

# A DEB-IBM for the understanding of the drivers of change in the dynamics of small pelagic fish in the Bay of Biscay

## Contribution to ecosystem-based management

Martin Huret, Clara Menu, Matthieu Caillaud, Denis Gourves, Laure Pecquerie



# SPF ecological issues in the Bay of Biscay, and link to management

## 1. Abundance : collapse of anchovy in the 2000's

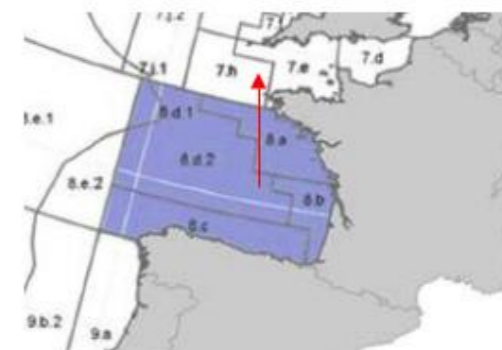
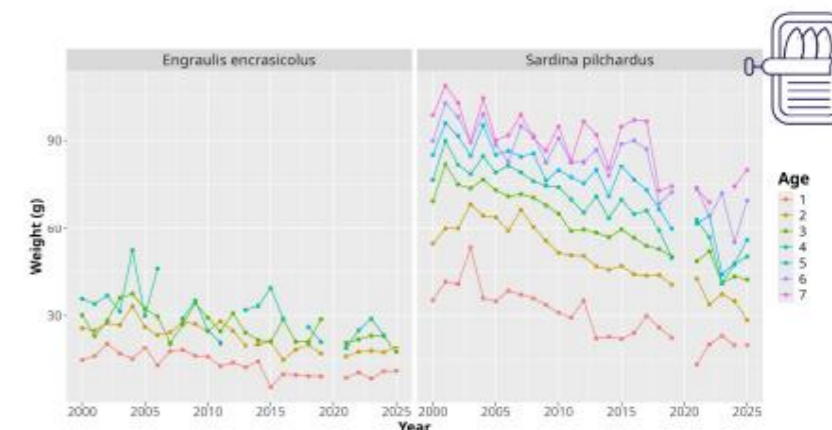
- Fishery closure 2005-2010 (WGHANSA, 2025)
- Lack of anchovy market after 2010 (Beckensteiner et al., 2024)

## 2. Size : shrinking over the last 20 yrs

- Sardine : a threat for the fishing industry (Huret et al., 2026)
- Anchovy : lack of market opportunities (Beckensteiner et al., 2024)

## 3. Distribution : what stock structure ?

- What connectivity with the English Channel for anchovy and sardine ?



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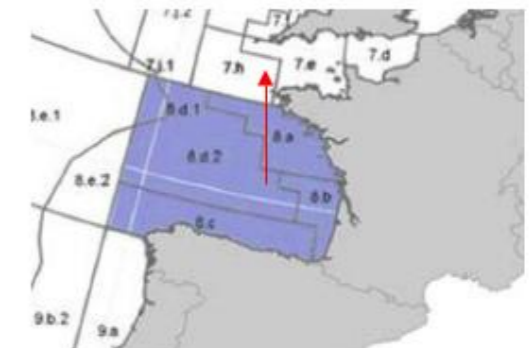
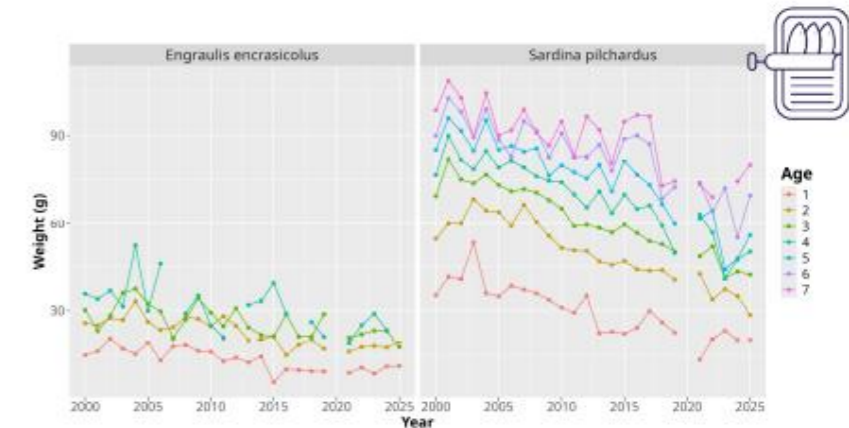
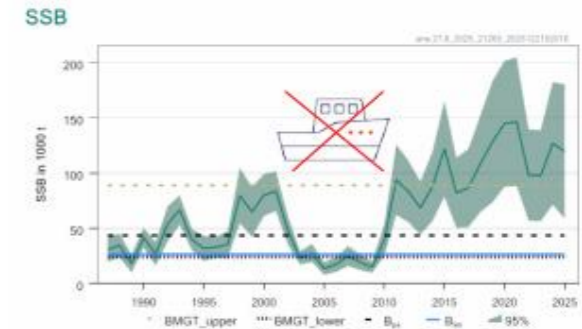
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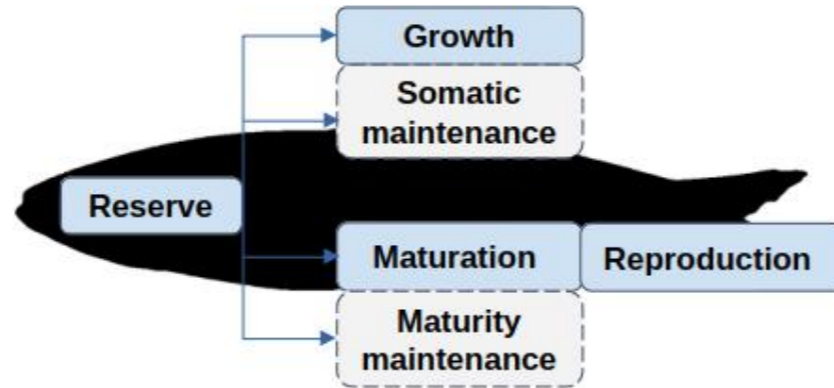
## 3. Distribution : what stock structure ?

- What connectivity with the English Channel for anchovy and sardine ?

→ How can a DEB-IBM help research and management ?

