Sensitivity of anchovy population to environmental change in the Bay of Biscay using a bioenergetic model

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

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Research within the framework of the European project CERES

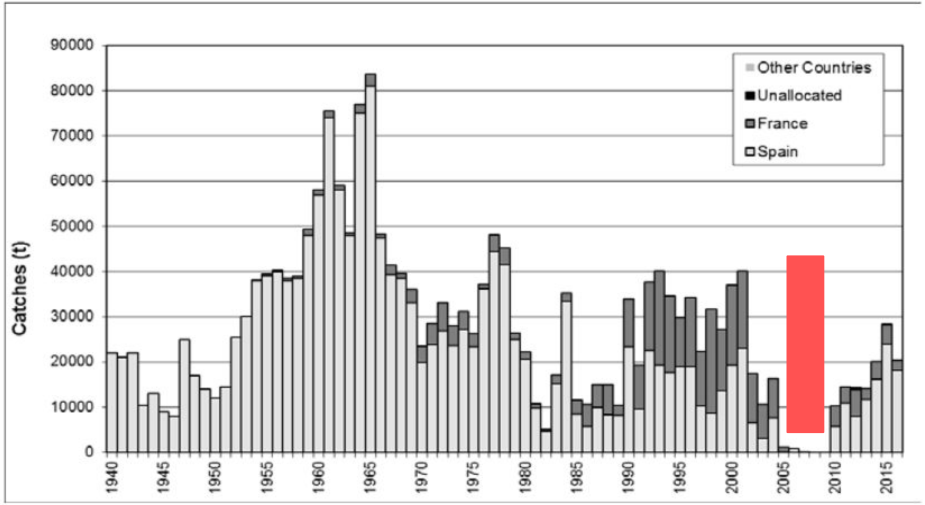
https://ceresproject.eu

Introduction

- Study area and species
- Conceptual framework

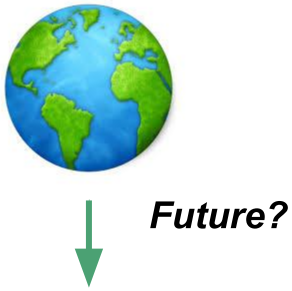
Wikipedia

Study area and species:
Bay of Biscay
Engraulis encrasicolus

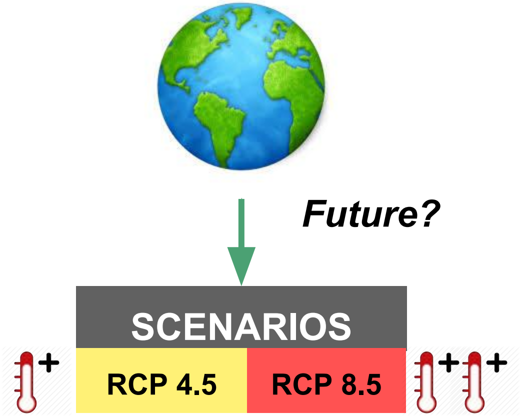


ICES. 2017. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)

