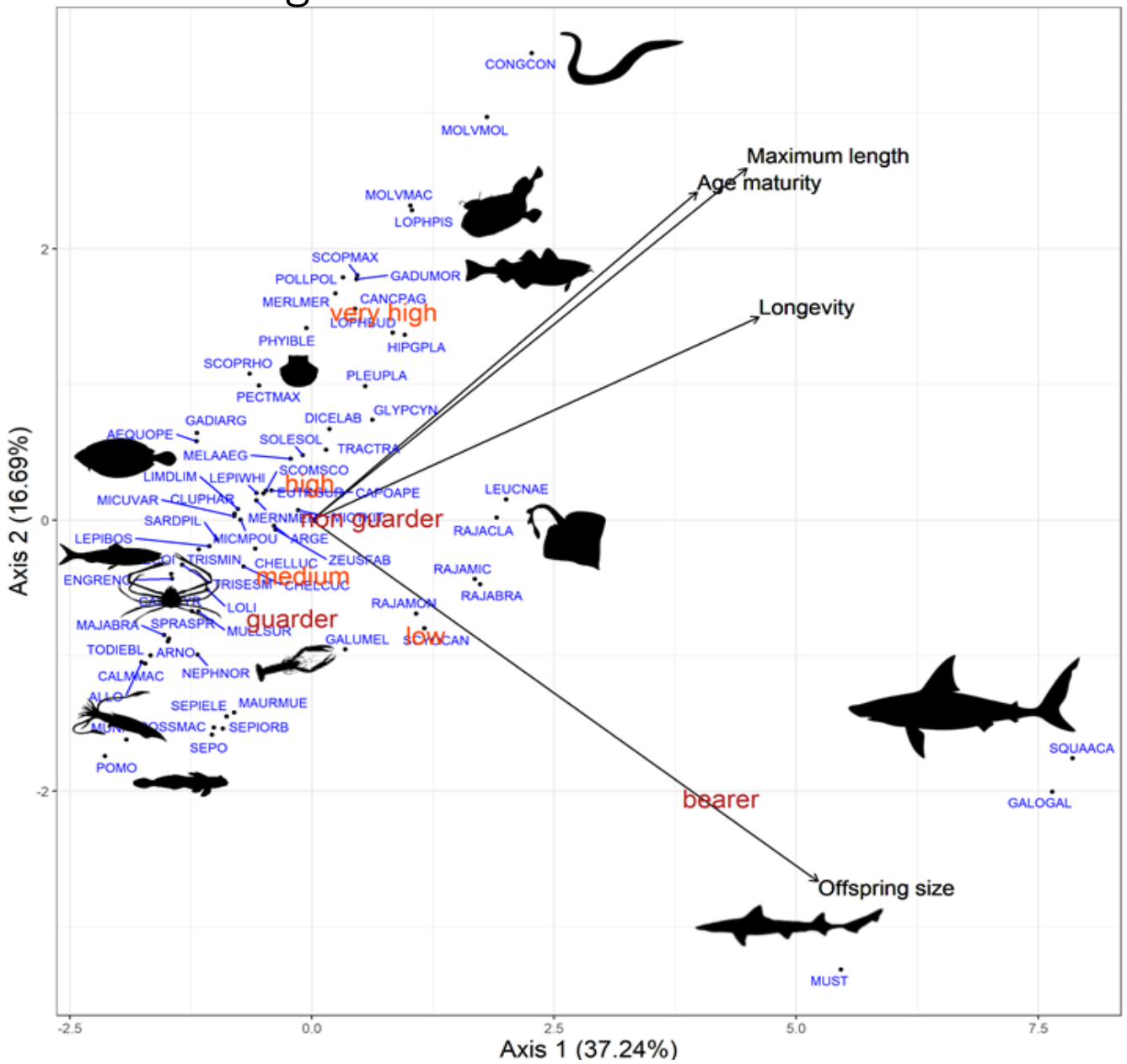
How to evaluate sensitivity ?

→ Use of biological traits related to life strategy

→ Get an integrative metric of that sensitivity: multivariate analysis



1- Sensitivity of species to fishing



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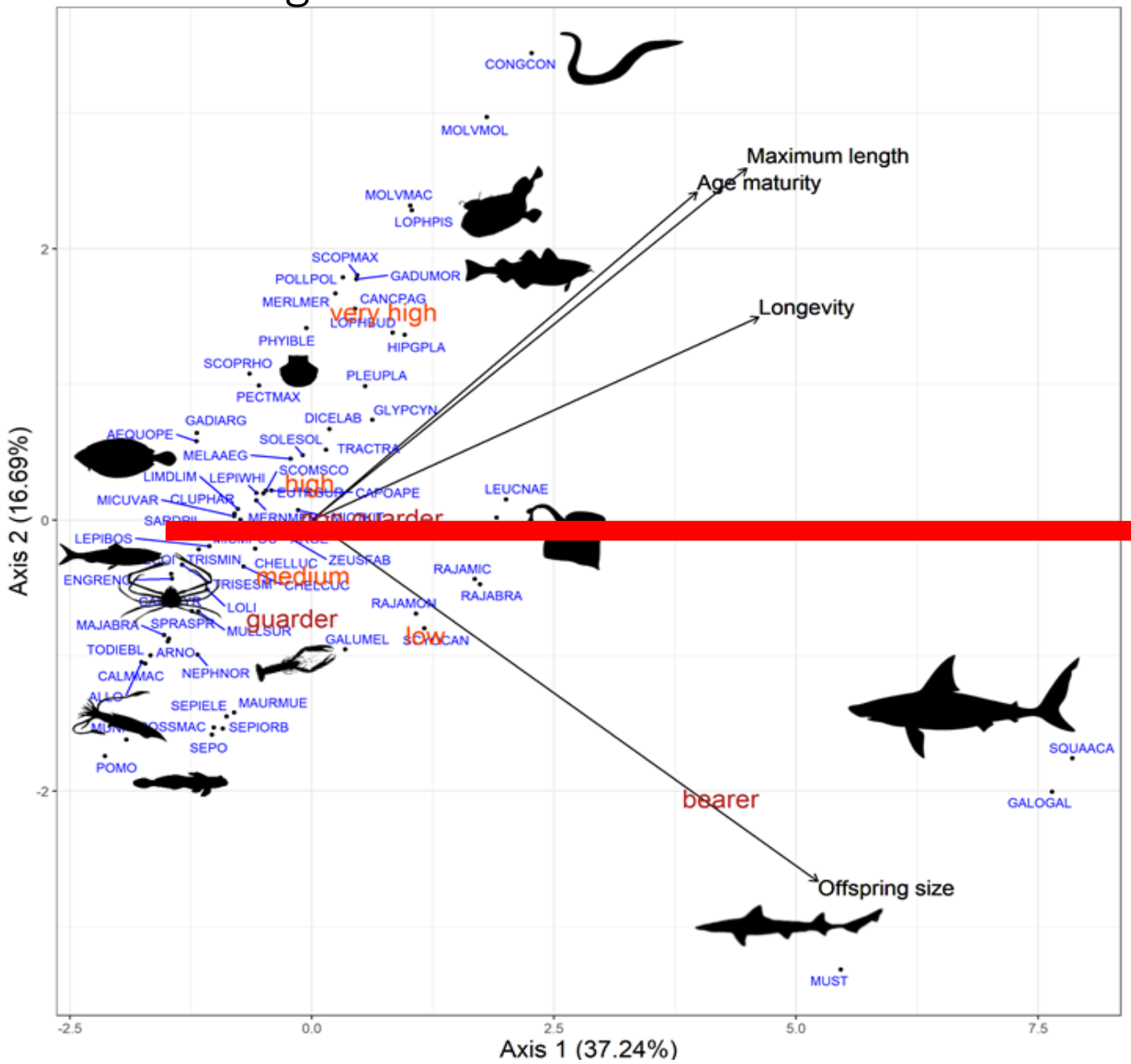
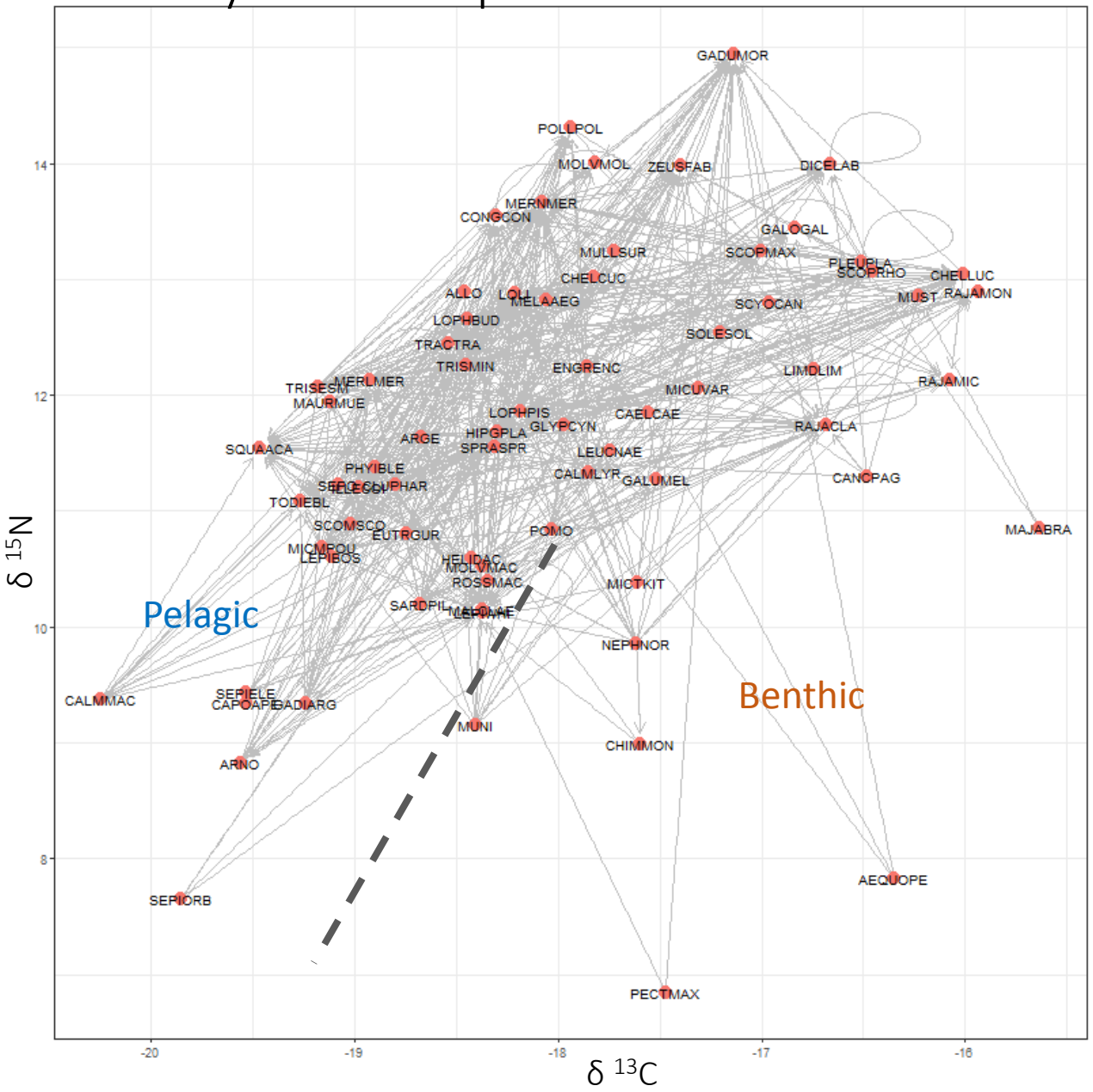


