Integration of a DEB model in an IBM for European anchovy: population hindcast and other applications

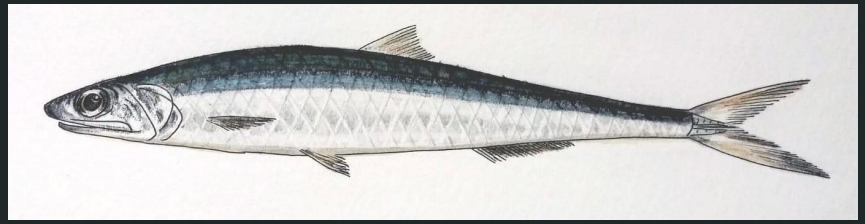
Juan Bueno Pardo, Pierre Petitgas, Susan Kay, Martin Huret

6th International Symposium on Dynamic Energy Budget theory

April 12th 2019, Brest

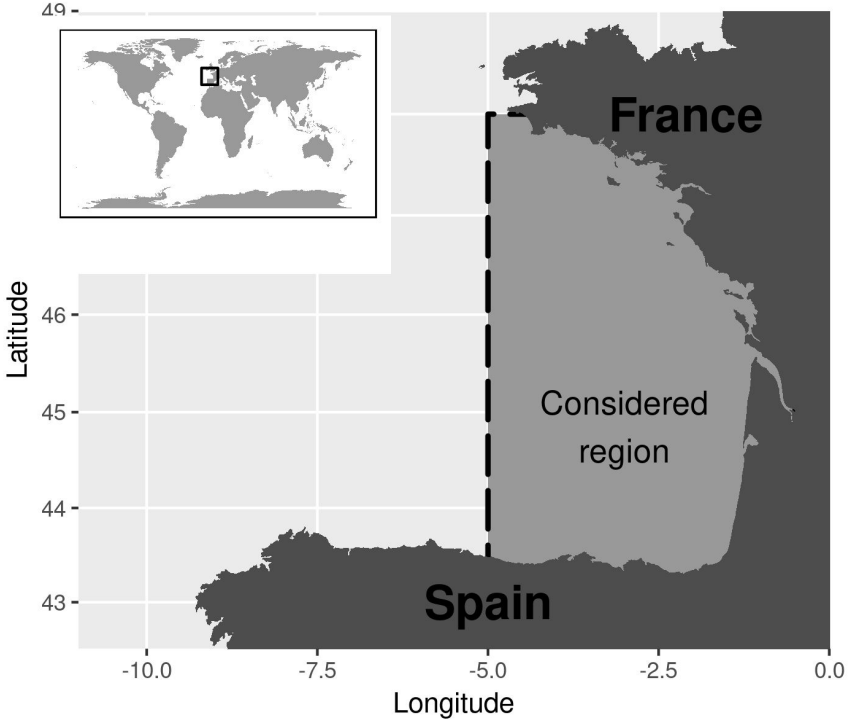
Introduction

- Study area and species
- Objectives
- Conceptual framework



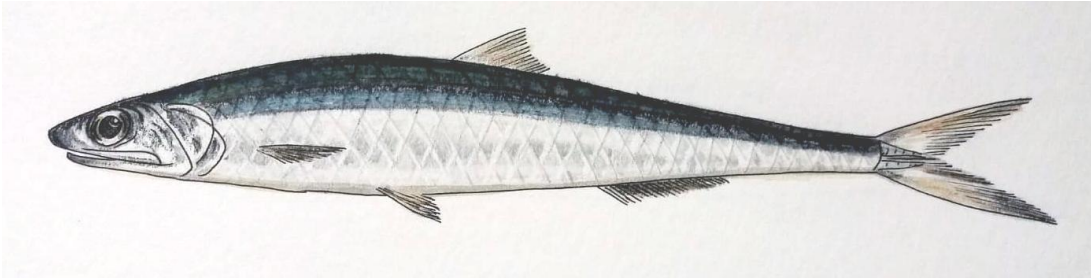
Introduction

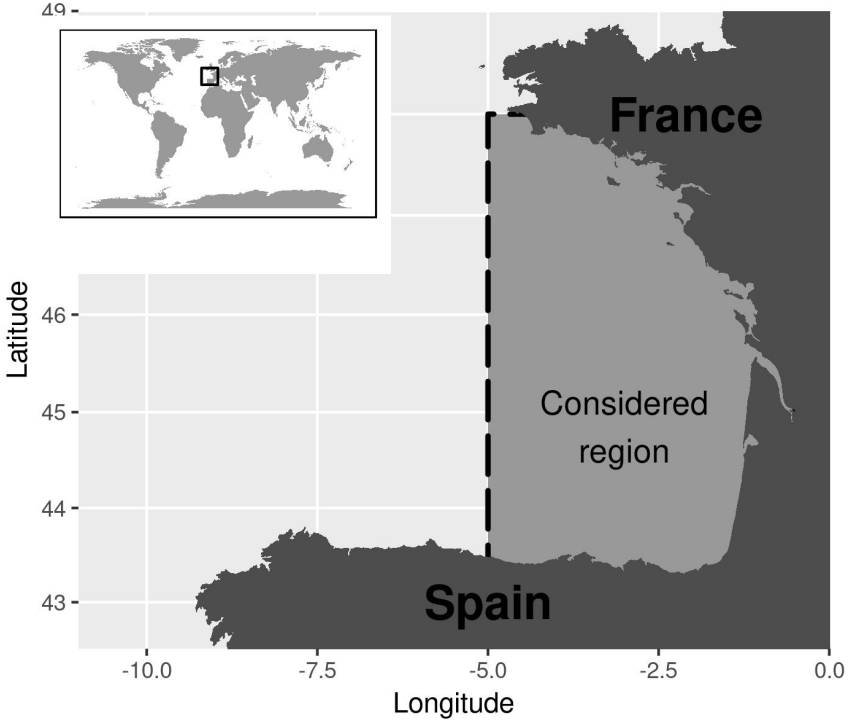
Bay of Biscay



Introduction

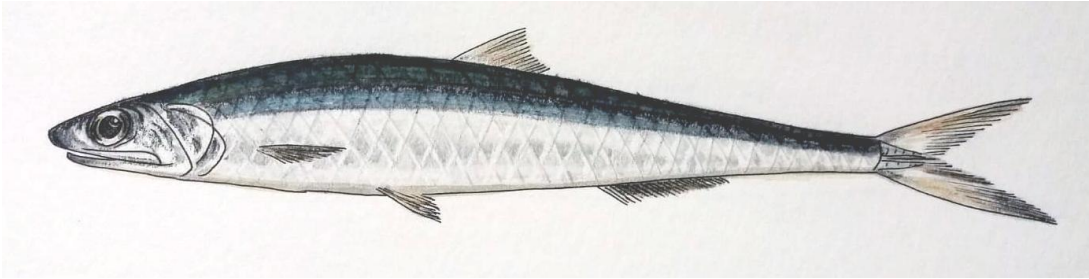
Engraulis encrasicolus

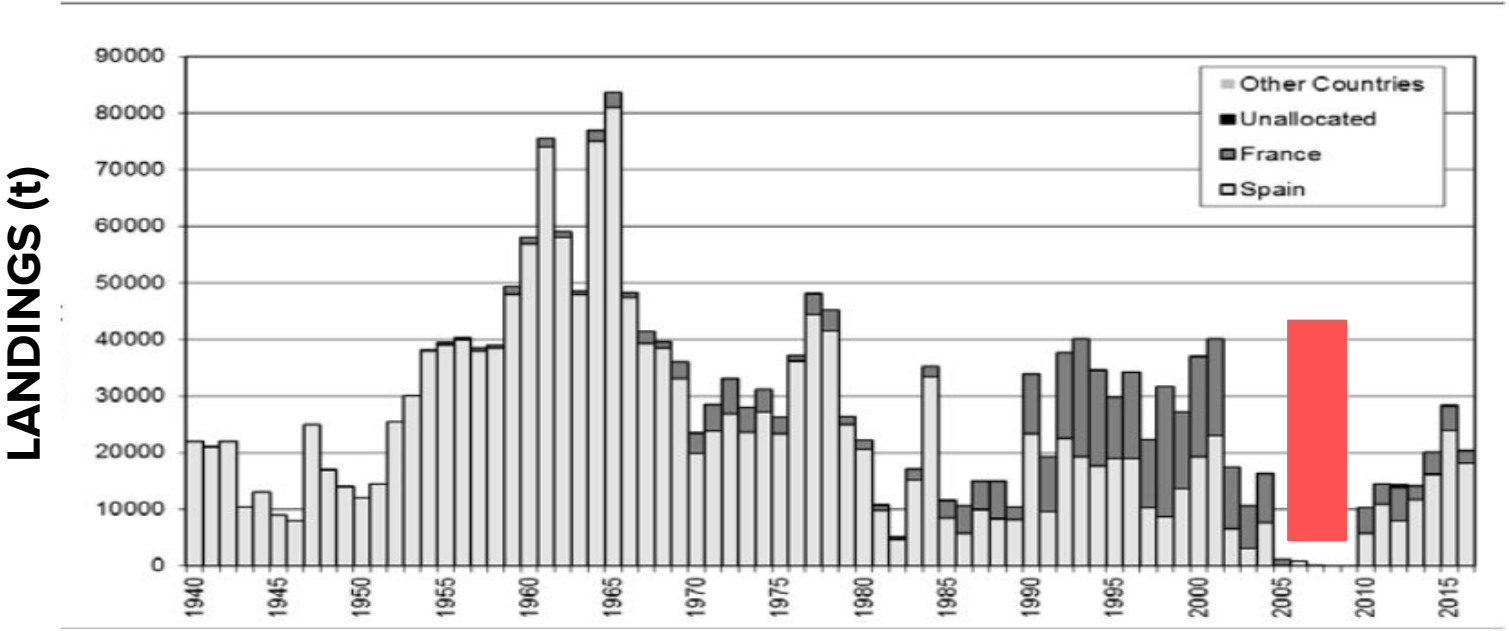




Introduction

Engraulis encrasicolus





Introduction

Main objective:

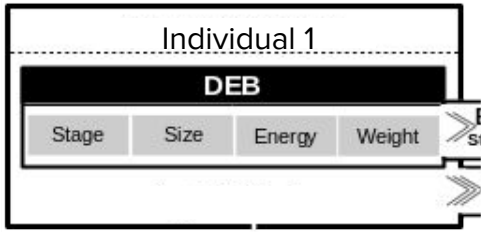
- Identify the drivers of the population dynamics, disentangling the effects of fishing and environment

DEB-Questions:

- What improvement is obtained when DEB theory is considered in a population model?
- What DEB theory can tell us about the collapse and recovery of the population?
- What can DEB theory tell about the future of the population?

