

Modelling trophic flows in ecosystems to assess the efficiency of Marine Protected Area (MPA) : a case study on the coast of Senegal

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Introduction

Developing MPA viewed as an efficient way to preserve biodiversity and to protect specific habitats

BUT

the impact on the entire trophic network is still poorly known

Aim

- **Analyse the impact of the MPA**

HOW...

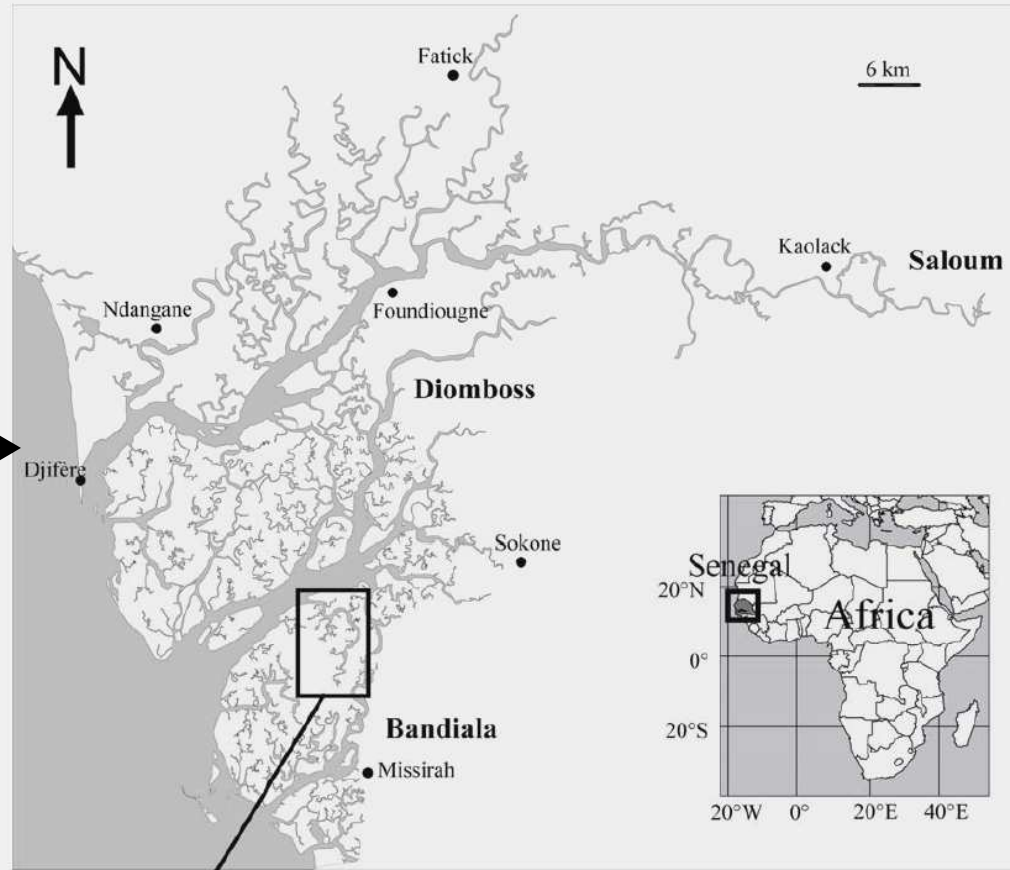
- The MPA impacts the biomass of the fishery-targeted species?
- This impact is reflected on the other biological compartments via the trophic network?
- All of this modifies the general characteristics of the ecosystem ?

-> Use of the modelling software EwE and EcoTroph

Introduction

- Sine-Saloum inverse estuary: nursery, reproduction site, high biodiversity and fishing place
- Senegalese association project + French researchers
-> Setting up the MPA and scientific survey

Sine-Saloum estuary



Bolong of Bamboing MPA



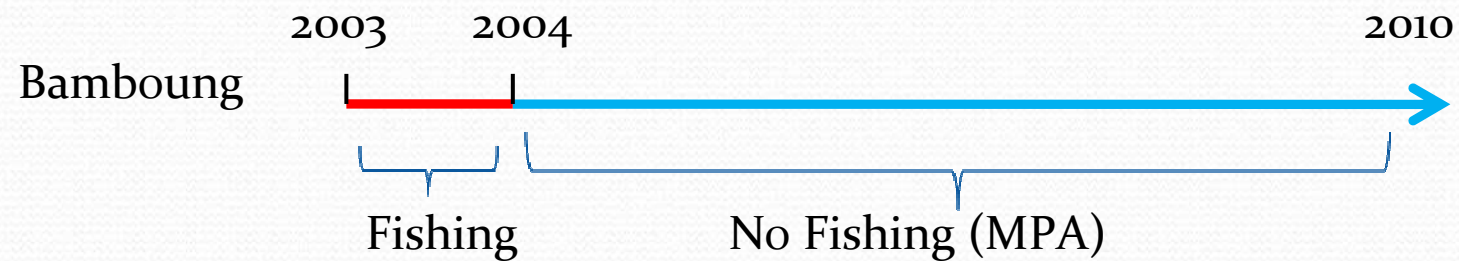
- Zone centrale de l'AMP
- Zone tampon
- Limite de l'AMP
- Stations échantillonnées

Localisation of the MPA (Albaret, 2005)

Introduction

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Introduction



Sangako

2008



➔ Before/After Control Design situation

Step of the analysis

1. Estimation of yearly abundance indices
2. Construction of a 2003 mass-balanced Ecopath model
3. Simulation of the MPA effect using EcoTroph
4. Comparison between the Bamboung MPA and a still heavily fished area (Sangako)