Sensitivity score

2- Stability of the trophic network



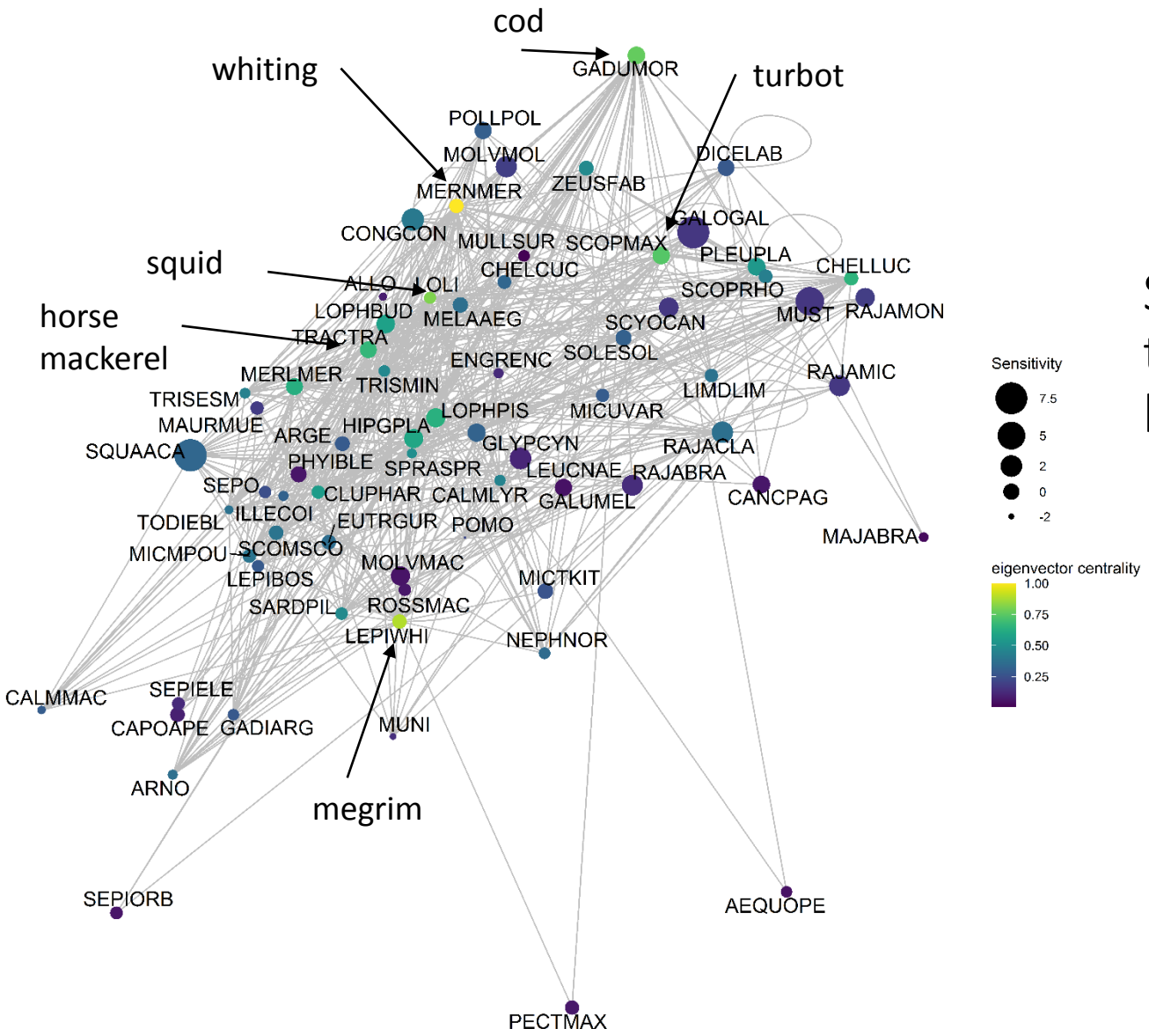
Trophic network structure determined from isotope measurements

Structuring properties of the food web to characterize its robustness: notion of centrality (total number of the in and out links)

Eigen centrality : quantify if a species is linked to highly connected species

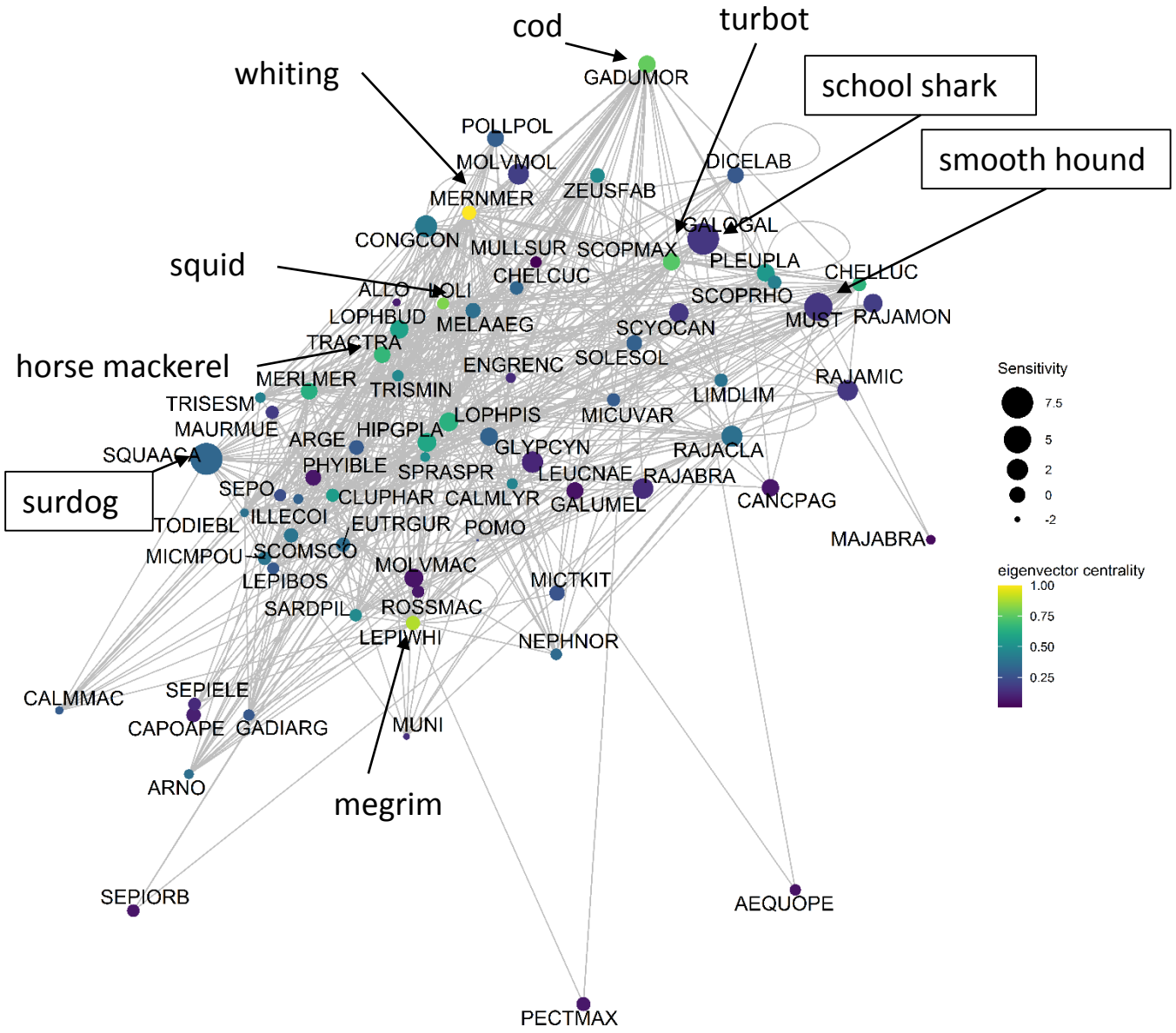
→ central species if threaten would have spreading effects across the whole network

