Does body-size matter when marine systems face climate change?

Susa Niiranen, James Watson and Thorsten Blenckner

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Affects basic metabolic processes and other rates (e.g, movement, prey handling) of individuals.

Largely defines if you get eaten or not.

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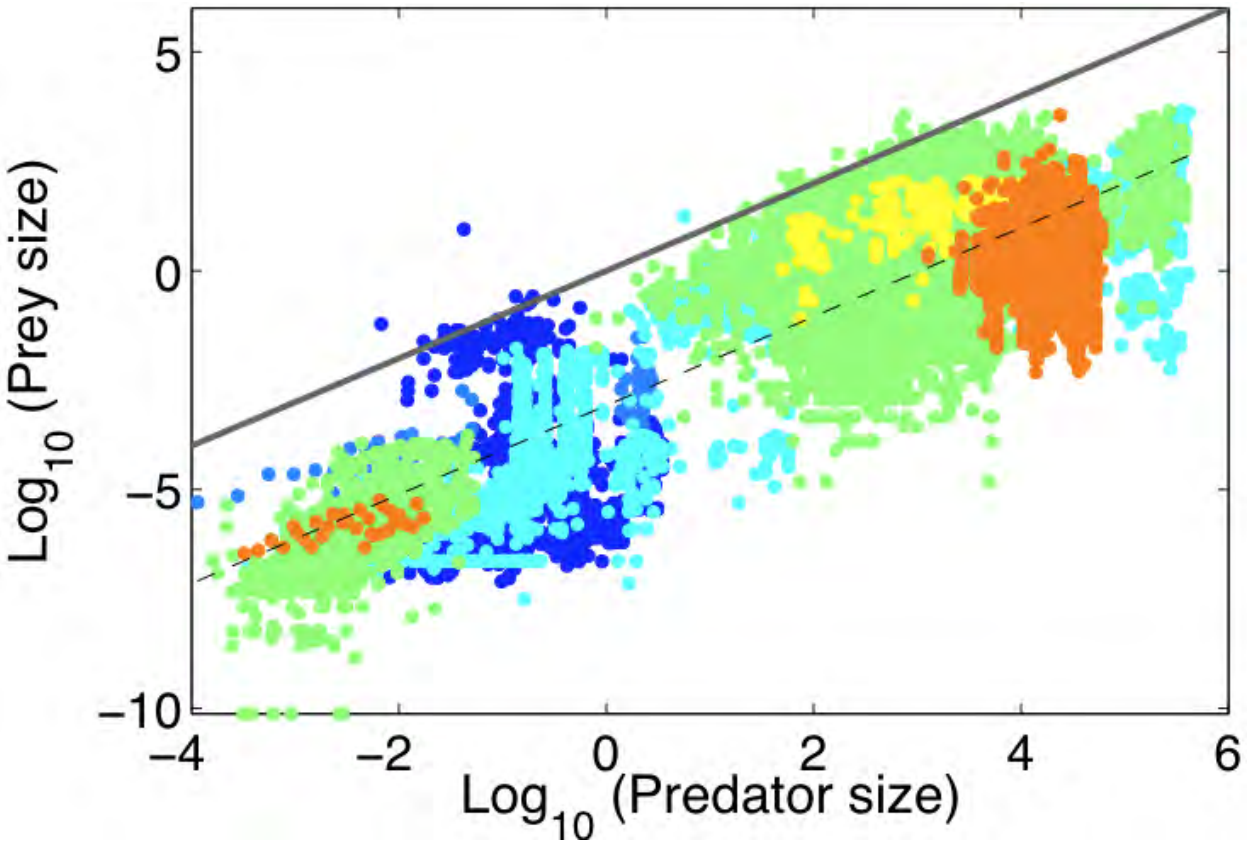
Predator-prey size ratio in world's marine systems



Barnes *et al.* (2009)

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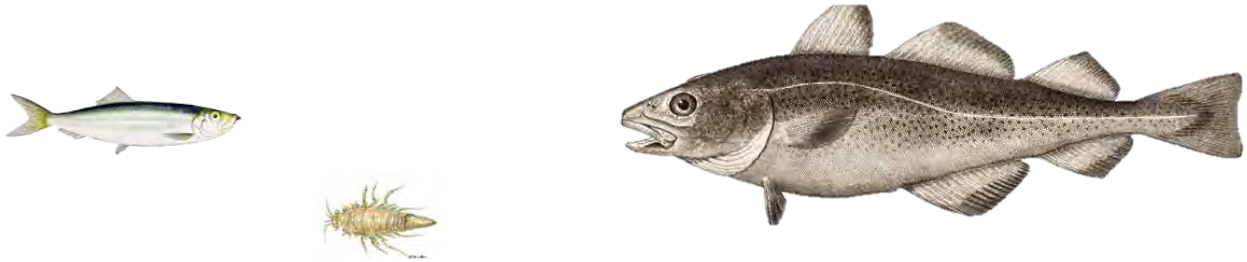


Organism size distribution and its changes impact ecosystem dynamics.

CLIMATE and size

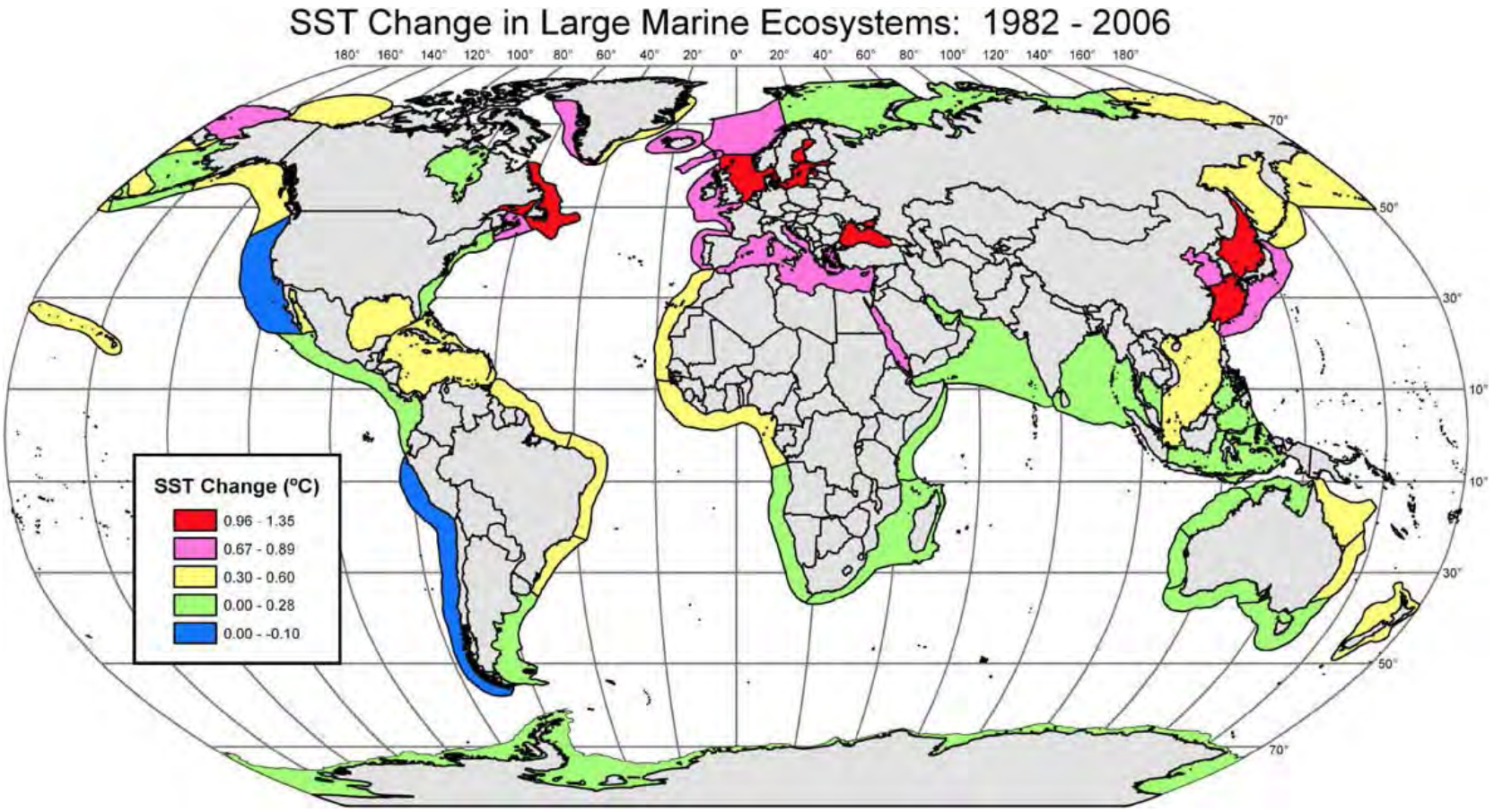
- Effects of increasing temperature, but also changes in O_2 and salinity