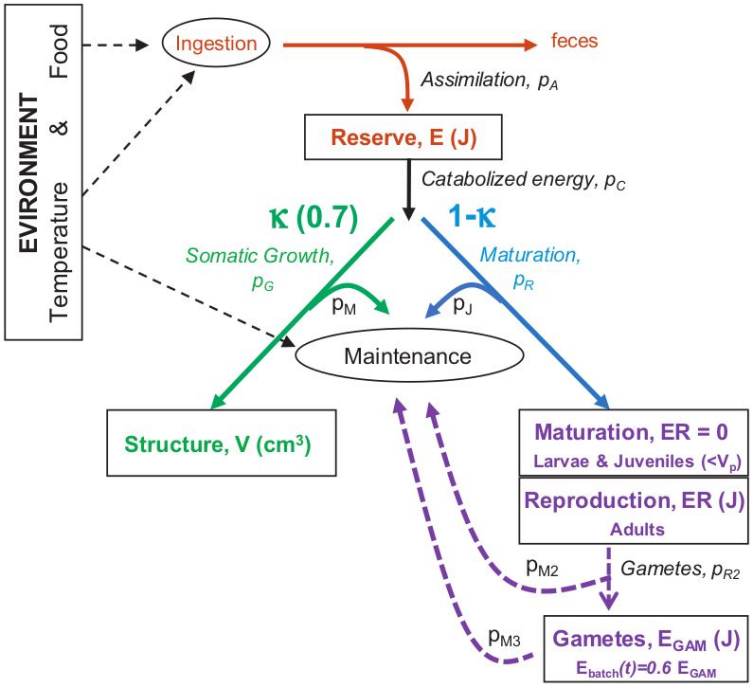
Introduction

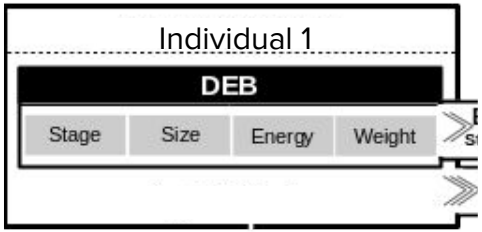
Conceptual framework



Introduction

Conceptual framework

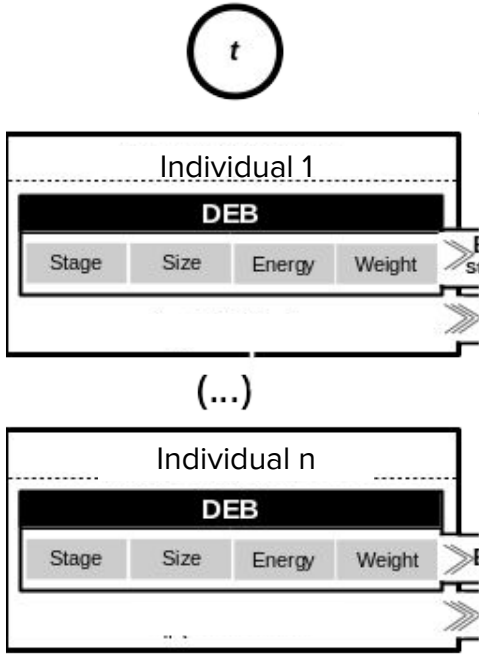




H. Pethybridge et al. / Ecological Modelling 250 (2013) 370–383

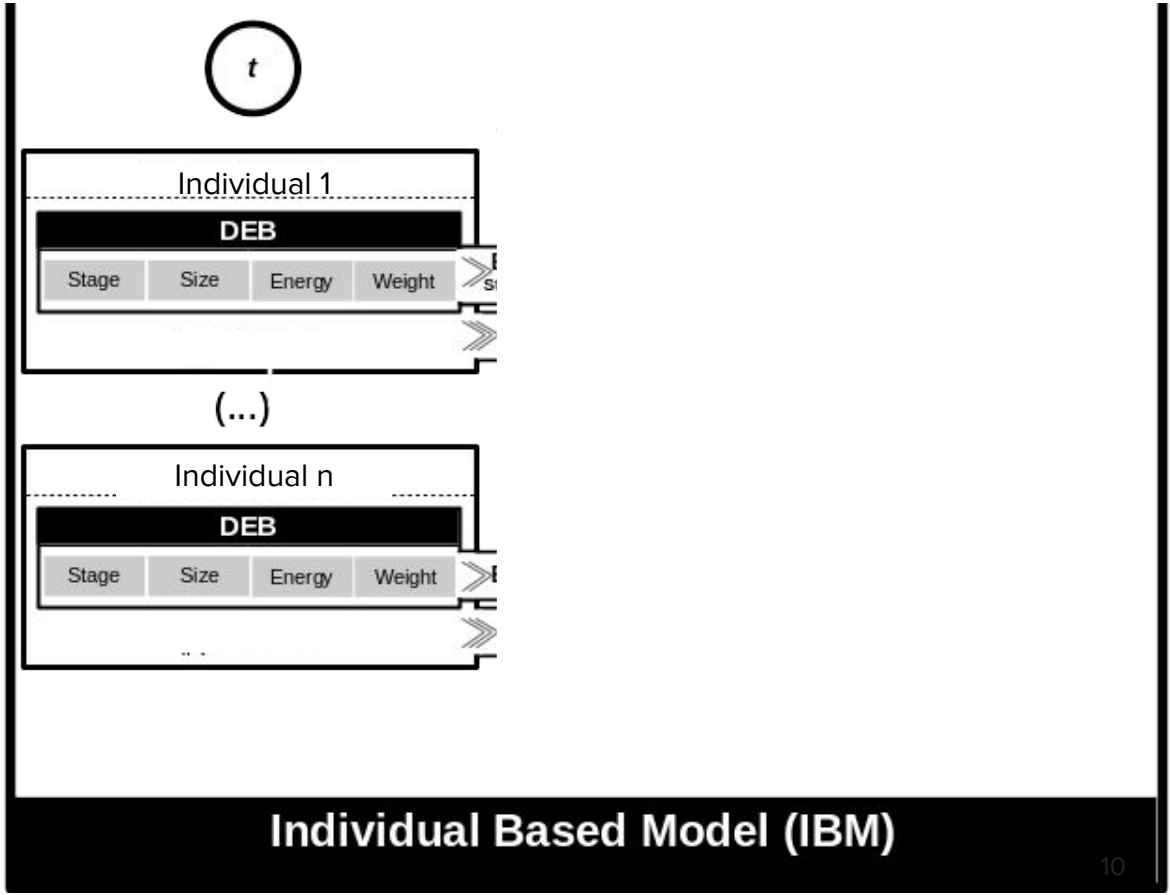
Introduction

Conceptual framework



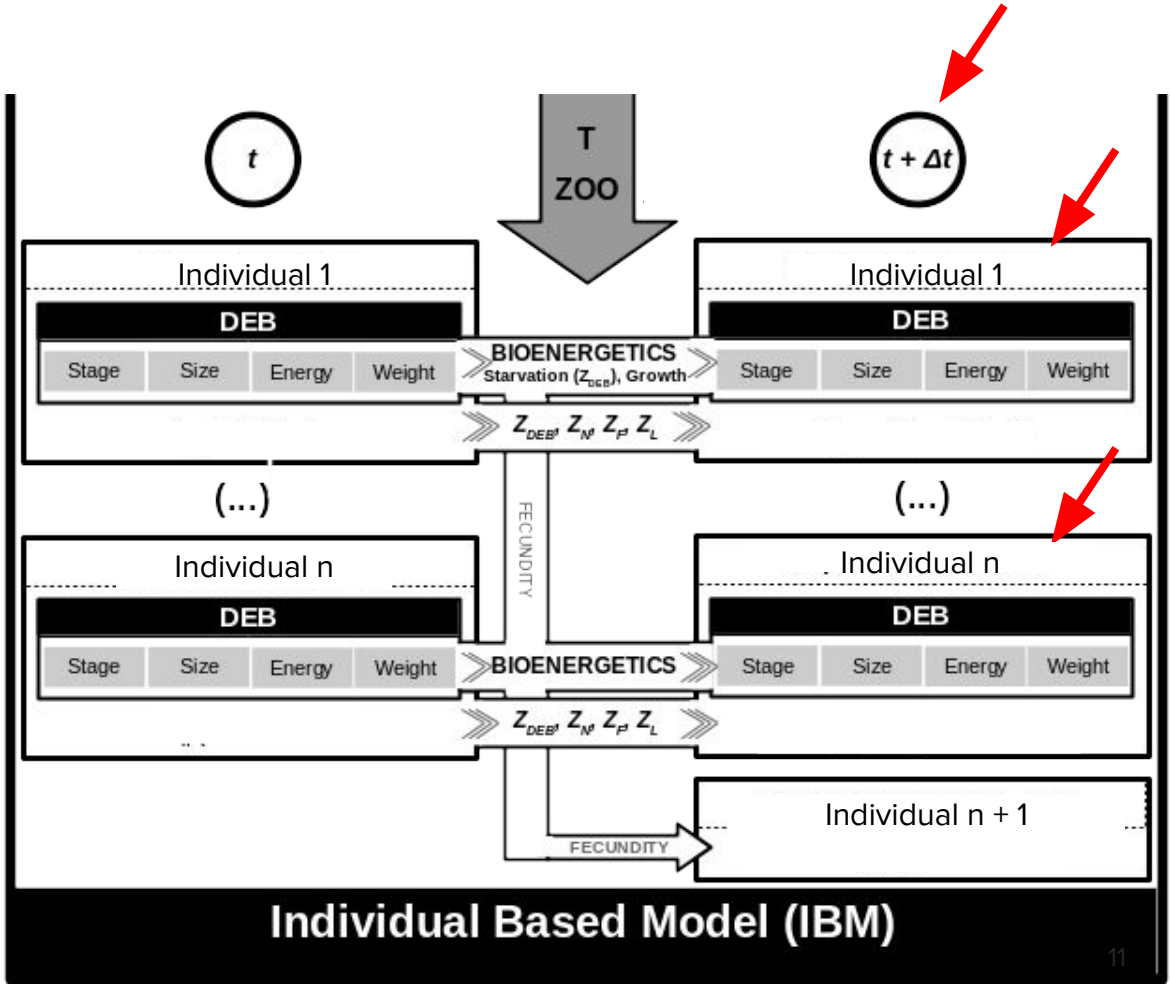
Introduction

Conceptual framework



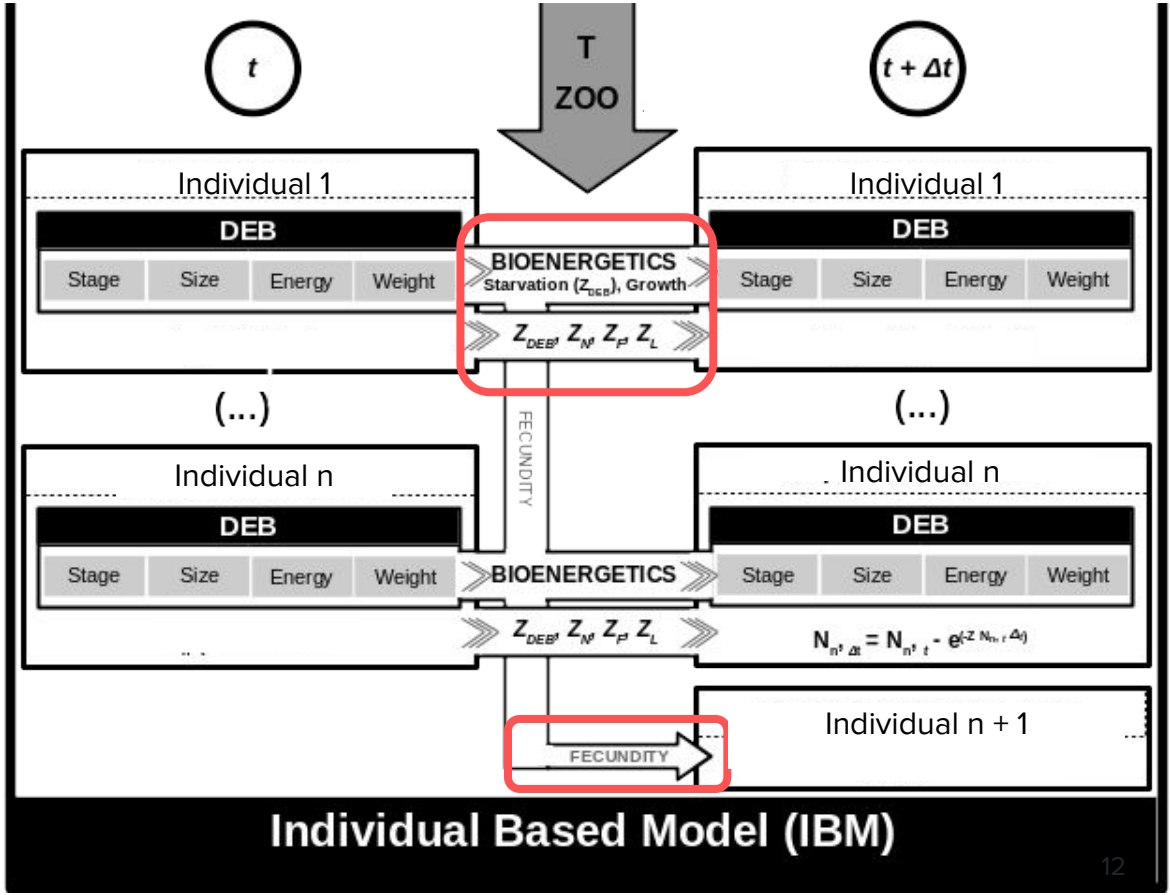
Introduction

Conceptual framework