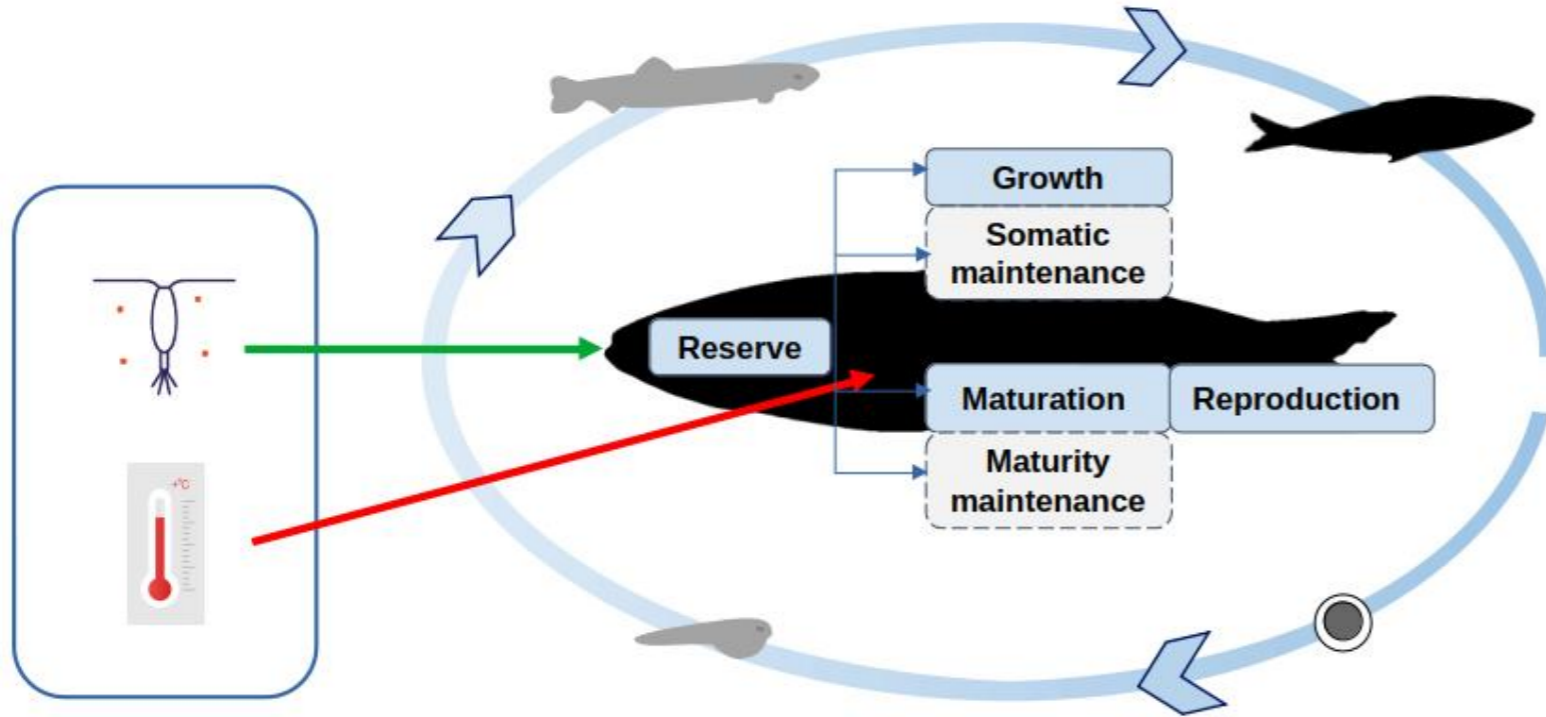


# The DEB-IBM model



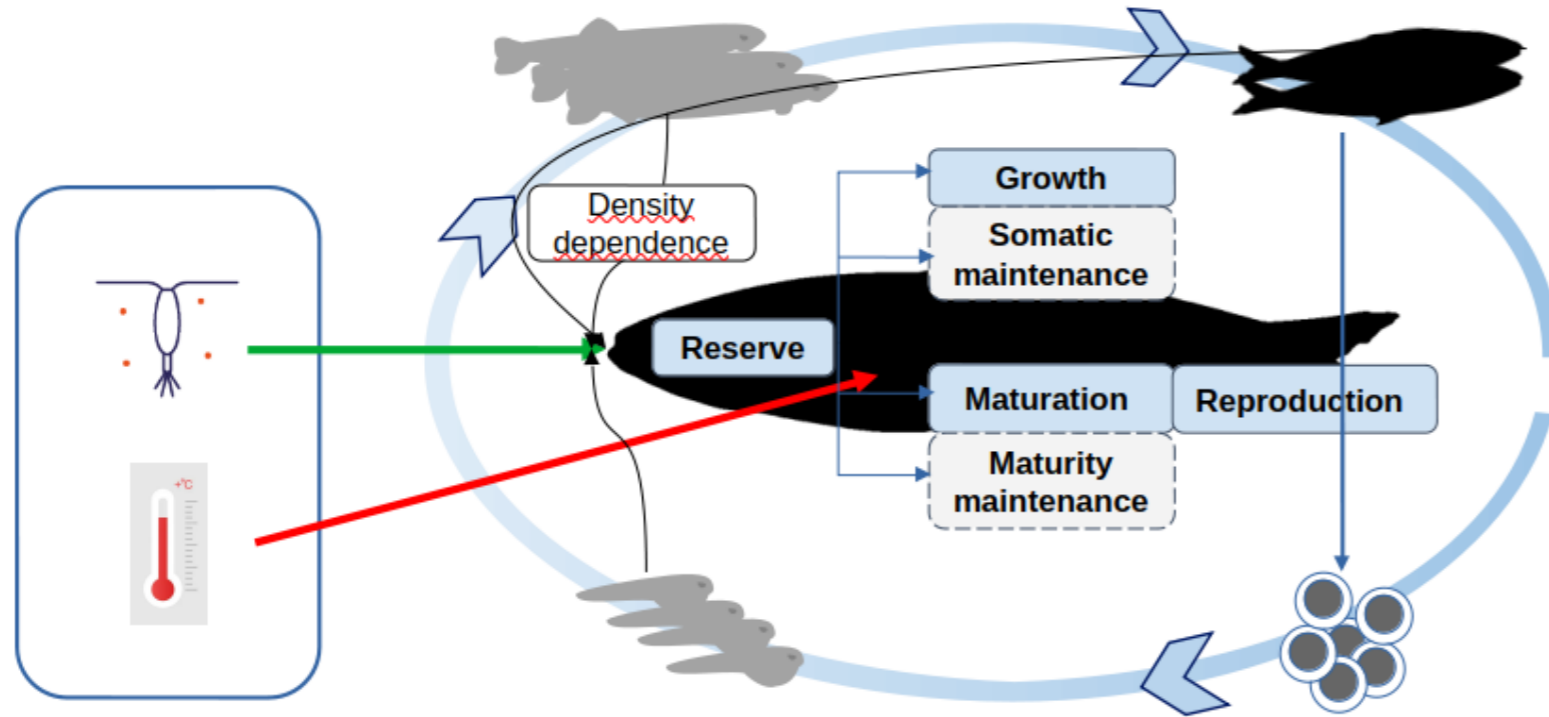
- DEB bioenergetic module
  - \* growth
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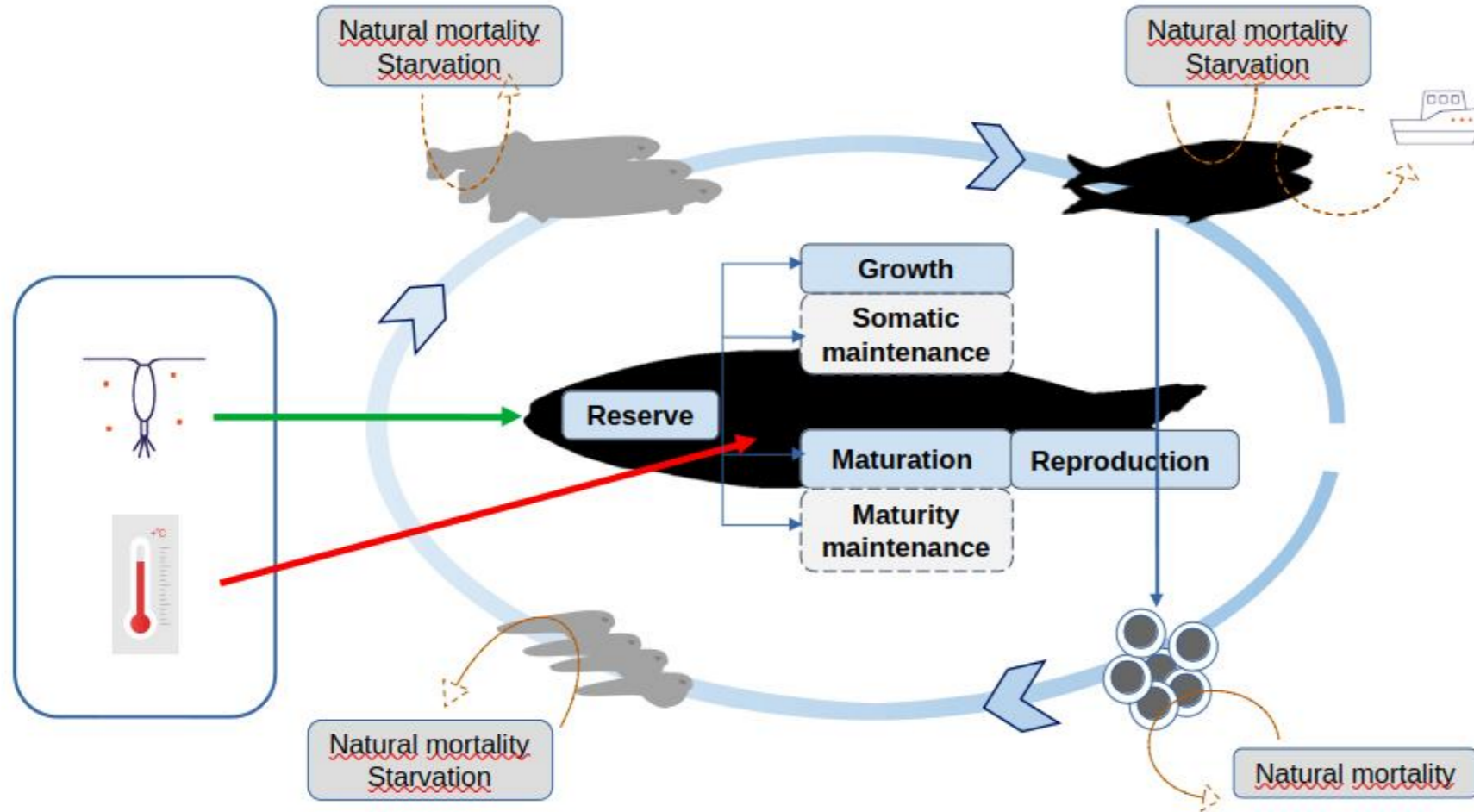
- DEB bioenergetic module
  - × growth
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- Full life cycle
- Environmental forcing
  - × physical fields
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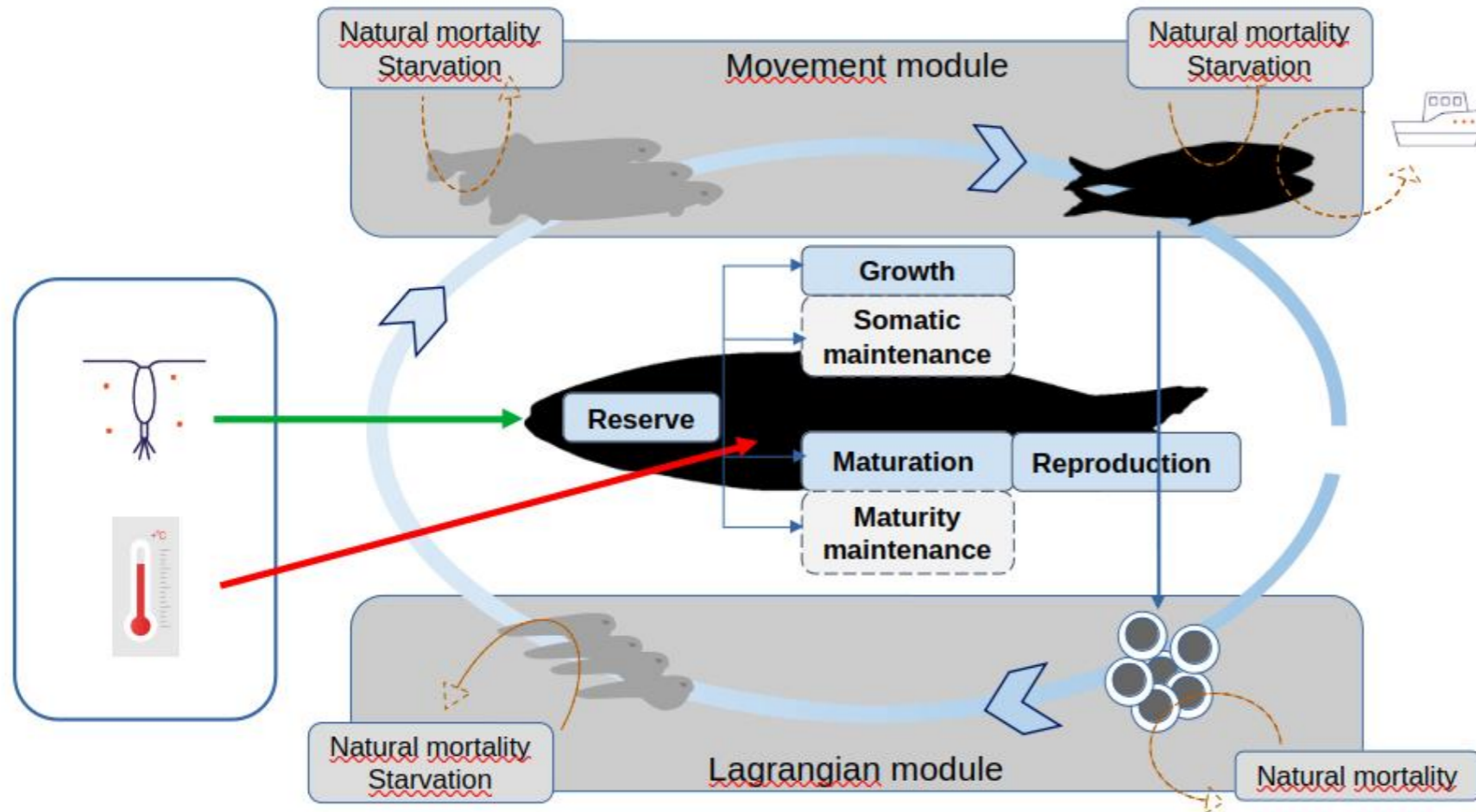
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- Transport modules
  - × Eggs and larval drift
  - × Juvenile and adult movement