Plan

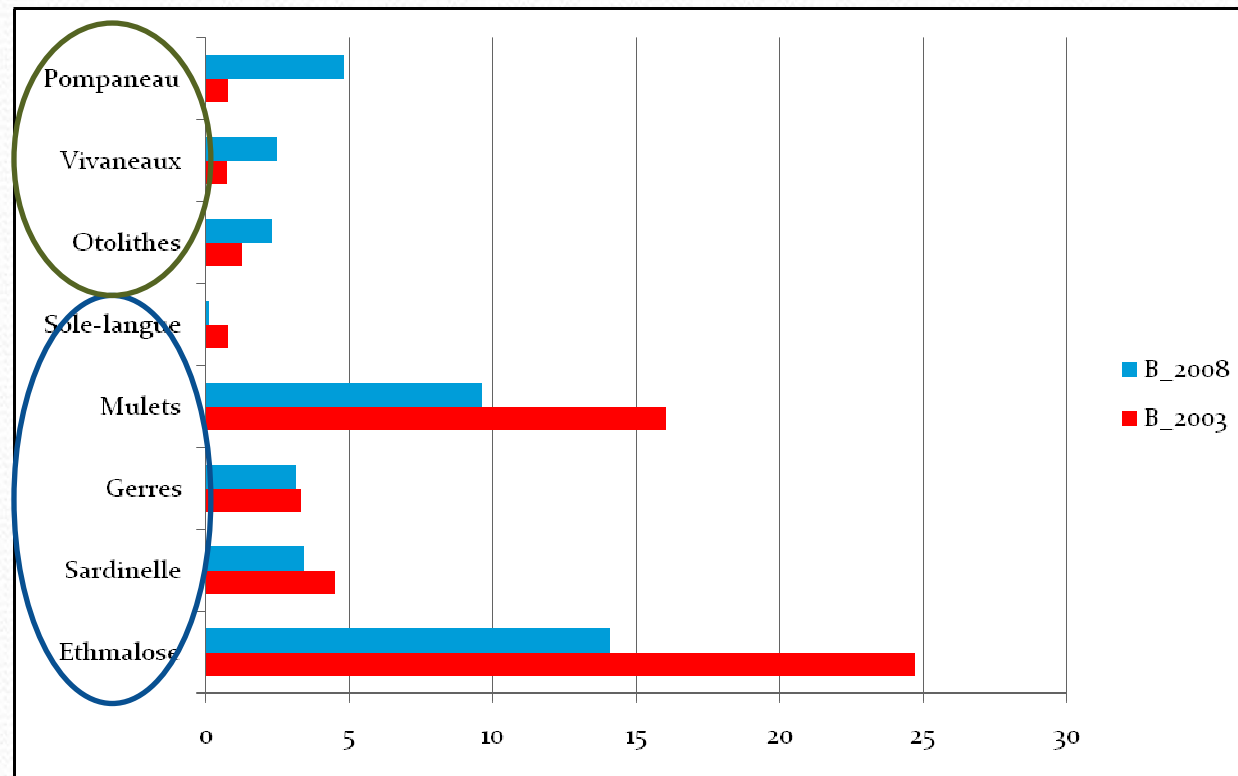
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Introduction	Abundance Indices	2003 Model	MPA effect	MPA/Fished area	Discussion/Conclusion
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Group	Added variables	Binomial model				Added variables	Positive value model		
		Residual degrees of freedom	Explained deviance (%)	Significance			Residual degrees of freedom	Explained deviance (%)	Significance
Arius	Null	215				Null	90		
	Season	213	5.22	0.000		Season	88	11.67	0.003
	Sector	211	3.87	0.003		Sector	non significant		
	Year	non significant				Year	non significant		
Barracudas	Null	215				Null	22		
	Sector	213	4.25	0.044		Sector	20	24.16	0.041
	Season	non significant				Year	non significant		
	Year	non significant				Season	non significant		
Breton africain	Null	215				Null	60		
	Year	non significant				Sector	58	9.91	0.041
	Season	non significant				Year	non significant		
	Sector	non significant				Season	non significant		

Predator

Prey



-> But it's hard to define a global evolution

Plan

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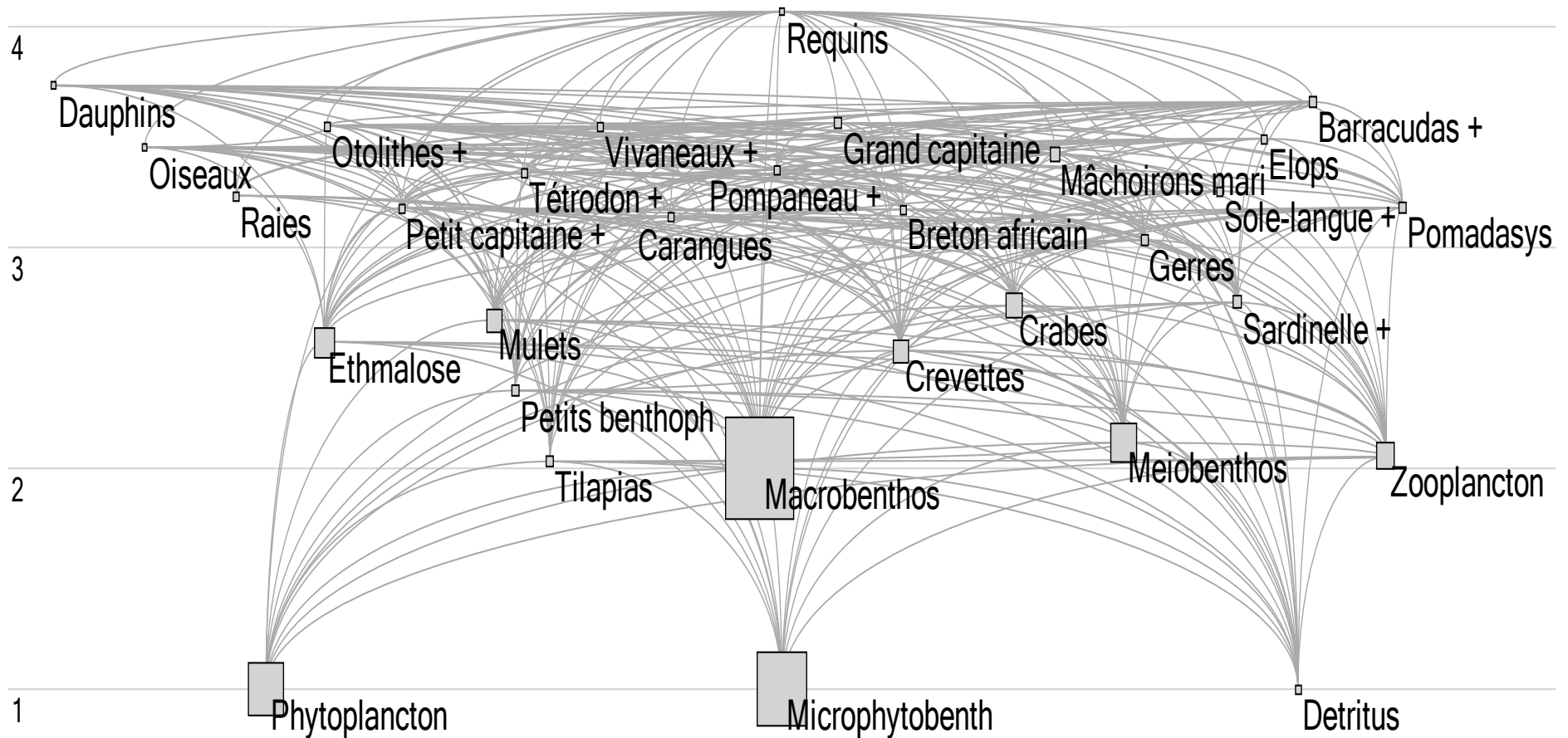
Construction of the model

Input Data	Sources
Construction of trophic groups	Literature + survey
Calculation of input parameters: *B *P/B, Q/B *EE	*Survey *Empirical formula (Expert, Lit.) *Expert + Literature
Construction of a diet matrix	Literature (Sine-Saloum Ecopath model)
No catch data -> Fishing mortality hypothesis	Expert knowledge

Results

1. Representation of the trophic network
2. Quantification of trophic links

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Trophic network of the Bamboung in 2003

