

# An Indicator for Ecosystem Externalities in Fishing

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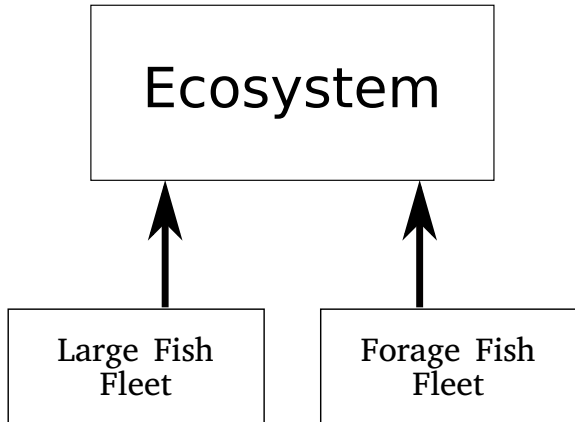
†National Institute of Aquatic Resources,  
Technical University of Denmark, Charlottenlund

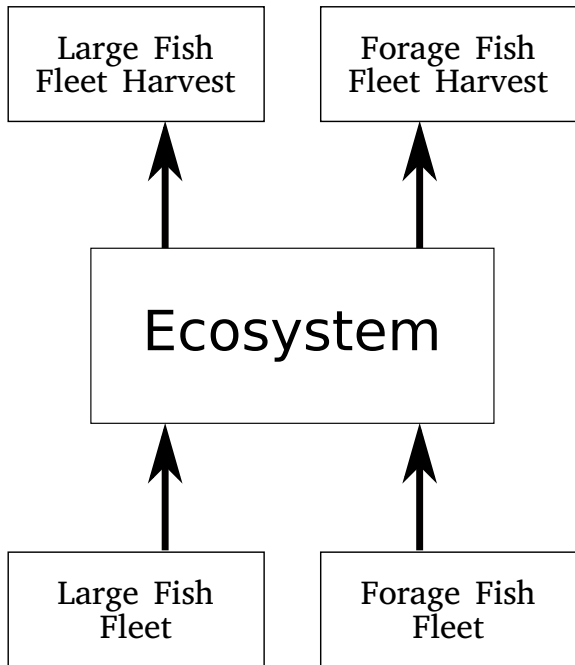
NAAF, Ketchikan, May 19–22, 2015

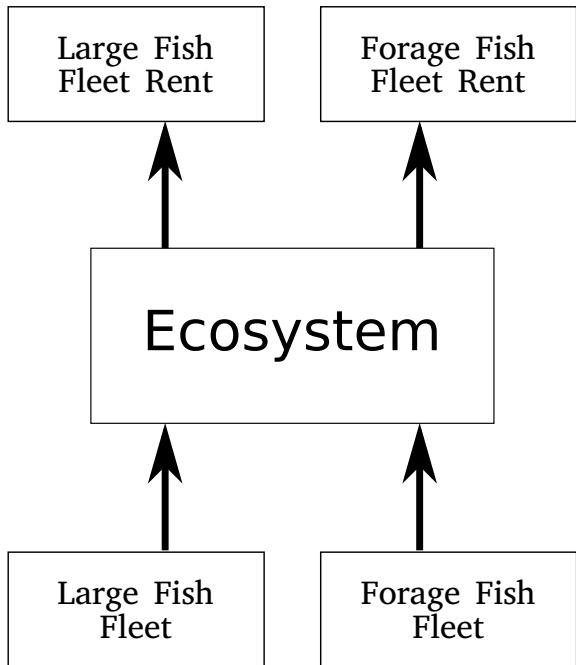
## Question

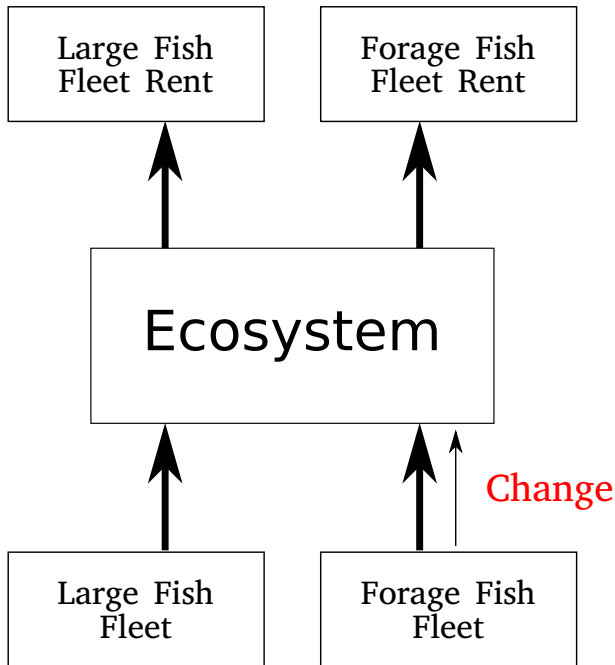
What is the ecosystem externalities of fishing on forage fish?

