

Biophysical modelling of early life stages of sprat in the North and Baltic Seas:

process knowledge gained during the German GLOBEC programme

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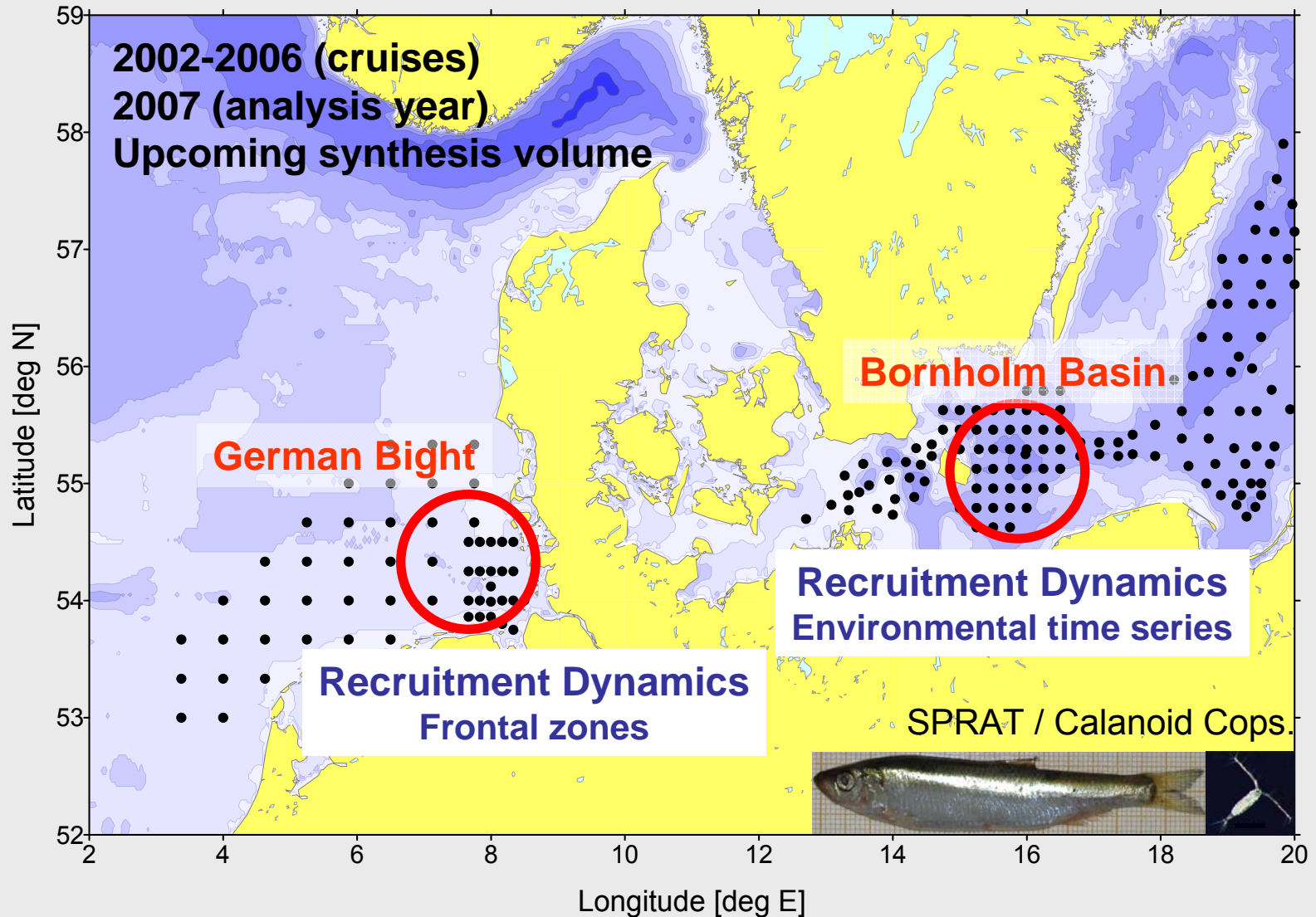
5) Sustainable Fishery, Dept. of Economics, University of Kiel
Kiel, Germany



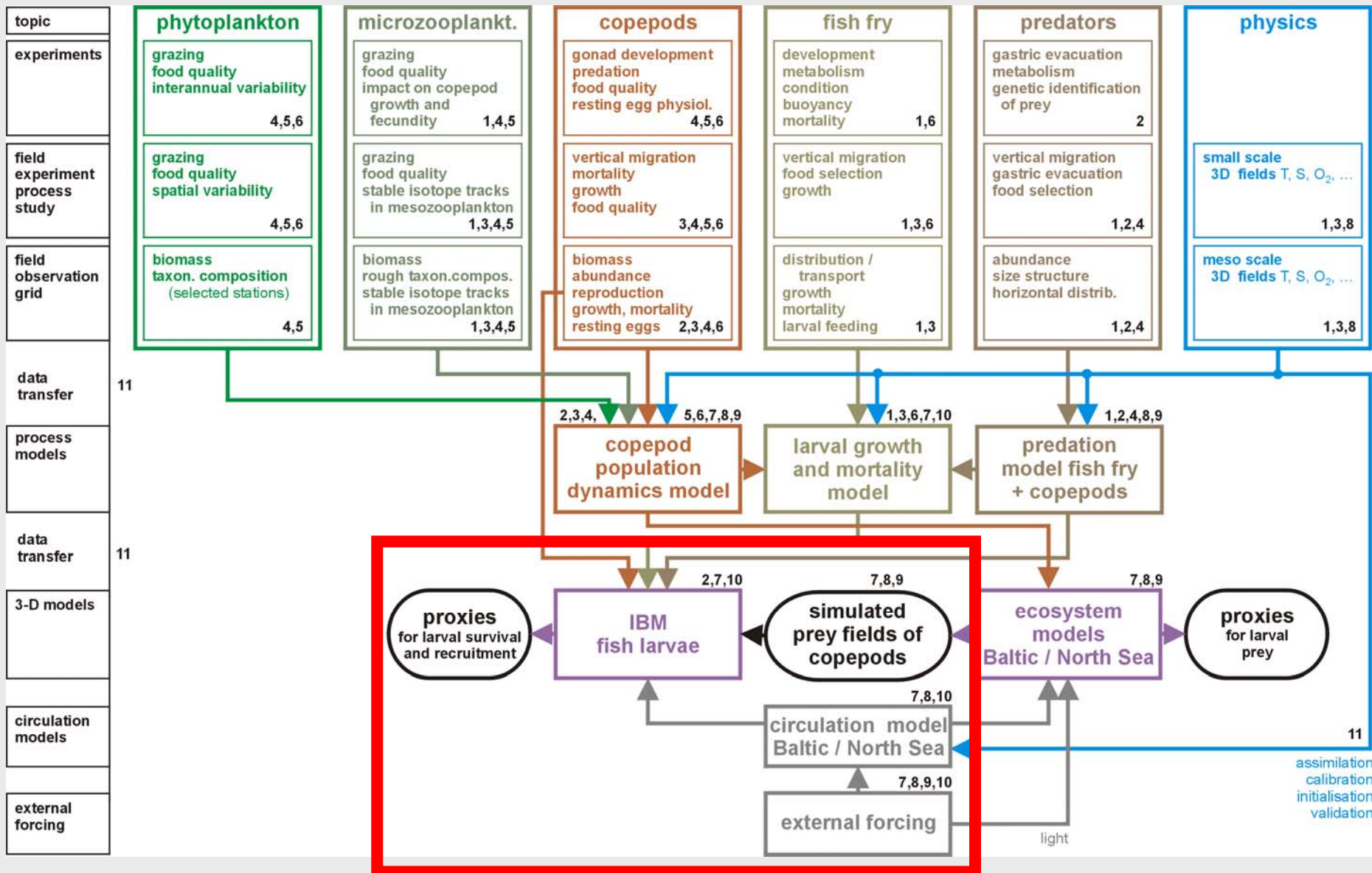
GLOBEC
Germany



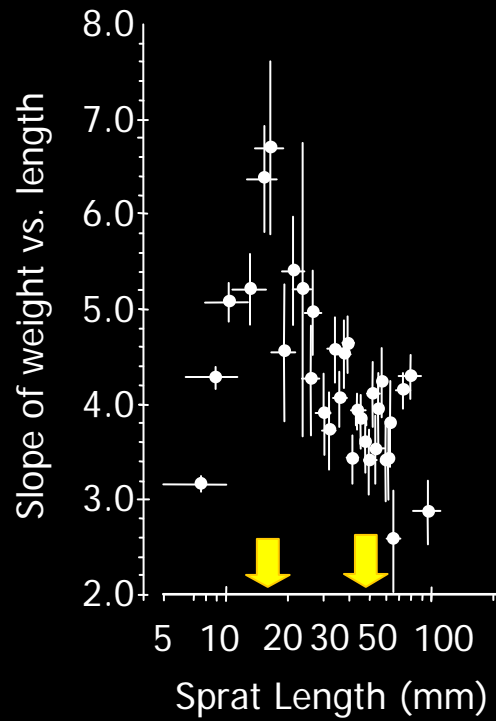
German GLOBEC Baltic & North Sea station grids



German GLOBEC Program



Sprattus sprattus



15 mm



23 mm



25 mm



27 mm



37 mm



43 mm



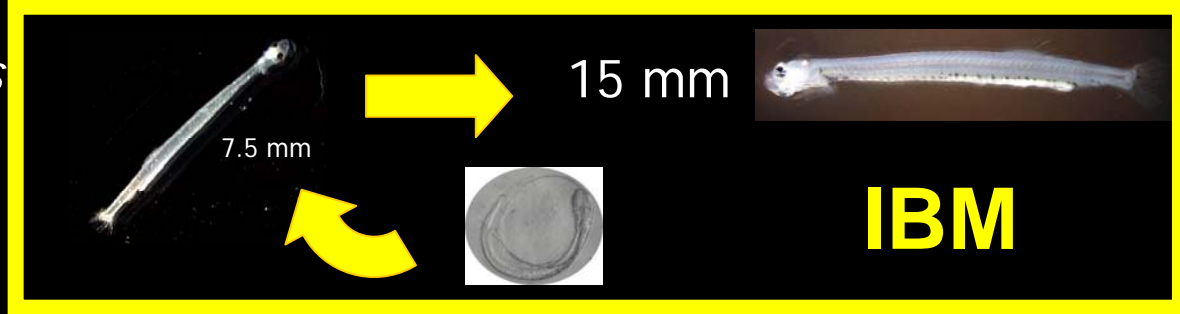
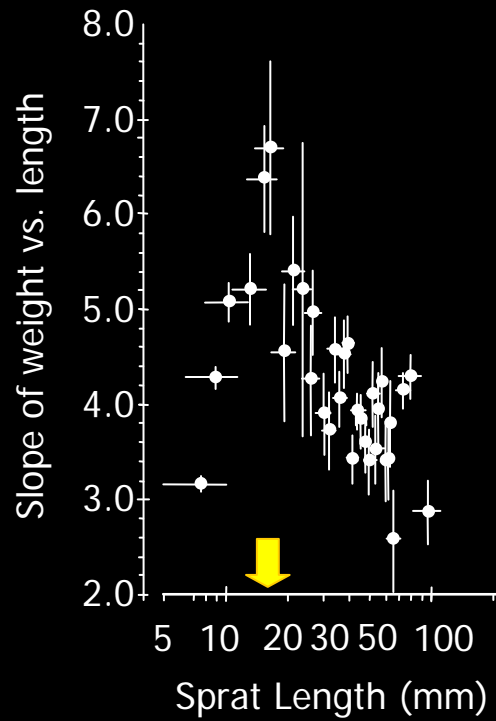
50 mm



63 mm



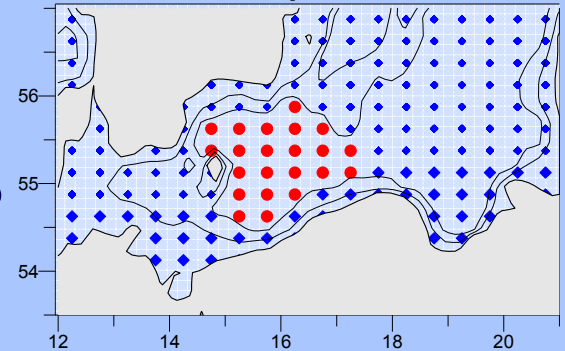
Sprattus sprattus



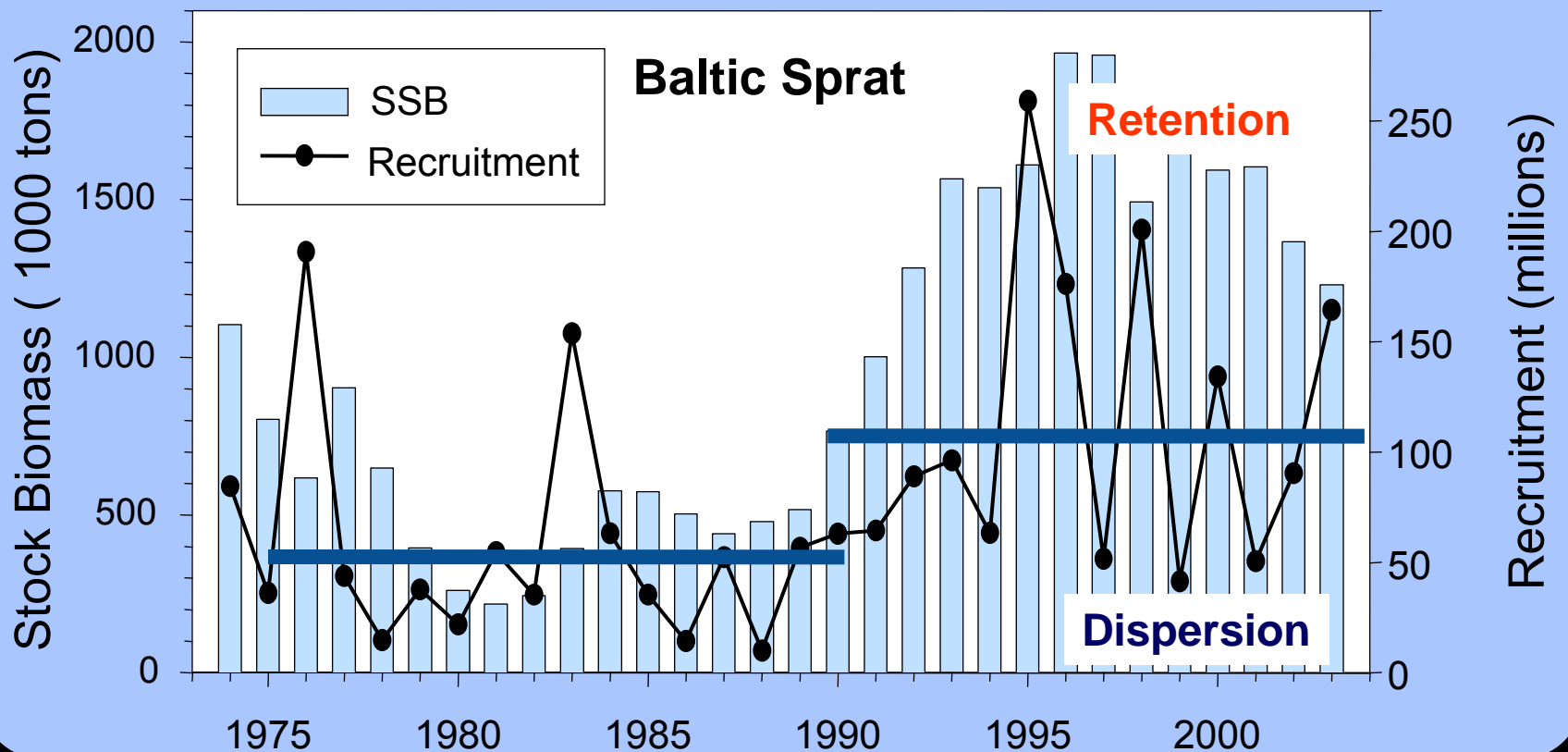
2) Lagrangian transport model

1) Hydrodynamic Model (3d)

