Defining Yield Policies in a Viability Approach

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Introduction

- Study of the Southern Benguela ecosystem by Mullon

  C. Mullon, P. Curry and L. Shannon
  Viability model of trophic interactions in marine ecosystems.
  Natural Resource Modeling, 17:27-58, 2004.

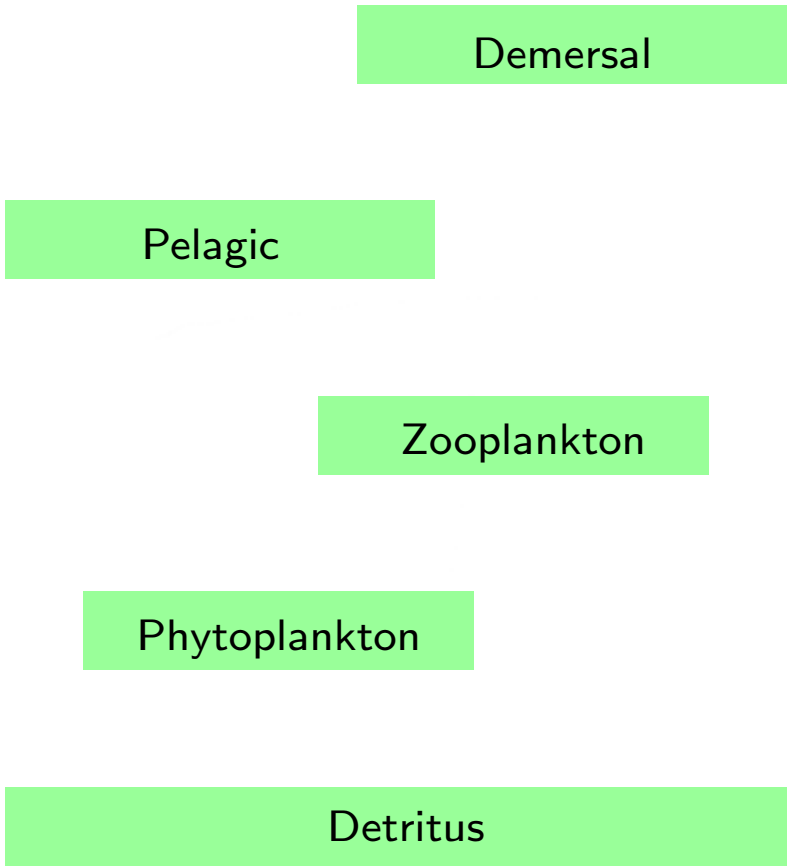
- Problem: Given constant values of fisheries, how ensuring the persistence of the ecosystem ?
- Solution: Study the model in a viability perspective
- We focus here on the yield policies