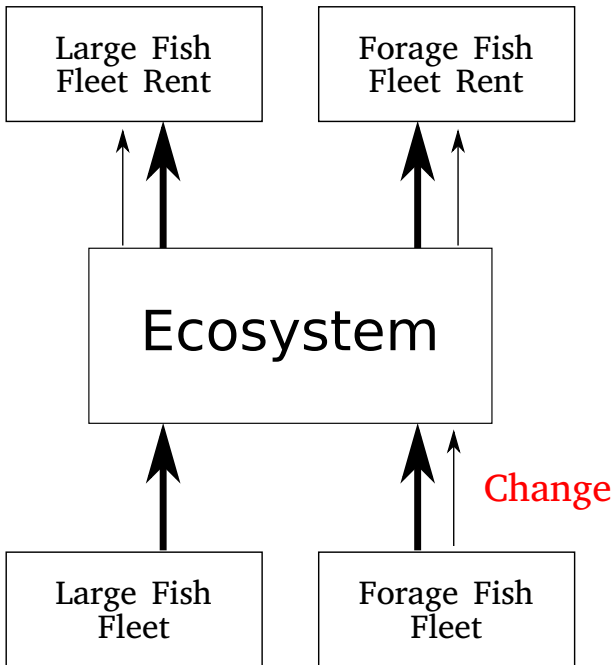
What is the ecosystem externalities of fishing on piscivorous fish (large fish)?

