Economic consequences of fisheries induced evolution - the case of North East Atlantic cod

Presentation at SINTEF workshop Esbjerg 2009

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Introduction

- Evolution is a natural continuously ongoing process

- In commercial fisheries the fishing mortality is many times higher than the natural mortality.
  - For cod the natural mortality after the first year is assumed to be 0.2, the average annual fishing morality of a cohort ranged from 0.4 (1947)-0.8 (1990).

=> Fishing will be a selective force in the evolution of many commercially exploited fish stocks

Life history traits

Physiological or behavioral traits that are partly of fully inheritable.

Examples:

- Foraging strategies
- Territorial behavior
- Signaling behavior
- Reproductive behavior
- Schooling behavior
- Longevity
- Size/age at maturation

Life history theory

Predictions on which type of traits will be favored in different environment and how traits will evolve over time

Traits evolve over time to max fitness.

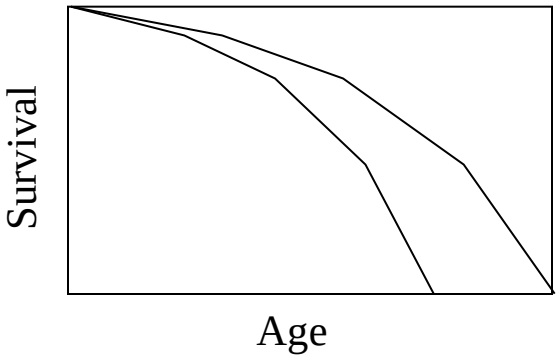
Constraints:

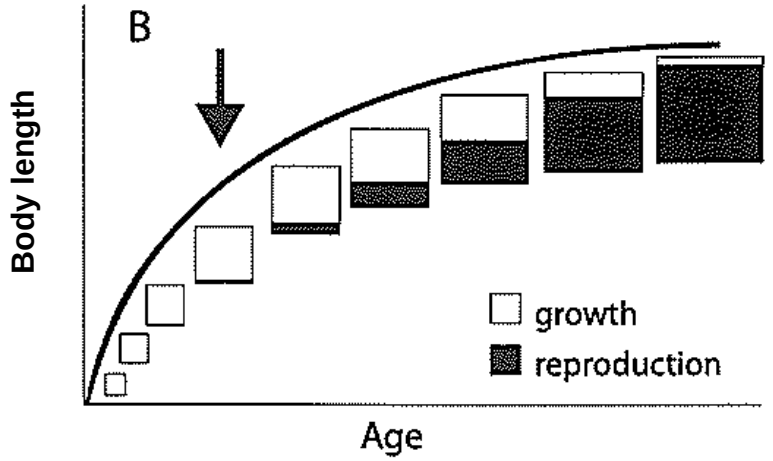
Life is short!

Resources are limited

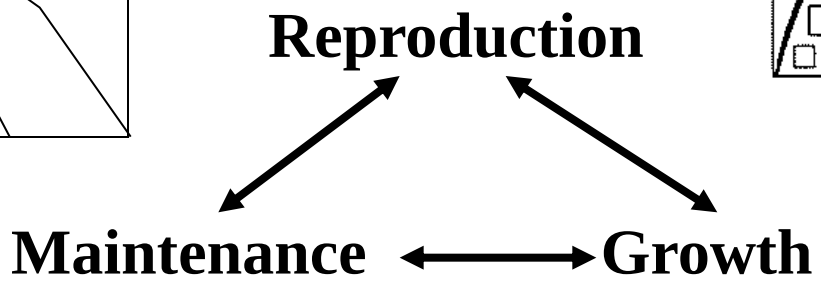
=> Trade-offs between traits

Trade-offs associated with age/size at maturation





Source: Kozlowski 2006



Benefit of maturing early: increases the probability of being able to spawn
Cost: reduced growth and survival and loss of fecundity

Effects of early maturation

Smaller fish

=> Lower fecundity

=> Lower biomass

Higher variation in abundance

=> less resilience

Ecology versus evolution

But fishing mortality induce an ecological response as well:

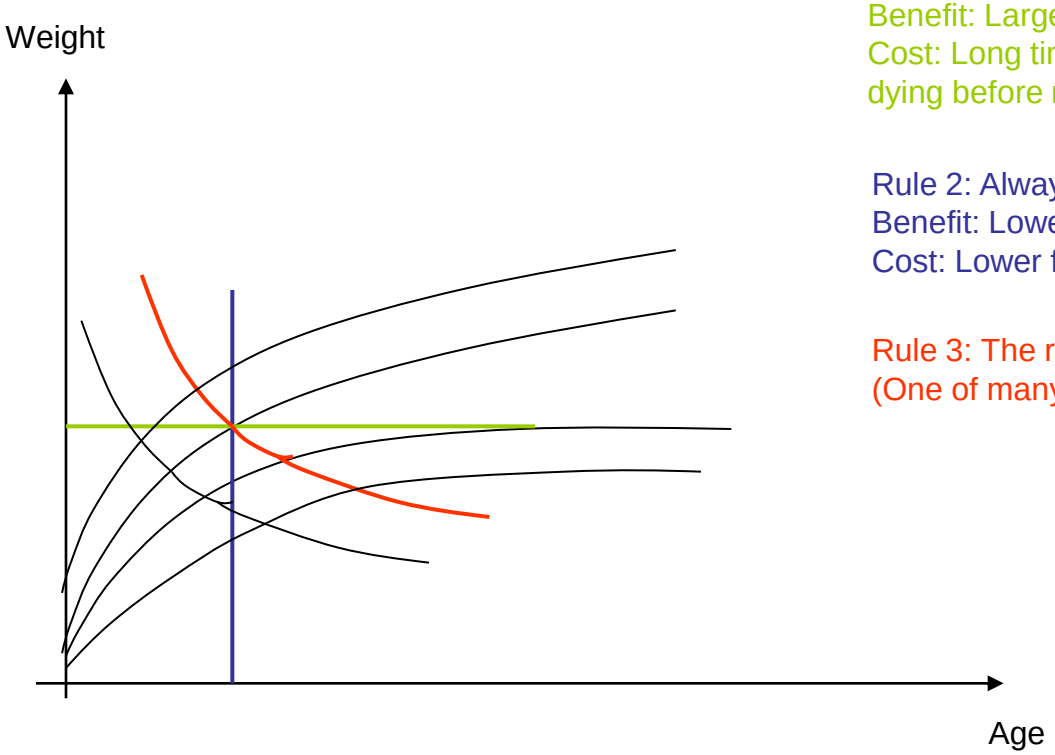
With less fish in a stock there is less competition.

=> More resources available for each fish

=> Faster growth

=> Earlier maturation

Disentangling evolution from ecology - maturation norms



Rule 1: Always mature at same age.
Benefit: Larger adult size and higher per spawning fecundity
Cost: Long time until age of maturity is reached, higher risk of dying before maturation is reached

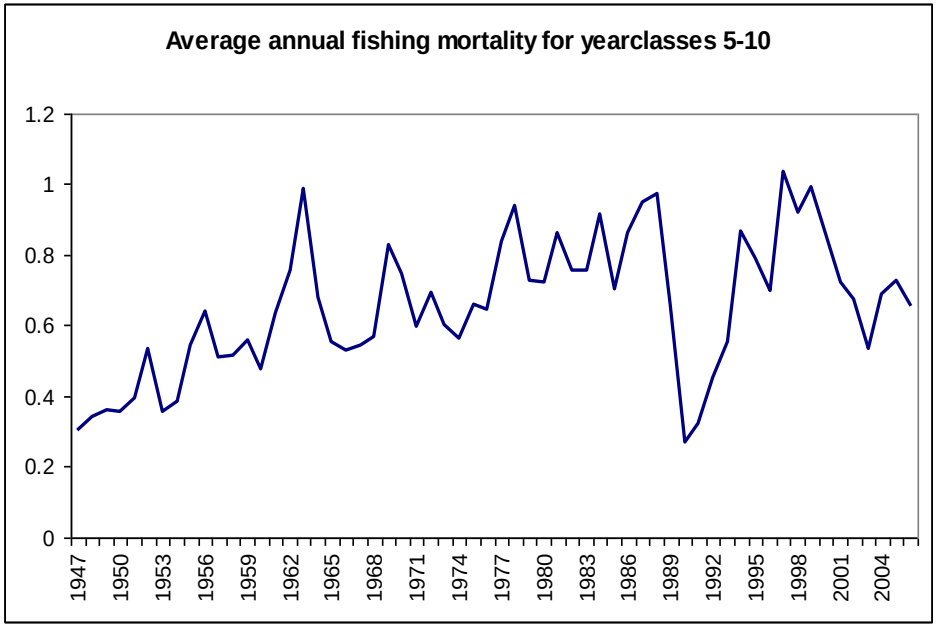
Rule 2: Always mature at same weight.
Benefit: Lower risk of dying before being able to spawn
Cost: Lower fecundity