2- Stability of the trophic network: Eigen centrality



Species that are linked to a lot of species that are themself linked to a lot of species have the highest eigen centrality score

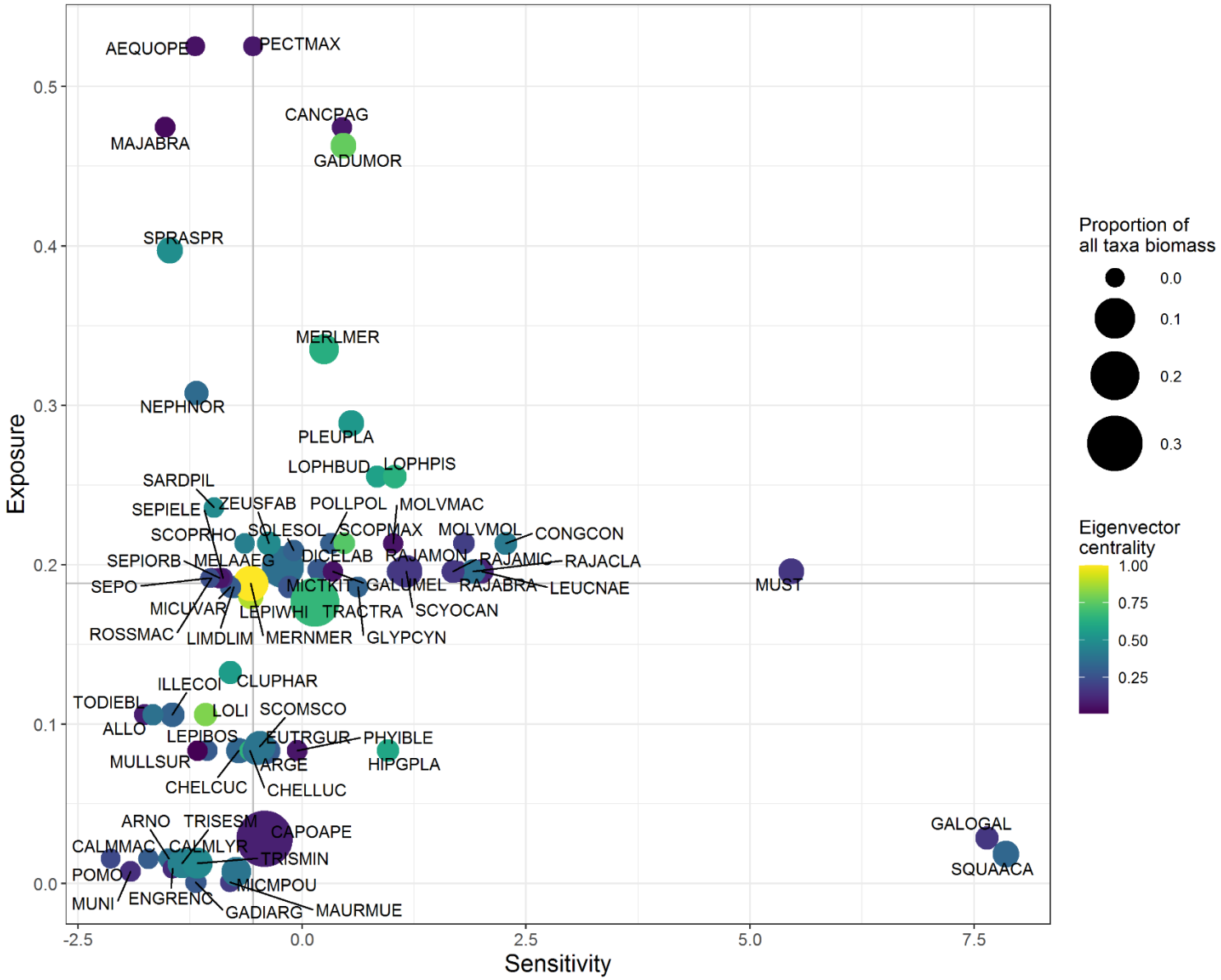
3- Sensitivity of species to fishing and implication for the stability of trophic networks



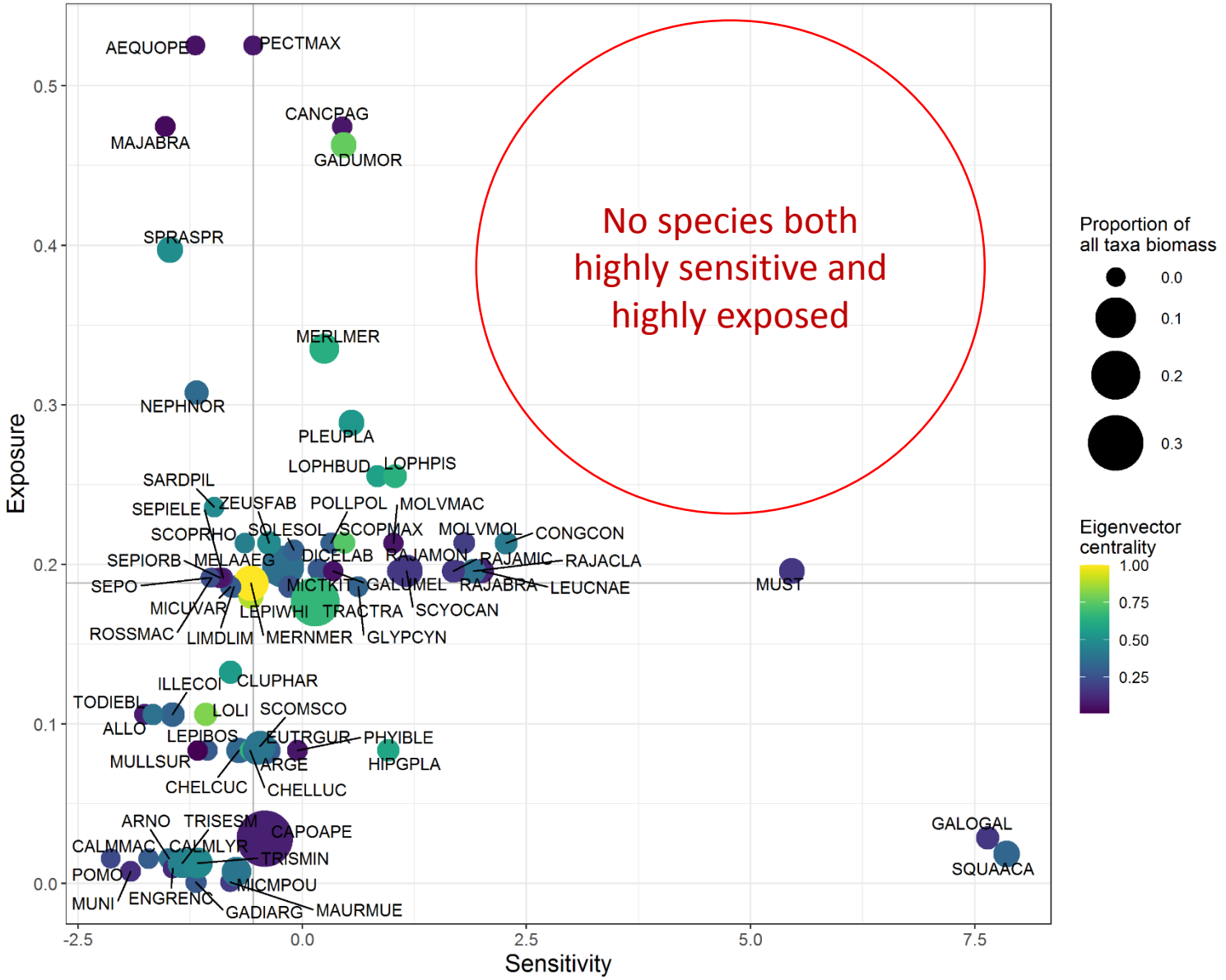
Sensitivity (framed species) and centrality:
No both highly sensitive and highly central species

But some species that are not among the more sensitive can also be threaten

3-Sensitivity of species to fishing and implication for the stability of trophic networks