Bornholm Basin Retention vs Dispersion



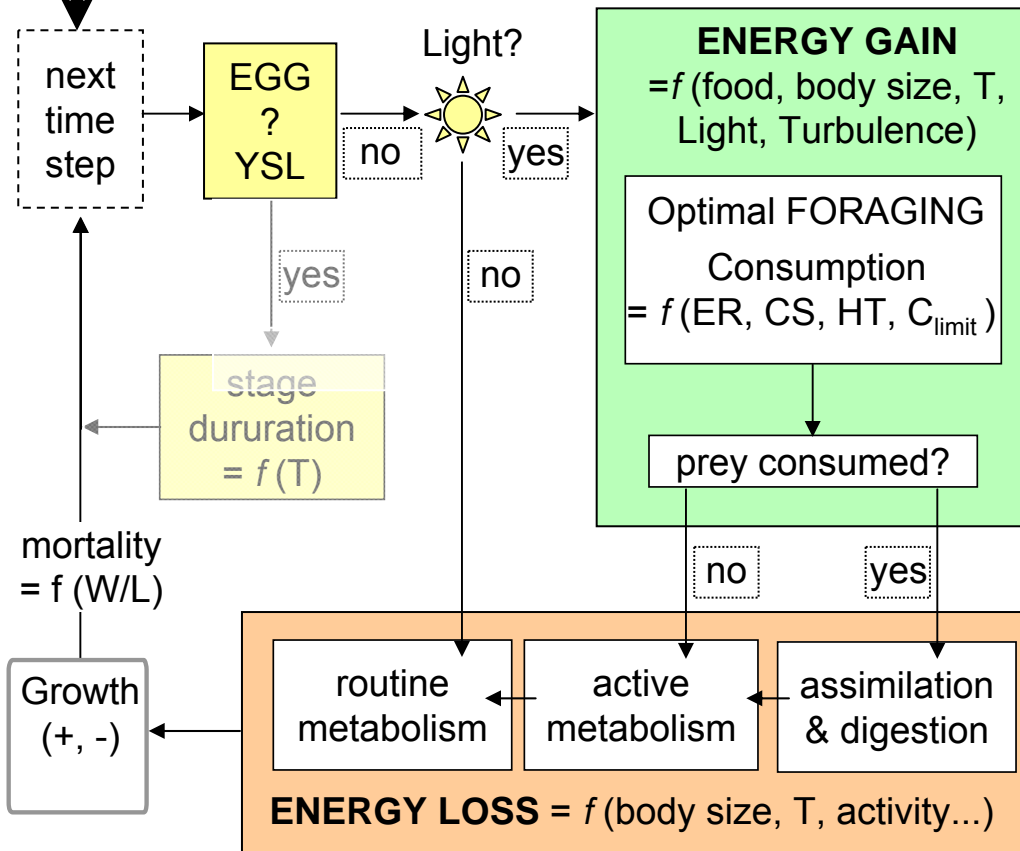
Model with SSB +T + Drift explains >70% Recruitment variability in Baltic Sprat (Baumann, Hinrichsen et al.)



2) Lagrangian transport model

1) Hydrodynamic Model (3d)

3) individual-based model



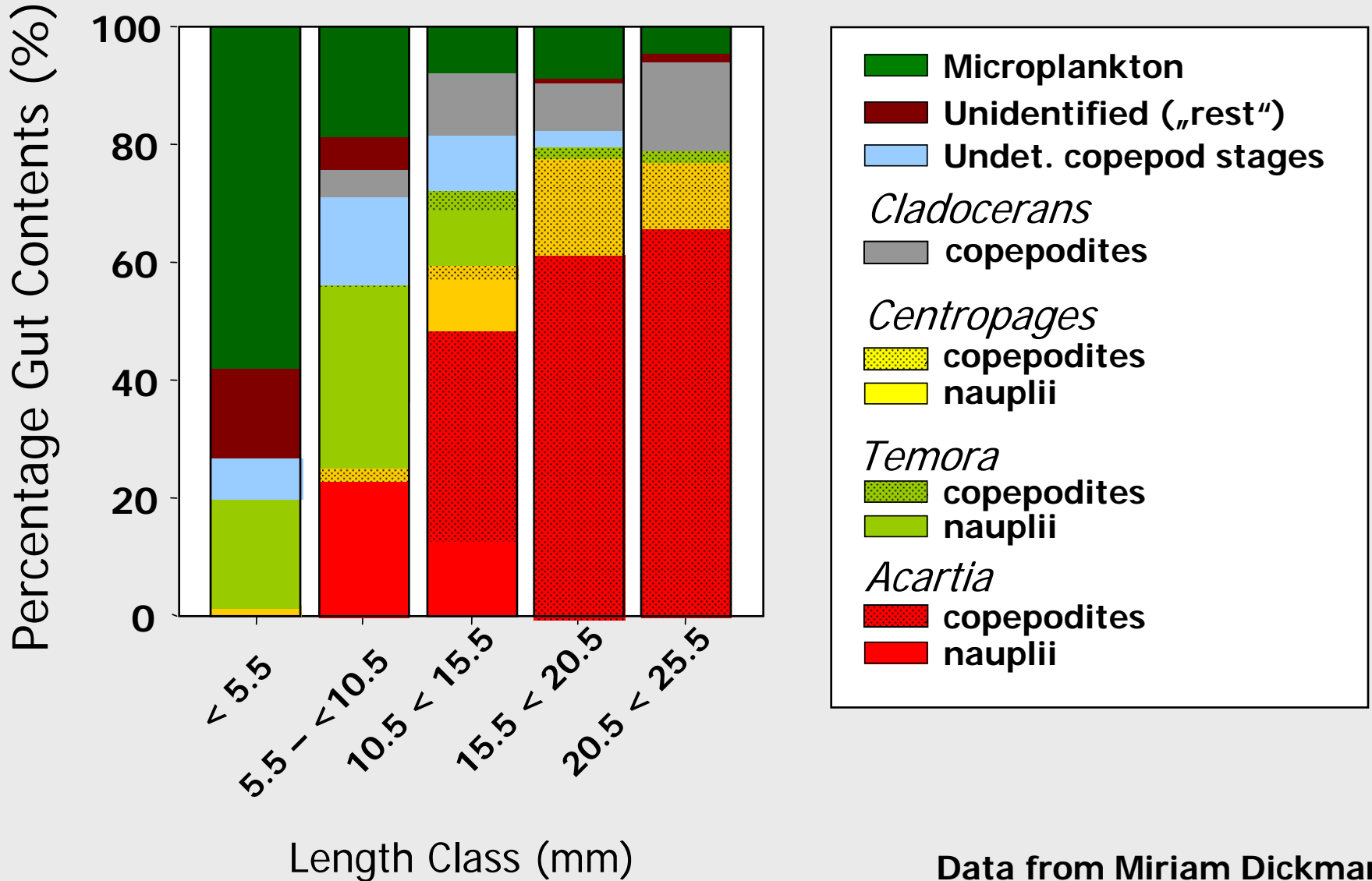
METHOD 2

assess
Measurements
(depth resolved
and bottom
Multinet, VPR)

In situ Eye
Field

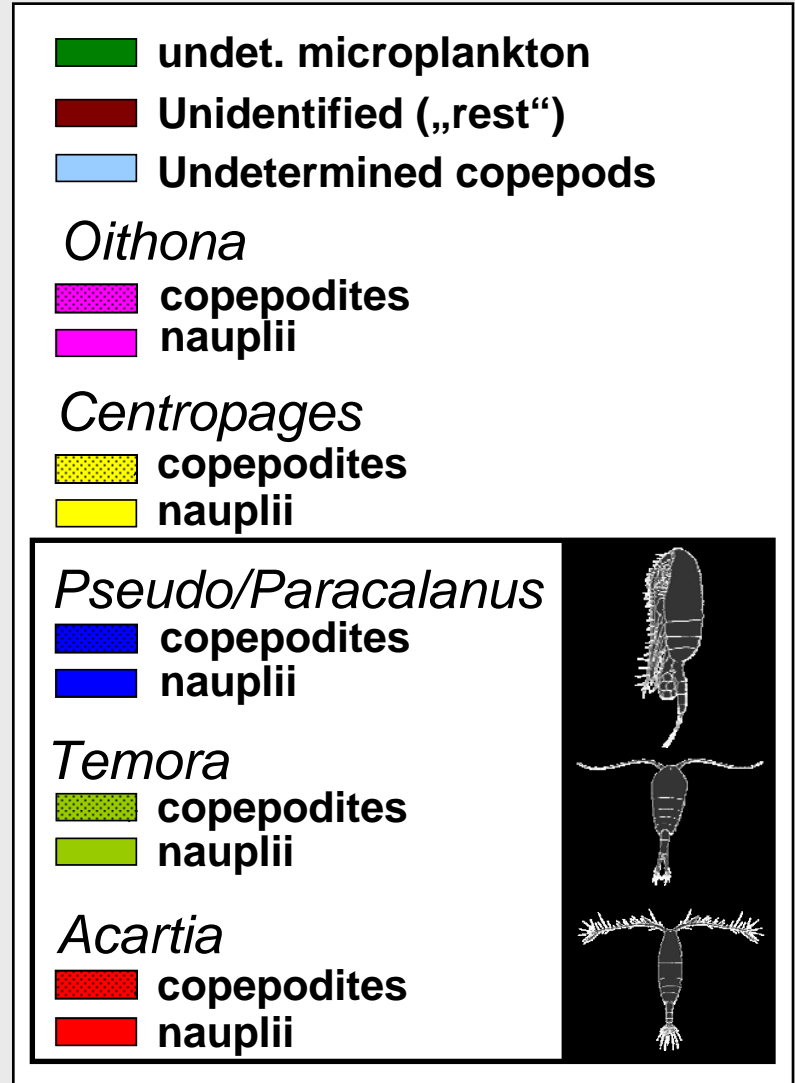
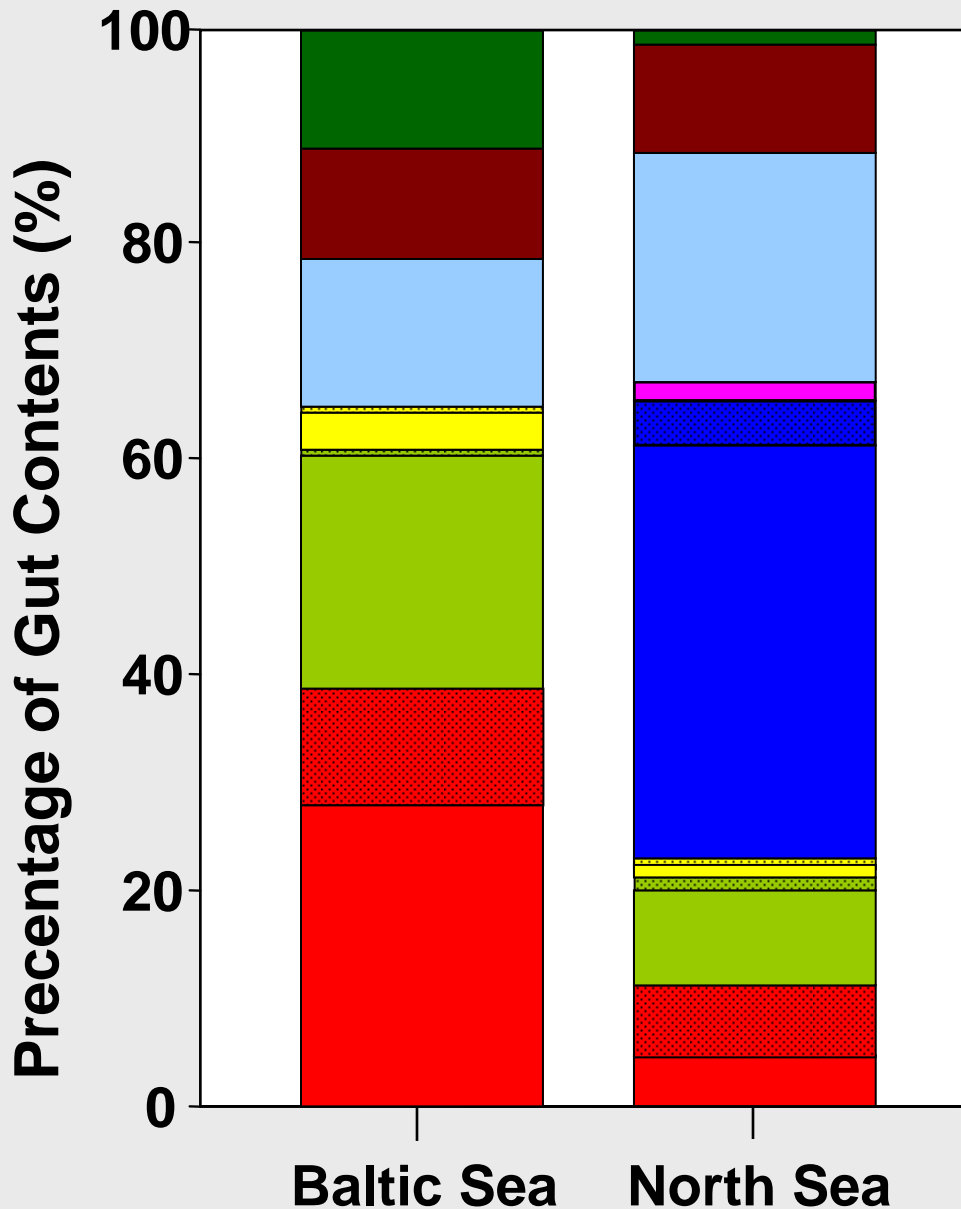


What do larval sprat eat in the Baltic Sea?



