Decadal changes in reference points for stocks of EU interest in the northeast Atlantic

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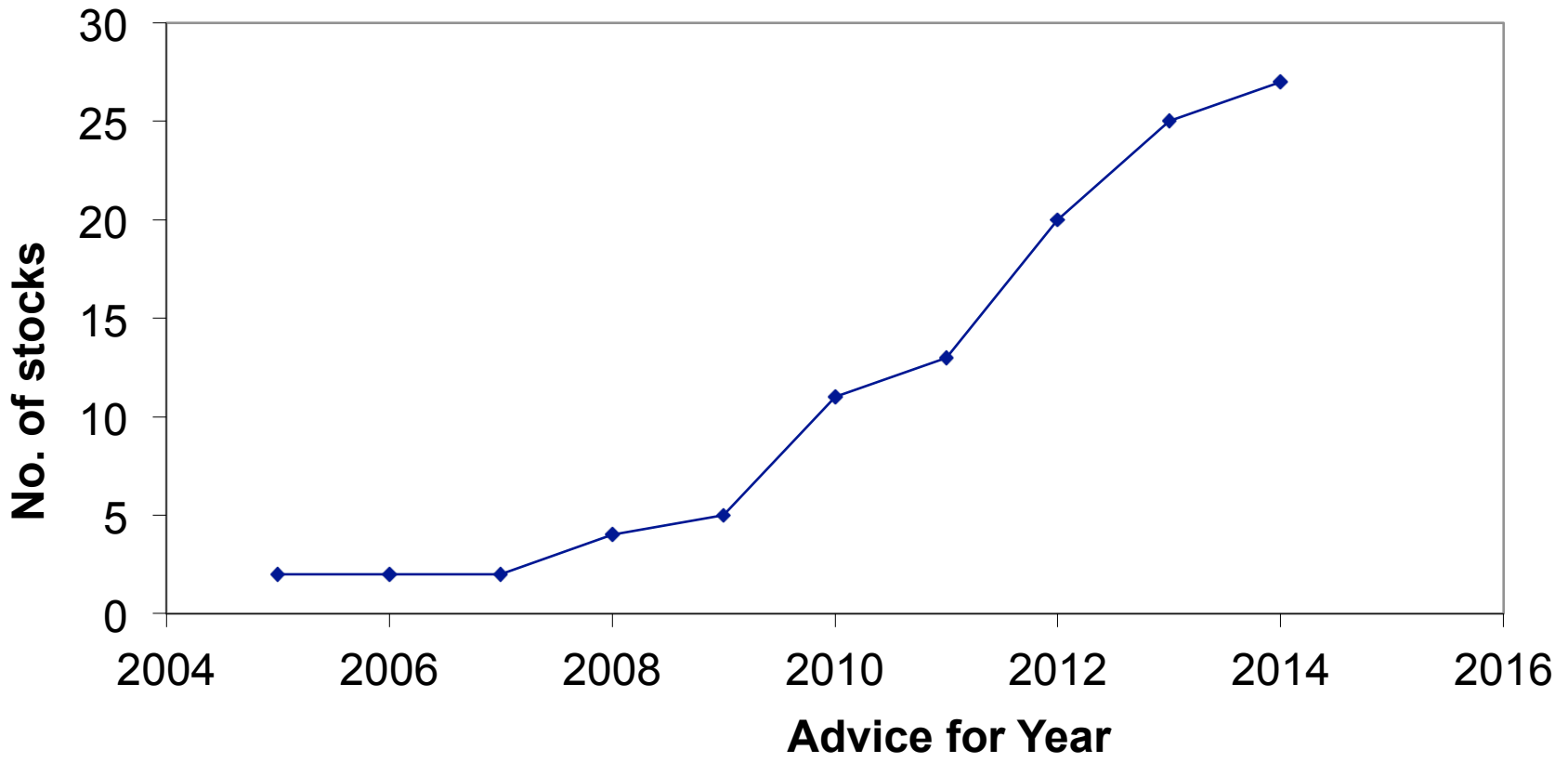