1) Organism metabolism (size dependent)
2) Resource availability
    - Large to small phytoplankton, stratification
    - Amplification of effects to HTLs (Lefort *et al.* 2015)
3) Range shifts

- Also habitat specific species responses can affect organism size-distribution

Increase in global sea surface temperatures

(Belkin 2009)



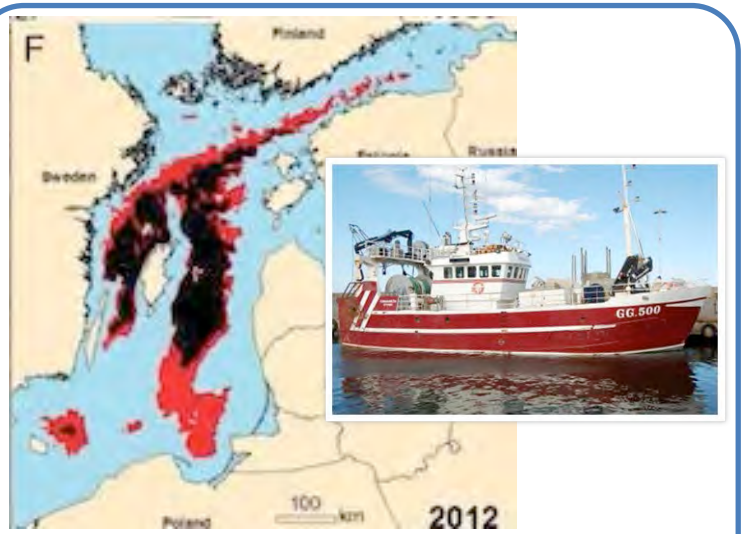
Fastest increase in SST (1.35 °C) in 1982-2006 in the Baltic Sea

Baltic Sea

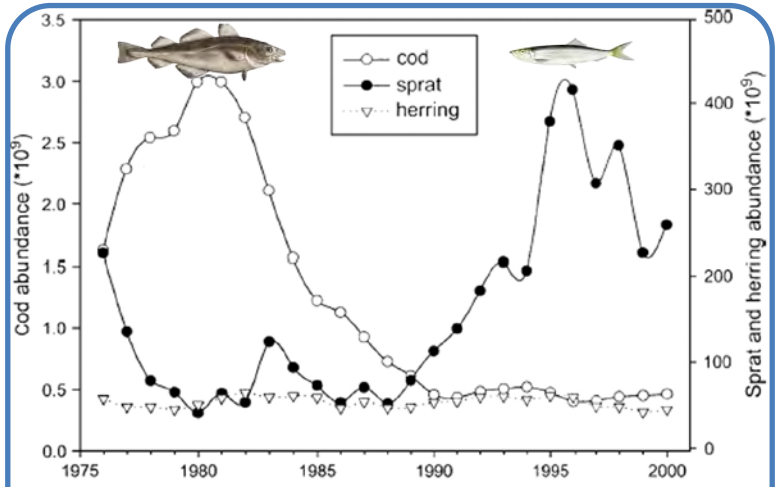
- Semi-enclosed, brackish water body
- Species at the edge of their physiological tolerance
- large catchment area (85 million people)
- Strong anthropogenic stressors
  - high nutrient loads
  - intensive fishery

➢ The combination of anthropogenic and climate drivers has caused ecosystem reorganizations in the past (e.g. Möllmann et al. 2009, Casini et al. 2008)

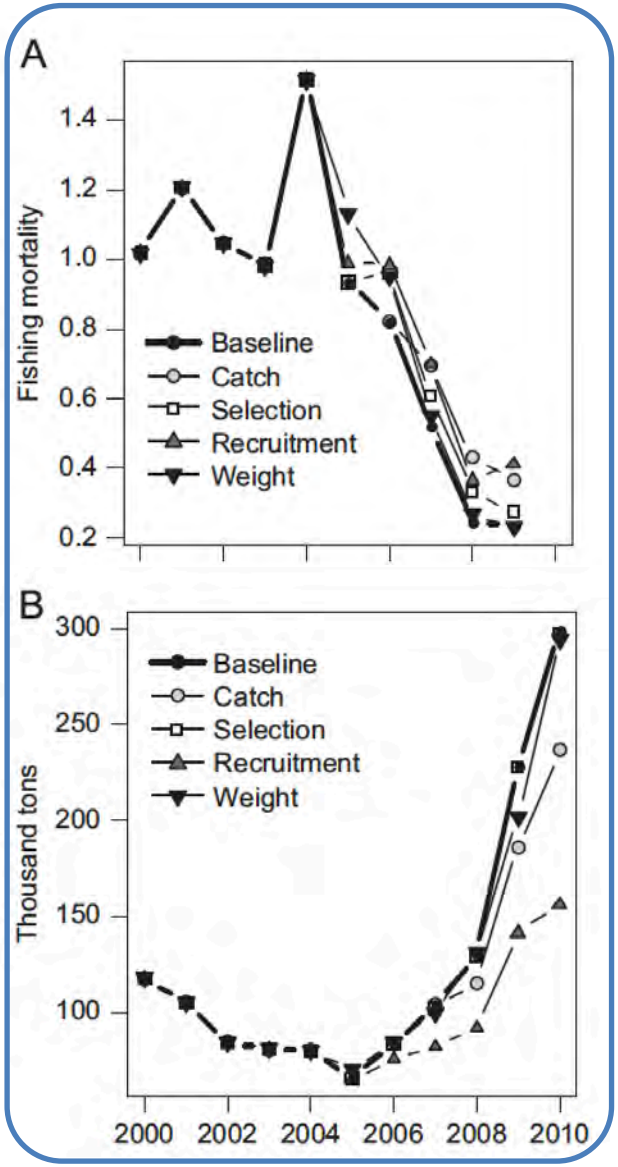
Baltic Sea Regime shift (late 1980s) – cod collapse