Data from Miriam Dickmann

Larval sprat diet: Baltic vs. North Sea (2003-2005)



Data from Miriam Dickmann

2) Lagrangian transport model

1) Hydrodynamic Model (3d)

ecosystem (NPZD) model

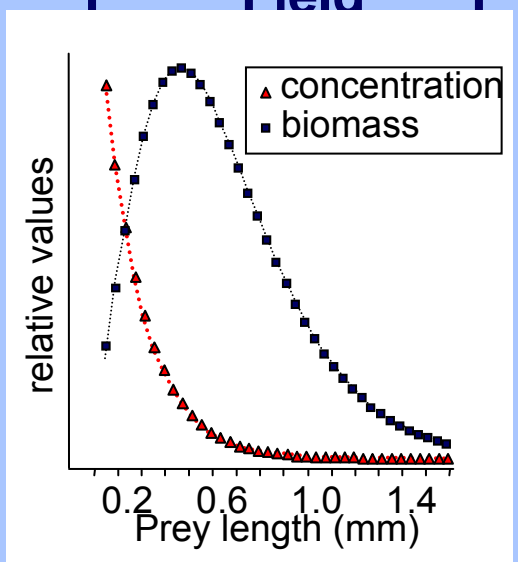
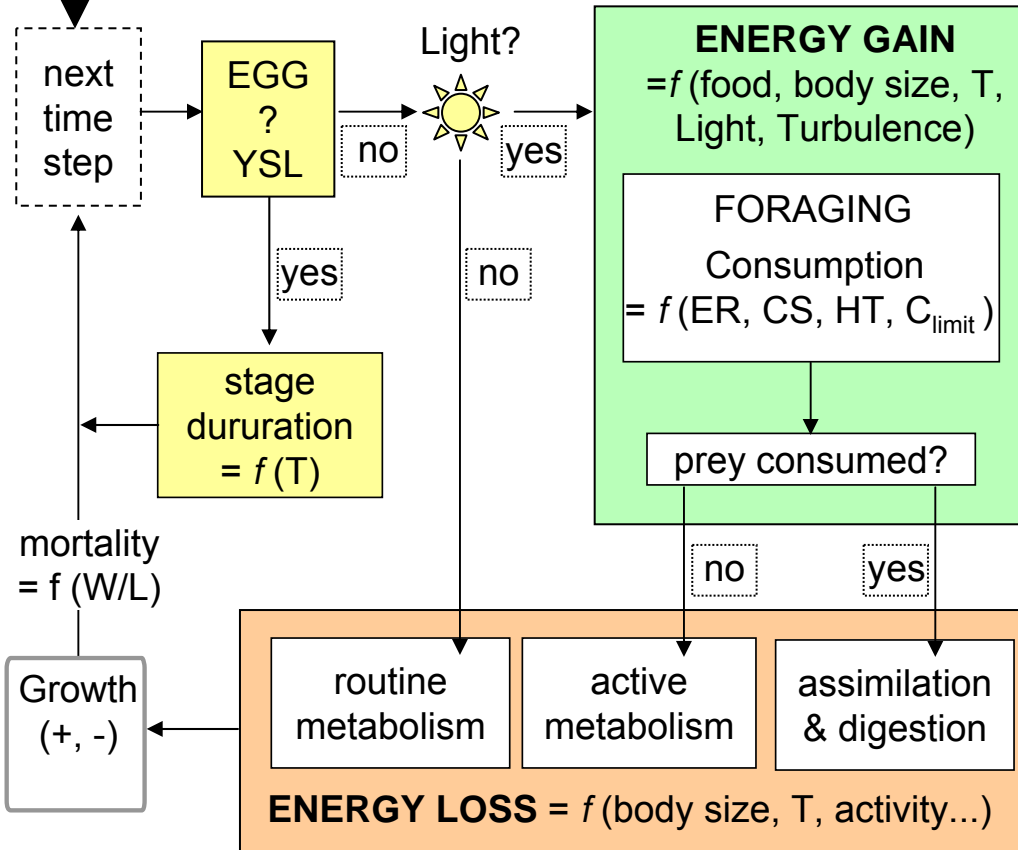
METHOD 3

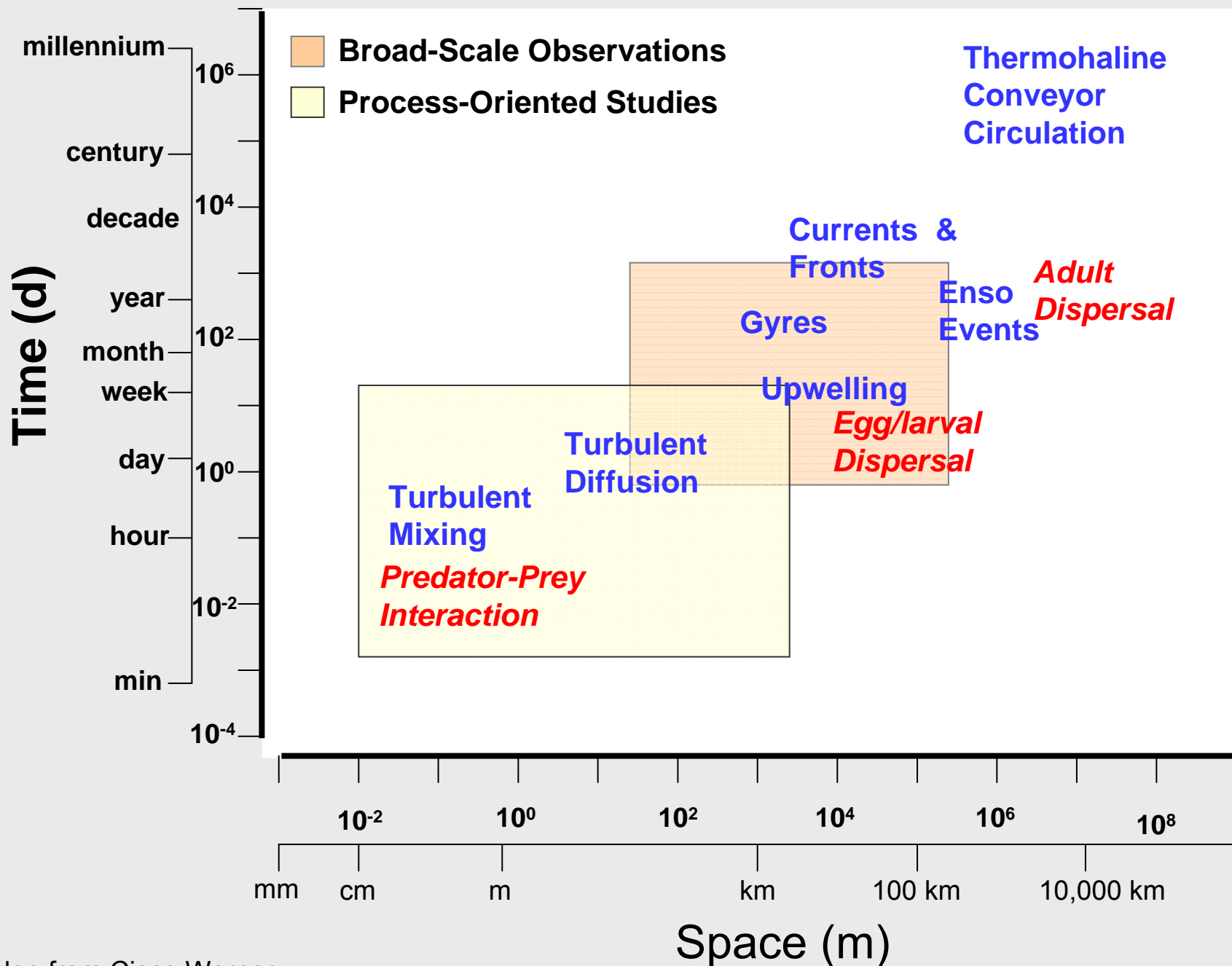
zooplankton biomass

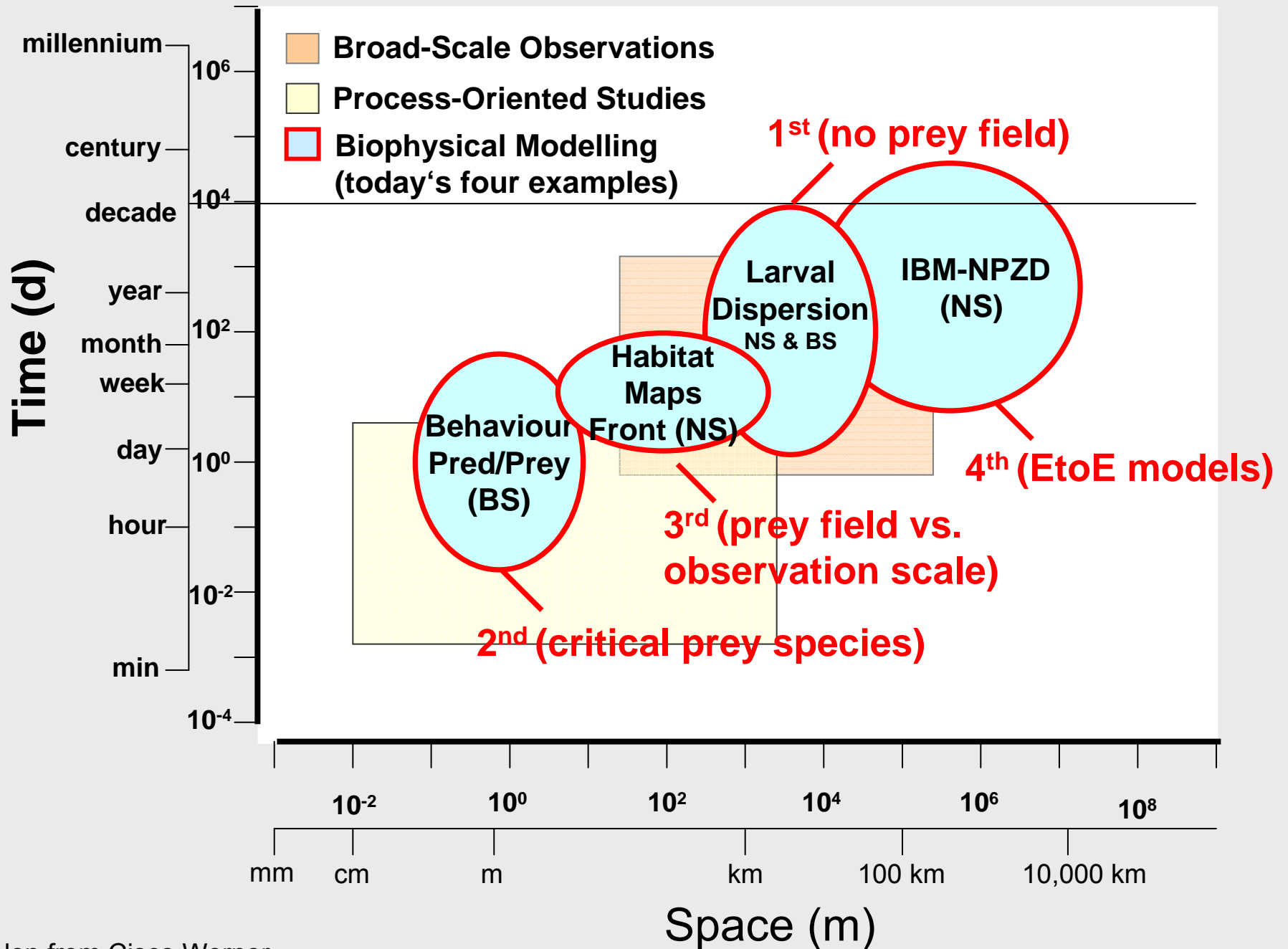
(depth resolved Multinet, VPR)

In situ Prey Field

3) individual-based model







Previous / ongoing Studies

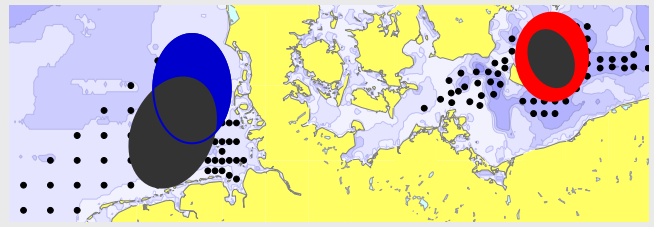
- 1) Peck, Daewel (2007) **Physiologically based** limits to food consumption, and **individual-based modeling of foraging and growth** of larval fishes. Mar Ecol Prog Ser 347:171-183
- 2) Kühn, Peck, Hinrichsen & 9 co-authors (2008) Defining **habitats suitable for larval fish** in the German Bight (southern North Sea): An IBM approach using spatially and temporally resolved, **size-structured prey fields**. J Mar Syst 74:329-342
- 3) Daewel, Peck, Kühn, St. John, Alekseeva, Schrum (2008) **Coupling ecosystem and individual-based models** to simulate the influence of environmental variability on potential growth and survival of larval sprat (*Sprattus sprattus* L.) in the North Sea. Fish Oceanogr 17:333-351
- 4) Hinrichsen, Peck, Schmidt, Huwer, Voss (In Prep) **Decadal changes in the diel vertical migration** behaviour in Baltic sprat larvae: causes and consequences. Limnol Oceanogr
- 5) Hinrichsen, Kühn, Peck, Voss (In prep) The impact of physical and biological factors on the **drift and spatial distribution of larval sprat**: A comparison of the **Baltic and North Seas**. Prog Oceanogr
- 6) Peck, Kühn & 5 co-authors (In prep) **Larval growth rate variability at frontal zones** in the southern North Sea: Is the mean all that matters? Prog Oceanogr