Results

1. Representation of the trophic network
2. Quantification of trophic links

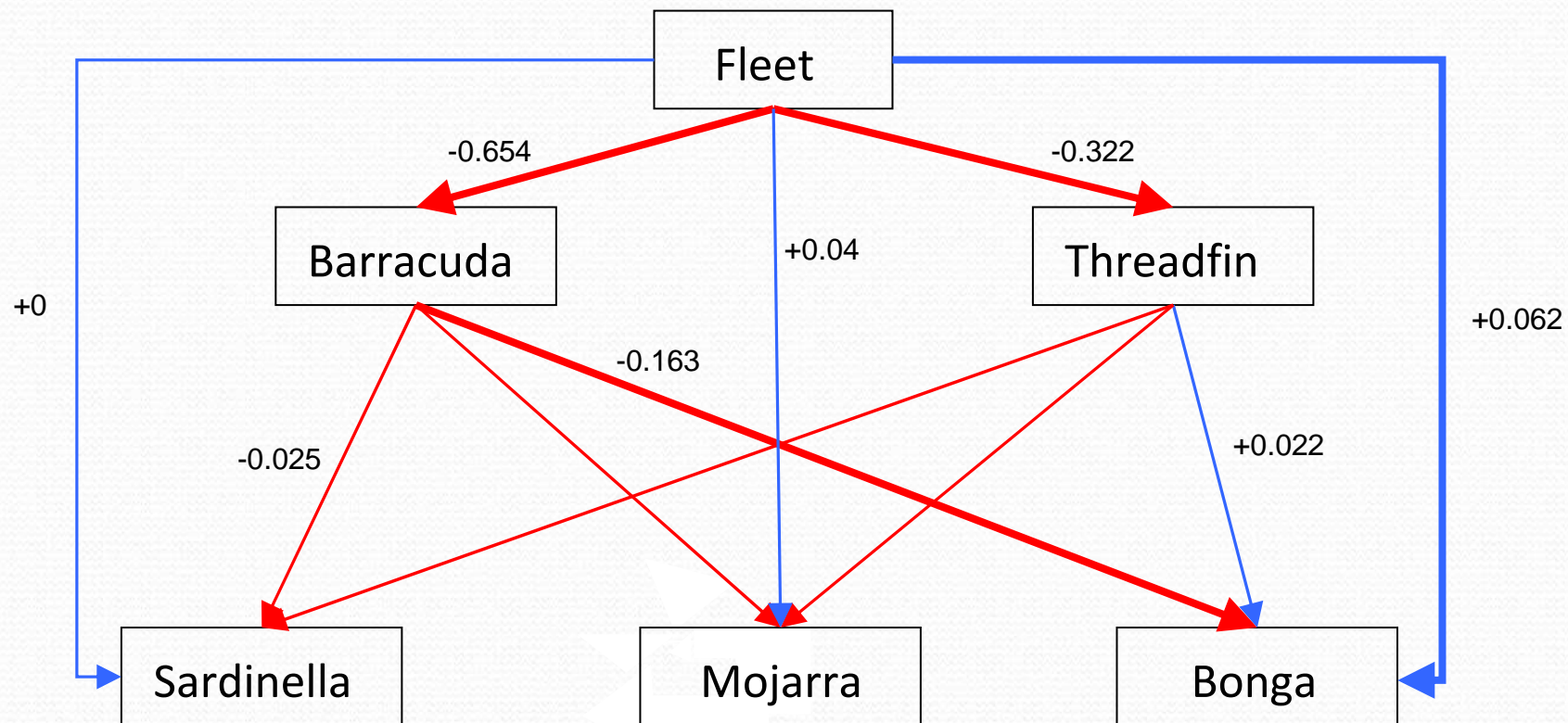


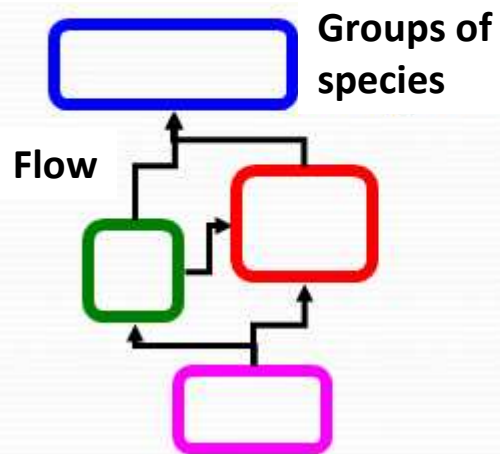
Diagram of the Mixed Trophic Impact: Focus on the fleet

Plan

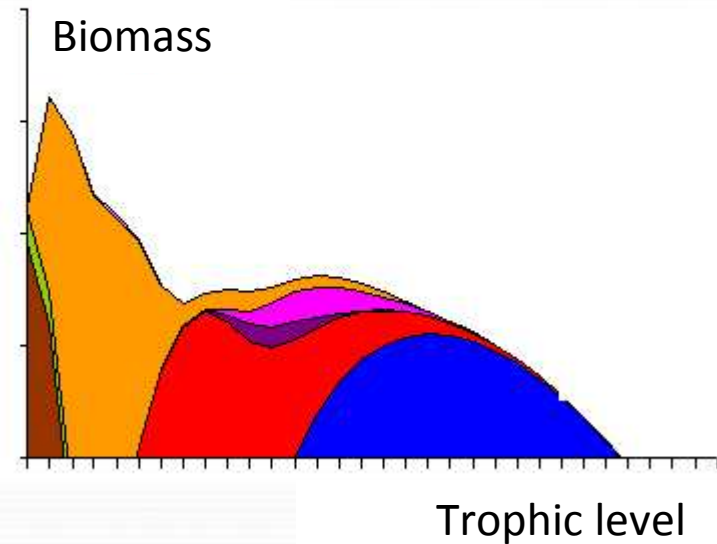
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EcoTroph

Ecopath: Representation of a marine mass-balanced ecosystem



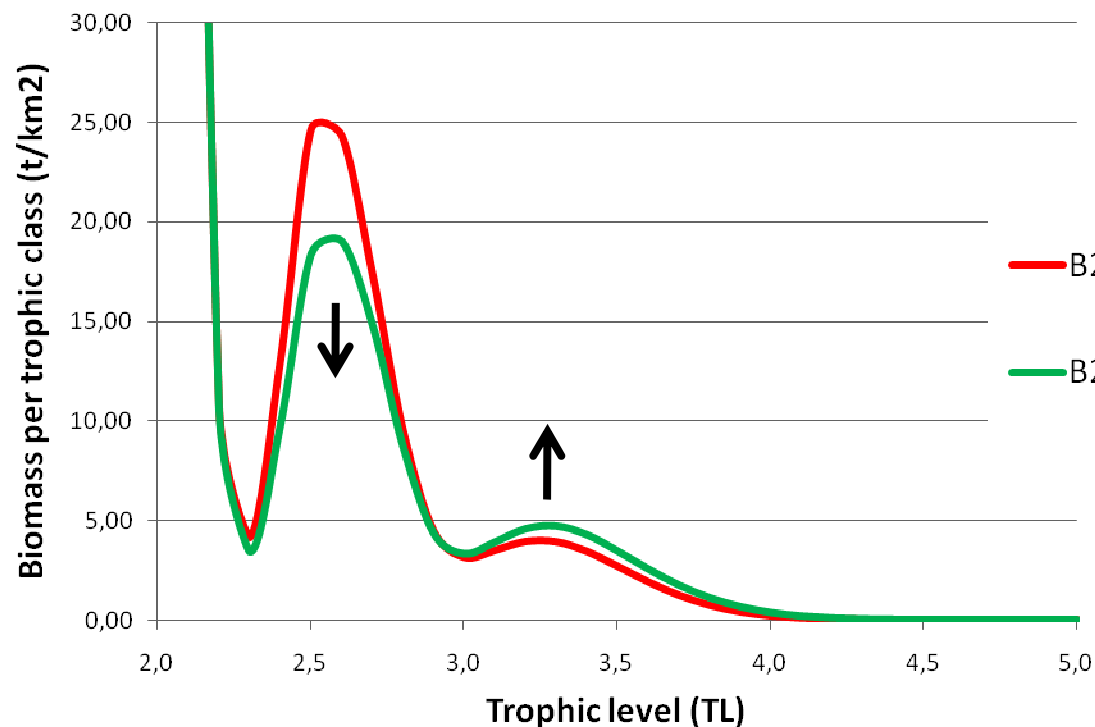
EcoTroph: Modelisation of the biomass distribution across the trophic level