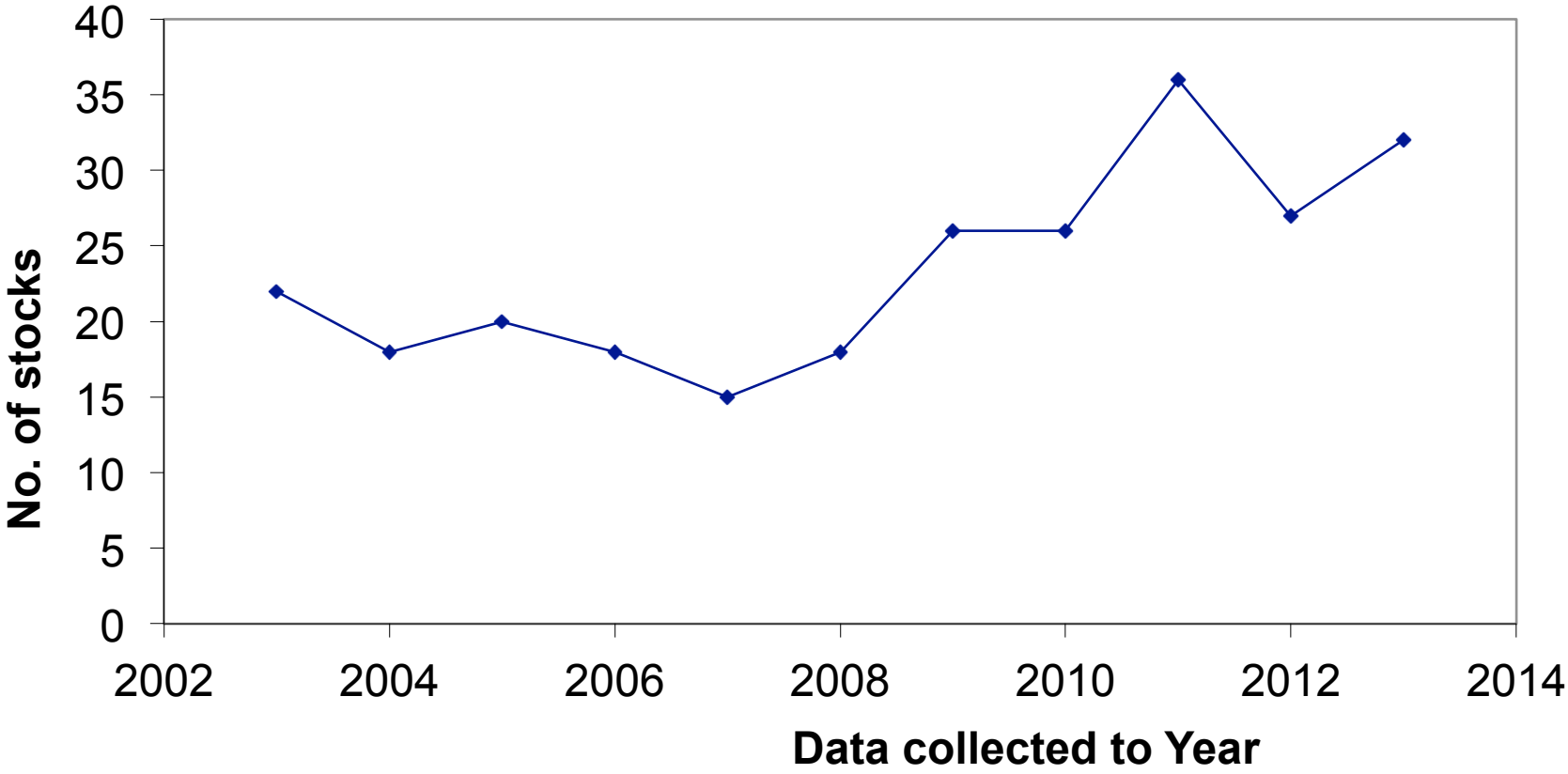
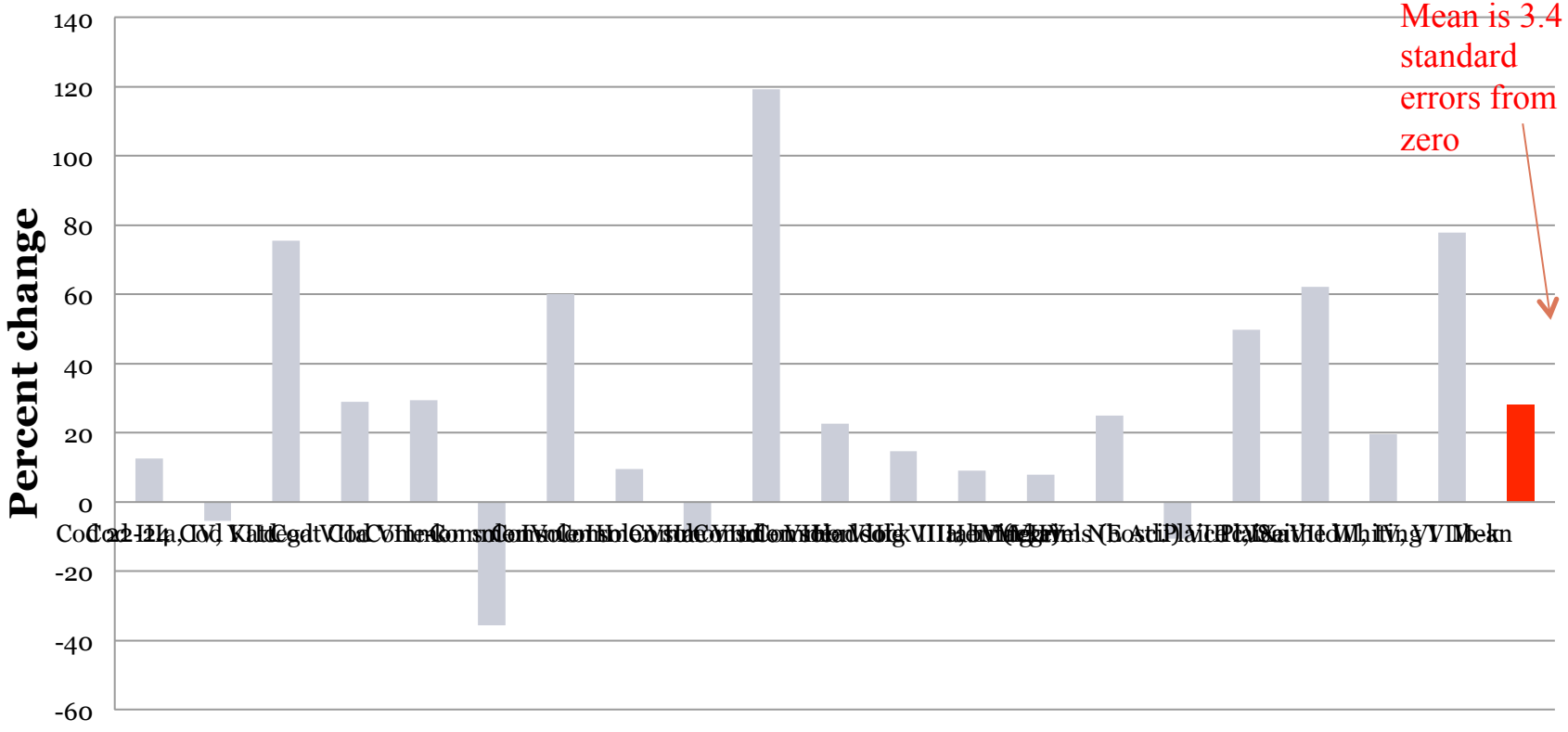
No. of stocks where F< Fmsy in NE Atlantic, North Sea and Baltic Sea, according to annual advice