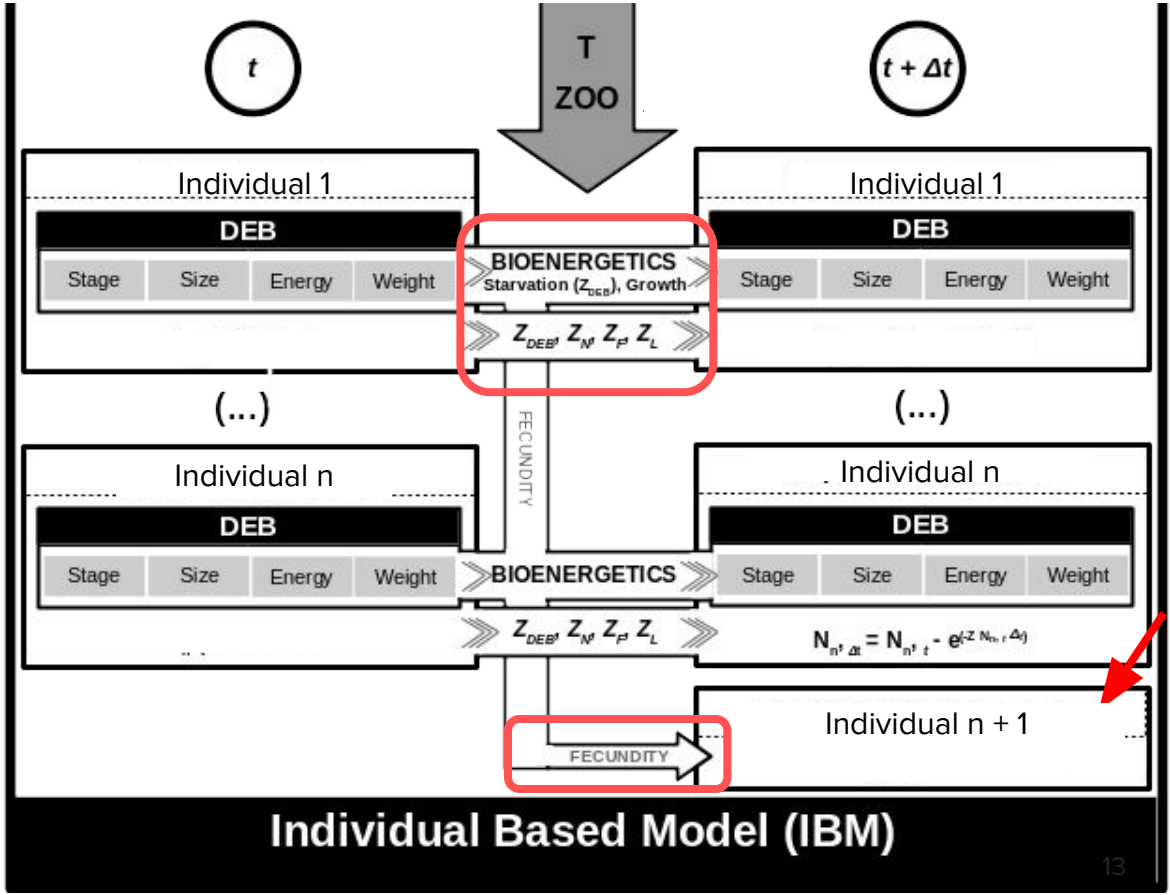
Introduction

Conceptual framework



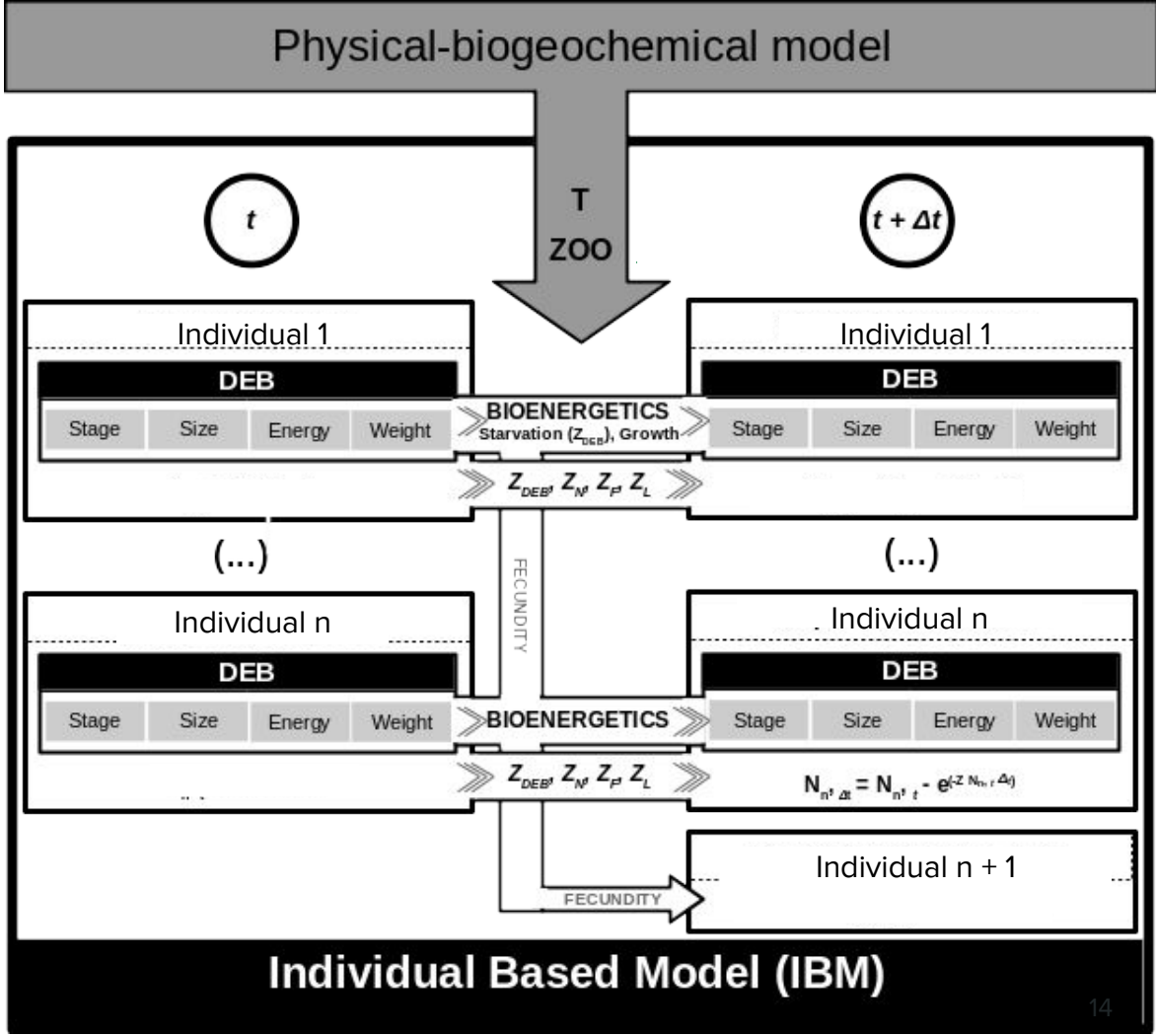
Introduction

Conceptual framework



Introduction

Conceptual framework



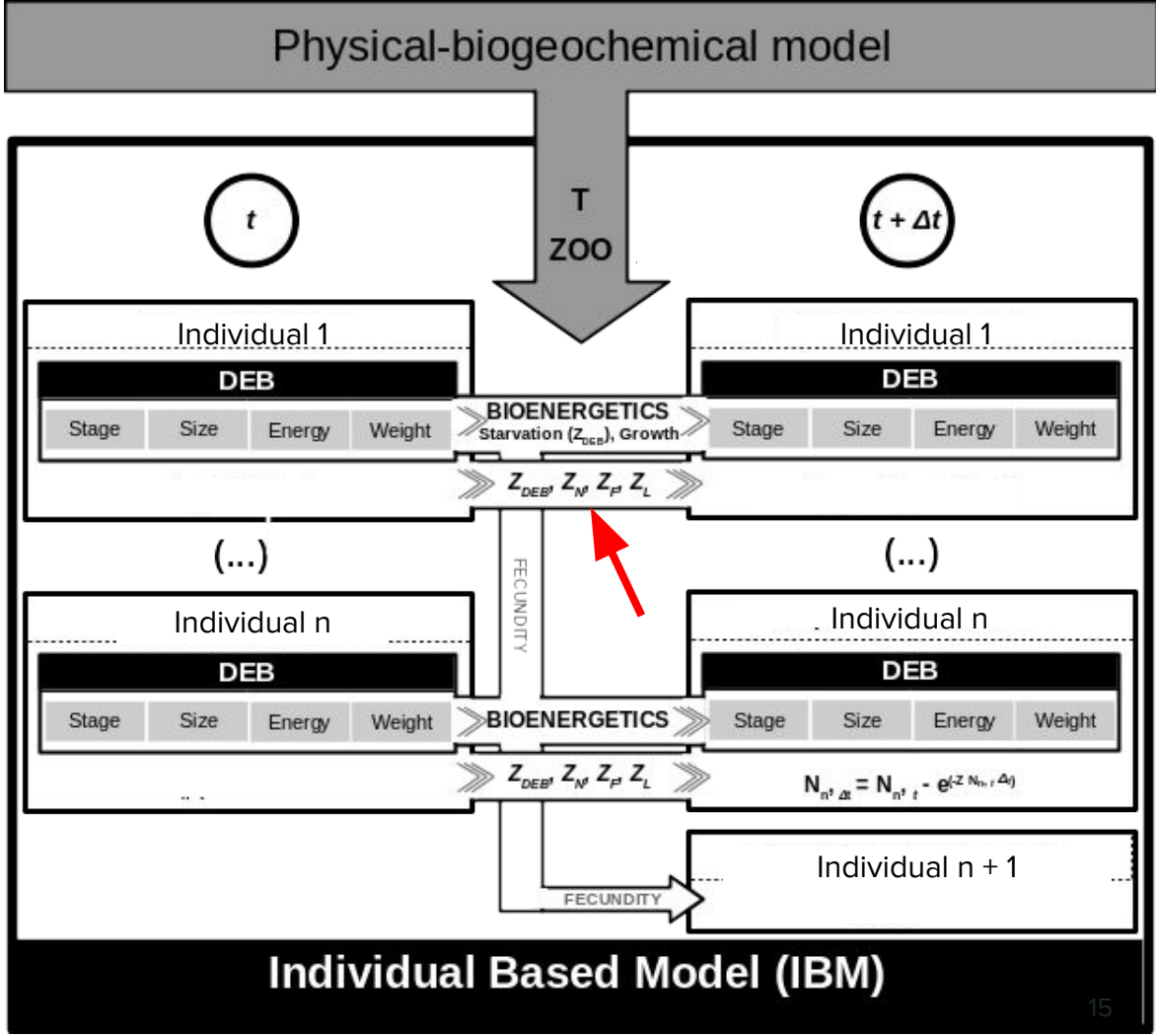
Introduction

Conceptual framework

Four kinds of mortality are considered:

- ZDEB — **DEB module**
- ZN
- ZF
- ZDD

IBM module

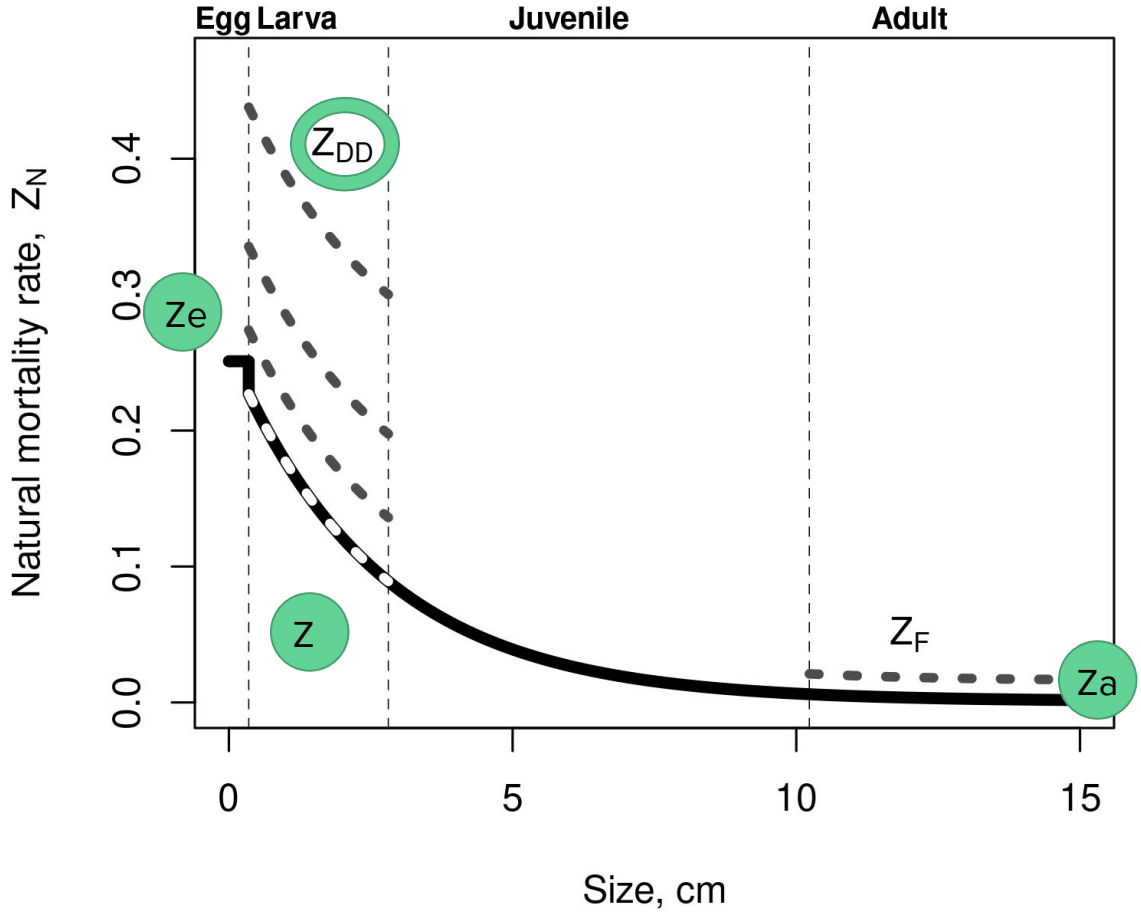


Introduction

Conceptual framework

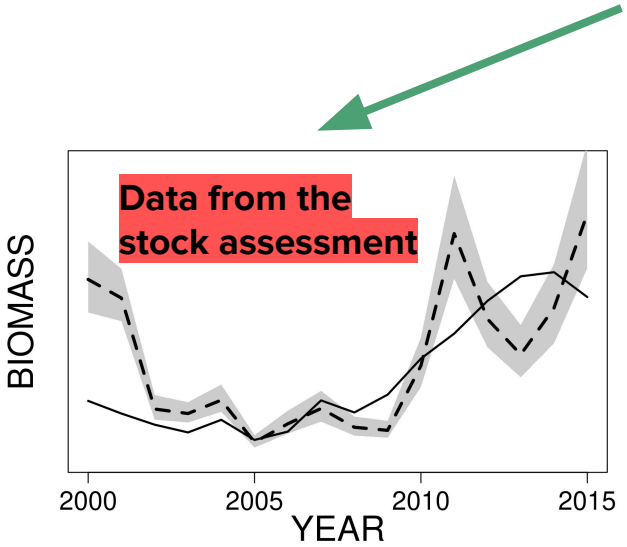
Four kinds of mortality are considered:

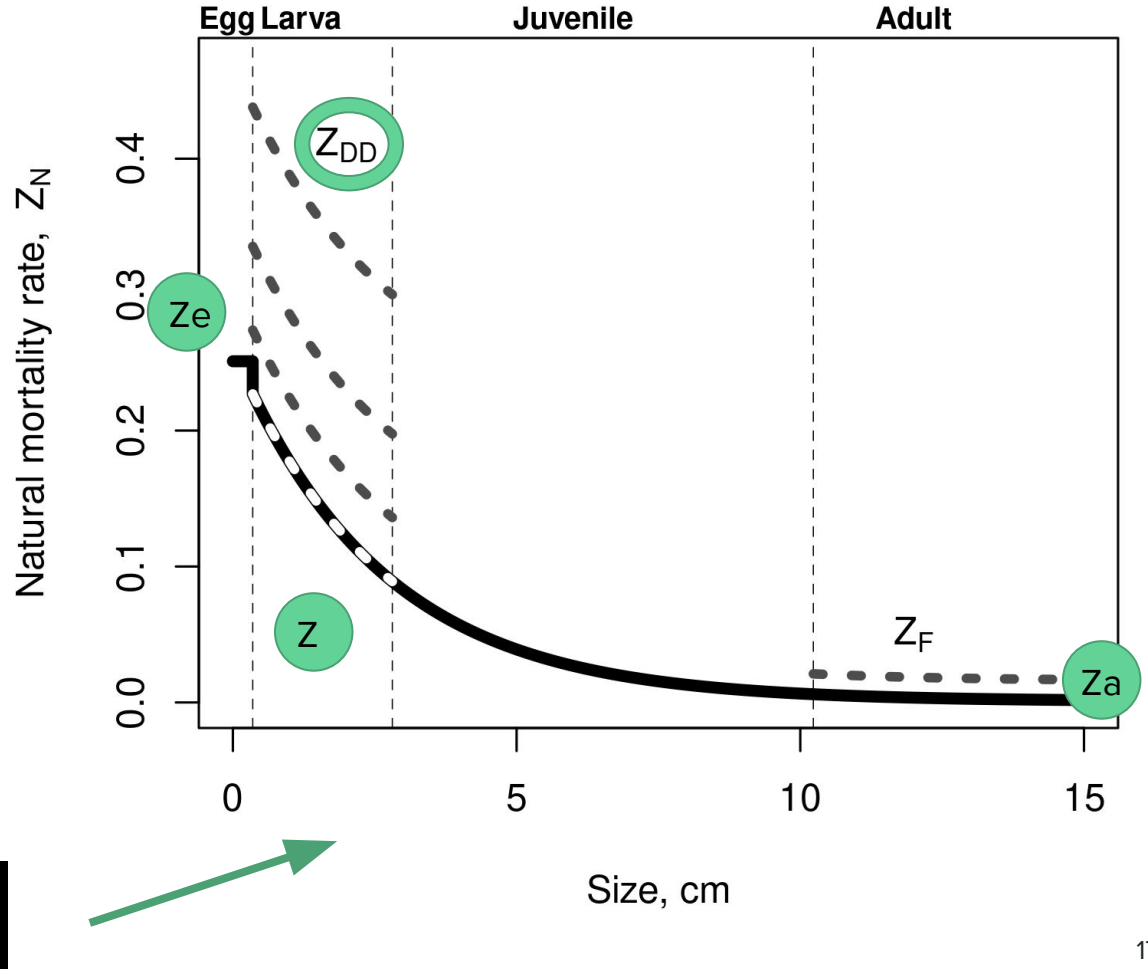
- ZDEB — **DEB module**
- ZN
- ZF
- ZDD — **IBM module**



Introduction

Conceptual framework





Fcost

Results

- Individuals
- Population
- Drivers of population dynamics
- Future

Results

Individuals

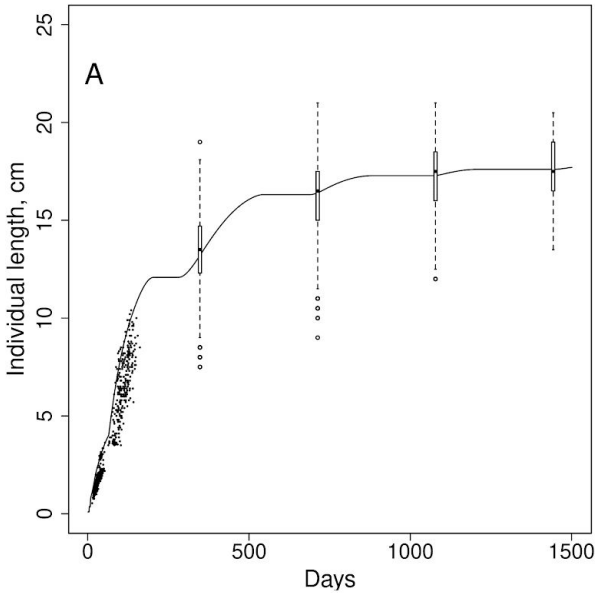
Contents lists available at ScienceDirect

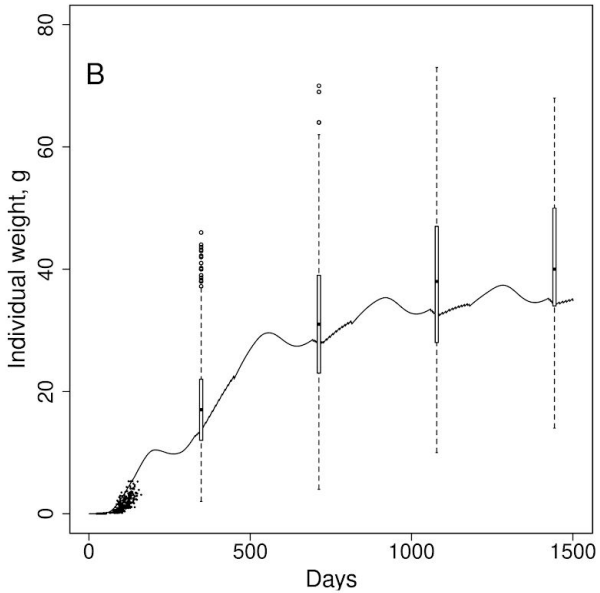
Ecological Modelling

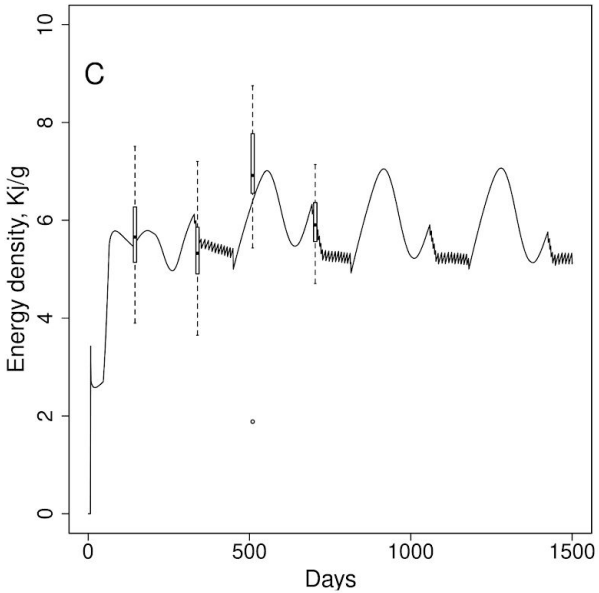
journal homepage: www.elsevier.com/locate/ecolmodel

Comparing biological traits of anchovy and sardine in the Bay of Biscay: A modelling approach with the Dynamic Energy Budget

Paul Gatti[a,*], Pierre Petitgas[b], Martin Huret[a]



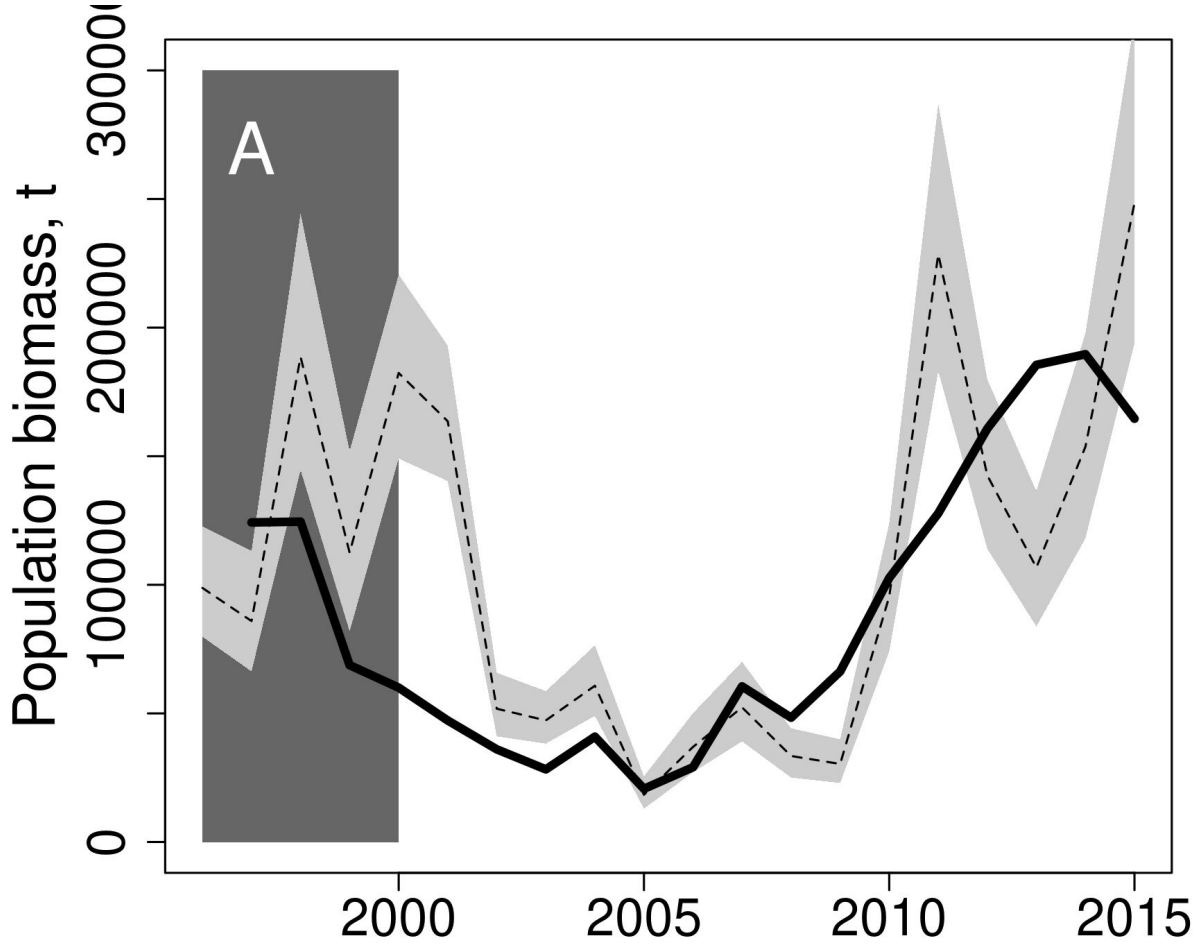




Results
Population

Optimized parameters:

- **Ze = 0.25 d^{-1}**
- **Za = 0.00001 d^{-1}**
- **ZL = 0.1418 d^{-1}**
- **Z = 0.35 cm^{-1}**