Outline

1. Southern Benguela ecosystem
2. Viability theory
3. Results
4. Summary

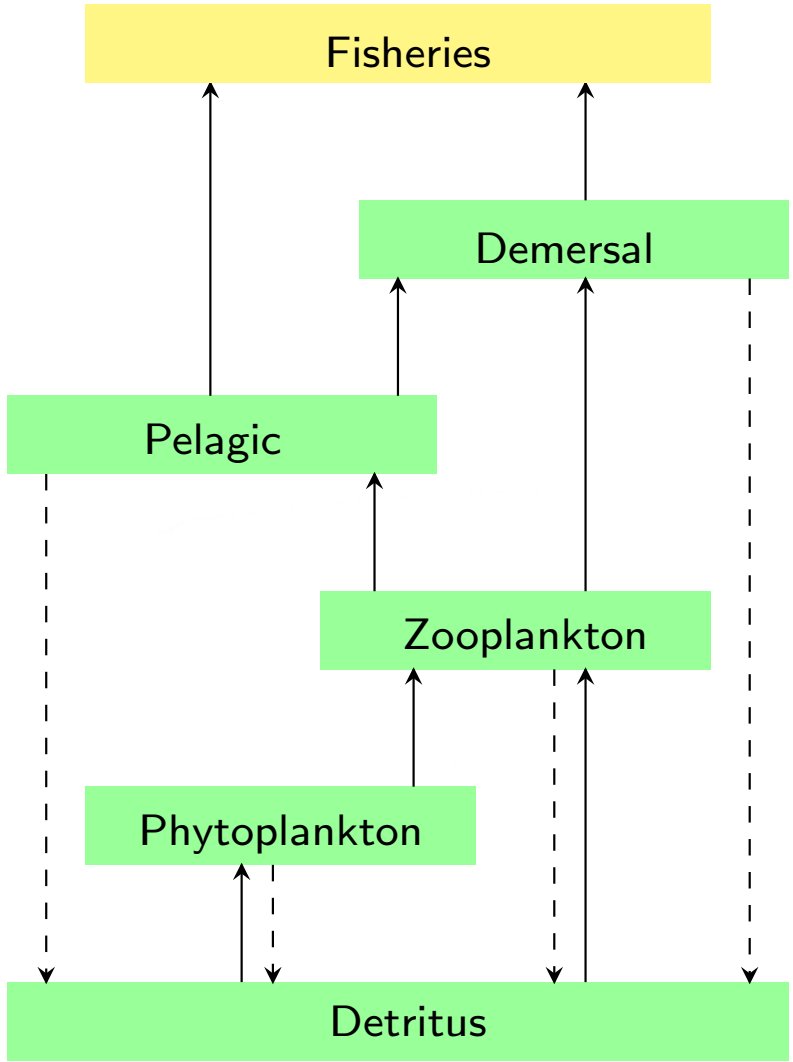
Southern Benguela ecosystem
Description

- 5 groups
  - Detritus
  - Phytoplankton
  - Zooplankton
  - Pelagic Fish
  - Demersal Fish
- Sustainable system: the biomass of each species must remains in a given interval