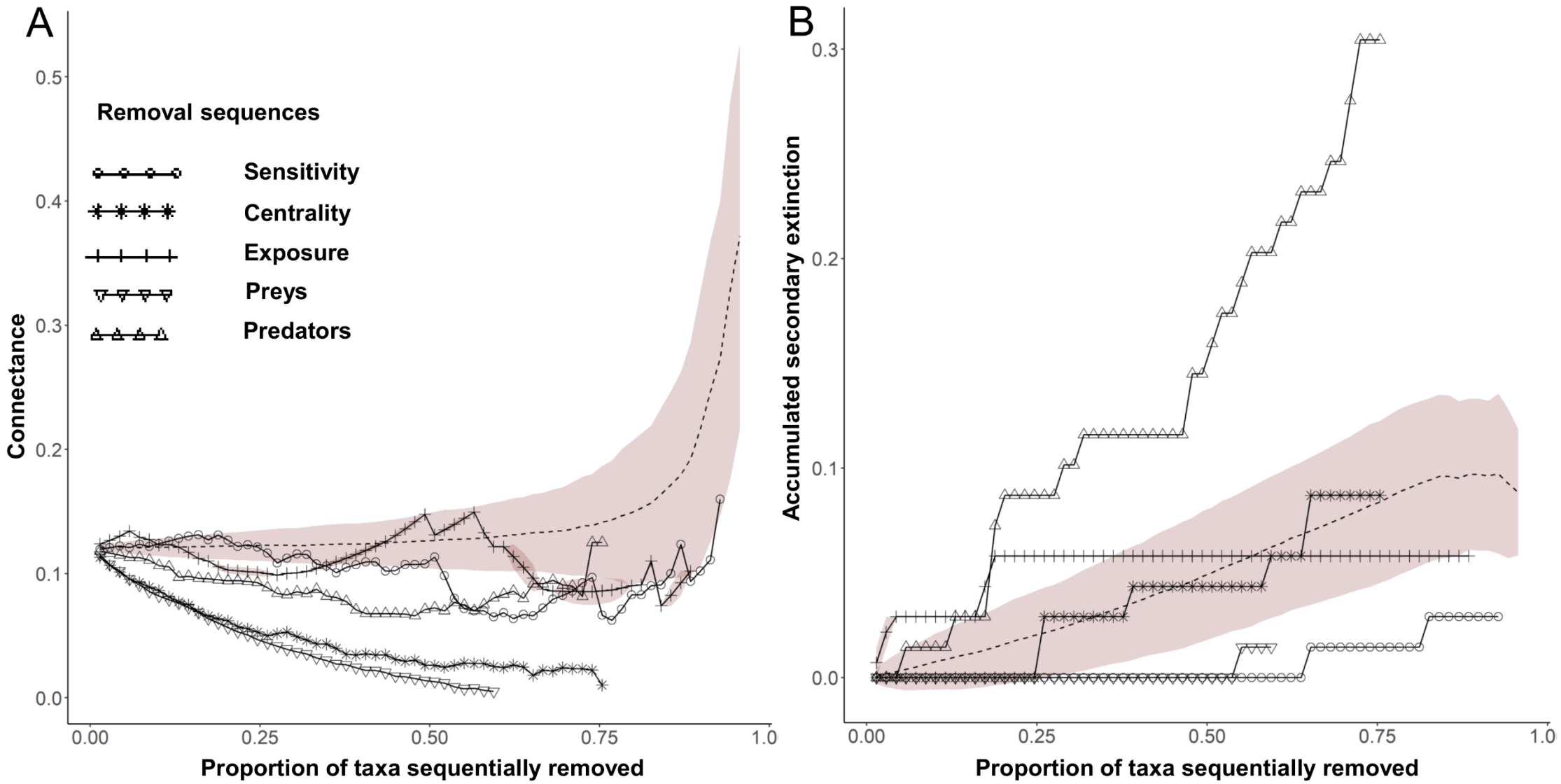


3-Sensitivity of species to fishing and implication for the stability of trophic networks



No species highly vulnerable

4-Secundary extinctions: which removal sequence lead to the lowest robustness ?