-> Flow modelisation in function of the trophic level

Comparison 2003/2008

- Construction of a 2008 Ecopath model
- Comparison of the biomass trophic spectra



-Bpred increases by 25%

-Bprey reduces by 20%

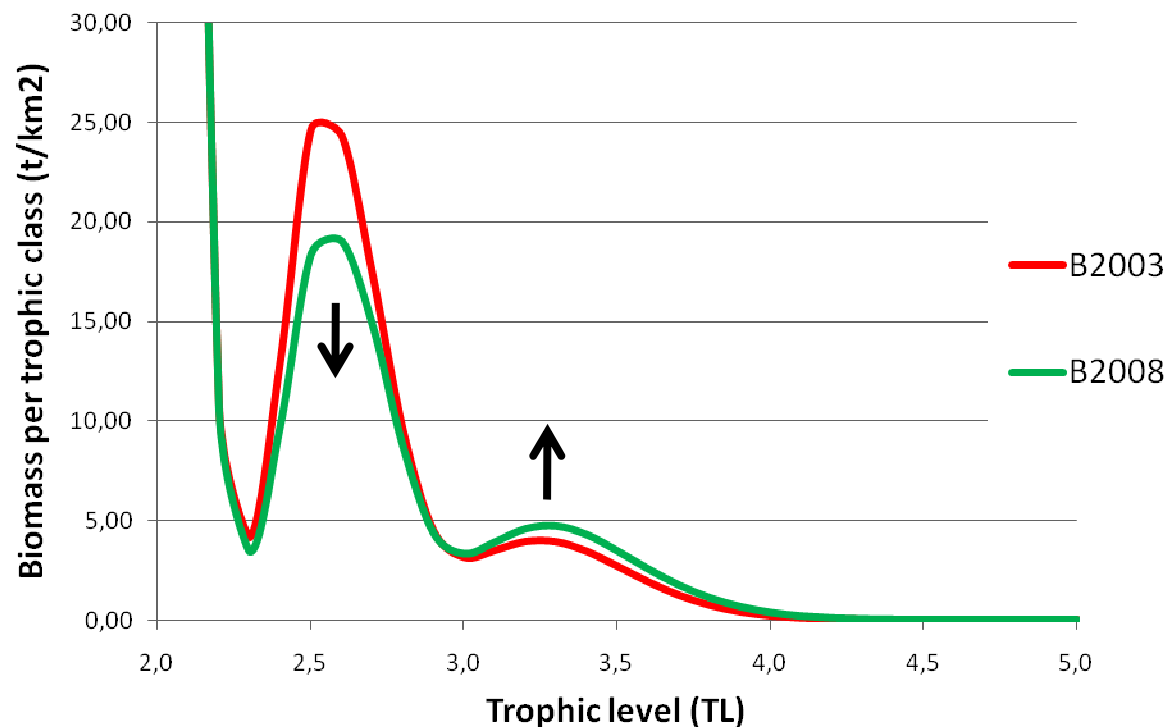
-> Are these changes due to a MPA effect?

2008 Ecopath model

- Same construction process as the 2003 Ecopath model
- Three hypotheses for the **P/B evolution**:
 - P/B remains constant ($B_{2008}=B_{2003}$ for Invertebrates)
 - $P/B = Z - F$ ($B_{2008}=B_{2003}$ for Invertebrates)
 - Calculation of a new P/B using an ET equation
- Weak impact on the biomass trophic spectrum
-> Reference model: P/B ET

Comparison 2003/2008

- Construction of a 2008 Ecopath model
- Comparison of the biomass trophic spectra



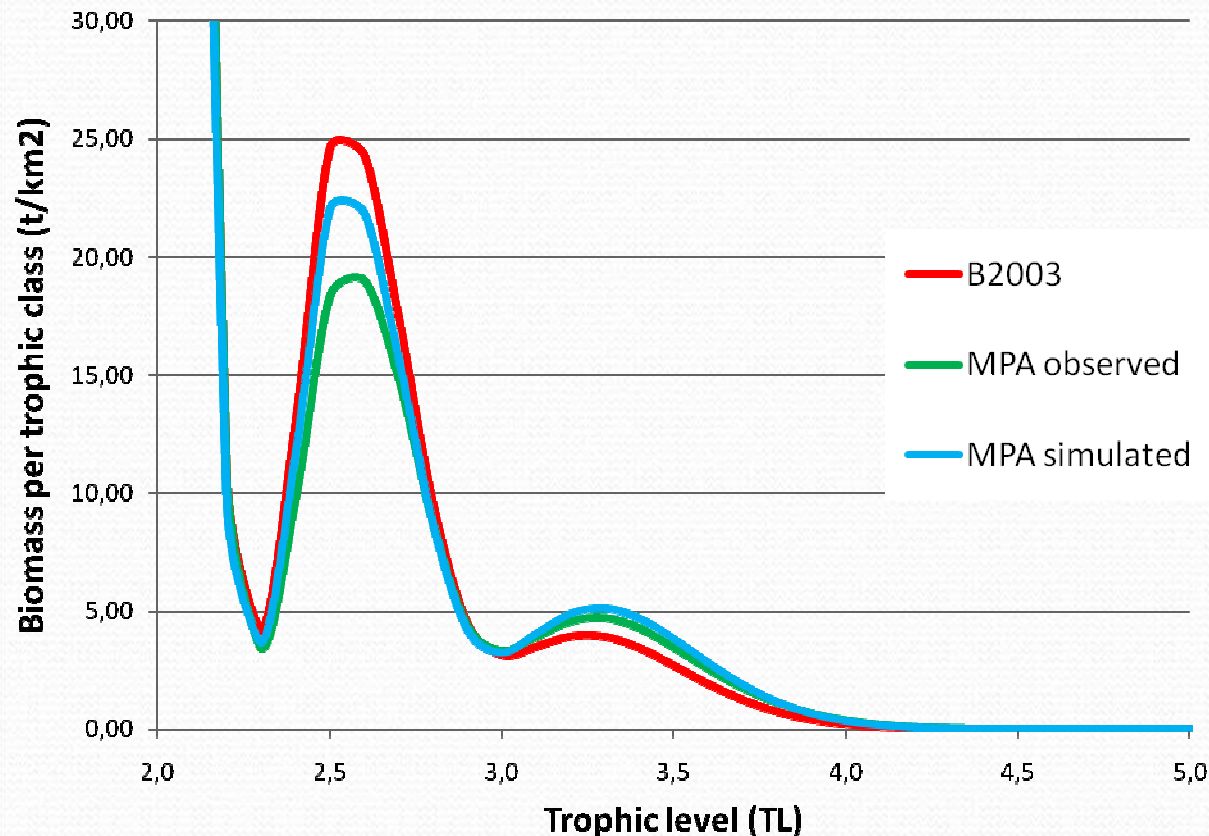
-Bpred increases by 25%

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-> Are these changes due to a MPA effect?

