

Drivers of recruitment dynamics in northeast Atlantic pelagic fish stocks

F. Zimmermann, D. Ricard, T. Perälä,
M. Heino, and K. Enberg

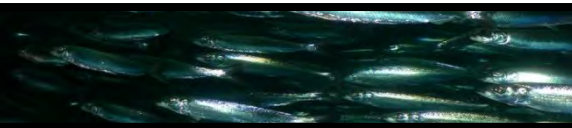
Small pelagics symposium

Victoria, BC

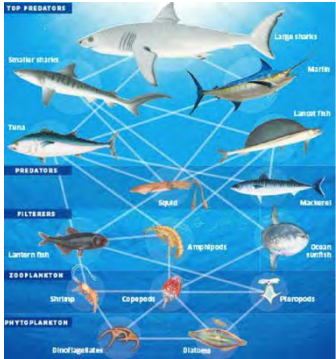
07.03.2017



ConEvolHer



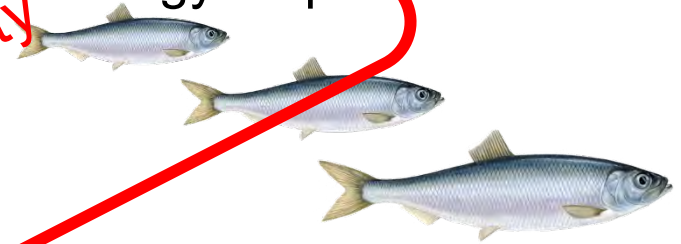
Recruitment dynamics



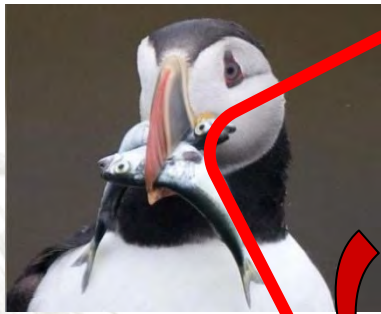
Food web interactions



Stock composition
Life history
Energy acquisition/condition



Spatio-temporal variability on varying scales

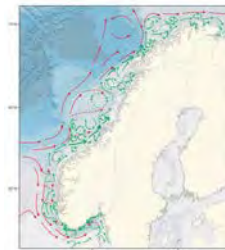
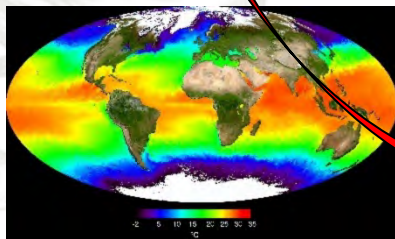


Environmental change

Food availability
Salinity
Oxygen
Predation
Temperature
Turbidity
Transport



Ocean circulation and climate



Stock-recruitment relationship

Recruits

Density regulation

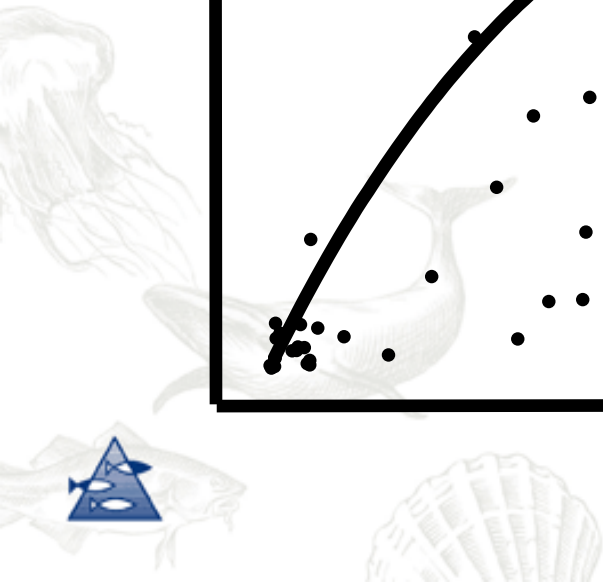
- Stock structure/condition
- Other forms of density regulation?
- Inter-cohort interactions

«Other stuff»