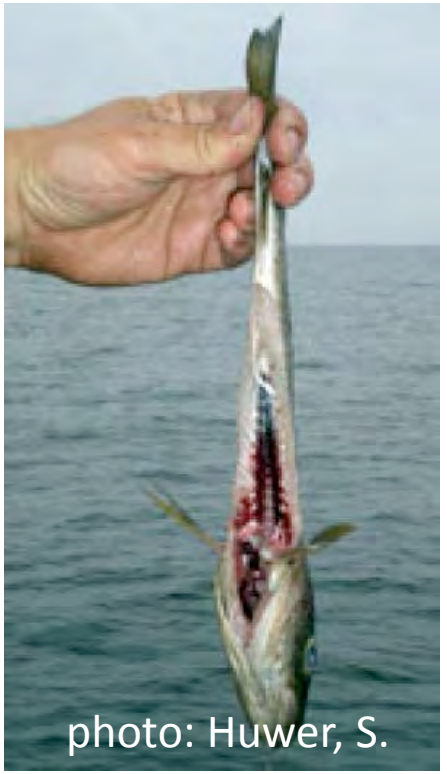


Carstensen *et al.* (2014)



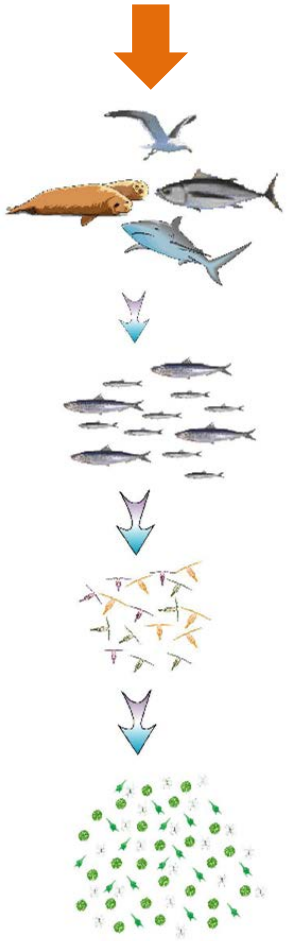
Alheit *et al.* (2005)



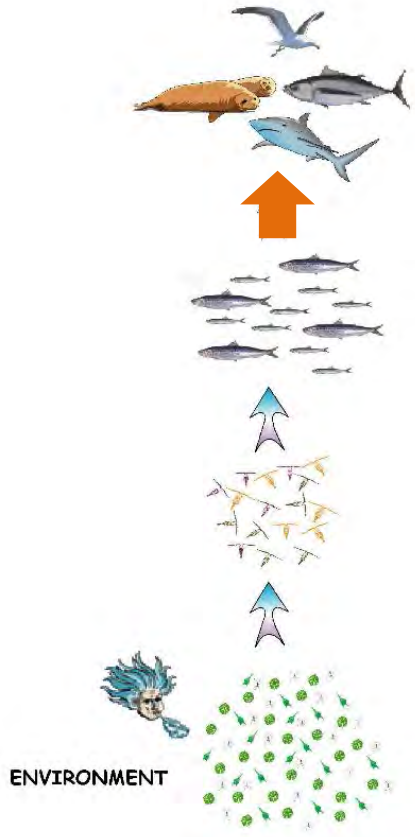


Eero *et al.* (2012)

From top-down to bottom-up control?

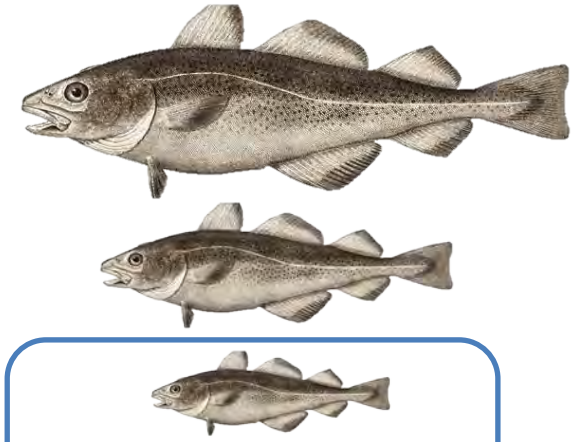


Top- Down

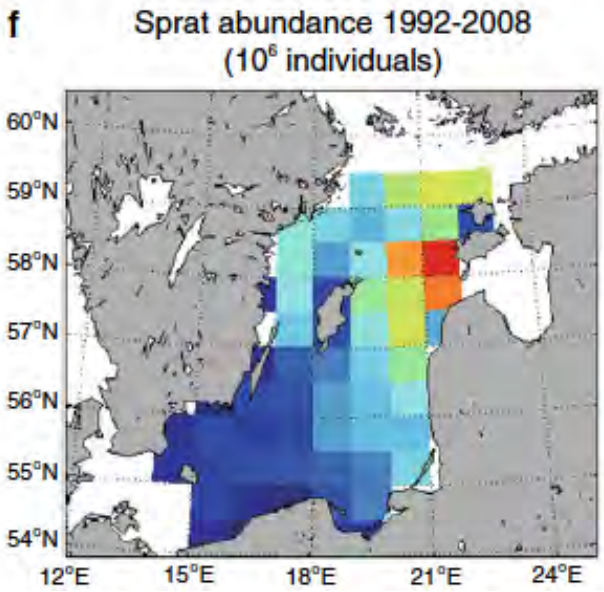


Bottom-Up

(Cury et al. 2007)

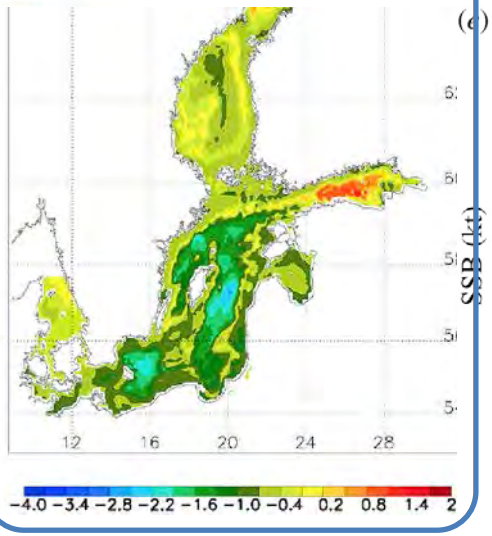
What does  eat?