MPA effect simulation

- Use of ET-Diagnosis to simulate various fishing mortality multiplier:



- Model properly simulates the MPA effect on the highest trophic levels

- Simulated decrease for the intermediate trophic levels is less important than in the reality

Sensibility analysis

- To the fishing hypothesis:

Fishing hypothesis in 2003	Simulation closest to the 2008 observed trophic spectrum for :
F=0.07	Total closure (mF=0)
F=0.1	Partial closure (mF=0, mF=0.2 for predators)
F=0.25	Partial closure (mF=0.4 -> F=0.1)

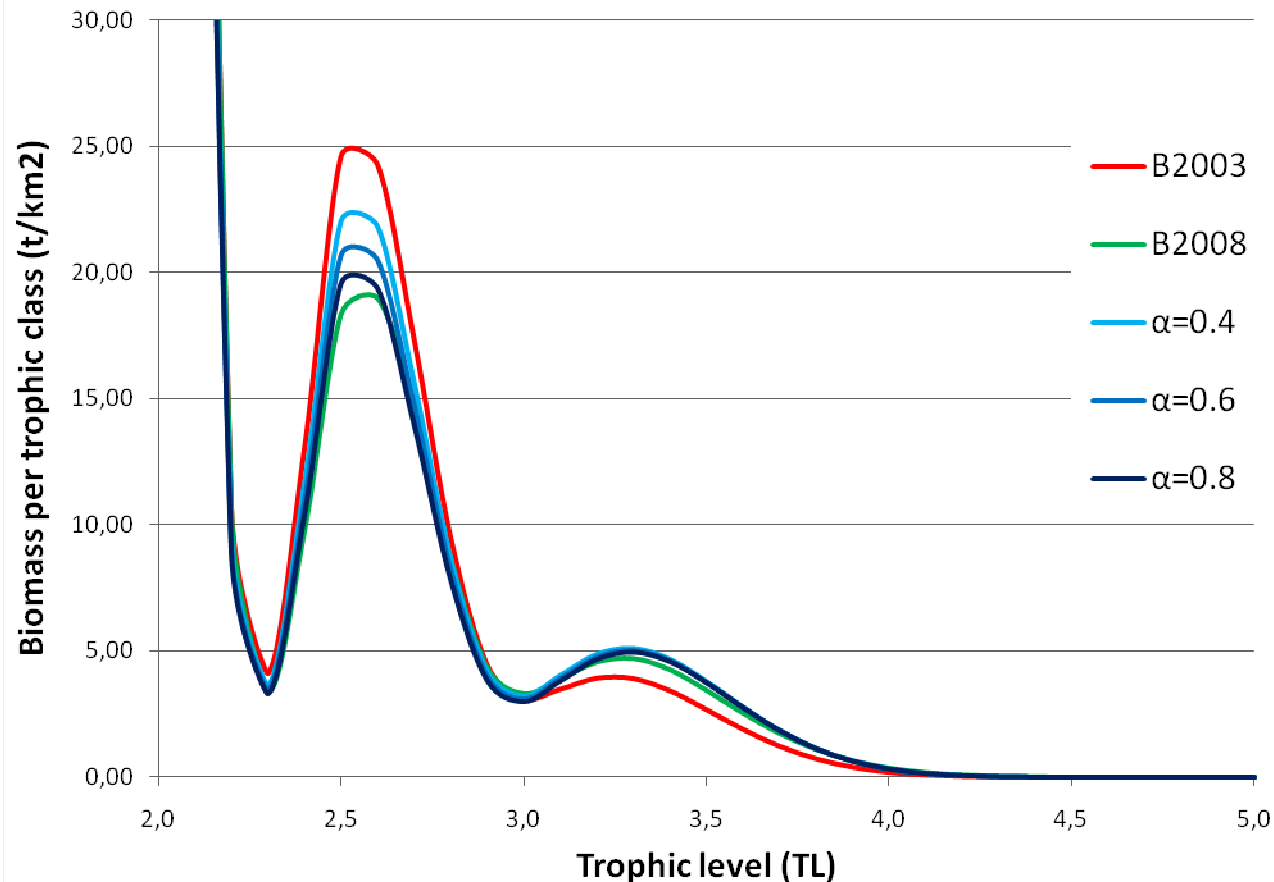
-> MPA effect is simulated by:

-A total closure of fishing if we assume low F in 2003

-A partial closure of fishing if we assume higher F (illegal fishing?)

Sensibility analysis

- To the top-down parameter:



- Increase α
->reduce the gap for intermediate TL

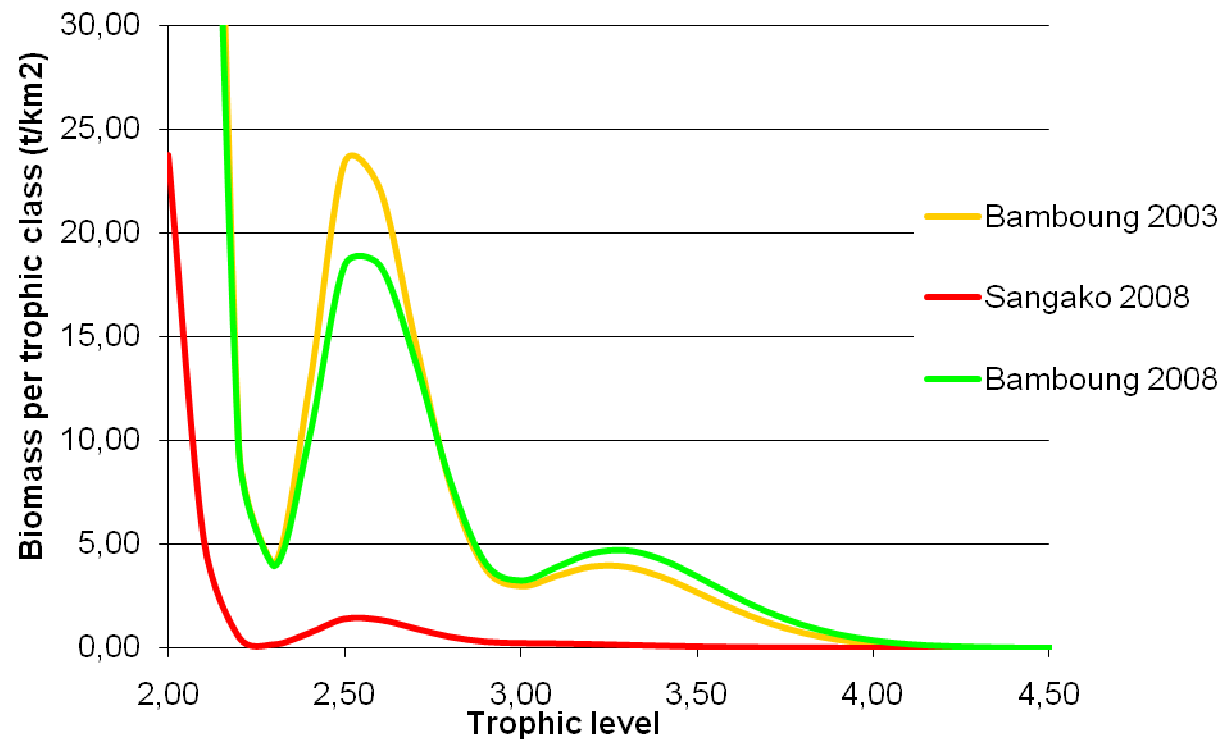
- Emphasizes the role of the top-down effect in the B evolution