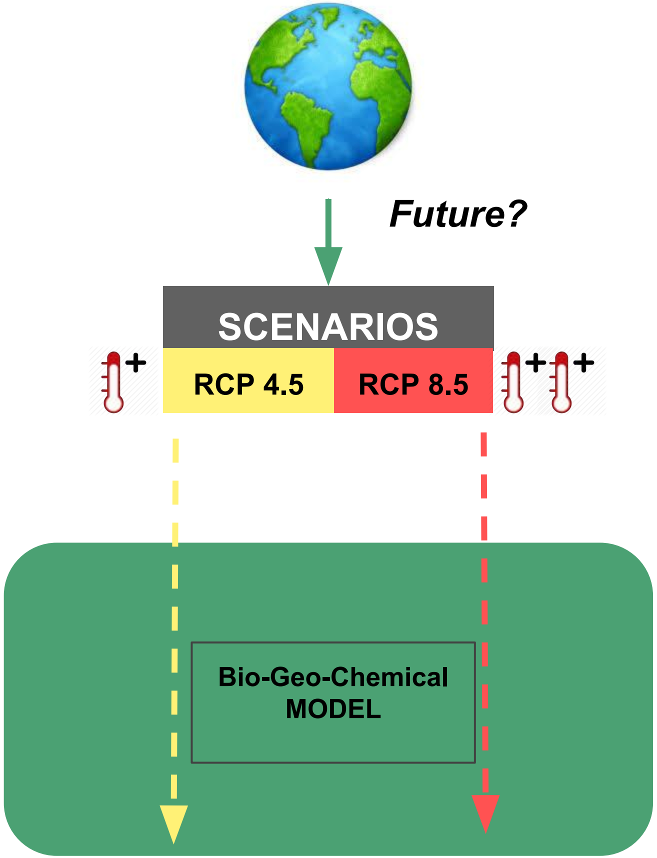
Conceptual framework



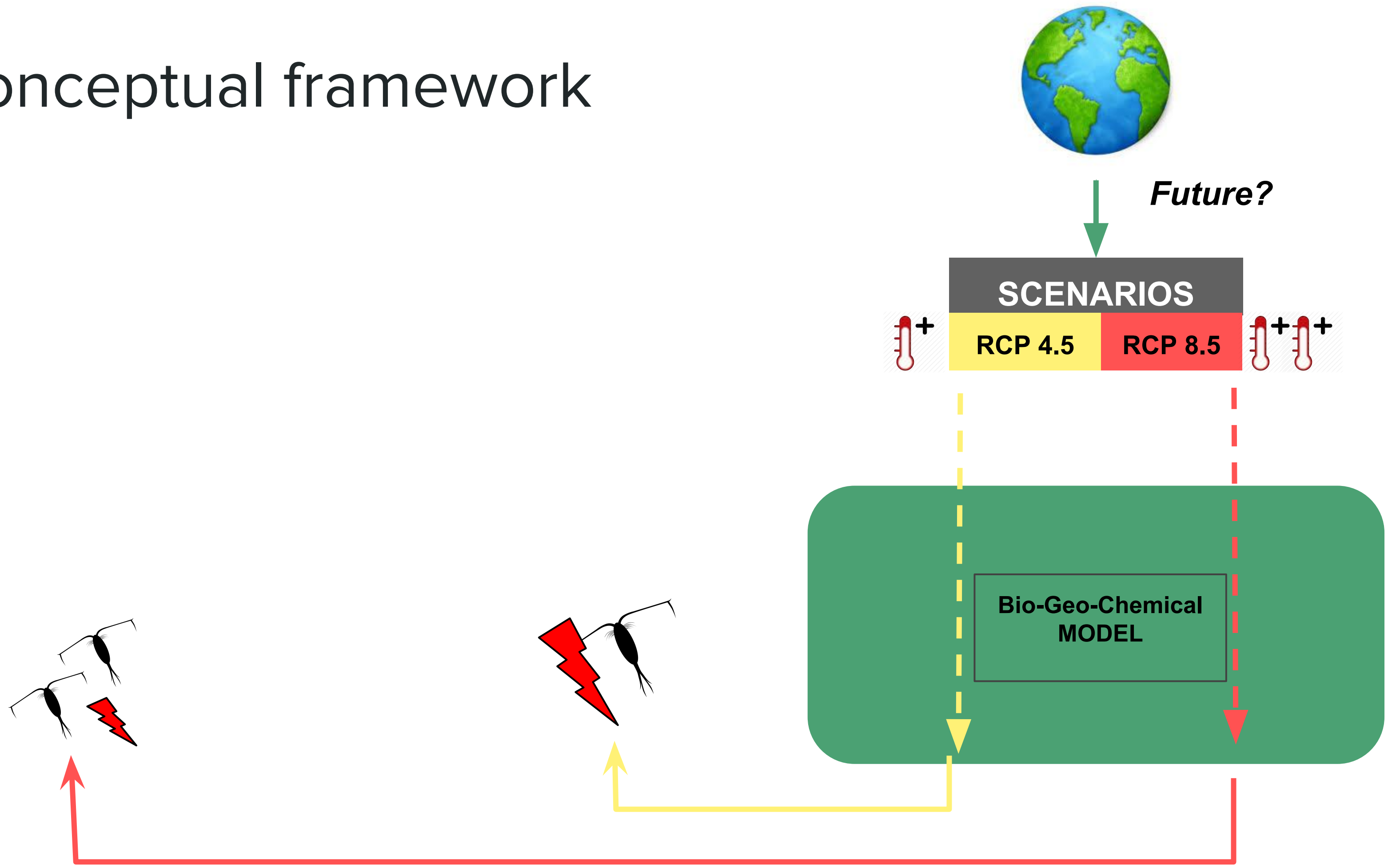
Conceptual framework



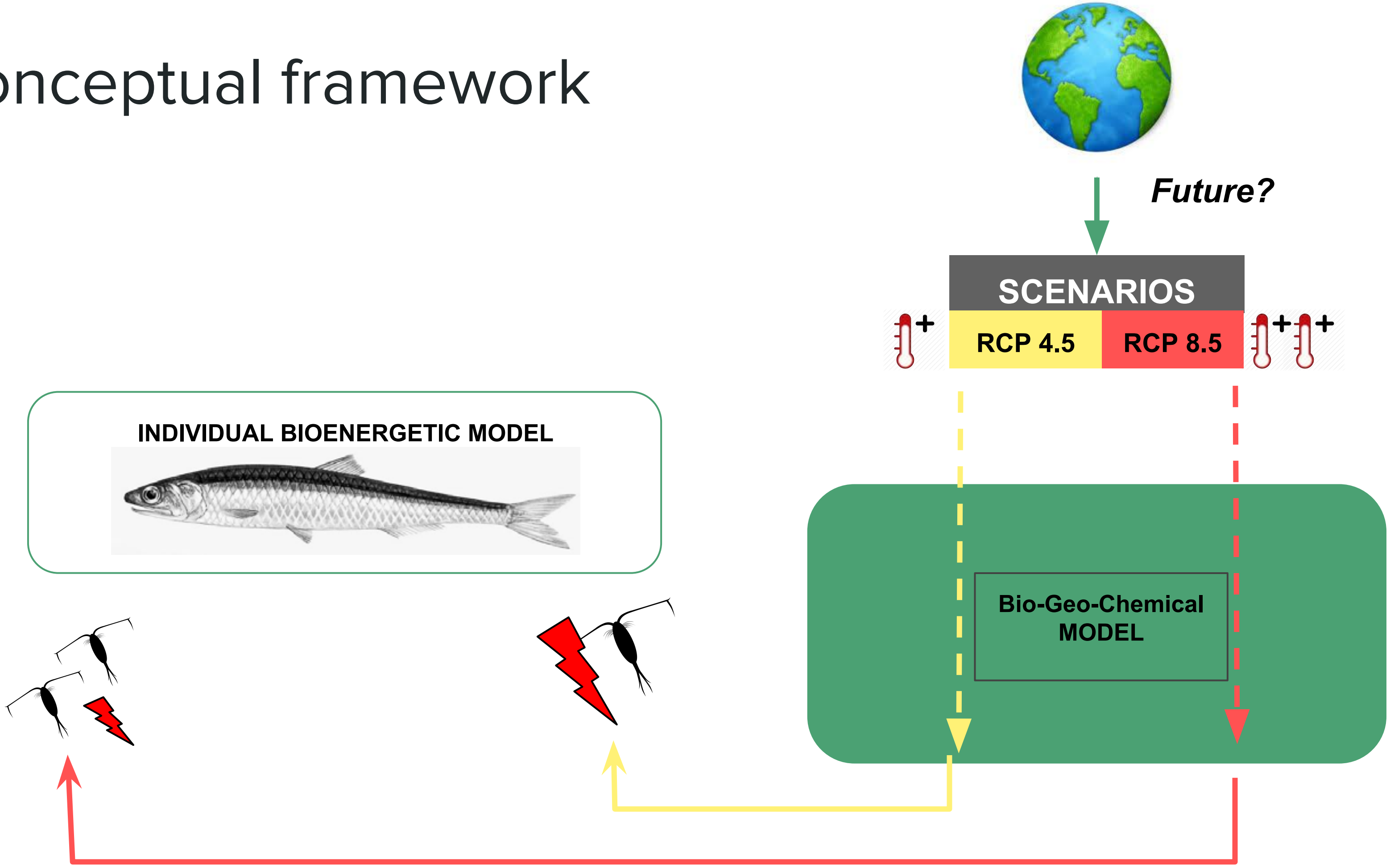
Conceptual framework



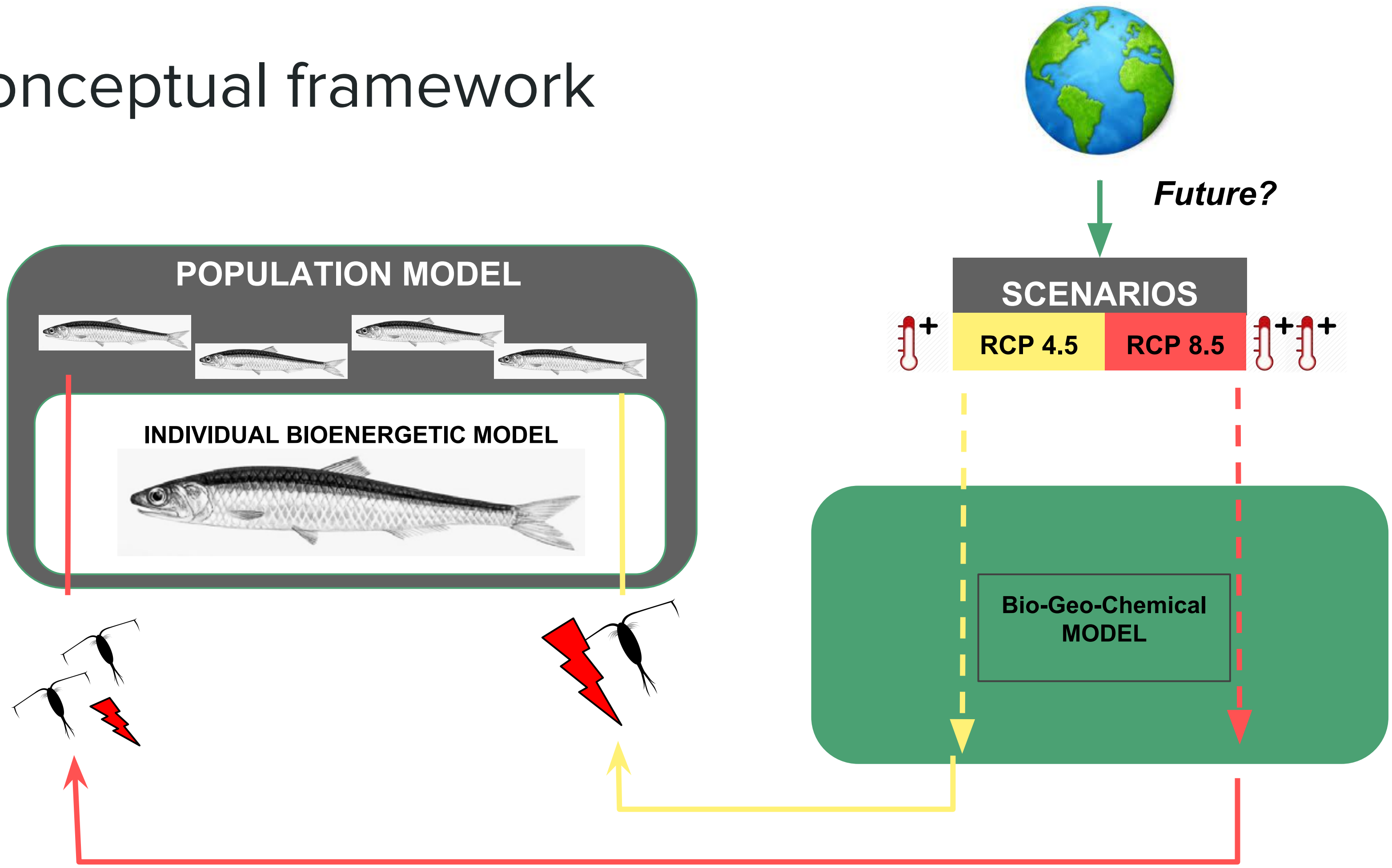
Conceptual framework

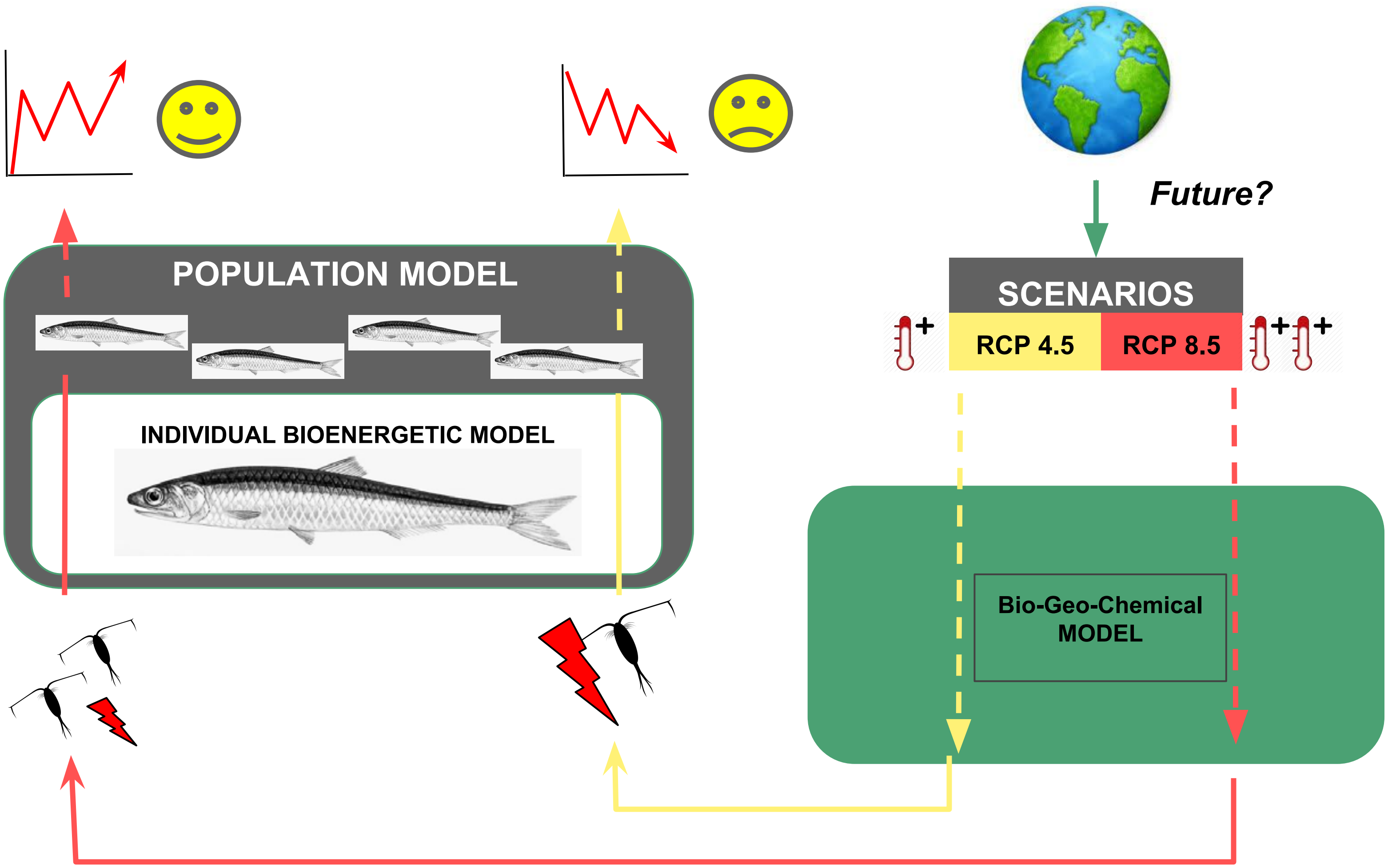


Conceptual framework



Conceptual framework



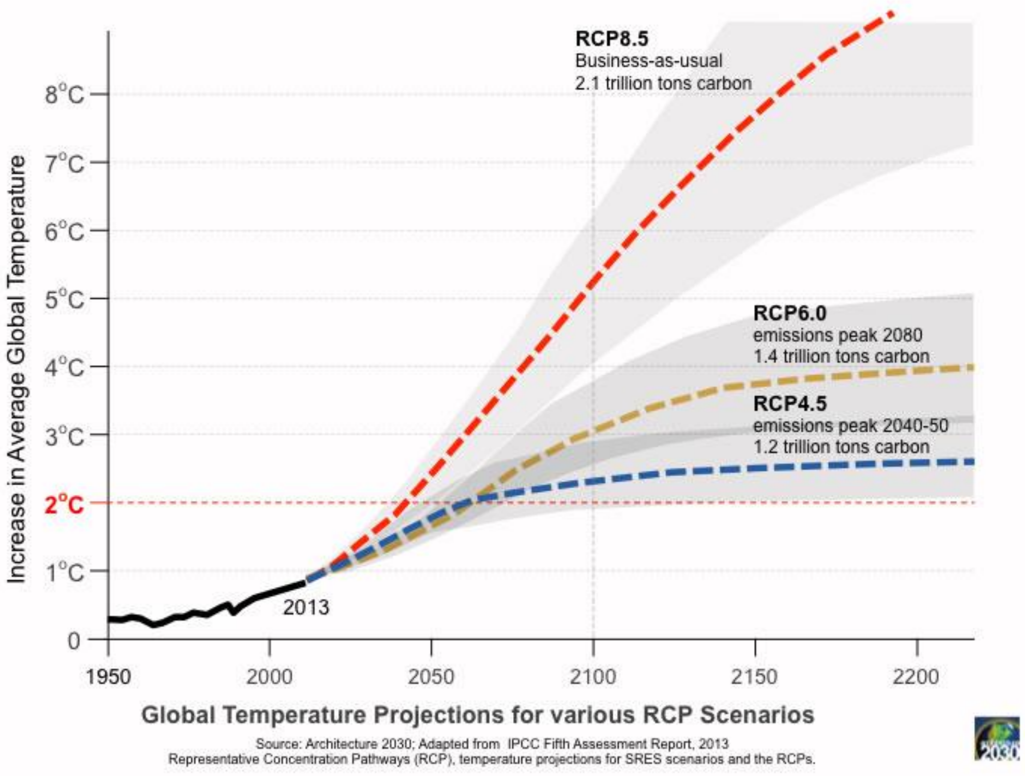

Future?
SCENARIOS
RCP 4.5
RCP 8.5
+
++
POPULATION MODEL
INDIVIDUAL BIOENERGETIC MODEL
Bio-Geo-Chemical
MODEL

Methodology

- Climate change scenarios
- Environmental modelling
- Individual bioenergetics model
- Population model

Climate change scenarios proposed by IPCC
RCP 4.5 and 8.5

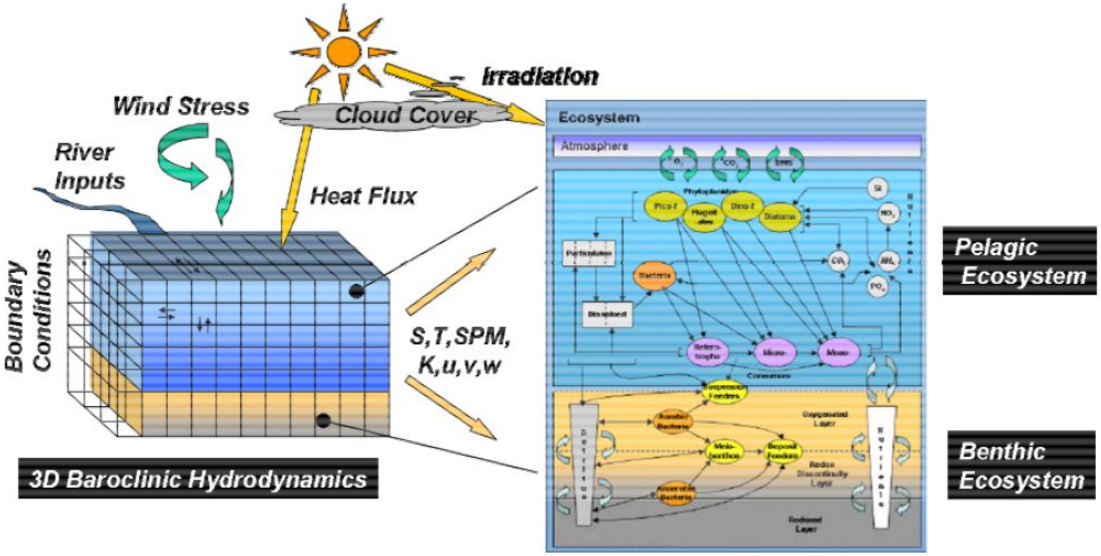
Representative
Concentration
Pathways



Regional bio-geo-chemical model

POLCOMS-ERSEM (Plymouth Marine Laboratory)

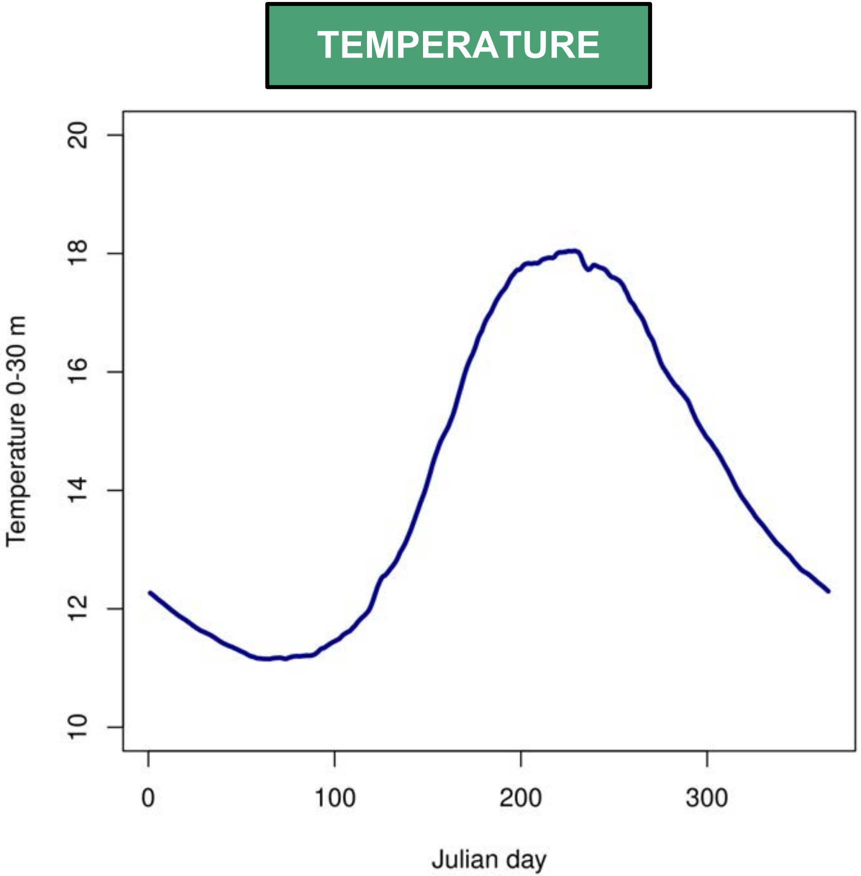
- 2040-2060 / 2080-2100
- Temperature: 30 and 150 m
- Zooplankton: 50 m



Proctor et al., 2005

Climatic model
POLCOMS-ERSEM

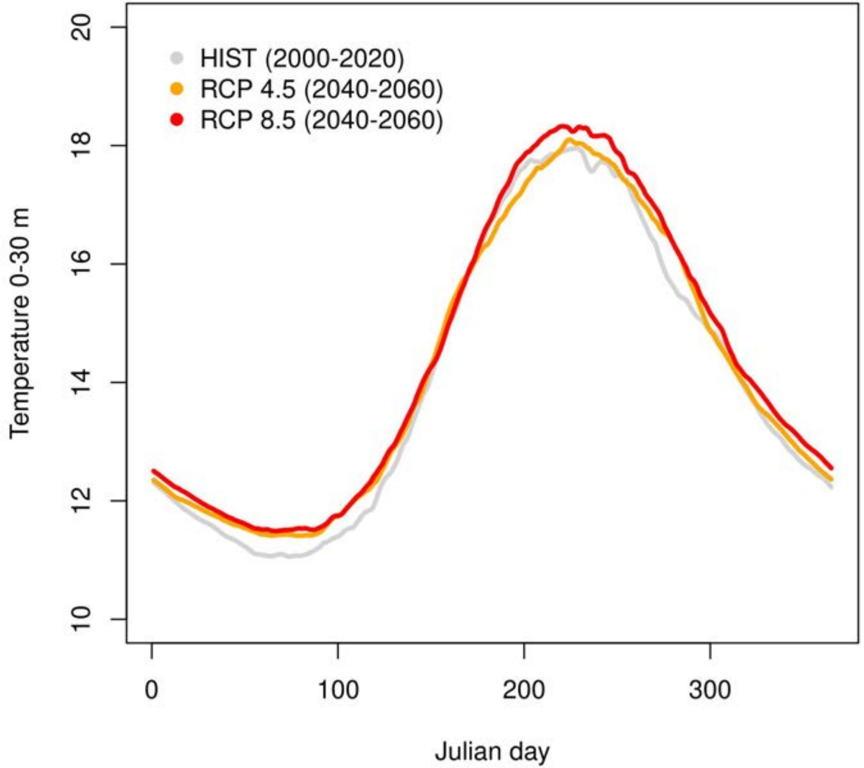
- Historical Run 1996 - 2015 used for hindcast



Climatic model
POLCOMS-ERSEM

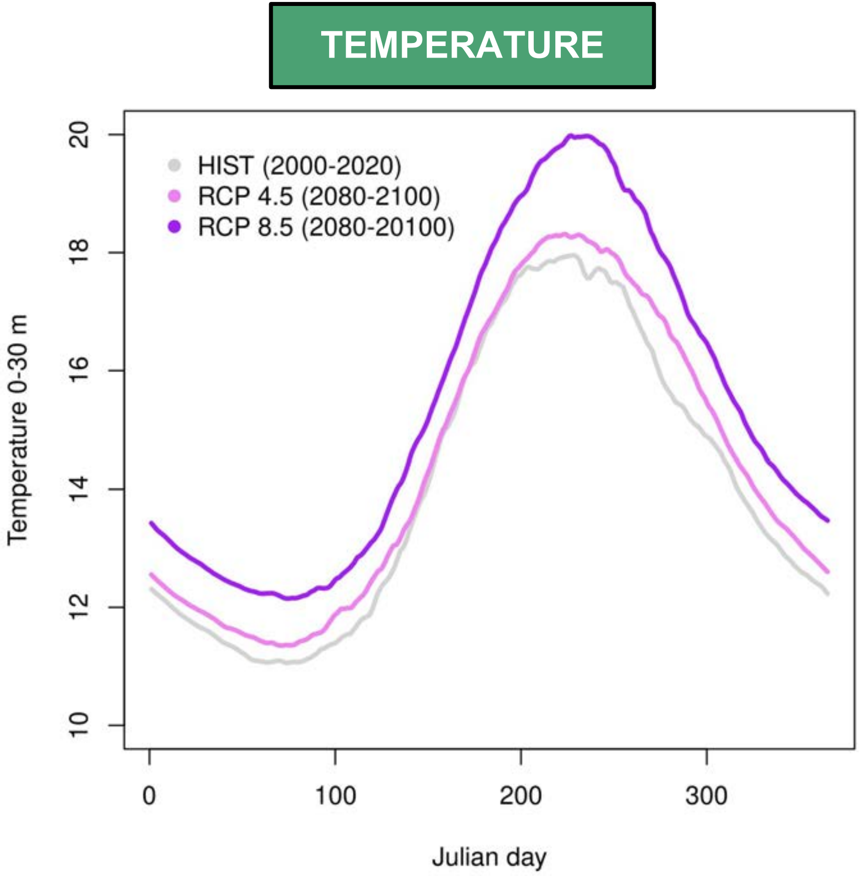
- Historical Run 1996 - 2015 used for hindcast
- Climate Run 2040 - 2060
  a. RCP 4.5
  b. RCP 8.5

TEMPERATURE



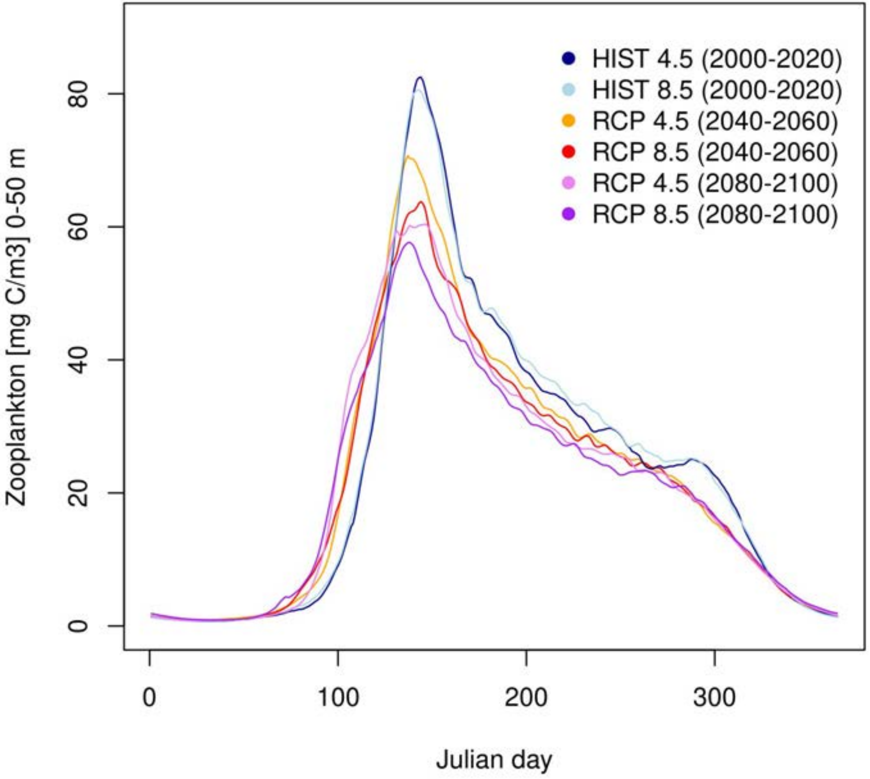
Climatic model
POLCOMS-ERSEM

- Historical Run 1996 - 2015 used for hindcast
- Climate Run 2080 - 2100
  a. RCP 4.5
  b. RCP 8.5