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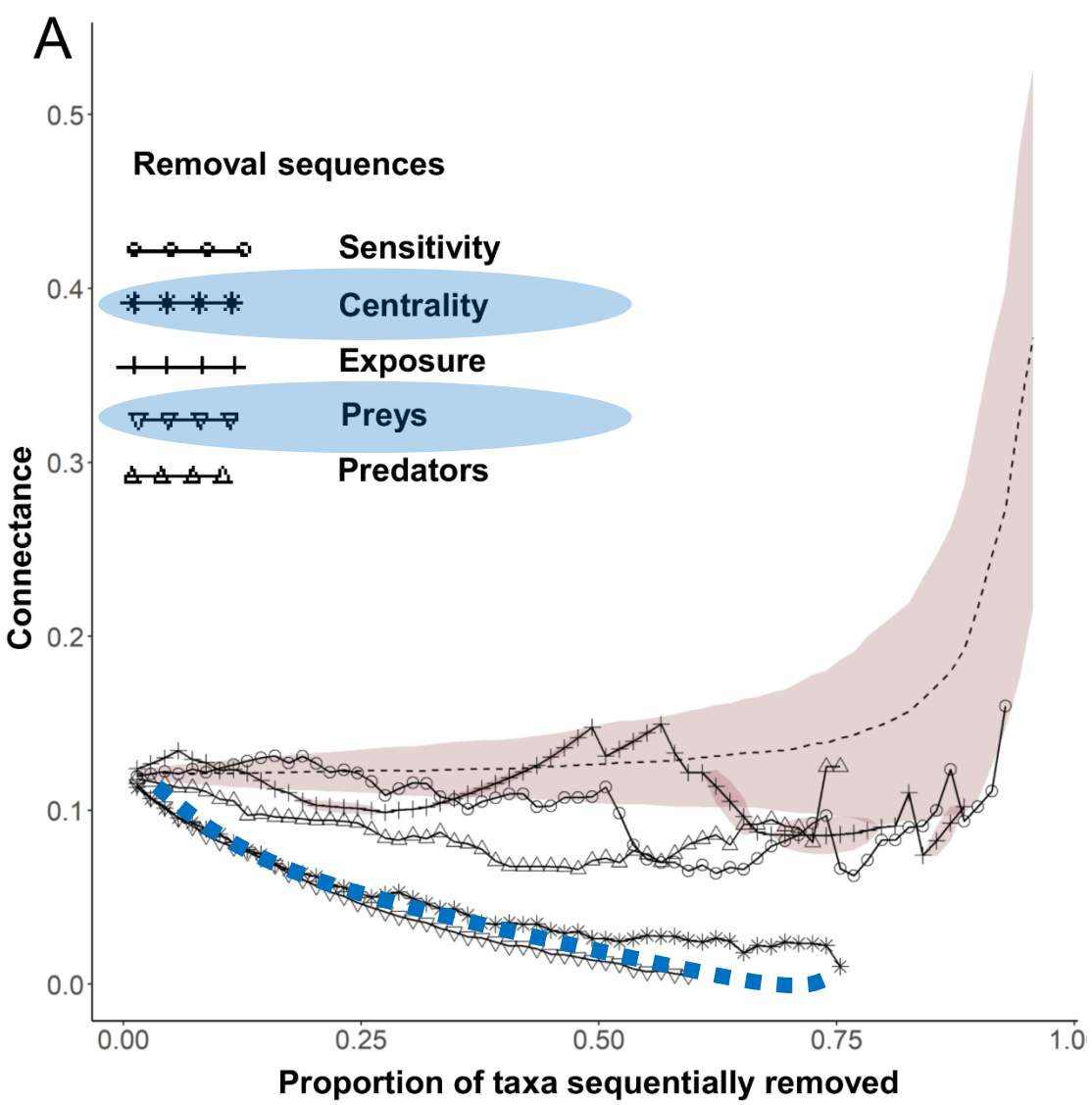
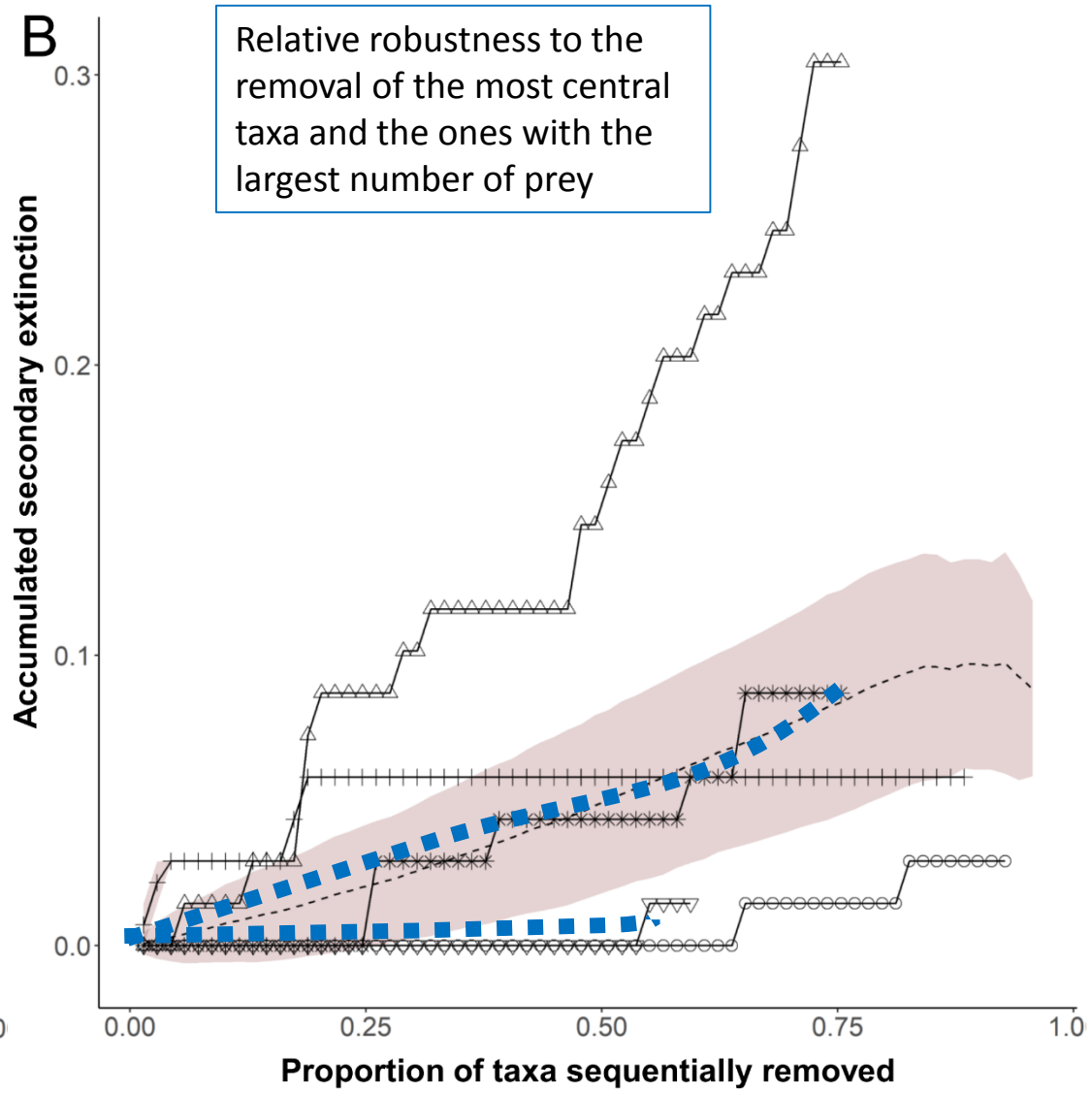
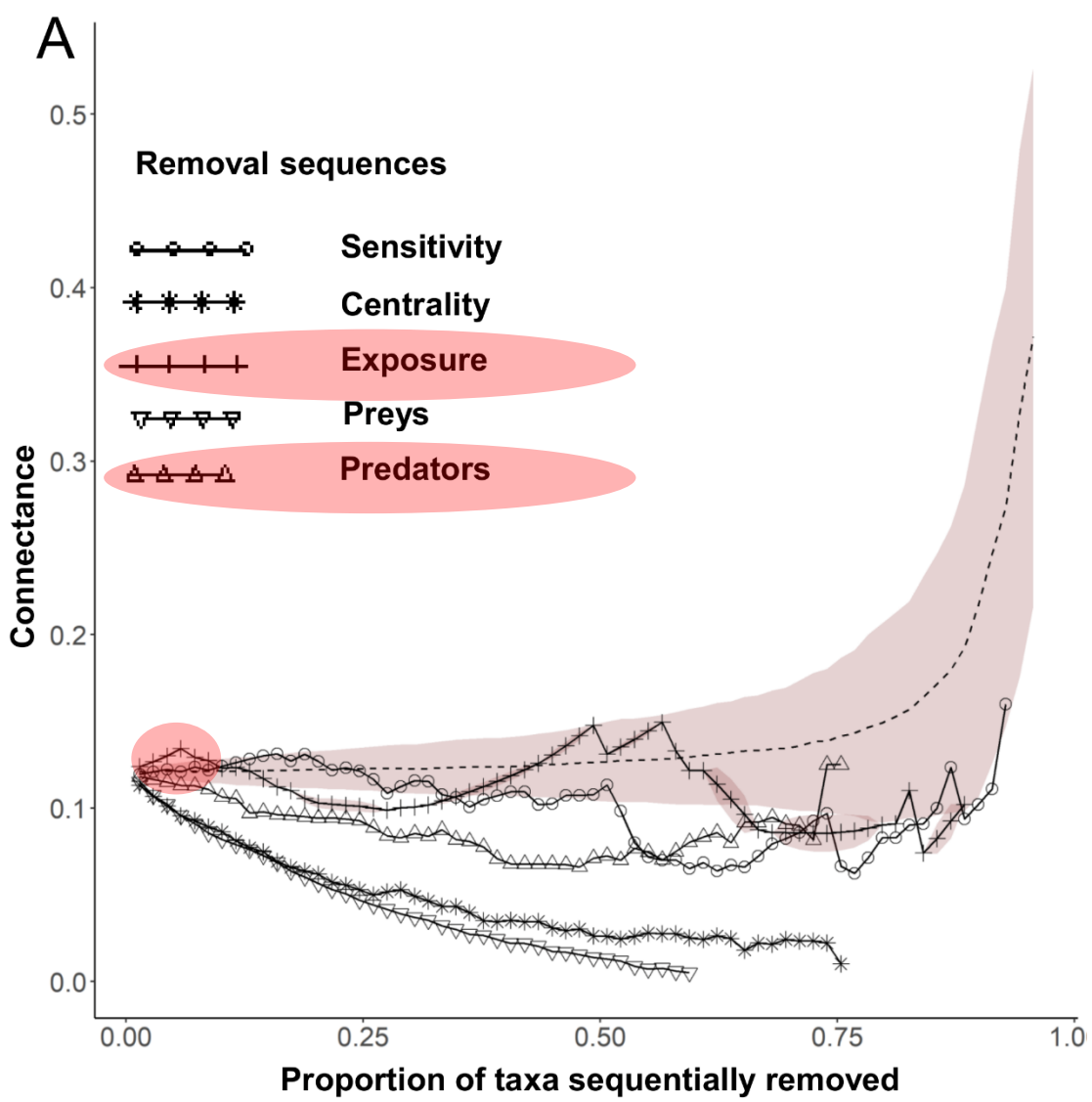
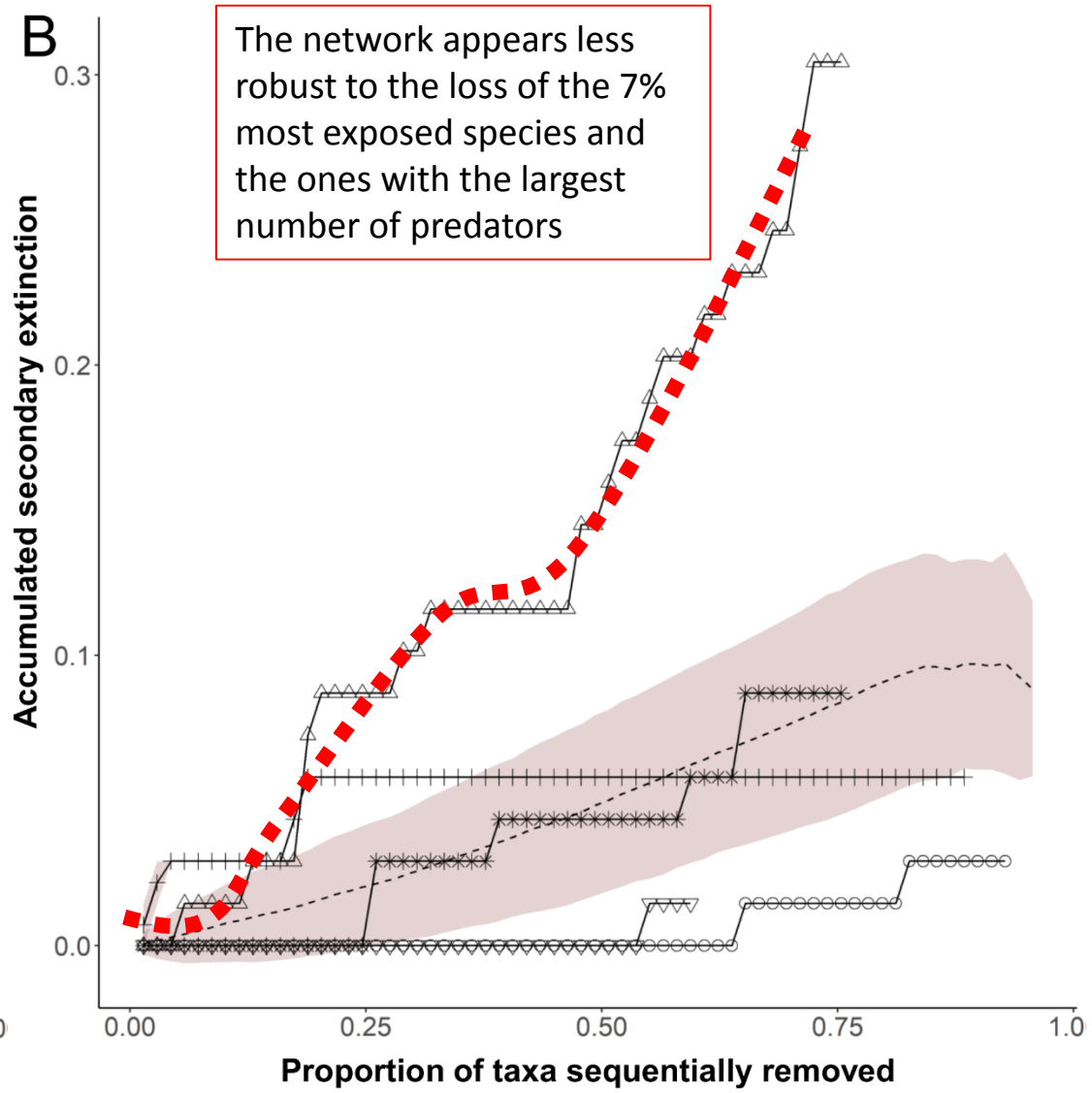




Relative robustness to the removal of the most central taxa and the ones with the largest number of prey

4-Secundary extinctions: which removal sequence lead to the lowest robustness ?





