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MOOVES, an individual-based model to study the functioning of a tropical marine ecosystem and its reaction to fishing pressure

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Context

- Ecosystem Approach to Fisheries (FAO, 2003)
  - Not only commercial species in monospecific assessment
  - But interacting species & their environment
- European project « Ecological Fishing in Guinea »

- Exploratory approach with a

  knowledge-based
fish-oriented } ecosystem model

Outline

- Overview of the model:
  - Description
  - Quick display
- Disturbance in this study:
  - Elementary fishing scenarios
  - Tools to investigate their effects
- First results:
  - Do simulated indicators follow reference direction?
  - What does that mean?
- Prospect: a study of response curves

Introduction

Which ecosystem?

- Guinean coastal system
- Mainly demersal community (the « Sciaenids »)
- Old industrial fishery / recent small-scale fishery

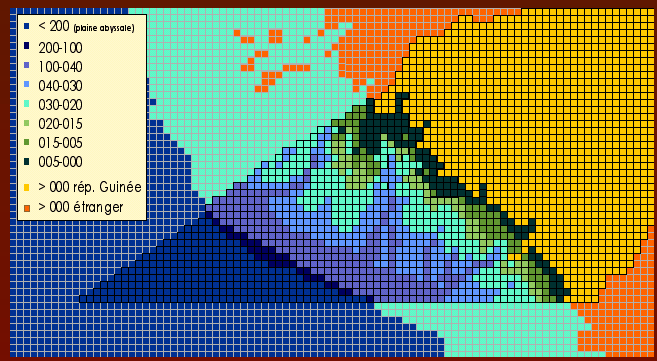
Why a simulator?

- To analyse the properties of a **neritic tropical** system from the representation of the processes
  - observed at the individual / populational scale
  - that seemed important to represent the system functioning in a fishing pressure context
- To simulate fishing scenarios and investigate the reaction of the system

The simulator

MOOVES

Marine Object-Oriented Virtual Ecosystem Simulator



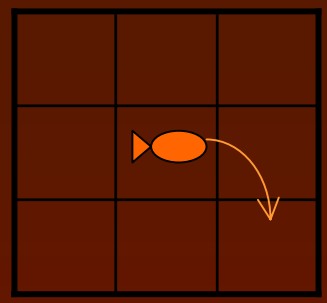
- Individual-based model (IBM)
- Spatially-explicit
- 4 living compartments:
plankton, detritus, benthos, other macroorganisms
- « Bio-functional groups »
- Whole life cycle of fish

Colomb et al., ECEM 2004

The simulator: Life processes of fish

Search for suitable environment: the moving process

$c \in [1;9]$



The agent moves to the cell with Max(Final I_c)

Suitable habitat

Abiotic I_c = $\prod$ HSI(physical parameters)