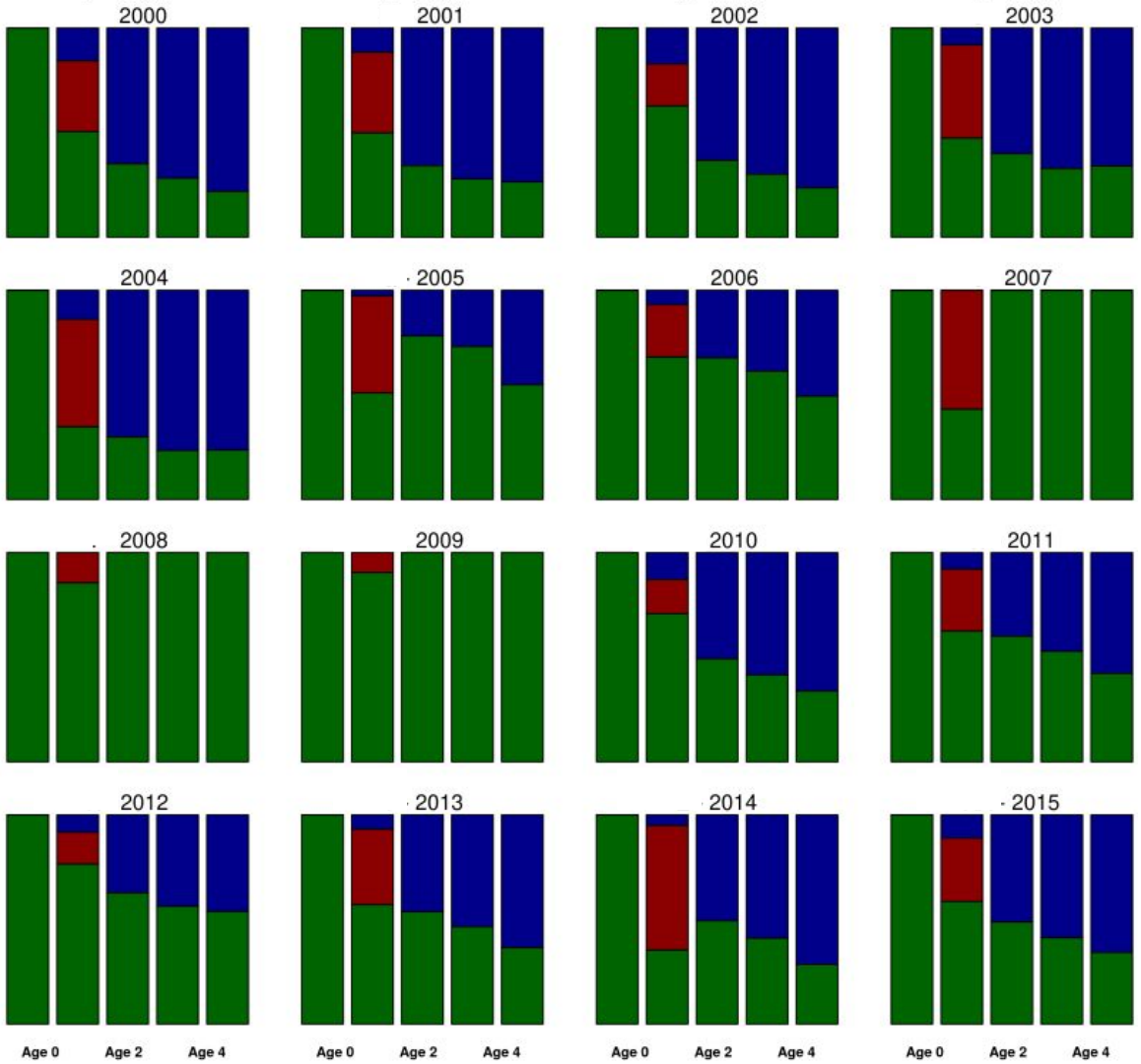


Results

Population

MORTALITY SOURCES

- **FISHING**
- **DEB**
- **NATURAL**



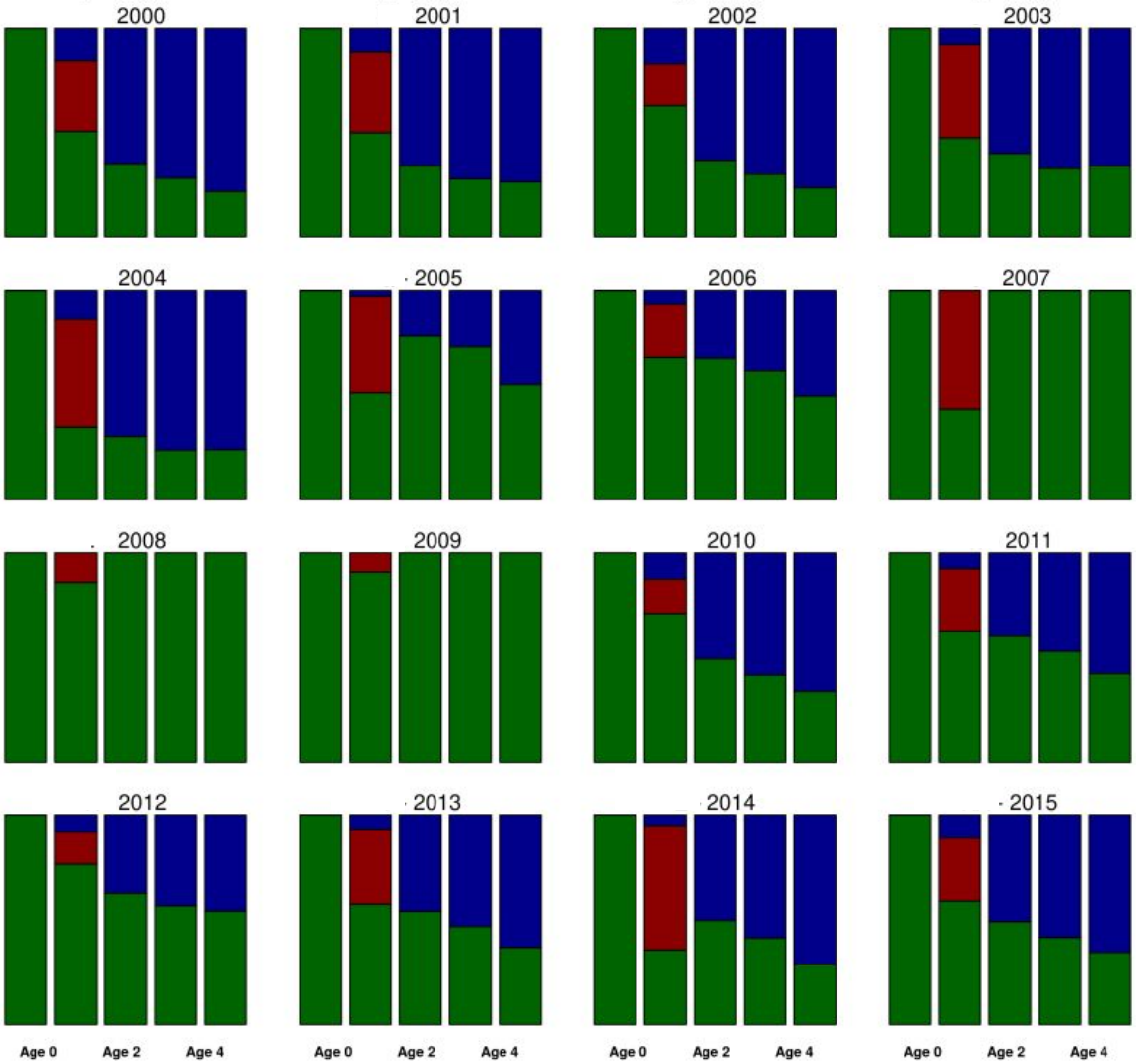
Results

Population

MORTALITY SOURCES

- **FISHING**
- **DEB**
- **NATURAL**

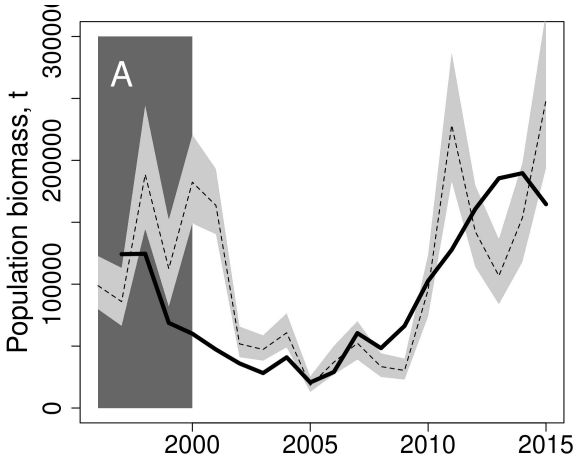
QUESTION 1: What is the improvement of integrating a DEB in an IBM?

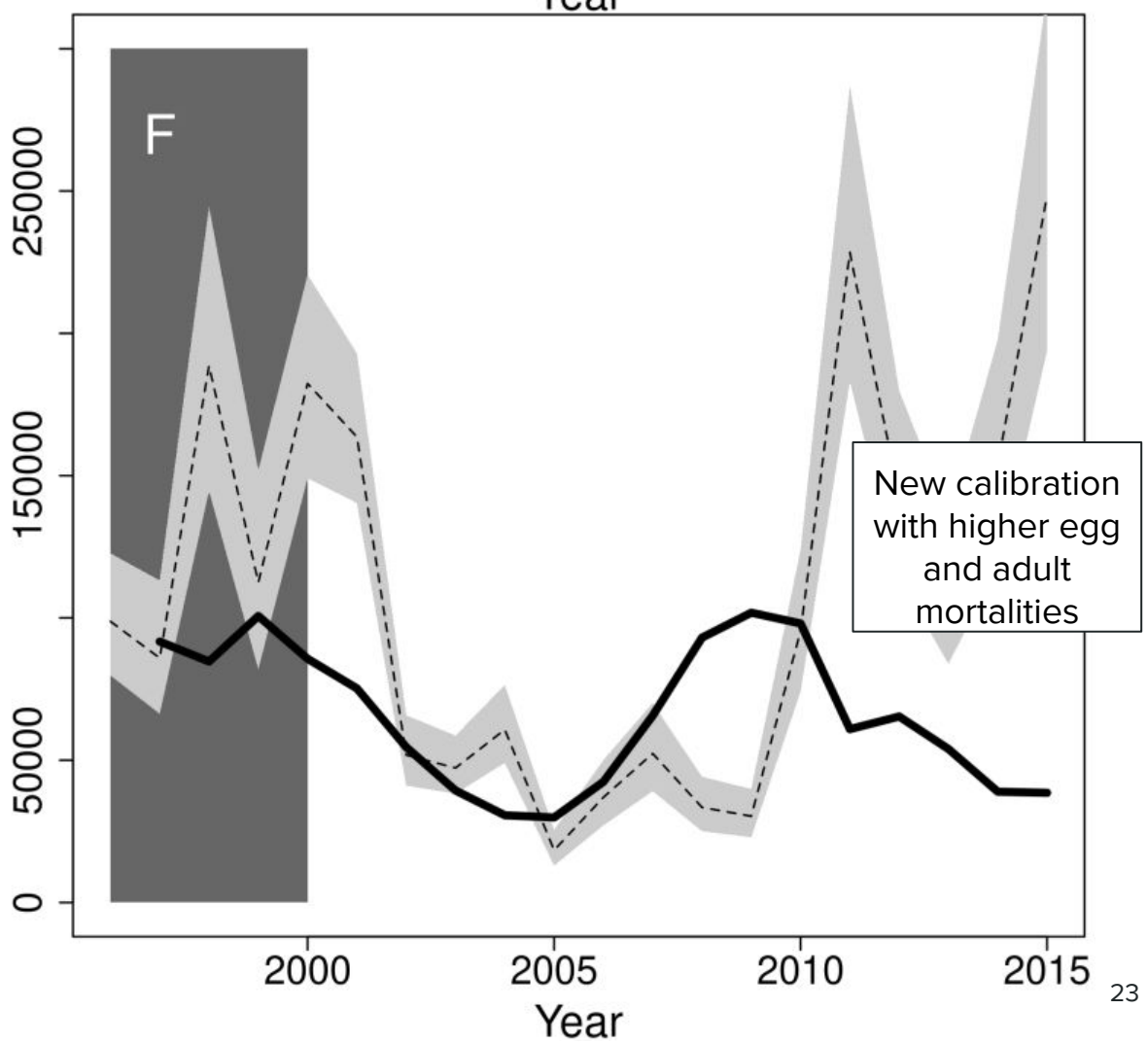


Results

Population

Scenario of no DEB mortality





QUESTION 1: What is the improvement of integrating a DEB in an IBM?

Results
Population

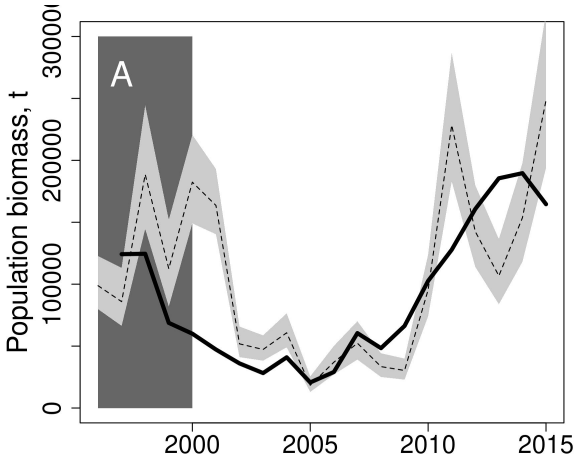
Conclusion #1:

Including a mortality by energetic failure largely improves the hindcast ability of the model, both in the short and long term.

Results

Drivers

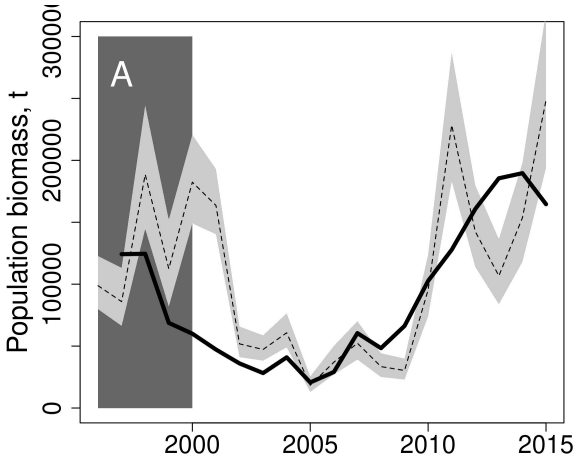
OBJECTIVE: Identify the main drivers of the population dynamics