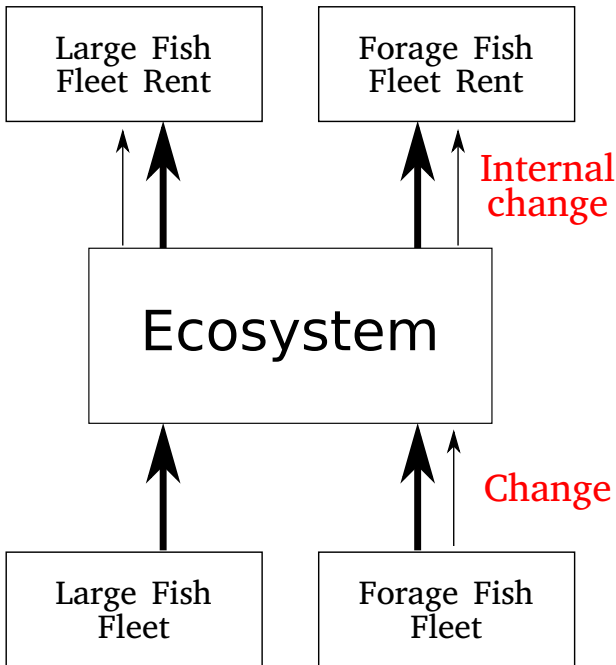




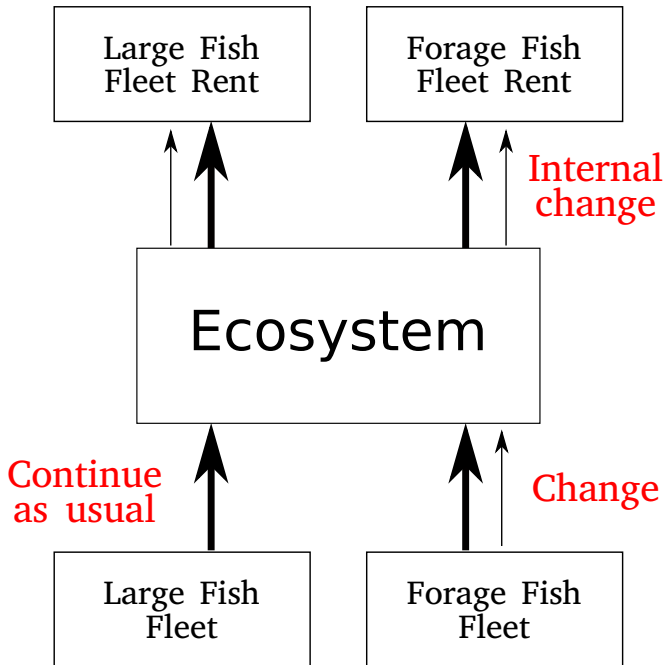


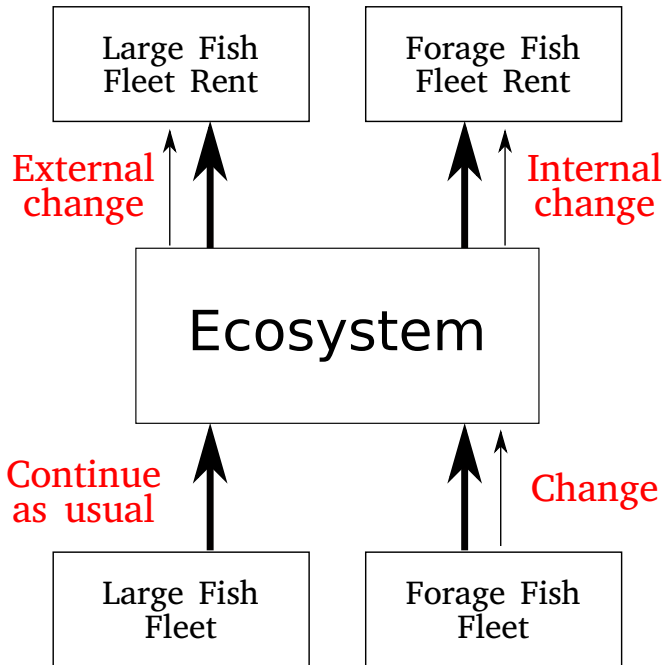


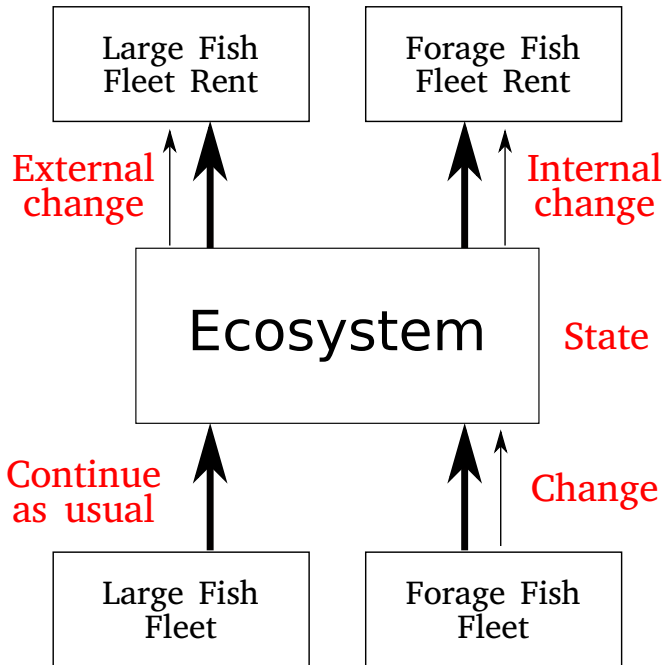


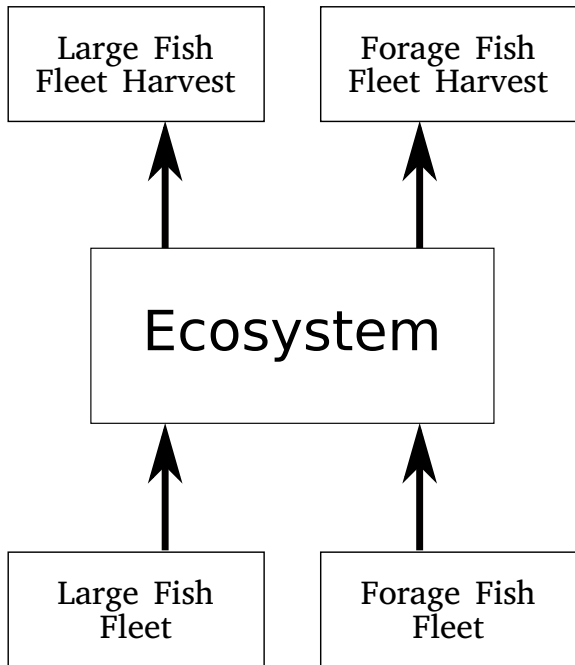


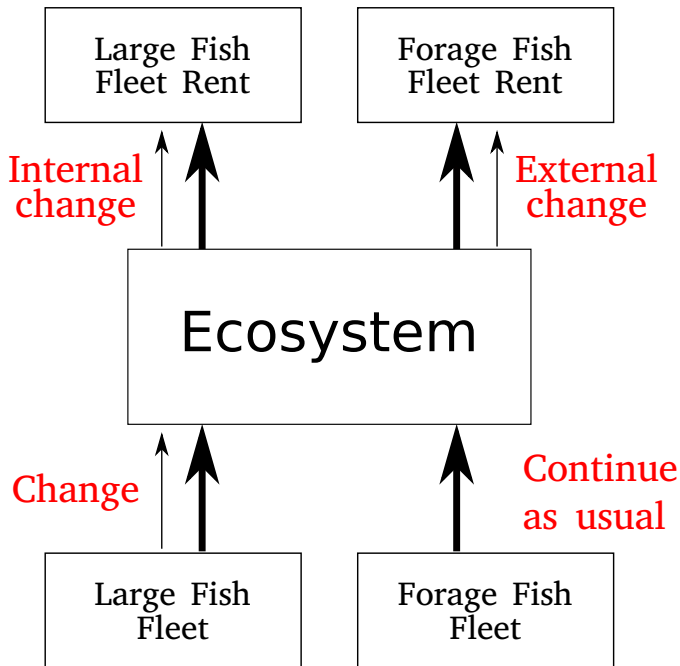












## Ecological Model

- Trait based community size spectrum model
- Two dimensions:
  - Size (mass) of individual fish 0.001 g—100 kg