The network appears less robust to the loss of the 7% most exposed species and the ones with the largest number of predators

Discussion / Conclusion

- The more central species are not the ones the more sensitive to fishing: to be linked with the long story of exploitation of this area ?
- Robustness of the network to the loss of sensitive and species with many preys: tend to be at the end of the chain and do not cause further extinctions
- Robustness facing the removal of the most central because increase modularity and decrease nestedness → remove redundant interactions
- the robustness of the trophic network to the spread of a perturbation cannot directly be inferred from the vulnerability of its components

Perspectives

- Same kind of framework, but with sensitivity to sea bottom temperature (Climate Change)
- This would provide a flexible framework to prioritize the monitoring and conservation of certain species

Thank you for your attention

https://www.researchgate.net/profile/Laurene_Merillet

@LaureneMerillet

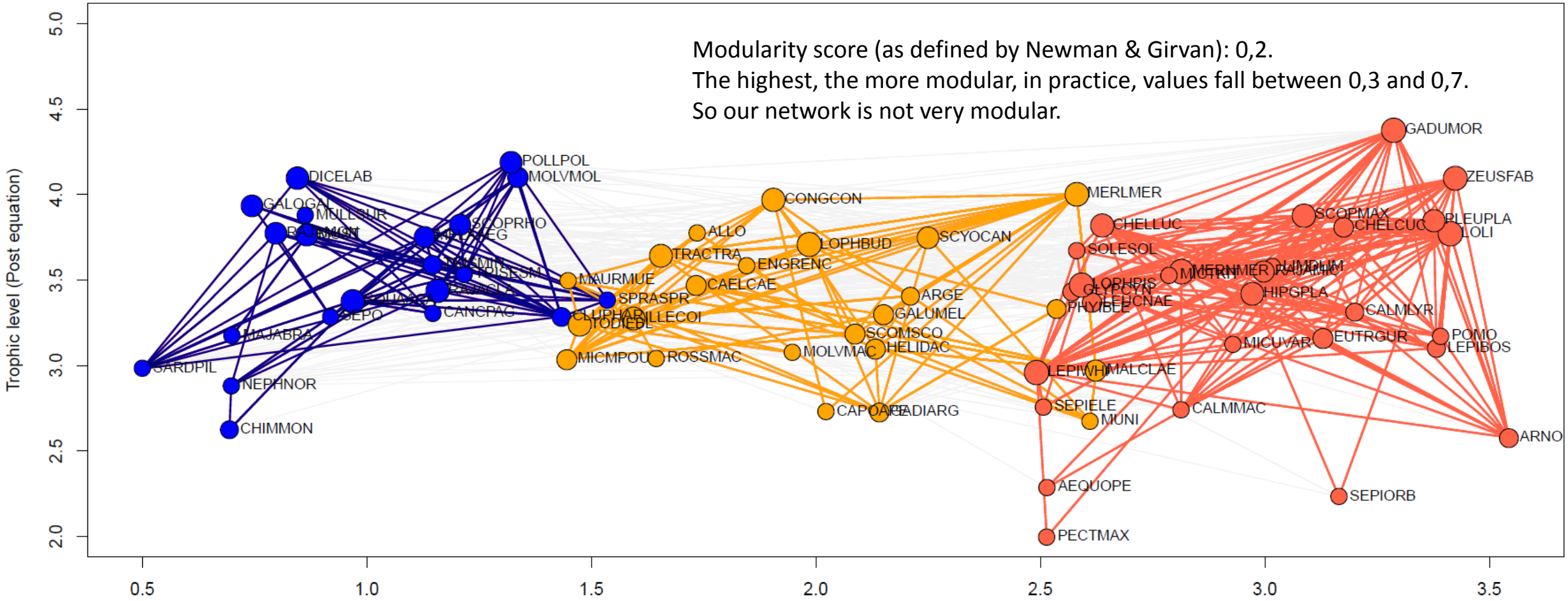
Aim: Sensitivity of species to fishing and implication for the stability of trophic networks

How to evaluate sensitivity ?

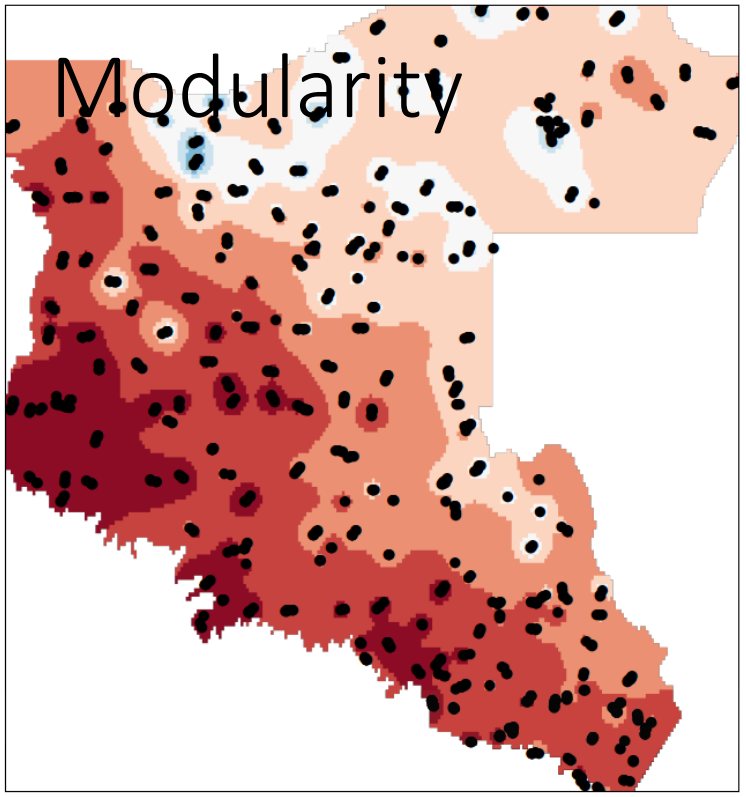
→ Use of biological traits related to life strategy

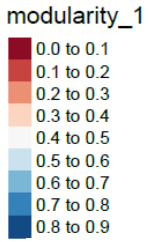
Biological traits	Type	Levels	Reason
Max length	numeric		Small species favored in fishing ground (Jennings et al. 1998, Shephard et al. 2012, Wiedmann et al. 2014)
Reproductive guilds	factor	Bearer, non-guarder, guarder	Parental care and energy allocated to raise the offspring (Klug and Bonsall 2007)
Longevity	numeric		Short lived species favored fishing ground (Jennings et al. 1998, Shephard et al. 2012, Wiedmann et al. 2014)
Fecundity	factor	low, medium, high, very_high	High fecundity species favored in fishing ground (Jennings et al. 1998, Shephard et al. 2012, Wiedmann et al. 2014)
Offspring size	numeric		High fecundity species favored in fishing ground (Jennings et al. 1998, Shephard et al. 2012, Wiedmann et al. 2014)
Age at maturity	numeric		Species maturing early are favored in fishing ground (Jennings et al. 1998, Shephard et al. 2012)