Cod (*Gadus morhua*)



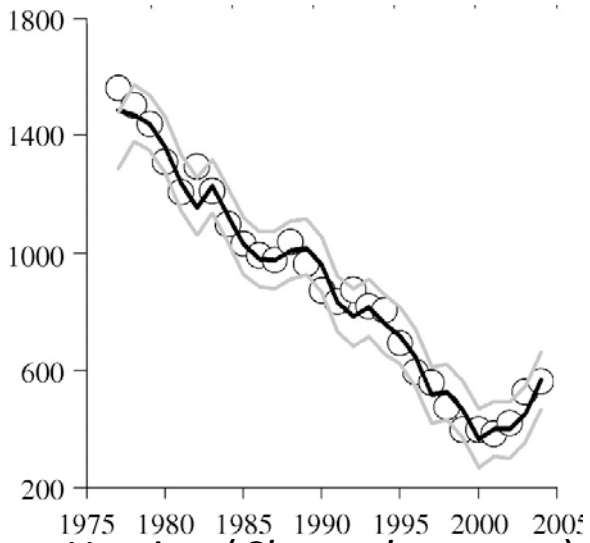
Sprat (*Sprattus sprattus*)

(Casini *et al*. 2011)



Saduria entomon

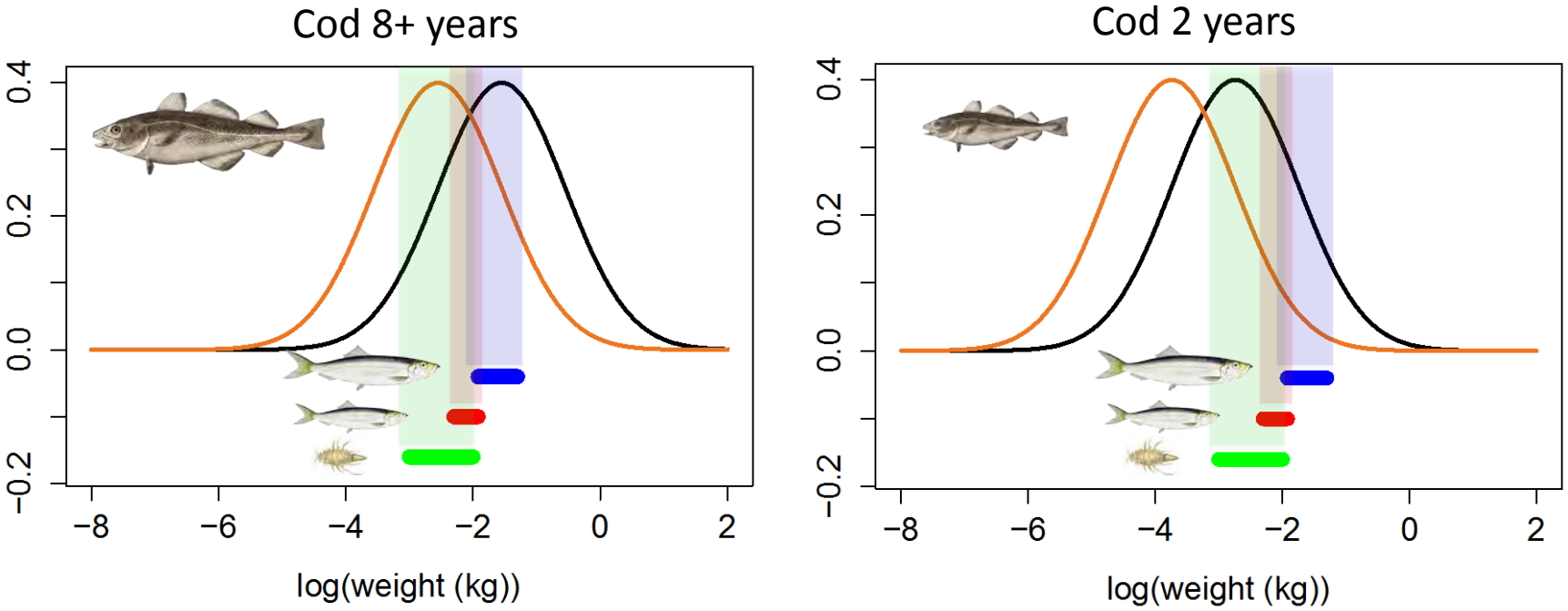
(Meier *et al*. 2011)



Herring (*Clupea harengus*)

(Lindegren *et al.* 2010)

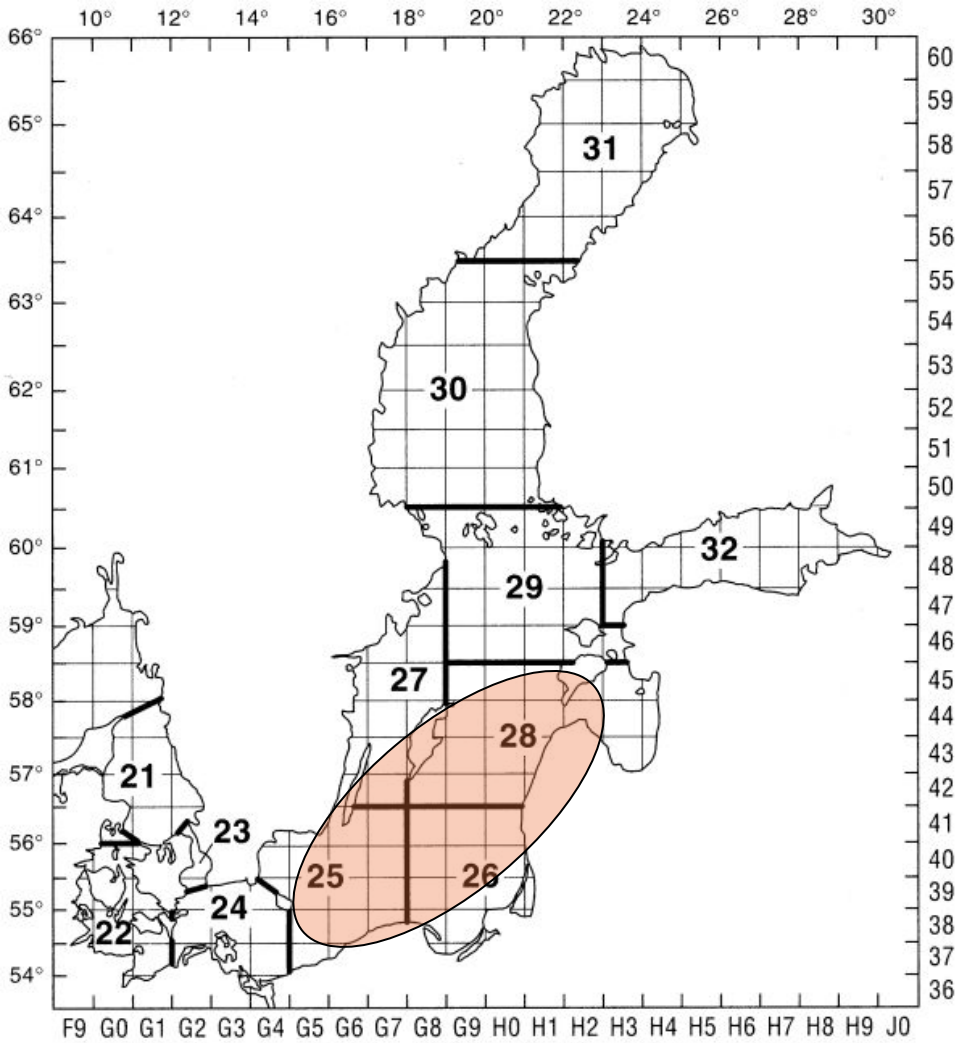
Optimum predator-prey ratio - available prey size



$$\varphi(x - x') = \frac{1}{\sigma\sqrt{2\pi}} \cdot \exp\left(-\frac{(x - x' - 3)^2}{2\sigma^2}\right)$$

- Barnes *et al.* (2009): pred-prey ratio = log(3) = **1000**
- Blanchard *et al.* (2009) : pred-prey ratio = log(2) = **100**