  - Asymptotic size 4 g—100 kg
- Explicit links mortality—consumption—somatic growth

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## Economic Model

- Two fleets, knife edge wrt. species
- Price
  - Increasing price wrt size for Large fish
  - Flat price for Forage fish

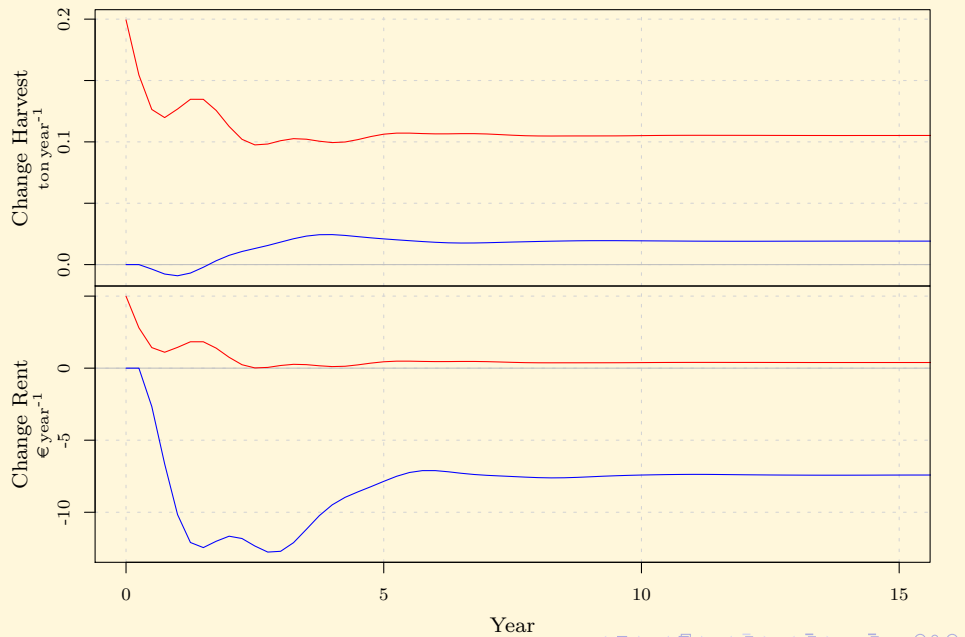
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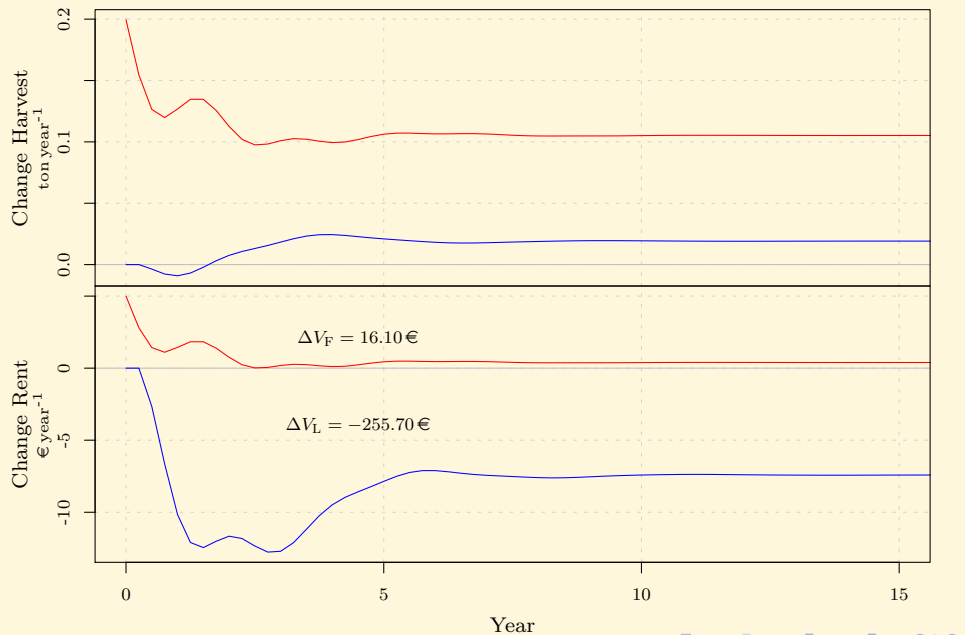
# Method