IBM Example 1: Drift of Feeding Sprat Larvae

Temperature-dependent growth
(from 10 to 17 mm)

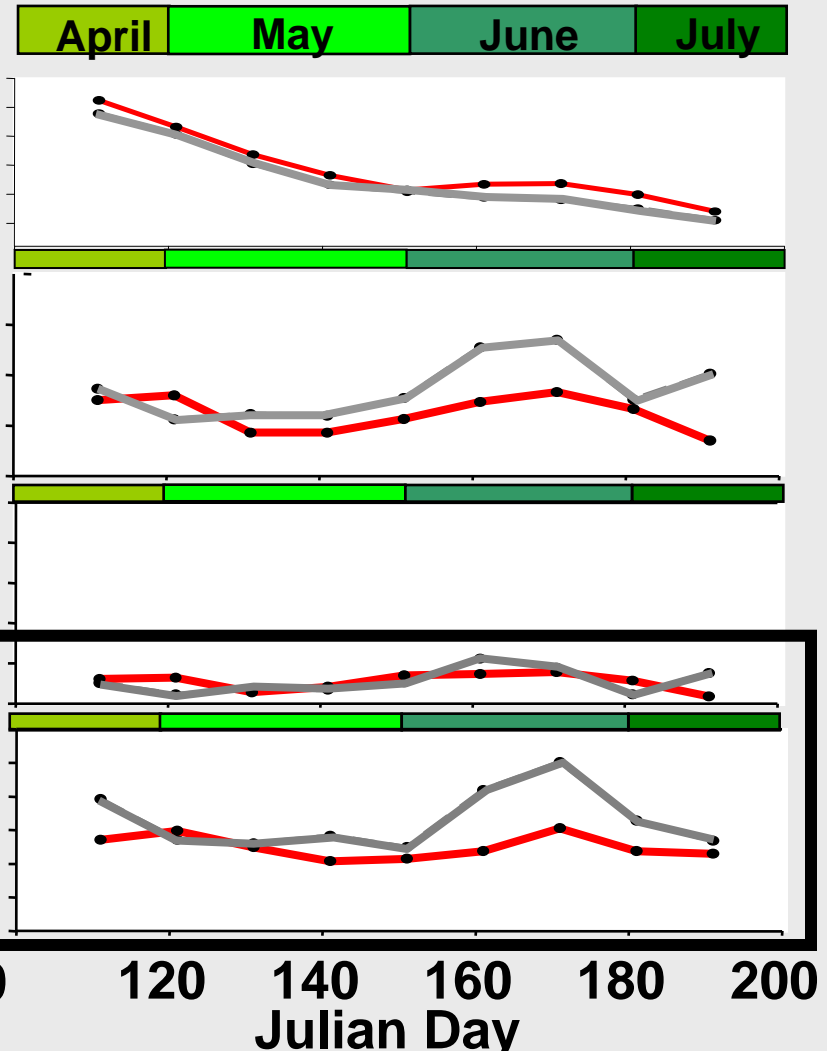
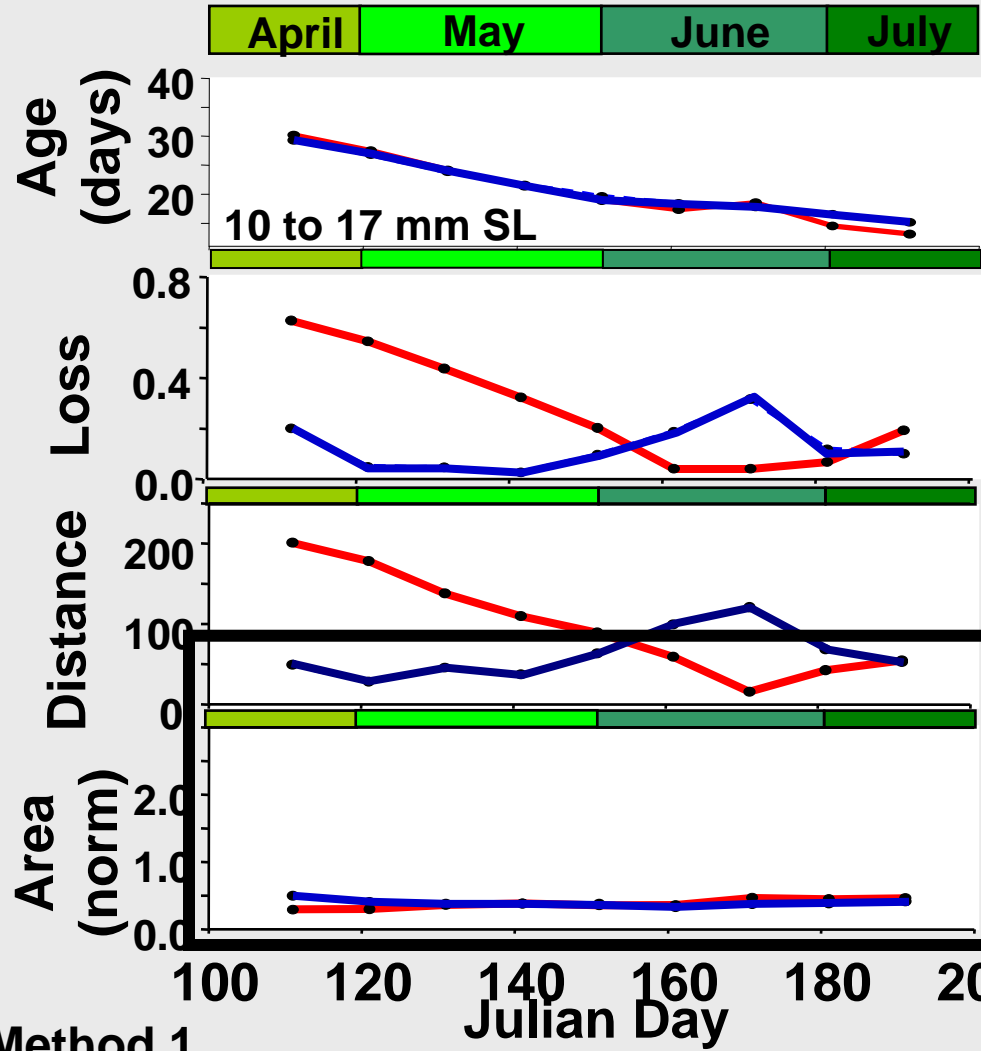
Dispersion
Kernels



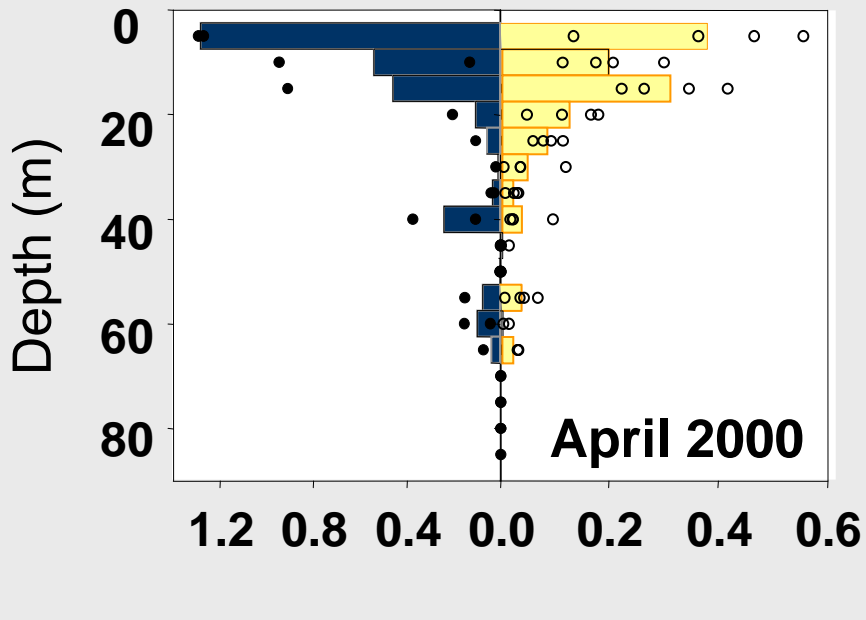
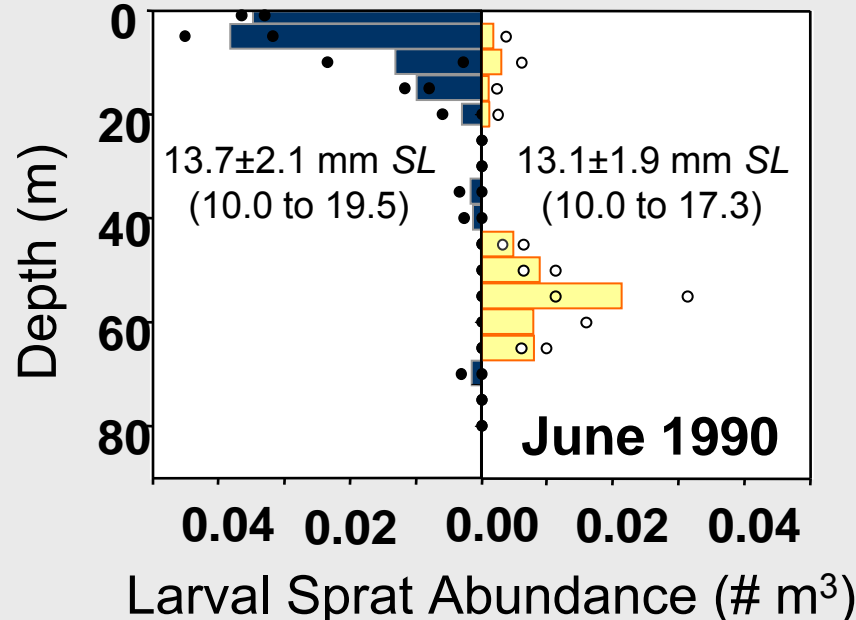
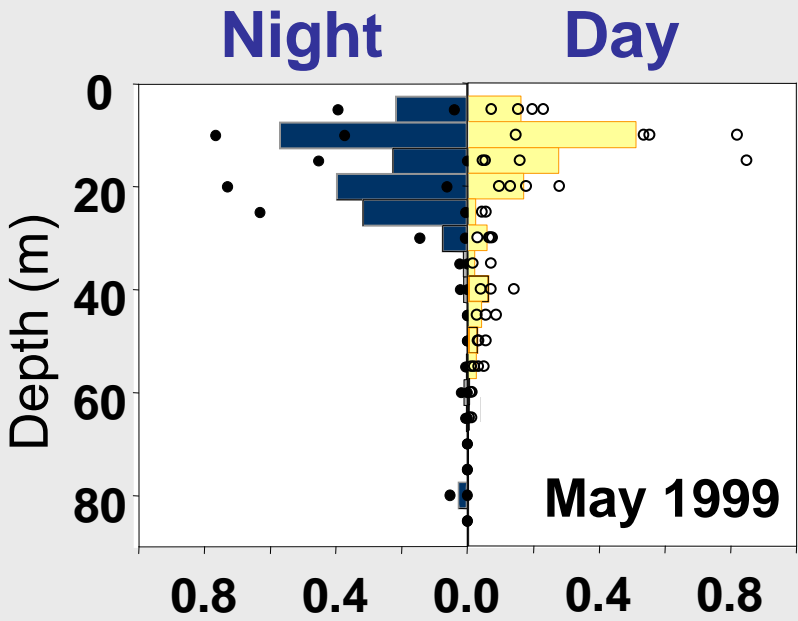
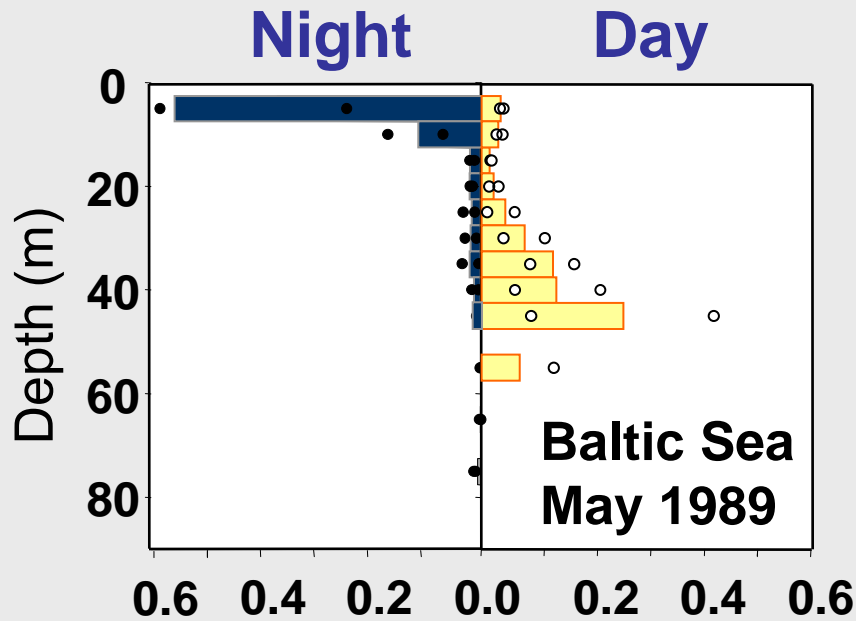