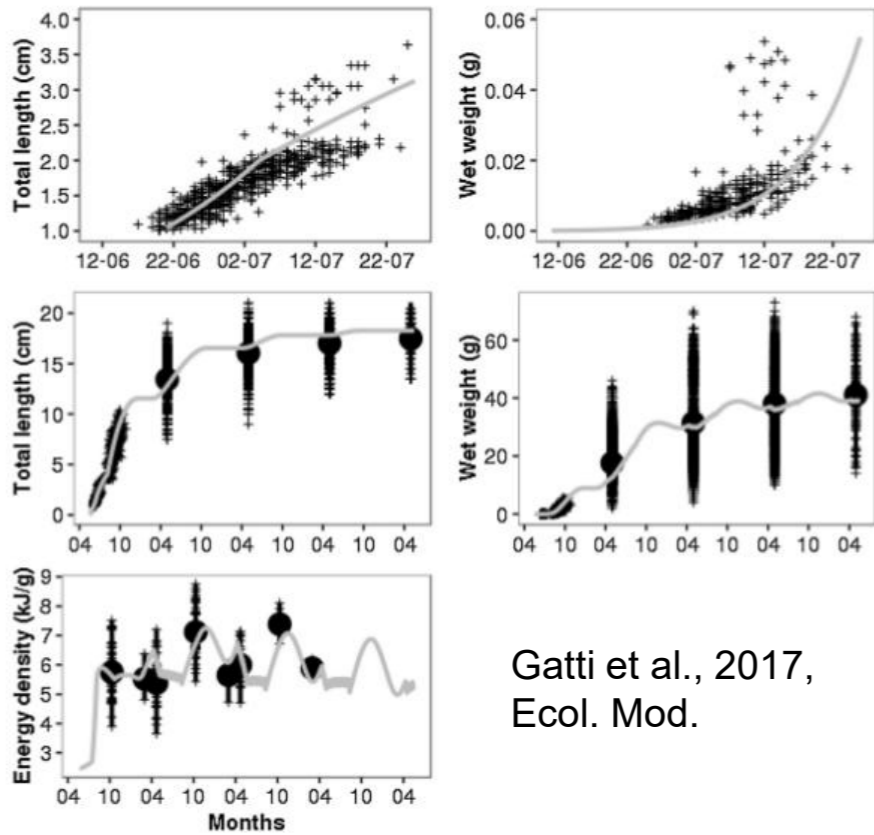
# The DEB-IBM model – various configurations

- **0-D configuration – individual scale**
  - Calibration of the bioenergetics (DEB)
  - Off-line forcing for temperature and food
- **0-D configuration – population scale**
  - Calibration of the IBM (mortality parameters, density dependence, etc.)
  - Off-line forcing for temperature and food
- **3-D configuration**
  - Historically coupled to MARS3D hydrodynamic model → CROCO (ROMS)
  - Forcing with velocity and temperature 3D fields
  - Off-line forcing for food (ERSEM from PML)

# Calibration of the DEB-IBM



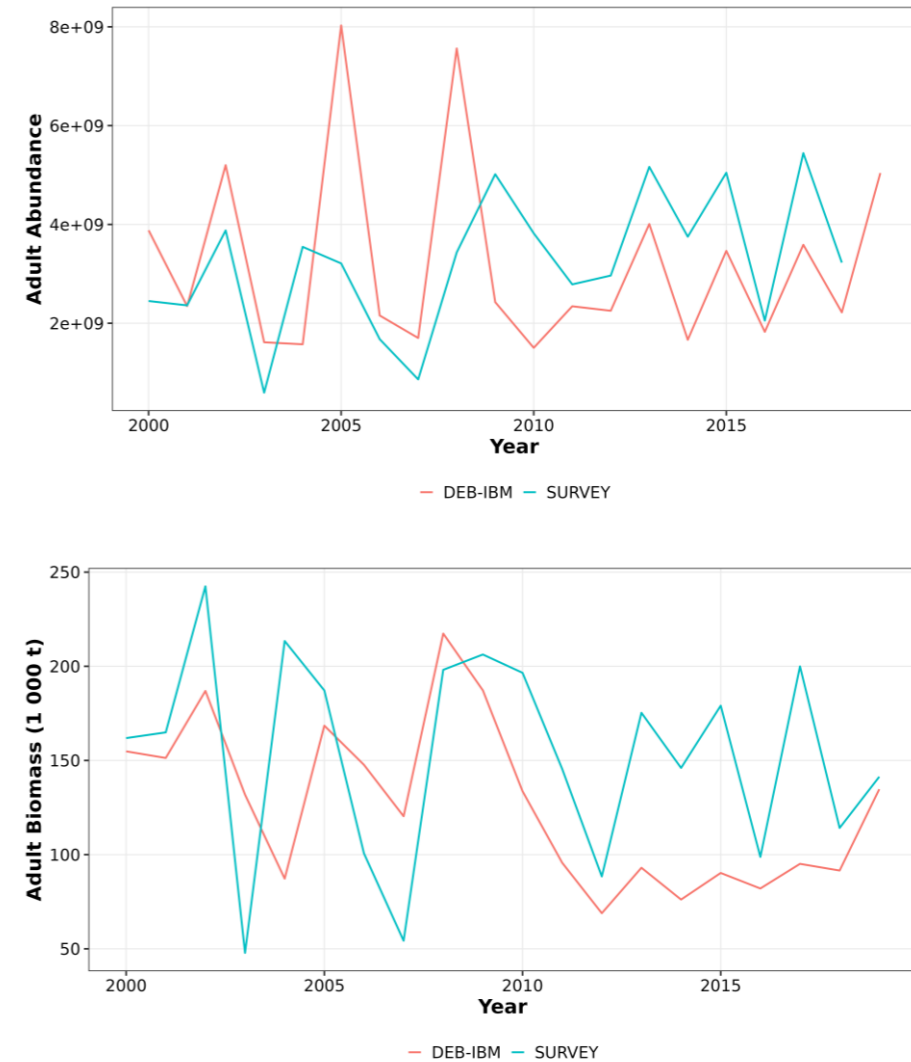
0-D individual



Gatti et al., 2017, Ecol. Mod.



