Effectiveness and efficiency of alternative fishery management approaches

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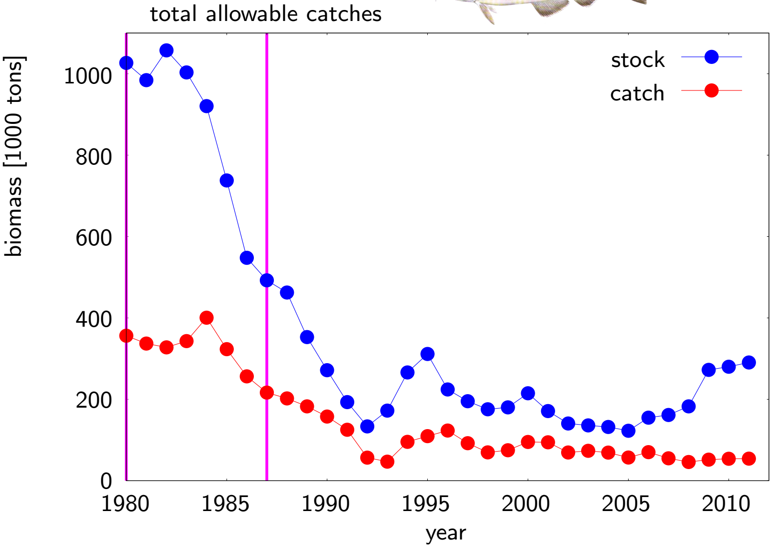
IIFET 2016

Baltic cod



- minimum landing size since 1940 in Denmark
- mesh size regulation since 1950 in Denmark

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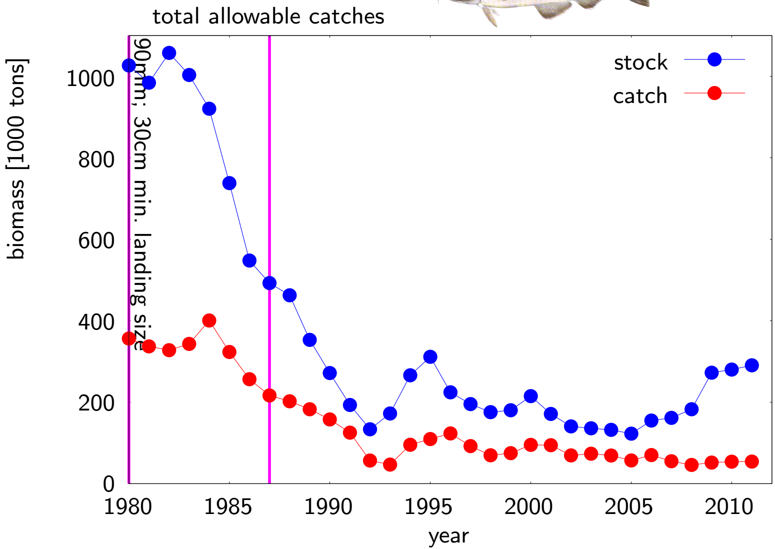

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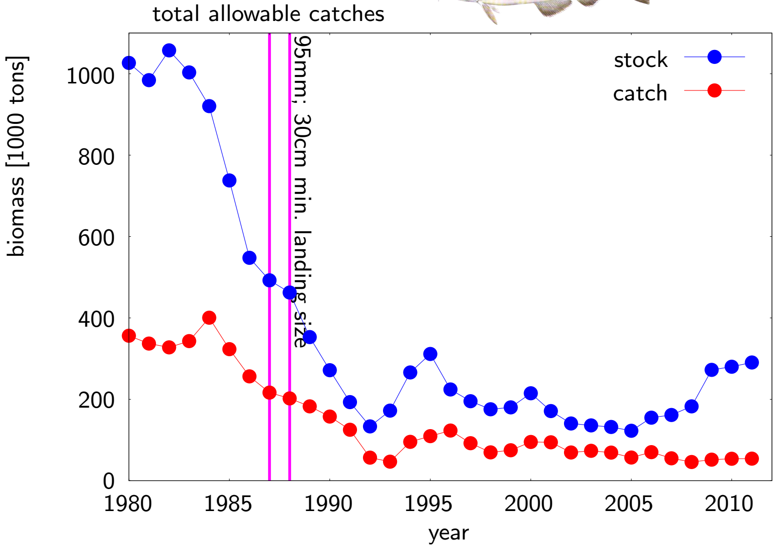