North Sea 2003 vs 2004

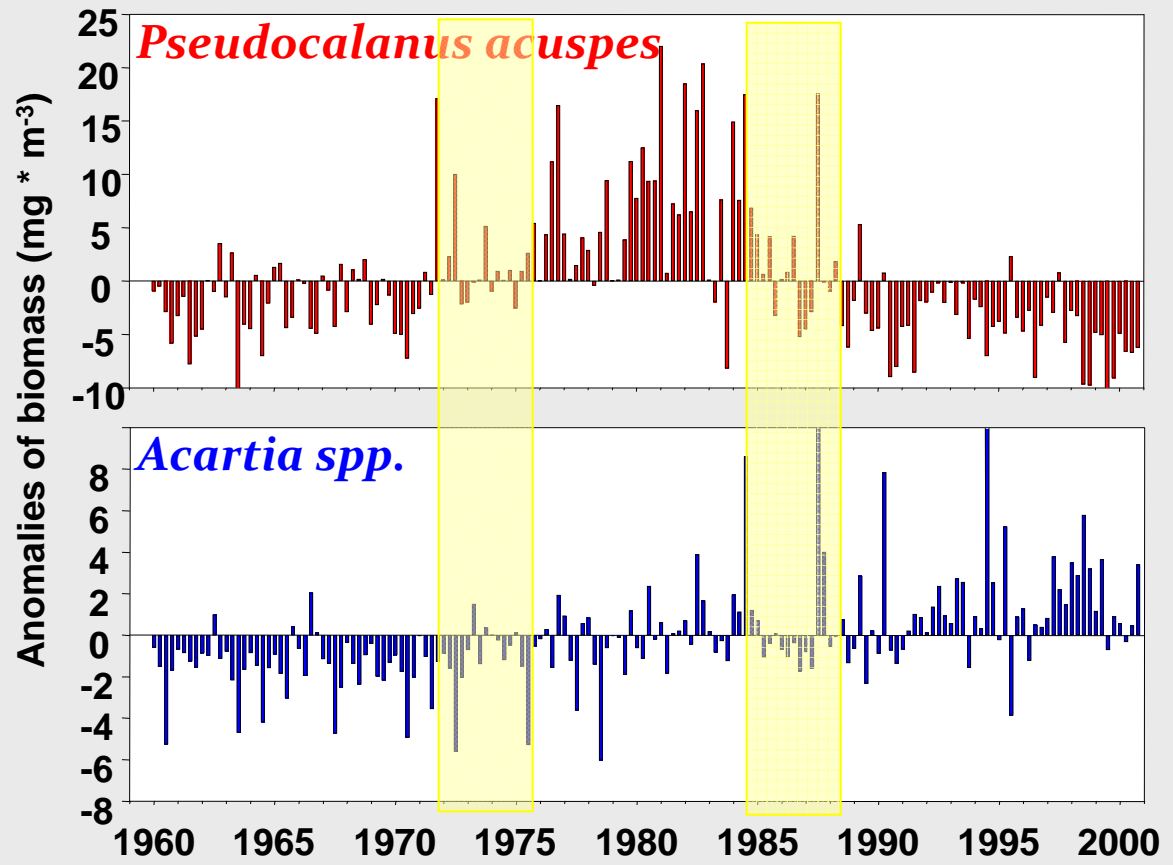
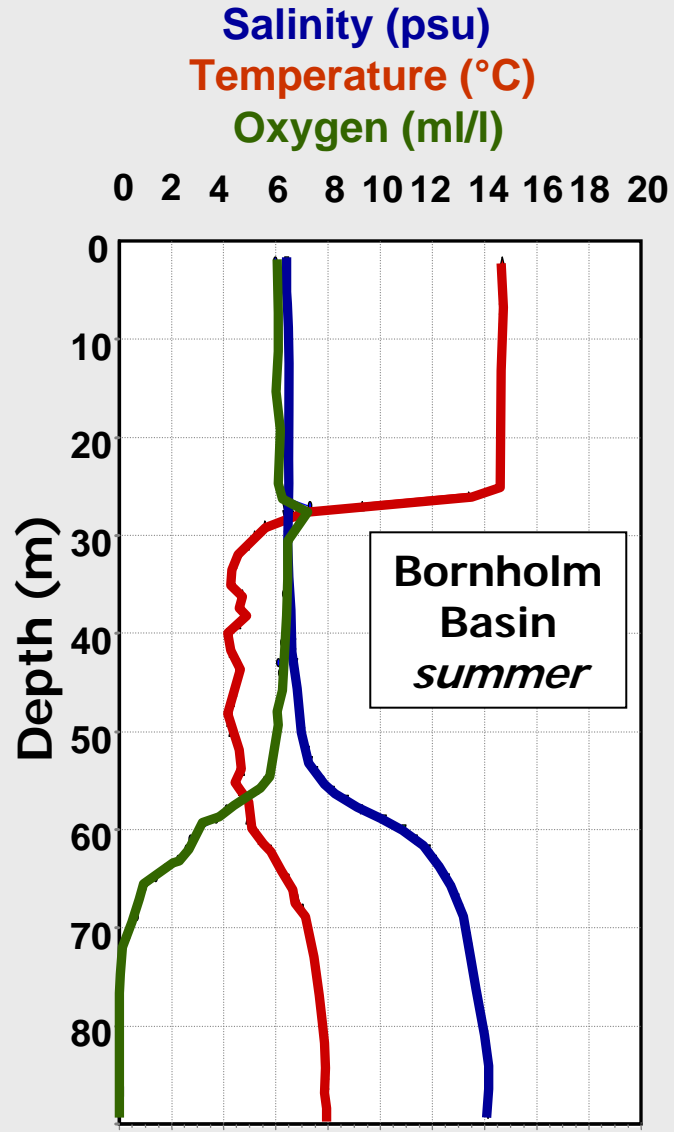
Baltic Sea 2002 vs 2003



IBM Example 2: Critical Prey Species / Life History Strategy



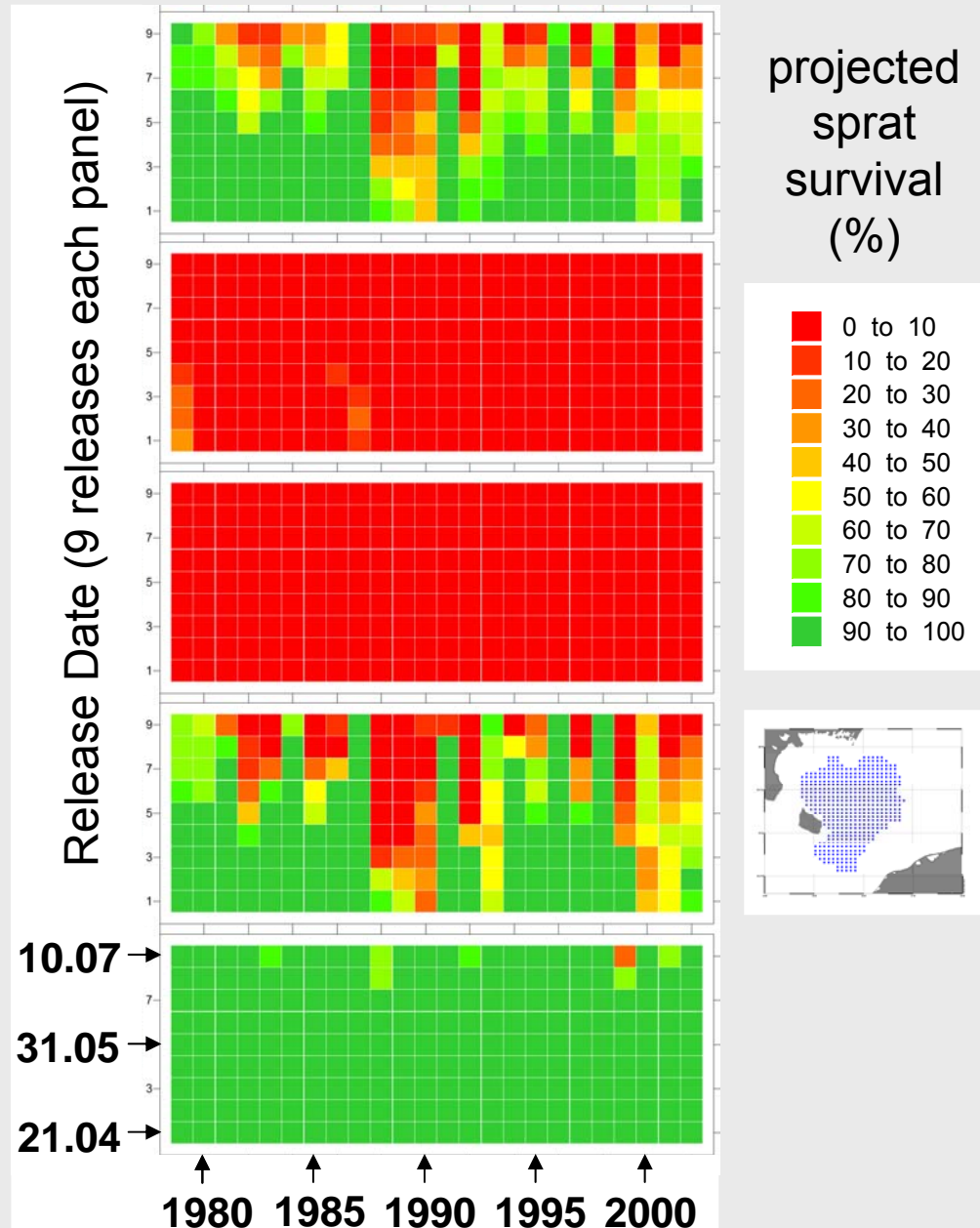
IBM Example 2: Critical Prey Species / Life History Strategy



Copepod depth differences
(*Pseudo* deeper than *Acartia*)
Fitness tradeoffs (behaviour / predator-prey dynamics)
Employed depth-resolved temperature time series

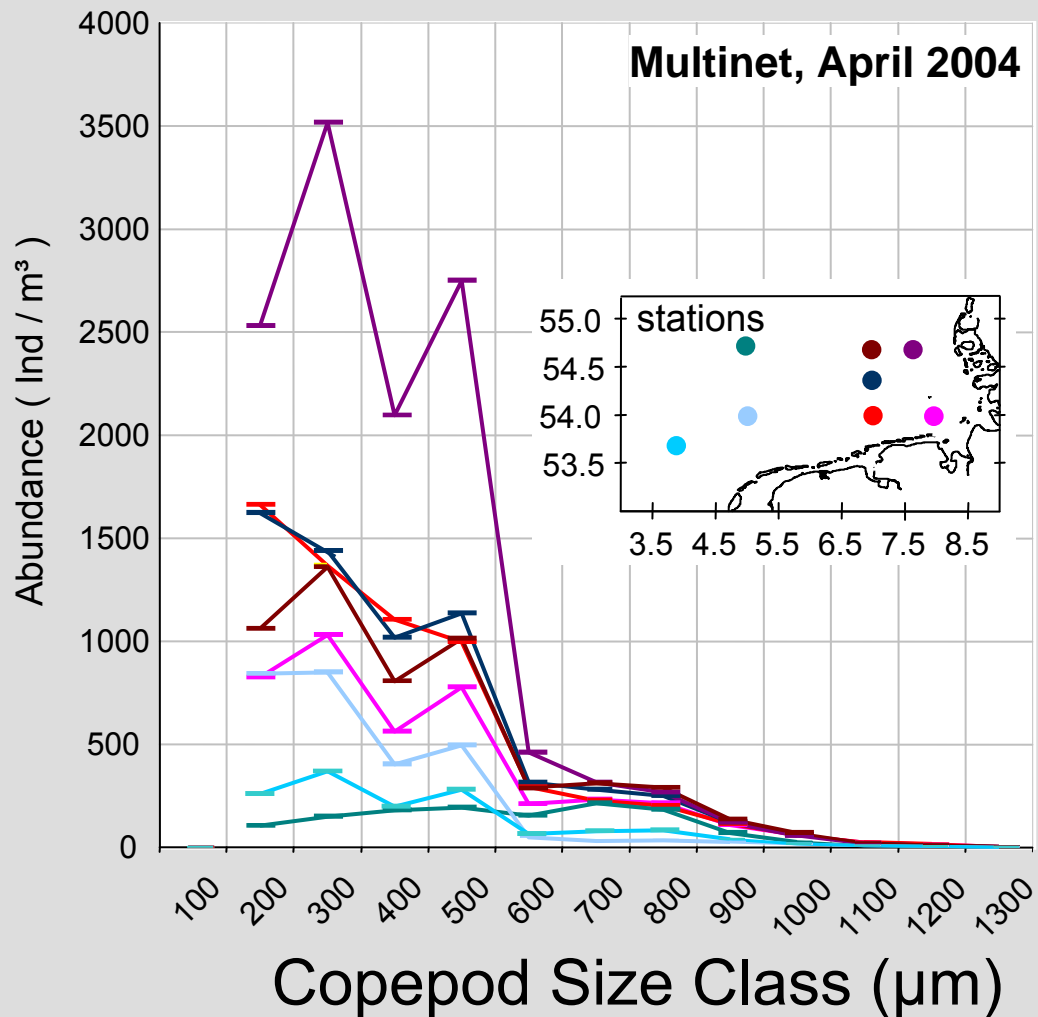
Biophysical Model Scenarios

Vertical Migration	<i>Pseudo.</i>	<i>Acartia</i>
YES	150%	100%
YES	100%	100%
YES	50%	100%
NO	50%	100%
NO	50%	150%