= external factors

- Environmental factors
- Ecological interactions
- «Data» quality/uncertainty

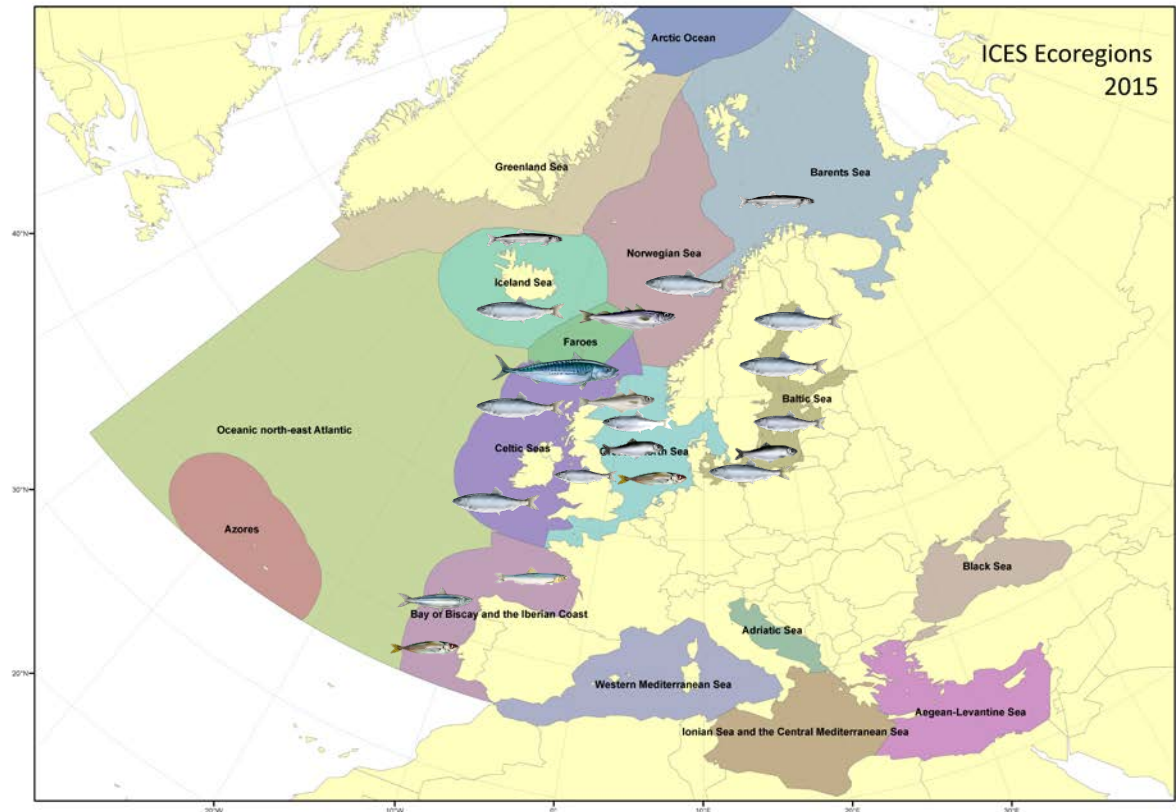
SSB



Approach

Approximating a solution to recruitment dynamics from different angles:

1. Comparative analysis of density-dependent growth/ recruitment
2. Autocorrelation analysis of recruitment residuals
3. Correlation analysis with abiotic and biotic factors
 - Based on literature review of suggested drivers



Data: 22 stocks from NE Atlantic

Anchovy (Bay of Biscay)

Atlantic herring:

- Celtic Sea/South of Ireland
- West of Scotland
- Irish Sea
- Iceland
- North Sea
- Norwegian spring spawners
- Western Baltic spring spawners
- Eastern Baltic
- Gulf of Riga
- Bothnian Sea
- Bothnian Bay

Atlantic mackerel

Blue whiting

Capelin

- Barents Sea
- Iceland

Horse mackerel:

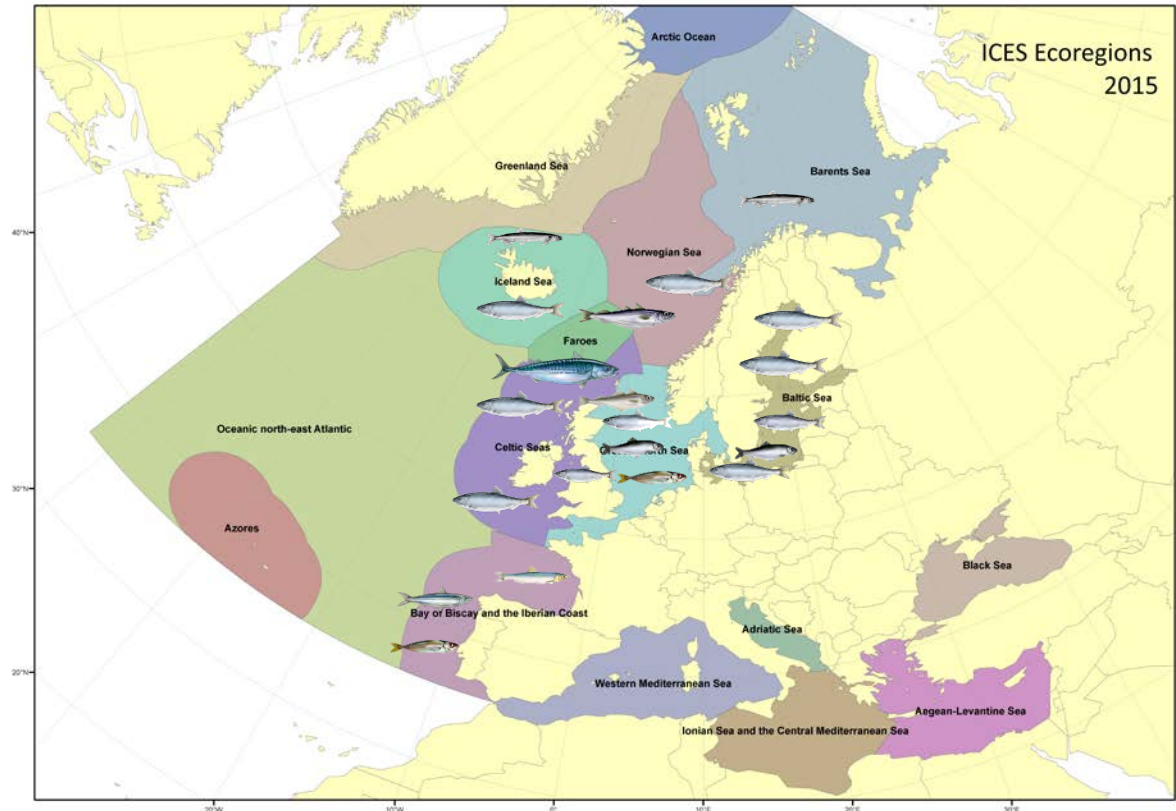
- Western stock
- Southern stock

Norway pout

Sardine

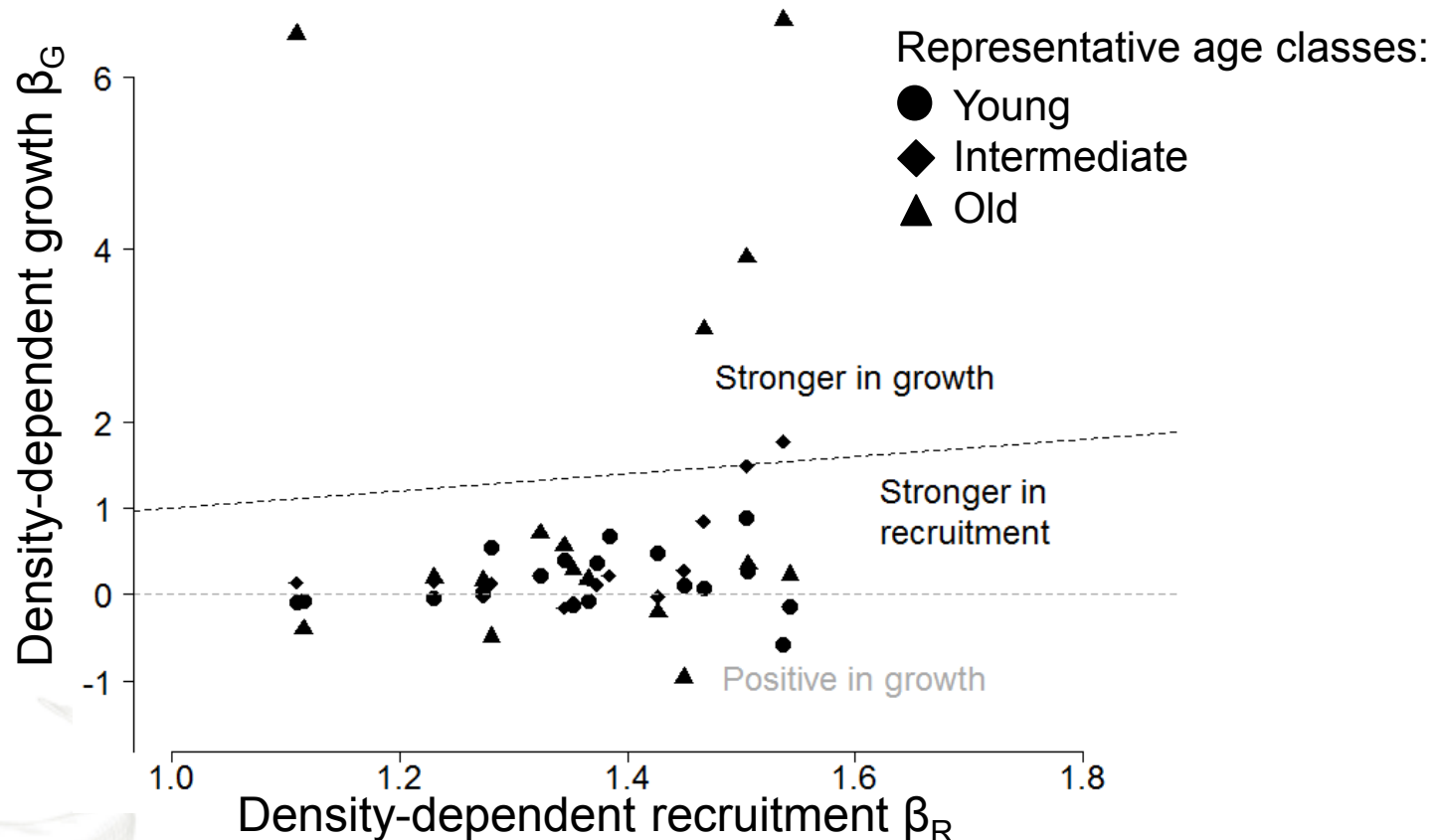
Sprat

- Baltic Sea
- North Sea



Density-dependent growth vs. recruitment

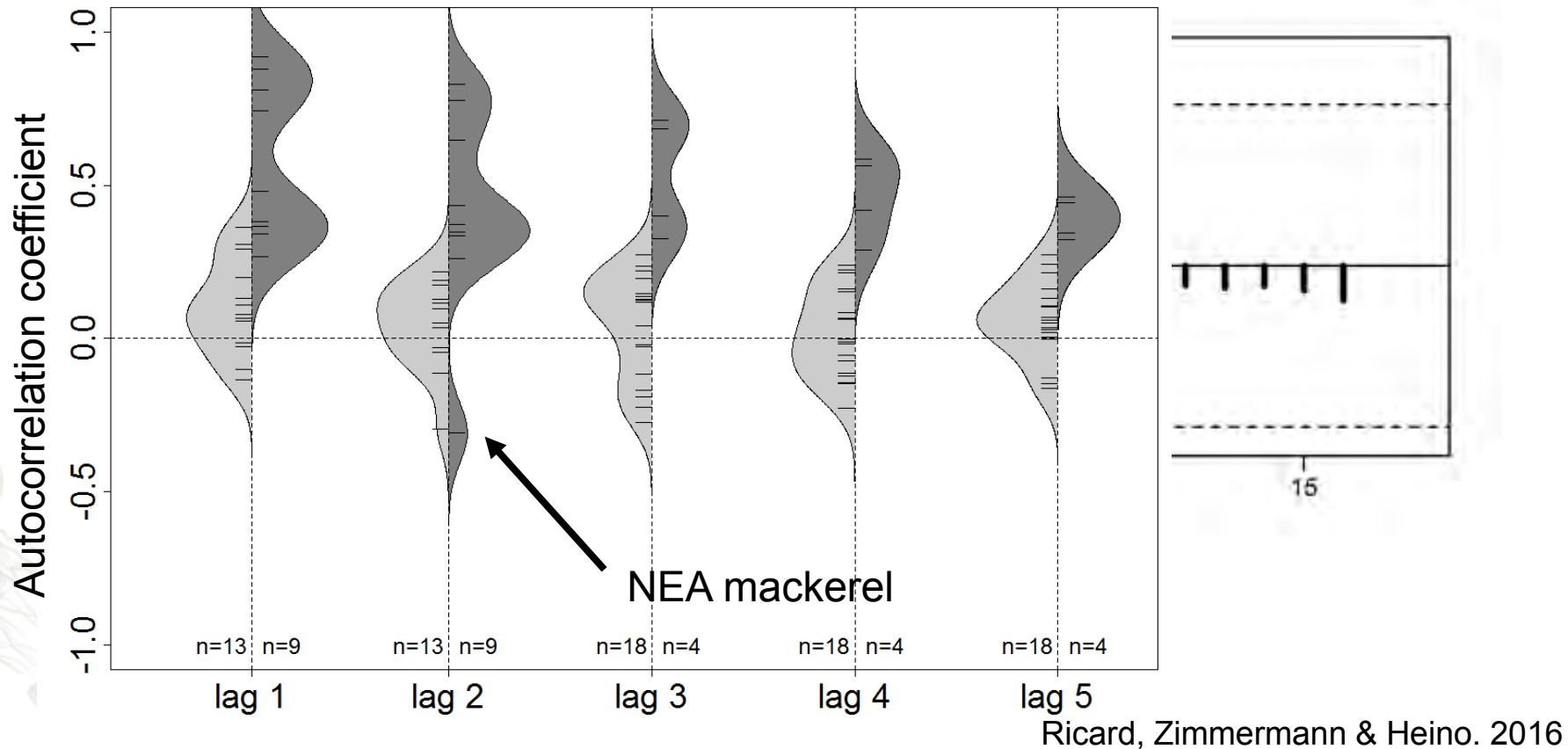
Estimating comparable parameters for growth increments/recruitment



- Both forms of density regulation present in most stocks
- Density-dependent recruitment > growth
- Implications? Interactions? Common drivers?

