Threshold-like switches in the Baltic Sea ecosystem - the effects on herring growth-

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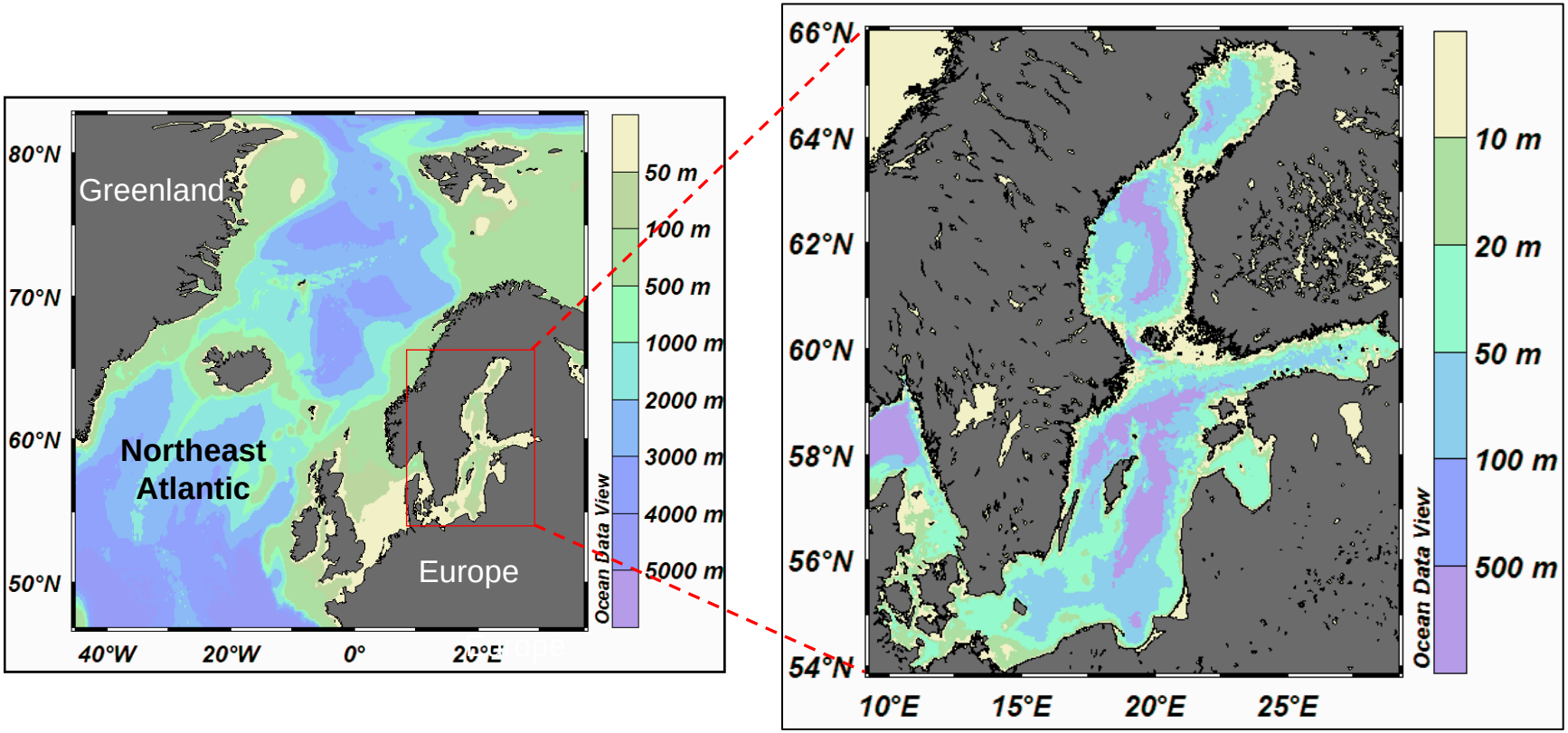
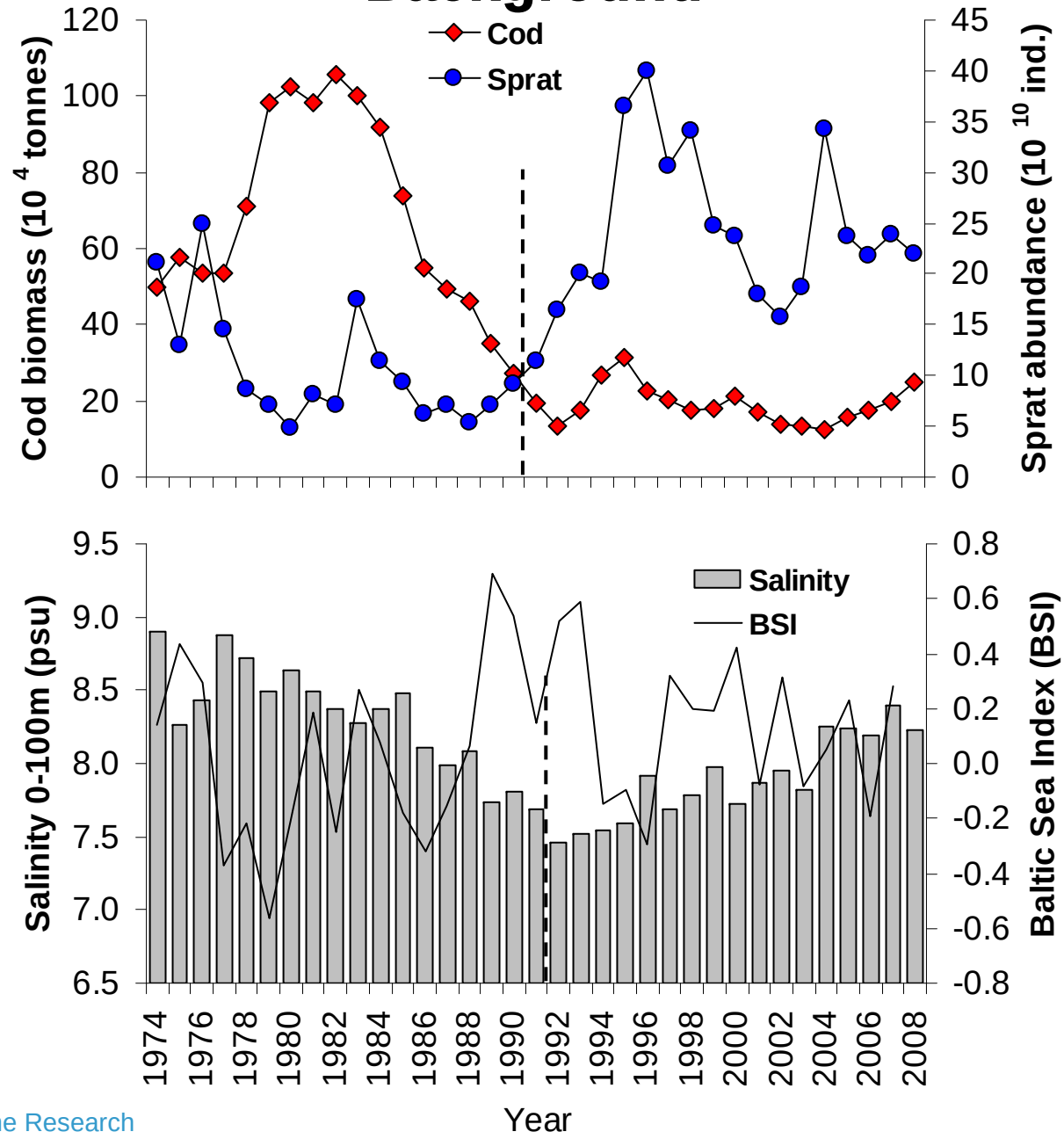
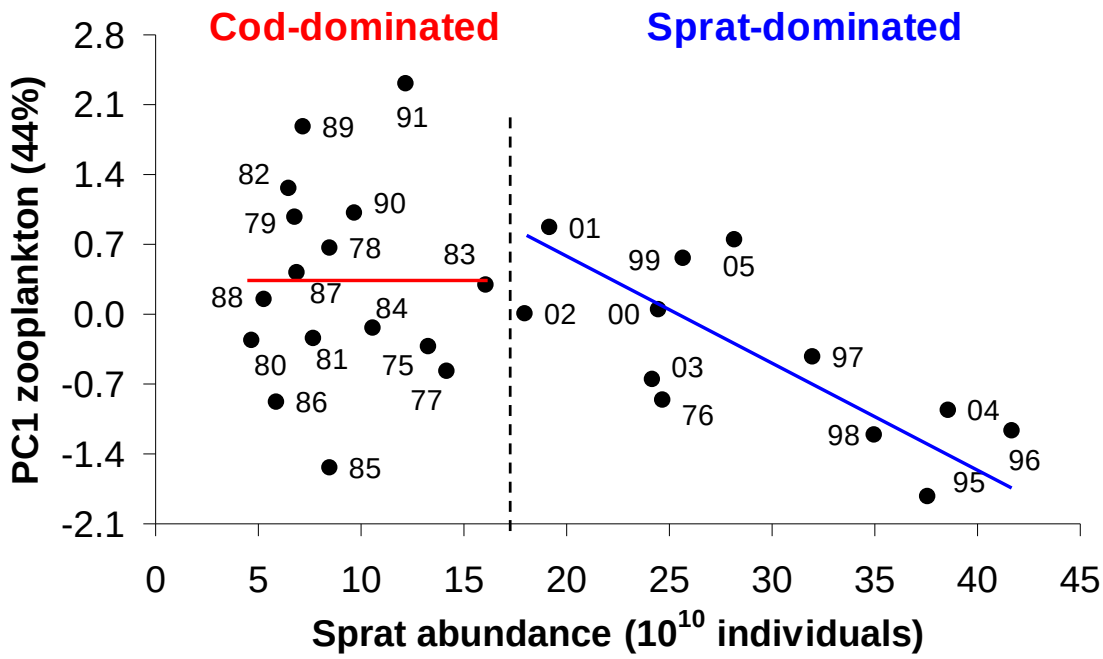
Study area