A marginal change of forage fleet's fishery:

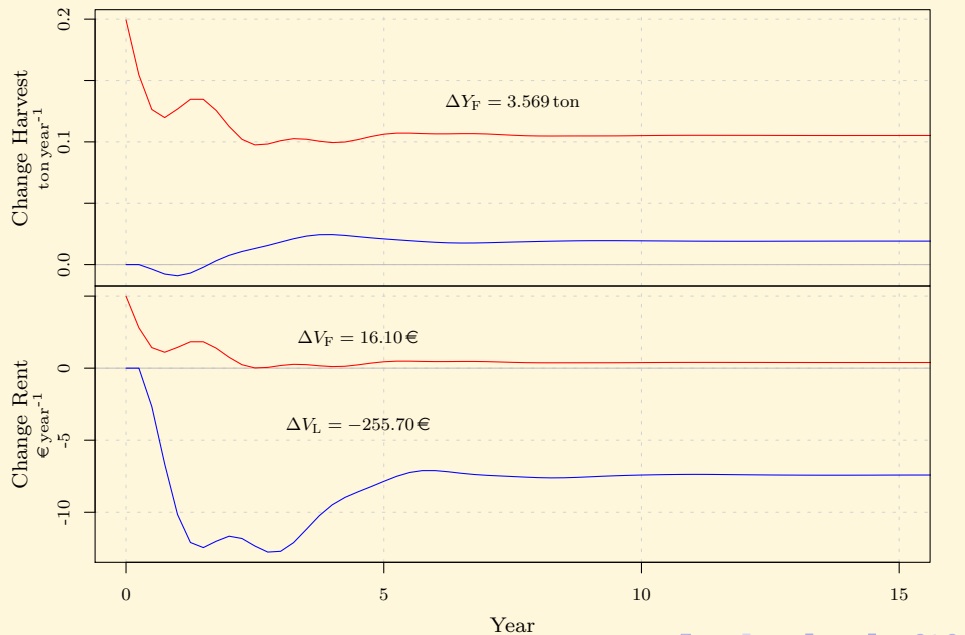
# Change in forage fish's fishing mortality



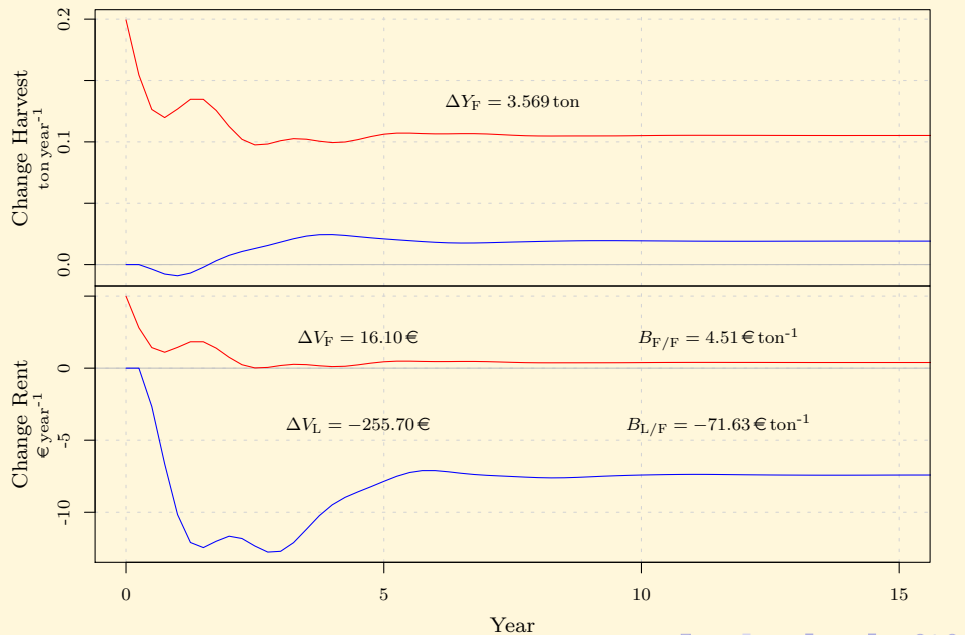
## Change in forage fish's fishing mortality