Inter-cohort interactions

Autocorrelation in recruitment residuals at different time lags

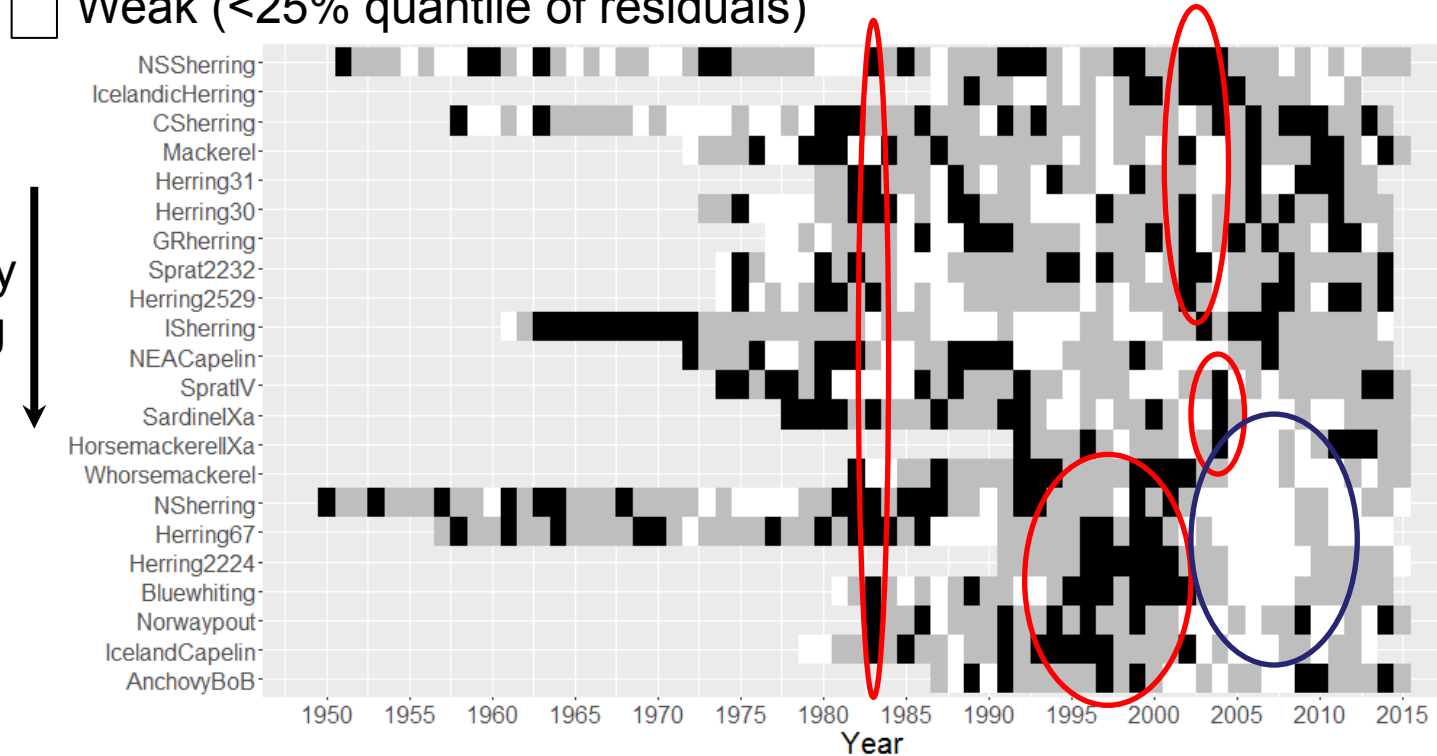


- Few and weak negative autocorrelation
- Positive autocorrelation: Ageing issues vs. external drivers?
- Common patterns among stocks?

Synchrony in recruitment variability?

- Strong (>75% quantile of residuals)
- Average (25-75% quantile of residuals) year classes
- Weak (<25% quantile of residuals)

Ordered by
clustering

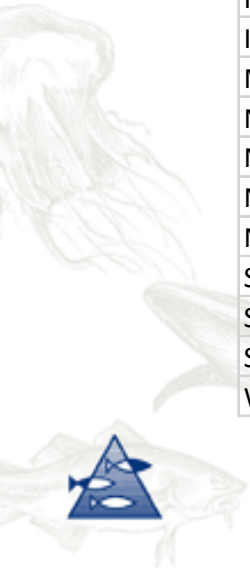


- Qualitative patterns: common years of strong/weak year classes
- However: no real synchrony, few and spurious correlations
- Does not refute common underlying patterns

Back to the roots

Influence **known/suggested**, **possible**, not known in literature

Stock name	Climate	Drift	Current	Temperature	Salinity	Prey	Predator	Freshwater runoff	Ice cover
AnchovyBoB	known/suggested						known/suggested	possible	
Bluewhiting		known/suggested	known/suggested				known/suggested		
CSherring		known/suggested					known/suggested		
GRherring	known/suggested			known/suggested			known/suggested		
Herring2224				possible	possible		known/suggested		
Herring2529				possible	possible		known/suggested		
Herring30	known/suggested						known/suggested		
Herring31				known/suggested			known/suggested		
Herring67				known/suggested			known/suggested		
HorsemackerelIXa	known/suggested					known/suggested			
IcelandCapelin		known/suggested	known/suggested			known/suggested			
IcelandicHerring	known/suggested	known/suggested	known/suggested						
ISherring							known/suggested		
Mackerel						known/suggested			
NEACapelin	known/suggested		known/suggested				known/suggested		
Norwaypout									
NSherring		known/suggested	known/suggested			known/suggested			
NSSherring		known/suggested	known/suggested				known/suggested	possible	
SardineIXa	known/suggested	known/suggested					known/suggested		
Sprat2232	known/suggested			known/suggested		known/suggested			known/suggested
SpratIV		known/suggested	known/suggested						
Whorsemackerel									