Greenland
Northeast Atlantic
Europe
80°N
70°N
60°N
50°N
40°W
20°W
0°
20°E
50 m
100 m
500 m
1000 m
2000 m
3000 m
4000 m
5000 m
Ocean Data View
66°N
64°N
62°N
60°N
58°N
56°N
54°N
10°E
15°E
20°E
25°E
10 m
20 m
50 m
100 m
500 m
Ocean Data View

Background

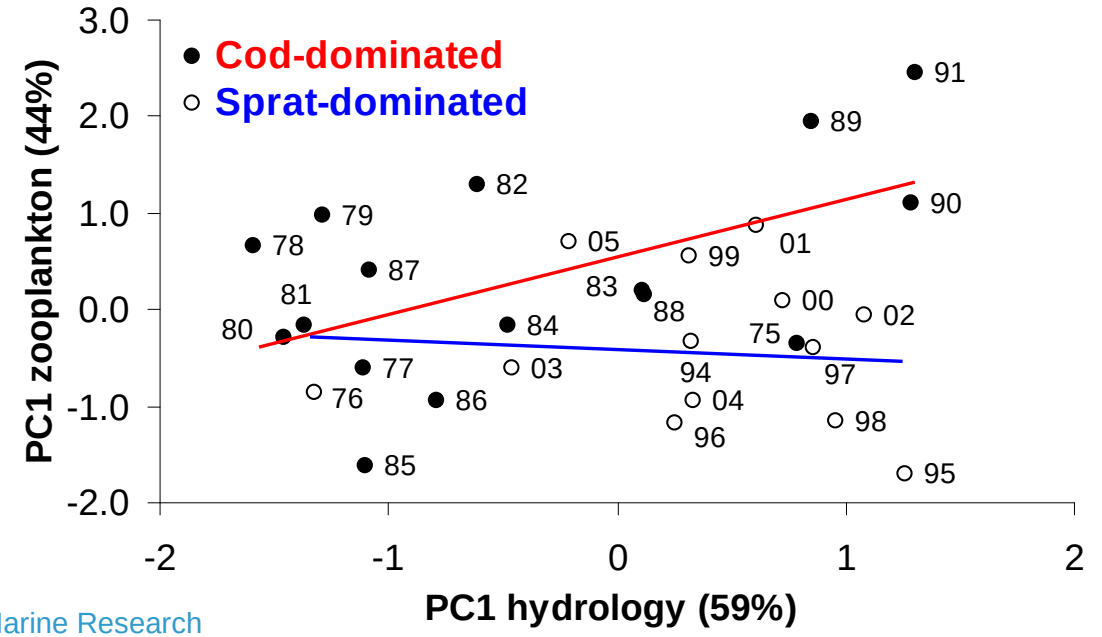

Cod
Sprat
Cod biomass (10 4 tonnes)
Sprat abundance (10 10 ind.)
120
100
80
60
40
20
0
45
40
35
30
25
20
15
10
5
0
Salinity
BSI
Salinity 0-100m (psu)
Baltic Sea Index (BSI)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year

Background



TGAM analysis:

Break-point =
~ 17 * 10^{10} sprats

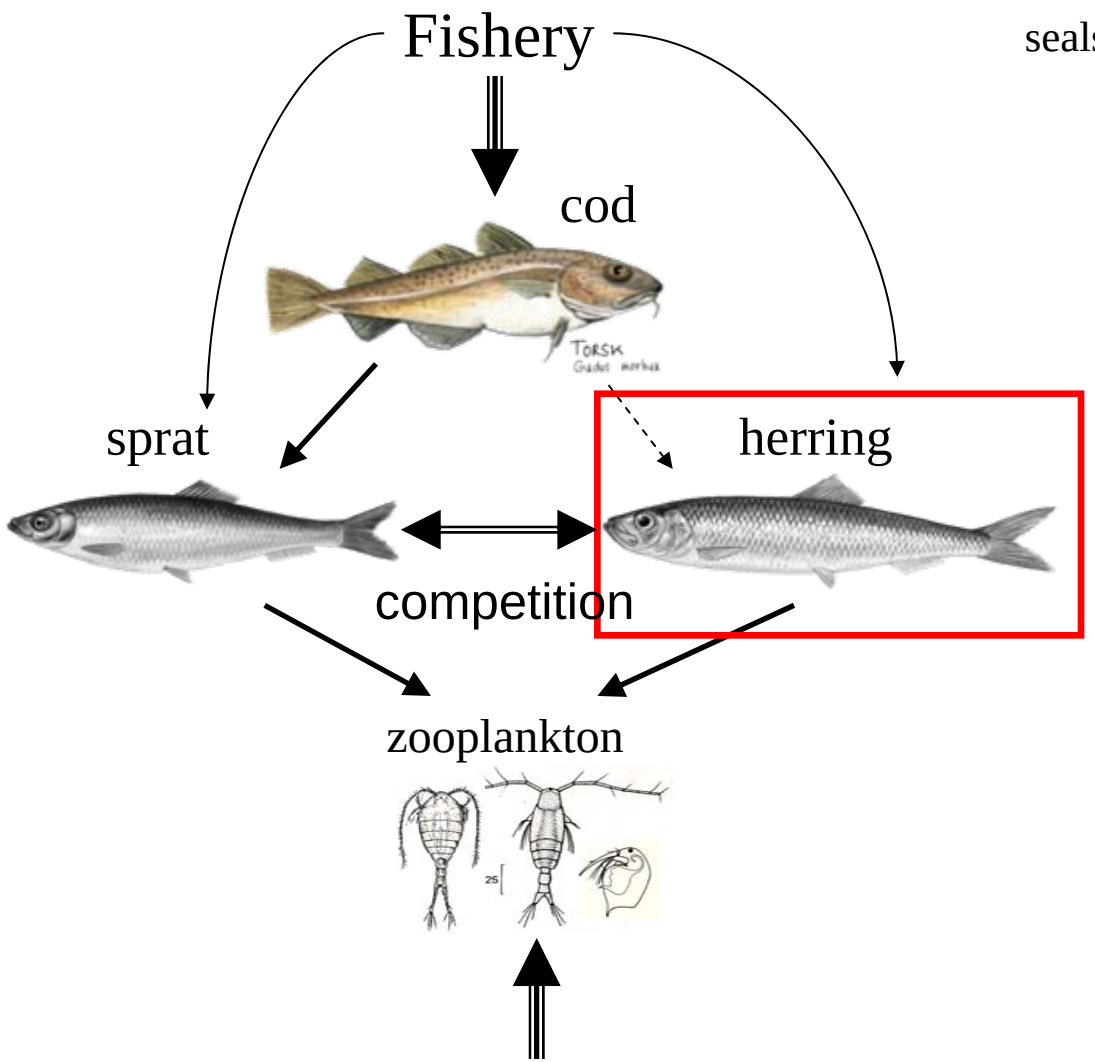


Casini et al. 2009 (PNAS)

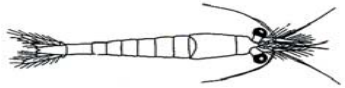
Background

seals

sticklebacks



nektobenthos



phytoplankton

Aims

Considering:

1) the threshold dynamic in zooplankton regulation mechanisms

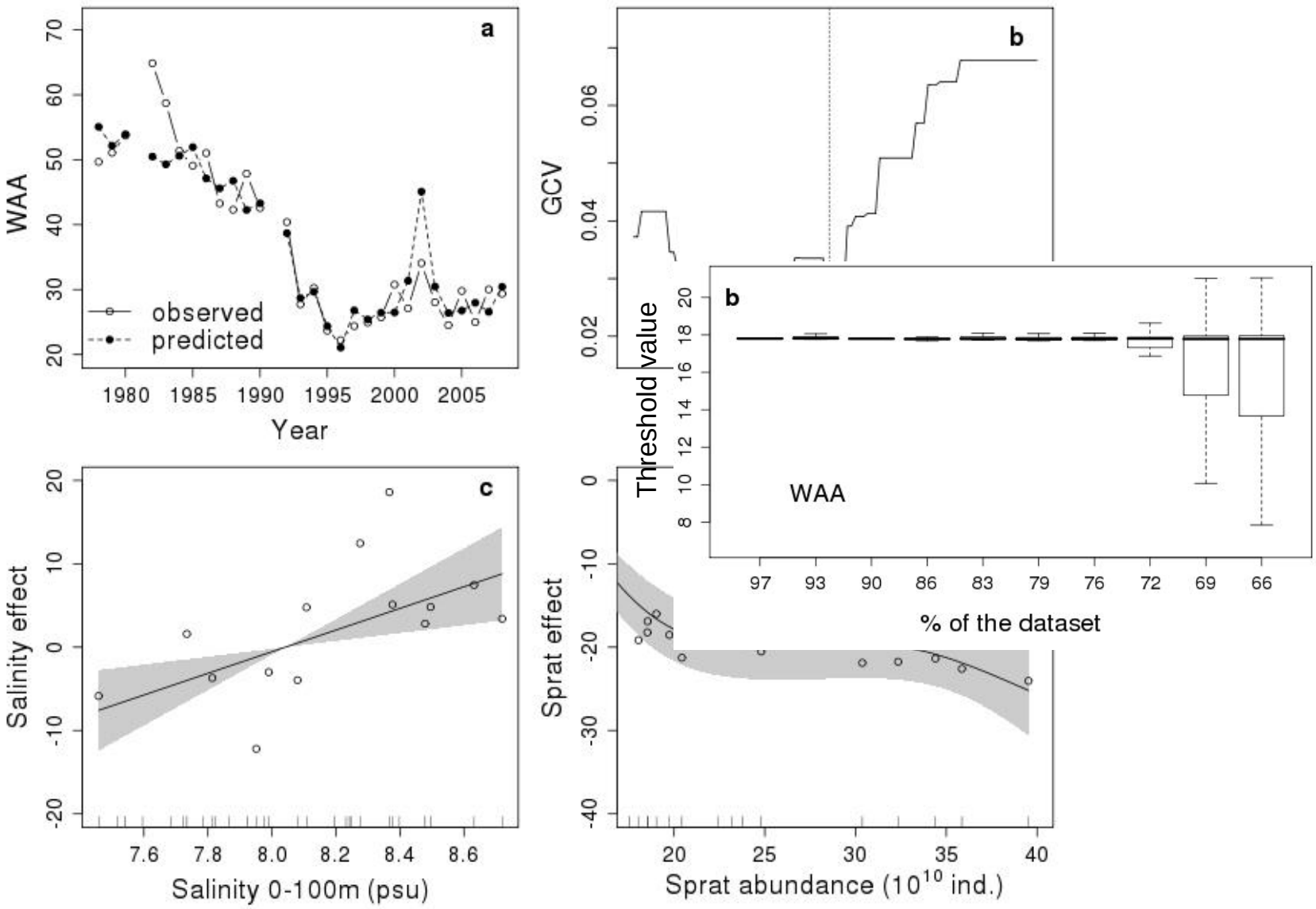
2) the inter-specific food competition between sprat and herring

We want to:

- Testing the hypothesis that threshold features known for the zooplankton are transferred at other trophic levels
- In the specific investigate the consequences for herring growth
- Evaluate some of the implications for herring stock size

Shift in trophic control

TGAM analysis



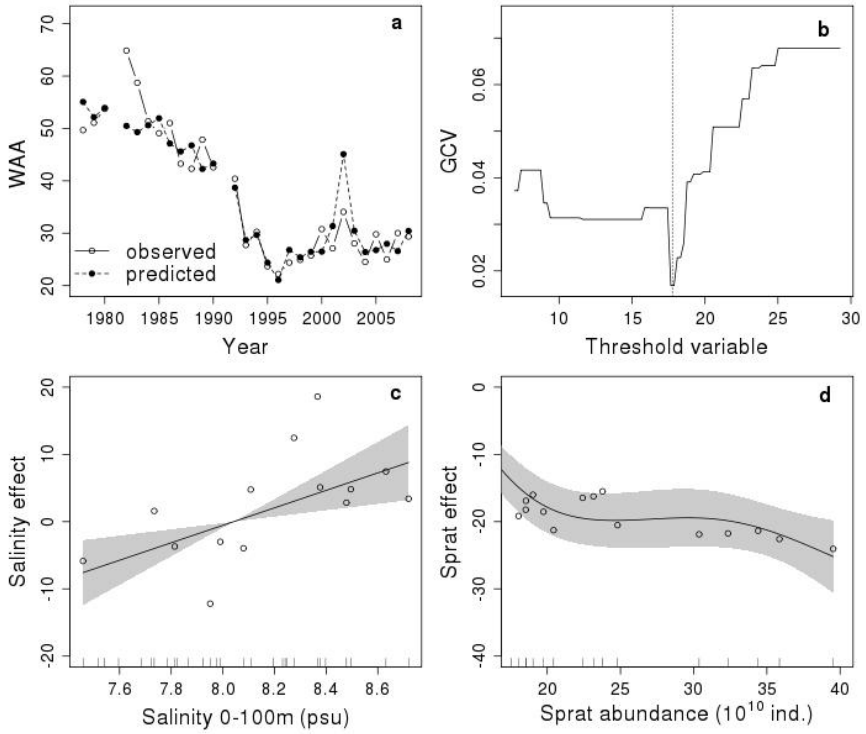
Casini et al. 2010 (MEPS)