No. of stocks where F< Fmsy in NE Atlantic, North Sea and Baltic Sea, according to 2014 estimates



Change in ICES F_{msy} advised values between 2004 and 2014



Note: corrections have been made for alterations to changes in the ages for reference F

Why does this matter ?

- Average 28% higher "target" F may have consequences for:
  - Fleet capacity and its balance with resources
  - Employment and investment
  - Appropriate levels of fishing effort
  - Fuel burn
  - Ecological impacts

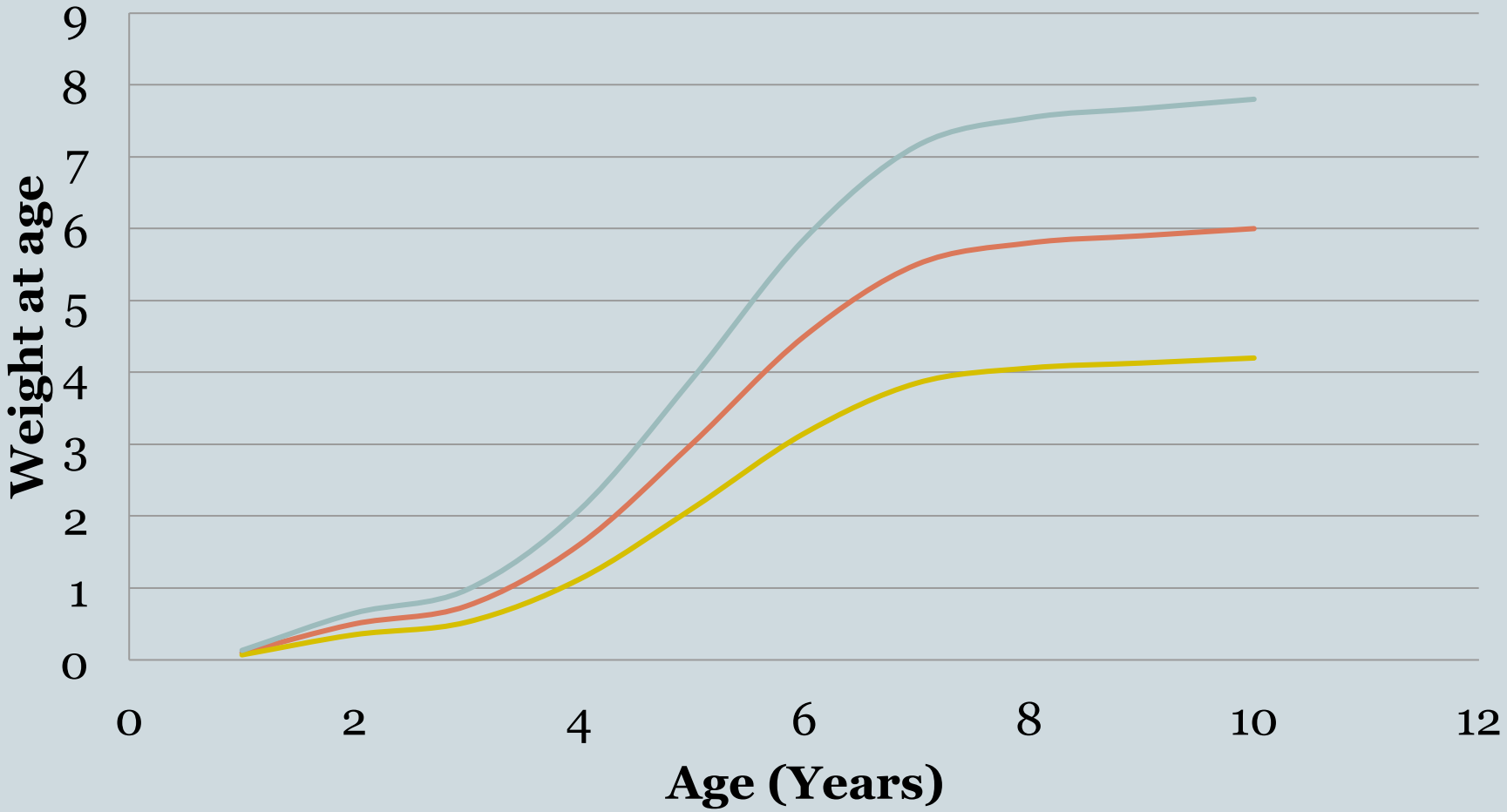
Drivers and management consequences

Driver	Implication
• More size-selective fishing ?	• Success of technical measures. Higher fishing effort for Fmsy. Lower discards. Larger fish in markets. Implications for fuel efficiency? Different ecological impact.
• Growth change or altered natural mortality ?	• Evaluate multispecies impacts and review ecosystem management
• Bias in growth at population level driven by lower F ?	• Use alternative evaluation model
• Change in evaluation method ?	• Document, record.

Potential external drivers

- Change in selection pattern
  - Change from 100mm to 120mm basic mesh size in NE Atlantic
- Change in natural mortality
  - Larger stocks of predators (~30% higher SSBs over the period)
- Change in growth, possibly driven by:
  - warmer waters
  - fishery selection (F reduced by 20% on average)

Selective fishing slows population growth



Potential methodological issues

- Current evaluations are mostly made with a stochastic age-structured production model with
  - bootstrapped recruitment residuals
  - bootstrapped life-history parameters
  - AIC-weighted stock-recruit model
  - median estimates.

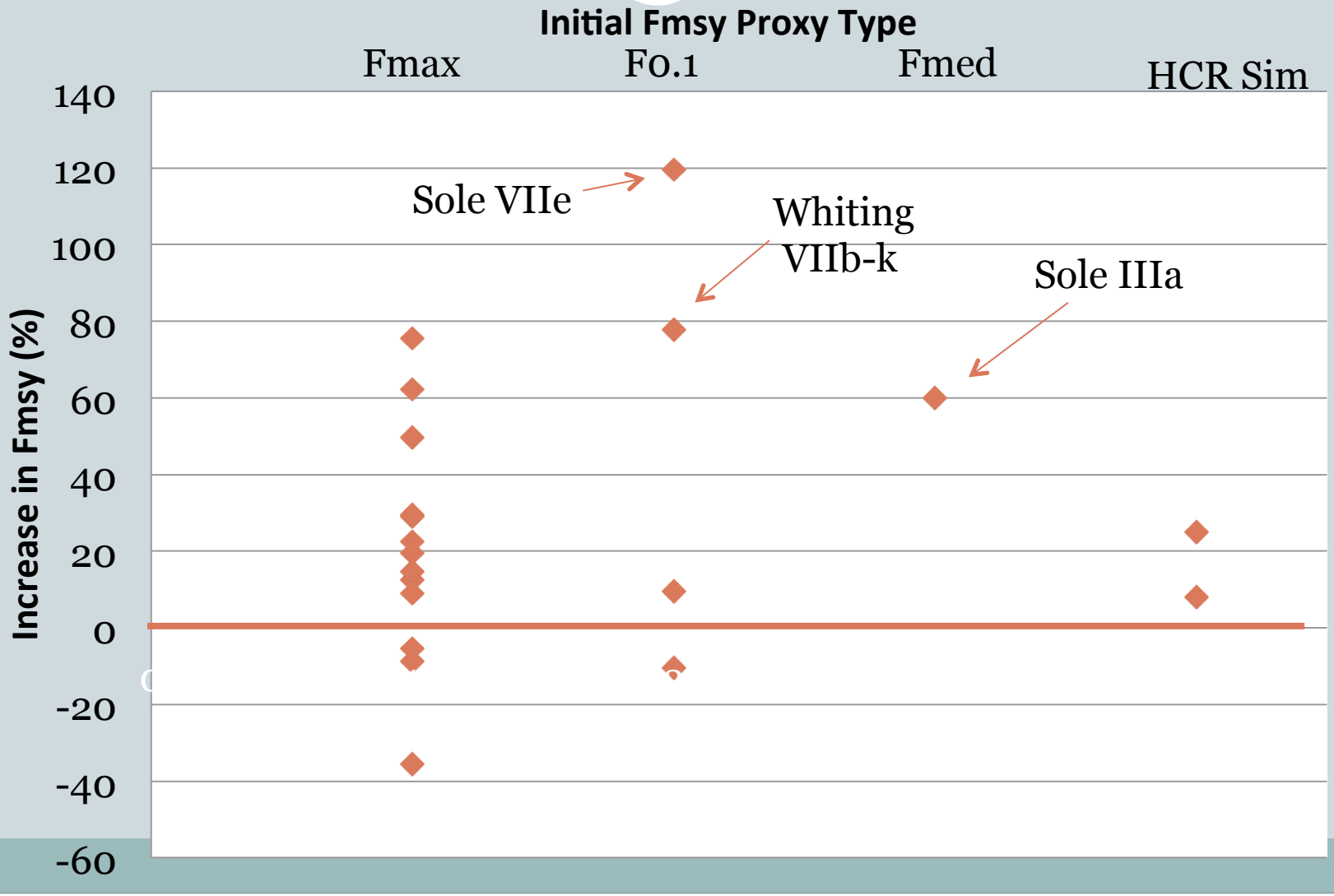
Possible sensitivity of change from :