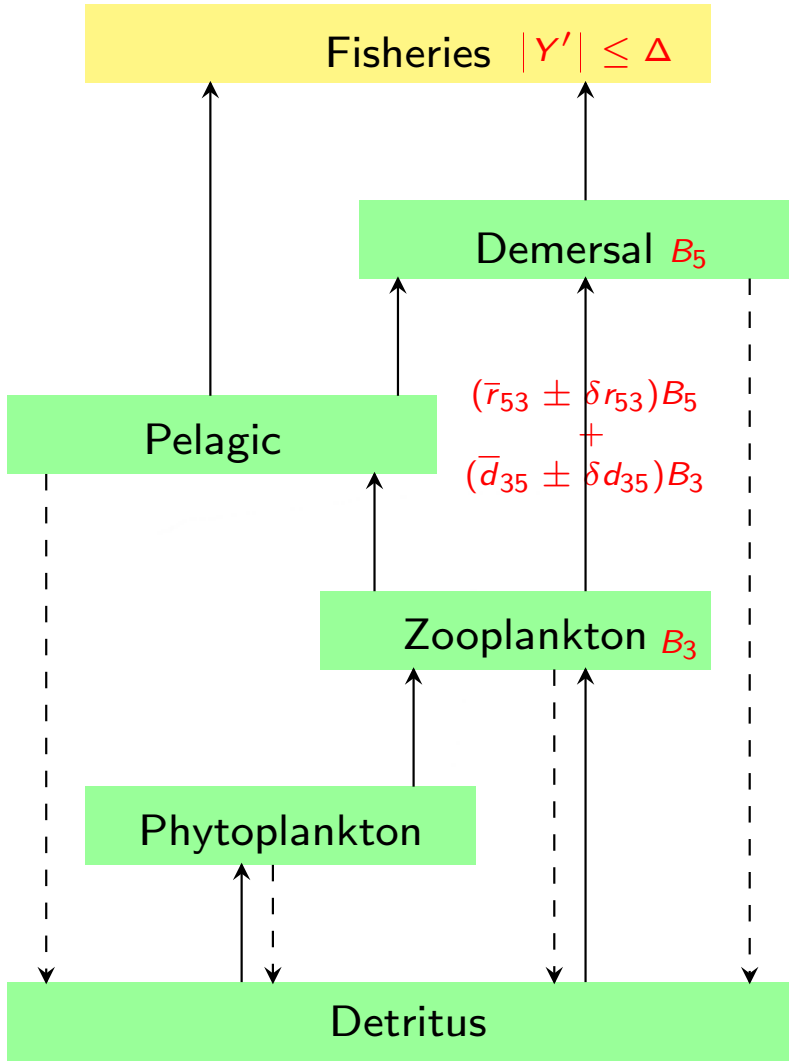
Southern Benguela ecosystem
Model

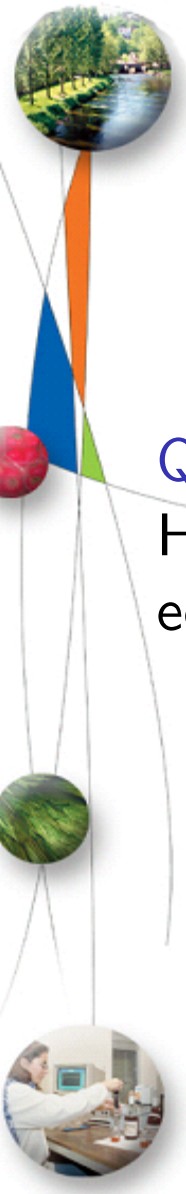
- Dynamical model of biomass evolution of each species, including
  - consumption
  - predation
  - yield
  - non-assimilated biomass (only for detritus)
- 6^{th} compartment: fisheries



Southern Benguela ecosystem
Specifications of the model

- Thresholds for biomass
  $m_i \leq B_i \leq M_i$
- Trophic flows fixed by the predator and the prey
- Thresholds for fisheries
  $y_m \leq Y \leq y_M$
- Maximal variation $|Y'| \leq \Delta$

