Investigating the potential impact of MPAs on fisheries: what can be learnt from basic bioeconomic modelling?

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Purpose of the presentation

- To investigate, from a theoretical point of view, what is the economic case for MPA-based fisheries management.
- Analytic tool: a simple bioeconomic model, derived from Hannesson (1998) and Anderson (2002).
- Unlike H and A, our model allows for space heterogeneity, both as regards:
  - ✧ecology (different zones may have different natural productivities)
  - ✧and economy (effort costs may differ between zones, e.g. according to distance from harbour).

Major limitations of the model

- Scope limited to fishing: does not account for non-fishery benefits of MPAs
- Only two zones: FZ and NTZ
- Only one stock
- Deterministic framework
- Run under equilibrium conditions (comparative statics)

Some key-variables

$$x_i = \frac{X_i}{K_i}$$ Stock pressure on local ecosystem

$$D_i = \frac{K_i}{A_i}$$ Natural productivity of zone i

$$v_i = \frac{rK_i - s}{rK_i}$$ Ability of zone i to retain surplus biomass

$$c_i = \frac{C_i}{D_i qP}$$ Real unit cost of fish harvested in a pristine zone i

Basic relationships

$dX_i / dt = N_i - T_{ij} - Y_i$	Stock dynamics
$N_i = rK_i x_i (1 - x_i)$	Local biomass surplus production
$T_{ij} = s(x_i - x_j)$	Inter - zone net biomass transfer
$Y_i = qD_i x_i E_i$	Catch function
$\pi_i = PY_i - C_i E_i$	Local fishing profitability
$dX_i / dt = 0$	Comparative statics
$E_1 = 0$	Fishing ban in zone 1

How it works…

Biological equilibrium conditions in:

1. The no-take zone

$$N_1 = T_{12}$$

→ A relationship between x_1 and x_2, <u>not</u> depending on fishing effort

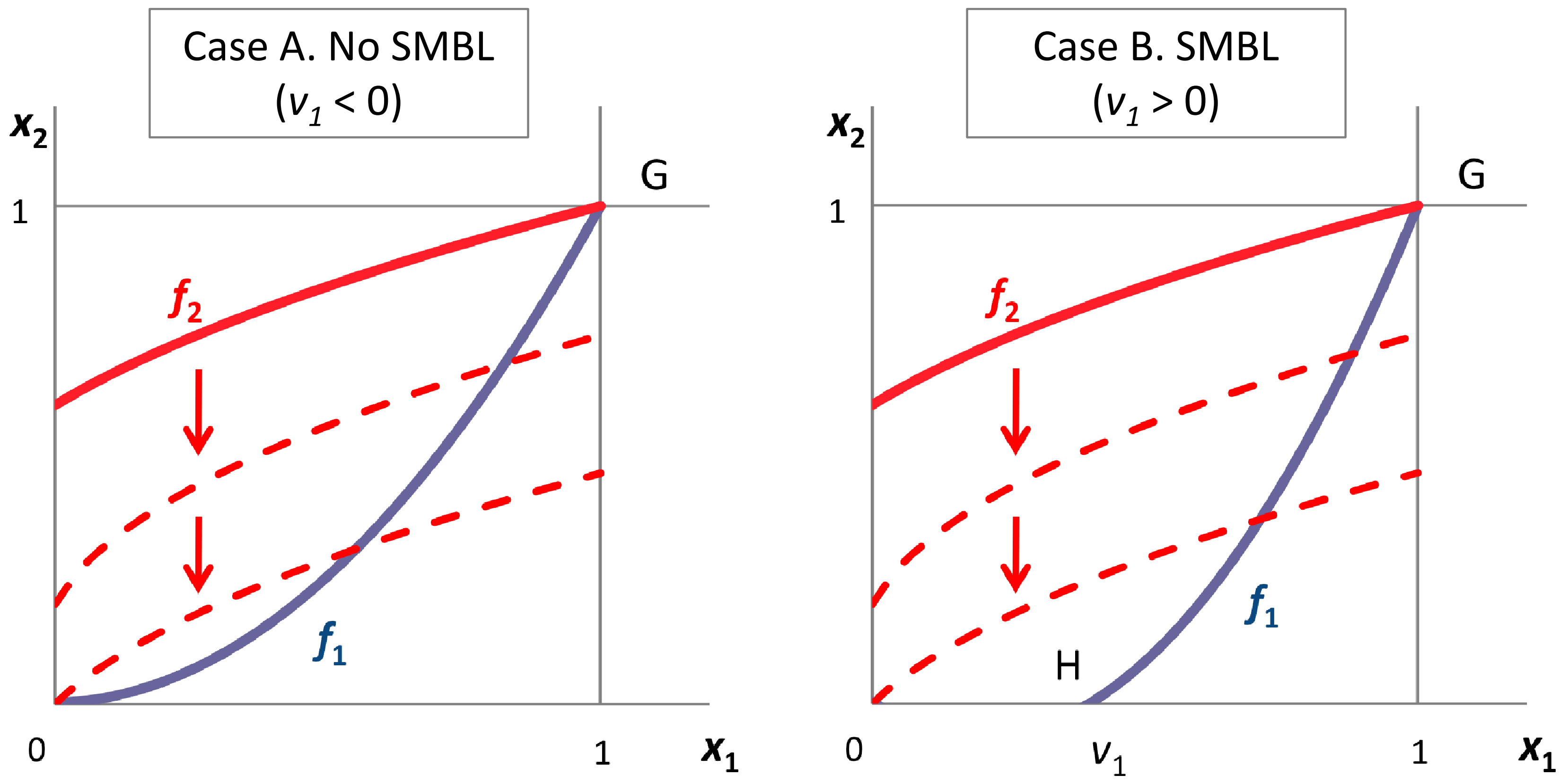
2. The fishing zone

$$Y_2 = N_2 + T_{12}$$

→ Another relationship between x_1 and x_2, depending on the level of fishing effort

Under equilibrium conditions, both relationships must hold simultaneously

Determination of local equilibrium biomasses in the NTZ (1) and in the FZ (2), according to the rate of fishing mortality

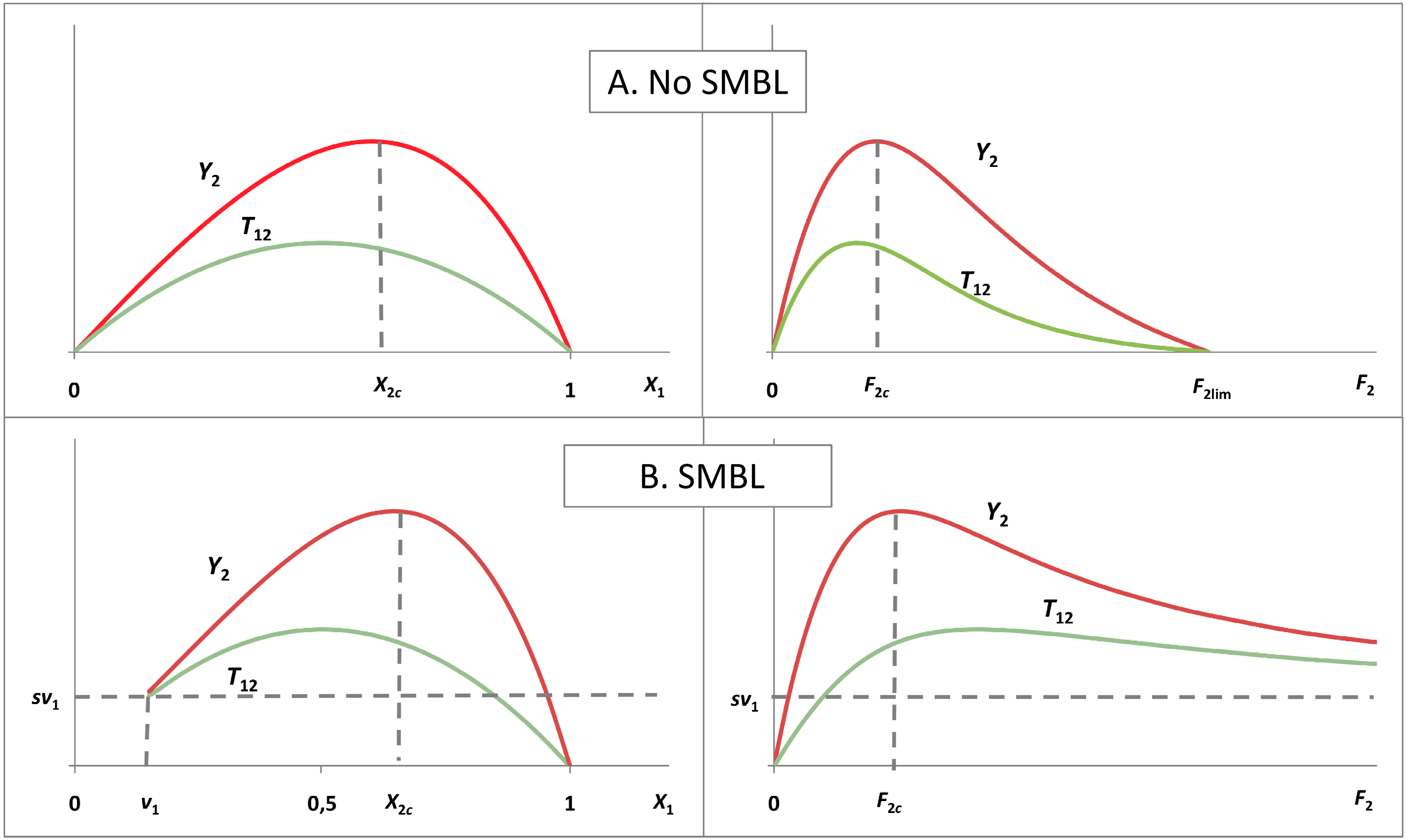


- x_i = X_i/K_i = pressure exerted by local stock biomass on ecosystem of zone *i*.
- f_i = biological equilibrium relationship in zone *i*
- *SMBL* = Safe Minimum Biomass Level (v_1, if $v_1 > 0$)
- The downward arrows indicate an increasing rate of mortality in the fishing zone.