0-D population

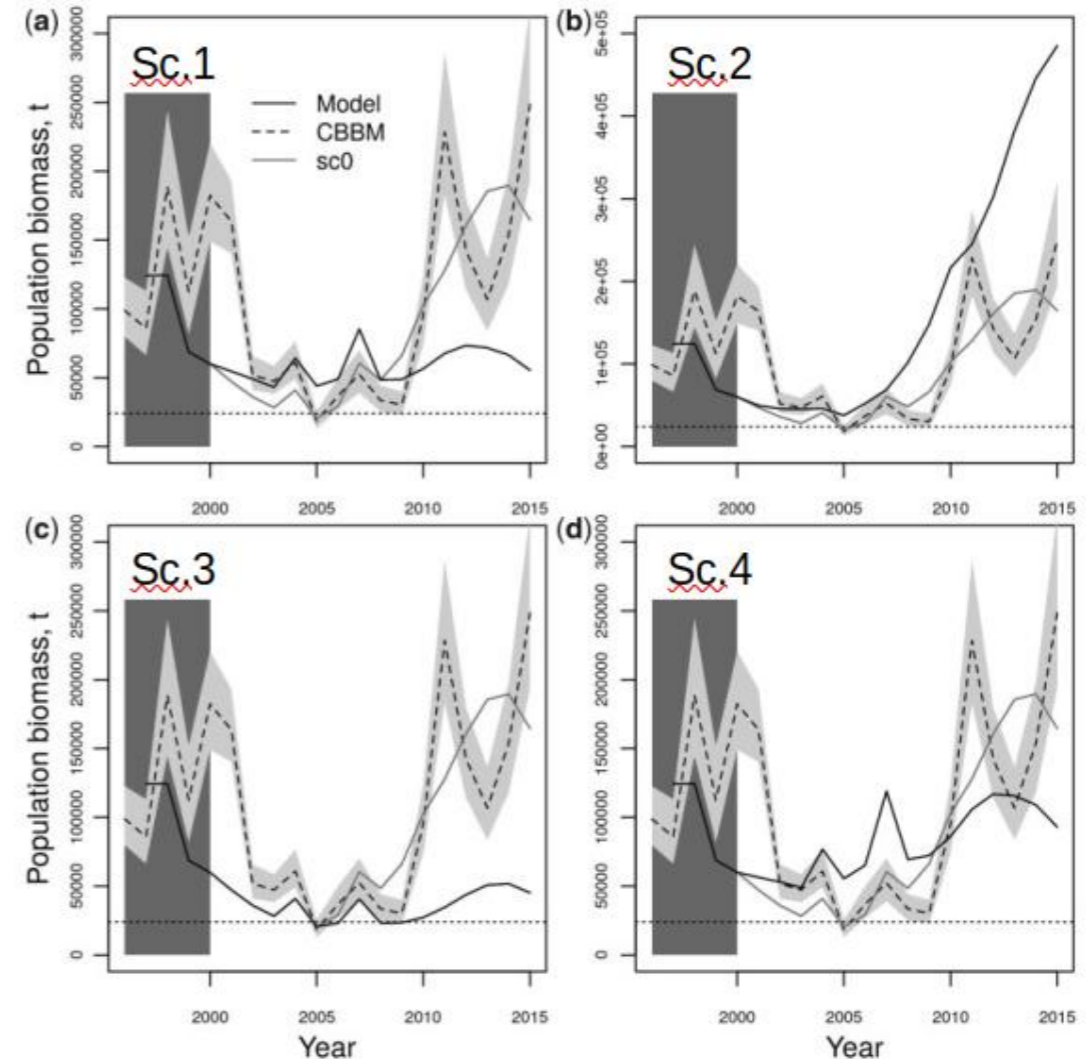


Menu et al., in prep.

# 1. Abundance : collapse of anchovy in the 2000's



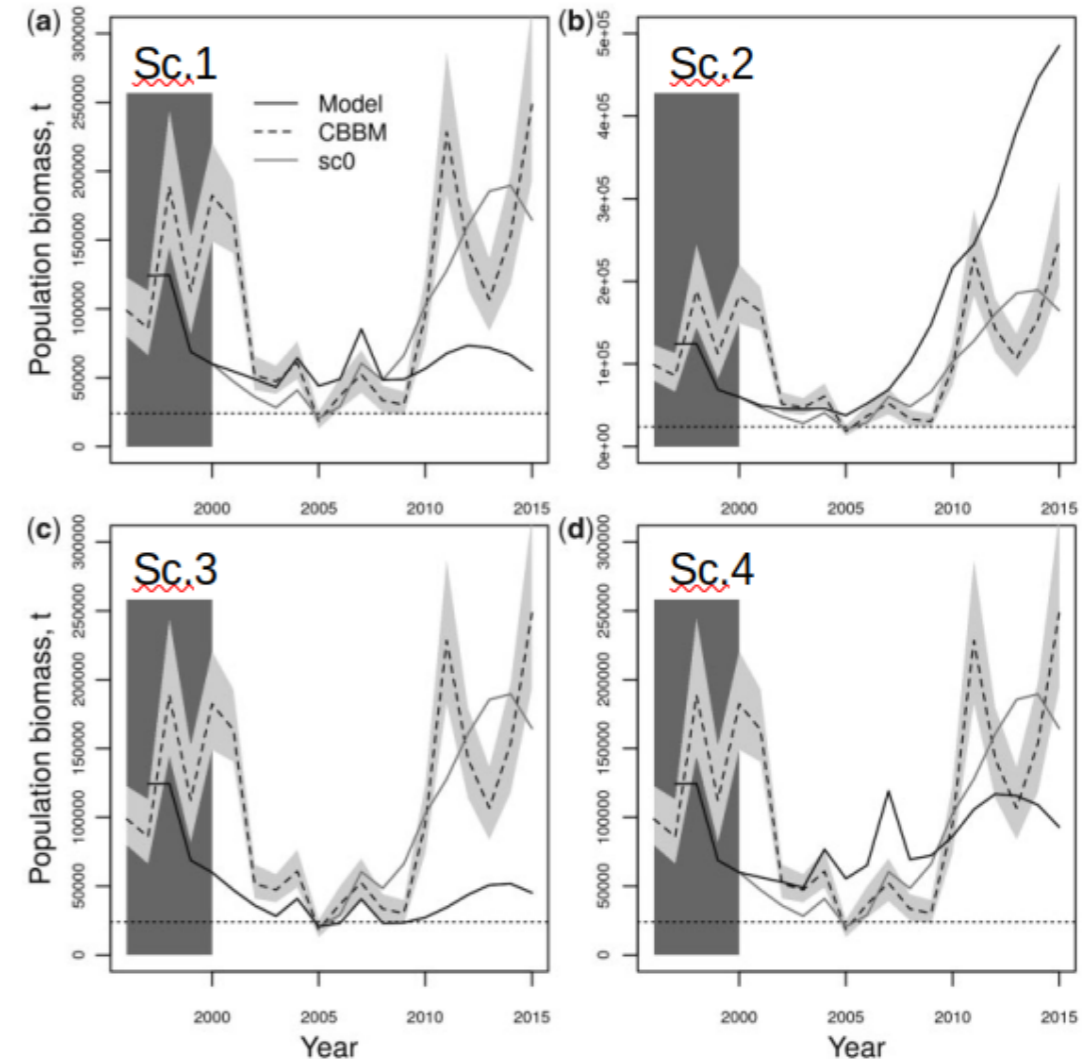
- Scenario 0 : base case
  - Sc.1 : constant fishing mortality
  - Sc.2 : constant environment (T, food)
  - Sc.3 : no closure between 2005 and 2010
  - Sc.4 : current HCR on the whole period



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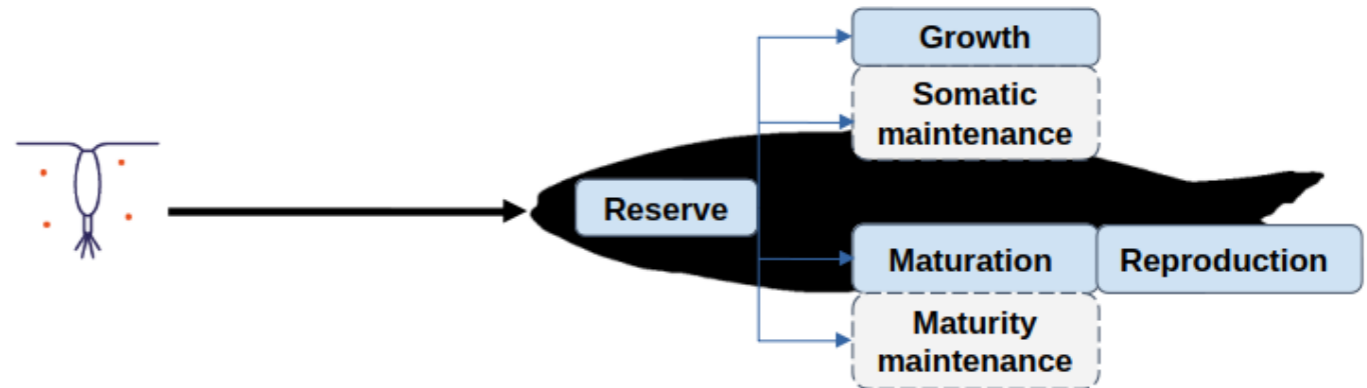
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- Outcomes :
  - Both high fishing pressure and bad food conditions were responsible for the collapse
  - Without closure → no real recovery
  - Current HCR set earlier would have prevented the collapse