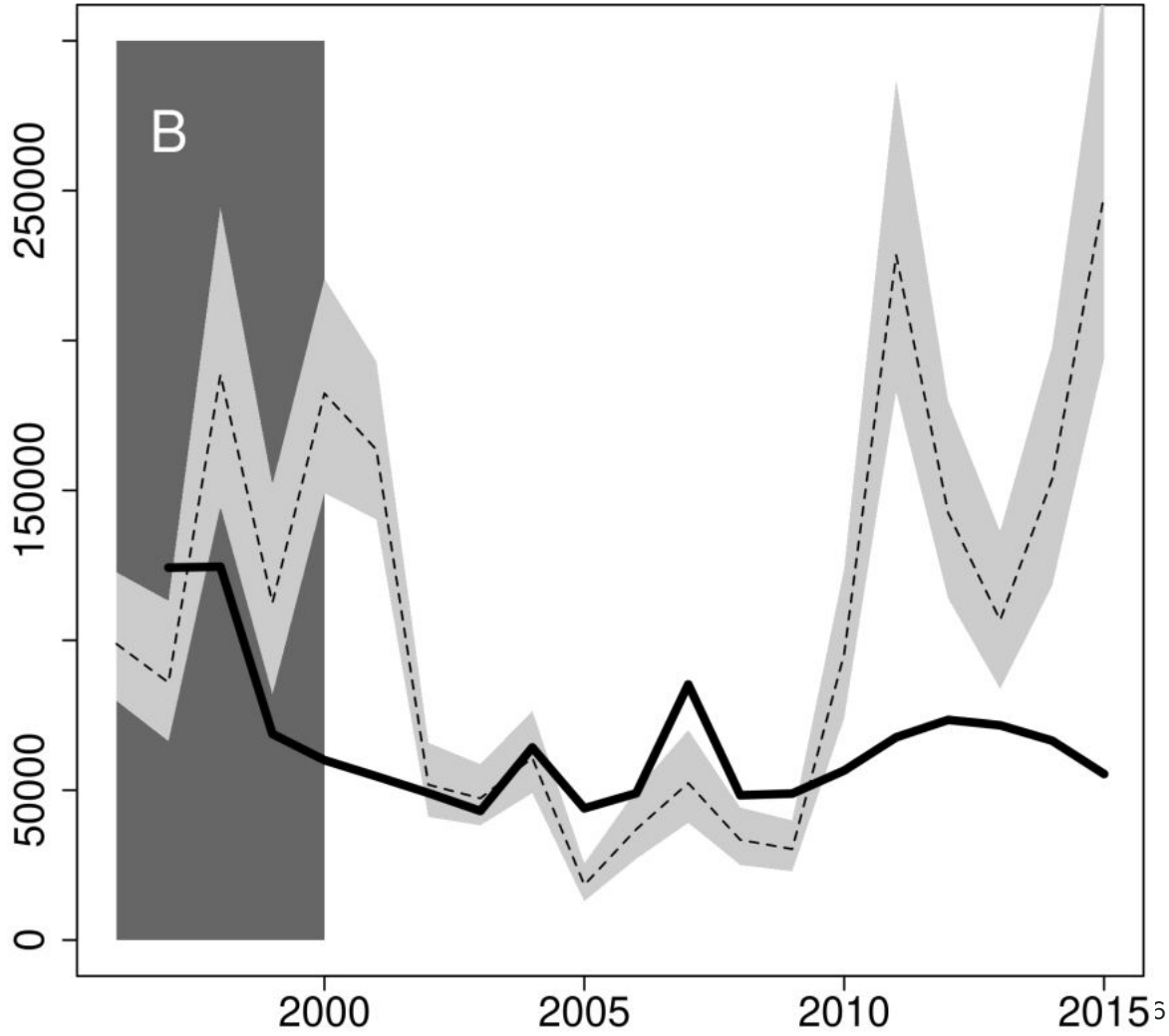


Results

Drivers

Scenario of constant fishing mortality

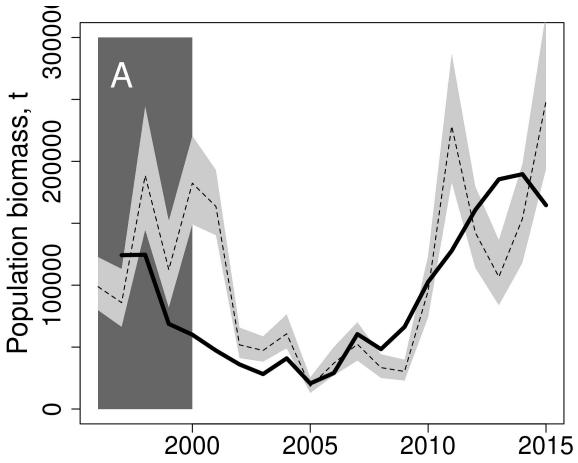


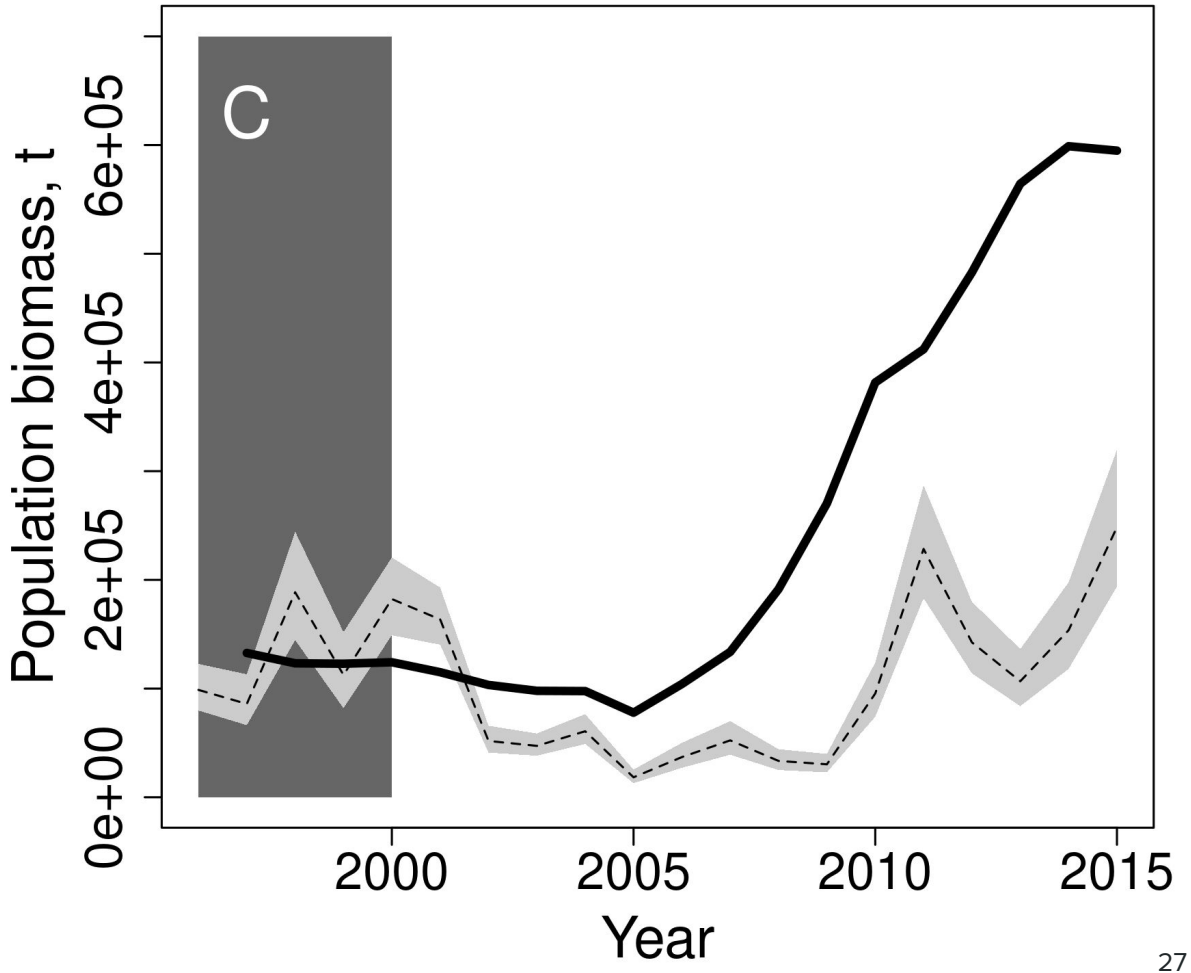


Results

Drivers

Scenario of constant environment (climatology)





OBJECTIVE: Identify the main drivers of the population dynamics

Results
Drivers

Conclusion #2:

The interannual variability is mainly influenced by environmental stressors, while longer-term patterns of decrease - increase seem to be ruled by fishing

Conclusion #3:

The closure of the fishery was fundamental for the recovery of population after 2005

OBJECTIVE: Identify the main drivers of the population dynamics

Results
Drivers

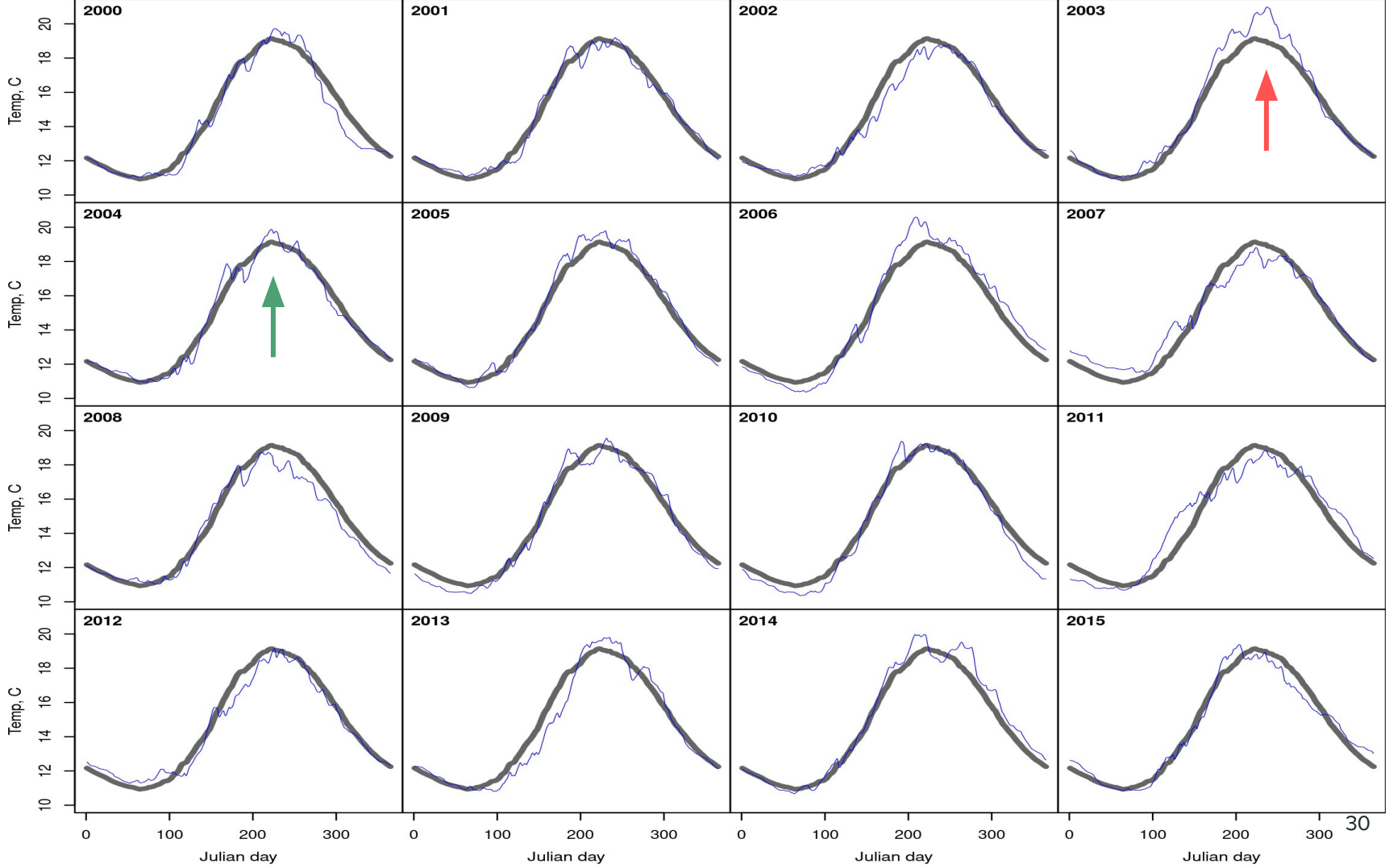
Conclusion #2:

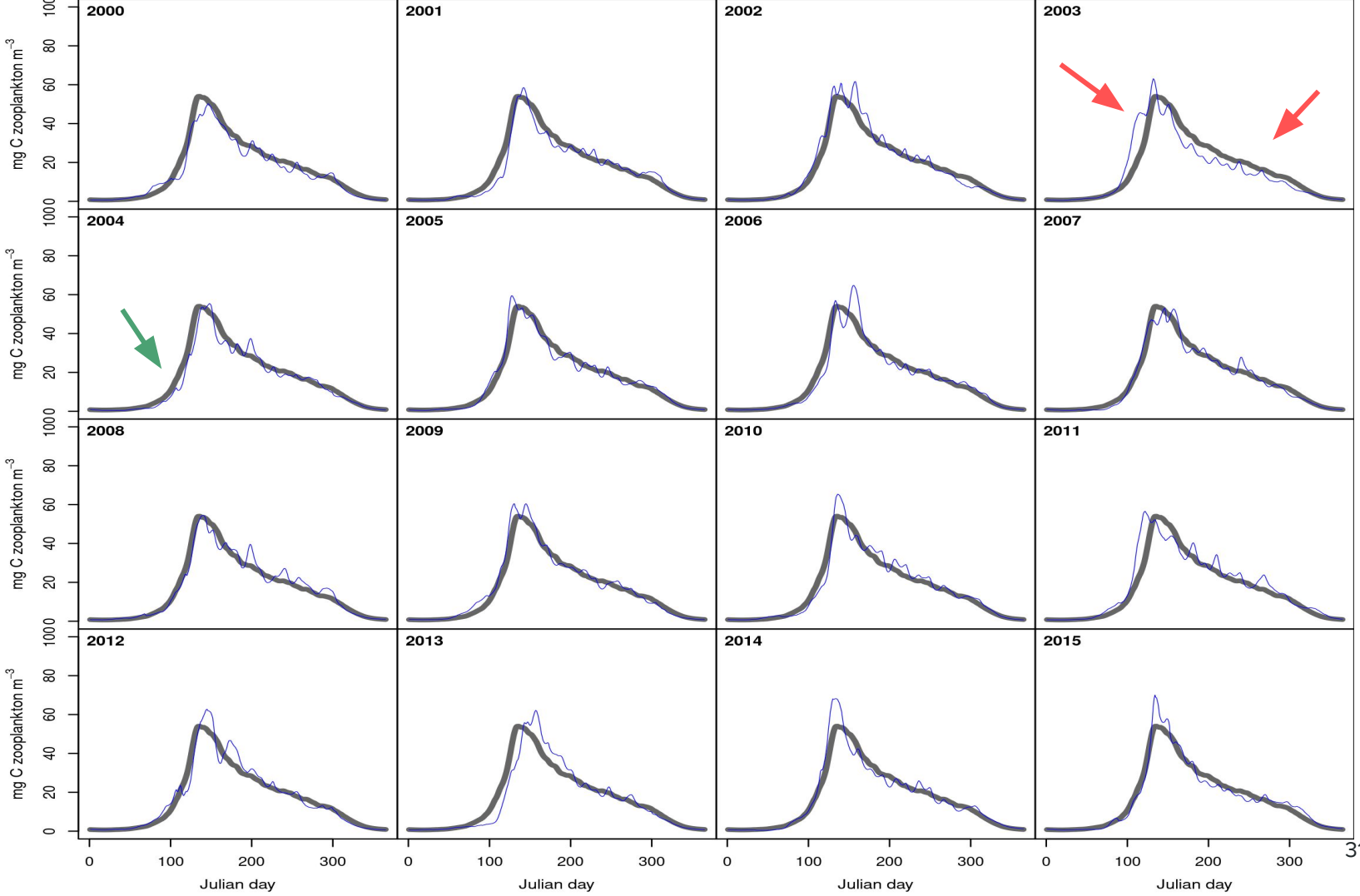
The interannual variability is mainly influenced by environmental stressors, while longer-term patterns of decrease - increase seem to be ruled by fishing