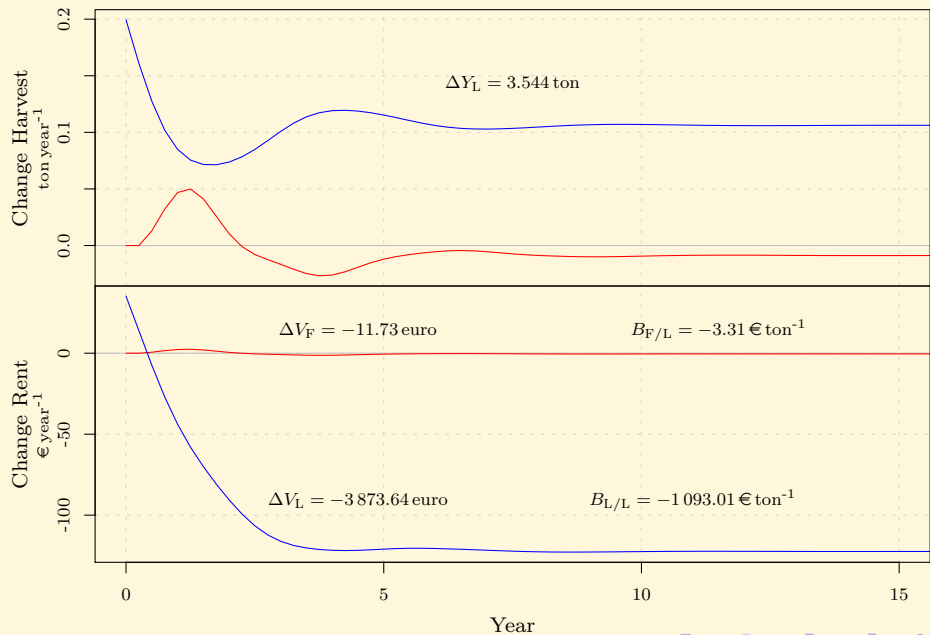
# Change in forage fish's fishing mortality



## Change in forage fish's fishing mortality



# Change in large fish's fishing mortality





## Net Benefit Indicator

- Present value of rent

$$V_j \equiv \int_0^{\infty} \pi_j(t) e^{-\rho t} dt$$

- Present value of harvest

$$Y_i \equiv \int_0^{\infty} y_i(t) e^{-\rho t} dt$$

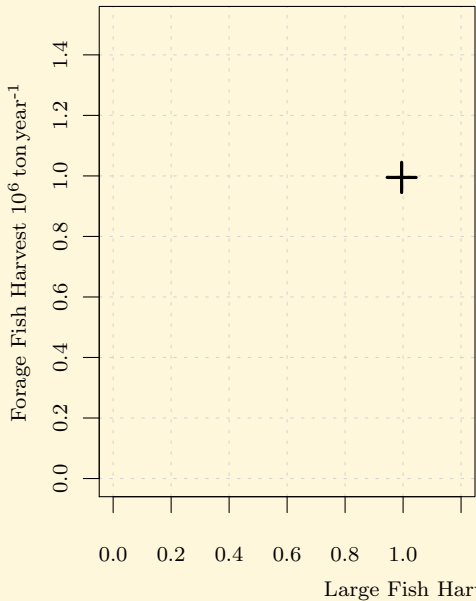
- Net Benefit Indicator

$$B_{j/i} \equiv \frac{\partial V_j}{\partial Y_i}$$

# Net Benefit Indicator

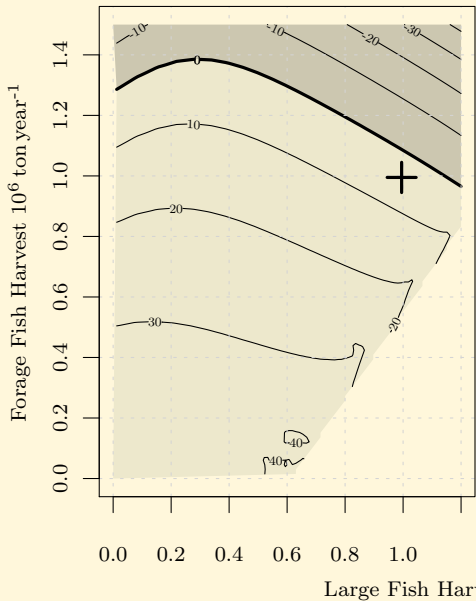
## Present use of the North Sea

With respect to	Forage fish fleet	Large fish fleet
Internal Benefit	4.5 € ton <sup>-1</sup>	-1 093 € ton <sup>-1</sup>
External Benefit	-71.6 € ton <sup>-1</sup>	-3 € ton <sup>-1</sup>
Total Benefit	-67.1 € ton <sup>-1</sup>	-1 096 € ton <sup>-1</sup>