Feeding satisfaction

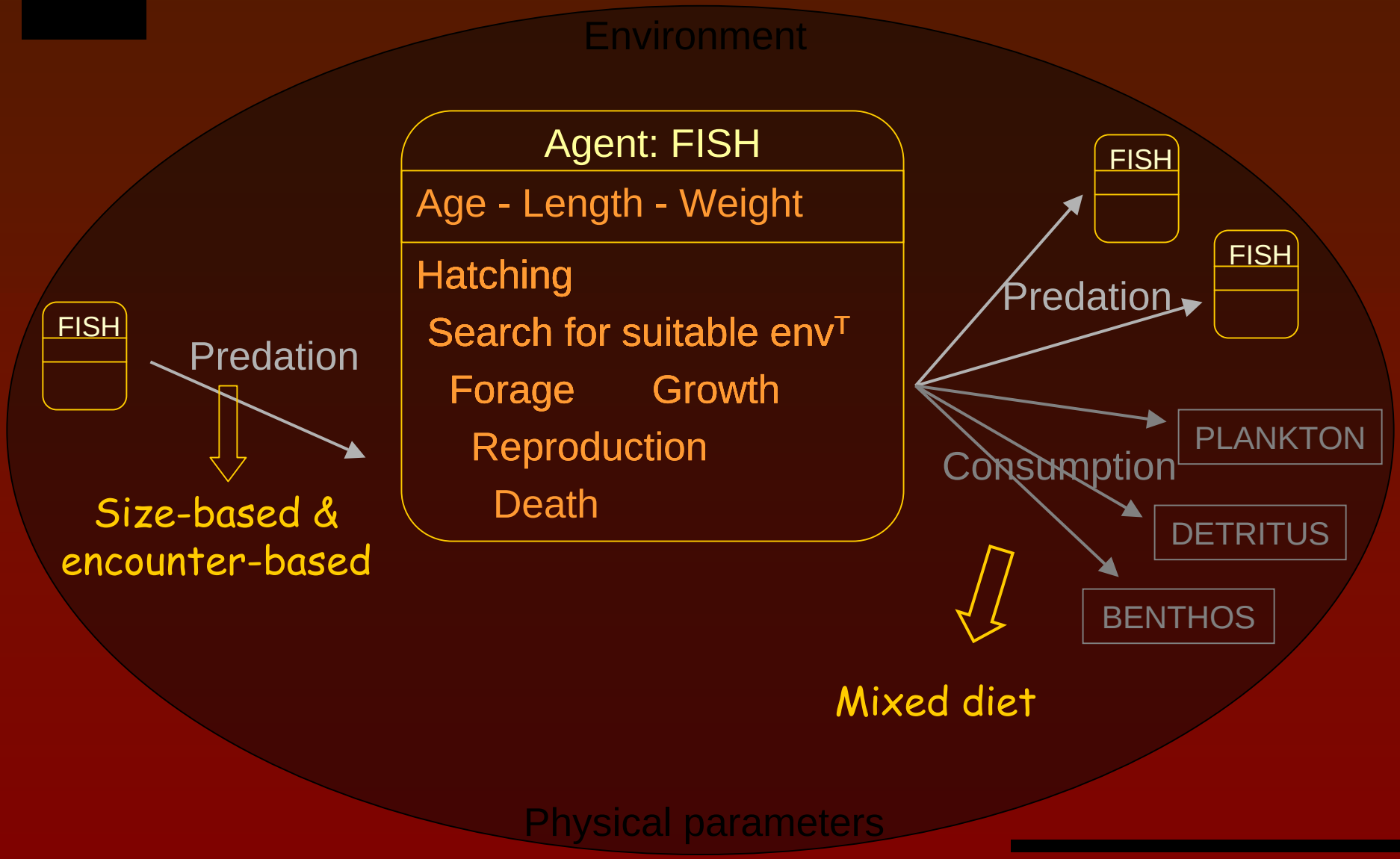
Trophic I_c = $\sum$ satisfaction(diet compartments)