- Proxy used in 2004 (e.g. deterministic Fmax)
- Use of Ricker stock-recruit model
- Change from maximum likelihood to median likelihood ?

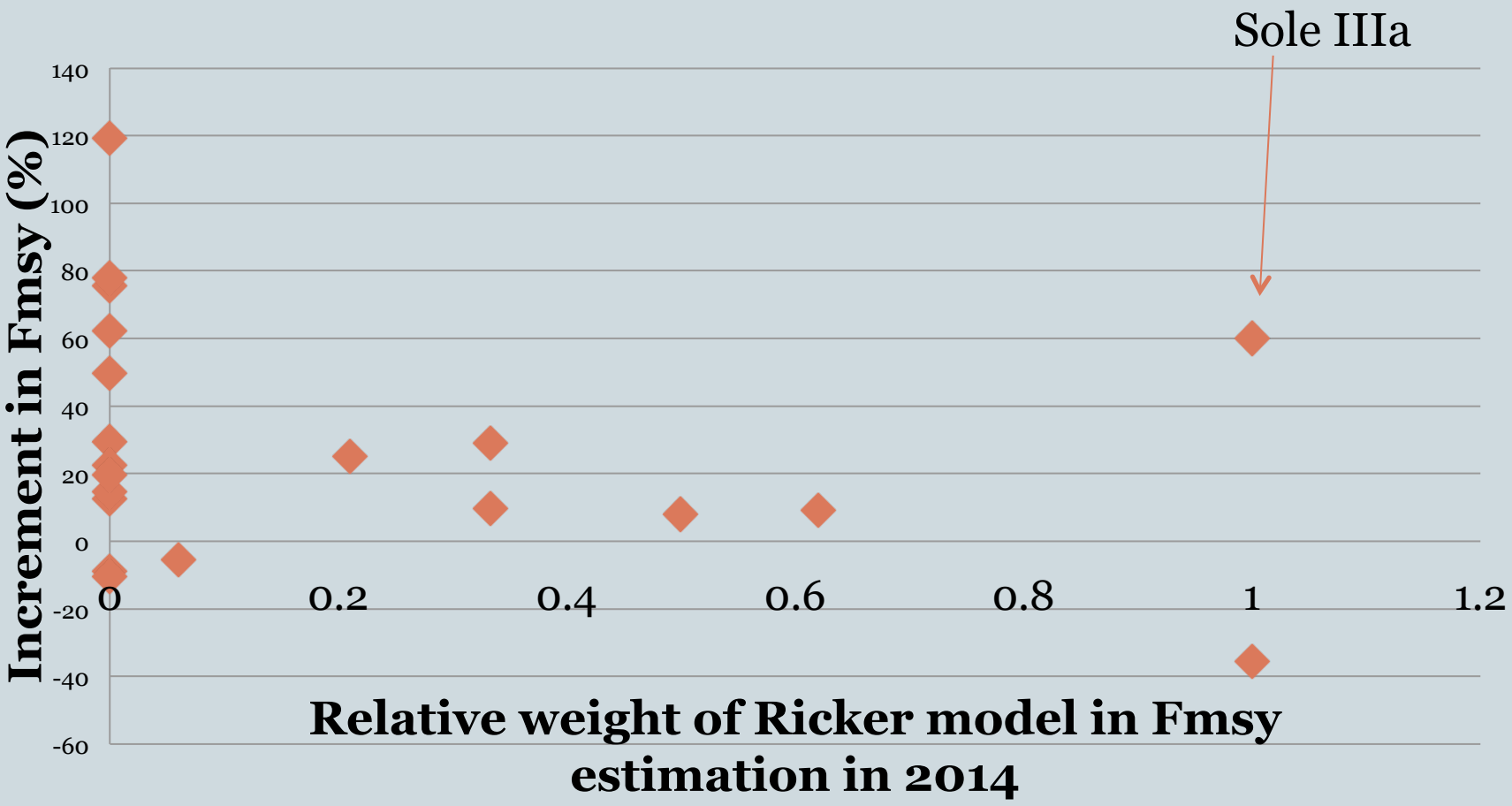
Investigating the issue

- Constraints
  - Full disaggregated data series not publicly available in database form
  - Methods and data not always fully documented
- Approach
  - Look for method features that might drive higher Fmsy
    - (Proxy type, stock-recruit, estimation method)
  - Compare "snapshots" of data in 2000-03 with 2010-13
  - Look for data features that might drive higher Fmsy
    - (Growth, natural mortality, selection)