# Forage Fish Fishery

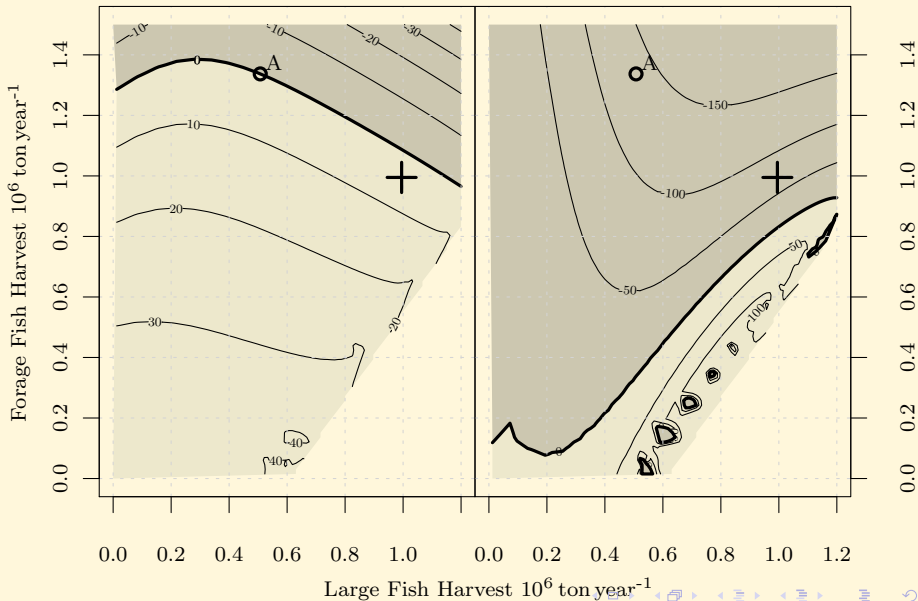
Internal Benefit



# Forage Fish Fishery

Internal Benefit

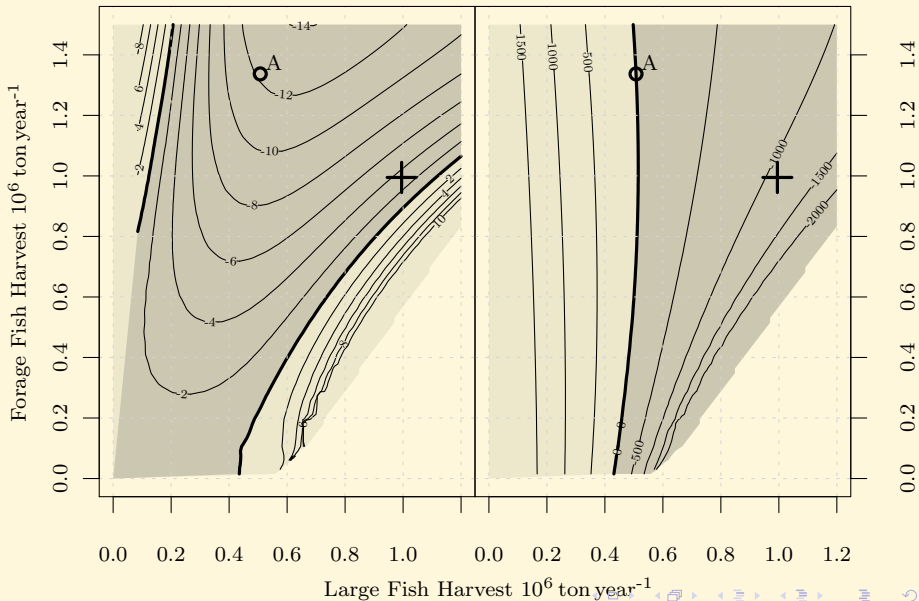
External Benefit



# Large Fish Fishery

External Benefit

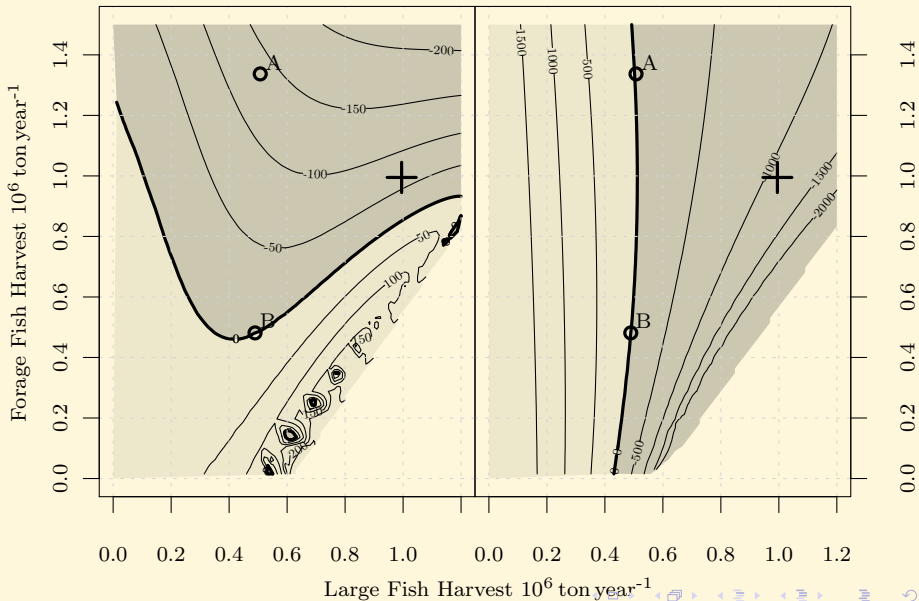
Internal Benefit



# Marginal Net Benefit

Wrt. Forage Fish

Wrt. Large Fish



## Conclusion

- Forage fish fishery have a notable economic impact on large fish fishery. Not the other way around.