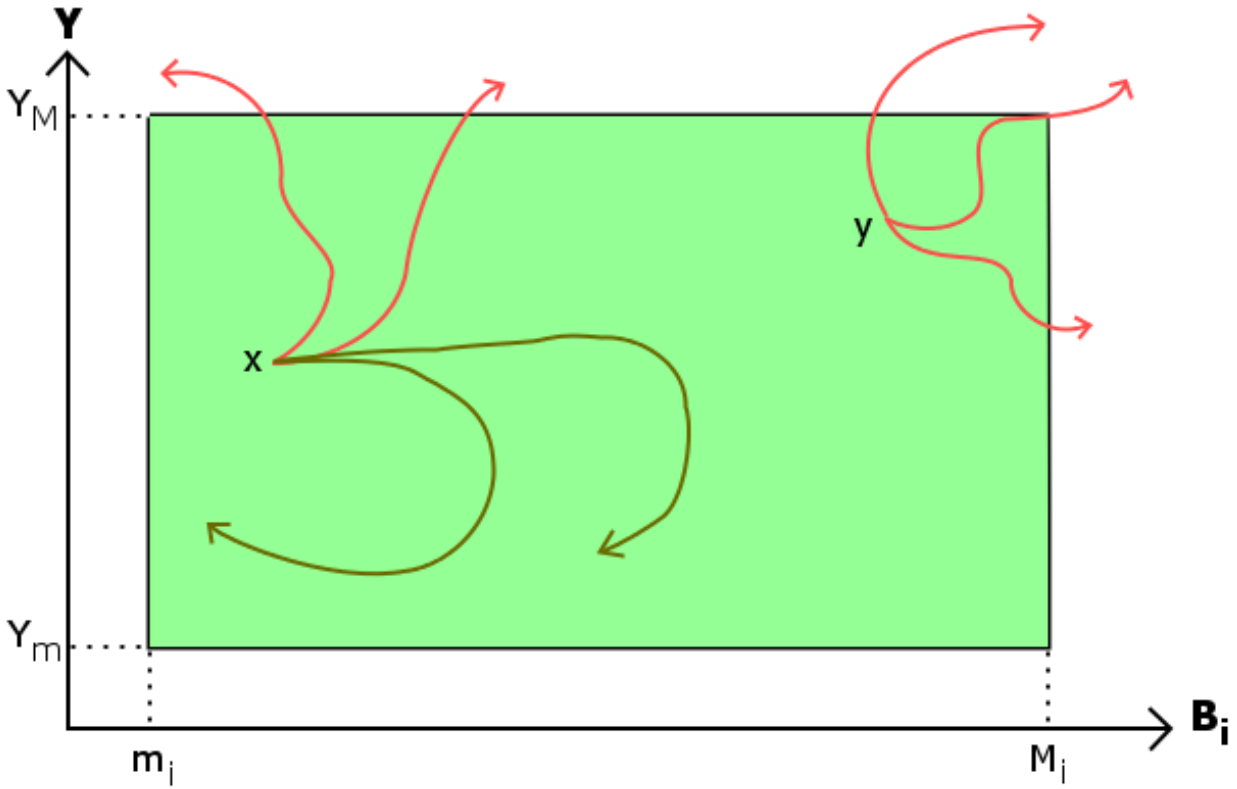




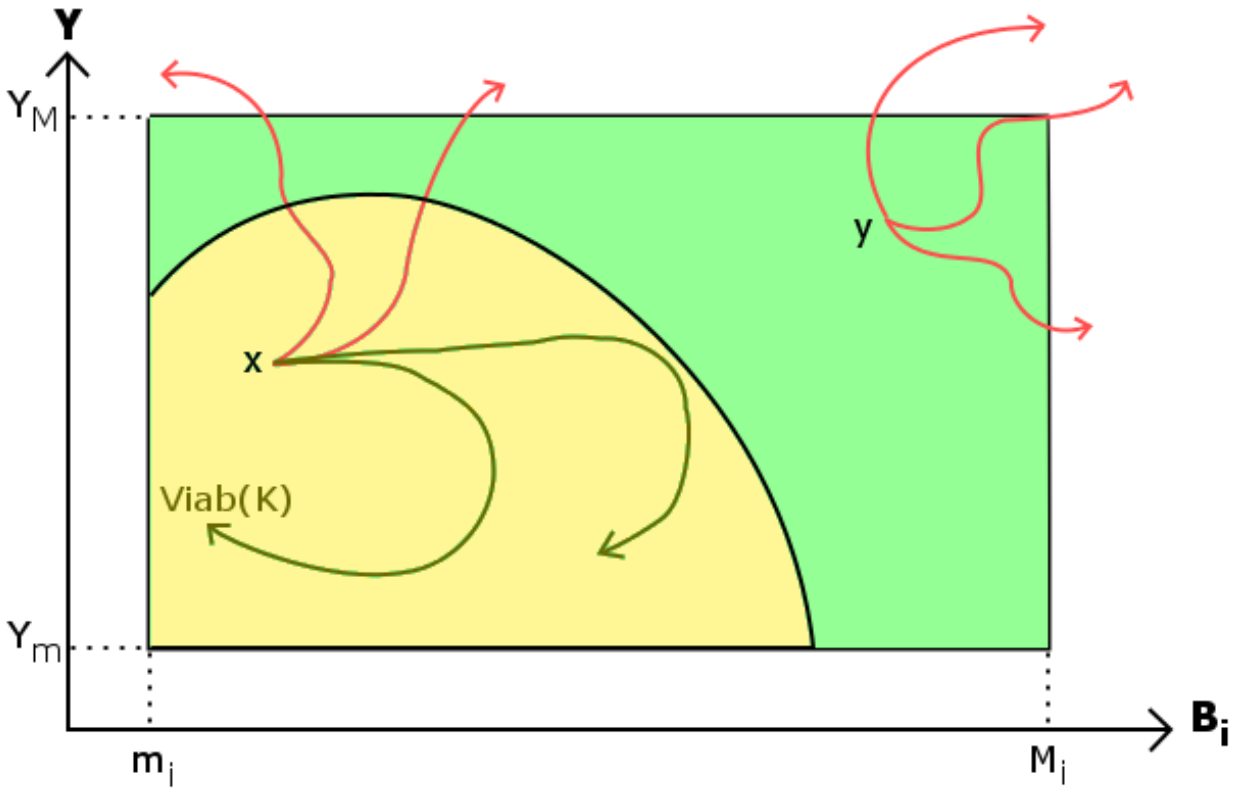
Question:

How define yield policies that allow the sustainability of the ecosystem ?