Climatic model
POLCOMS-ERSEM

ZOOPLANKTON



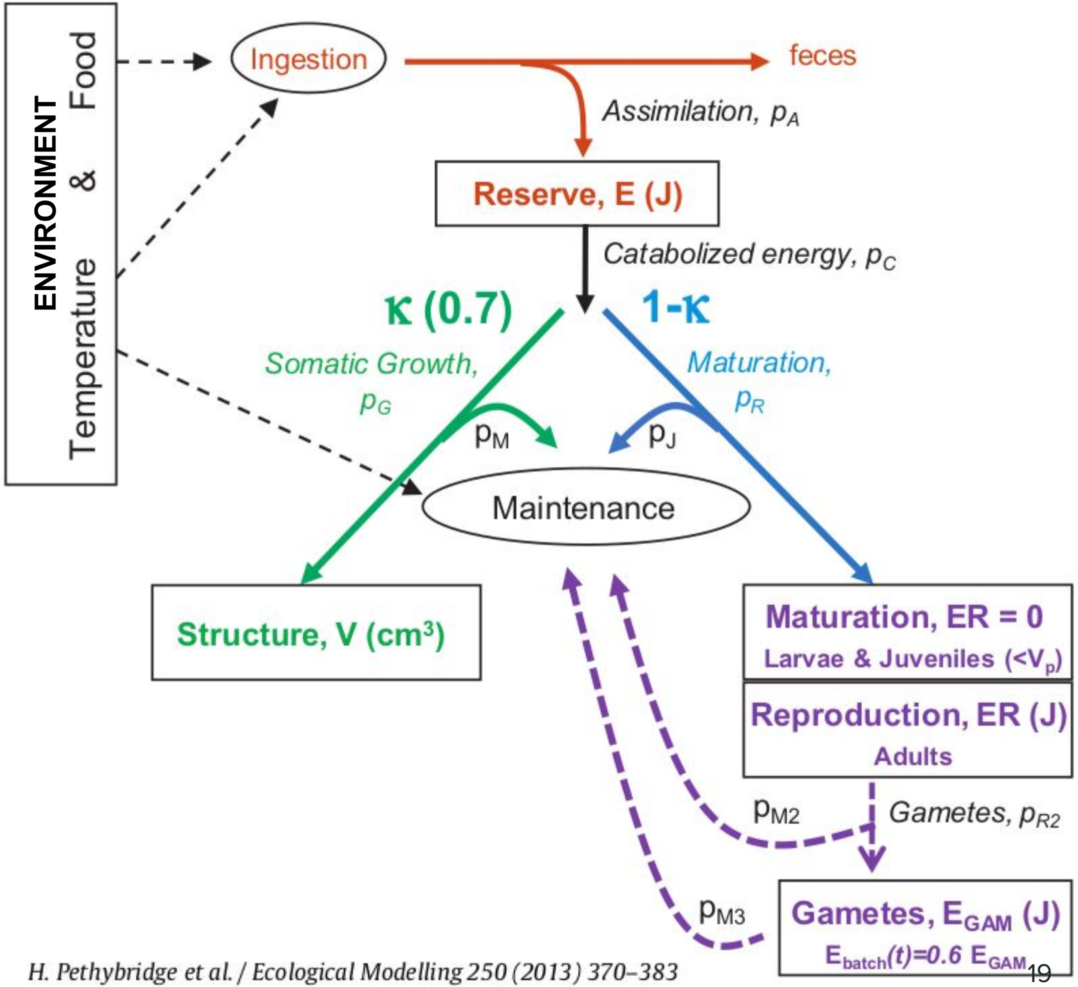
Individual model:
Dynamic Energy Budget

S.A.L.M. Kooijman

One individual is represented by four state variables:

- Reserves (E)
- Structure (V)
- Maturation (E_H)
- Reproduction (E_R)

Food (**zooplankton**) and **temperature** are the forcing variables



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

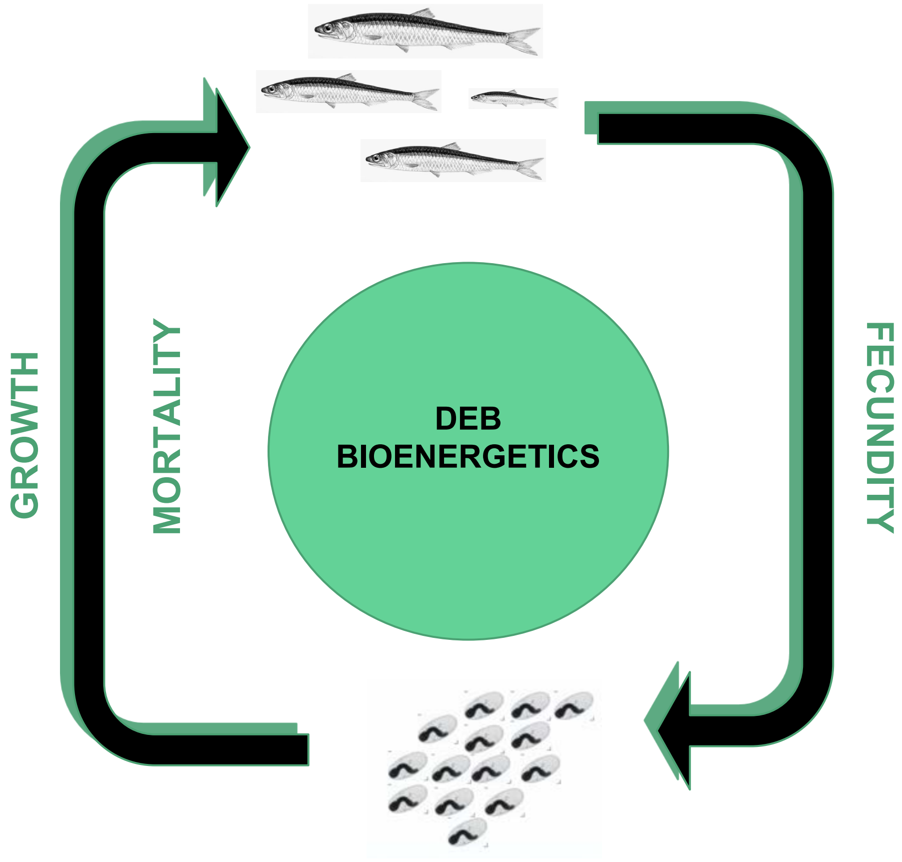
Population model:
Individual Based Model

The model is not spatialized

Super-individuals as modelling units

Mortality at three levels:

- DEB (starving mortality)
- Natural (calibrated)
- Fishing (semestral, ICES)

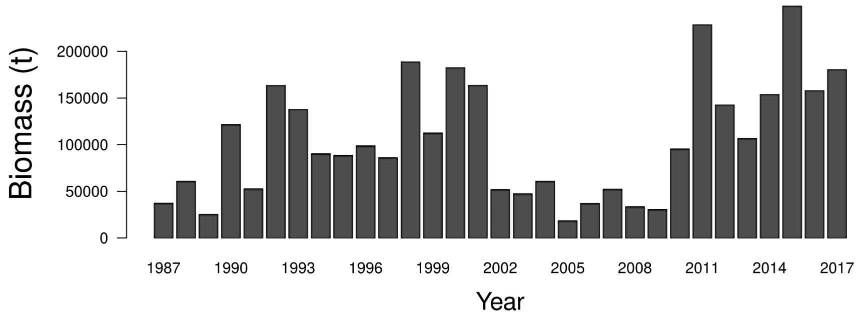


Results

- Calibration of population model
- Forecast

Model calibration
Population level

- Fit to CBBM time series between 1996-2015
- Optimization of mortality parameters by iteration:
  - Egg mortality rate (d^{-1})
  - Adult mortality rate (d^{-1})
  - Decrease coefficient of natural mortality with size (cm^{-1})

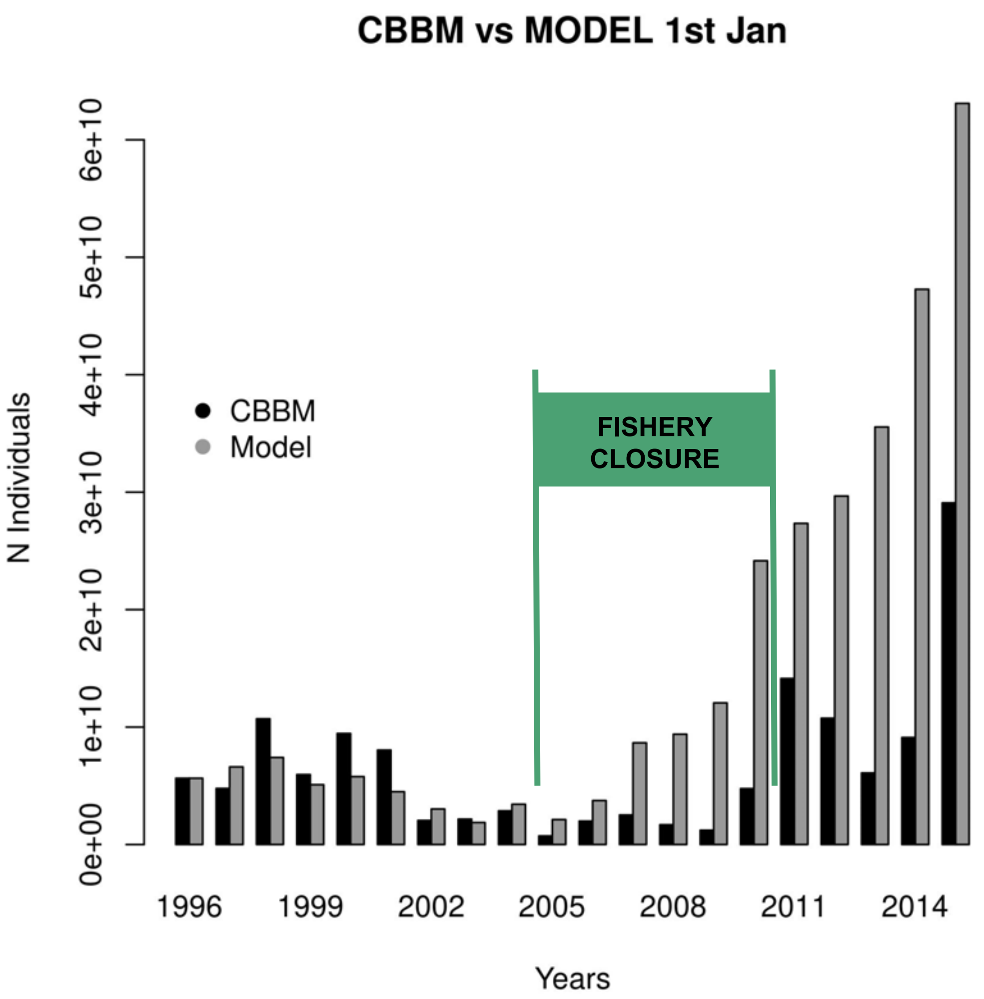


Model calibration
Populational level

Optimized parameters:

- Egg mortality: 0.24 d^{-1}
- Adult mortality: 0.0002 d^{-1}
- Decrease coefficient: 0.36 (cm^{-1})

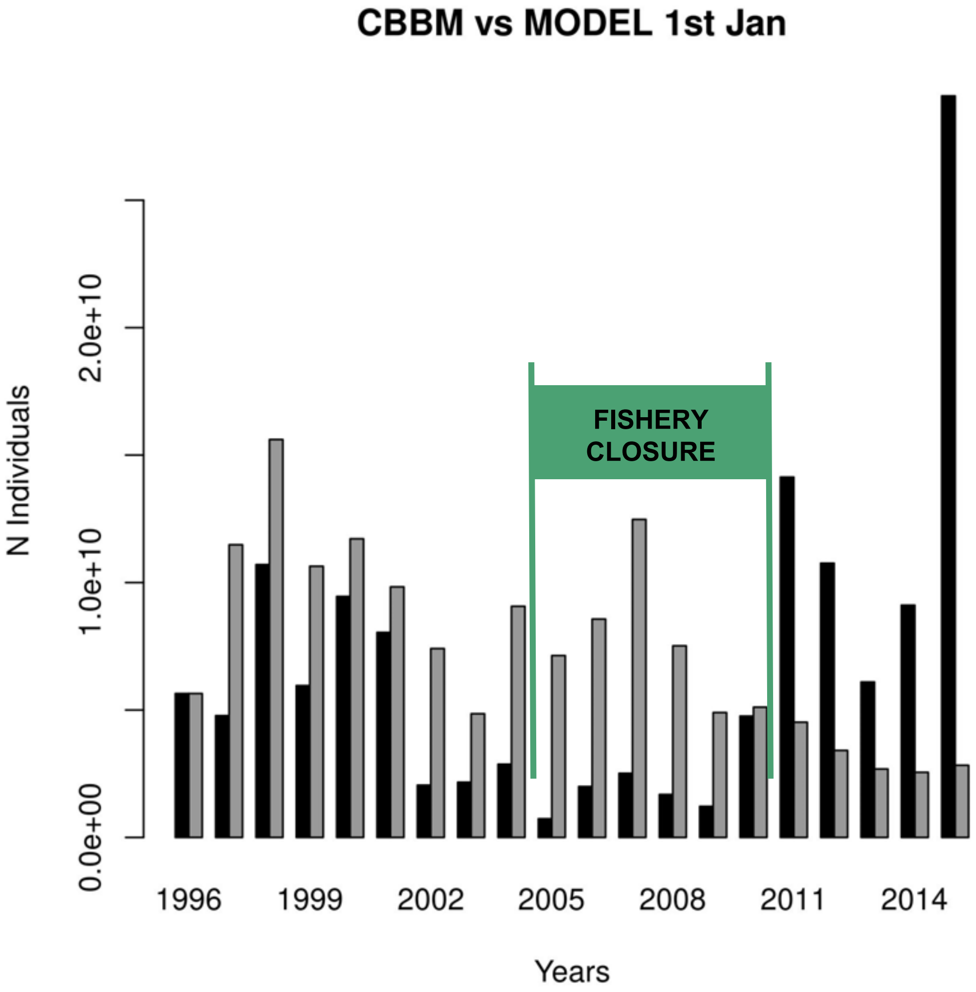
Fishing mortality considered: semestral from the ICES report