- Present management of the North Sea not far from the right balance; but present exploitation is too high.

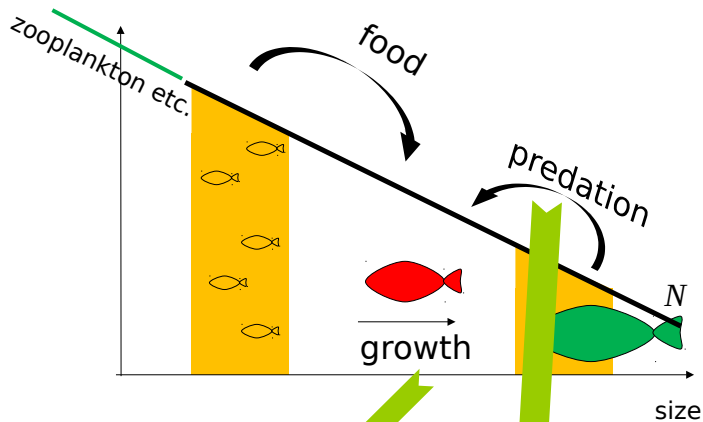


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# Community size spectrum model

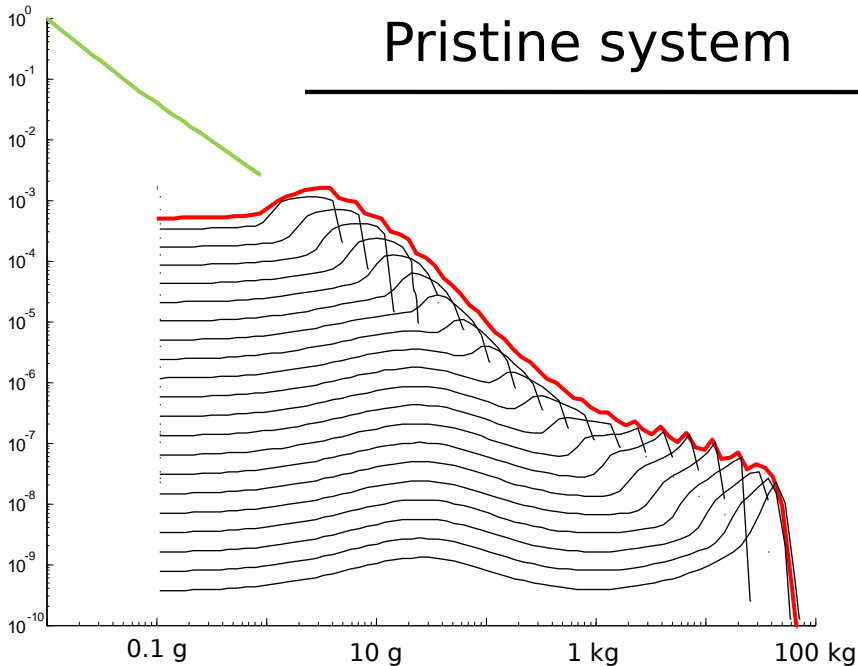


$$\frac{\partial N(w, W_\infty)}{\partial t} + \frac{\partial gN(w, W_\infty)}{\partial w} = -\mu N(w, W_\infty)$$

# Pristine system

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Biomass density



## Example: fishing large fish