Conclusion #3:

The closure of the fishery was fundamental for the recovery of population after 2005

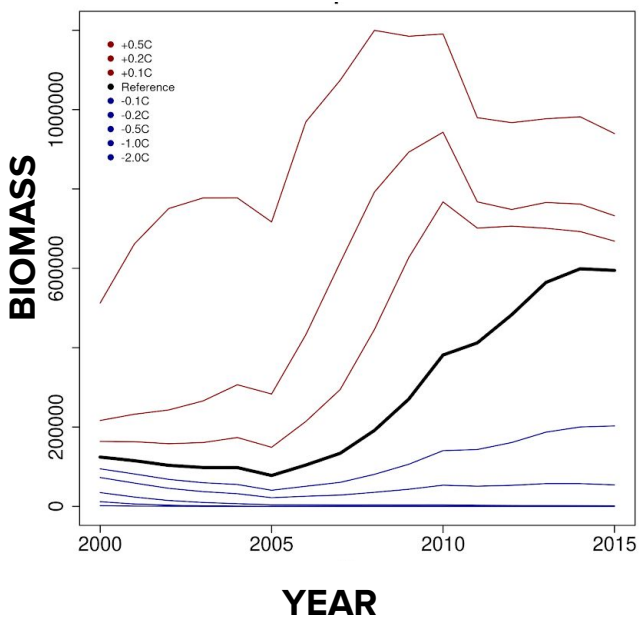
... but what happened in the beginning? Why the population actually collapsed?


2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Temp, C
10
12
14
16
18
20
0
100
200
300
Julian day

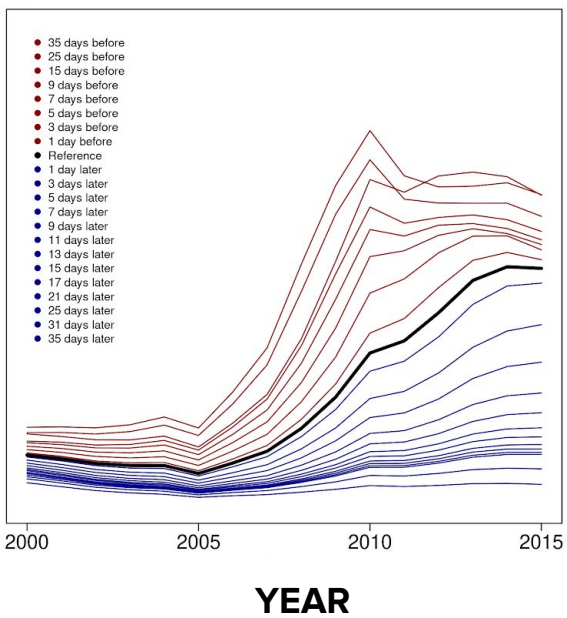

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
mg C zooplankton m^{-3}
0
20
40
60
80
100
1000
0
100
200
300
Julian day

QUESTION 2: what can DEB tell us about the population dynamics?

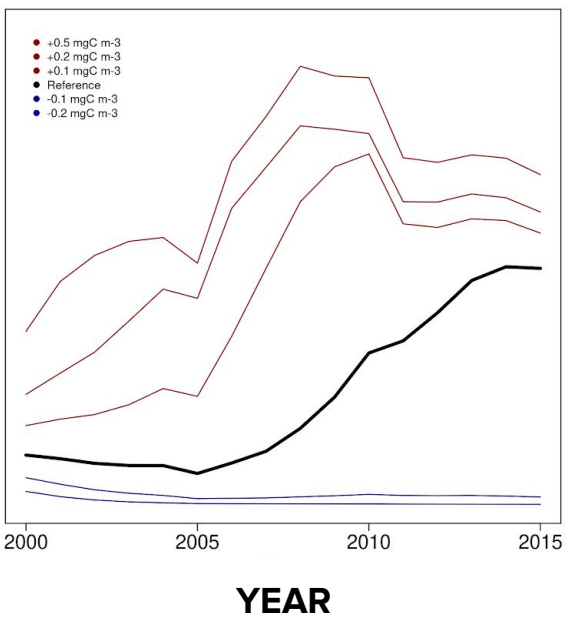
TEMPERATURE



FOOD PHENOLOGY

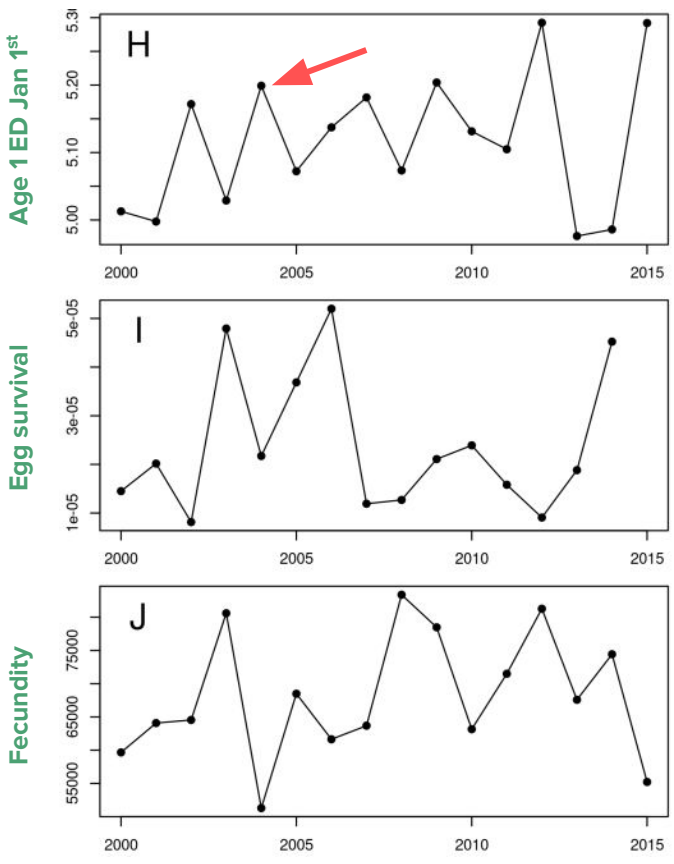


FOOD CONCENTRATION



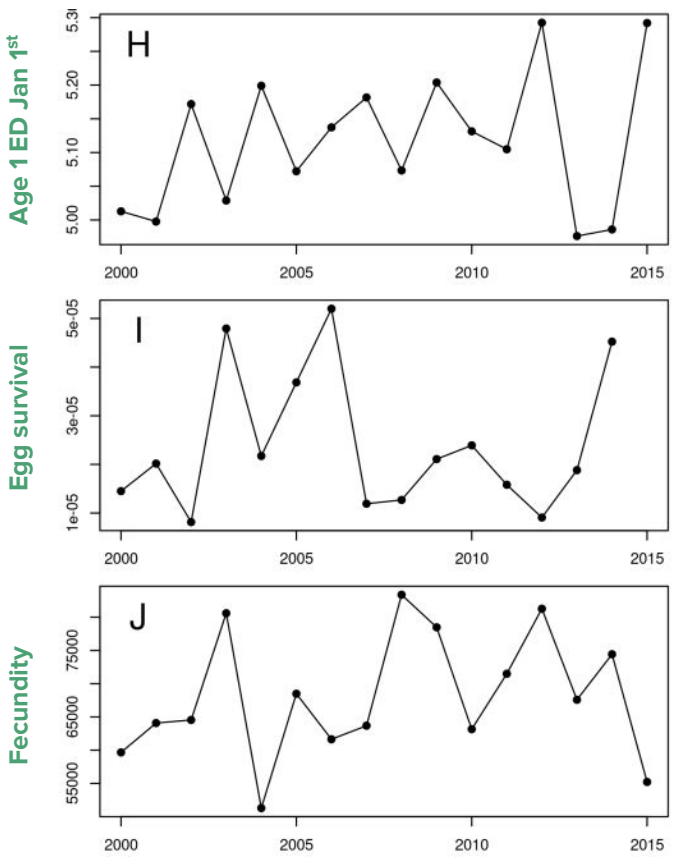
QUESTION 2: what can DEB theory tell us about the population dynamics?

Results
Drivers



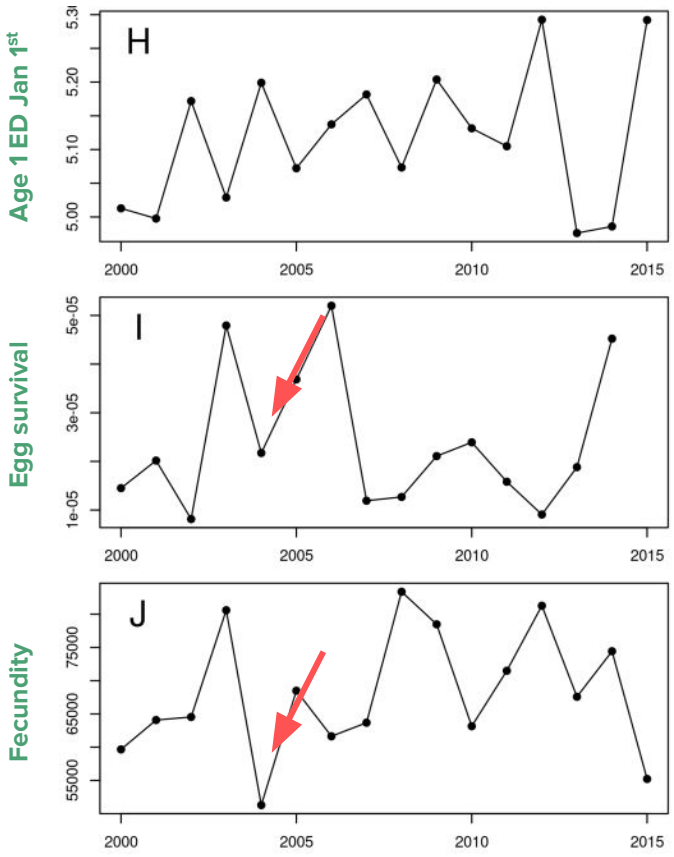
QUESTION 2: what can DEB theory tell us about the population dynamics?

Results
Drivers



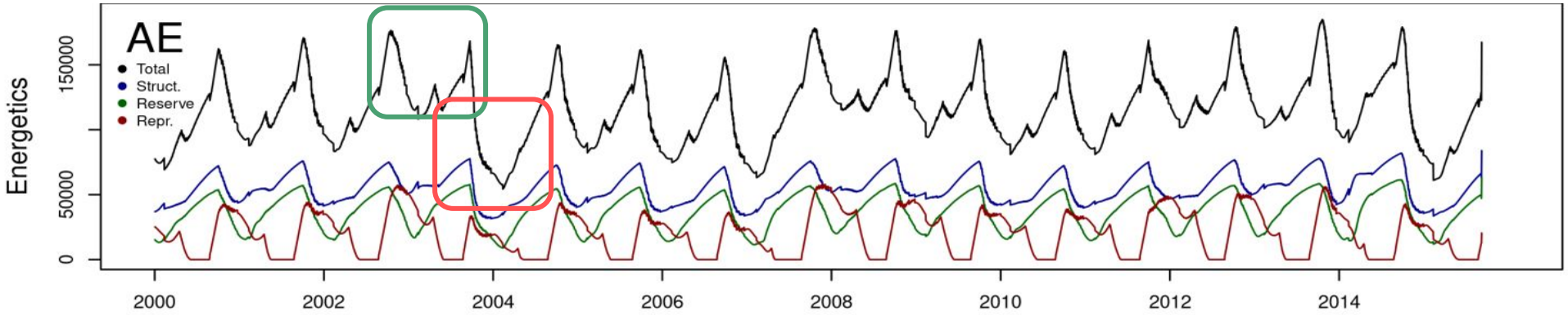
QUESTION 2: what can DEB theory tell us about the population dynamics?