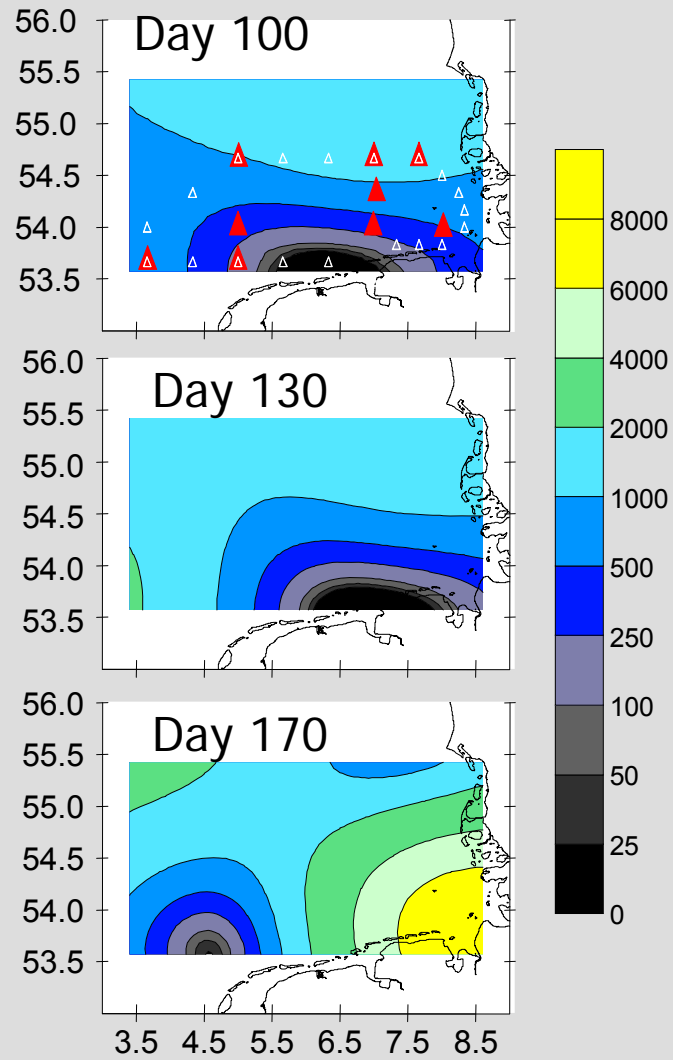


IBM Example 3: Habitat Maps & Frontal Zones

German Bight 2004, copepod abundance by size class (*Pseudocalanus*, *Temora*, *Acartia*) / February - September 2004



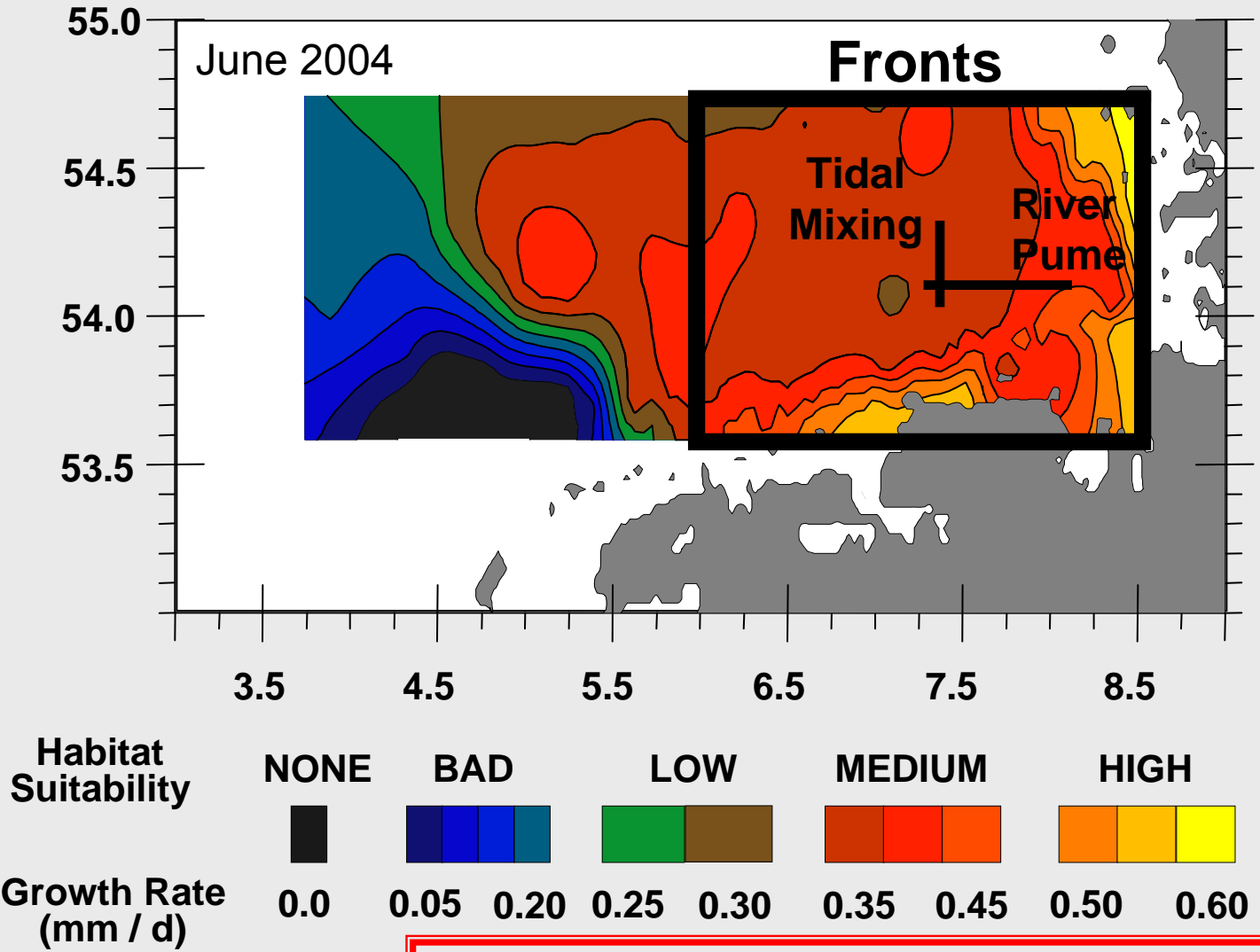
350-450 µm Size Class



Method 2

(Kühn et al. 2008)

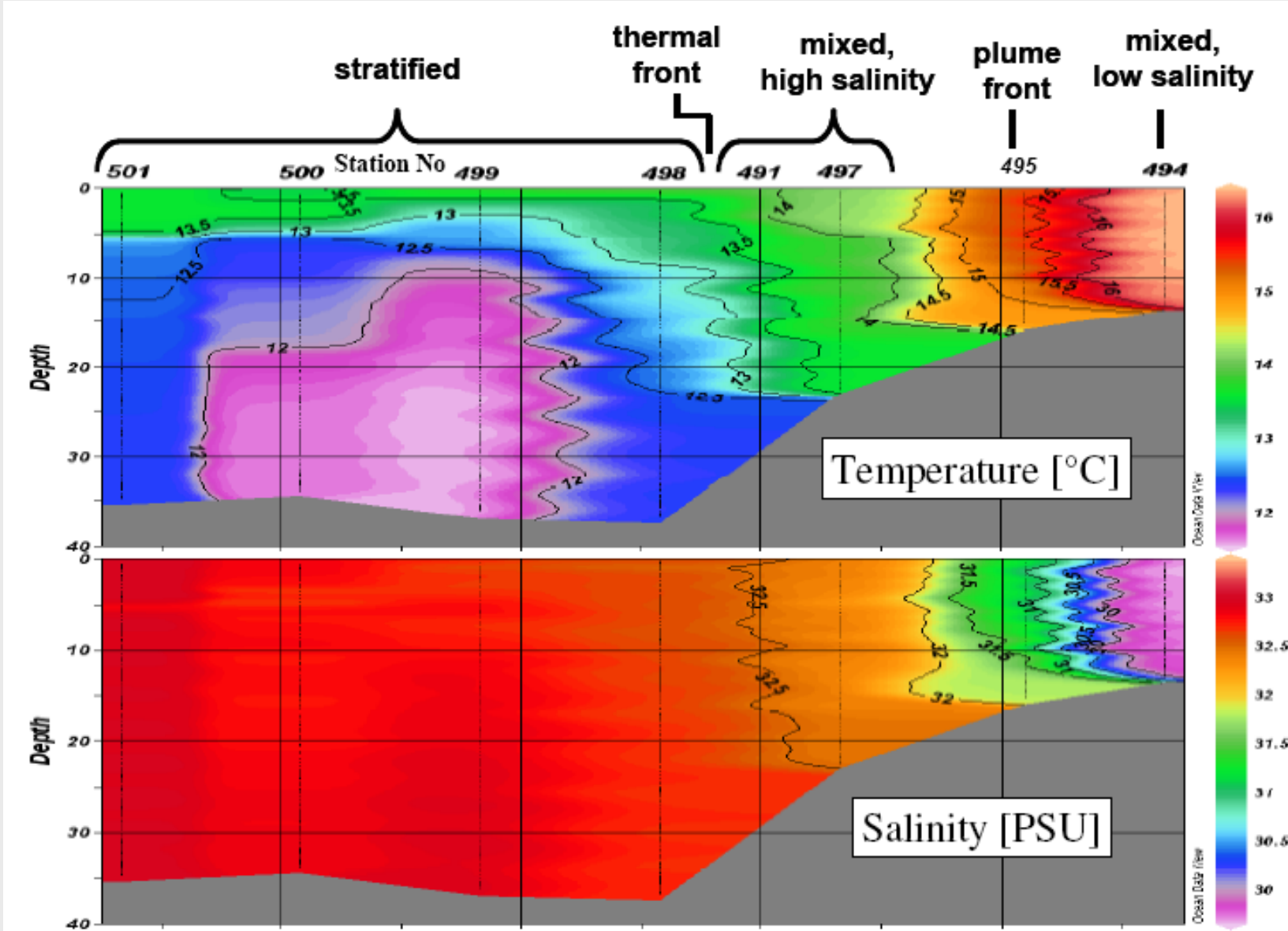
IBM Example 3: Habitat Maps & Frontal Zones



General agreement with mean field growth rates (0.4 to 0.5 mm d⁻¹)

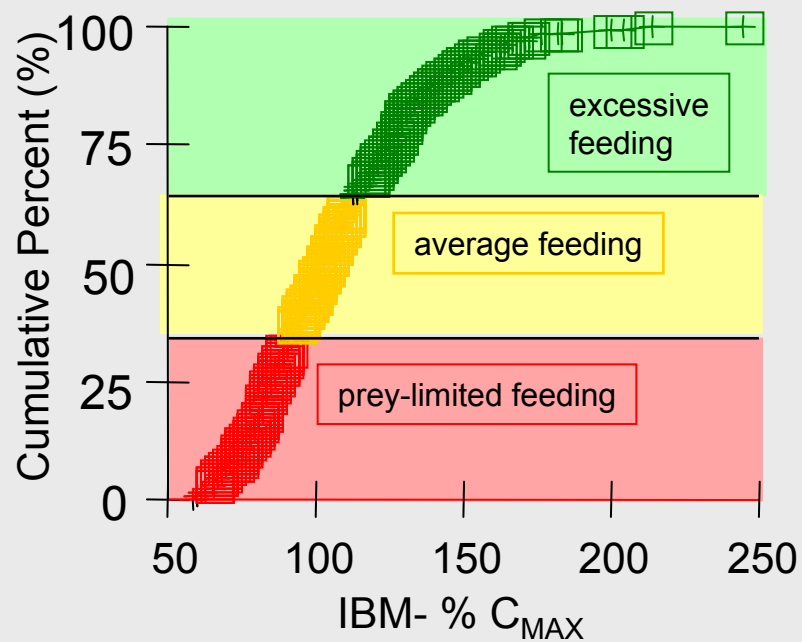
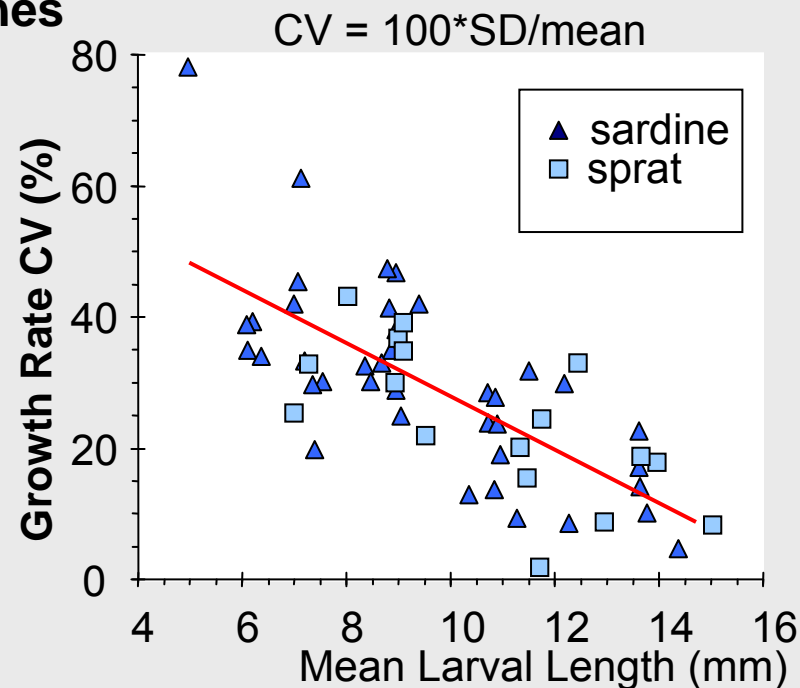
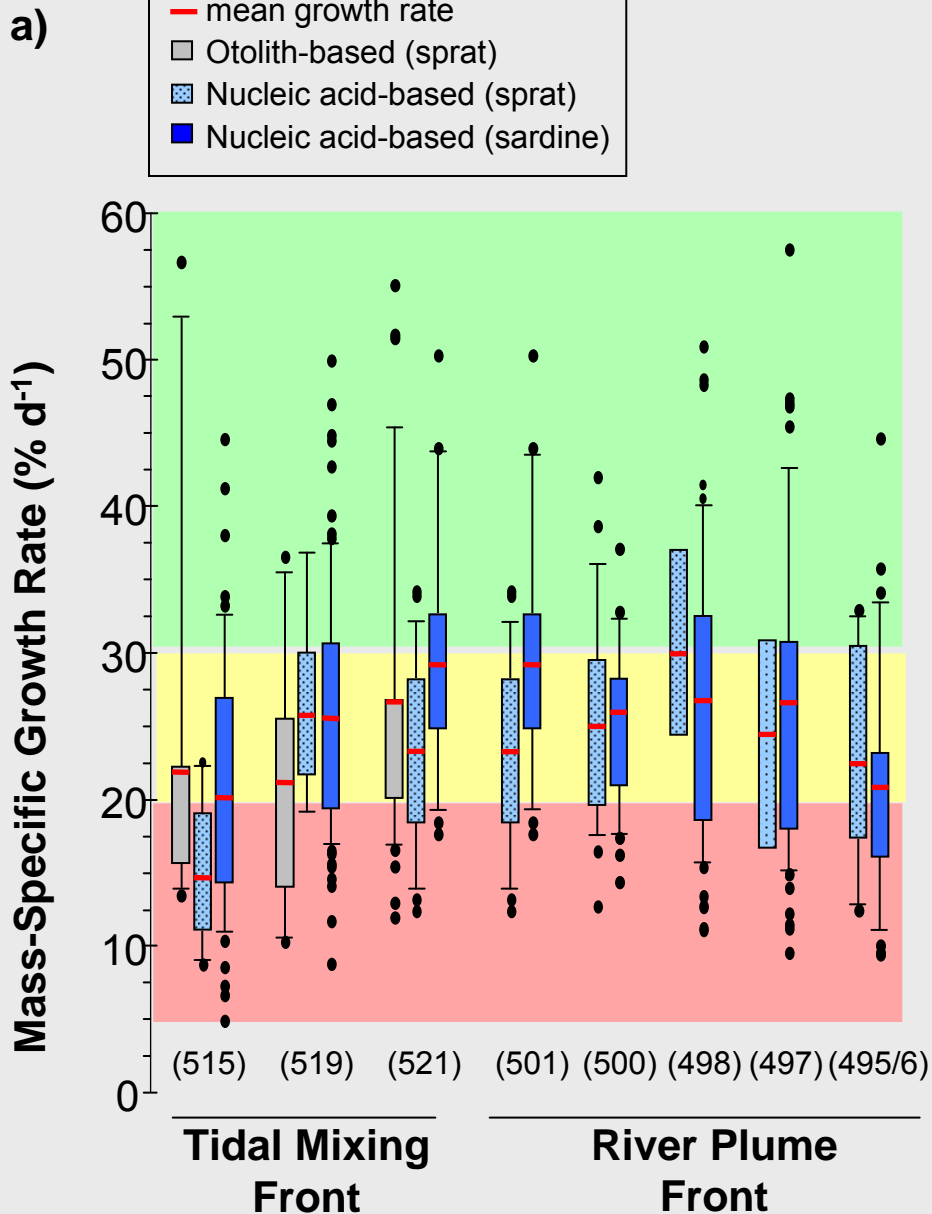
(Kühn et al. 2008)