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Comparison Bambang/Sangako

- Construction of a Ecopath model for the Sangako
- Comparison of the trophic spectra

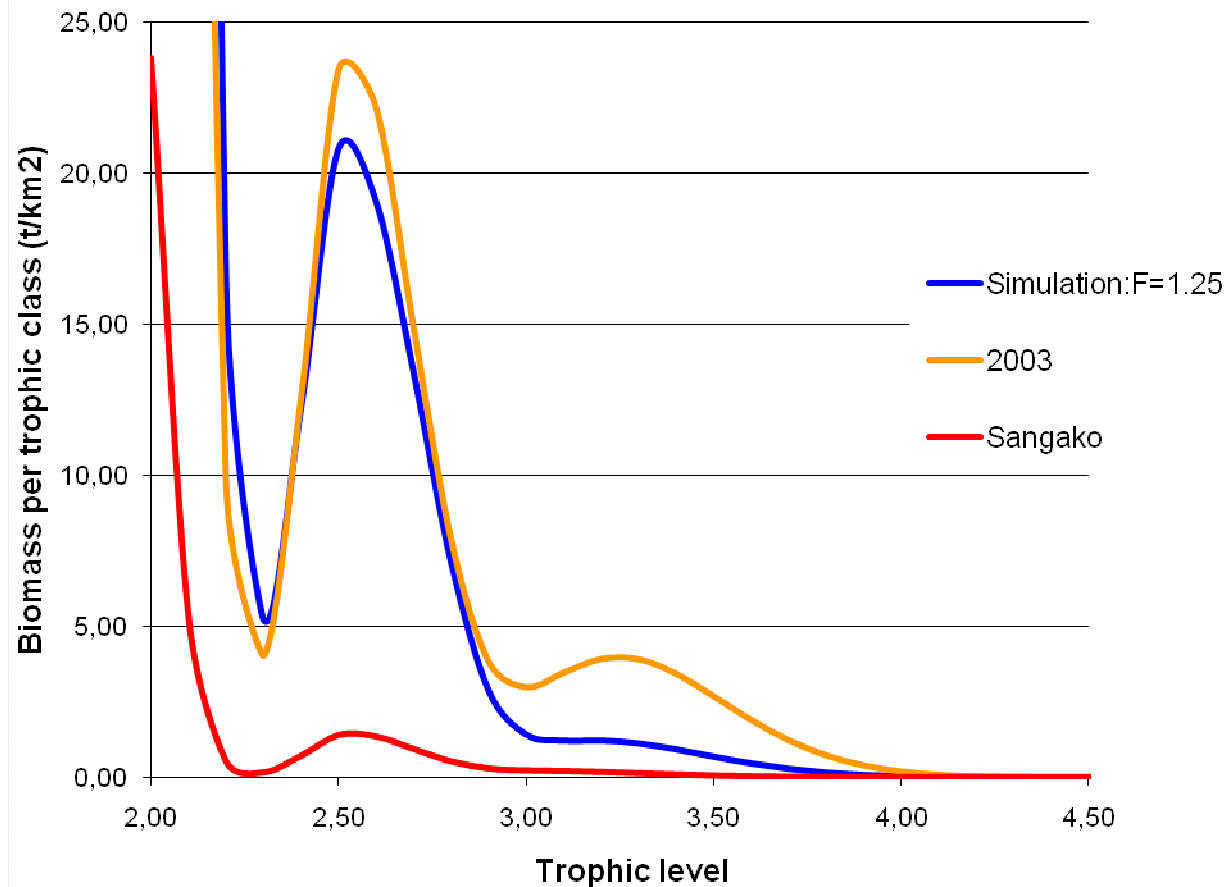


-Low biomass levels in Sangako

-Could this low biomass level be explained by a high fishing effort?

Comparison Bamboung/Sangako

- Fishing effect simulation:



- Simulation of a $F=1.25$ applied to the Bamboung in 2003

- Even with this high fishing mortality, the spectra are still really different

-> **Fishing effect is not the only driver**

Discussion and conclusion

- Demonstration of a MPA effect in the Bamboung
 - Increase in B for the high TL
 - Decrease in B for the intermediate TL
- But a limited effect possibly due to :
 - An already low fishing effort in 2003
 - Poaching: a remaining F in 2008
 - A partial compensation by an environmental effect (on small pelagics)
 - A still short period of simulation (only six years)

Discussion and conclusion

- Differences observed between the Bamboung and the Sangako could be due to:
 - Flee effect from the Sangako because of fishing
 - Strong effect as refuge for the Bamboung (already effective in 2003 because of low F)
- Finally, it could be interesting to study the MPA effect on the outside, coupling local and wider modelling:
 - Larval dispersion, Export effect (spillover)
 - Change in spatial biomass distribution



Thanks for your attention

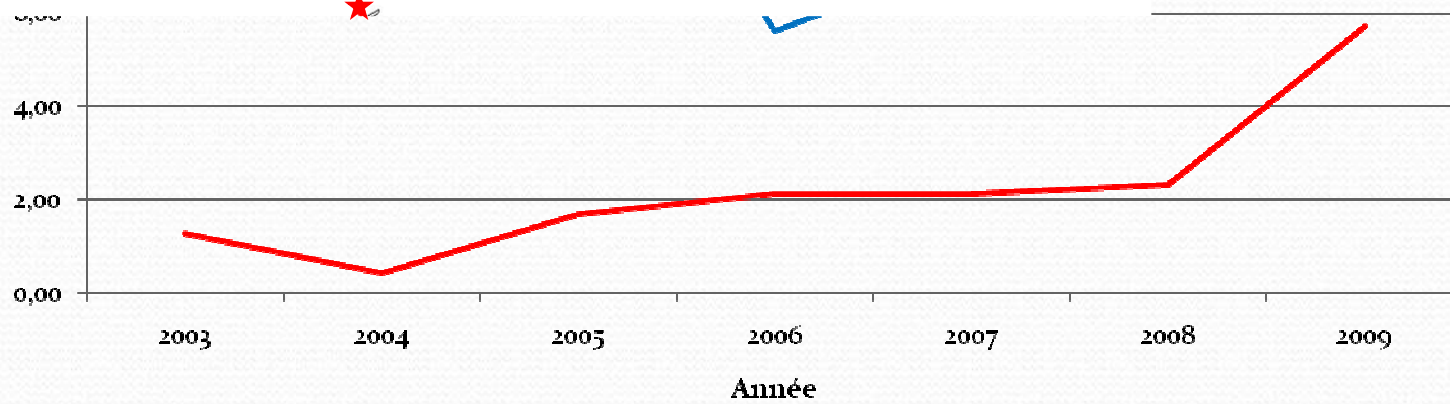
Conclusion

- Problématique actuelle de recherche : construction de modèles pour développer l'Approche Écosystémique des Pêches (AEP)
- Mise en évidence d'un effet réserve : augmentation de la biomasse des hauts niveaux trophiques et diminution pour les faibles
- Pas de conclusion sur effet réserve sur l'extérieur