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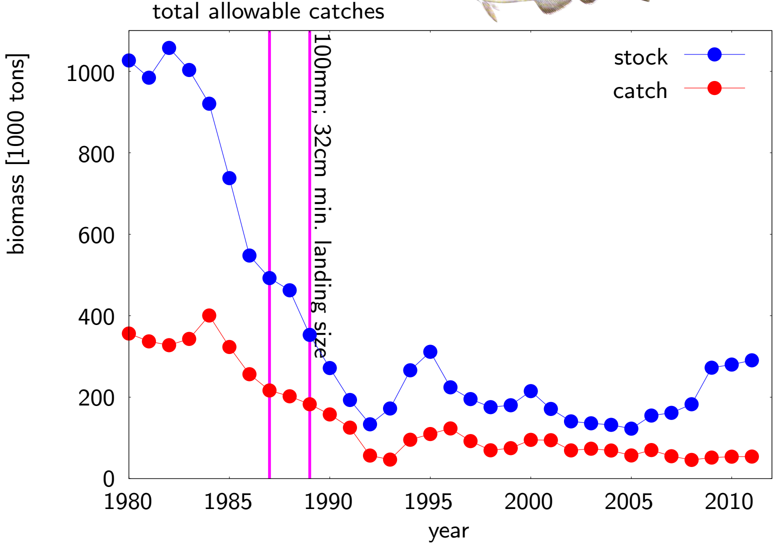

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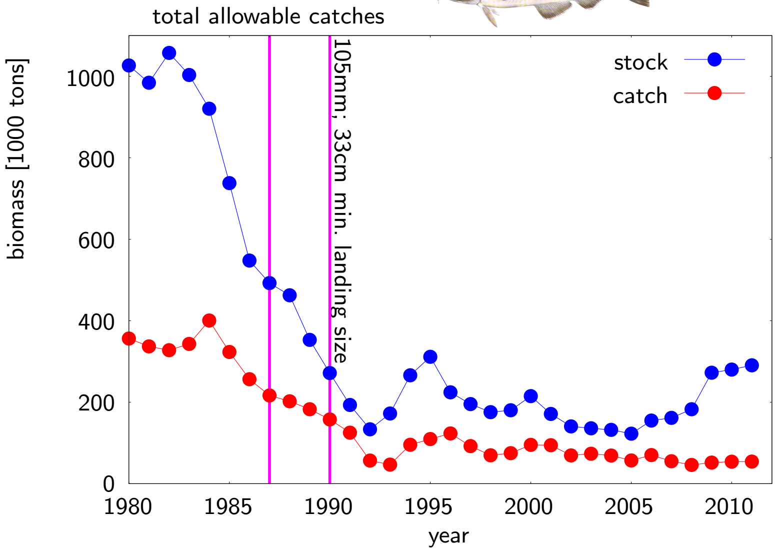

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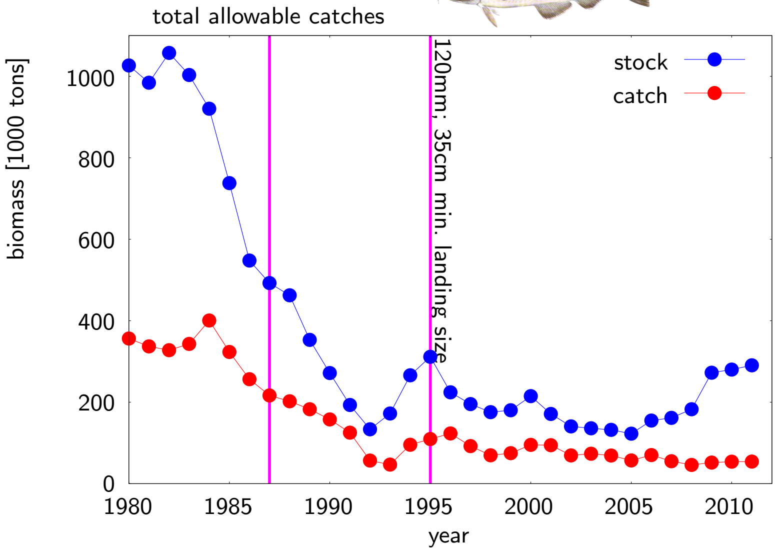