Model calibration

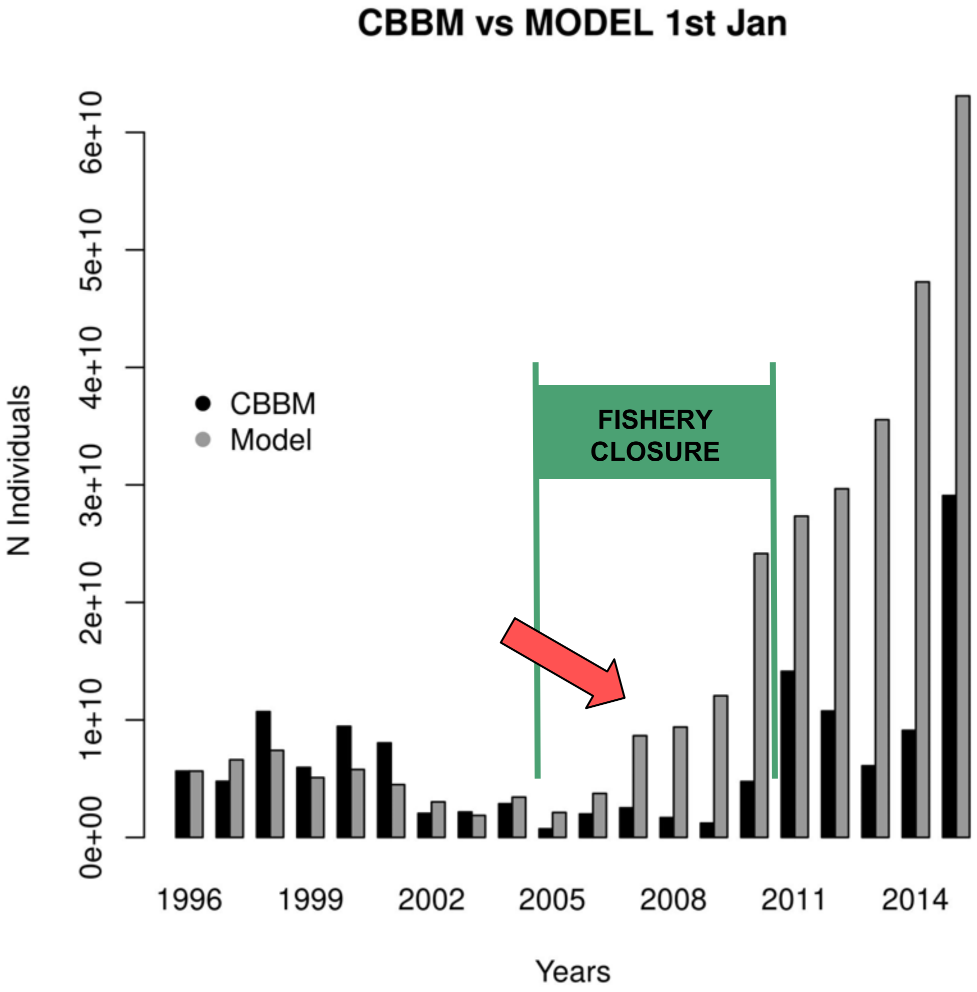
Populational level

Constant fishing mortality: 0.026



Model calibration

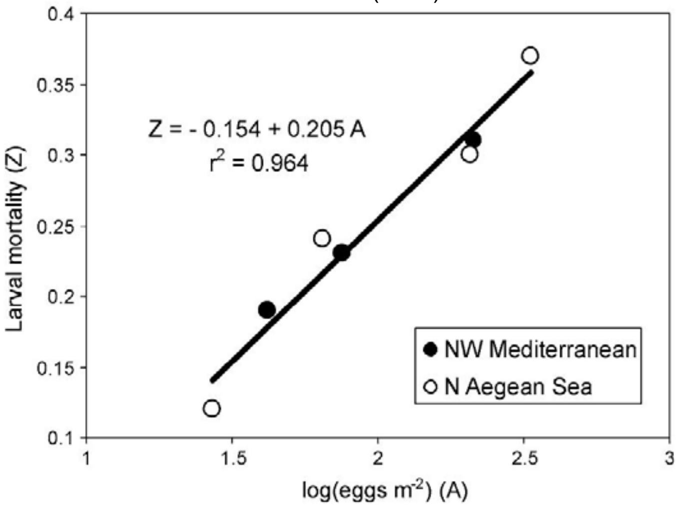
Populational level



Model calibration
Hindcast

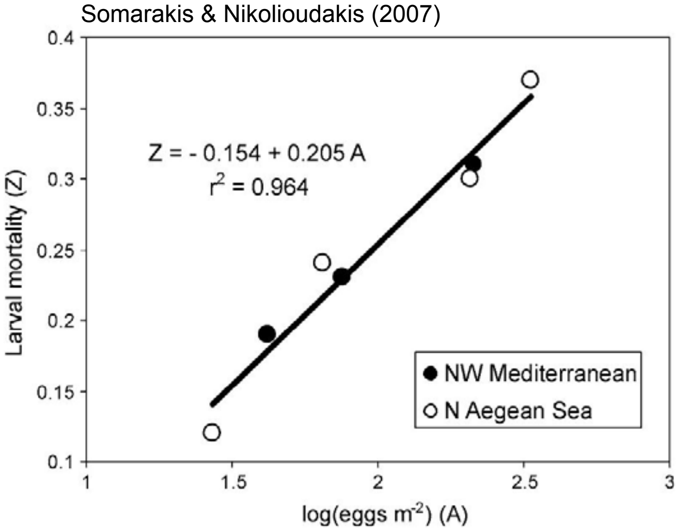
Density-dependent larval mortality

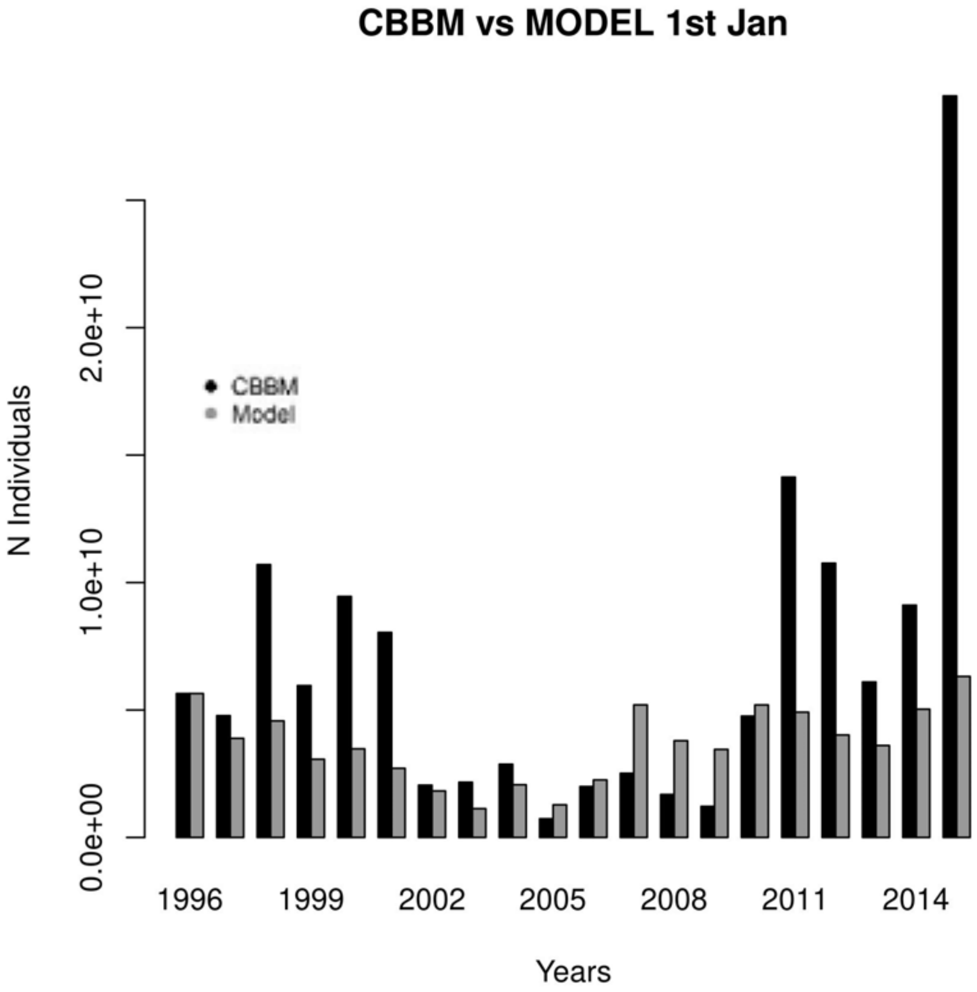
Somarakis & Nikolioudakis (2007)



Model calibration
Hindcast

Density-dependent larval mortality

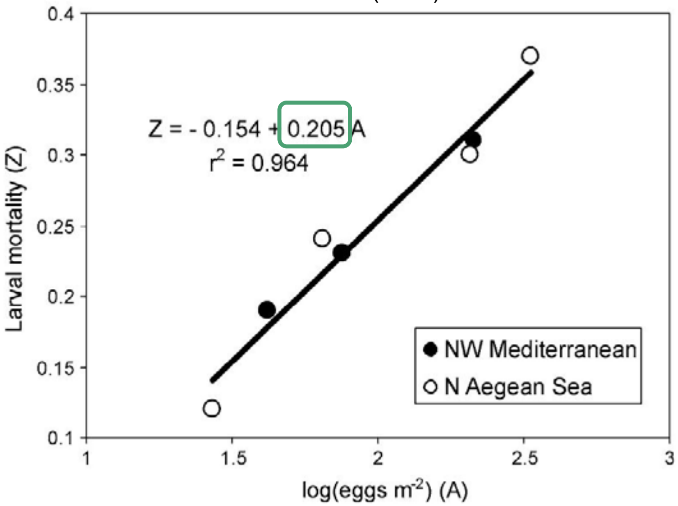


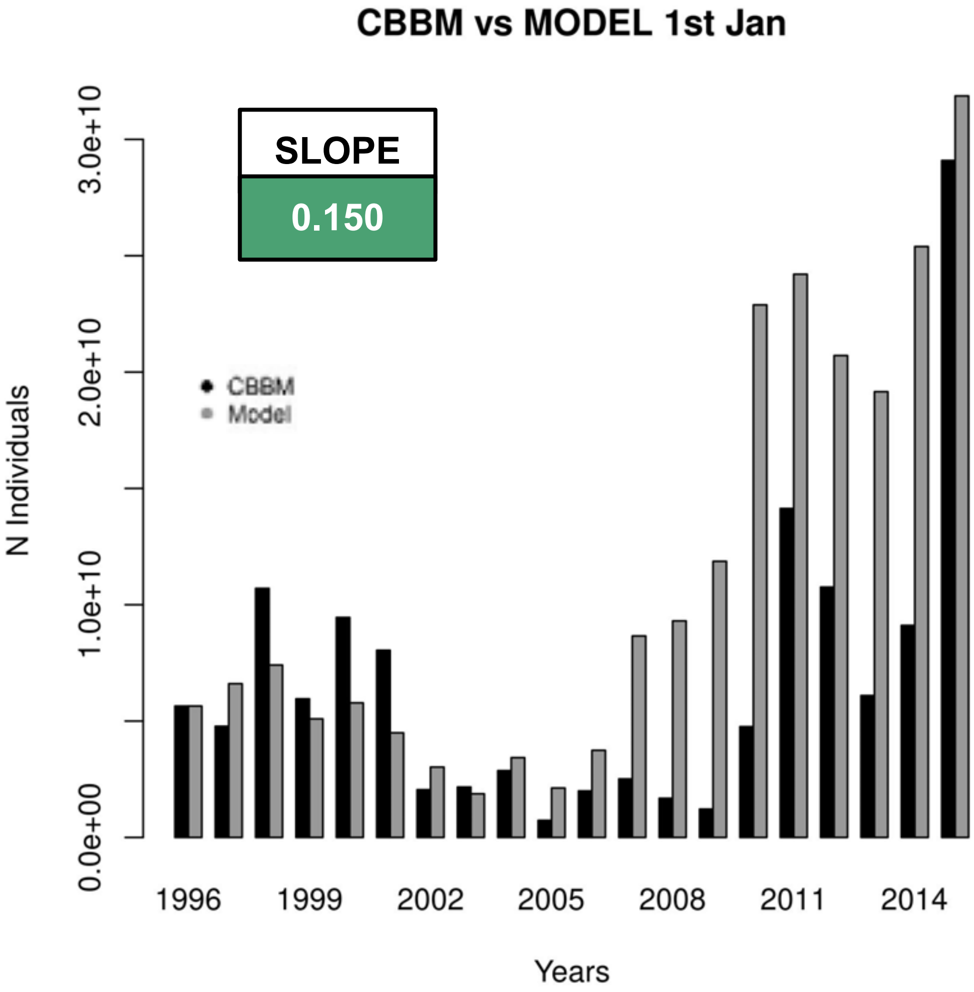


Model calibration
Hindcast

Density-dependent larval mortality

Somarakis & Nikolioudakis (2007)