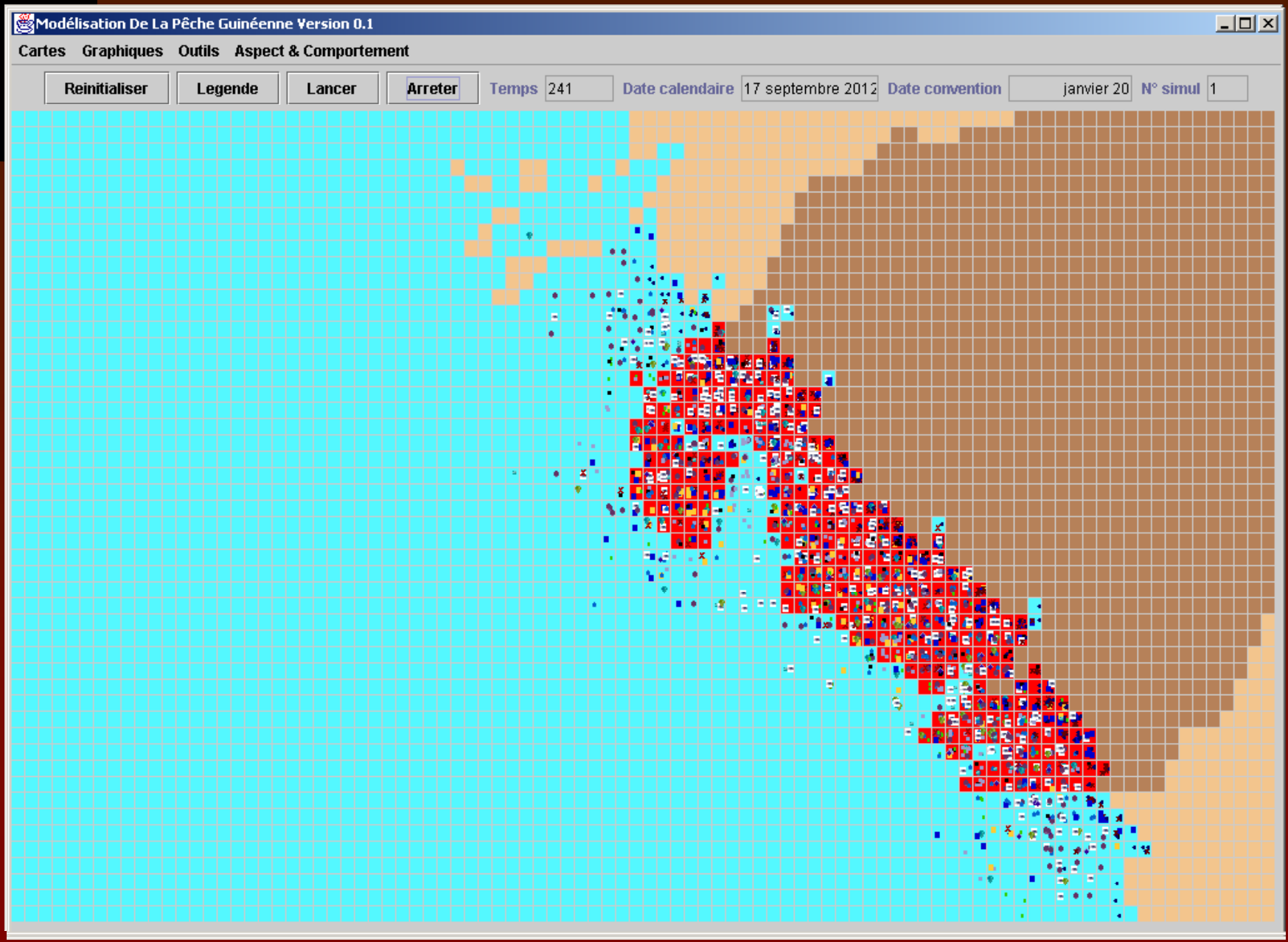
Final attraction index

Final I_c = [Abiotic I_c] ^{S} . Trophic I_c

Colomb et al., ECEM 2004

The simulator: Life processes of fish





Colomb et al., ECEM 2004

Simulated scenarios

How fishing process is modeled?

- Fishing is a mortality rate
- applied on all bio-functional groups
- on all individuals larger than a minimum catch length (19cm)

The fishing scenarios:

- Fref = 0.4
- Various simulations, with mF ranging from 1 to 3, with 0.25 step
- 10 replicates for each scenario

Followed community indicators

	Indicator	Formula	Expresses changes in:
Size-based	Lmean	$\Sigma L / N$	• the mean fish size of populations + the relative abundance of large and small species
	Lmax	$\Sigma(Linf_i * N_i) / \Sigma N_i$	• the relative abundance of large and small species
	Size-spectrum curvature	N by 10-cm size intervals in log scale + quadratic fit	• the relative abundance of large and small fish
Tropho-dynamics	TLmean	$\Sigma TL / N$	• the diets of fish