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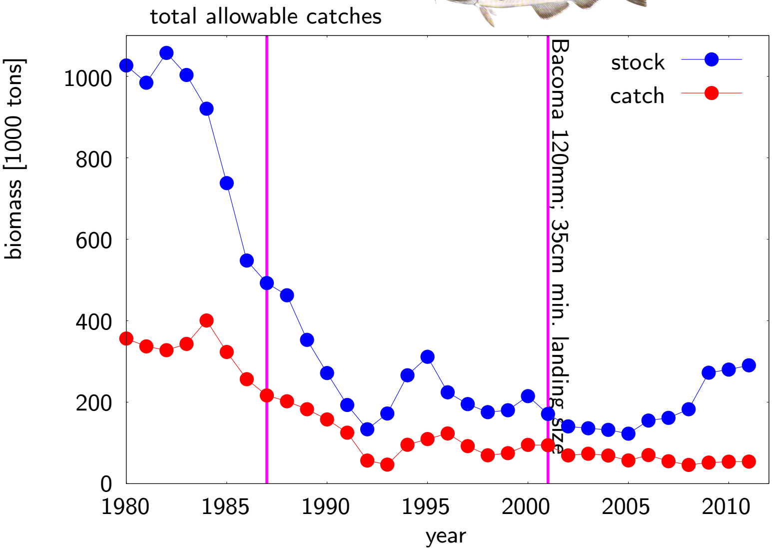

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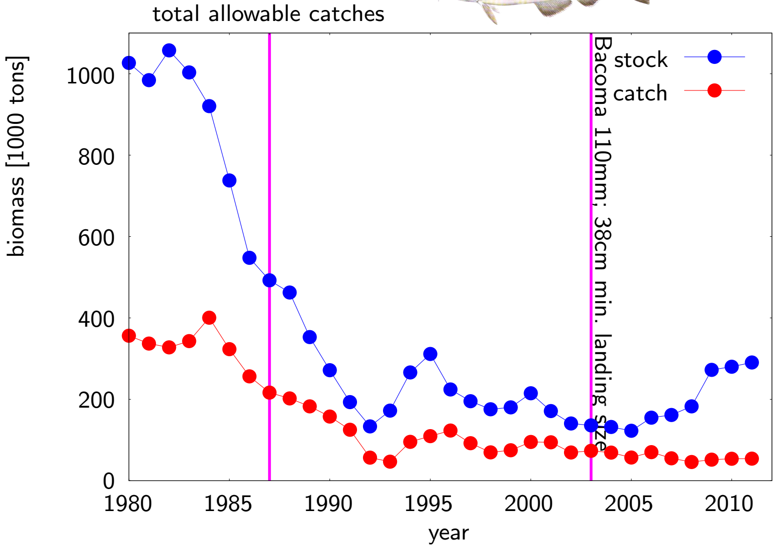

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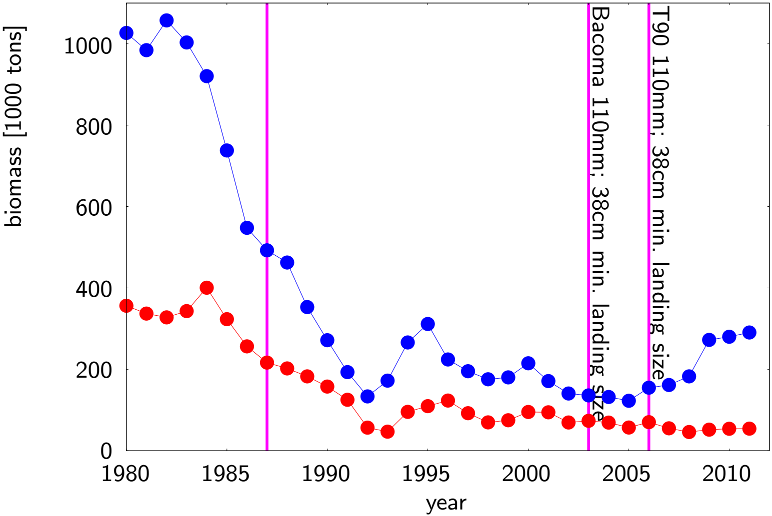