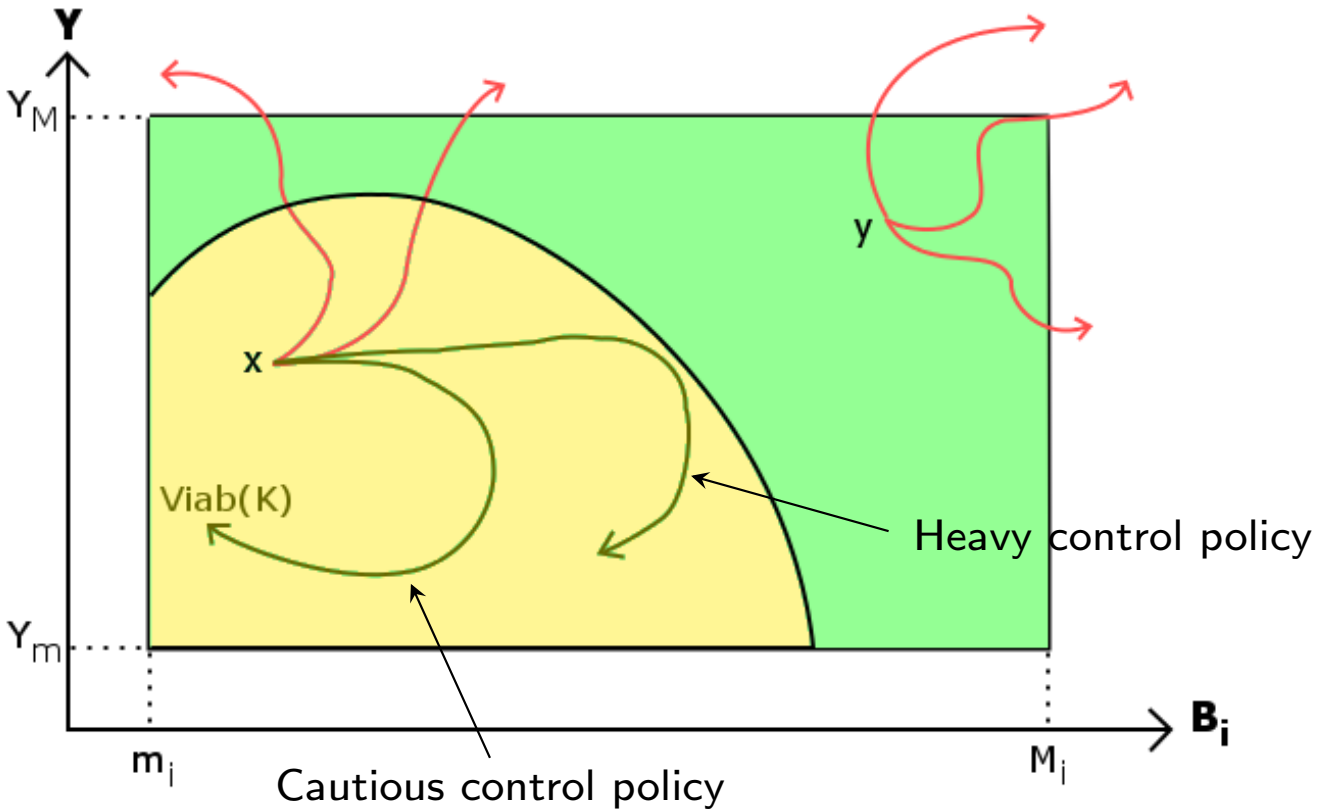
- Viable state: There exists at least one evolution which allows to stay in the viability constraint set