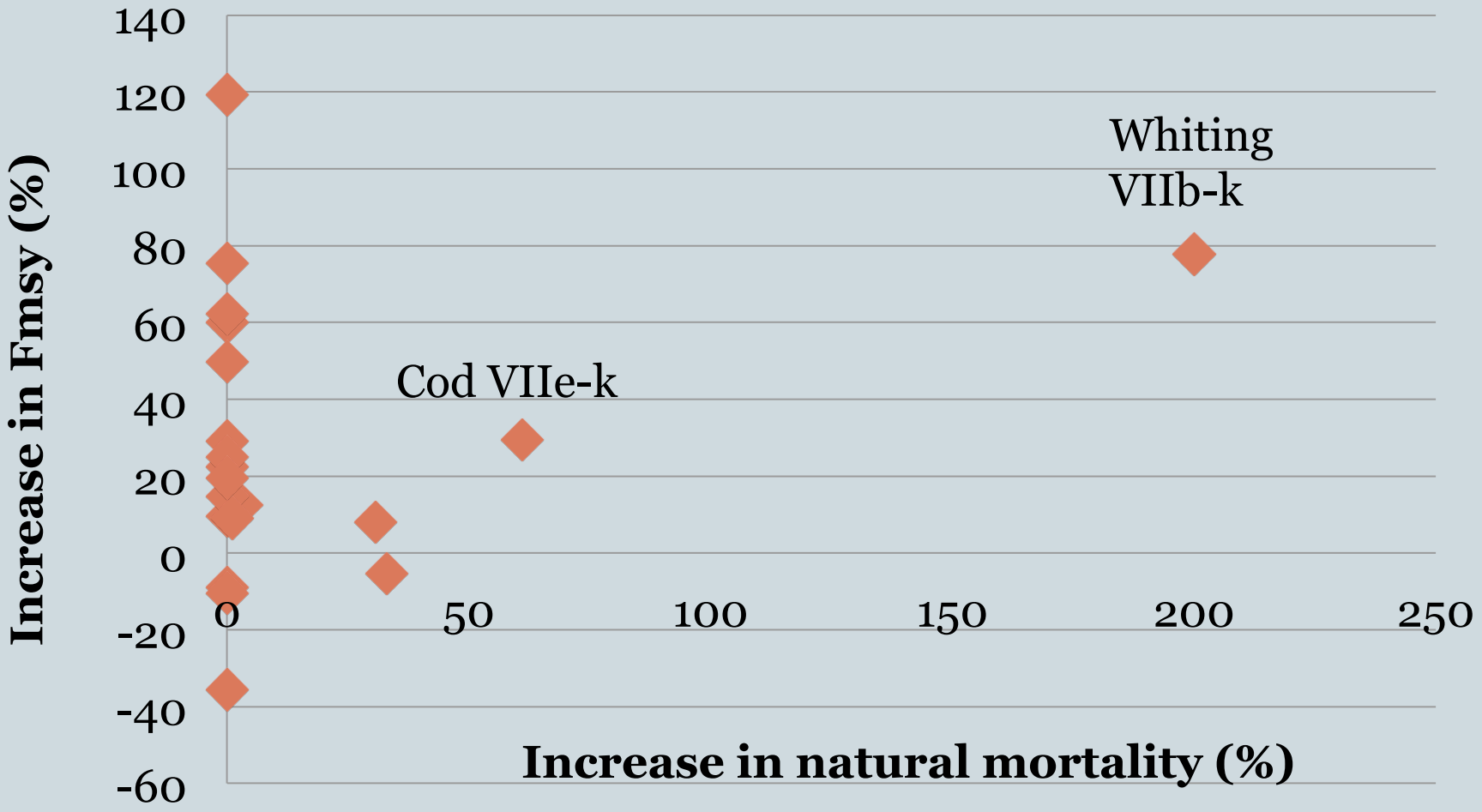
1. Use of different initial proxy



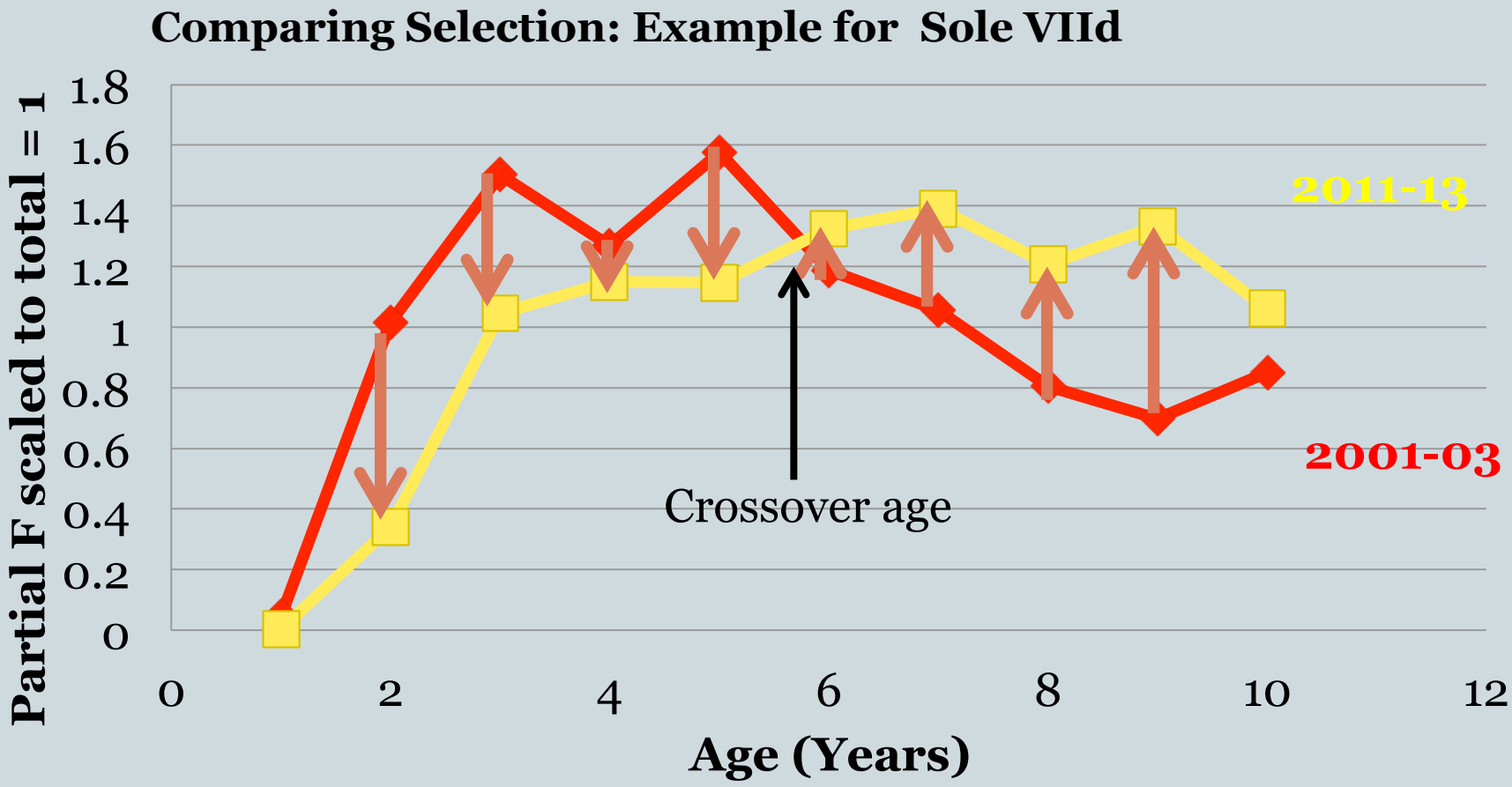