Rule 3: The rule that max expected lifetime fecundity
(One of many possible shapes)

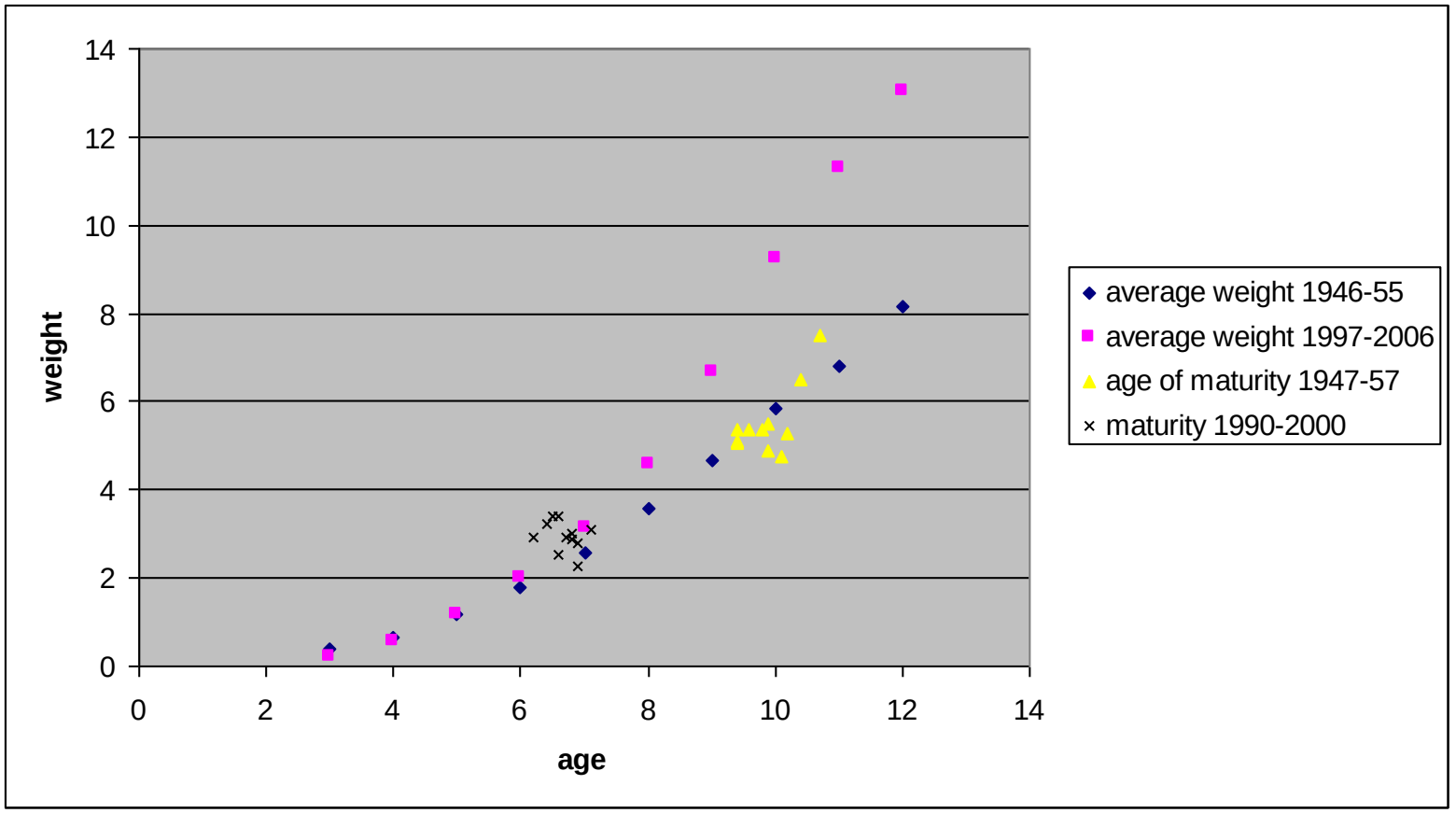
Movements along the reaction norm are ecological responses
Shifts in reaction norms indicate evolutionary change

The case of North-East Atlantic cod
Historical development

A there has been a significant reduction in the age and size of maturation over the last 50 years