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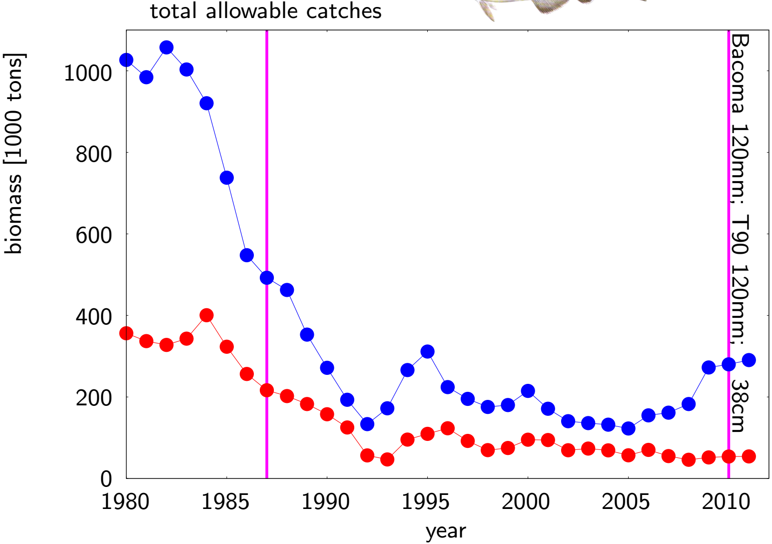

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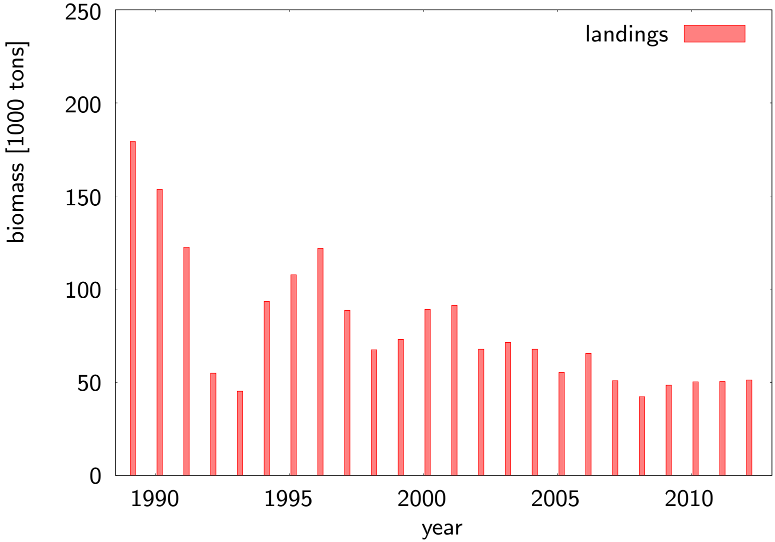
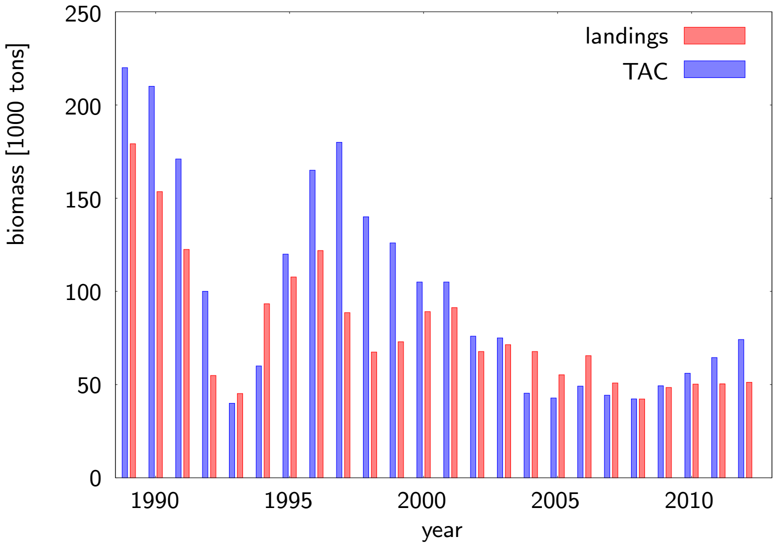