## 2. Size shrinking over the last 20 yrs : what drivers ?

Scenario based approach :

- Decrease in food quantity or quality, or impact on the related bioenergetic processes
- Try to fit the model to the decrease in size by estimating forcing/parameters

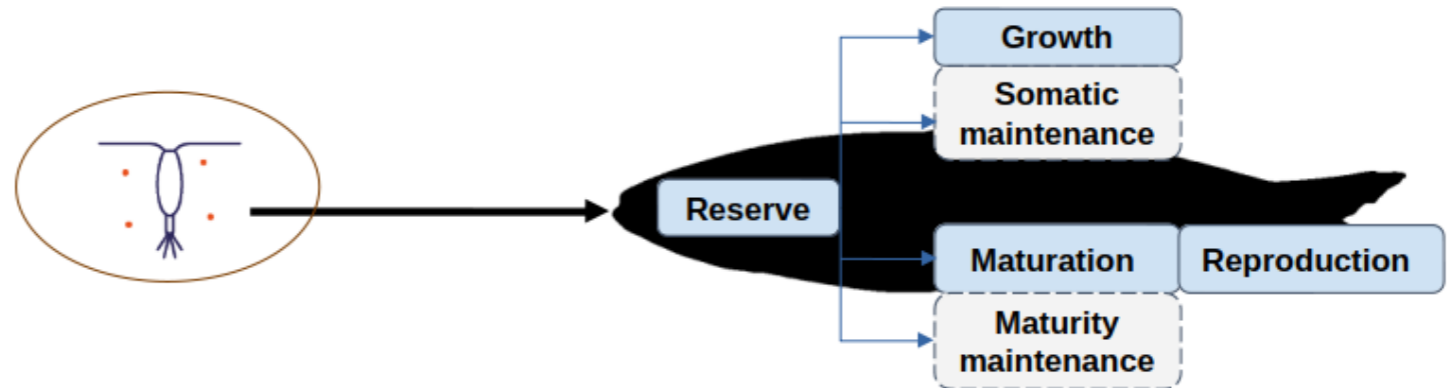


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**H1 - Decrease in zoo quantity (biomass)**



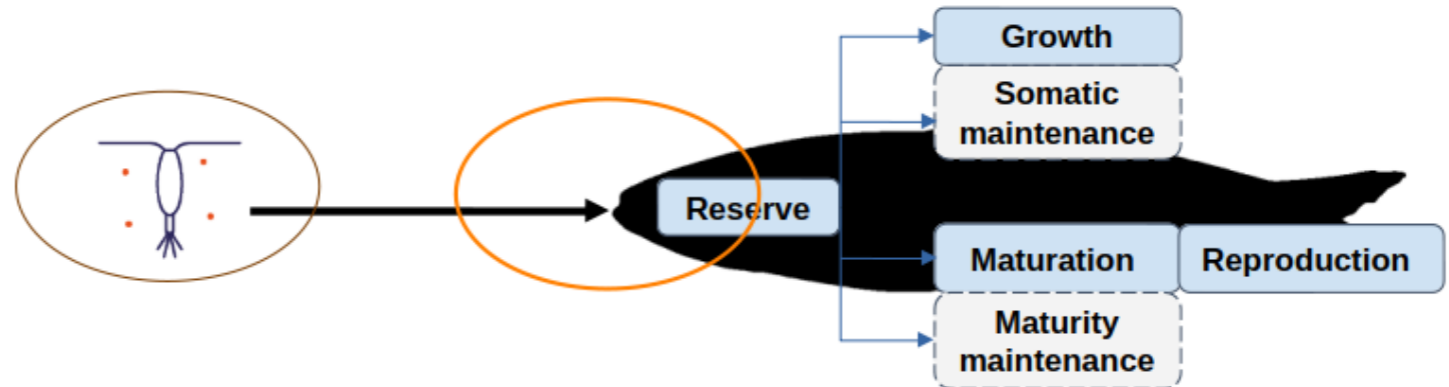
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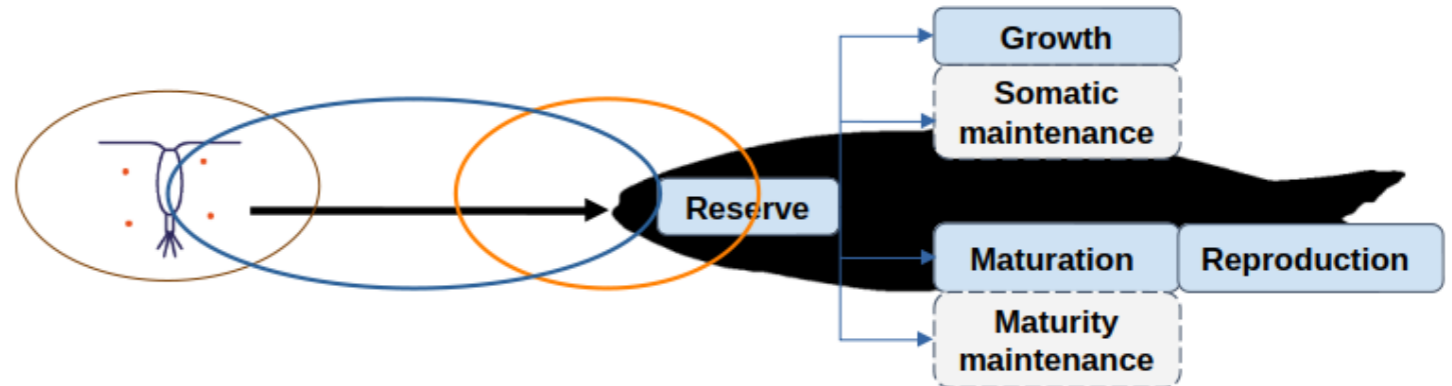
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(as a response to a decrease in food size -  
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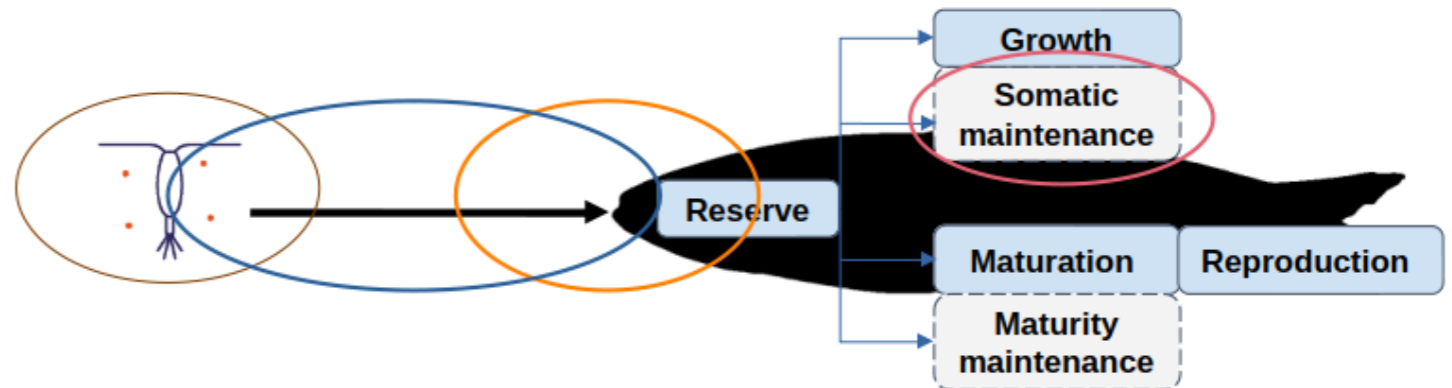
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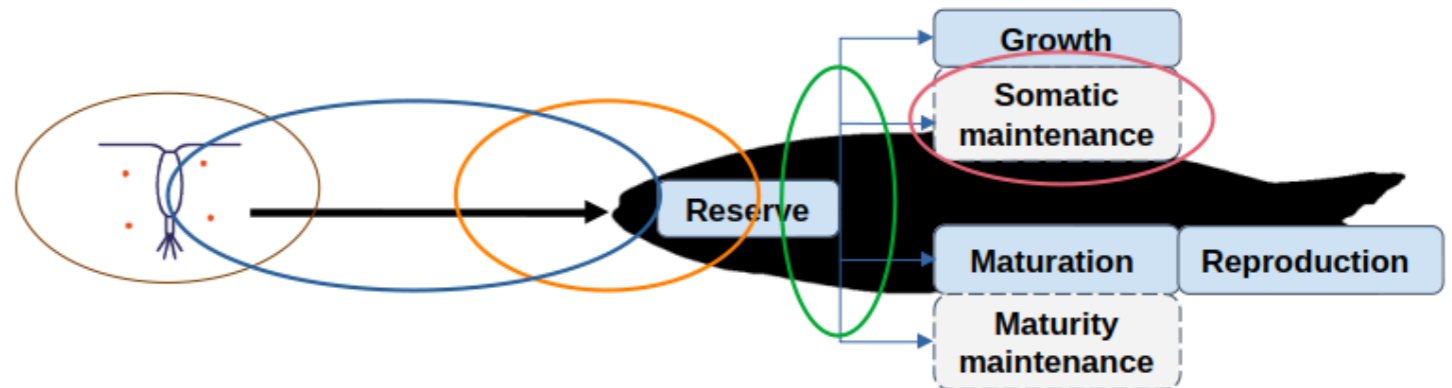
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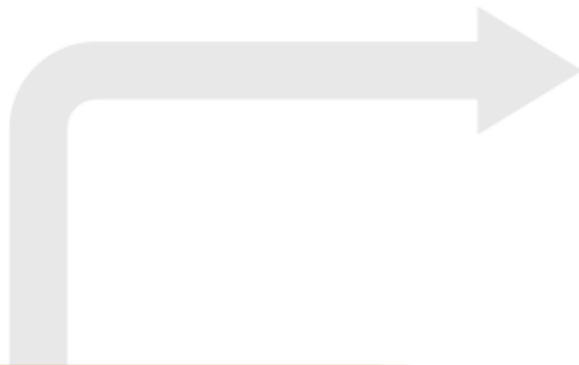
**H4 - Increase of foraging cost**  
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Queiros et al., 2024)