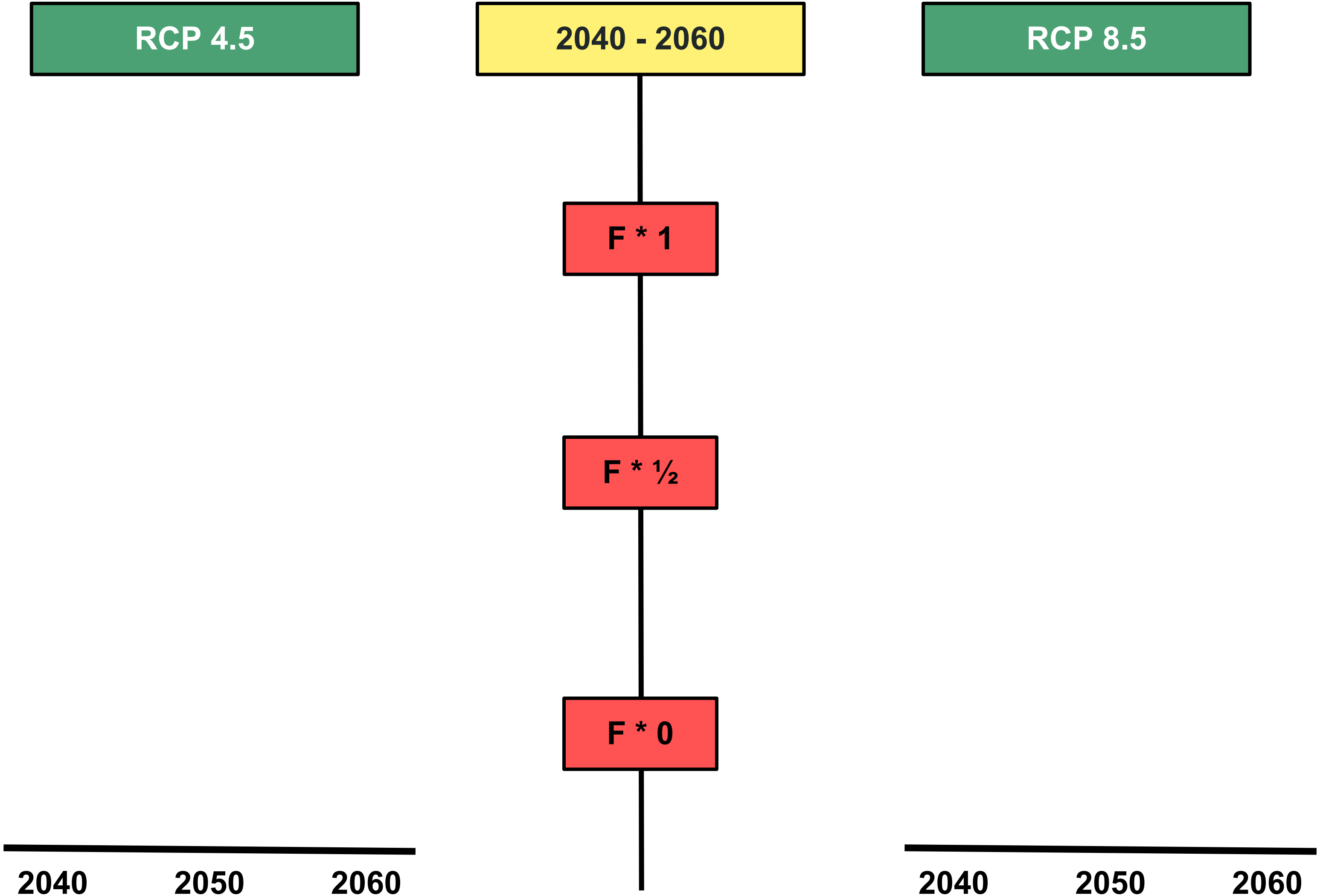


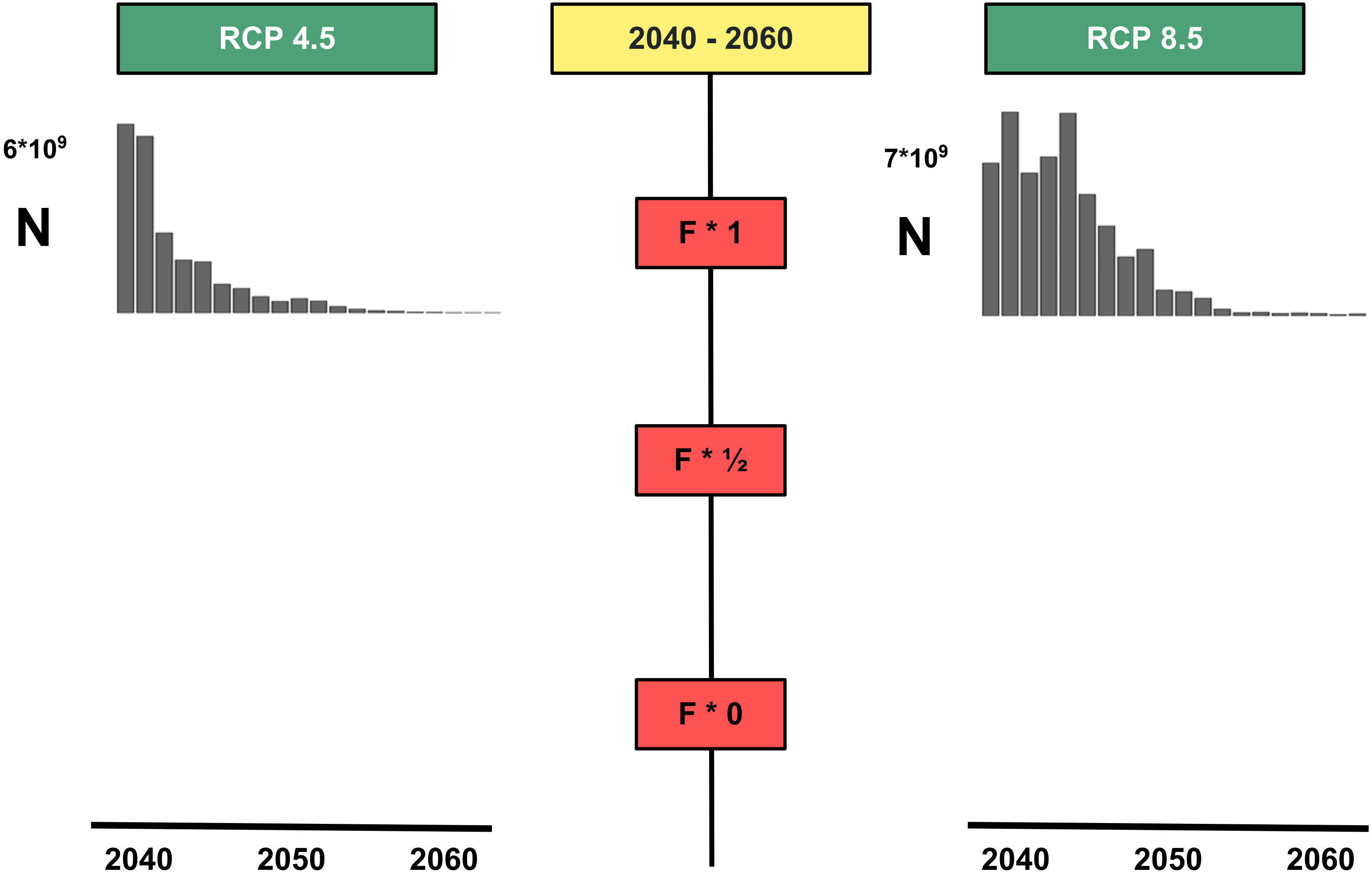


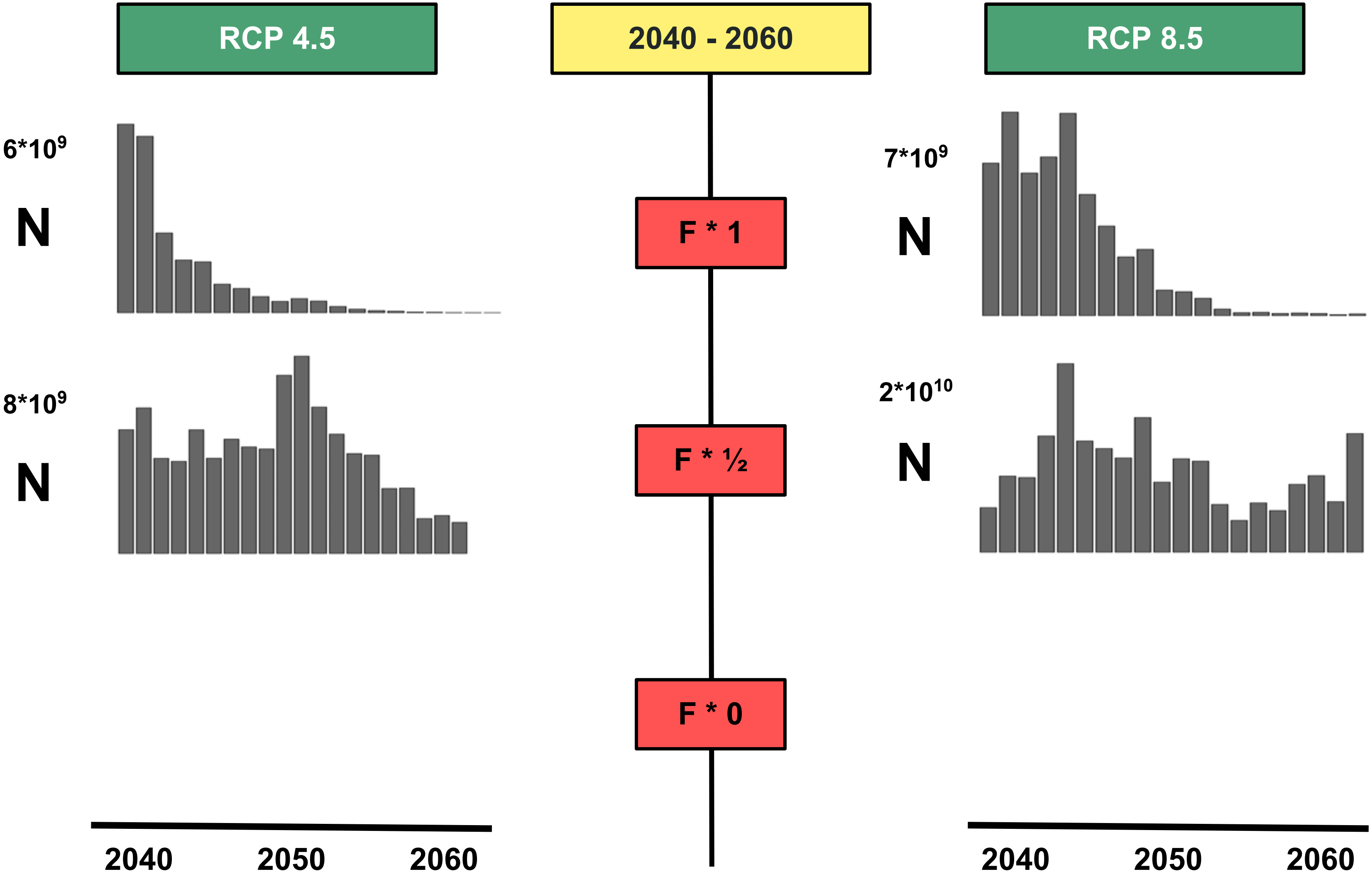
Forecast

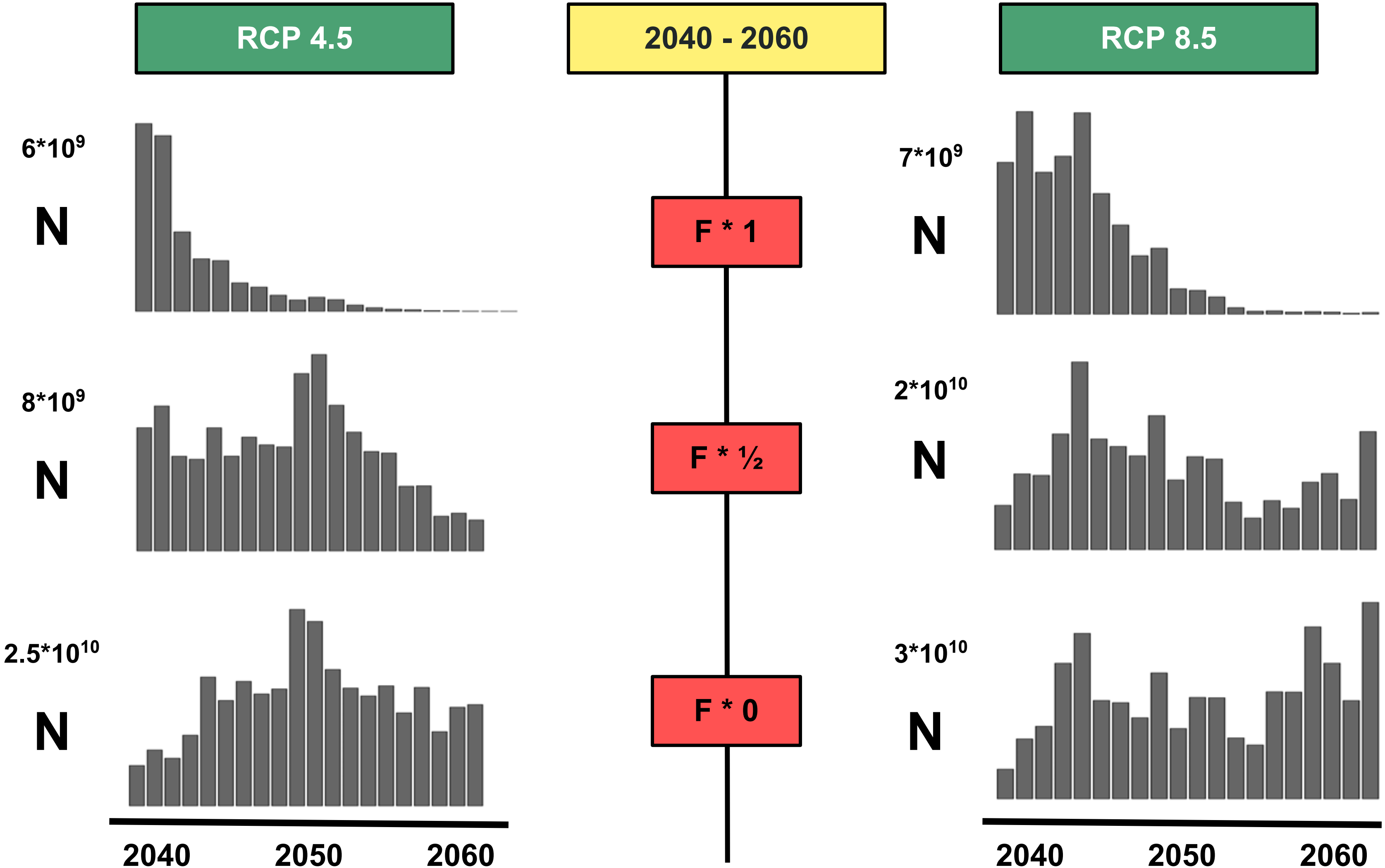
- 2040 - 2060 / 2080 - 2100
  - RCP 4.5 & RCP 8.5
  - 3 fishing scenarios
    - F * 1
    - F * ½
    - F * 0

2040 - 2060

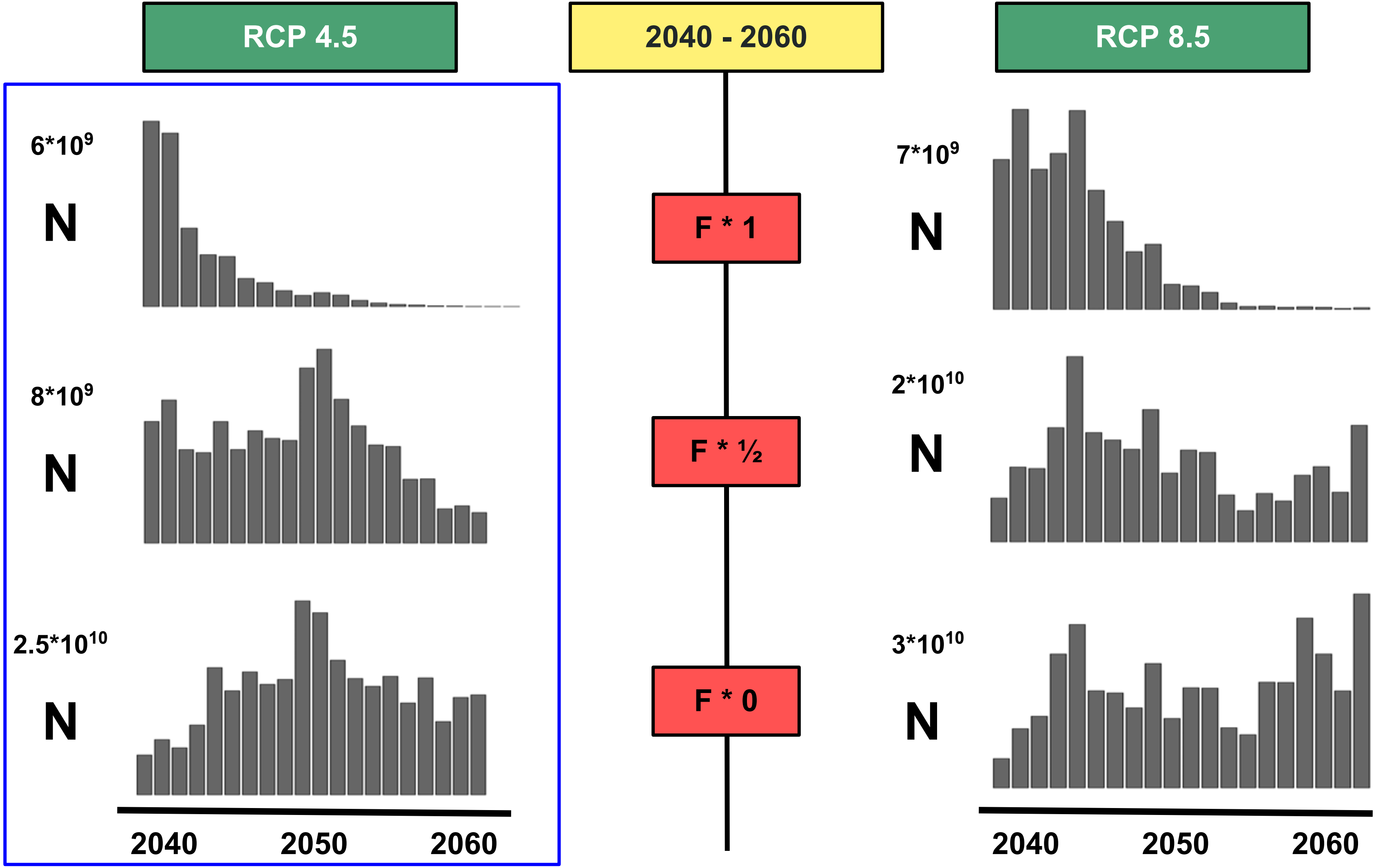

RCP 4.5
2040 - 2060
RCP 8.5
F * 1
F * ½
F * 0
2040
2050
2060
2040
2050
2060


RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
F * ½
F * 0
2040
2050
2060
2040
2050
2060

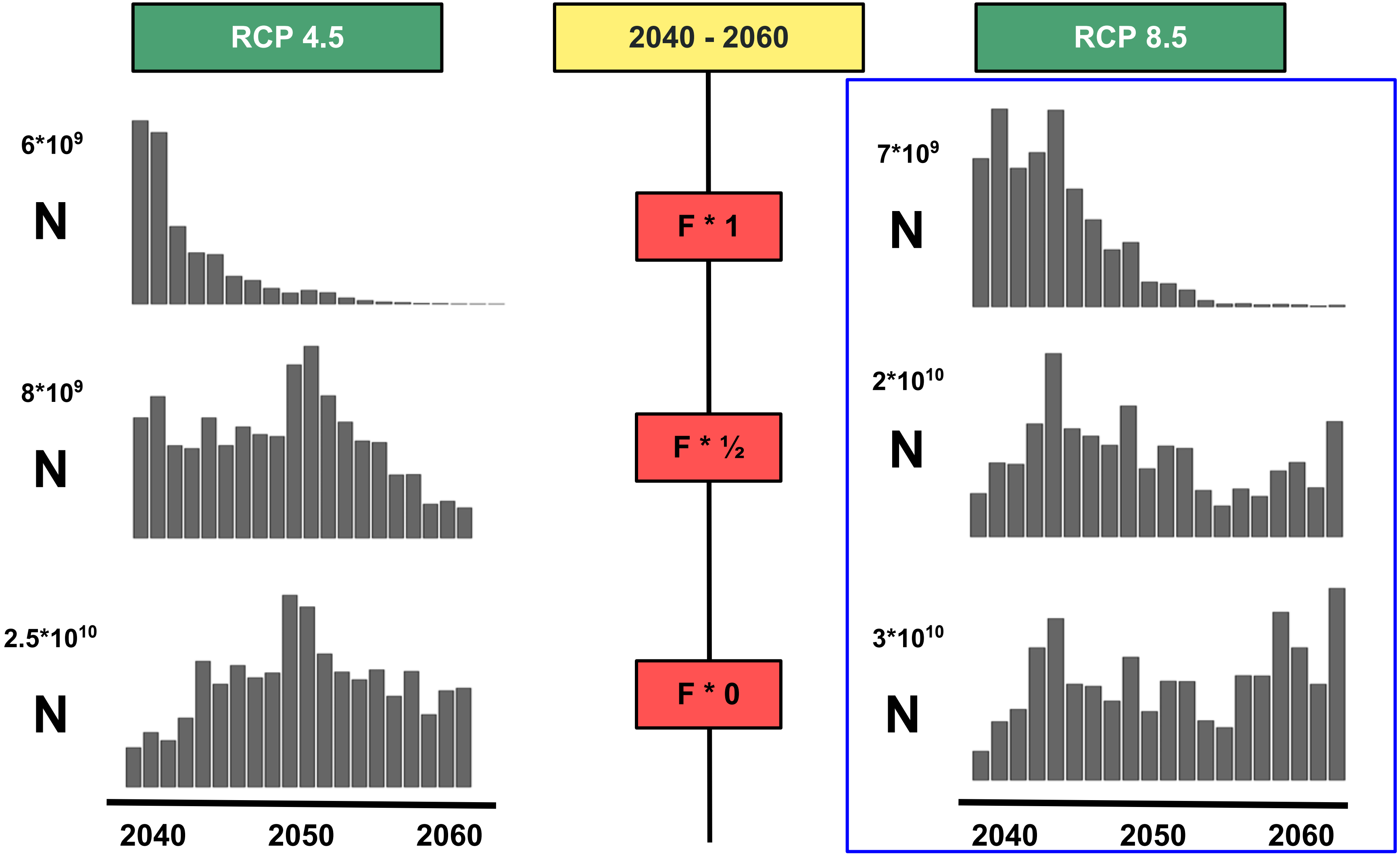

RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
7*10^9
N
F * 1
8*10^9
N
2*10^10
N
F * ½
F * 0
2040
2050
2060
2040
2050
2060