landings
biomass [1000 tons]
0
50
100
150
200
250
1990
1995
2000
2005
2010
year

Baltic cod



landings
TAC
biomass [1000 tons]
250
200
150
100
50
0
1990
1995
2000
2005
2010
year

Baltic cod fishery case study

- mesh size regulation has been an important management instrument in the past, besides TACs, which often have not been binding
- long-term management plan introduced in 2007 aims at maximum sustainable yield (MSY)

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- mesh size regulation has been an important management instrument in the past, besides TACs, which often have not been binding
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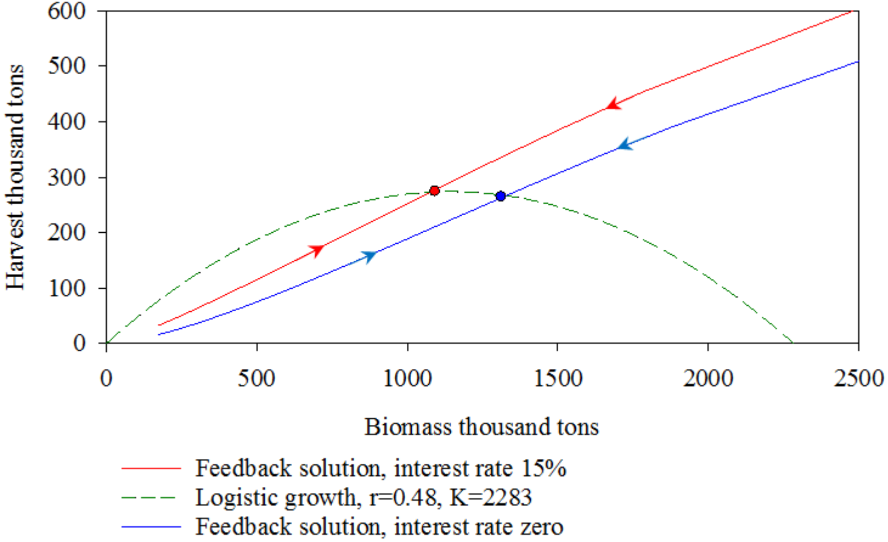
- how does MSY objective perform in an age-structured fishery, when both mesh-size and total catches can be optimized?

Baltic cod biomass model



- age-structured population model based on Tahvonen (JEEM, 2009), quantified using stock assessment data from ICES
- concept of *efficient biomass*

$$B_t = \sum_{s=1}^{n} w_s \, q_s(\sigma_t) \, x_{st}$$

w_s: weight at age s; x_{st} stock numbers in year t
$q_s(\sigma_t)$: catchability at age, depending on mesh size σ_t

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- objectives

maximum yield $\quad \max_{H_t, \sigma_t} \sum_{t=0}^{\infty} H_t$

1. "ultimate sustainable yield": assume perfect selectivity
2. "gear-constrained maximum yield": maximize yield with available gear
3. "maximum sustainable yield": max. equilibrium yield with available gear