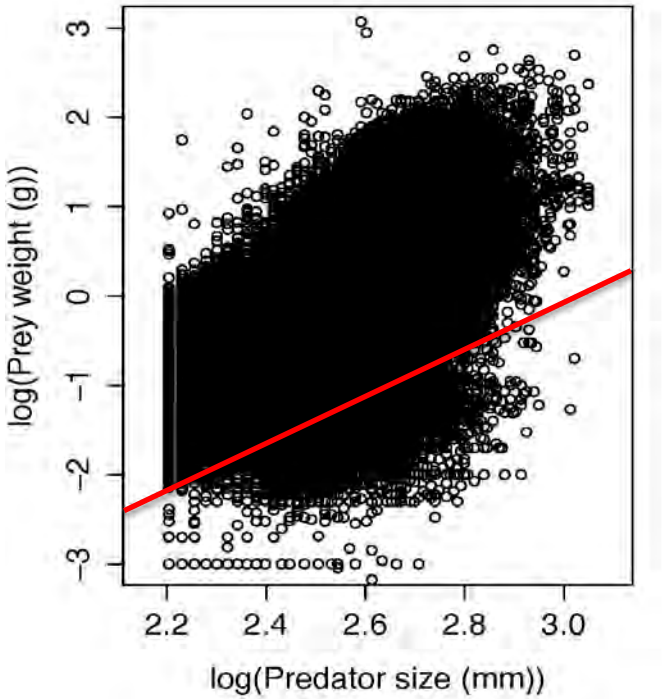
Eastern Baltic cod stomach data



Data provided by LATFFRI and the ICES Study Group SPATIAL

Median predator-prey weight ratio:

725



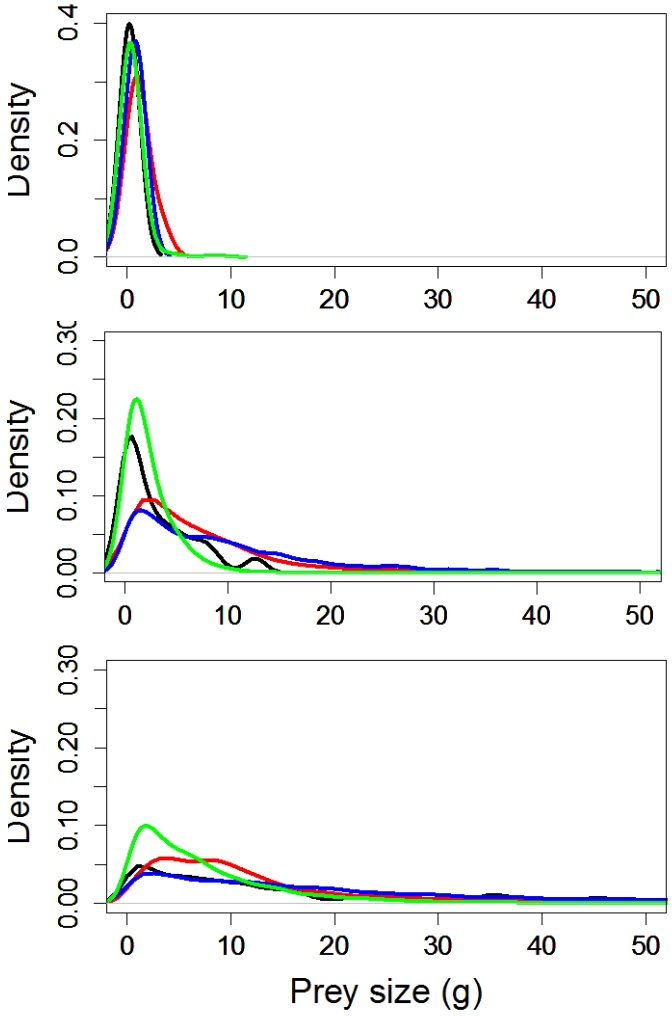
< 20 cm 20-40 cm > 40 cm

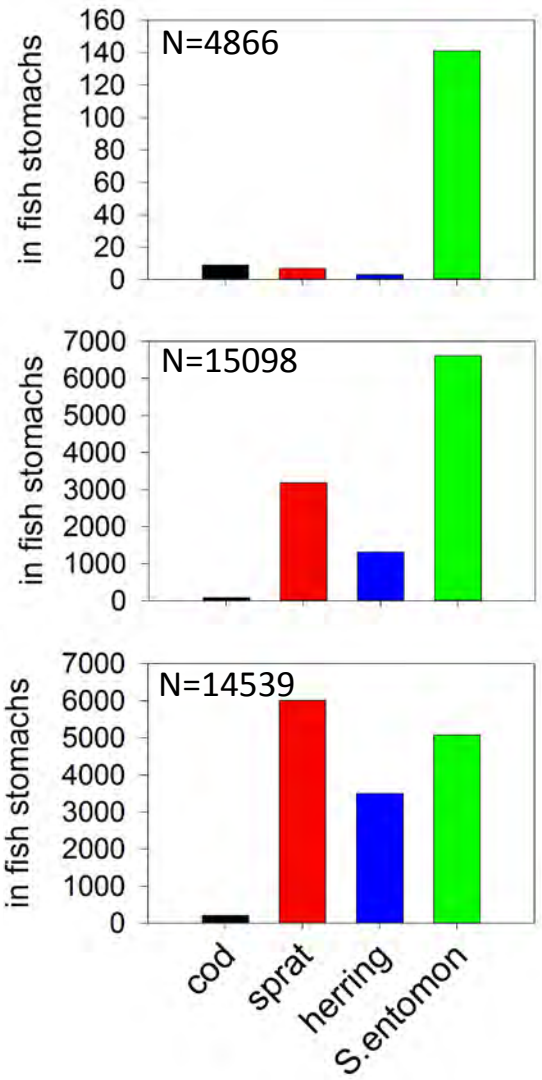
Prey size distribution in cod stomachs

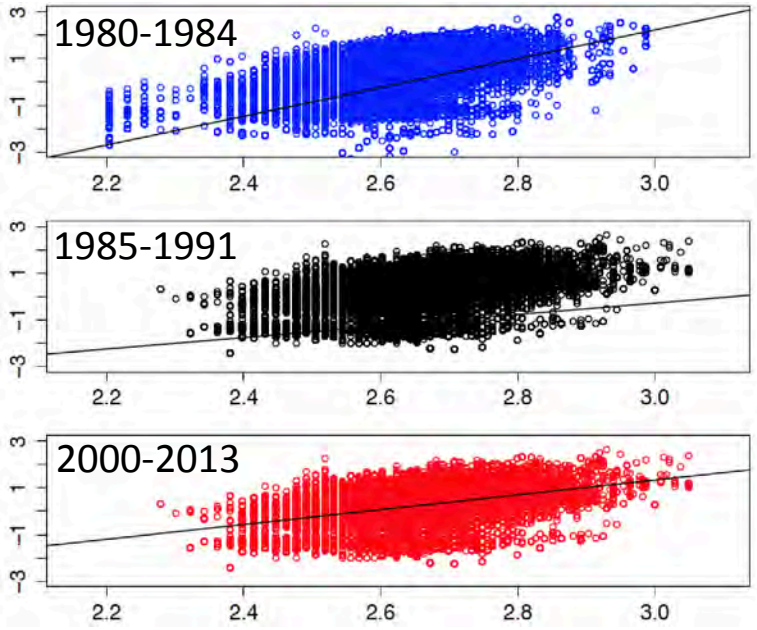
< 20 cm

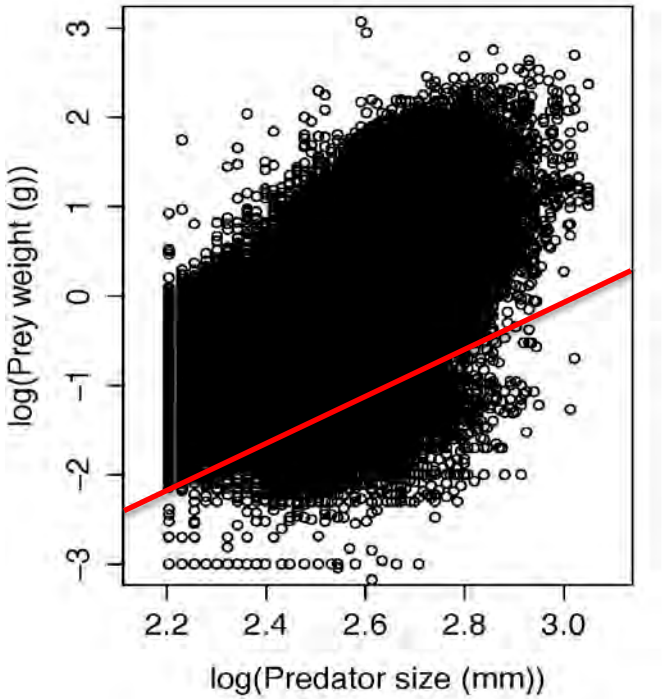
20 -40 cm

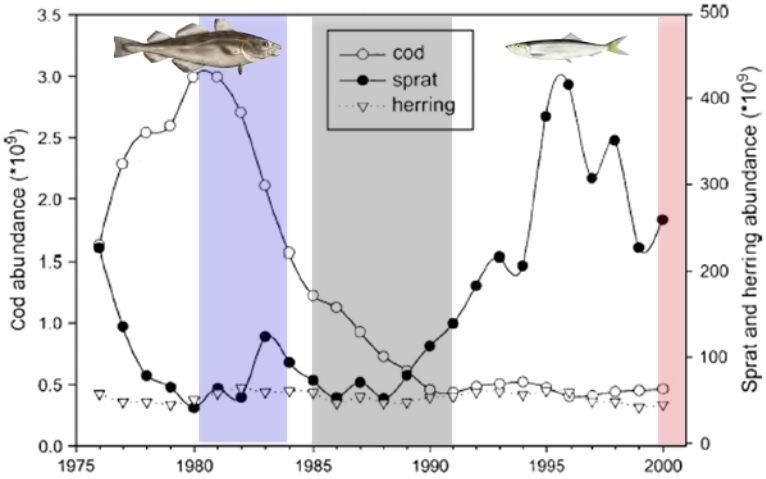
> 40 cm











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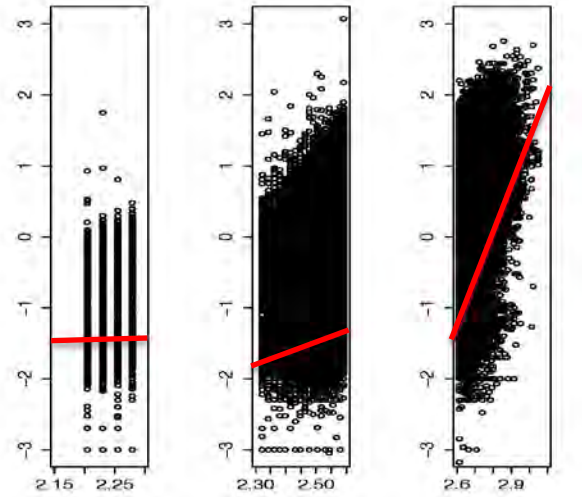
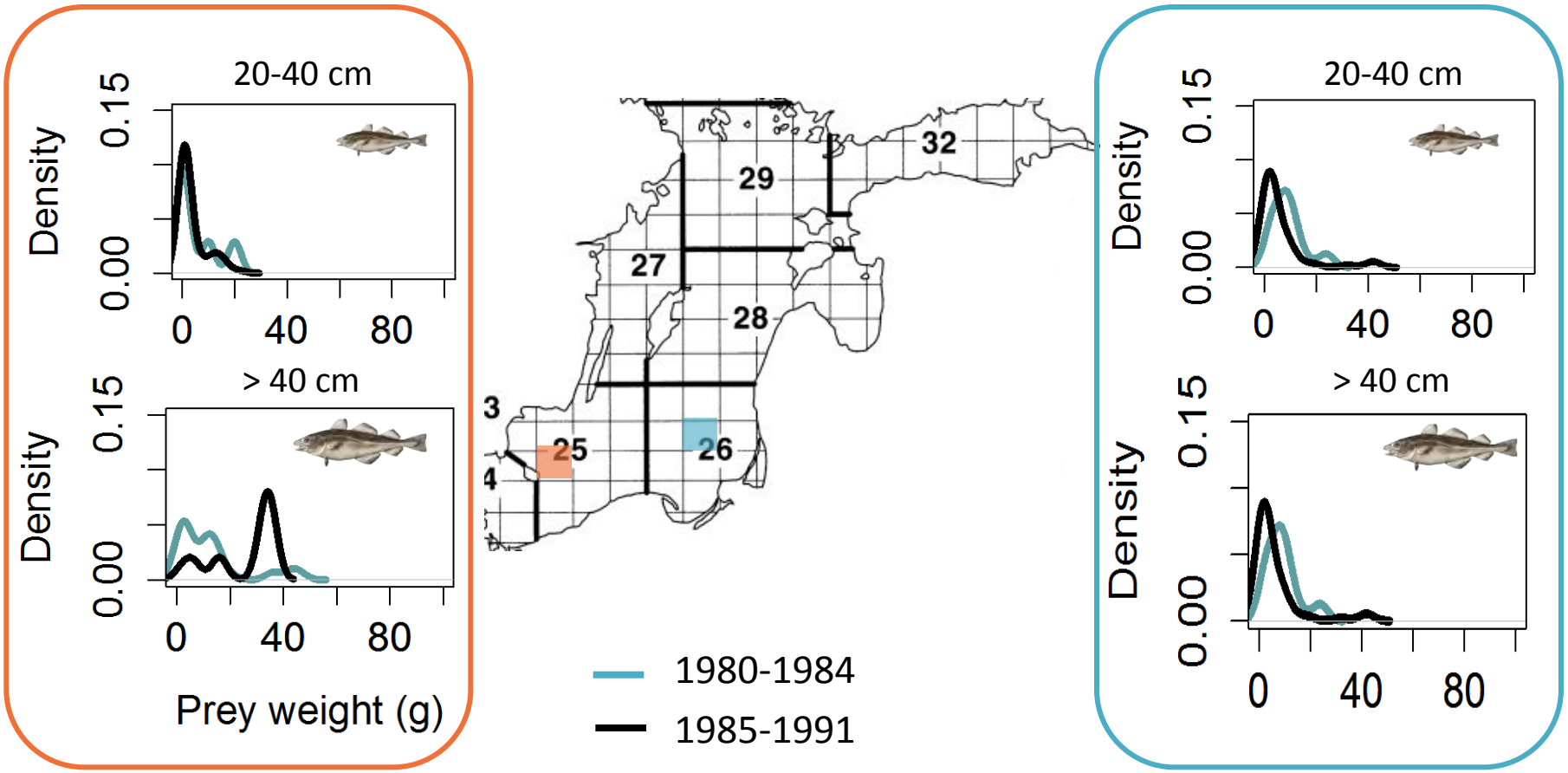