Colomb et al., ECEM 2004

Results: expected vs simulated directions

Indicator	Previous theory / empirical reference direction	Model
Lmean	↘ (Rochet & Trenkel 2003)	↘
Lmax	↘ (Jennings et al. 1999)	↗↘
SS curv.	↘ (Shin & Cury 2004)	↘
TLmean	↘ (Pauly et al. 2000)	↘

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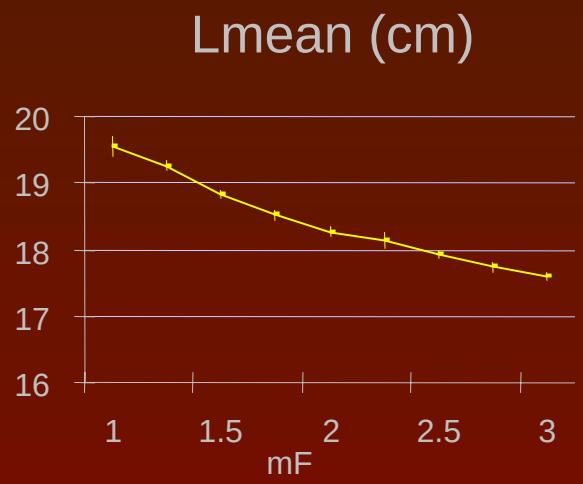

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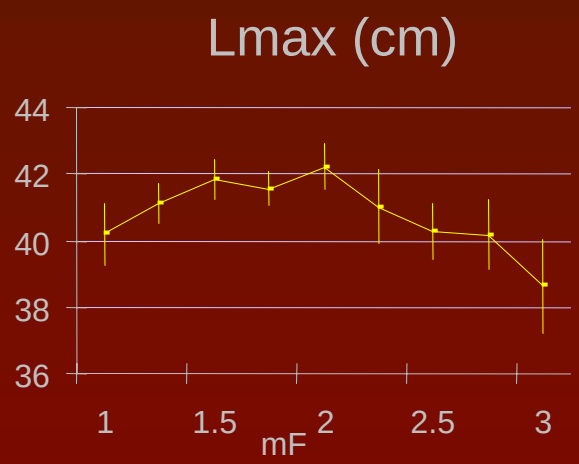

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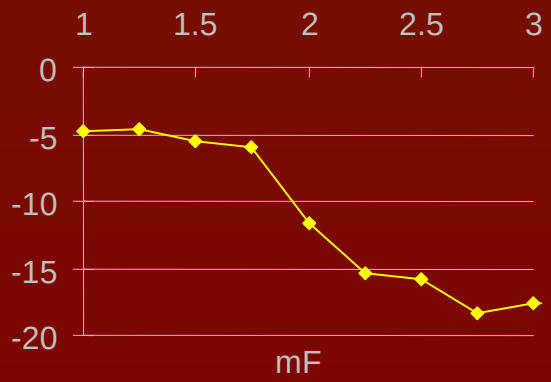
Size-spectrum curvature



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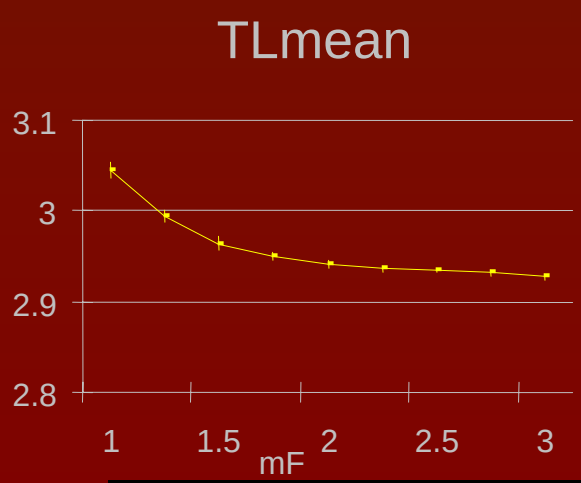