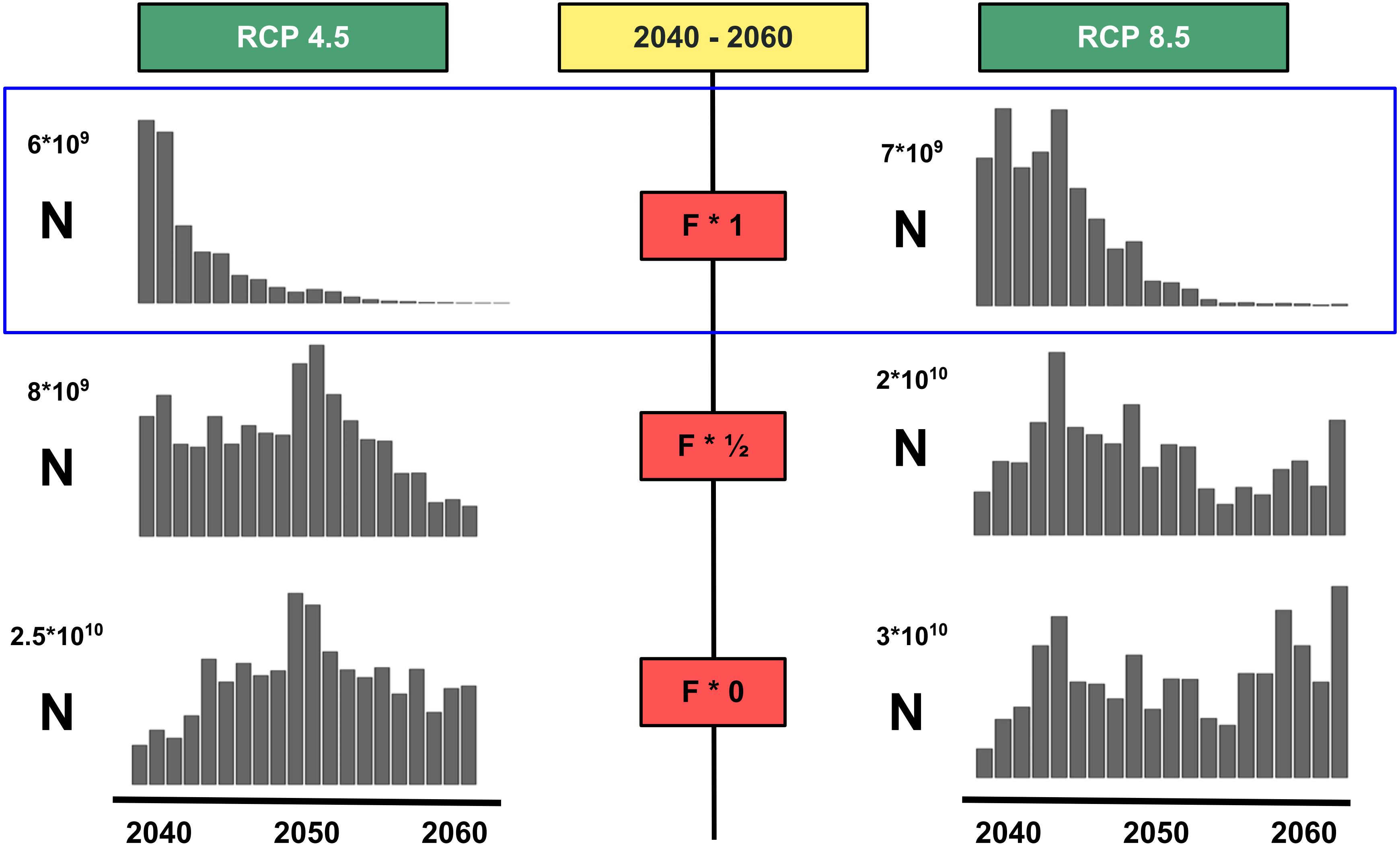


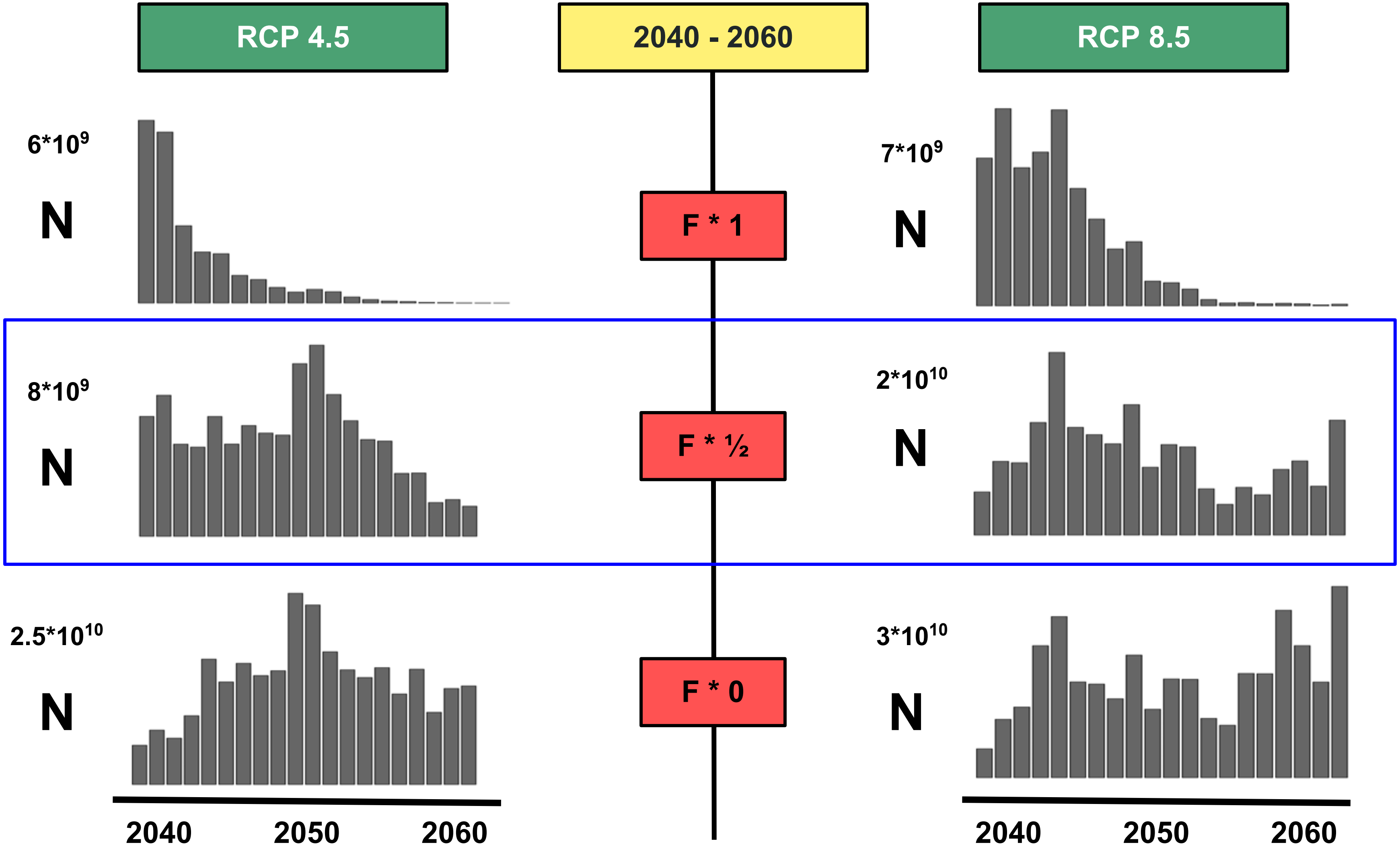
RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
8*10^9
N
F * ½
2*10^10
N
2.5*10^10
N
F * 0
3*10^10
N
2040
2050
2060
2040
2050
2060



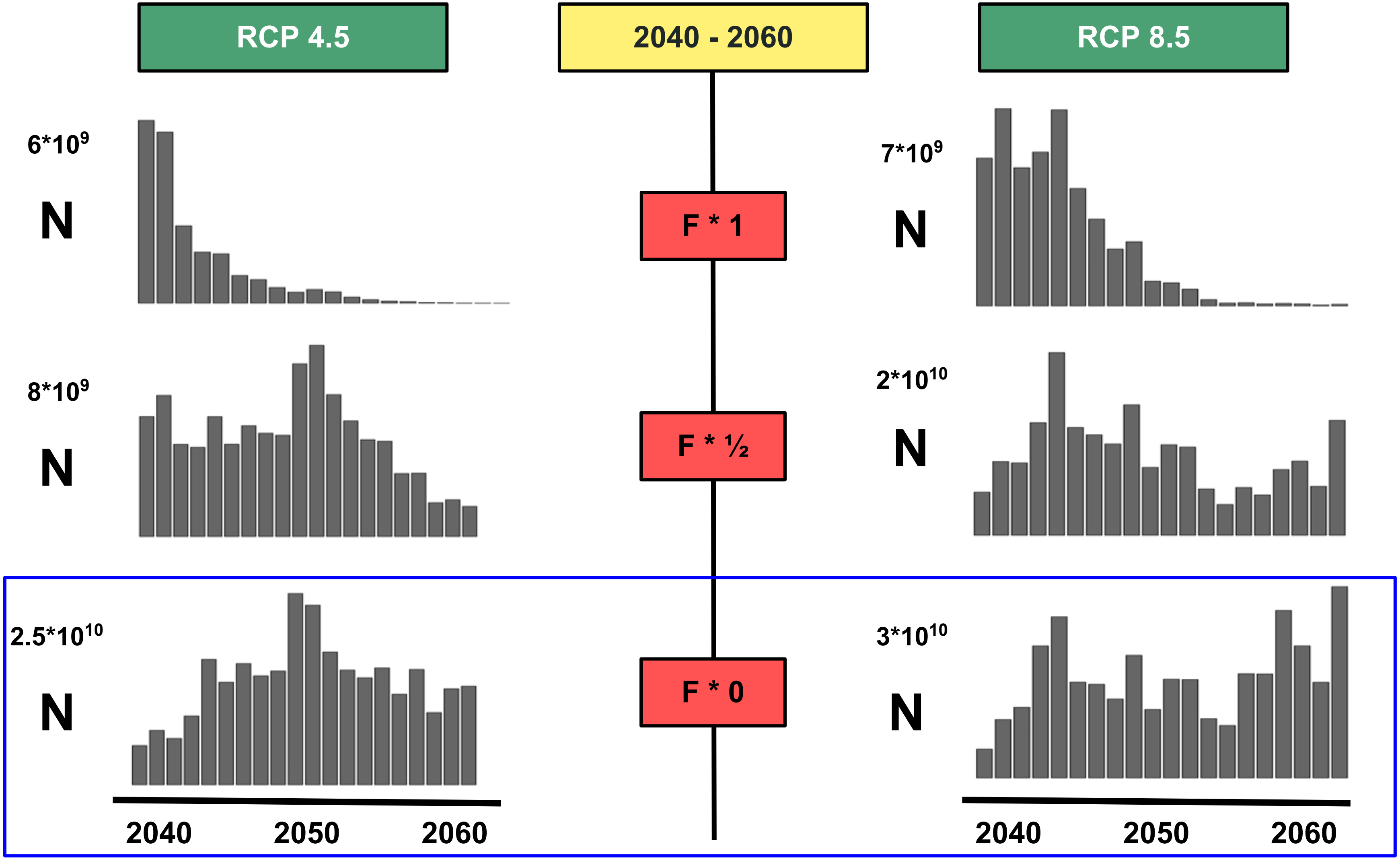
RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
8*10^9
N
F * ½
2*10^10
N
2.5*10^10
N
F * 0
3*10^10
N
2040
2050
2060
2040
2050
2060


RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
8*10^9
N
F * ½
2*10^10
N
2.5*10^10
N
F * 0
3*10^10
N
2040
2050
2060
2040
2050
2060


RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
8*10^9
N
F * ½
2*10^10
N
2.5*10^10
N
F * 0
3*10^10
N
2040
2050
2060
2040
2050
2060