Trophic network: Modularity

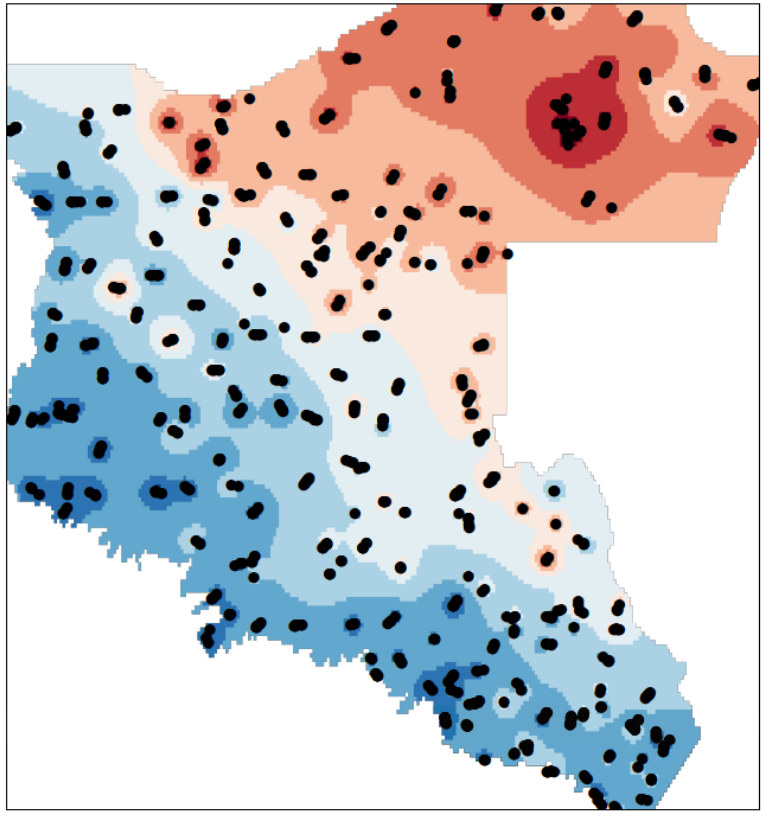


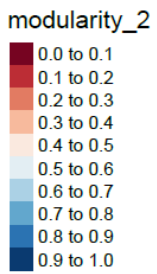
Modularity



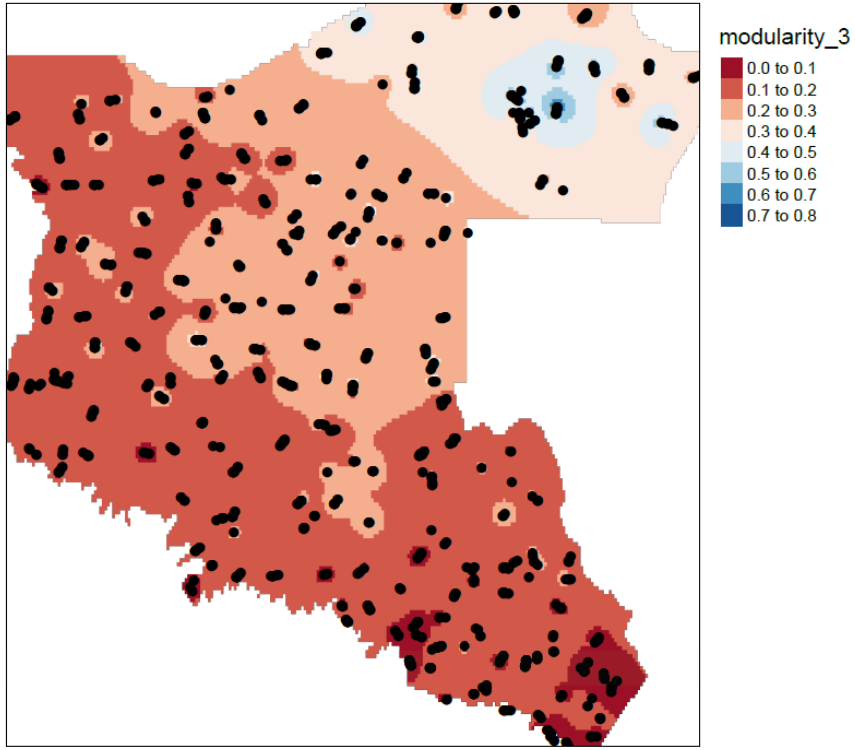


CANCPAG CHIMMON CLUPHAR DICELAB GALOGAL MAJABRA MELAAEG
MOLVMOL MULLSUR MUST NEPHNOR POLLPOL RAJACLA RAJAMON
SARDPIL SCOPRHO SEPO SPRASPR SQUAACA TRISESM TRISMIN



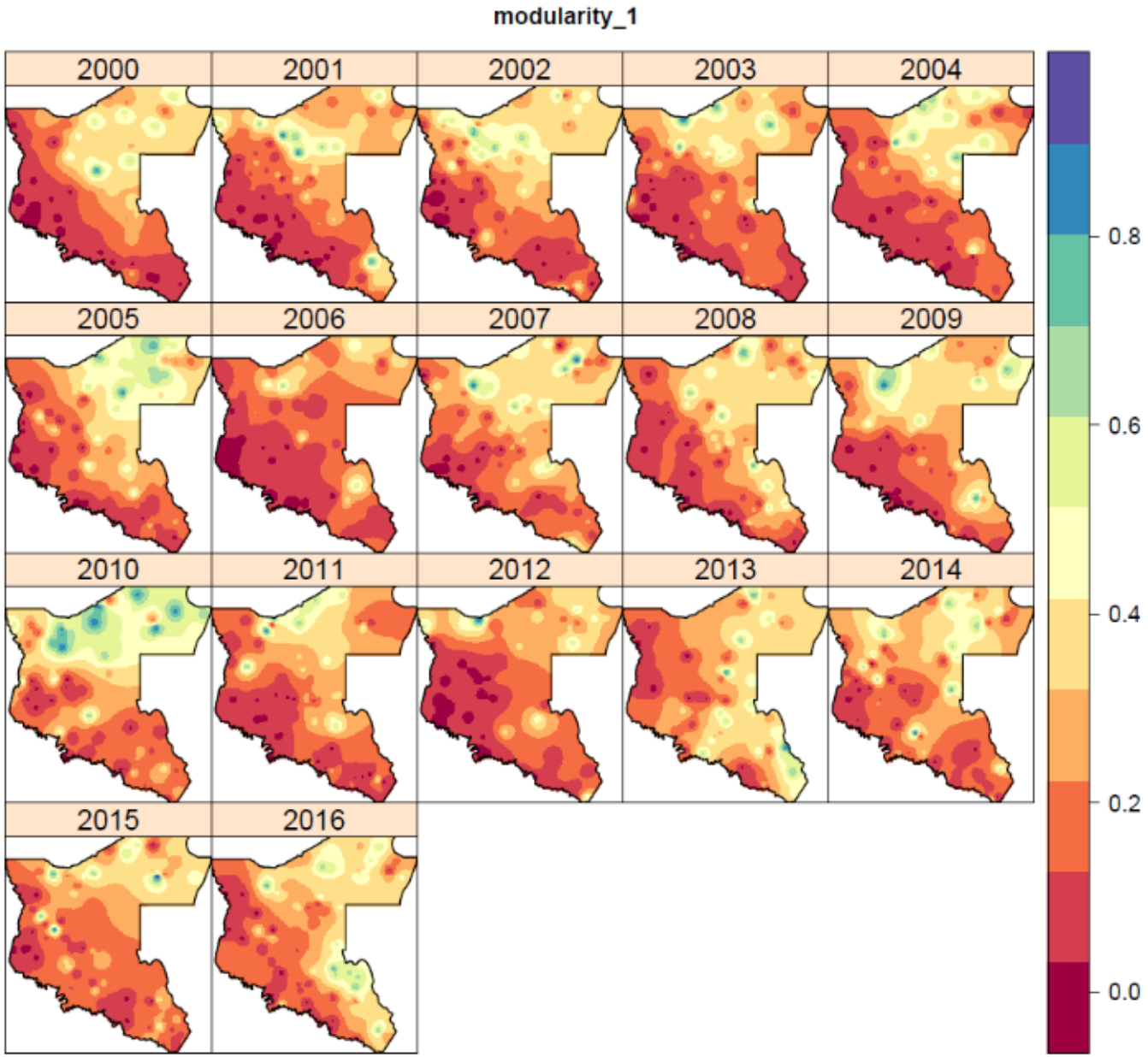


ALLO ARGE CAELCAE CAPOAPE CONGCON ENGRENC
GADIARG GALUMEL HELIDAC ILLECOI LOPHBUD MALCLAE
MAURMUE MERLMER MICMPOU MOLVMAC MUNI PHYIBLE
ROSSMAC SCOMSCO SCYOCAN TODIEBL TRACTRA



Pattern in space ? Yes
Spatial segregation of the different modules

AEQUOPE ARNO CALMLYR CALMMAC CHELCUC CHELLUC EUTRGUR
GADUMOR GLYPCYN HIPGPLA LEPIBOS LEPIWHI LEUCNAE
LIMDLIM LOLI LOPHPIS MERNMER MICUVAR MICTKIT PECTMAX
PLEUPLA POMO RAJAMIC SCOPMAX SEPIELE SEPIORB SOLESOL
ZEUSFAB