**H5 - Decrease in energy allocated to growth**  
**with respect to reproduction**  
Brosset et al., 2016

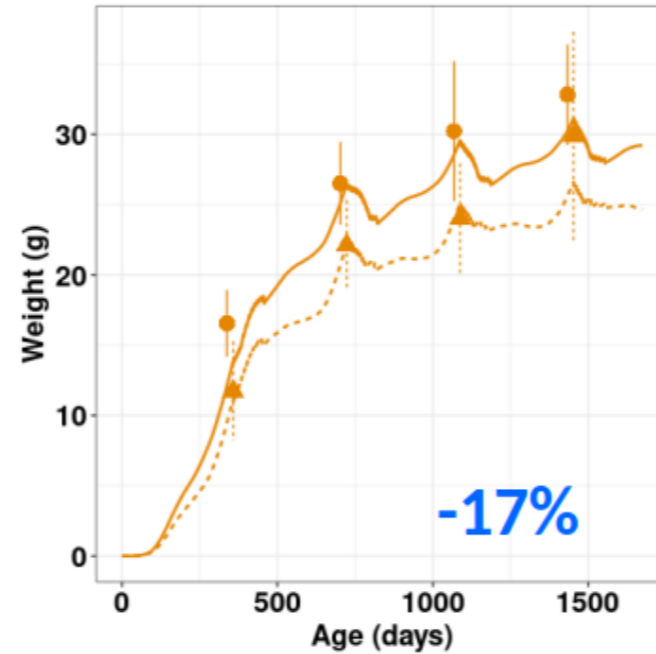


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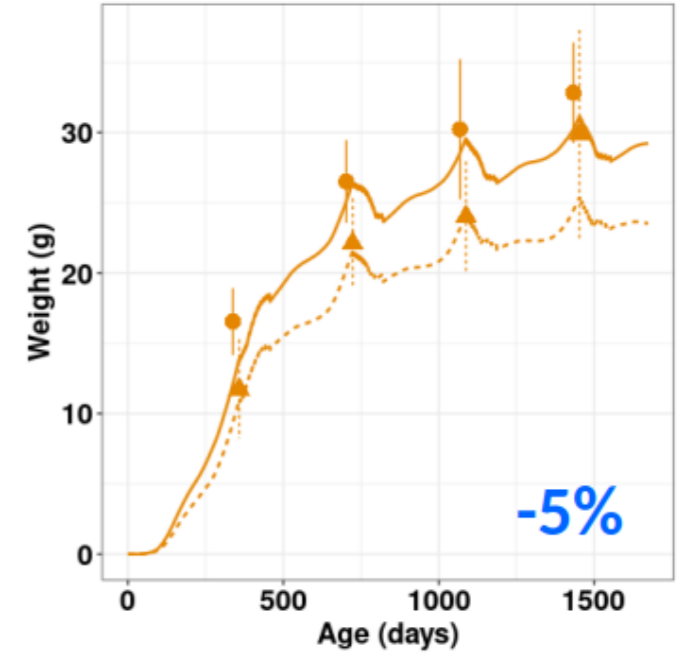
—●— 2000-2005    -▲- 2010-2015



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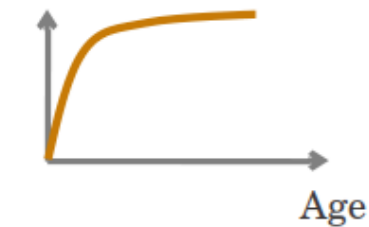
### **0-D DEB-IBM - Individual scale**

2000-2005

2010-2015

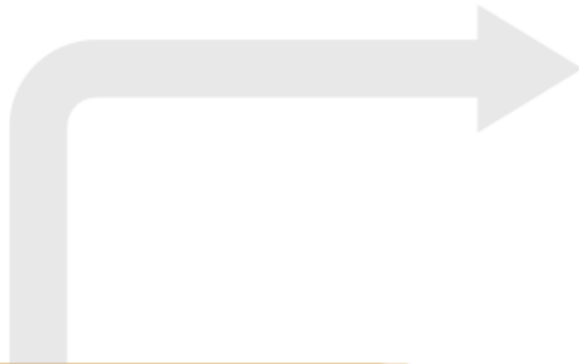
Growth

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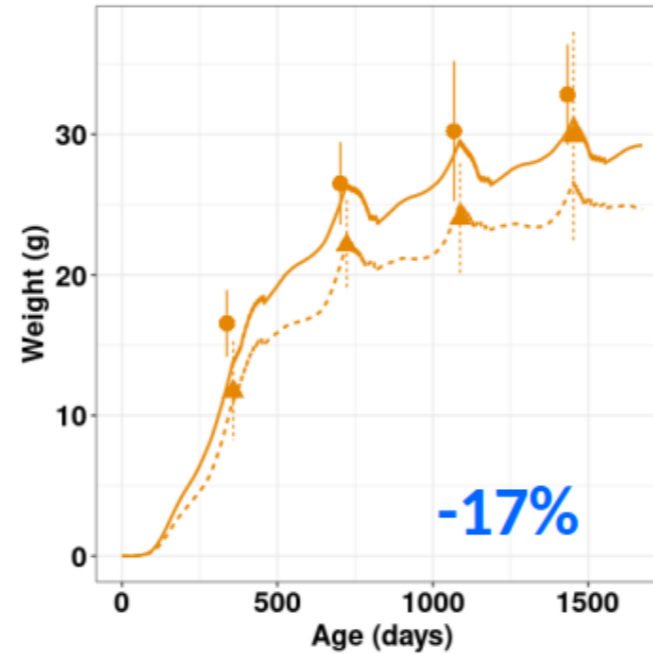


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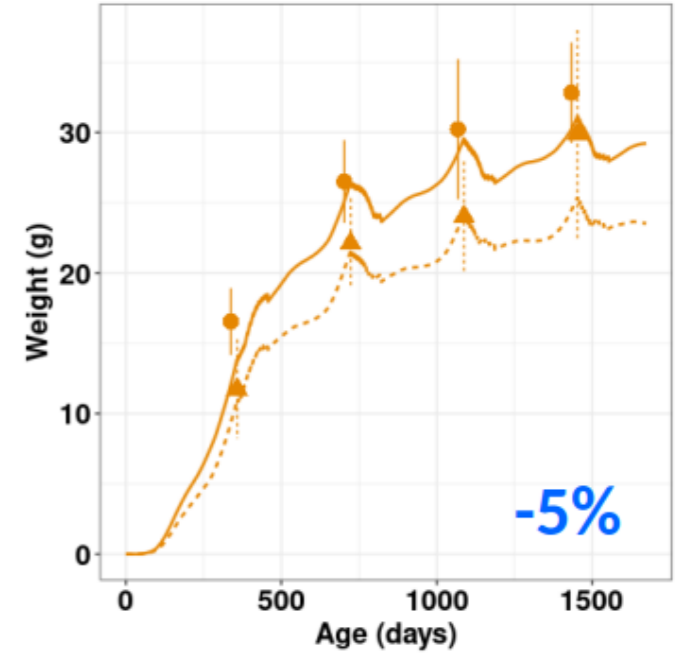
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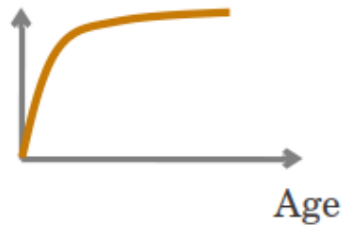
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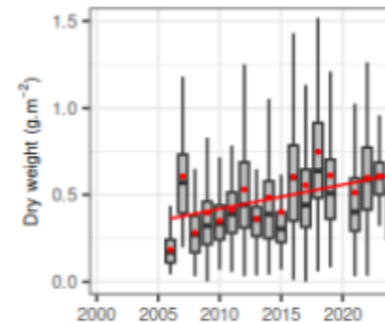
2010-2015