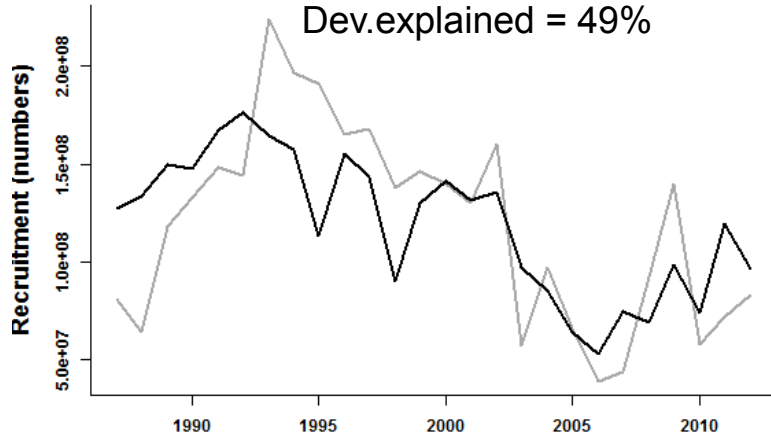


Correlation analysis

Total recruitment

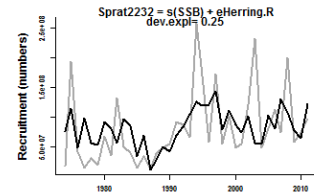
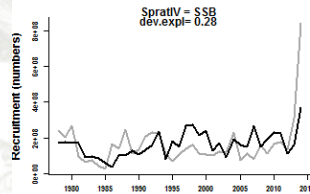
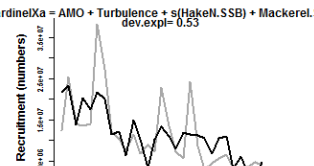
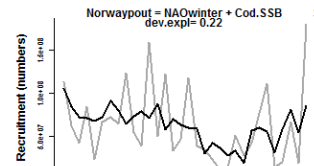
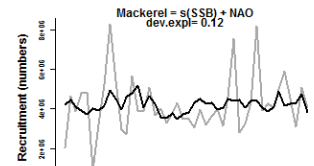
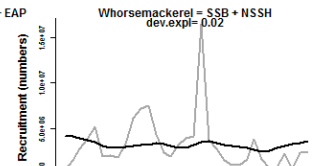
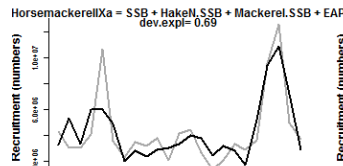
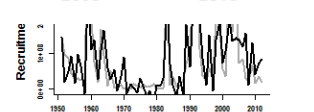
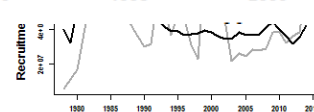
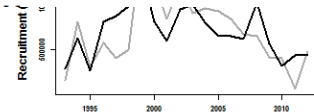
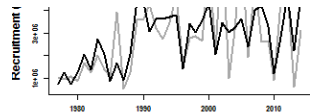
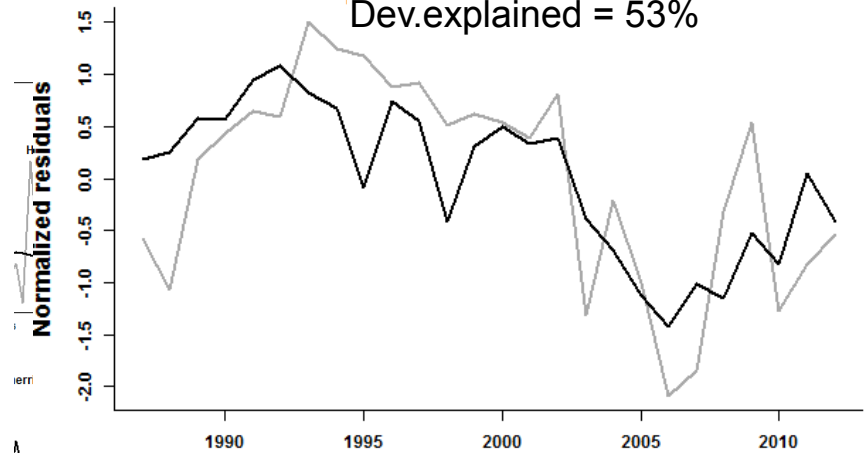
Icelandic Capelin