- Viability kernel: Set of all viable states



- Control policies: Flexibility for the stakeholders



Viability theory
Algorithm

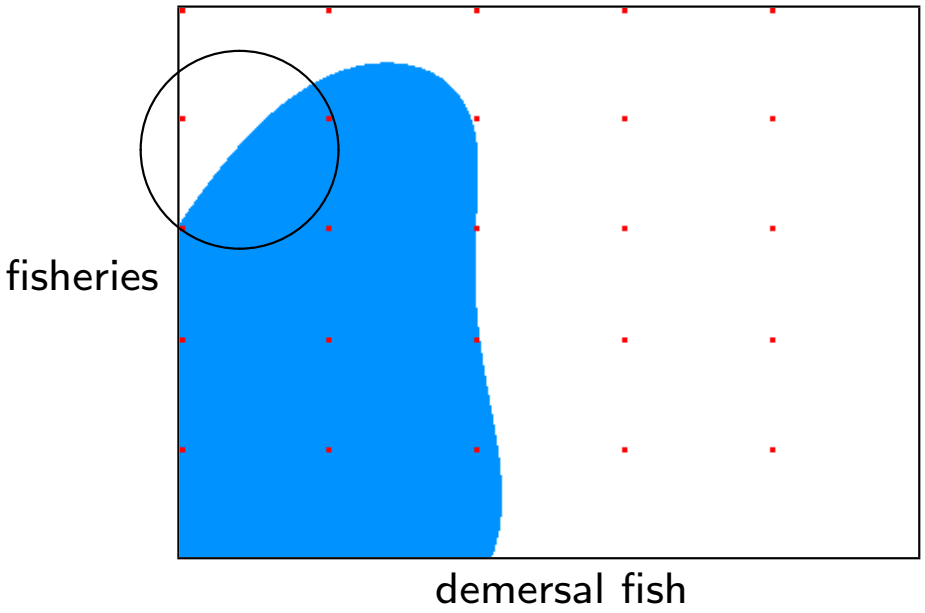
- 17 controls: trophic flows between species (δr_{ij}, δd_{ij}) and maximal variation of the yield ($|Y'|$)
- Particular algorithm, based on a statistical learning method, Support Vector Machines, which approximates the viability kernel
- Grid of 45000 points
- Viability kernel: subset of R^6

J.-P. Aubin
Viability theory.
Birkhauser, 1991.

P. Saint-Pierre
Approximation of viability kernel.
Applied Mathematics & Optimisation, 29:187-209, 1994.

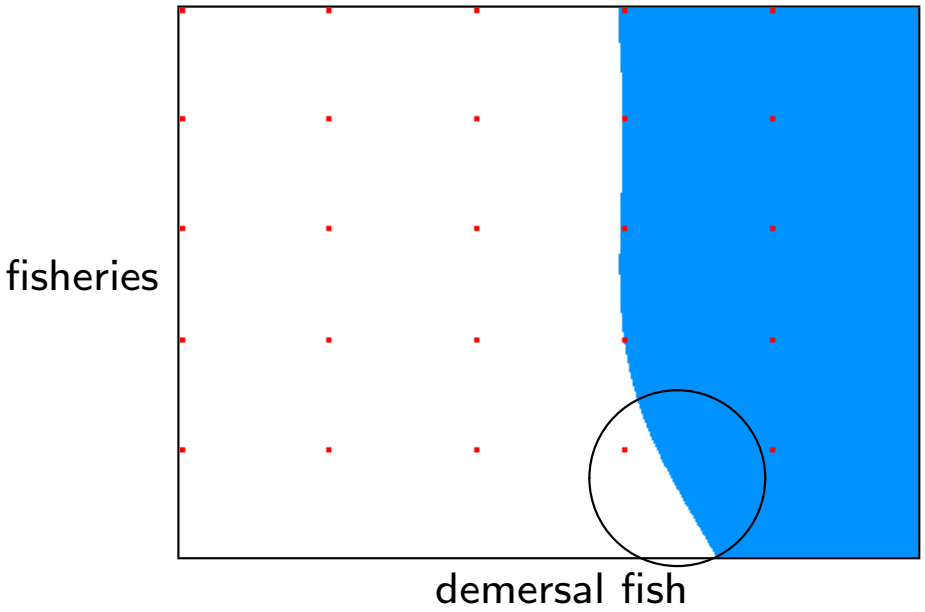
- A high level of detritus is necessary to ensure a viable path
- The levels of all the compartments have an influence on the boundary of the viability kernel
- Yield policies can be defined from the viability kernel

- Low level of pelagic fish



- maximal values of demersal fish
- maximal threshold for fisheries

- High level of pelagic fish



- minimal values of demersal fish
- minimal threshold for fisheries

Summary




- We focus on constraints on the ecosystem
- Fisheries can be included in the problem.
- Viability kernel helps to define yield policies

Future work

- Other parameters to include ?
- Improve the accuracy of the results