Colomb et al., ECEM 2004

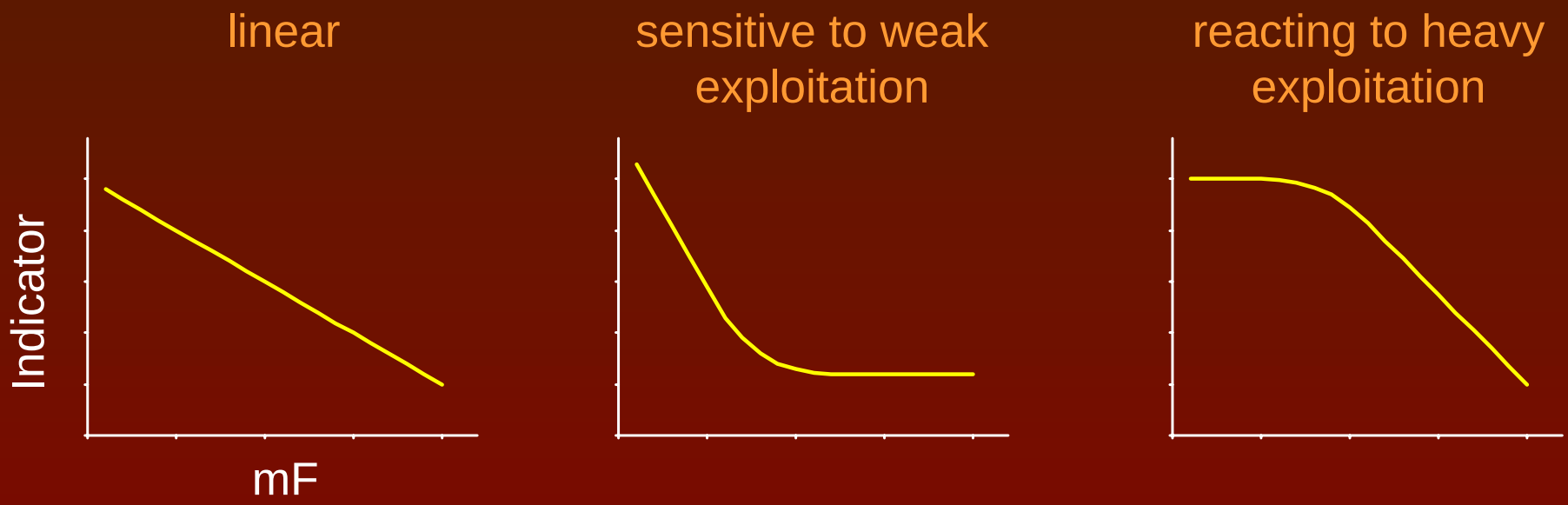
Results: meaning

- Fishing pressure resulted in:
  - a decrease of larger fish compared to small fish
  - and particularly at the species scale
  - but not necessary a decrease of large species
  - a decrease of ichtyophageous abundance
    « Fishing down marine food webs »

Advantage of the approach:
accessing all the information for a scenario,
and not empirical results from various surveys.

Perspective for community indicators: a typology of responses

- Various types of response to fishing pressure appear:



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Perspective for community indicators: a typology of responses