Shift in trophic control

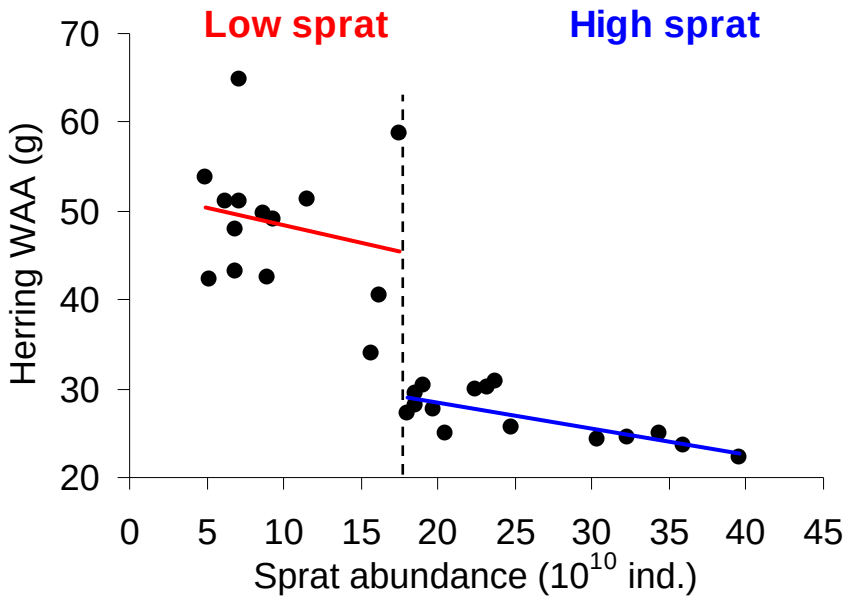
Model	Response	Threshold	Dev. Expl.	AIC	n	Factors	F	edf	p	n (T)
TGAM	Herring WAA	17.85	88.8	173.9	29	Salinity for sprat < t	9.9	1.0	0.0044	16
						Sprat for sprat >= t	47.3	3.0	< 0.0001	15
GAM	Herring WAA		79.0	189.9	29	Salinity	2.0	1.7	0.149	
						Sprat	18.8	2.1	< 0.0001	