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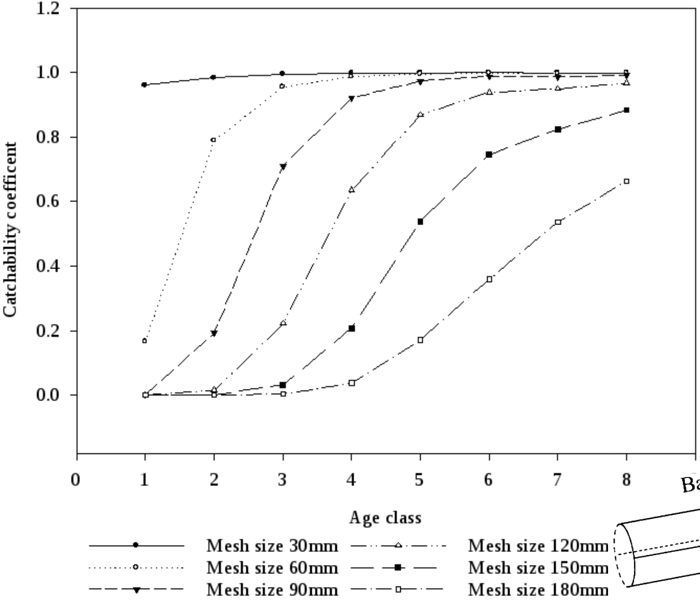
- objectives

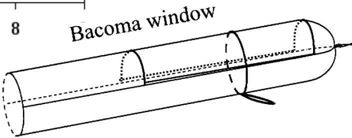
$$\text{maximum yield} \quad \max_{H_t, \sigma_t} \sum_{t=0}^{\infty} H_t$$

$$\text{economic objective} \quad \max_{H_t, \sigma_t} \sum_{t=0}^{\infty} \left(\frac{\bar{P}}{1-\eta} H_t^{1-\eta} - c \, B_t^{-\chi} \, H_t \right) b^t$$

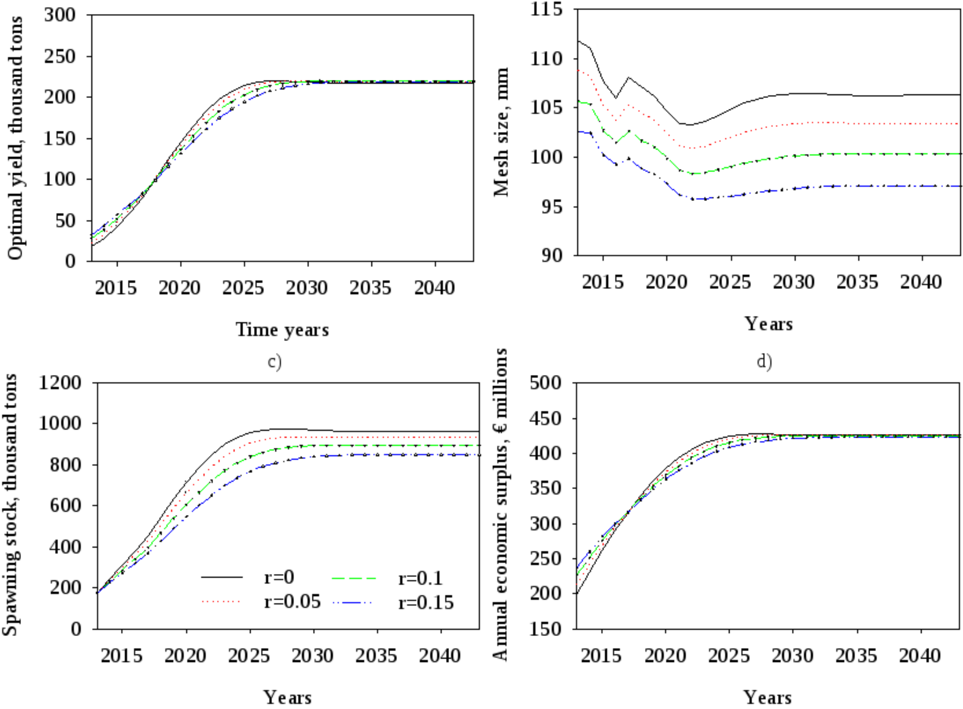
- utility from catch: $\bar{P} = 27$, $\eta = 0.65$ estimated using time series of prices from Danish fishery accounts
- cost function: $c = 6.6$, $\chi = 0.43$, est. assuming regulated open access
- discount factor $b = 1/(1+r)$, $r \geq 0$ varied