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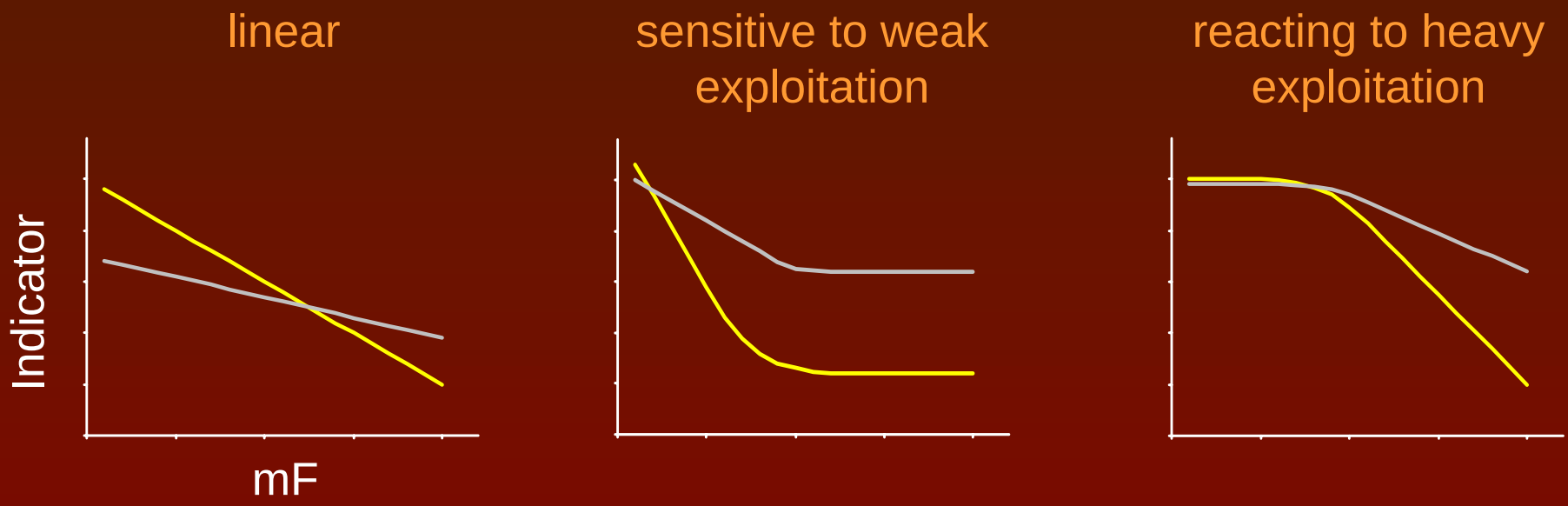

- Responses may differ by their amplitude

Colomb et al., ECEM 2004

Perspective for community indicators: a typology of responses

	Type of response	Amplitude
Size-based		
Lmean	linear	high
Lmax	no ref. direction	low
SS curvature	strong pressure	very high
Trophodynamic		
TLmean	light exploitation	low

low:	1-5%
high:	5-15%
very high:	+ 15%

Colomb et al., ECEM 2004

Perspective for community indicators: a typology of responses

	Type of response	Amplitude
Size-based		
Lmean	linear	high
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SS curvature	strong pressure	very high
Trophodynamic		
TLmean	light exploitation	low

Reliable whatever the pressure is

+

Strong reaction

⇩

Ideal indicator for sensitivity and amplitude criteria

Perspective for community indicators: a typology of responses

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Size-based		
Lmean	linear	high
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SS curvature	strong pressure	very high
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TLmean	light exploitation	low

Not valid

Perspective for community indicators: a typology of responses

	Type of response	Amplitude
Size-based		
Lmean	linear	high
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SS curvature	strong pressure	very high
Trophodynamic		
TLmean	light exploitation	low

For heavy exploitation
+
Strong reaction

⇩

Good indicator
in those cases

Colomb et al., ECEM 2004

Perspective for community indicators: a typology of responses

	Type of response	Amplitude
Size-based		
Lmean	linear	high
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SS curvature	strong pressure	very high
Trophodynamic		
TLmean	light exploitation	low

For developing exploitation (…!)

or

low intensive fisheries

or

tracking fisheries history…

Good indicator in those cases

Colomb et al., ECEM 2004

Conclusion

- The simulations point out the response of the system to fishing pressure
  - The directions match the theory and previous studies on demersal assemblages
  - and this approach precises some ***response curves*** (the linear response is particularly interesting)
- Theoretical advantage: by modelling the individuals, a huge amount of information is reachable (but do not drop the string!) so various types of data are available for the same « study »
- Perspectives…
  - Strong validation
  - What happens below the community level?
  - Environmental processes

Thank you for your attention

and thanks to the ISEM

Comments are welcome !