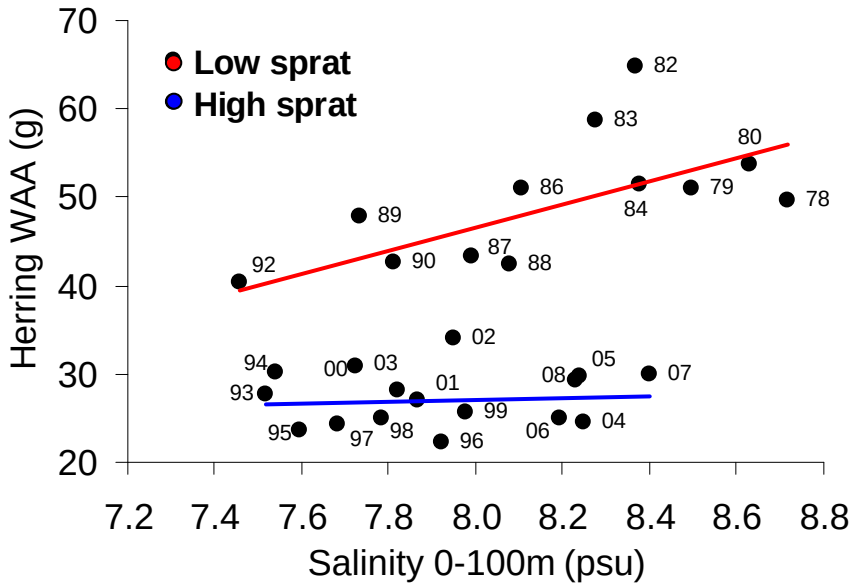
Comparison GAM / TGAM analyses

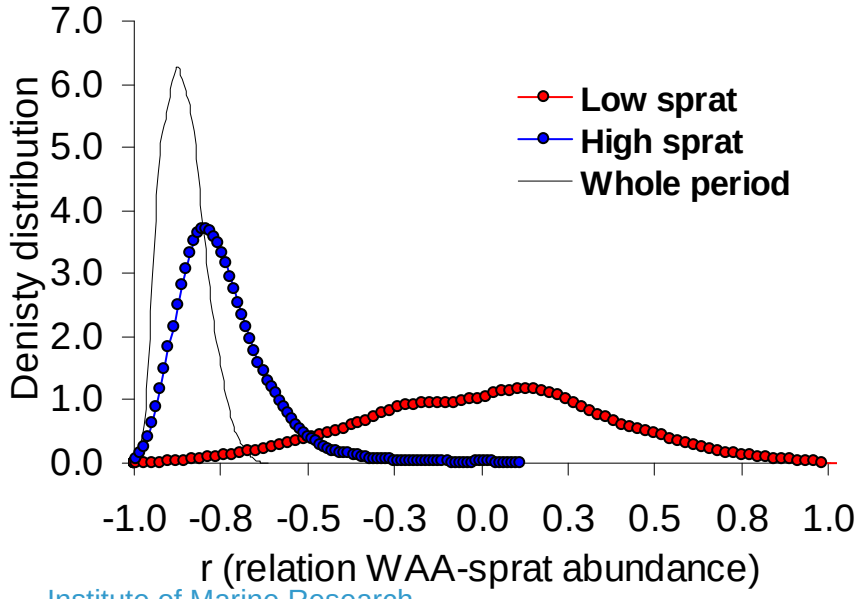
Break-point =
~ 18 * 10^{10} sprats

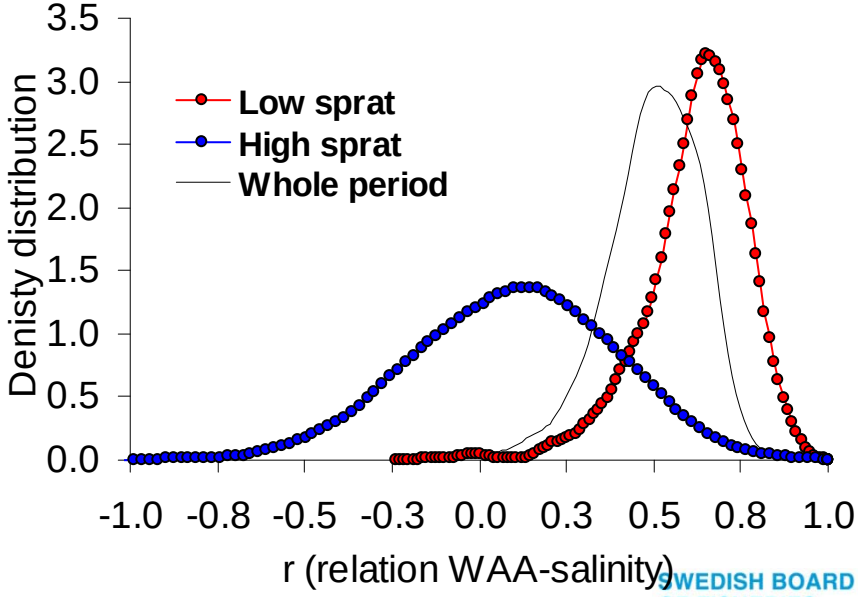


Shift in trophic control



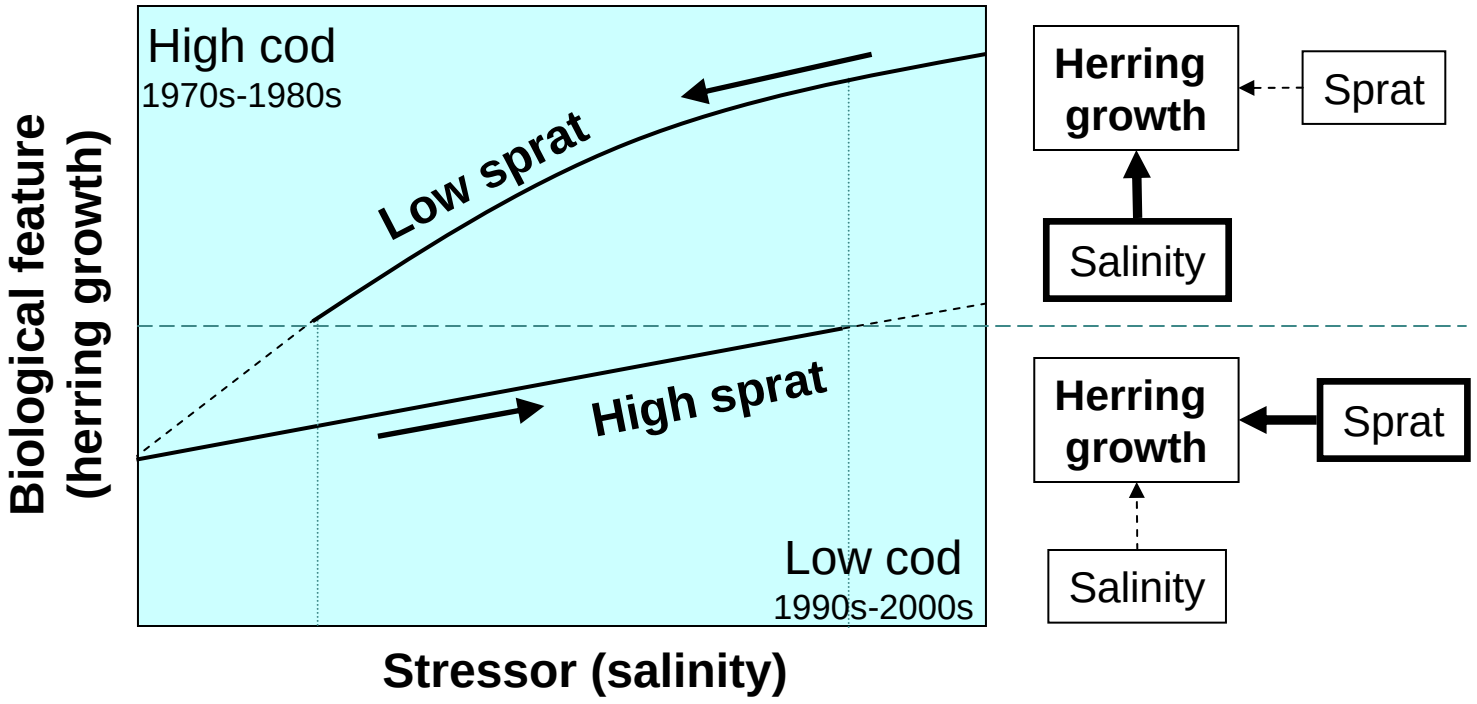




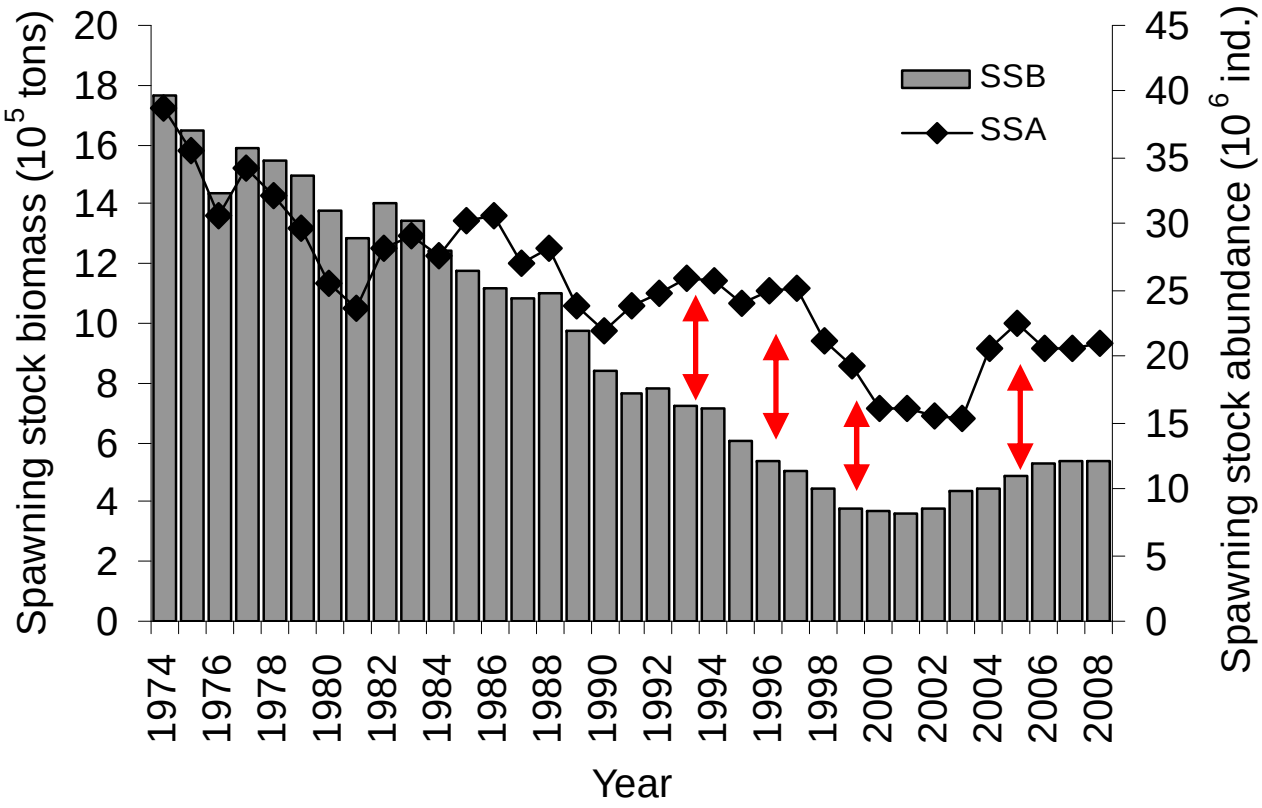


Implications for herring stock

The observed patterns indicate that there may exist alternative stable states in the Baltic Sea ecosystem, one cod- and one sprat-dominated



Implications for herring stock



Herring WAA affects:

1) Directly spawning stock biomass
2) Indirectly reproductive success (Cardinale et al. 2009)

General conclusions

1. Changes at the top of the food web can promote not only changes in the structure, but also shifts in the functioning, of ecosystems

2. The shifts can occur suddenly beyond certain ecological thresholds (break-point)

3. The response of ecosystem to external forces can be discontinuous (different responses under different conditions)

4. We have shown here an example from the Baltic Sea, involving two trophic levels, i.e. zooplankton and planktivore fish dynamics

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Sprat shoal
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