Sustainable catches in the FZ, as a function of:

Equilibrium biomass in the NTZ

Rate of fishing mortality in the FZ



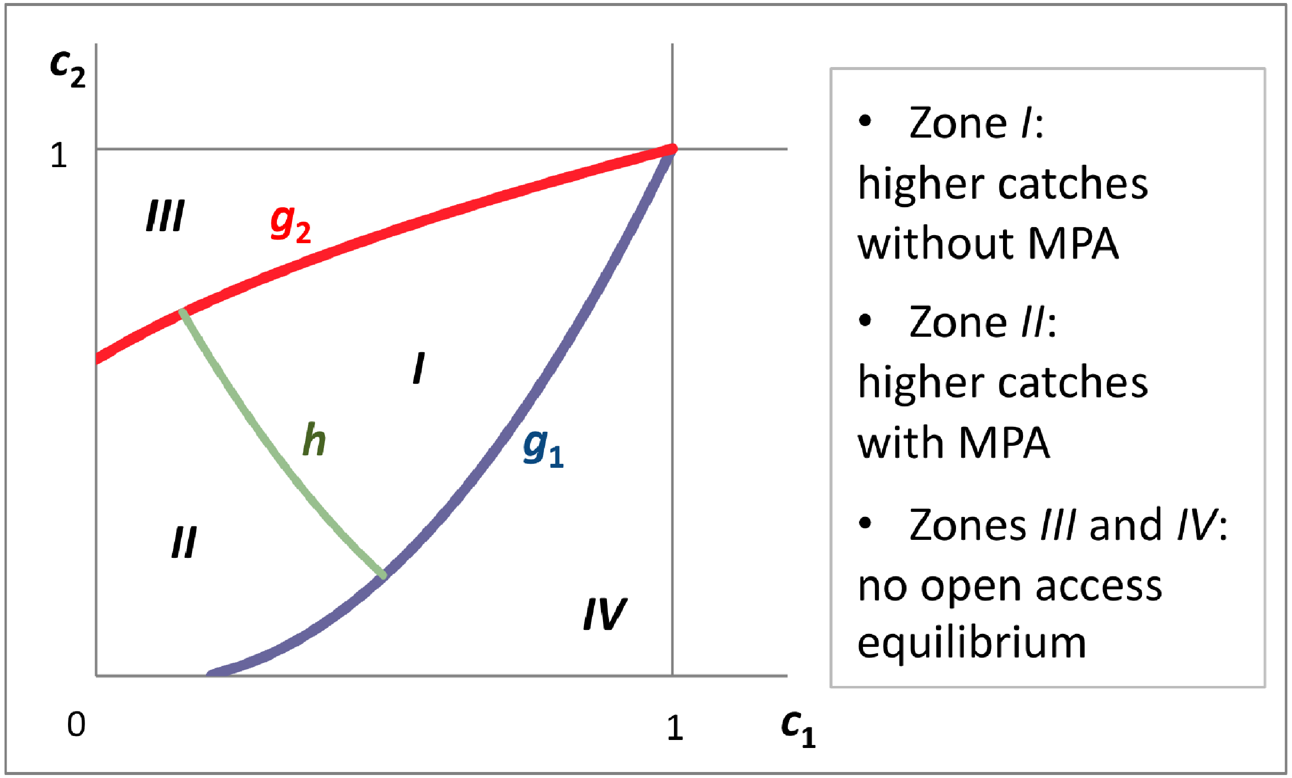
What is the case for MPA-based fisheries management?

- A question addressed under 3 alternative assumptions, concerning ability of managers to control fishing mortality in the FZ:
    1. Full control
    2. No control
    3. Limited control
- Assessment criteria:
    - Fishery rent
    - Sustainable catches

Answers provided by the model

1. If fishing mortality is fully controlled:
   - Conventional management performs better, as regards both criteria
2. If fishing mortality cannot be controlled except by a fishing ban:
   - MPA-management is unable to restore durably the profitability of the fishery
   - But it may improve sustainable catches (depending on fishing costs)

Sustainable open access catches, according to relative fishing costs in each zone



- $c_i = C_i/D_iqP$ = real cost of harvesting one unit of fish in zone *i*, assuming pristine local biomass (D_i = maximum equilibrium stock density in zone *i*)

3. The case of limited control of fishing mortality

- We assume that managers may limit fishing effort, though at a suboptimal level
- In this case, if the level of effort in the fishery is high, creating an MPA may increase both sustainable catches, and fishing rent.

→ MPA-based fisheries management as a second-rank optimum

Thank you for listening…