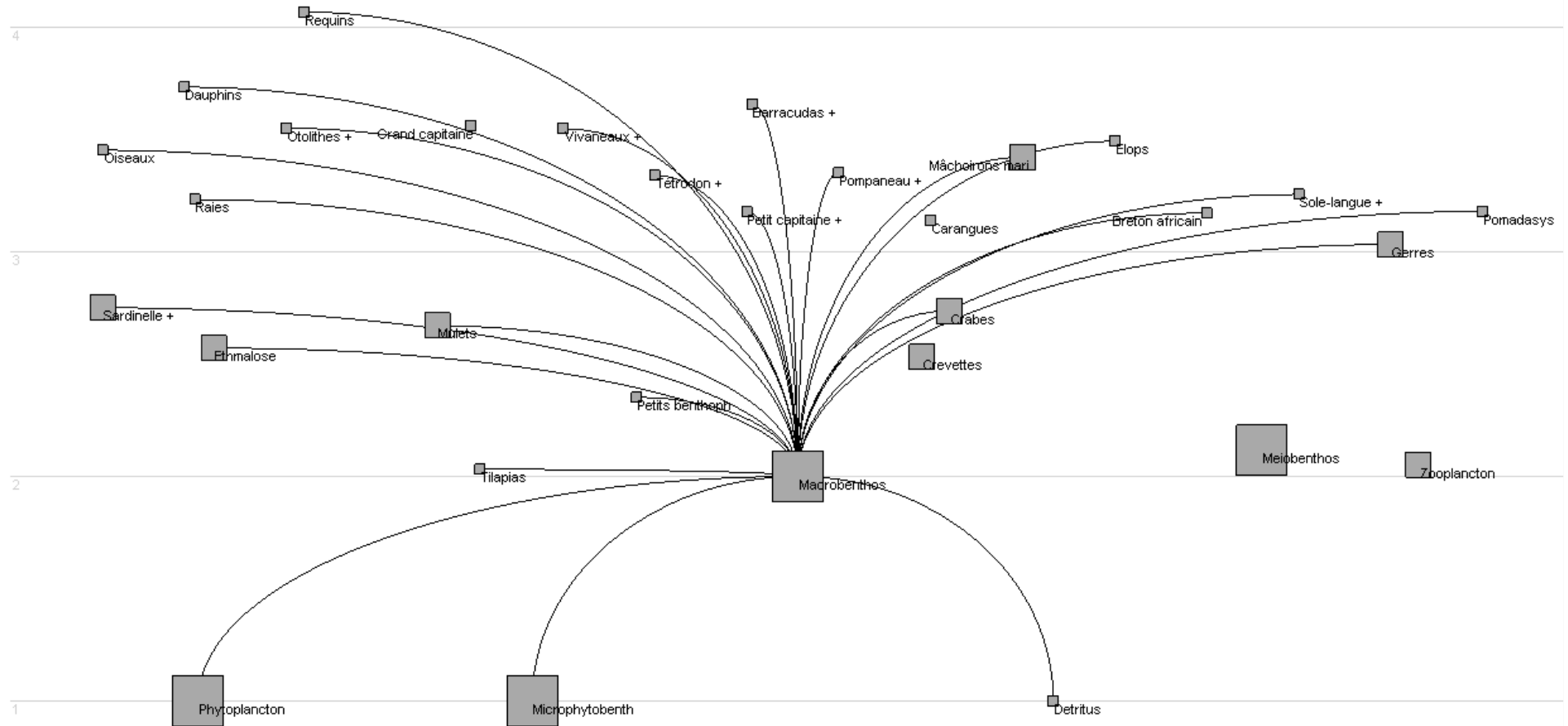
**Biomass
(t/km²)**



Mulets et Otolithes +



Résultats Ecopath 2003 1/3



Place du macrobenthos dans le réseau trophique du bolong de Bamboing en 2003

Résultats Ecopath 2003 1/3

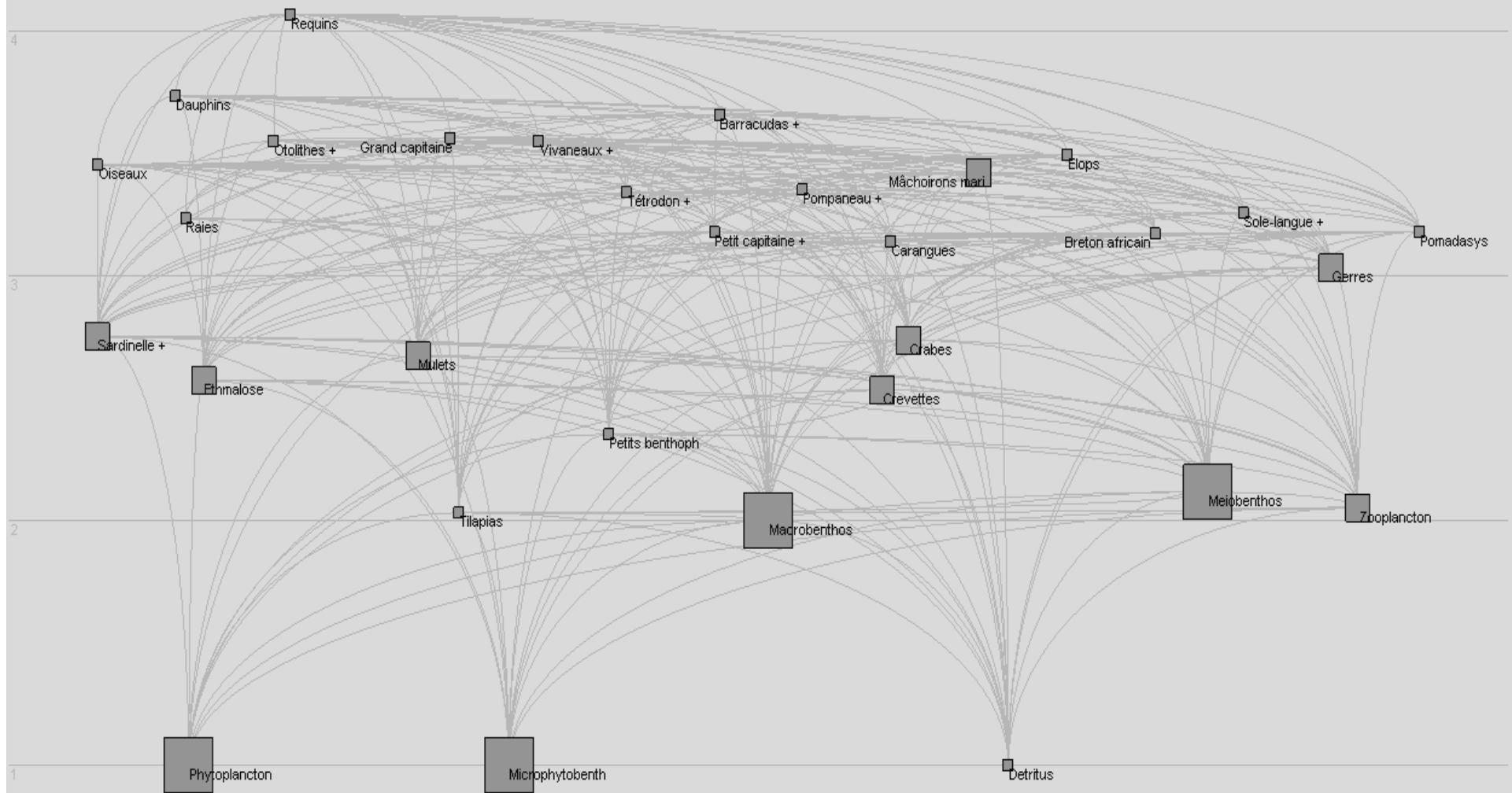