selectivity of trawl gear parametrized using experimental data

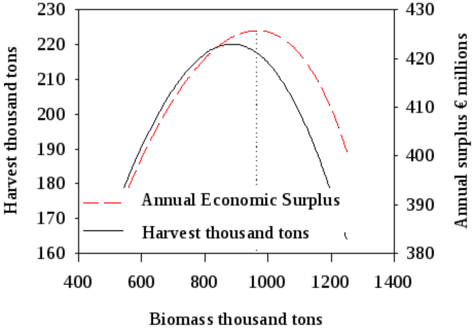


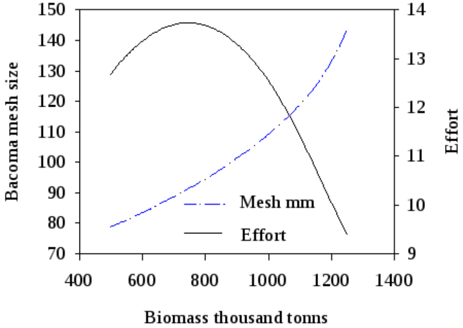


Tahvonen/Quaas/Voss (2016). What difference does it make? Age structure, gear selectivity, stochastic recruitment, and economic vs. MSY objectives in the Baltic cod fishery

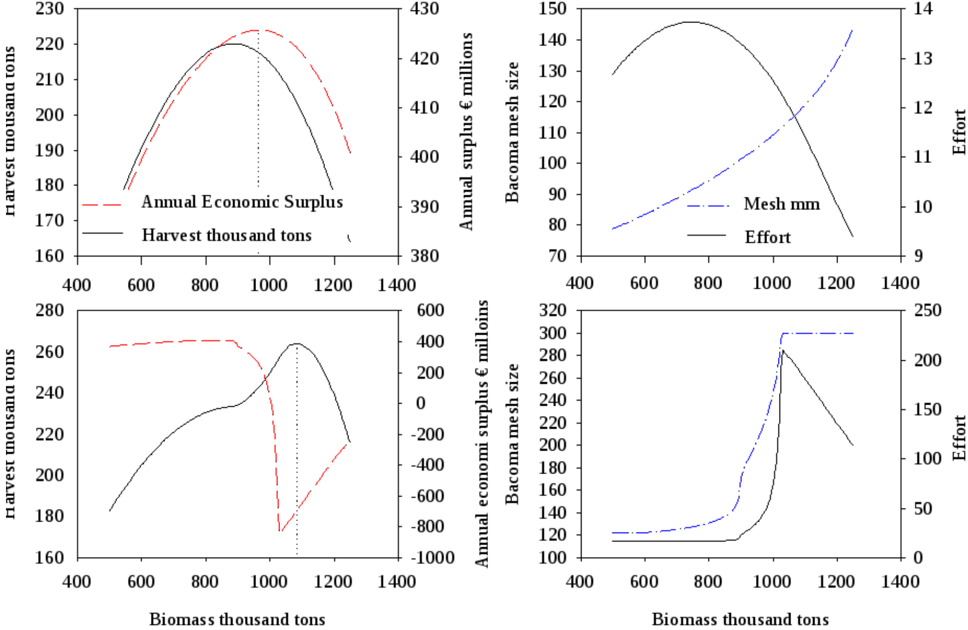

Optimal yield, thousand tons
300
250
200
150
100
50
0
2015
2020
2025
2030
2035
2040
Time years
Mesh size, mm
115
110
105
100
95
90
2015
2020
2025
2030
2035
2040
Years
c)
d)
Spawning stock, thousand tons
1200
1000
800
600
400
200
0
2015
2020
2025
2030
2035
2040
Years
r=0
r=0.1
r=0.05
r=0.15
Annual economic surplus, € millions
500
450
400
350
300
250
200
150
2015
2020
2025
2030
2035
2040
Years