AMO + Icelandic Herring SSB
Dev.explained = 49%

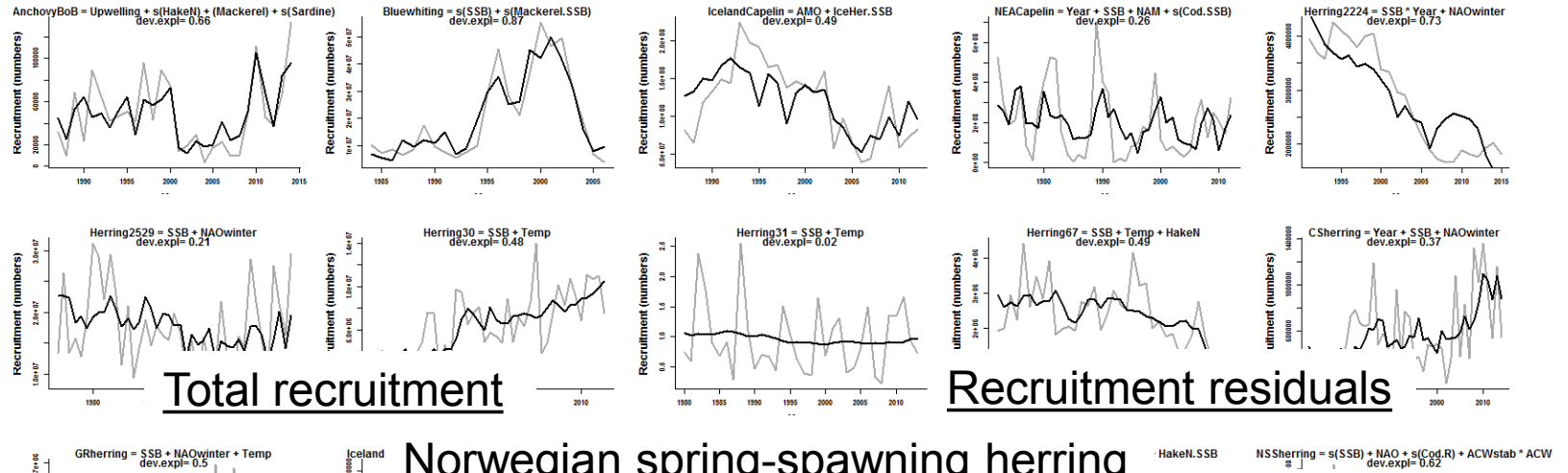


Recruitment residuals

AMO + Icelandic Herring SSB
Dev.explained = 53%



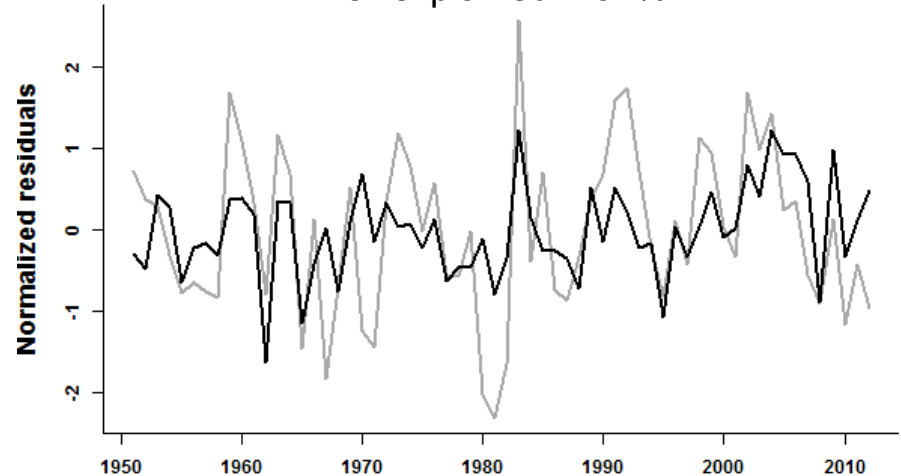
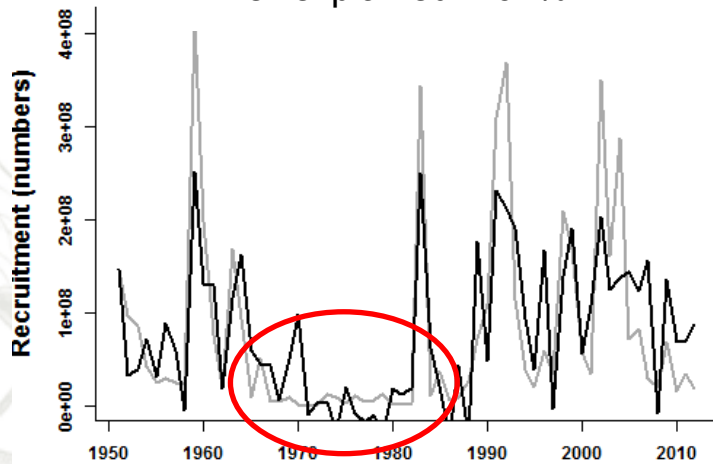
Correlation with environmental factors



Norwegian spring-spawning herring

$s(\text{SSB}) + s(\text{Cod recruitment}) + \text{T} + \text{ACW strength} * \text{stability}$
 $\text{Dev.explained} = 62\%$

$\text{Cod recruitment} + \text{T} + \text{ACW strength} * \text{stability}$
 $\text{Dev.explained} = 31\%$