Use of different stock-recruit model



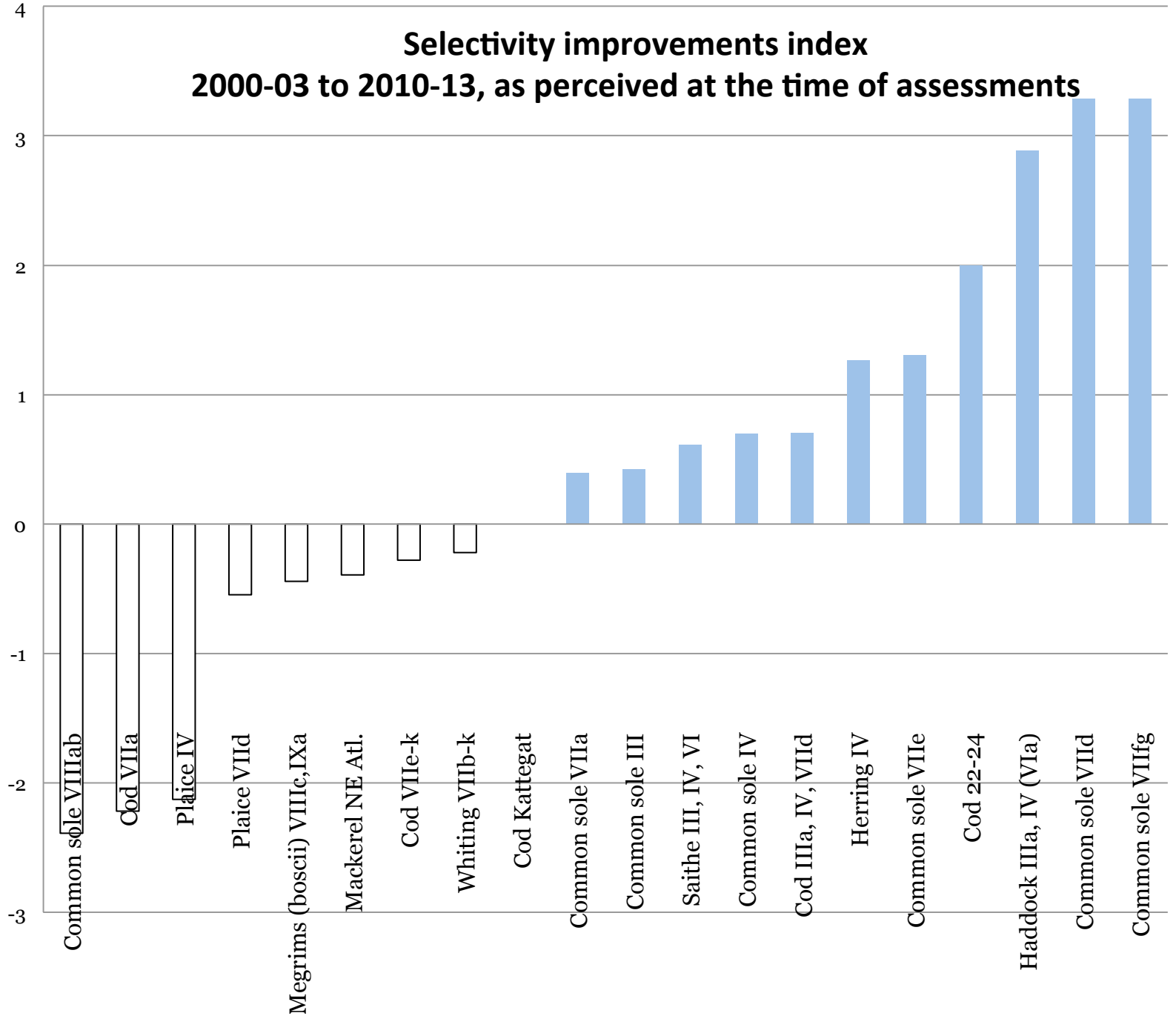
Change in natural mortality ?