modularity_1
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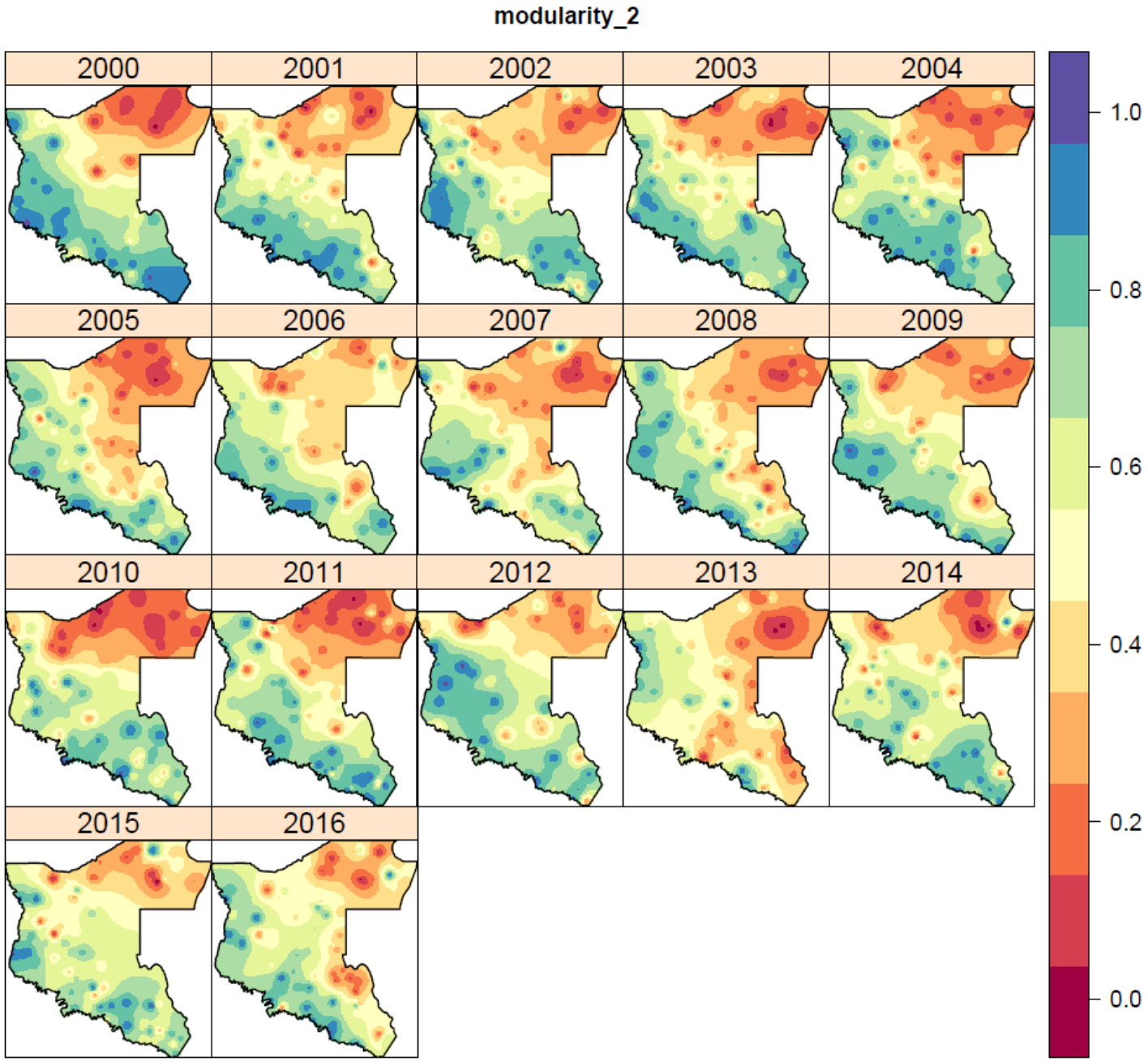
modularity_2
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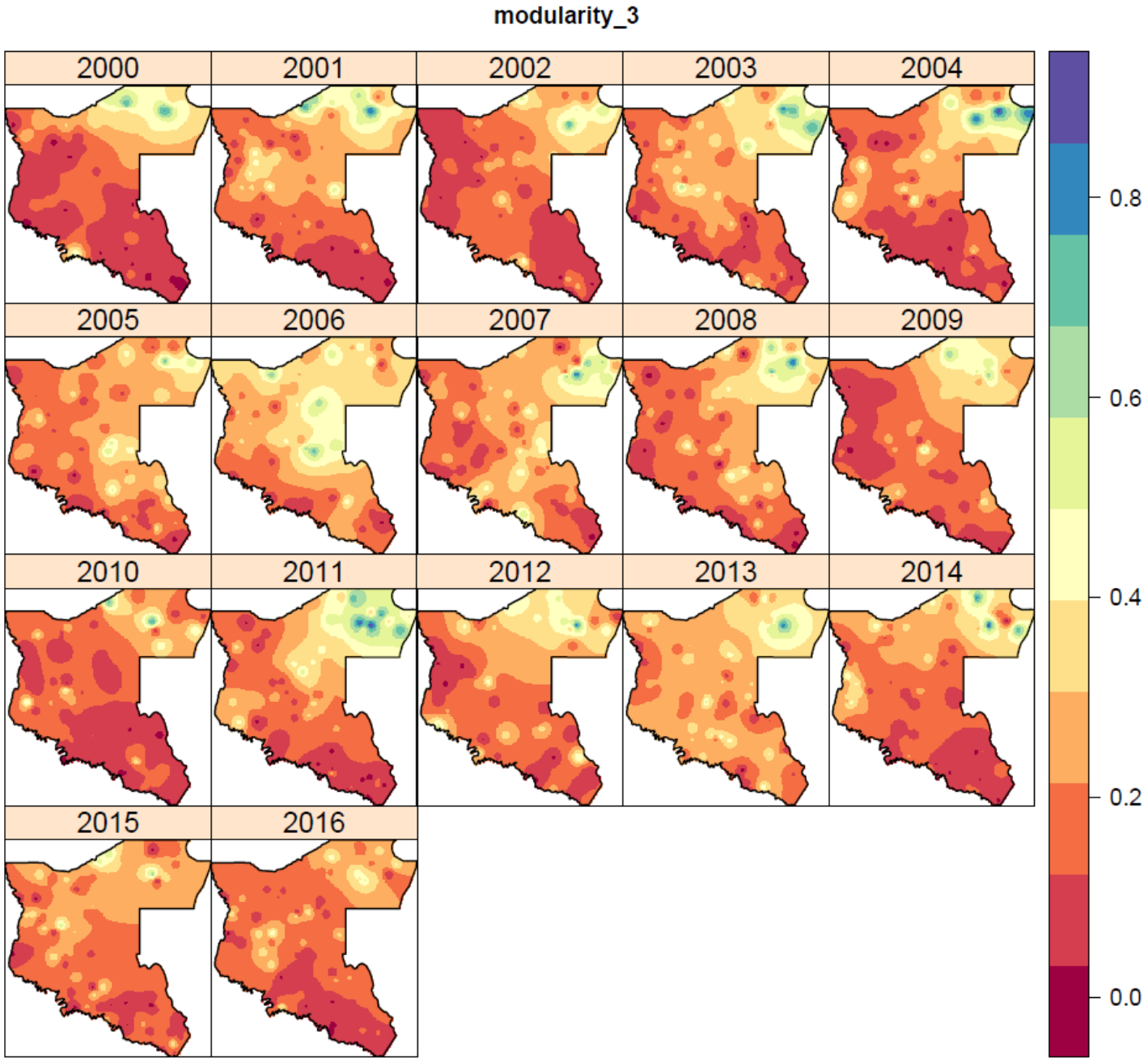
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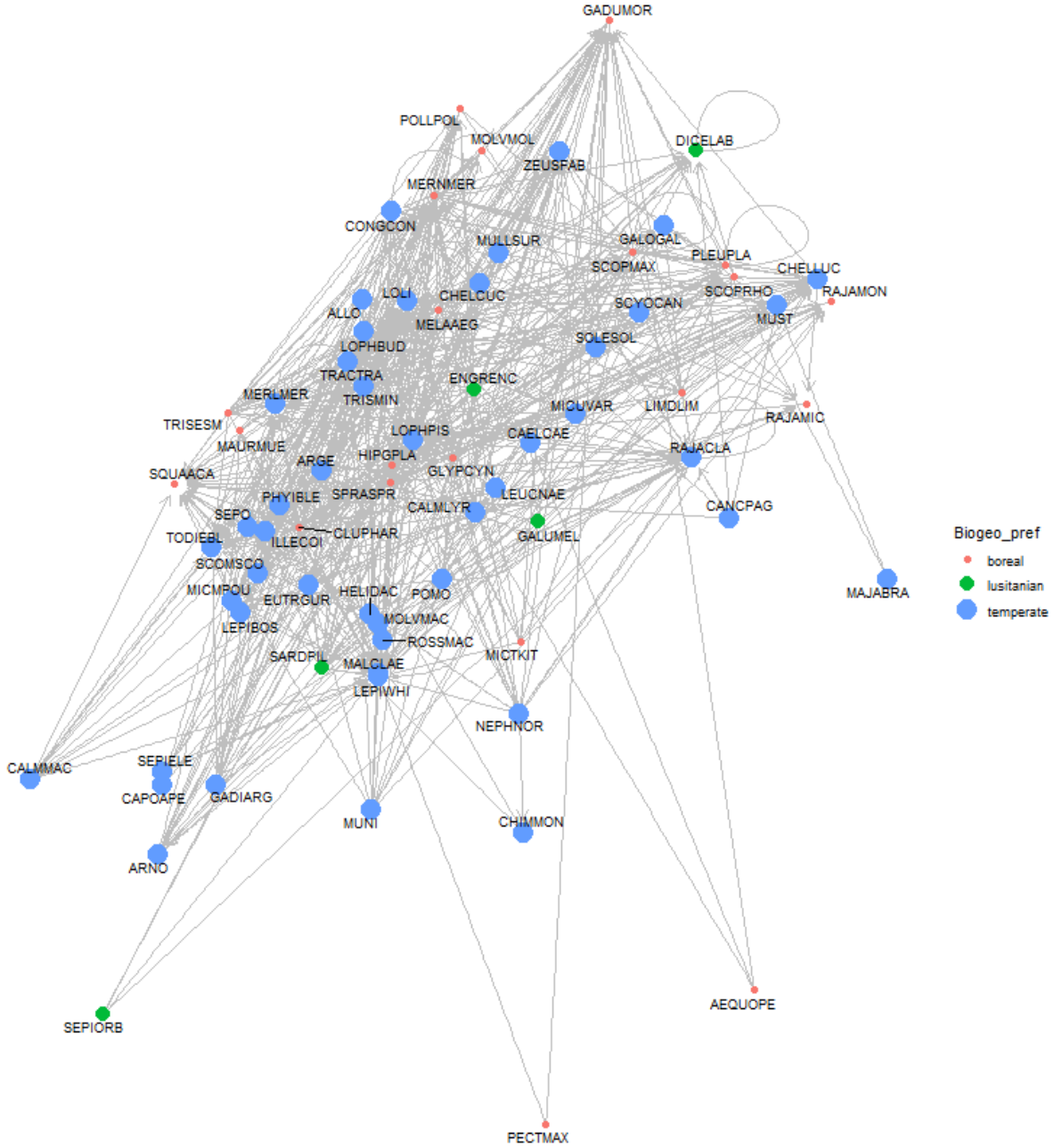
GADUMOR
POLLPOL
MOLVMOL
ZEUSFAB
DICELAB
MERNMER
CONGCON
MULLSUR
GALOGAL
SCOPMAX
PLEUPLA
CHELLUC
RAJAMON
SCORRHO
LOLI
CHELCUC
ALLO
MELAAEG
SCYOCAN
MUST
LOPHBUD
SOLESOL
TRACTRA
ENGRENC
MERLMER
TRISMIN
MIGUVAR
LIMDLIM
RAJAMIC
TRISESM
LOPHPIS
CAELCAE
MAURMUE
ARGE
HIPGPLA
RAJACLA
SQUAACA
GLYPCYN
PHYIBLE
SPRASPR
LEUCNAE
CANCPAG
SEPO
CALMLYR
TODIEBL
CLUPHAR
GALUMEL
ILLECOI
SCOMSCO
MICMPOU
EUTRGUR
HELIDAC
POMO
MAJABRA
MOLVMAC
LEPIBOS
ROSSMAC
SARDPIL
MALCLAE
MICTKIT
LEPIWHI
NEPHNOR
CALLMAC
SEPIELE
CAPOAPE
GADIARG
MUNI
CHIMMON
ARNO
AEQUOPE
SEPIORB
PECTMAX
Biogeo_pref
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temperate