Results
Drivers

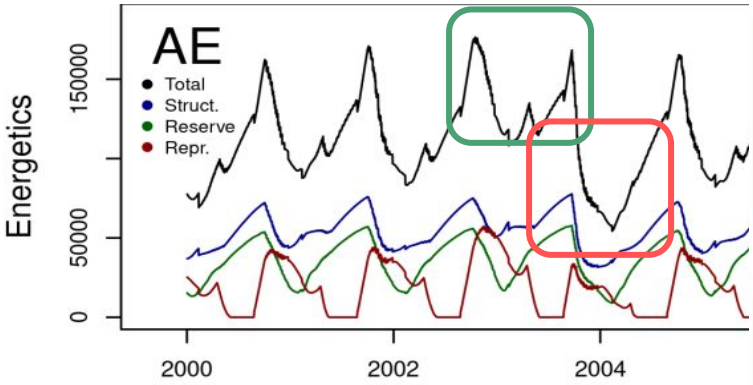


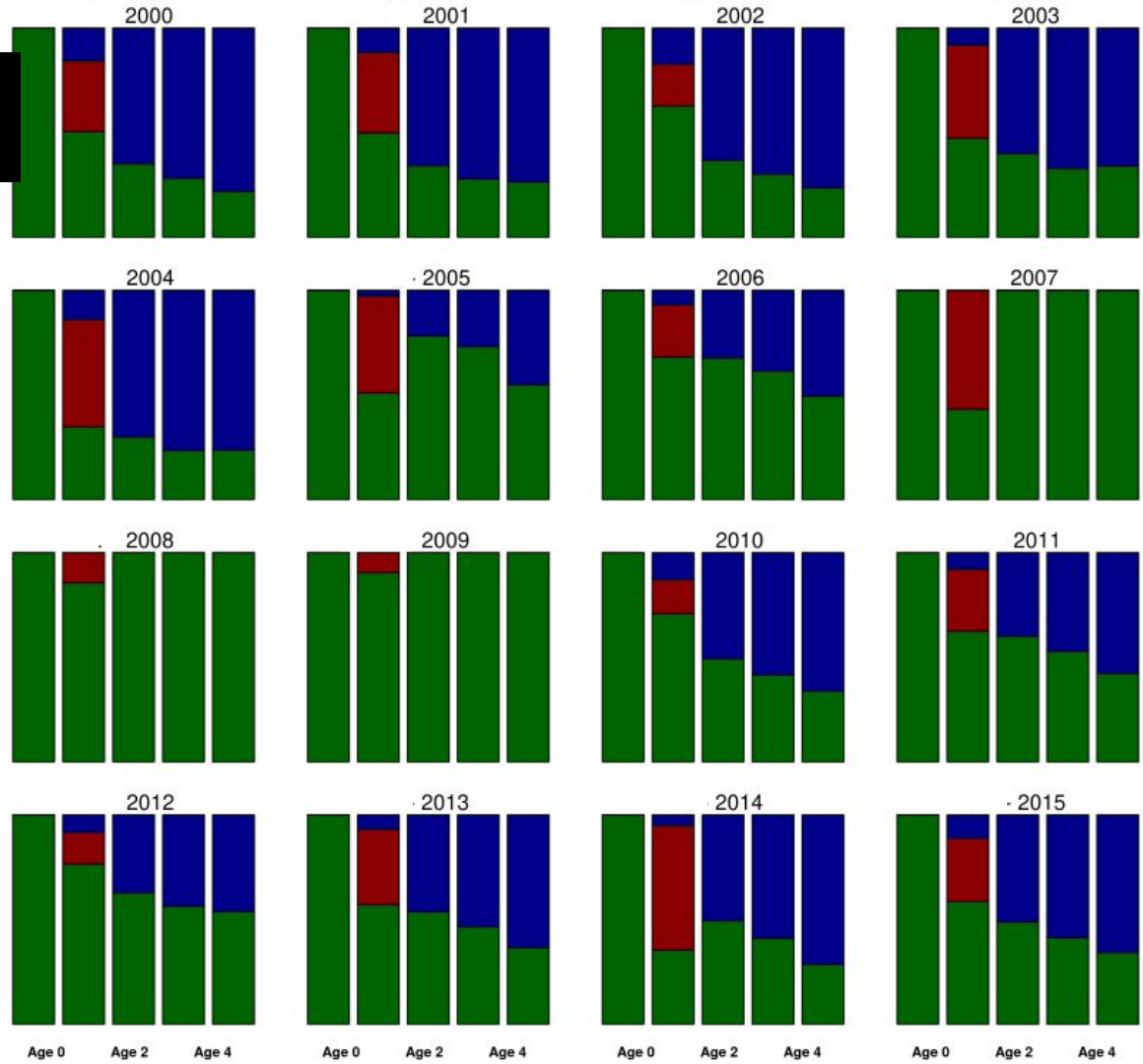
QUESTION 2: what can DEB theory tell us about the population dynamics?

Results
Drivers



QUESTION 2: what can DEB theory tell us about the population dynamics?





MORTALITY SOURCES

- FISHING
- DEB
- NATURAL

QUESTION 2: what can DEB theory tell us about the population dynamics?

Conclusion #4:

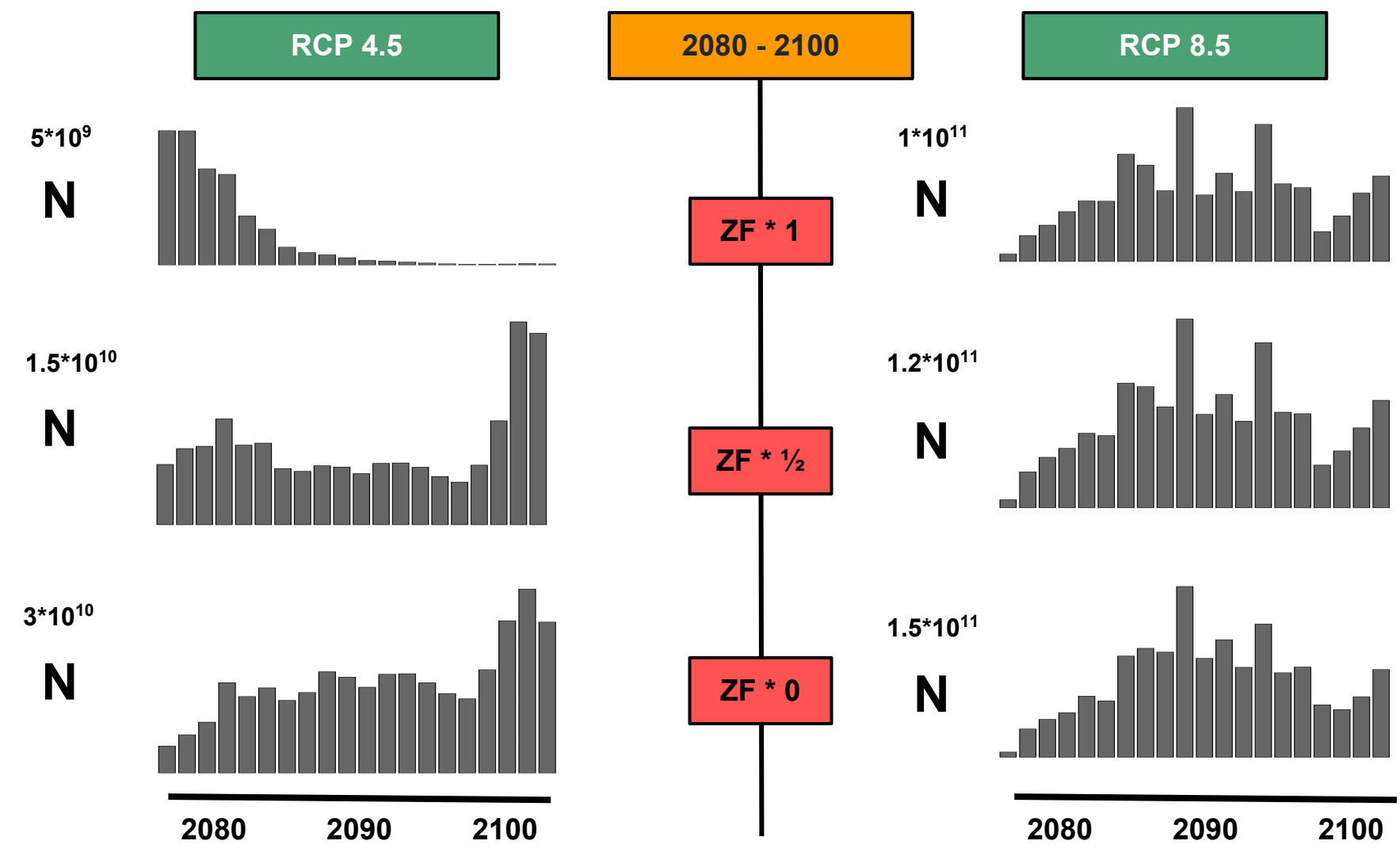
Warmer years (such as 2003) favoured survival, reproduction, and growth, originating larger individuals with higher energetic requirements.

Higher energetic requirements, however, could become a handicap for individuals trying to survive a long winter if the zooplankton bloom occurs at average dates in the next year (as in 2004).

Results

Future

QUESTION 3: What DEB theory can tell us about the future of the population of anchovy?


RCP 4.5
2080 - 2100
RCP 8.5
5*10^9
N
1*10^11
N
ZF * 1
1.5*10^10
N
1.2*10^11
N
ZF * ½
3*10^10
N
1.5*10^11
N
ZF * 0
2080
2090
2100
2080
2090
2100

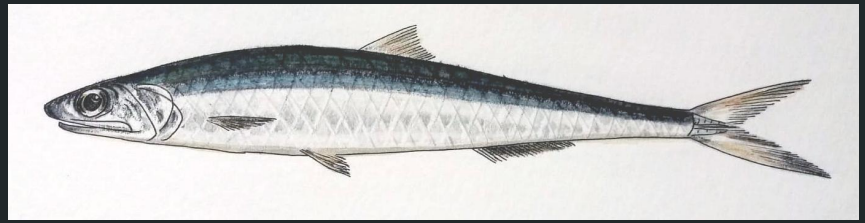
QUESTION 3: What DEB theory can tell us about the future of the population of anchovy?

Conclusion #5:

Temperature in the Bay of Biscay is expected to increase between 1.5 and 3 degrees by the end of the century.

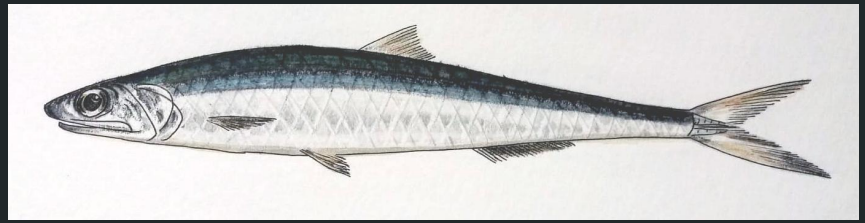
This could be beneficial for the population of anchovy (in principle).

Take home messages



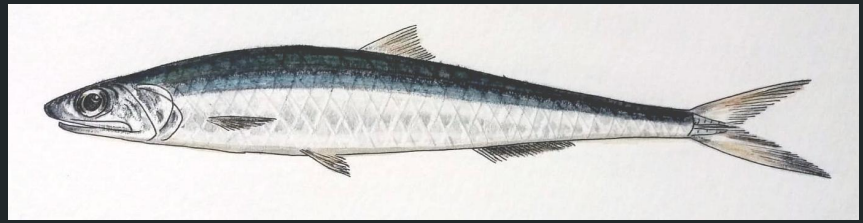
Take home messages

Including a mortality by energetic failure in a population model largely improves the ability of the model to hindcast the population dynamics



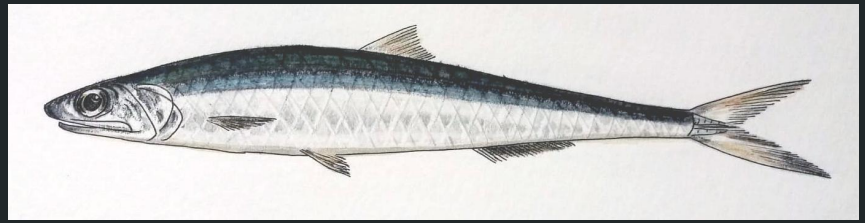
Take home messages

The collapse of the population was caused by a combination of high fishing pressure and environmental conditions



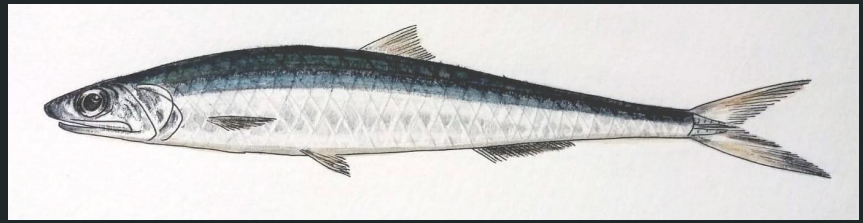
Take home messages

Warming favours fecundity and growth, involving higher energetic requirements



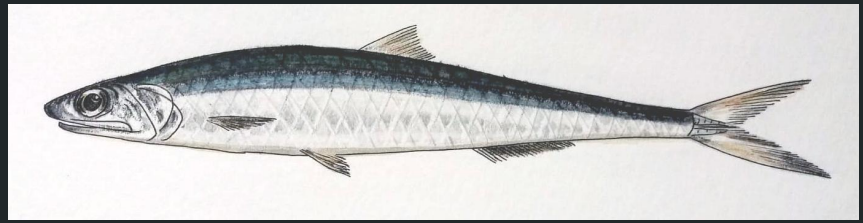
Take home messages

The recovery of the population after 2005 would not have been possible without the closure of the fishery



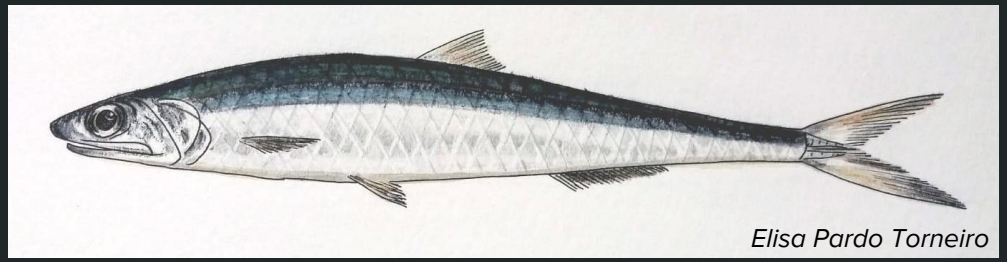
Take home messages

A good response of the population to global warming is theoretically expected



Merci de votre attention!

jbuenopardo@gmail.com



Elisa Pardo Torneiro