max. equilibrium annual economic surplus, given total biomass

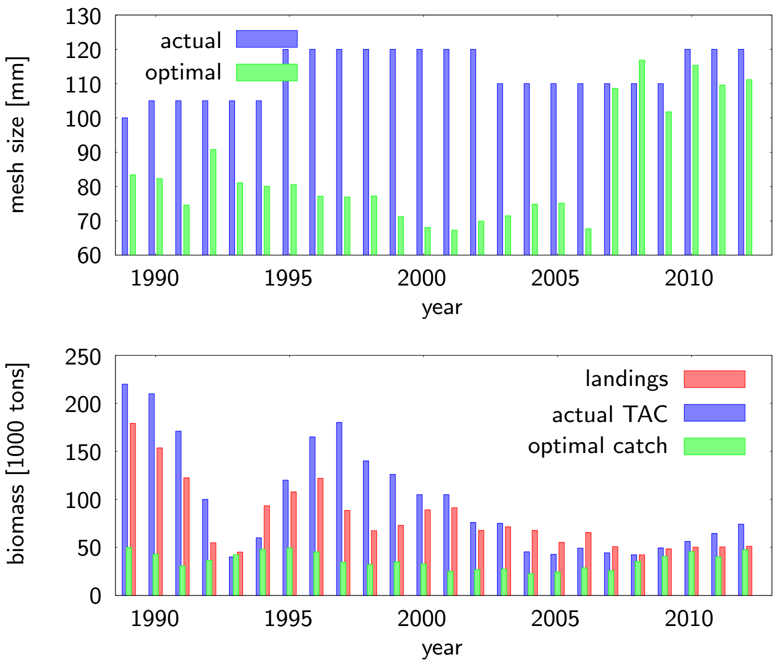




max. equilibrium annual economic surplus, given total biomass



max. equilibrium yield with available gear, given total biomass


130
120
110
100
90
80
70
60
mesh size [mm]
actual
optimal
1990
1995
2000
2005
2010
year
250
200
150
100
50
0
biomass [1000 tons]
landings
actual TAC
optimal catch
1990
1995
2000
2005
2010
year

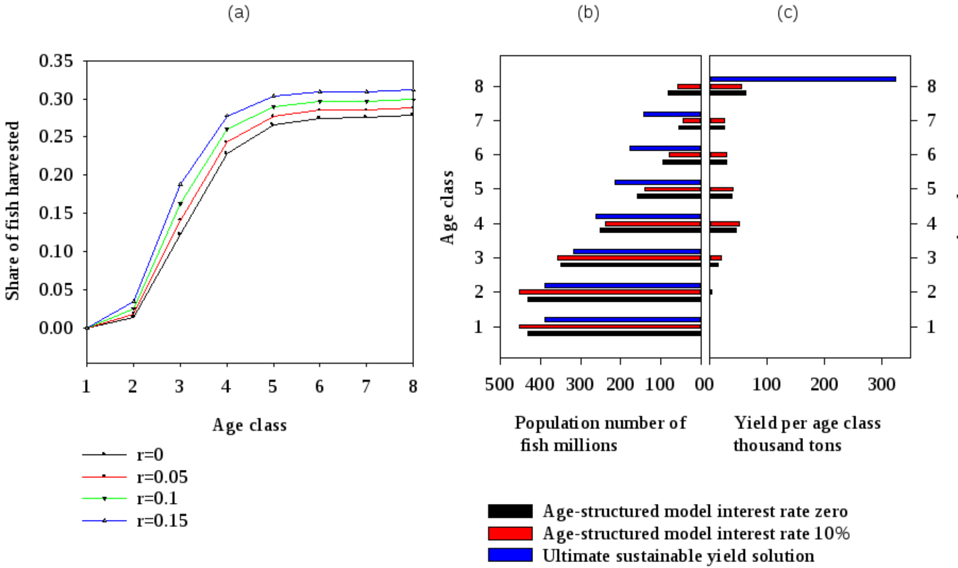
age-structured optimization model for Baltic cod fishery

- total catch and mesh size as optimized variables

- MSY and economic management approaches make big difference
- maximum of equilibrium annual economic surplus is obtained at smaller stock size than MSY

- in the past, mesh size has been set higher than optimal, while catches have not been restricted enough

Tahvonen/Quaas/Voss (2016). What difference does it make? Age structure, gear selectivity, stochastic recruitment, and economic vs. MSY objectives in the Baltic cod fishery



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