IBM Example 3: Habitat Maps & Frontal Zones



Method 2

IBM Example 3: Habitat Maps & Frontal Zones



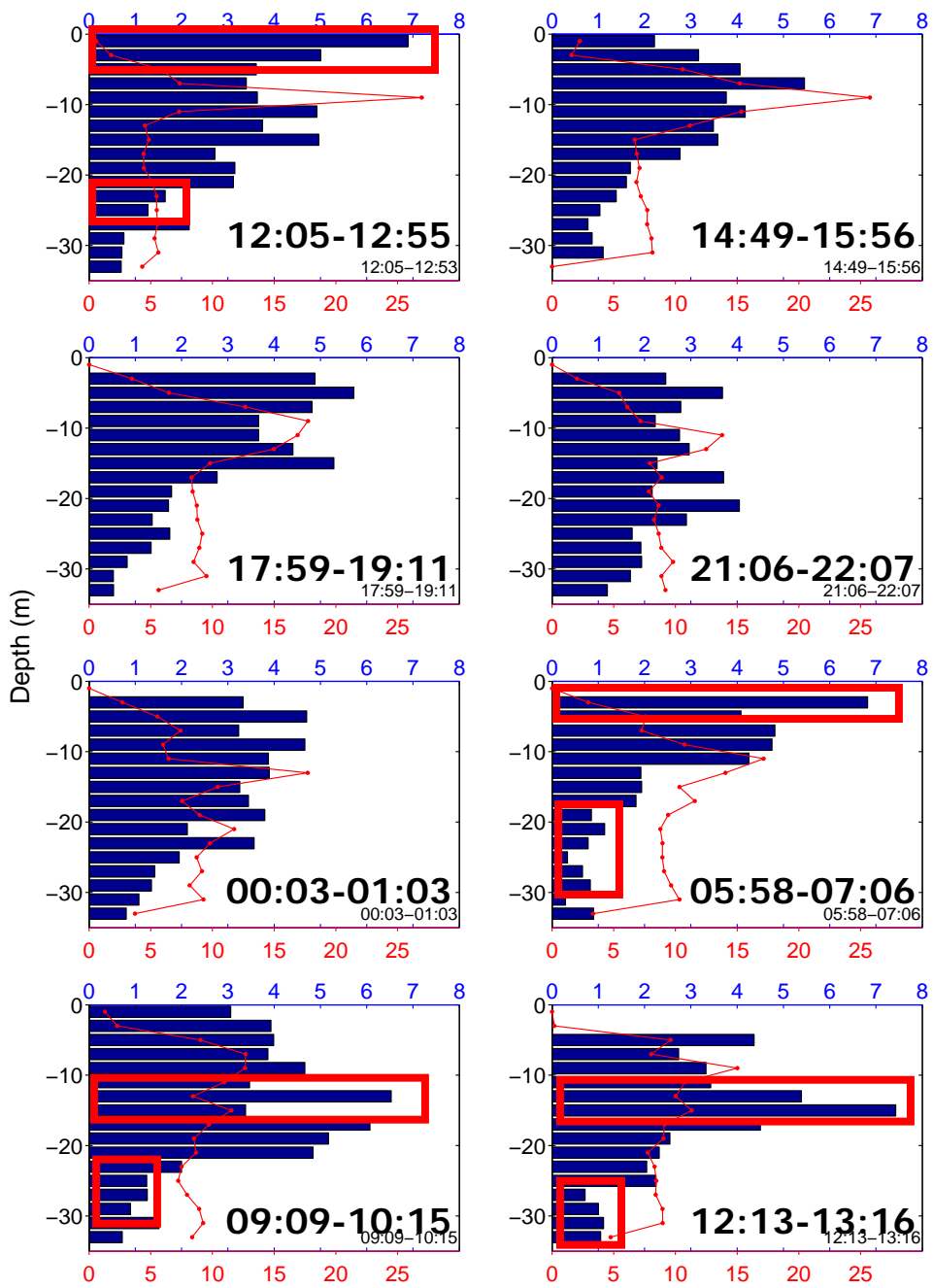
IBM Example 3: Habitat Maps & Frontal Zones

Video Plankton Recorder 2005

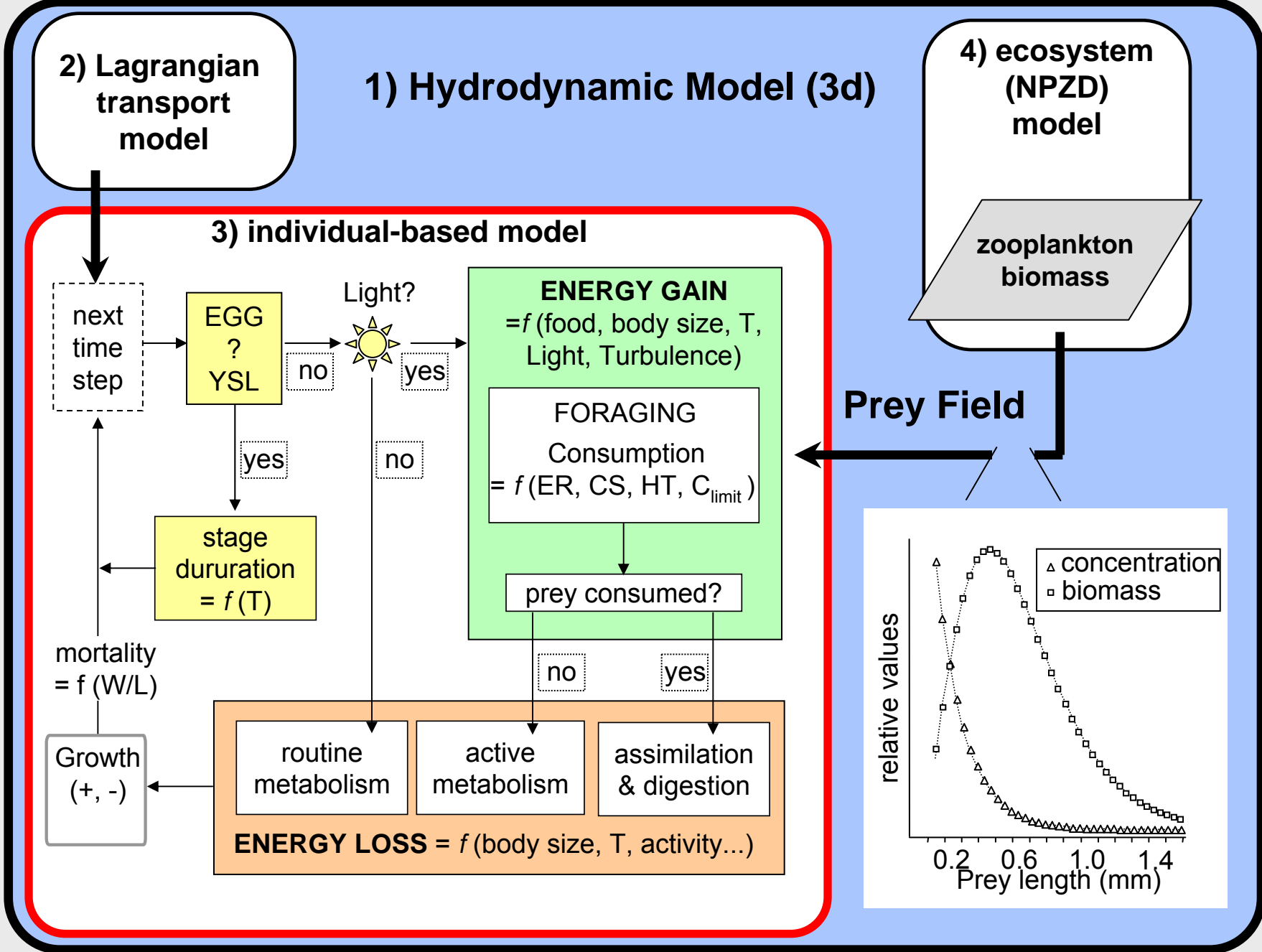


Method 2

Abundance (ind L⁻¹)