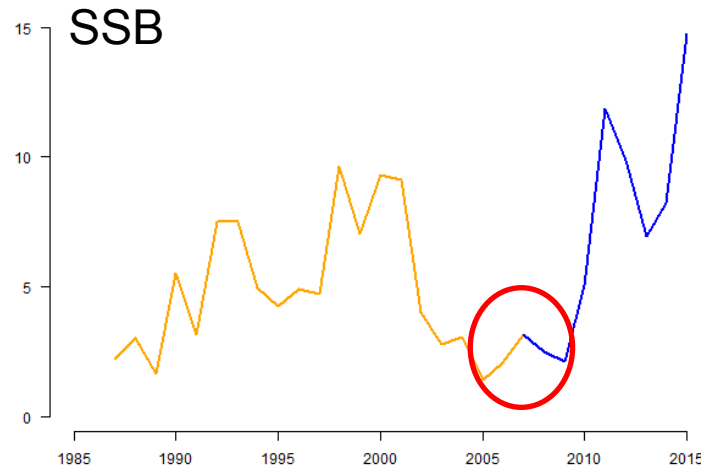
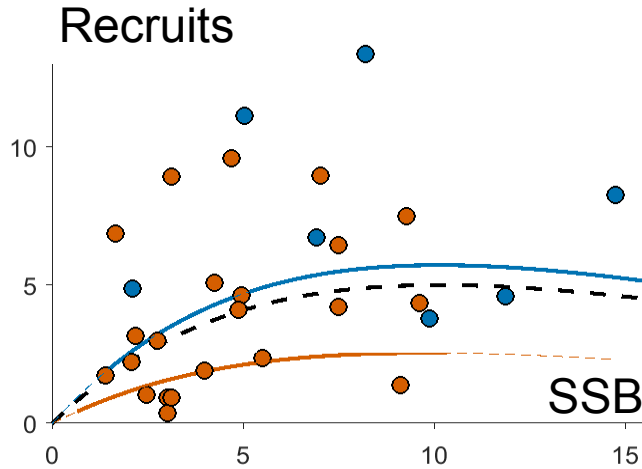
Collapses and regime shifts: temporal changes in recruitment drivers?



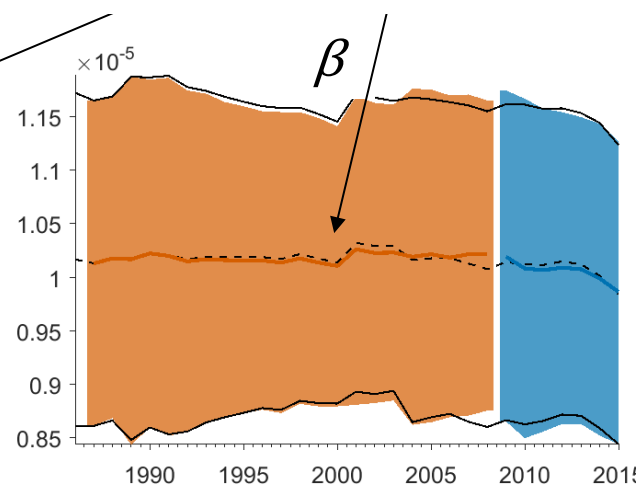
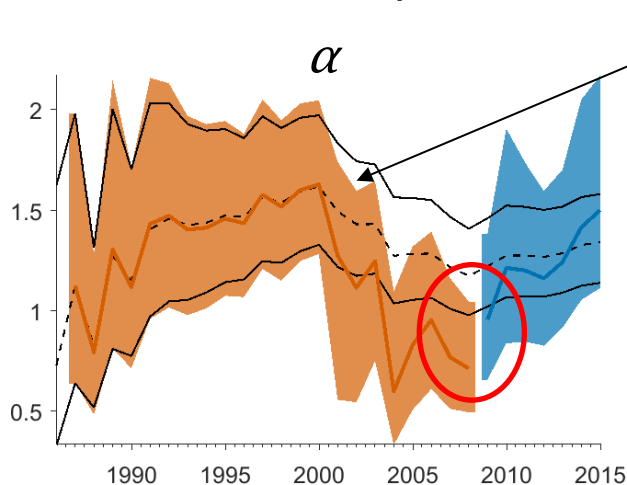
Temporal patterns and regime shifts

Bayesian switch-point models used to estimate temporal variability in stock-recruitment parameter and sudden changes («regime shifts»)

Example: Anchovy in Bay of Biscay



Ricker model parameters: $R = \alpha \cdot SSB \cdot e^{-\beta \cdot SSB}$



Collapse \rightarrow changes in stock productivity \rightarrow regime shift?

based on Perälä & Kuparinen 2016

Conclusion and outlook

- Density-dependent recruitment present in most pelagic stocks
 - Stronger than density-dependent growth
 - Few and weak year class interactions
 - Indication for external forcing?
 - Environmental/ecological drivers confirm (some) known relationships but also challenges
 - Relevance may vary over time and space
-
- Large scale vs. fine scale
 - Exploring further general variability and common events
 - Underlying variability patterns: linked to large-scale modes?
 - Increase spatio-temporal resolution (stock-recruitment and external drivers)
 - Mechanisms? (correlation \neq causality)
 - Data issues and uncertainty?



Thank you!

Collaborators:

- Katja Enberg (Institute of Marine Research)
- Daniel Ricard (Fisheries & Oceans Canada)
- Mikko Heino (University of Bergen)
- Tommi Perälä (University of Helsinki)
- Marion Claireaux (Institute of Marine Research)

ICES ANNUAL SCIENCE CONFERENCE 2017

Theme session P

Recruitment dynamics in a changing environment:
integrating spatial and temporal
variability into stock assessment and management
strategies.

Conveners:

Fabian Zimmermann (Norway)

LaTreese Denson (USA)

Katja Enberg (Norway)