Growth

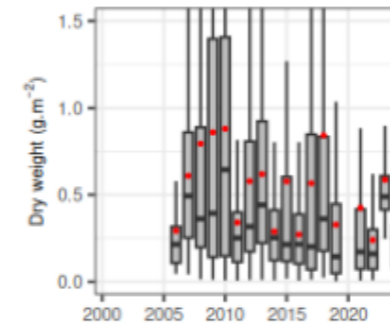
Growth



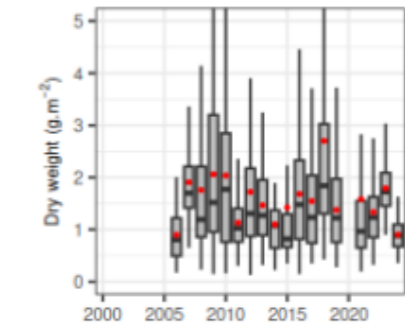
(a) Zooplankton DW (0.2-0.5 mm)



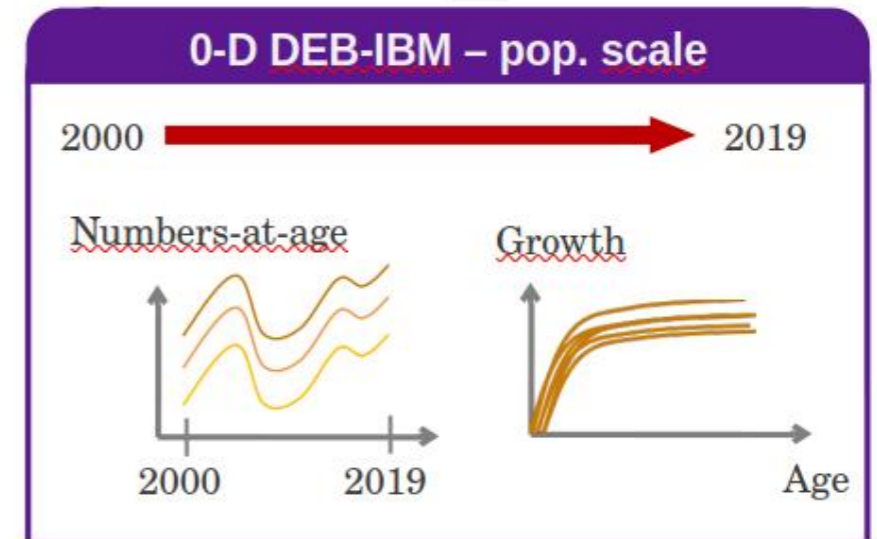
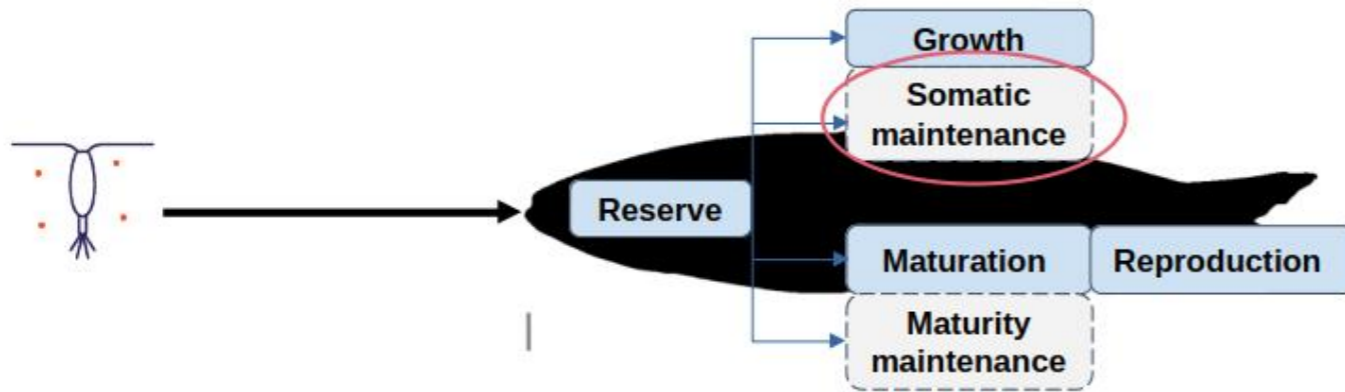
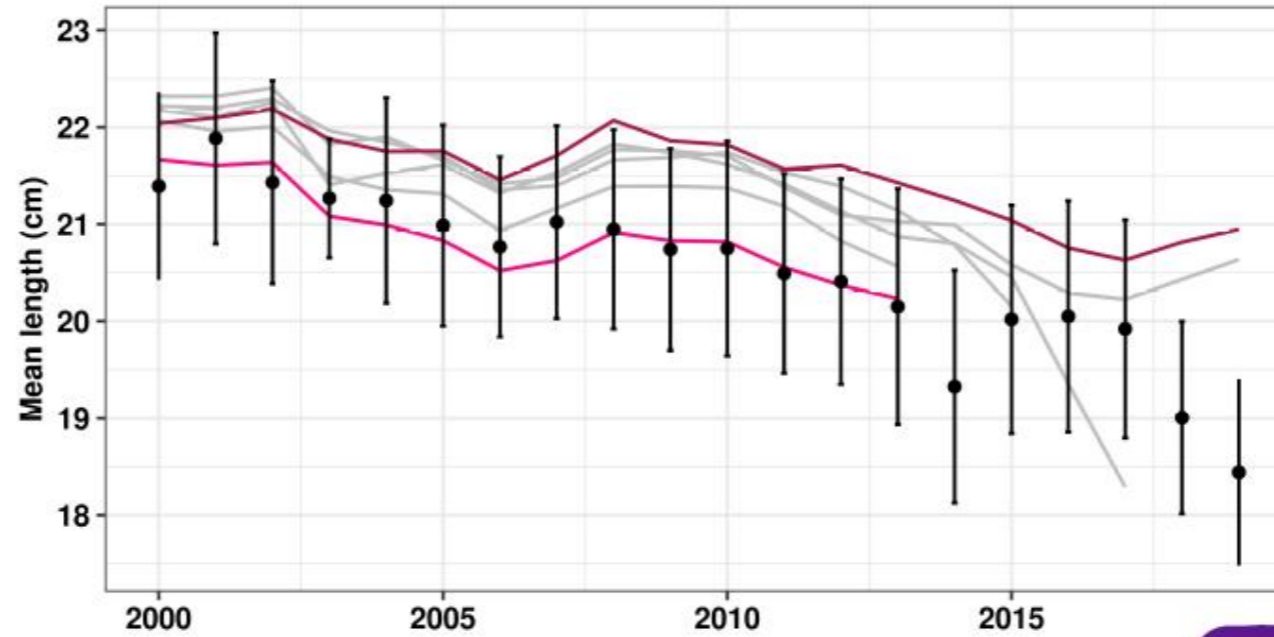
(b) Zooplankton DW (1-2 mm)



(c) Total Zooplankton DW (0.2-2 mm)

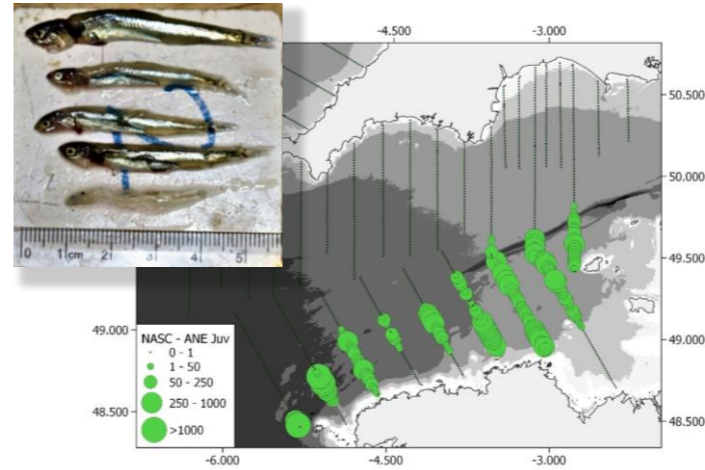
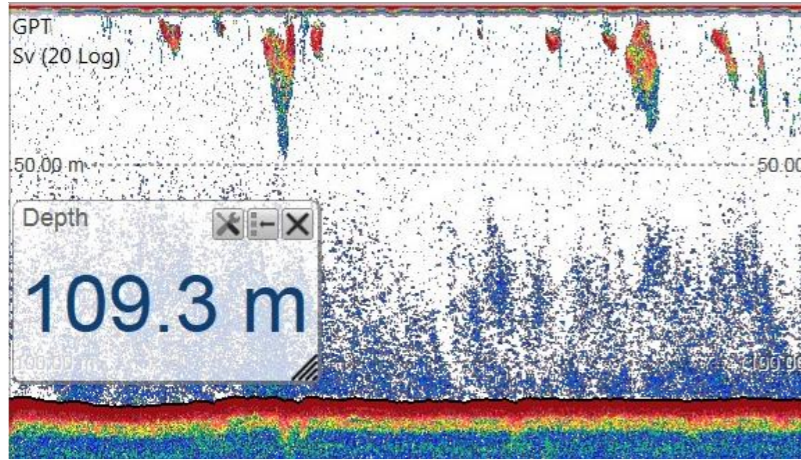
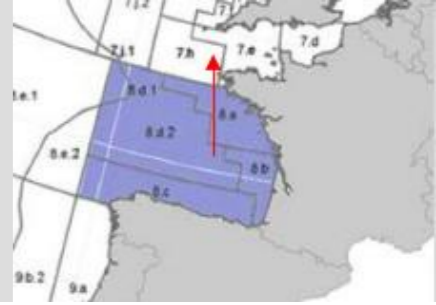