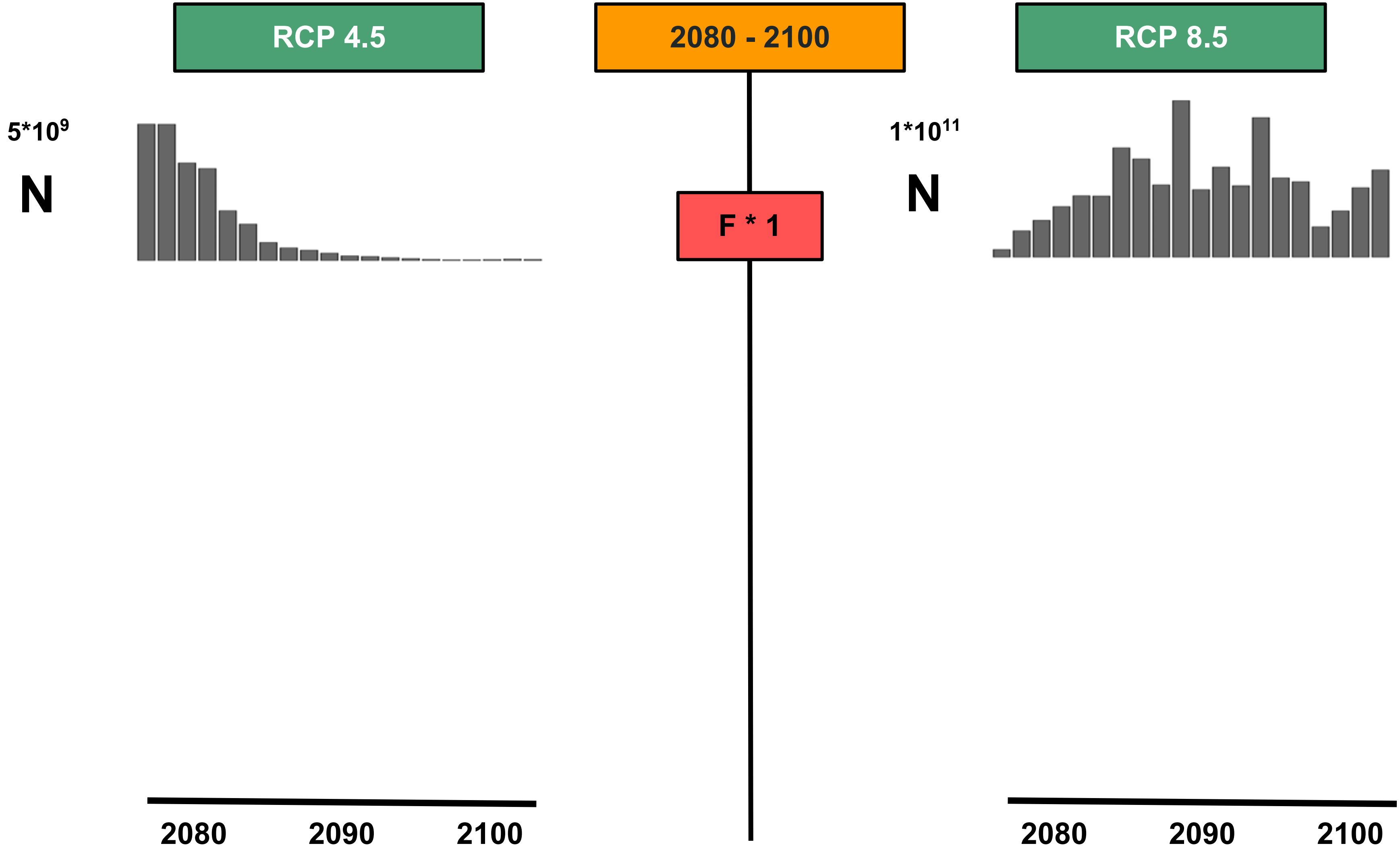


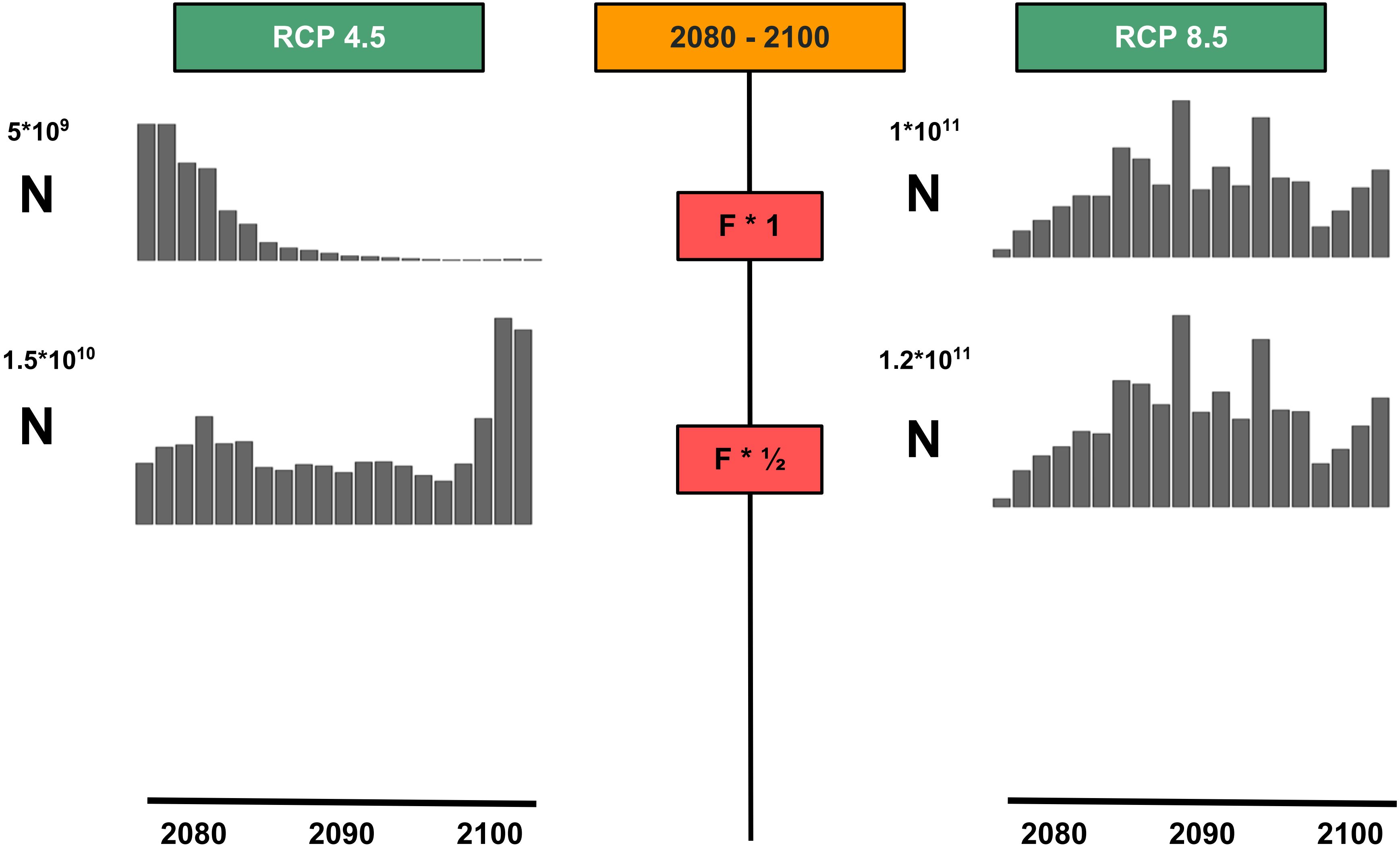
RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
8*10^9
N
F * ½
2*10^10
N
2.5*10^10
N
F * 0
3*10^10
N
2040
2050
2060
2040
2050
2060

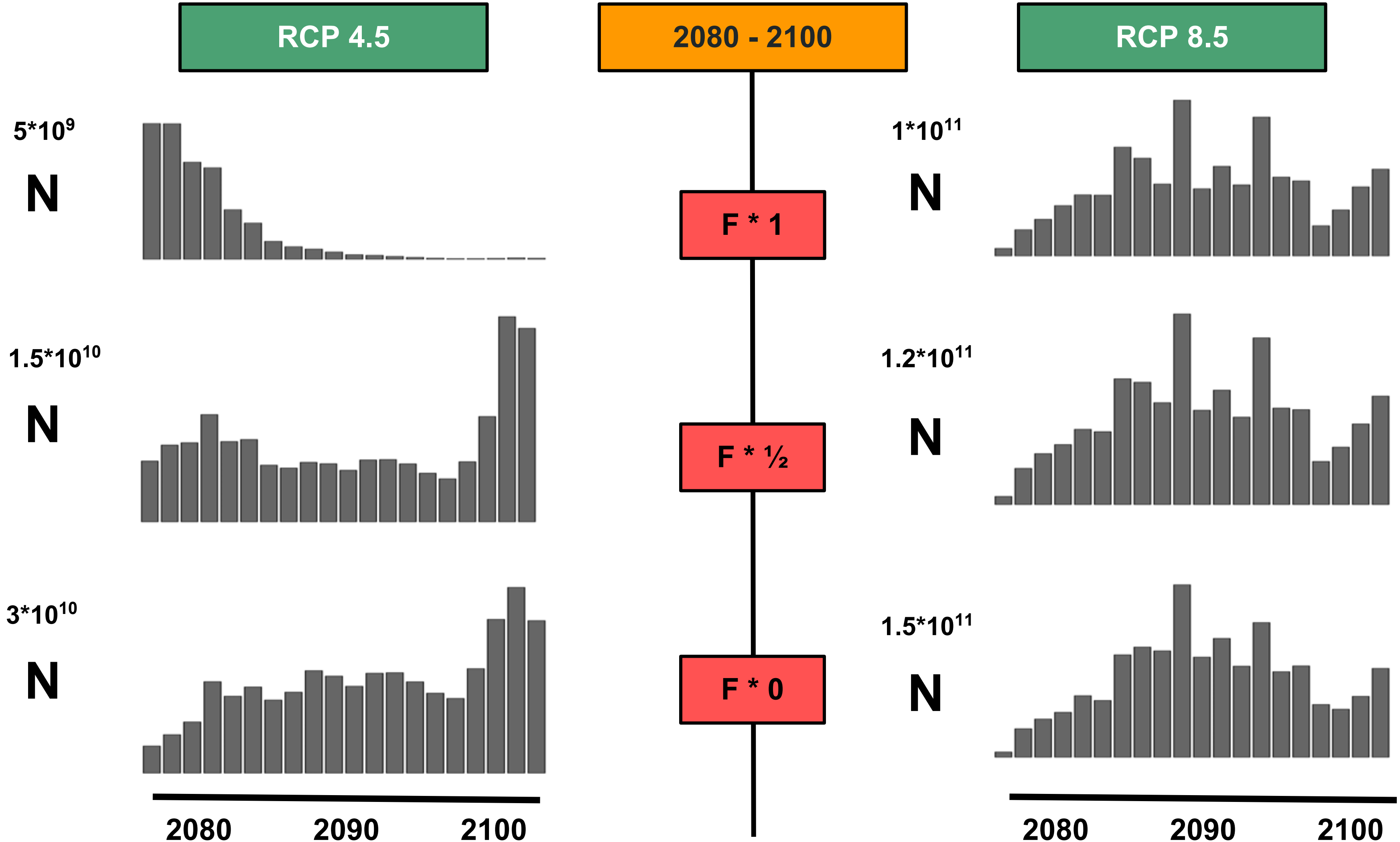


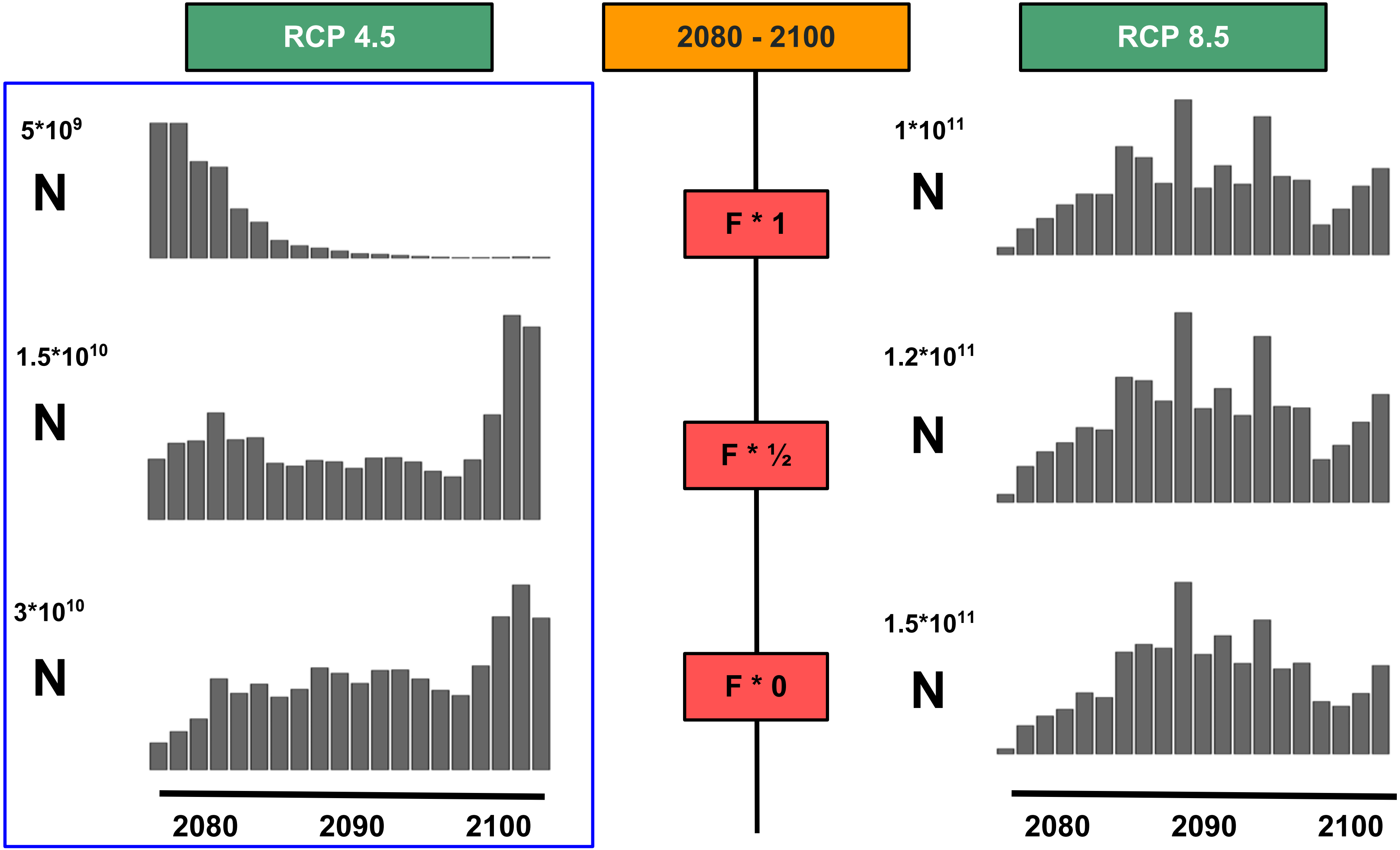
RCP 4.5
2040 - 2060
RCP 8.5
6*10^9
N
F * 1
7*10^9
N
8*10^9
N
F * ½
2*10^10
N
2.5*10^10
N
F * 0
3*10^10
N
2040
2050
2060
2040
2050
2060