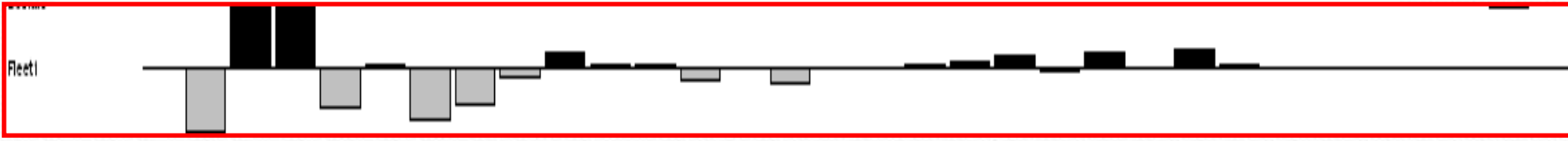
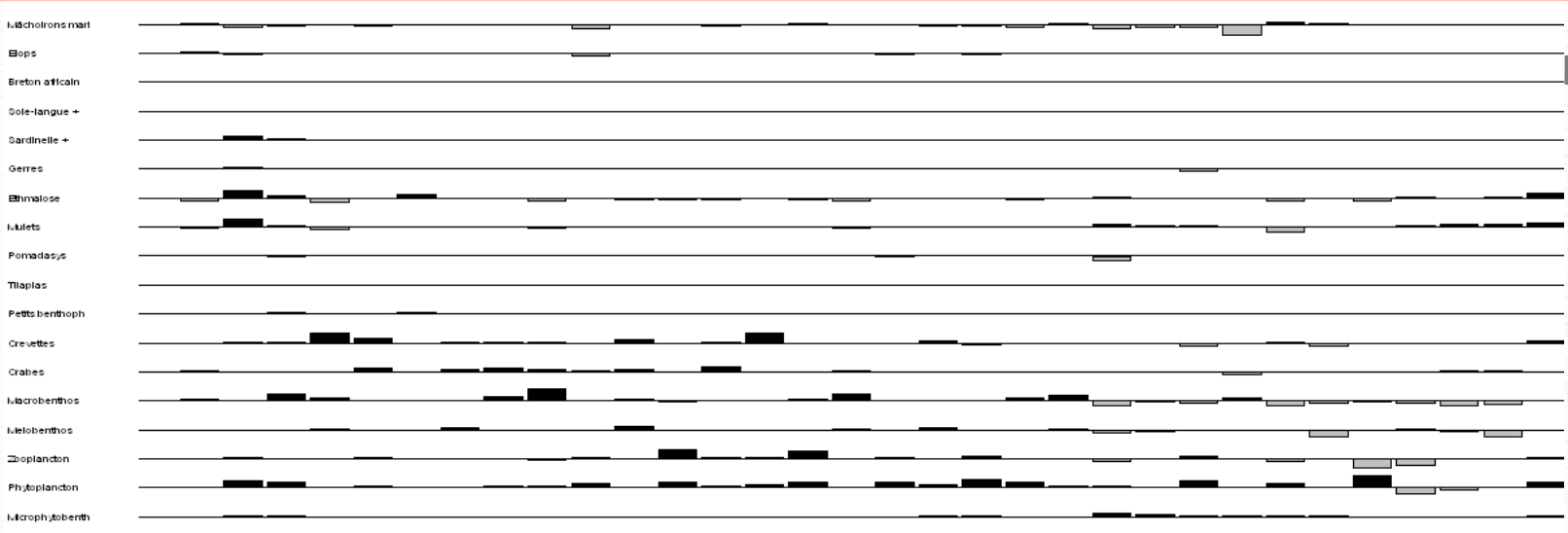
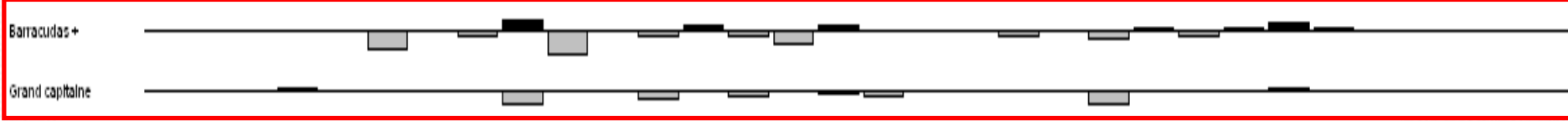
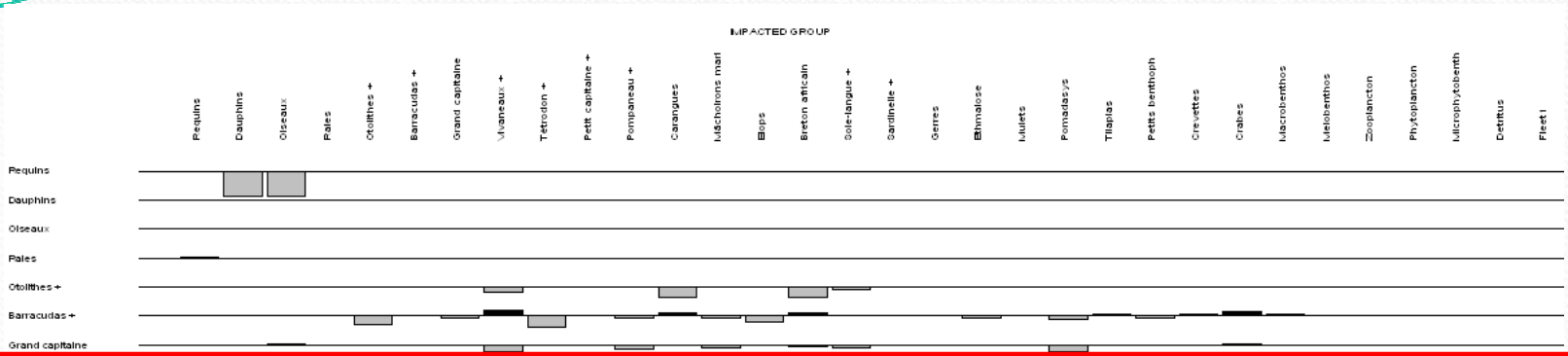


Schéma du réseau trophique du bolong de Bamboing en 2003



rts