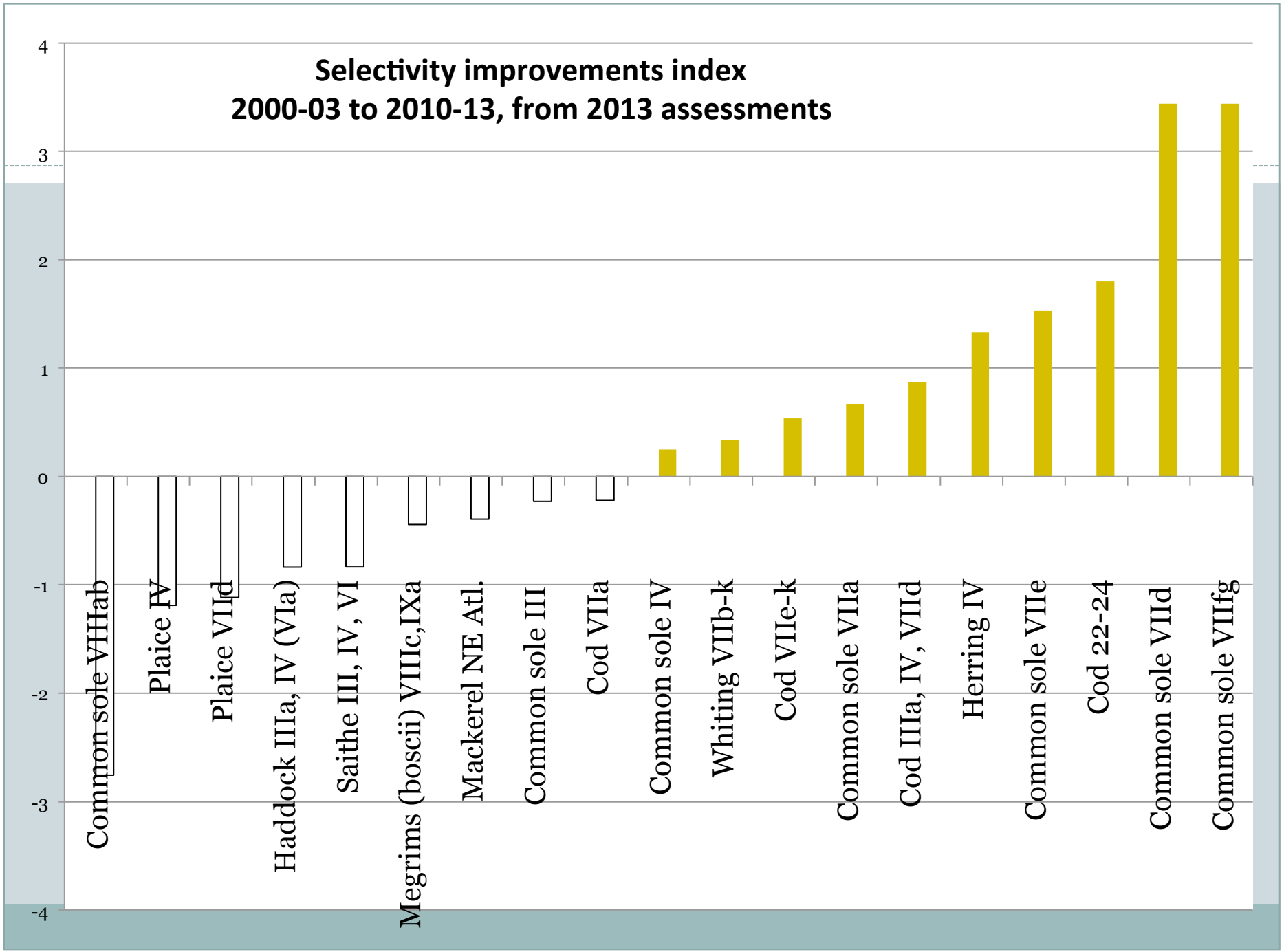


Changes in selection ?



Index of selection change = Sum of the brown arrows, having regard to direction


Selectivity improvements index
2000-03 to 2010-13, as perceived at the time of assessments
4
3
2
1
0
-1
-2
-3
Common sole VIIIab
Cod VIIa
Plaice IV
Plaice VIId
Megrims (boscii) VIIIc,IXa
Mackerel NE Atl.
Cod VIIe-k
Whiting VIIb-k
Cod Kattegat
Common sole VIIa
Common sole III
Saithe III, IV, VI
Common sole IV
Cod IIIa, IV, VIId
Herring IV
Common sole VIIe
Cod 22-24
Haddock IIIa, IV (VIa)
Common sole VIId
Common sole VIIfg


Selectivity improvements index
2000-03 to 2010-13, from 2013 assessments
4
3
2
1
0
-1
-2
-3
-4
Common sole VIIIab
Plaice IV
Plaice VIId
Haddock IIIa, IV (VIa)
Saithe III, IV, VI
Megrims (boscii) VIIIc,IXa
Mackerel NE Atl.
Common sole III
Cod VIIa
Common sole IV
Whiting VIIb-k
Cod VIIe-k
Common sole VIIa
Cod IIIa, IV, VIId
Herring IV
Common sole VIIe
Cod 22-24
Common sole VIId
Common sole VIIfg

Effect of Improving Selection?

Change in growth

- Beverton-Holt Yield-per recruit model:

- $$Y/R = W\downarrow inf\ e\uparrow -Mb\ F\downarrow \{1-e\uparrow -Zc\ /Z\ -3e\uparrow -Ka\ (1-e\uparrow -c(Z+K)\ )/Z+K+$$

$$3e\uparrow -2Ka\ (1-e\uparrow -c(Z+2K)\ )/Z+2K-e\uparrow -3Ka\ (1-e\uparrow -c(Z+3K)\ )/Z+3K\ \}$$

$a = t_c - t_o$; $b = t_c - t_r$; $c = t_{max} - t_c$

$Z = F+M$

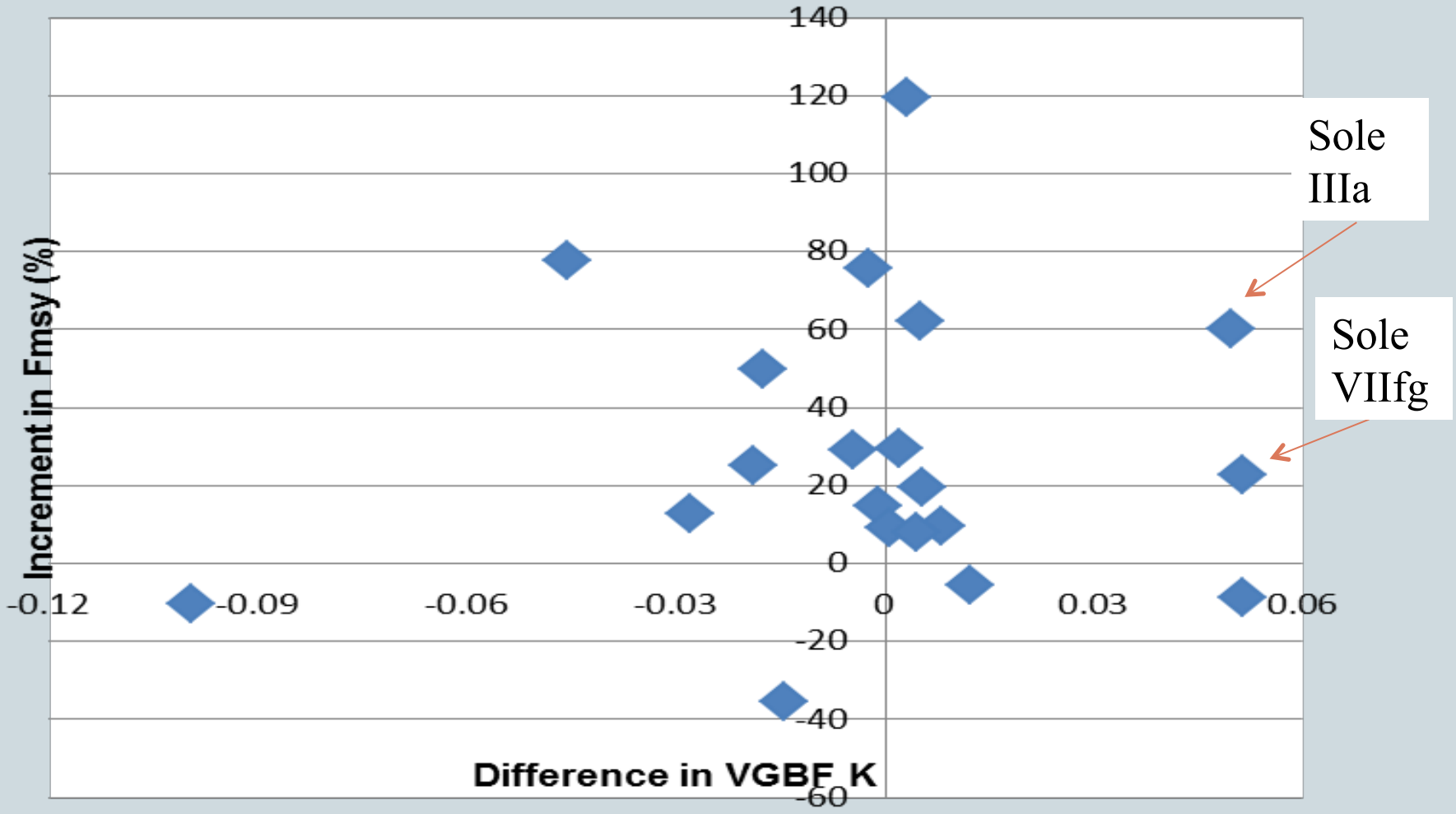
Estimating a change in K

- Model:

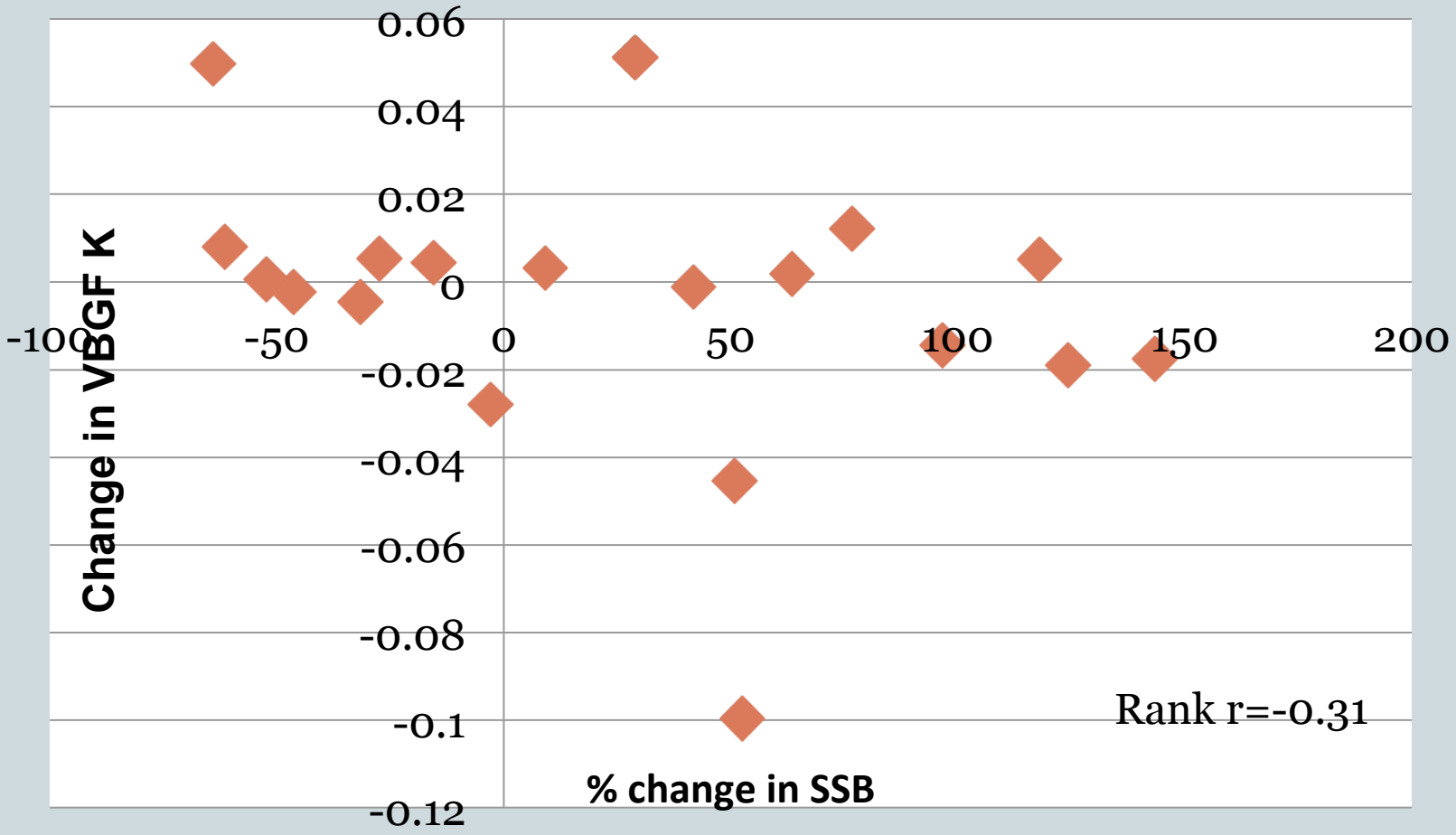
- $W_{a,y} = W_{inf}(1 - e^{-K_y (t - t_o)})^3 + \varepsilon_{a,y}$

- a=age
- y = average over 2001-03 or average 2011-13
- Data: weights-at-age 2001-03 and 2011-13

Effect of growth change?



Density-dependence of growth ?



Model-based analysis

- dFmsy ~ a.dK + b.dSel +c. dM + d.Ricker +e(proxy type)+error
  - All parameter estimates within 1.5 s.e. of zero
  - except d = -0.607, s.e. = 0.34
    - (negative Ricker effect seems a priori implausible).

Summary so far (1/2)

- Sole VIIe
  - - Improved selectivity
  - - Change from F0.1 proxy to Fmsy estimate
- Whiting VIIb-k
  - Higher natural mortality
  - Change from F0.1 proxy to Fmsy estimate
- Sole IIIa
  - Ricker Stock-recruit relationship
  - Faster growth
  - Change from Fmed to Fmsy

Summary so far (2/2)

- Cod VIIe-k
  - -Higher M
- Sole VIIfg
  - Faster growth
  - Improved selectivity
- Some indication of generalised density-dependence in weight at age (… consequences …)

And what else?

- Drivers identified for Fmsy increases in 5 out of 20 stocks, comprising both external drivers and method changes. *Other drivers may be hidden in the data.*
- And the rest ? Without these 5 stocks, the Fmsy change is still 17%
  - The change from maximum-likelihood estimate to median likelihood estimates was tested for "Eqsim" and not inculpated over CV=0 to 0.2.
  - Methodological issues ?

Sensitivity of Fmsy estimates

		Structural Assumption	
		1	2
Bootstrap method	1	0.198	0.295
	2	0.213	0.243

Conclusions

- Changes matter – but they are currently not well documented and are hard to trace.
- No evidence found of generalised ecosystem change ("régime shift") nor increased selectivity overall.
- Some specific drivers for change were identified.
- (*Possibly* some indication of density-dependence in growth)
- Implications for the MSY indicator ?
  - an indicator of performance of the management system against the historically available estimates ?
  - an indicator of performance of the whole system against current full data sets and best practices?