< 20 cm 20-40 cm > 40 cm

Changes in location specific size-distributions



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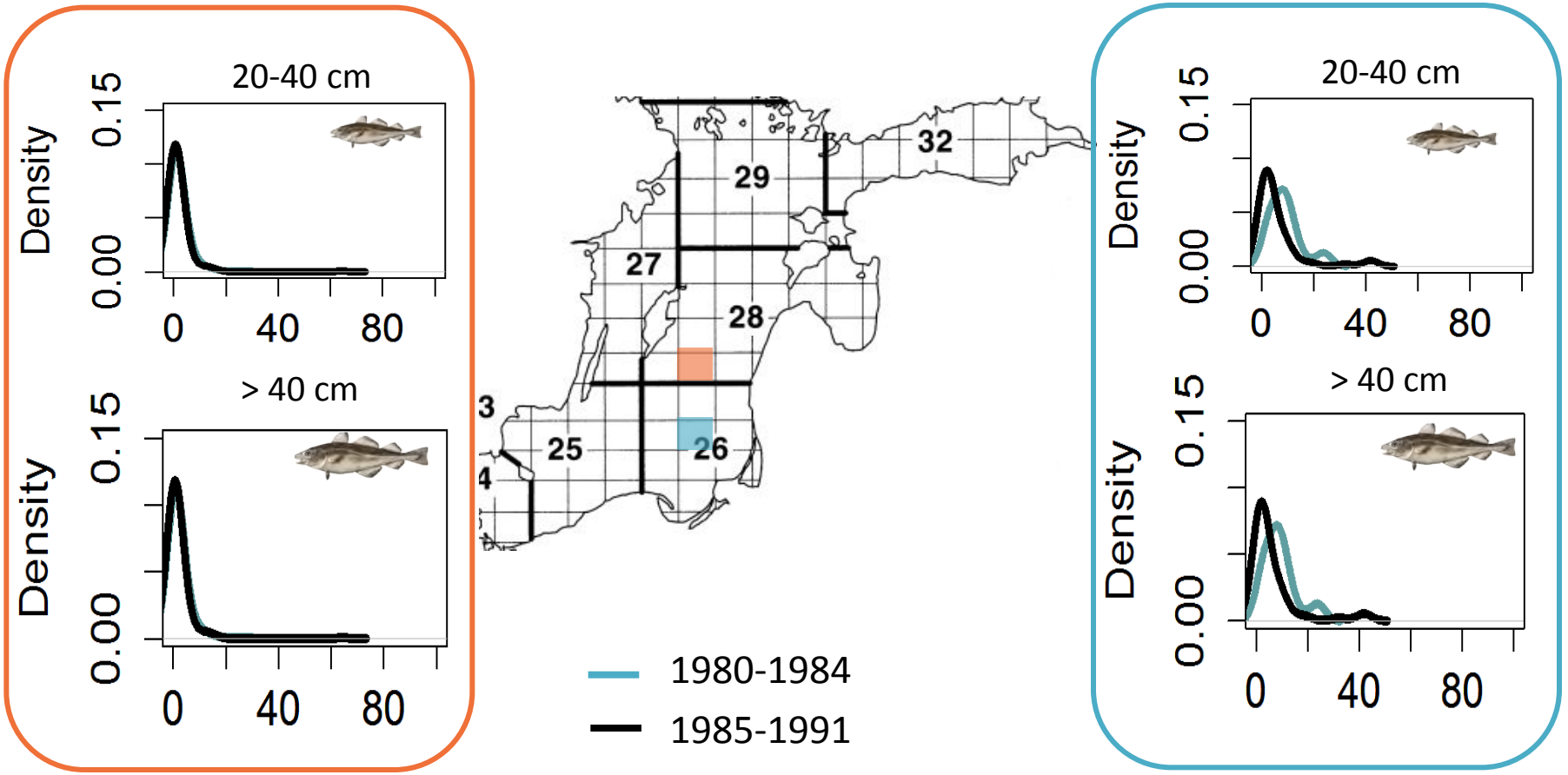


Size-structured modeling approach

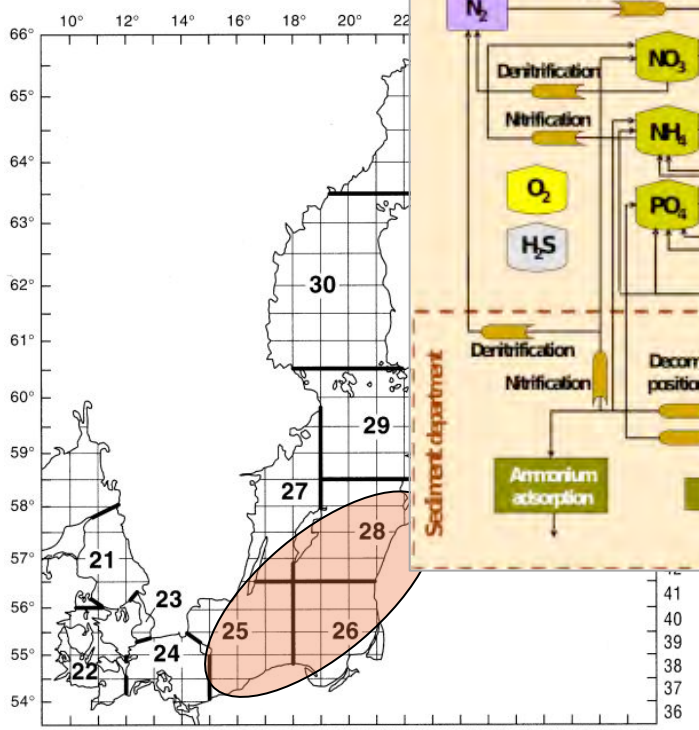
(Re-developed based on the global model by Watson *et al.* 2014)

- A size-structured spatially explicit (2D) food web model, which includes benthic and pelagic components that are linked by trophic interactions
- The feeding dynamics are based on preferred predator-prey size relationships (e.g., Barnes *et al.* 2010, Blanchard *et al.* 2009)
- Generalized formulations will be used to describe the most important biological rates (e.g., feeding, metabolic cost, energy allocated to reproduction and mortality). These formulations will include effects of organism size and environmental conditions (e.g., T, O2)