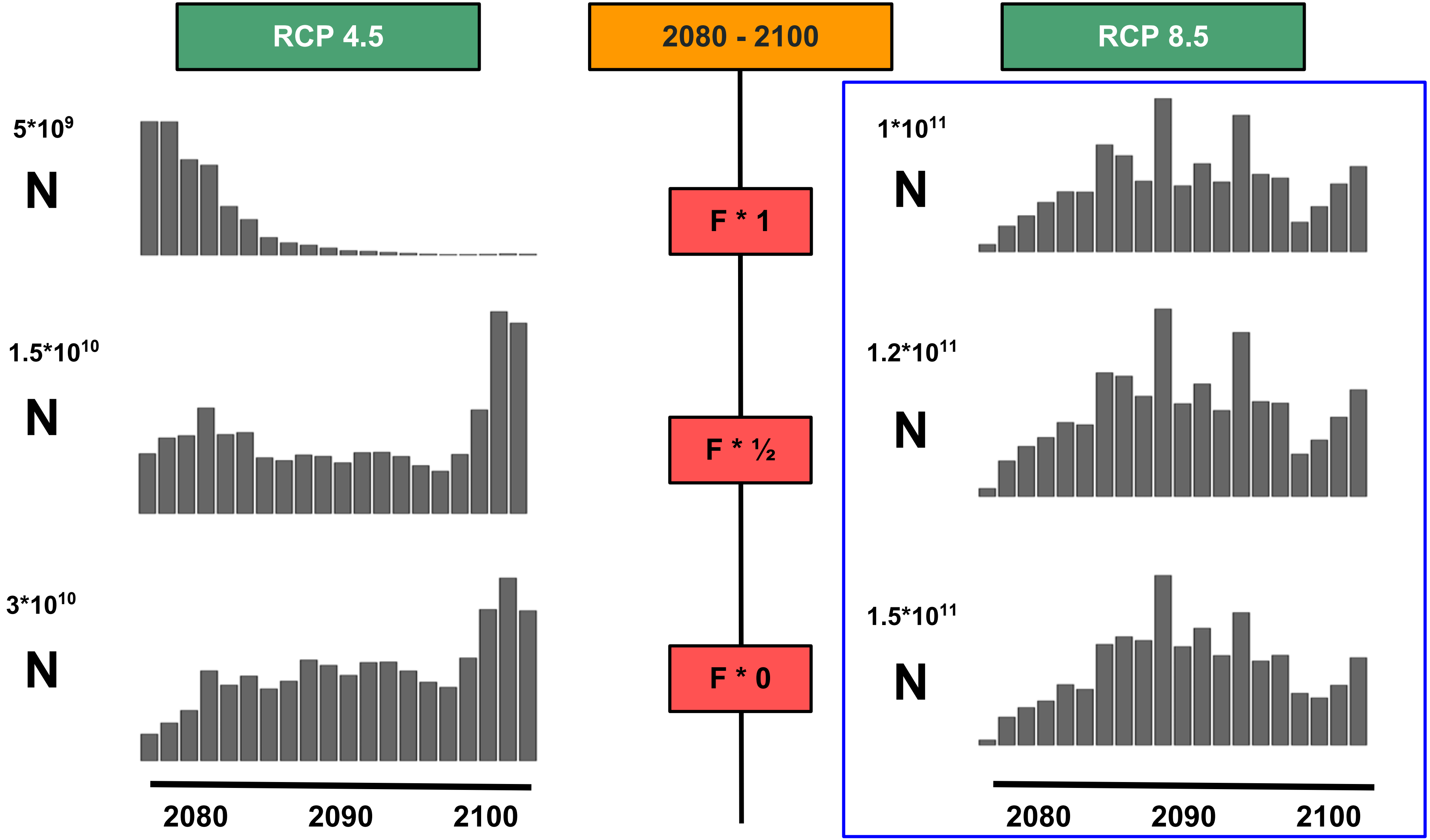
2080 - 2100


RCP 4.5
2080 - 2100
RCP 8.5
5*10^9
N
F * 1
1*10^11
N
2080
2090
2100
2080
2090
2100

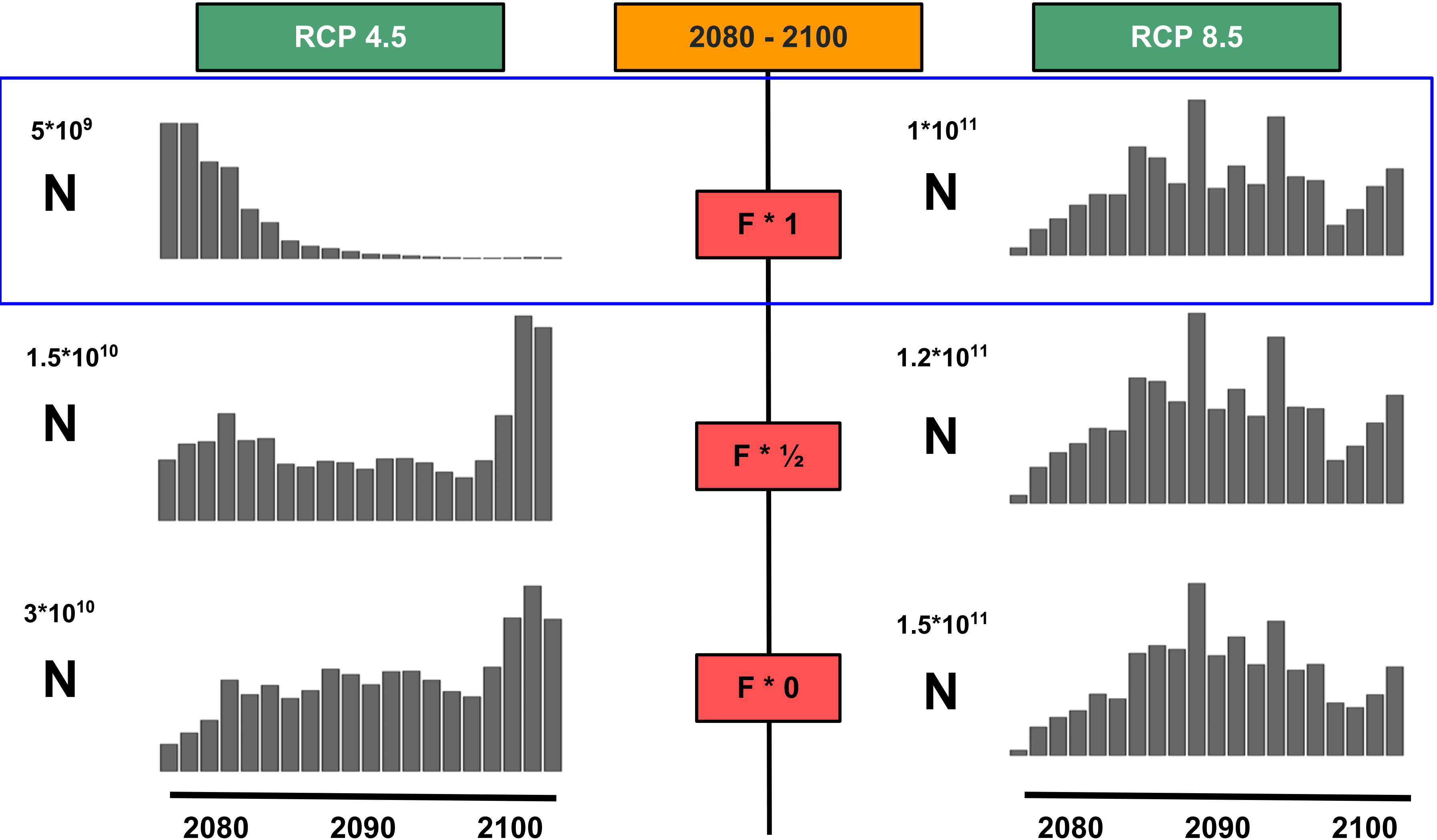

RCP 4.5
2080 - 2100
RCP 8.5
5*10^9
N
F * 1
1*10^11
N
1.5*10^10
N
F * ½
1.2*10^11
N
2080
2090
2100
2080
2090
2100

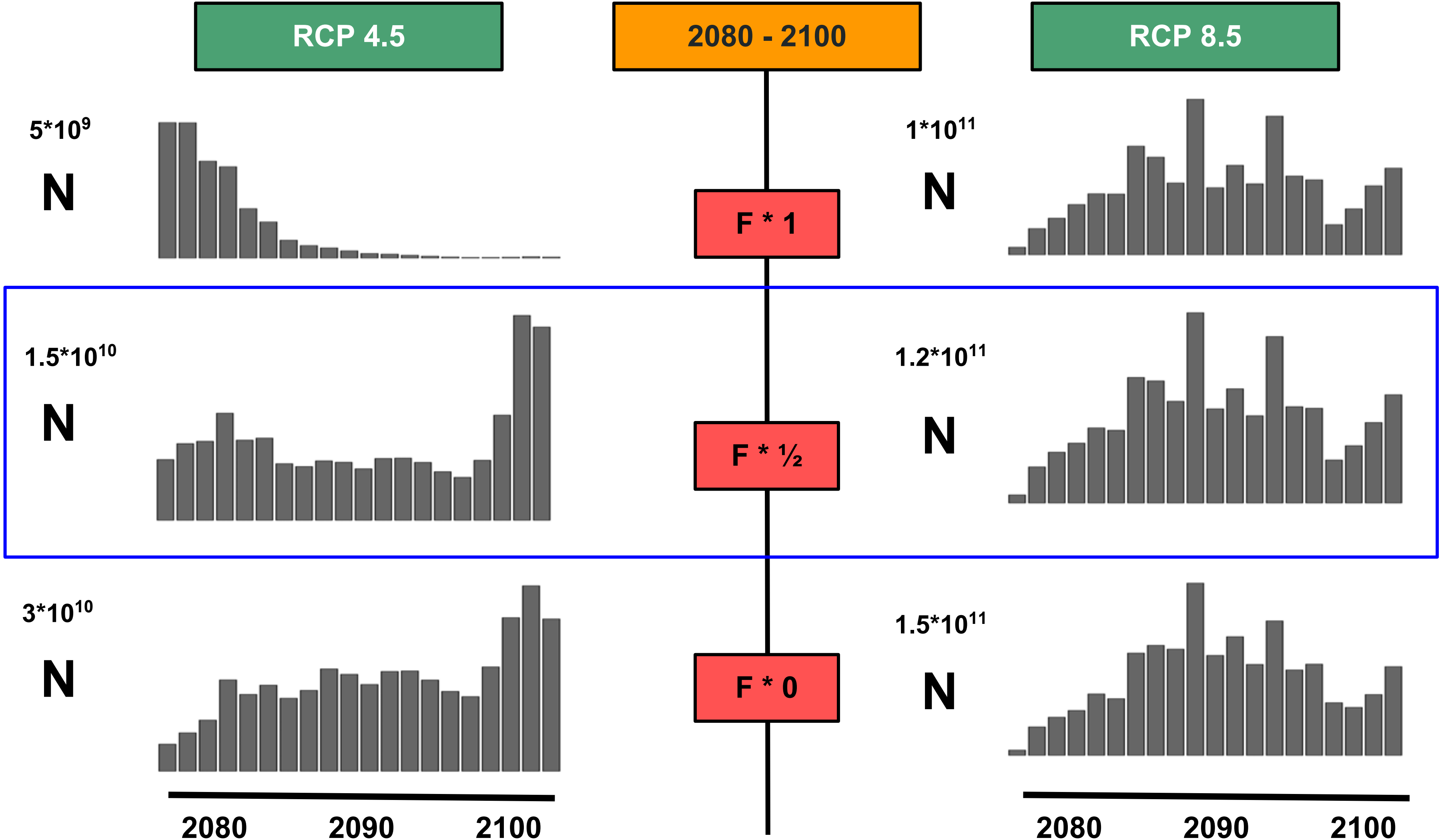

RCP 4.5
2080 - 2100
RCP 8.5
5*10^9
N
1*10^11
N
F * 1
1.5*10^10
N
1.2*10^11
N
F * ½
3*10^10
N
1.5*10^11
N
F * 0
2080
2090
2100
2080
2090
2100

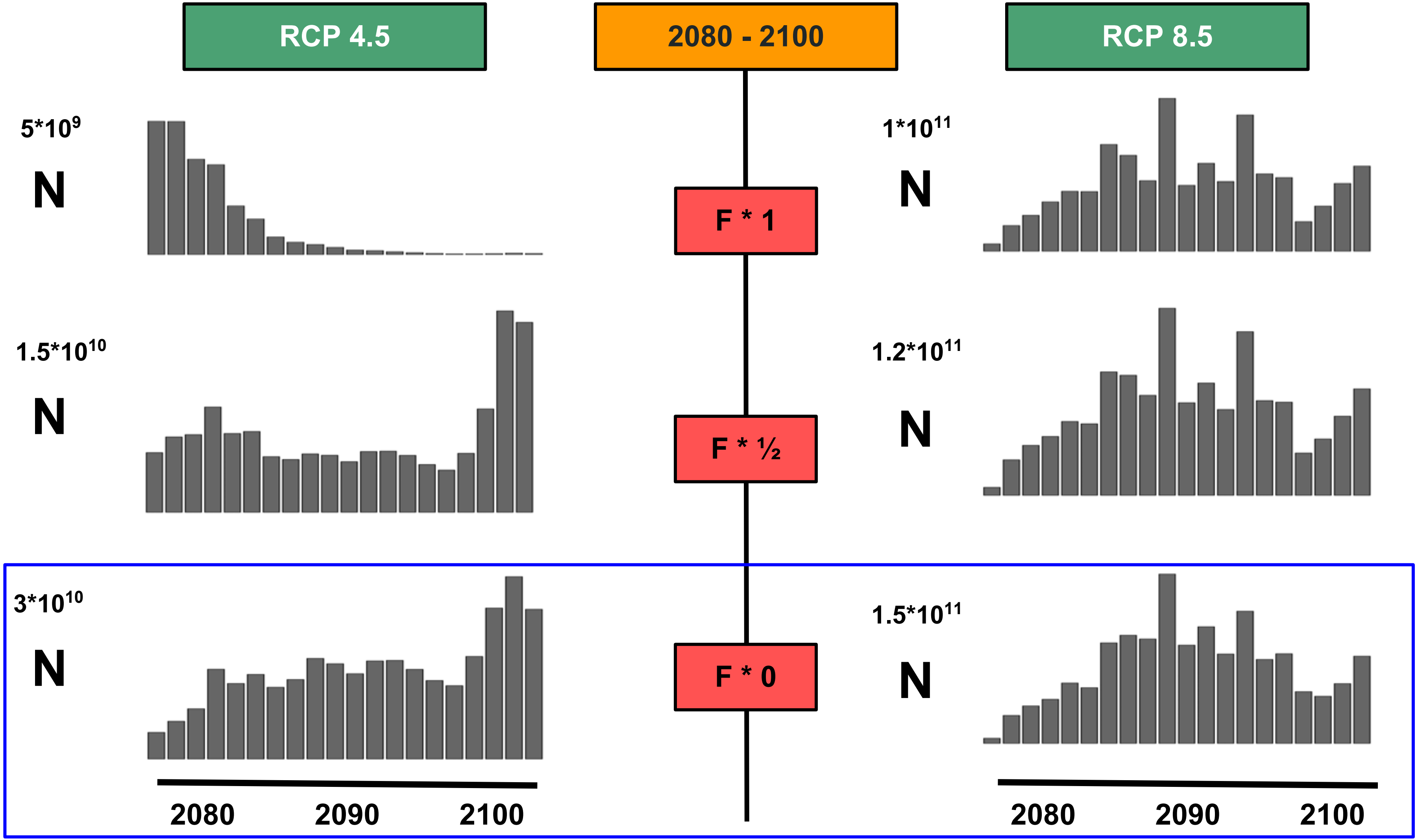

RCP 4.5
2080 - 2100
RCP 8.5
$5*10^{9}$
N
F * 1
$1*10^{11}$
N
$1.5*10^{10}$
N
F * ½
$1.2*10^{11}$
N
$3*10^{10}$
N
F * 0
$1.5*10^{11}$
N
2080
2090
2100
2080
2090
2100



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


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


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



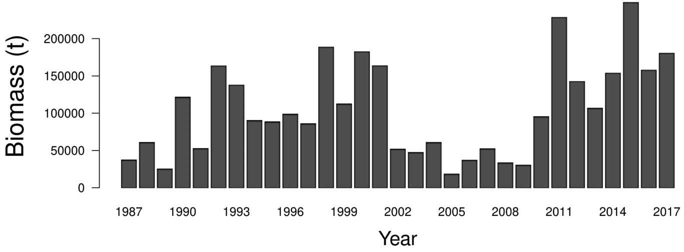
RCP 4.5
2080 - 2100
RCP 8.5
5*10^9
N
1*10^11
N
F * 1
1.5*10^10
N
1.2*10^11
N
F * ½
3*10^10
N
1.5*10^11
N
F * 0
2080
2090
2100
2080
2090
2100

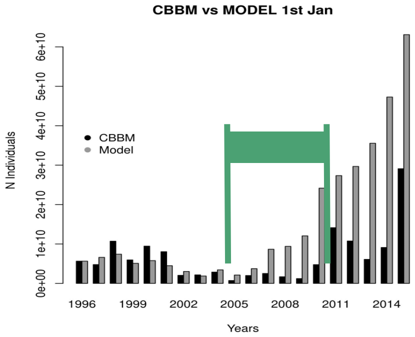
Further work / Conclusions

Conclusions

Our population model is able to hindcast the low population between 2005-2010

Fishing mortality is an important driving factor for the evolution of the population in our model.

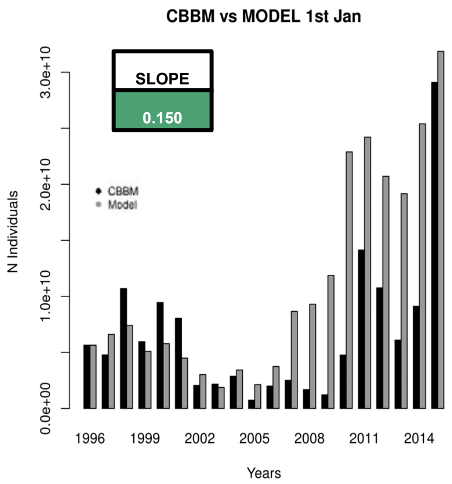


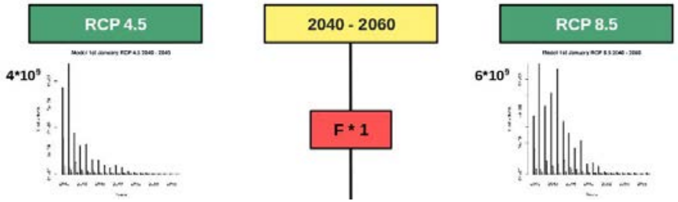


Conclusions

The inclusion of a density-dependent control of the population improves the fit to observed data

Under scenario 8.5, the population seems to be more resilient to fishing than under scenario 4.5





Further work

Better understand:

- Interannual variability in the forecast
- Interactions between physical variables and ind. energetics:
  - Zooplankton phenology
  - Temperature
  - Reproduction
  - Growth
  - Mortality

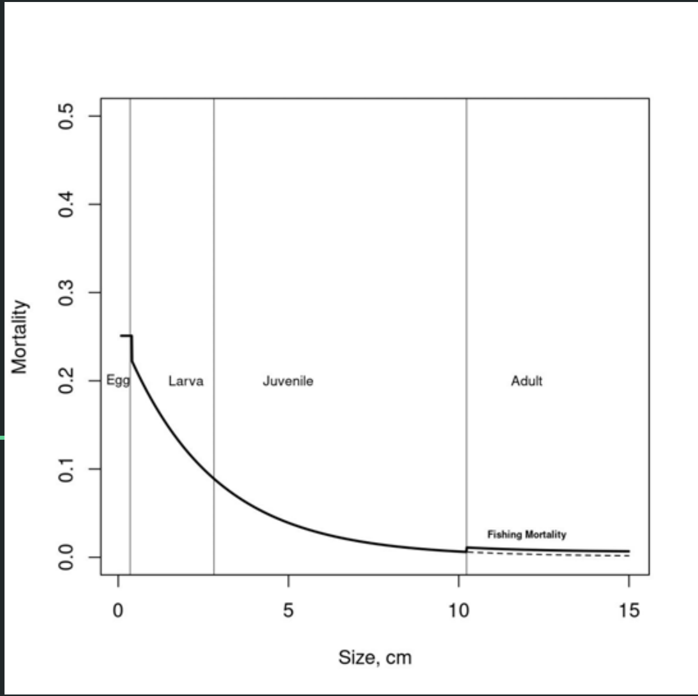
Improve:

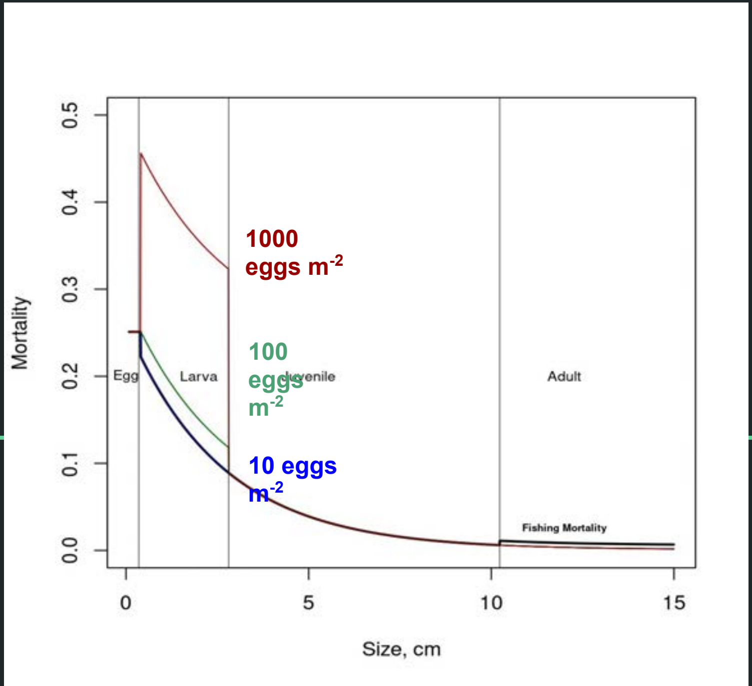
- Calibration of the model with new variables
- The density-dependent control of larval mortality
- Scenarios of future fishing
- Etc.

… more time and work needed

Thanks for your attention!

jbuenopardo@gmail.com


Mortality
0.0
0.1
0.2
0.3
0.4
0.5
Egg
Larva
Juvenile
Adult
Fishing Mortality
0
5
10
15
Size, cm


Mortality
0.0
0.1
0.2
0.3
0.4
0.5
Egg
Larva
Juvenile
Adult
1000 eggs m-2
100 eggs m-2
10 eggs m-2
Fishing Mortality
0
5
10
15
Size, cm