Growth of North East Atlantic cod



The case of North East Atlantic cod – research gaps

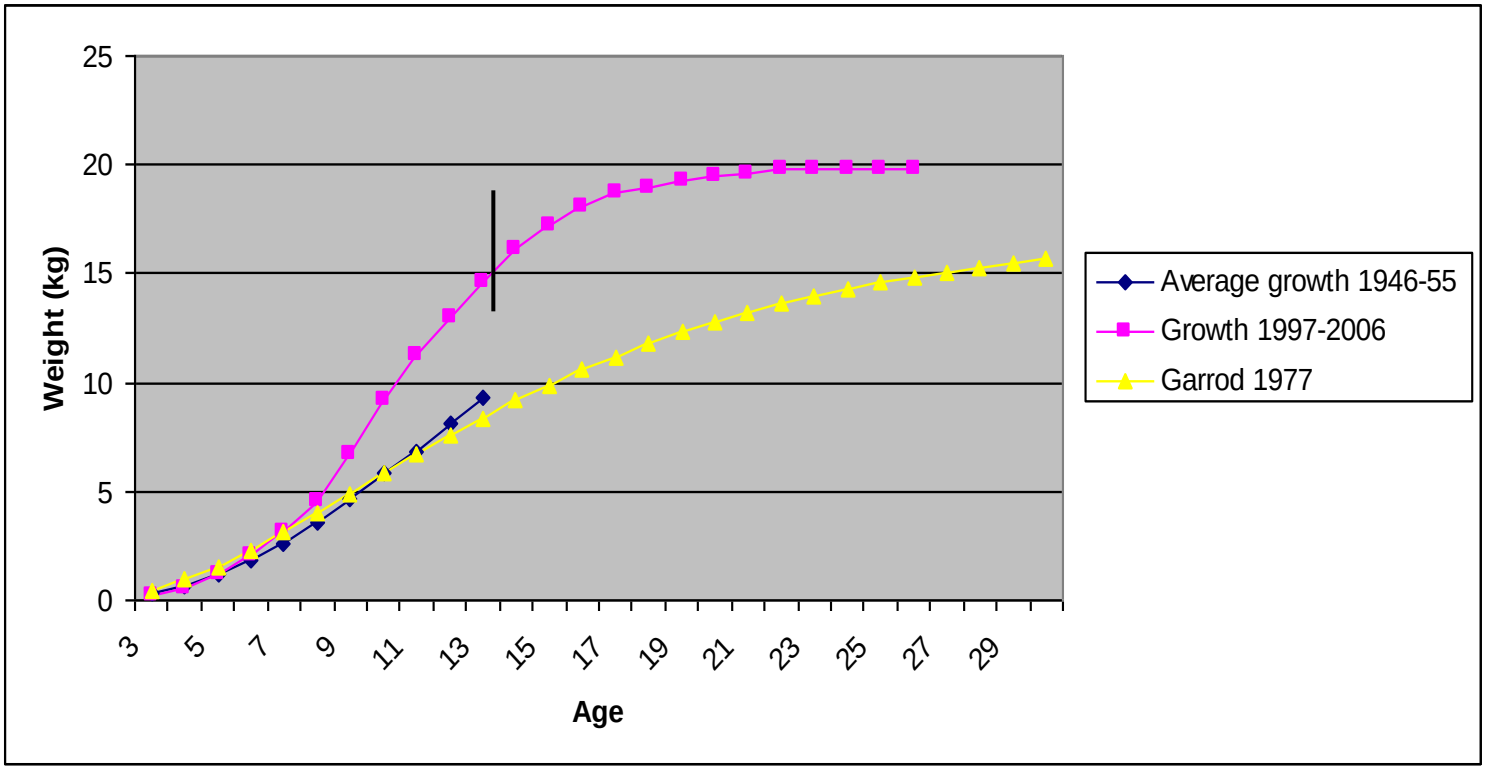
Has a shift in the maturation norm occurred?

If yes, will the positive effect of reduced intraspecific competition always outweigh the negative effect of smaller size at maturation?

Modeling the economic effect of changed growth

Simple yield per recruit model

Growth curves used:



The economic effect of changed growth

Modeling assumptions:

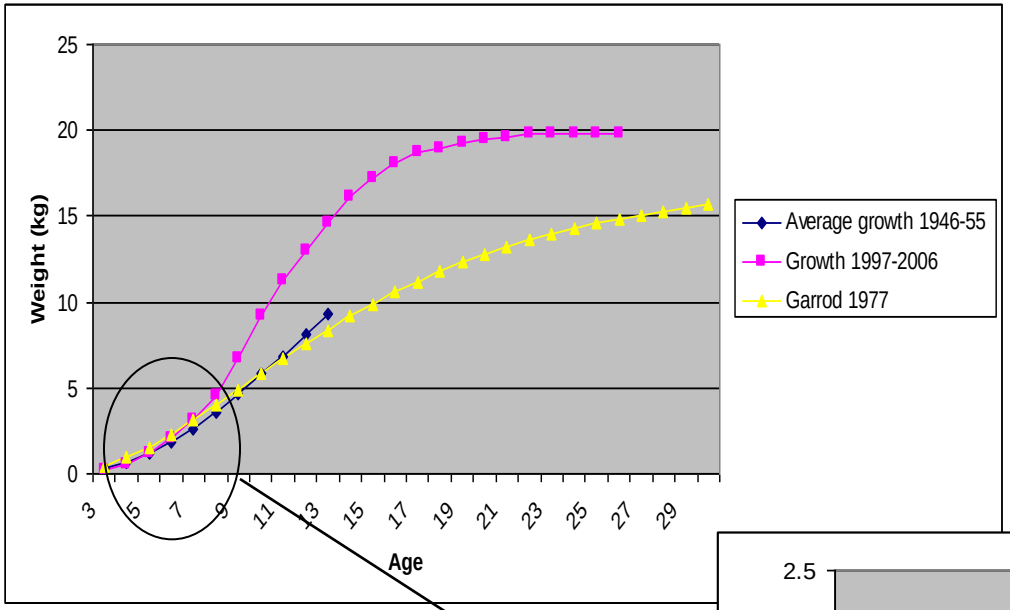
- Age at maturation = 6
- # of eggs*g^{-1} increase linearly with body weight
- Price increase with size of fish
- Coastal fleet catch 1/3 of TAC
- F_a = Average of F_a from the period 1997 – 2007

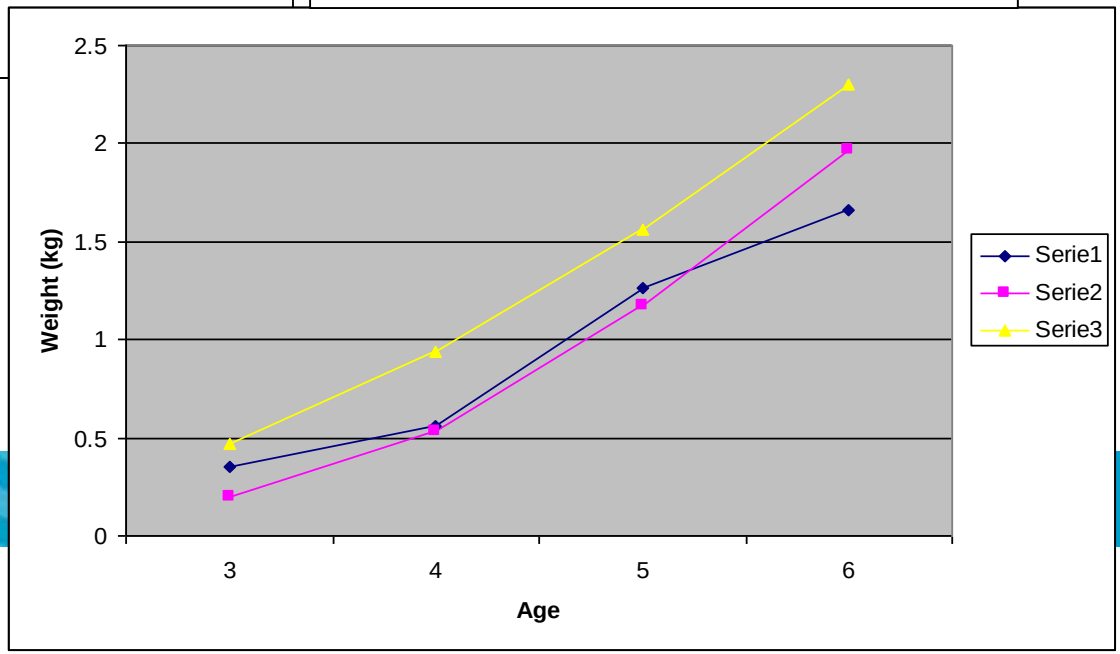
The economic effect of the change in growth

Profit per standardized vessel year (NOK)

	Growth	
Vessel group	Garrod 1977	Average of 1997-2006
Coastal	1 623 638	901 368
Trawlers	1 186 331	-4 139 675

The economic effect of changed growth





Conclusion

- With current harvesting pattern fisheries induced evolution will have little effect on expected profitability.
- Effect on variability in profitability?
- It may have a greater effect on optimal solution, but we need to know more about the joint effect of ecology and evolution to be able to make predictions