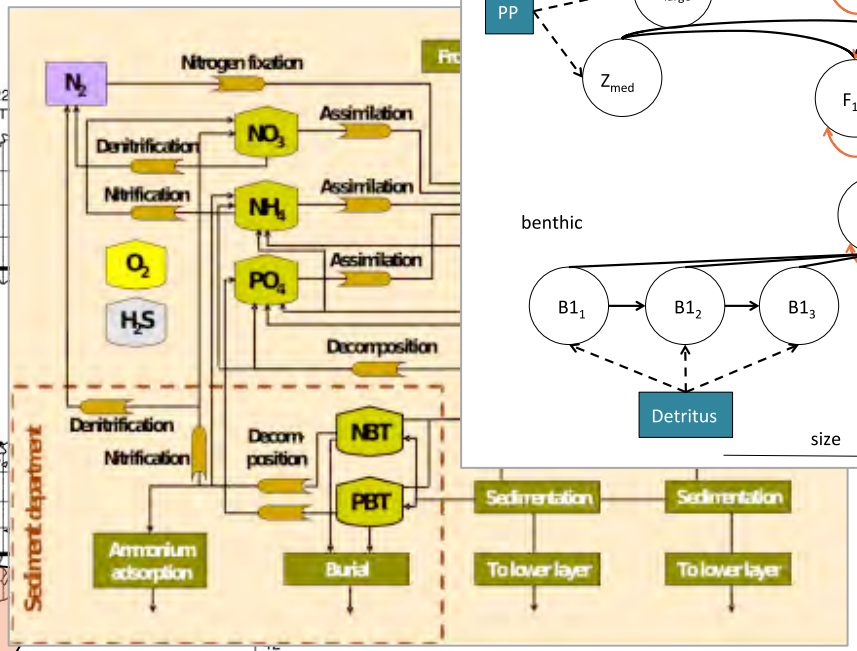
Size-structured modeling approach

- Baltic Sea

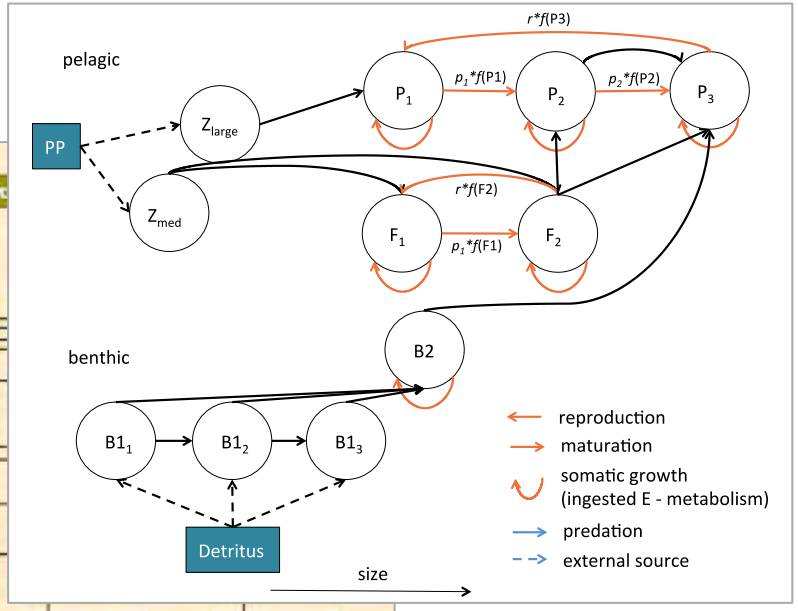
2D/2-layer



biogeochemistry

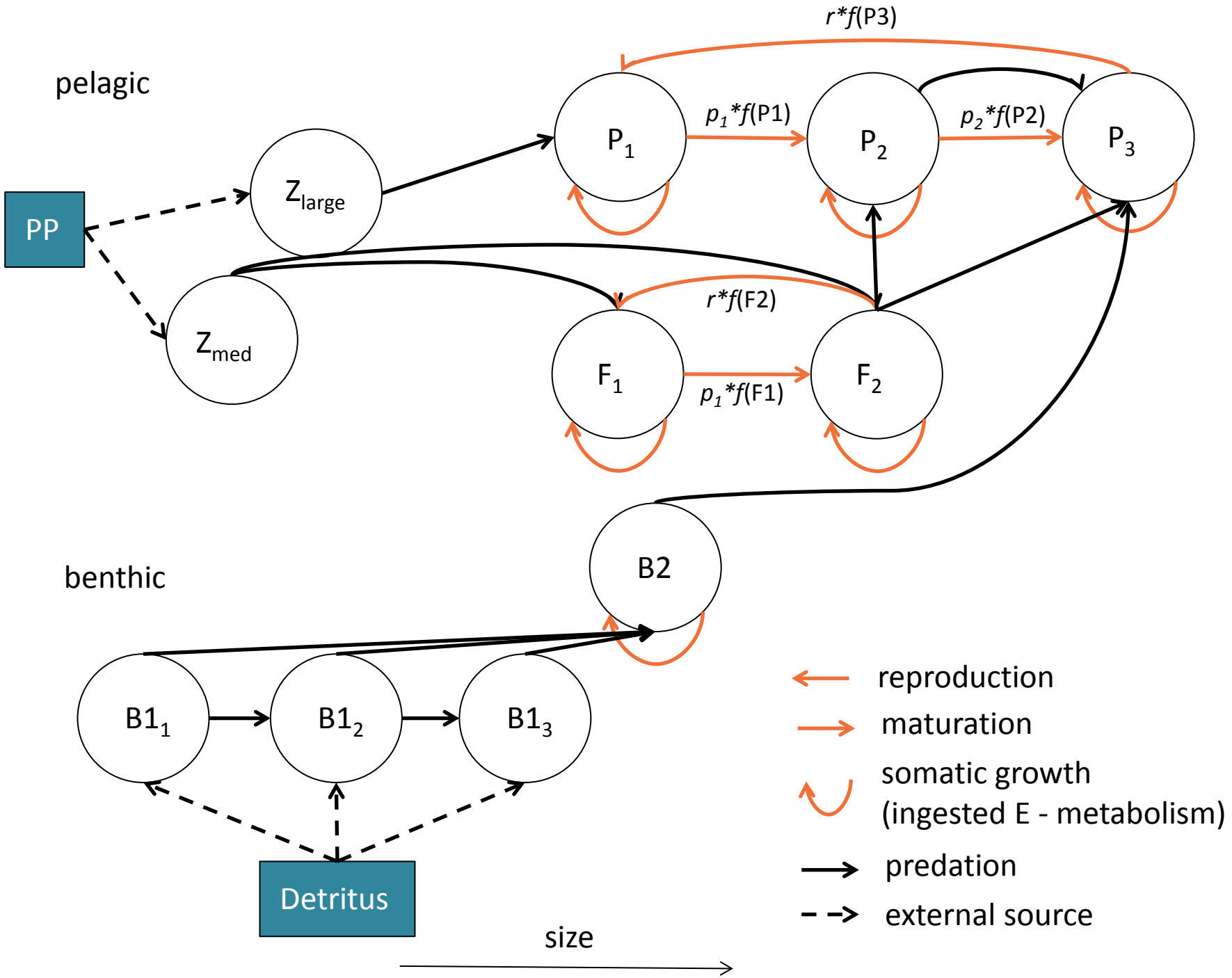


Size-structured food web



PP, DET

RCO-SCOBI (Eilola *et al.* 2009)


pelagic
benthic
PP
Z_{large}
Z_{med}
P_1
P_2
P_3
F_1
F_2
B2
$B1_1$
$B1_2$
$B1_3$
Detritus
$r*f(P3)$
$p_1*f(P1)$
$p_2*f(P2)$
$r*f(F2)$
$p_1*f(F1)$
reproduction
maturation
somatic growth
(ingested E - metabolism)
predation
external source
size

Appetizers

Can the size-structured model provide support to the “resource” theory (emergence of observed dynamics)?

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Can we go from global to regional and back?

Thank you.

Acknowledgements

- ICES Travel support
- ICES SG on the Spatial Analysis for the Baltic Sea (SGSPATIAL)
- GreenMAR

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

GreenMAR
GREEN GROWTH BASED ON MARINE RESOURCES: ECOLOGICAL AND SOCIO-ECONOMIC CONSTRAINTS