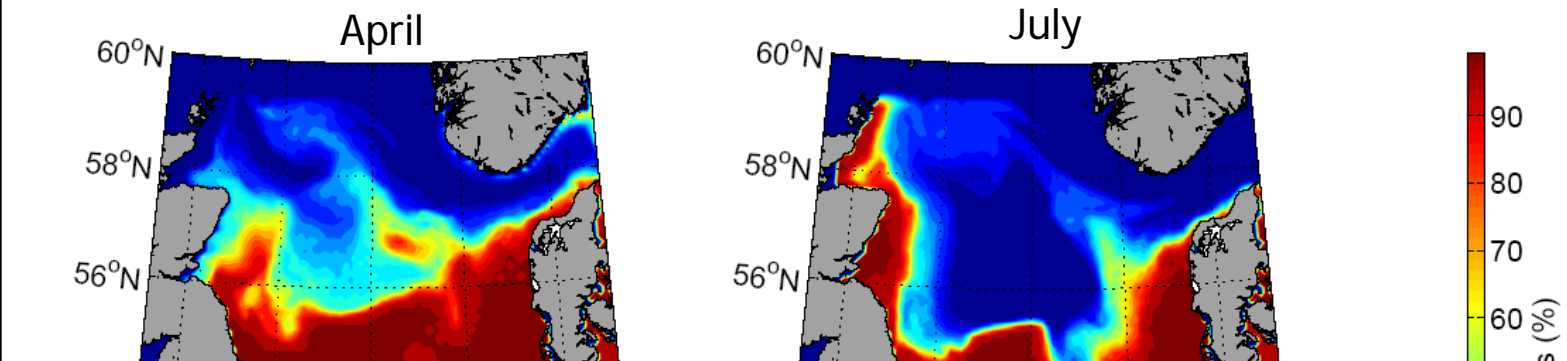


IBM Example 4: Coupled NPZD-IBM

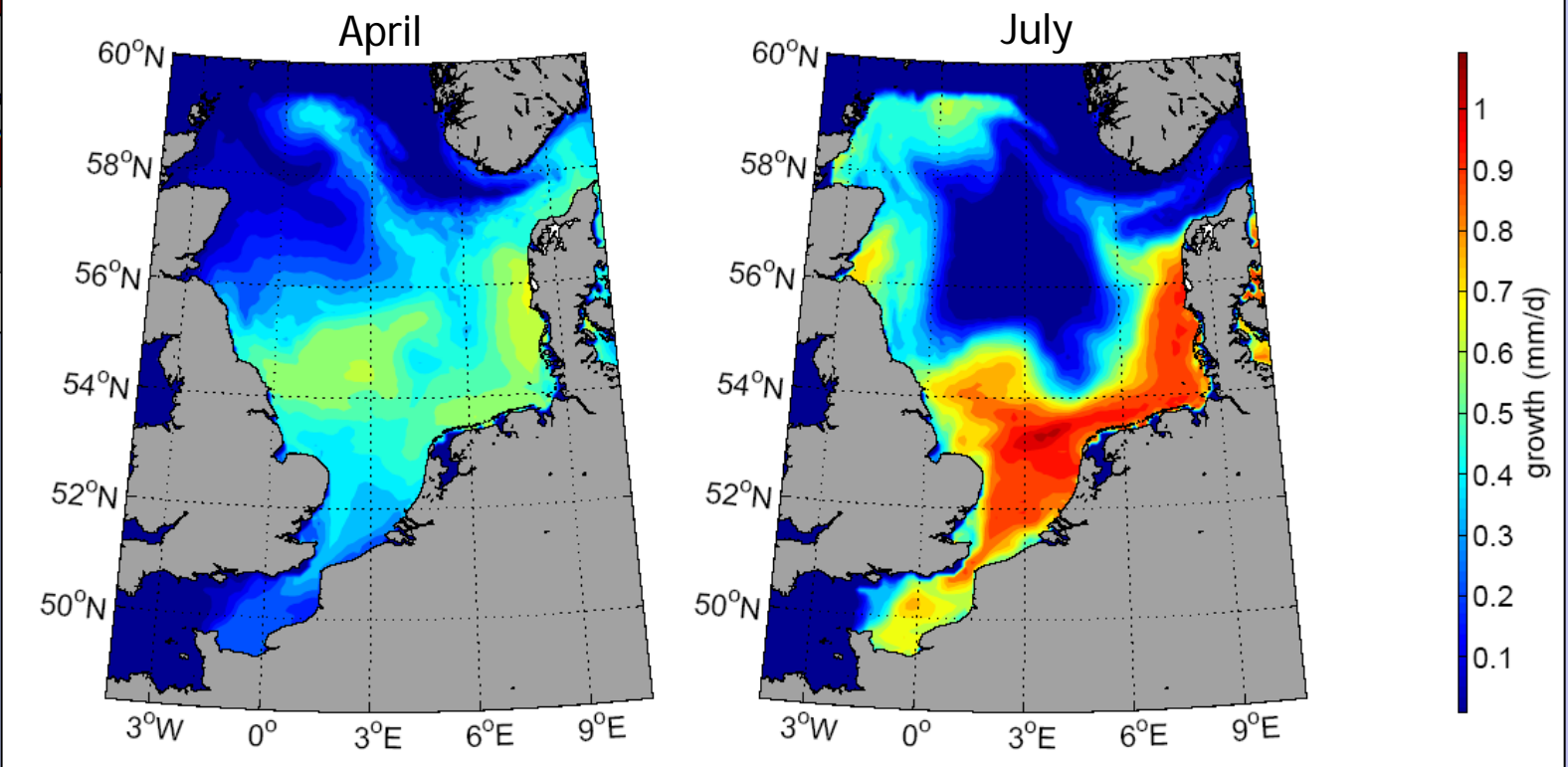


IBM Example 4: Coupled NPZD-IBM

% potential survivors concerning spawning location



Growth concerning spawning location through 10 mm SL

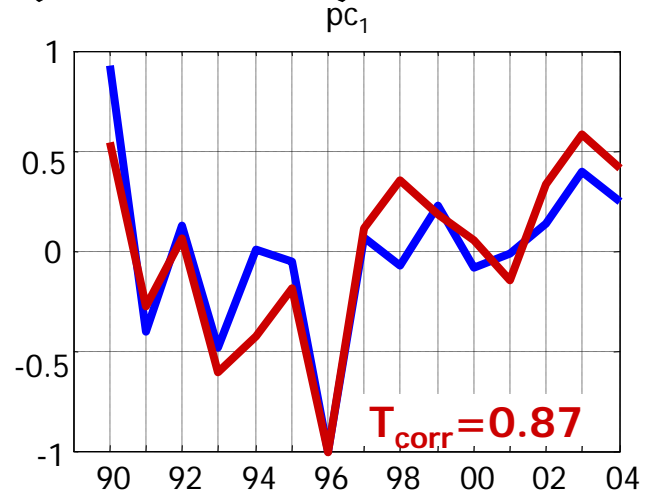
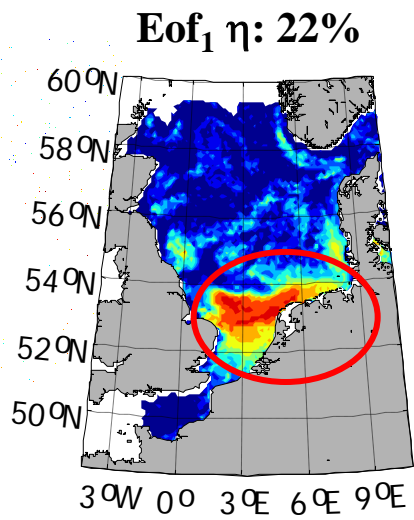


IBM Example 4: Coupled NPZD-IBM

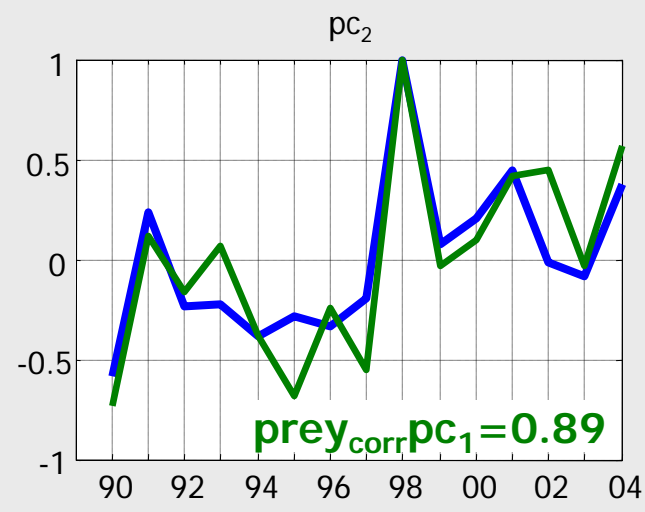
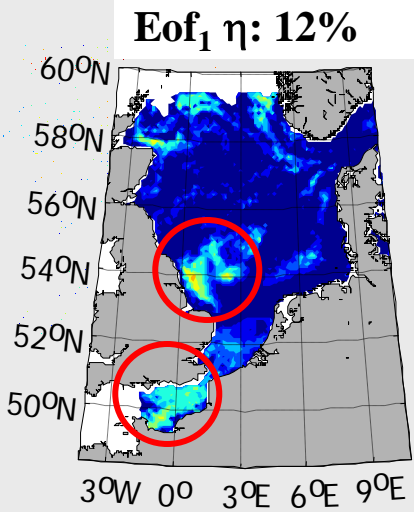
Empirical Orthogonal
Function (EOF)
Analysis (~ PCA)

Modelled Growth Rates (1990-2004)

Process?



Interannual variability
in **growth** related to
interannual variability
in **temperature**



Interannual variability
in **growth** related to
interannual variability
in **prey field**



20 40 60 80 %

Method 3

(Daewel et al. InPrep)

Summary / Discussion Points

(sprat IBM examples)

- **Different retention / drift processes** between North and Baltic Seas in same year (fate of particles unknown)
- Life history strategy (**behavioural adaptation to key prey species**)
- North Sea sprat may lack key sprat prey species – **intra-station growth variability not represented** by mean prey field (does it matter?)
- Spatial differences in key match-mismatch processes. Size spectrum coupling (NPZD-IBM) offers **reduced complexity for EtoE modeling**)

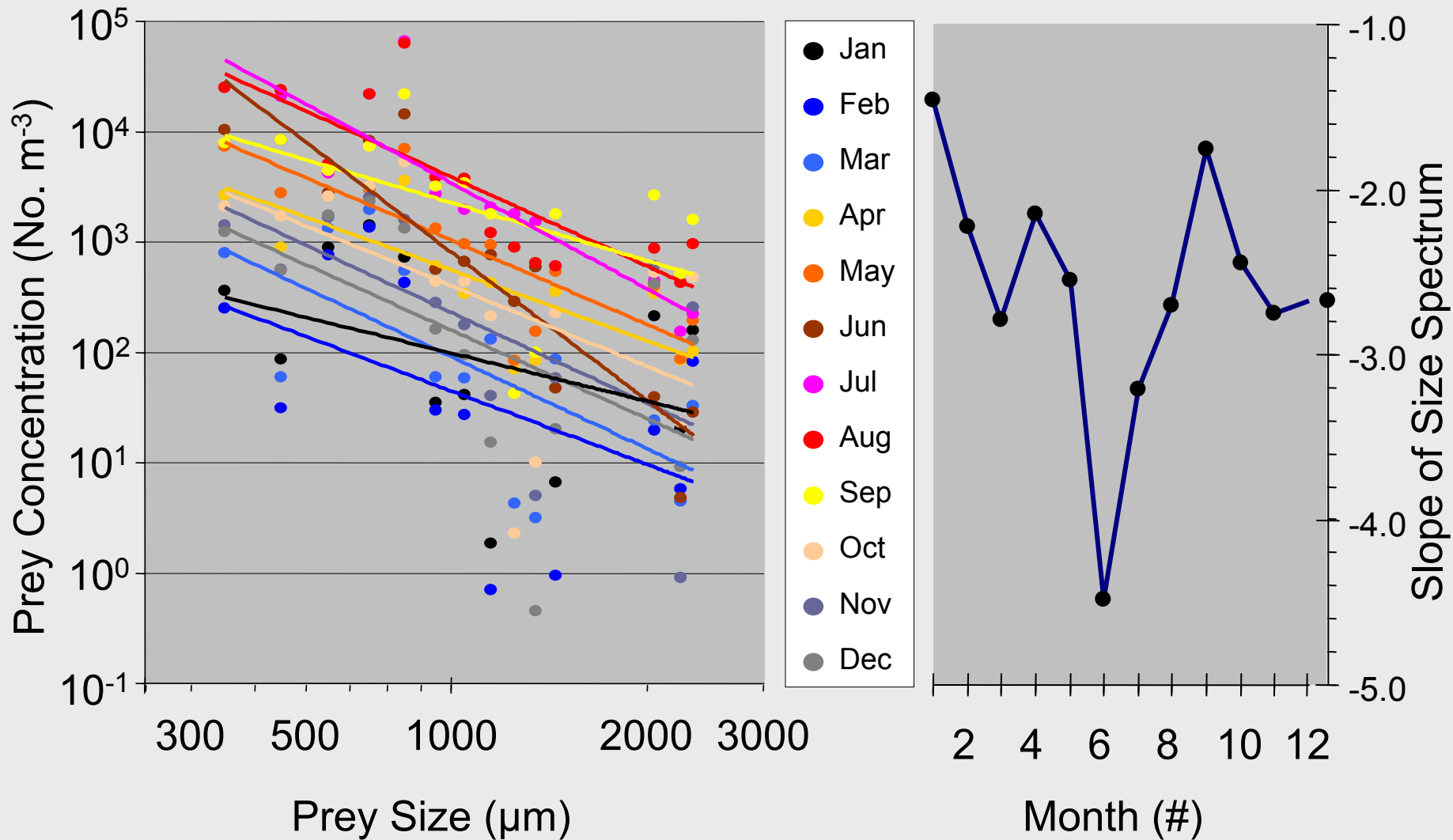
Bottom-up versus Top-down



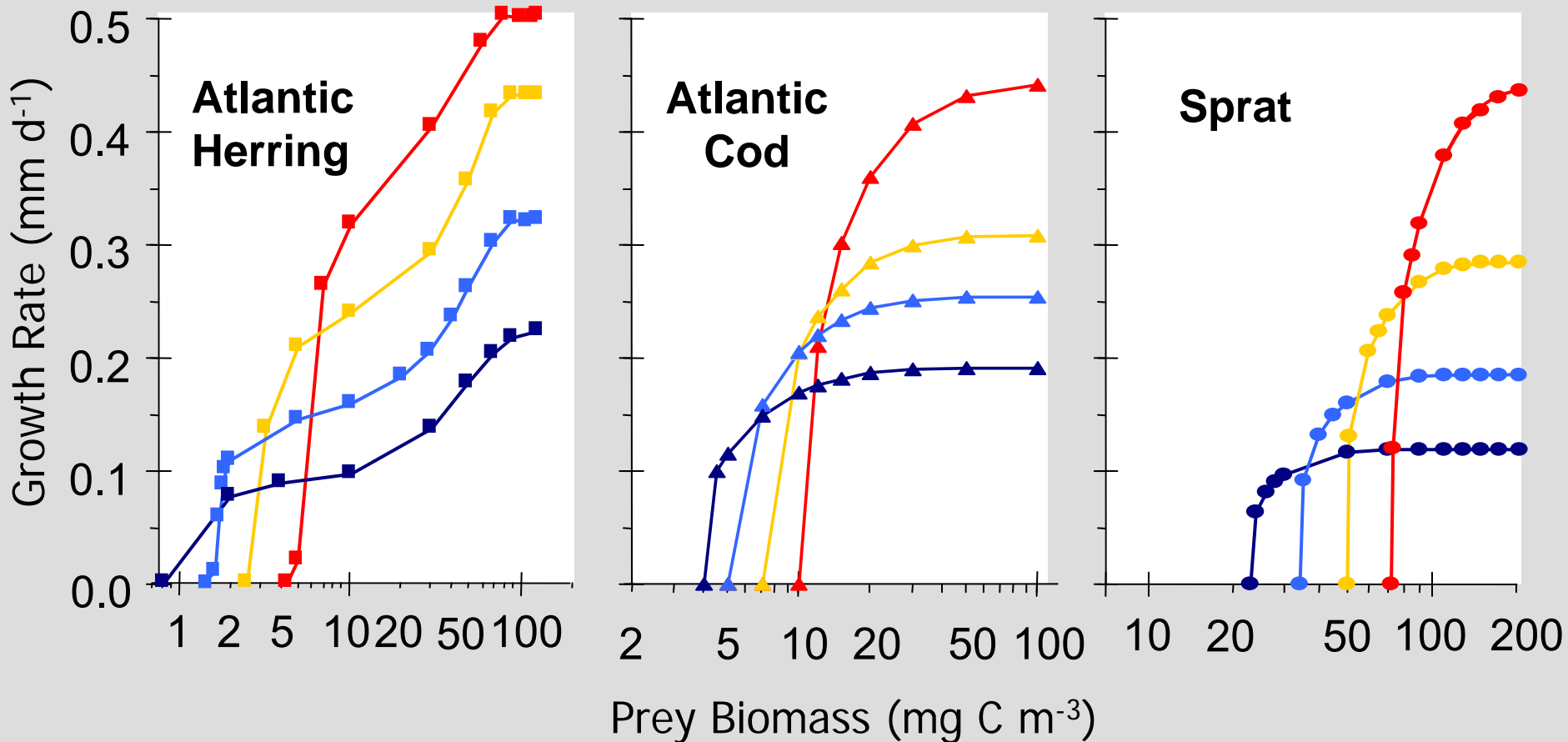
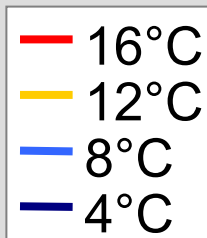
Horse mackerel stomach packed with sprat larvae!

**Photo:
Matthias
Bernreuther**

Model Coupling: NPZD-derived prey fields



Larval Growth: Temperature x Prey (Interspecific Differences)



Converted into size-specific prey field based on exponential size spectrum