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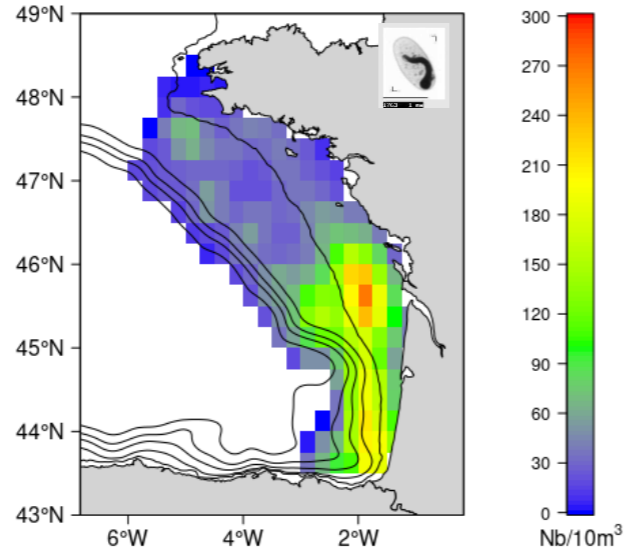
H4 – Increase of foraging cost as a consequence of a decrease in food quality

# 3. Change in anchovy connectivity between the Bay of Biscay and the English Channel ?

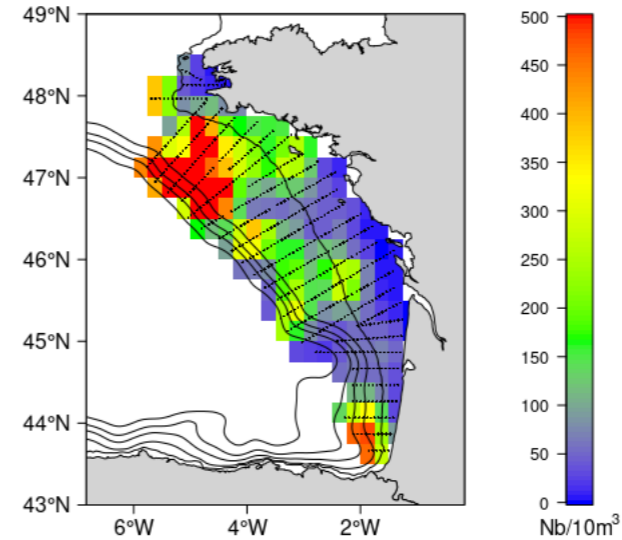


Van der Kooij et al. 2024, MEPS

Mean - anchovy eggs 2000-2024



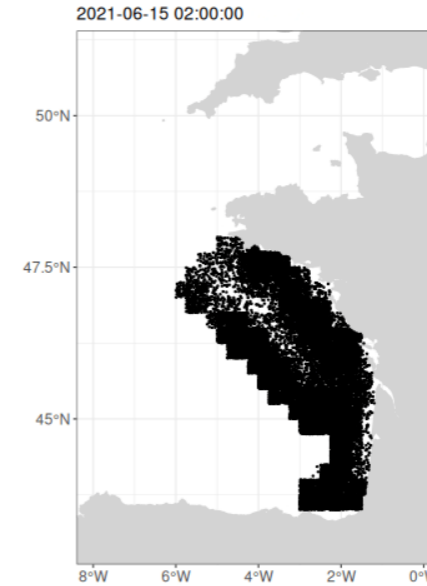
Anchovy eggs 2024



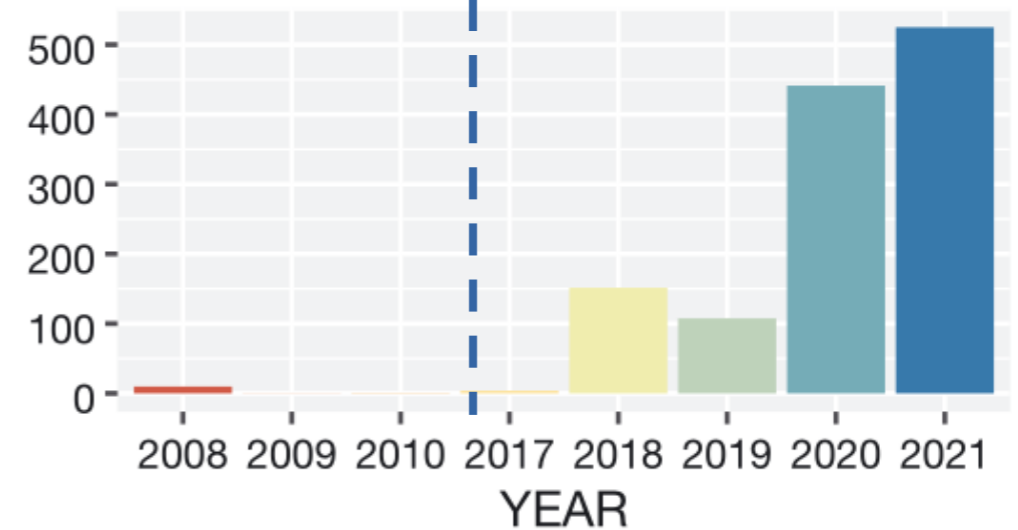
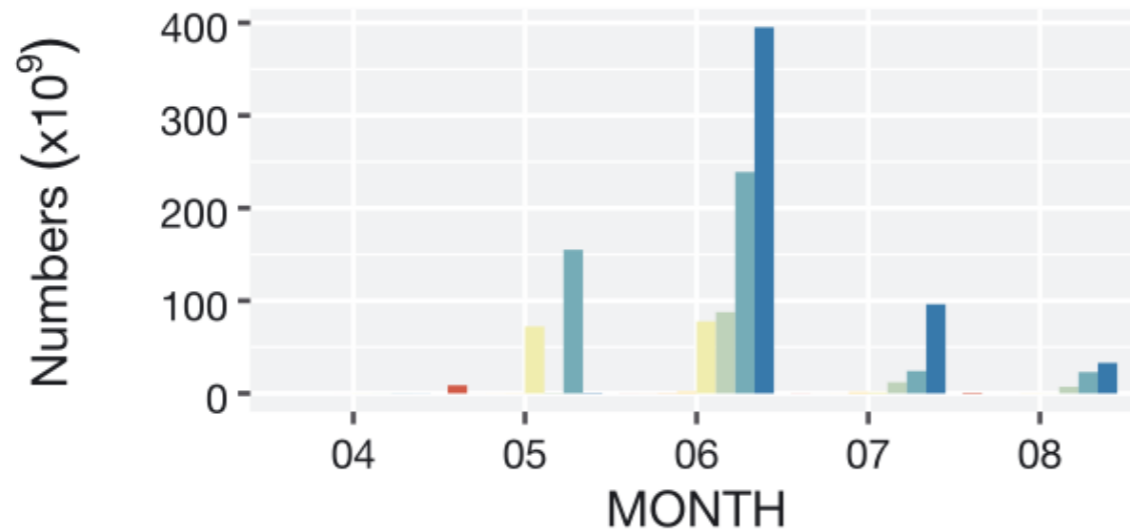
# 3. Change in anchovy connectivity between the Bay of Biscay and the English Channel ?



- 3-D configuration of the model
- Larval drift + bioenergetics (DEB)
- ~25000 particles per month between April and August
- Assess position when juveniles



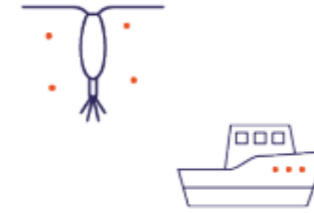
Number of individuals reaching the English Channel from Biscay



# DEB-IBM useful for research (and management ?)

- **Drivers of anchovy population dynamics in the 2000's**

- Zooplankton + fishing → collapse of anchovy in the early 2000's
- Without fishing closure → no recovery



- **Drivers of SPF size shrinking**

- Zooplankton quality rather than quantity → in agreement with zoo in-situ observations in the Bay of Biscay (Grandremy, 2024)
- Through increase of foraging energetic costs as a consequence of zoo shrinking → supported by experiments (Queiros et al., 2024)
- Need to include variability in growth (and mortality) in assessment, based on environmental indicators

- **Drivers of anchovy connectivity with English Channel**

- More anchovy spawning in the north of Biscay under density dependence spatial effect and warming
  - Recent increased connectivity at larval stage (van der Kooij et al., 2024)
  - To be tested on sardine for consistency with genetics
- } Re-assess stock structure ?

Thank you !

