SOMBEE

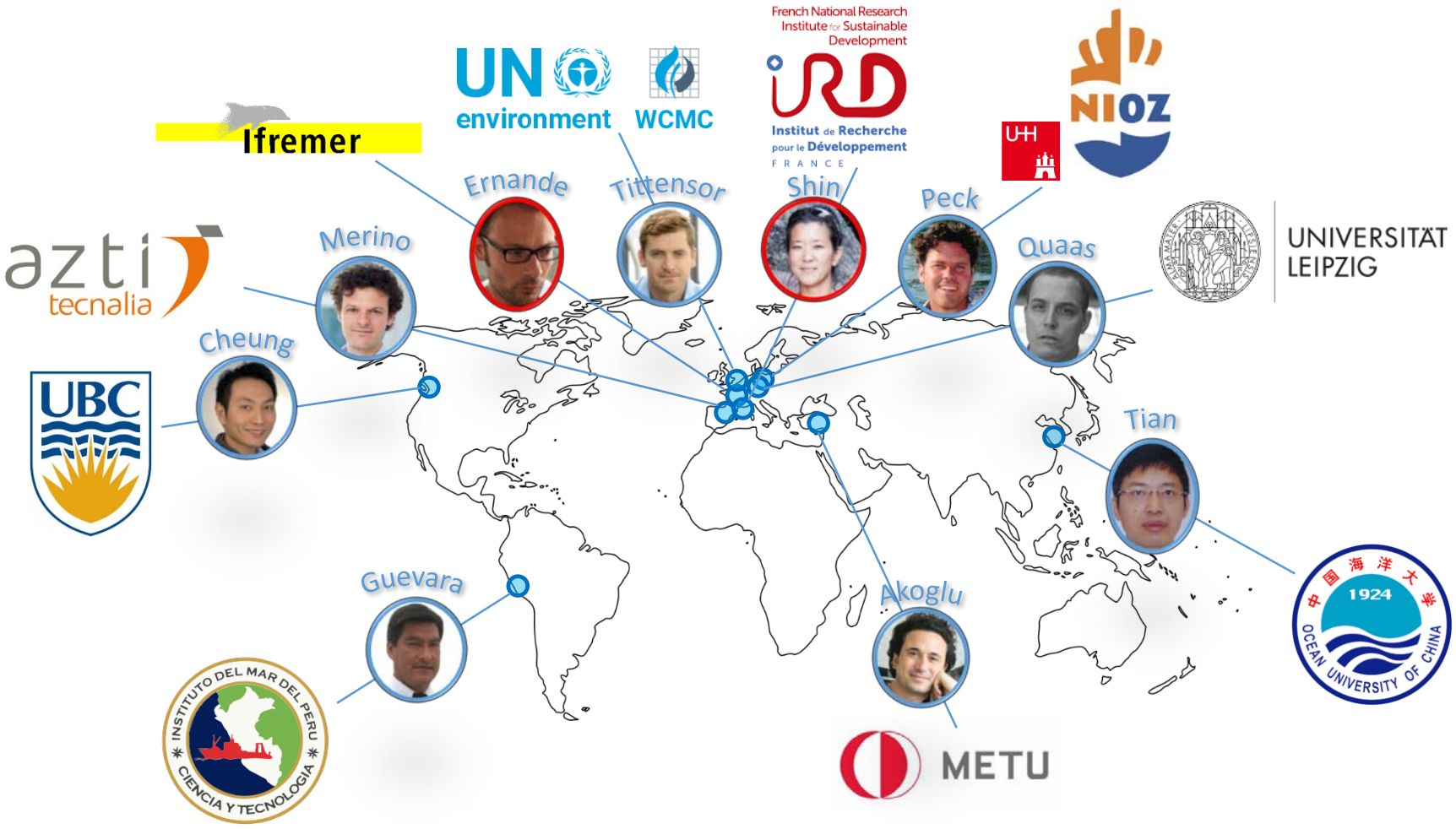
Scenarios Of Marine Biodiversity and Evolution under Exploitation and climate change

(2019-2022)

Yunne SHIN, Bruno ERNANDE, Ghassen HALOUANI

The Impact of Climate Change on Fisheries in the North Western Waters:
Examining policy, research, and potential mitigation and adaptation strategies
26 November 2020

Consortium


Ifremer
UN environment
WCMC
French National Research Institute for Sustainable Development
Institut de Recherche pour le Développement
FRANCE
NIOZ
azti tecnalia
UBC
UNIVERSITÄT LEIPZIG
Ernande
Tittensor
Shin
Peck
Merino
Quaas
Cheung
Tian
Guevara
Akoglu
INSTITUTO DEL MAR DEL PERU
CIENCIA Y TECNOLOGIA
1924
OCEAN UNIVERSITY OF CHINA
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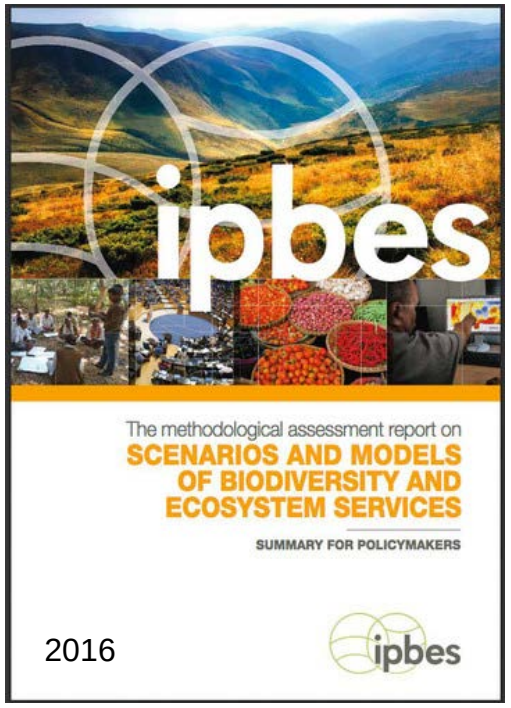
Context

Globally, **fishing** exploitation has had the largest impact on marine biodiversity.

Our future oceans will increasingly depend on the amount of **GHG emitted** today and in the coming decades



Scenarios are invaluable tools to guide long term strategic policies, prompt management actions and increase public awareness on future threats to biodiversity.

Context

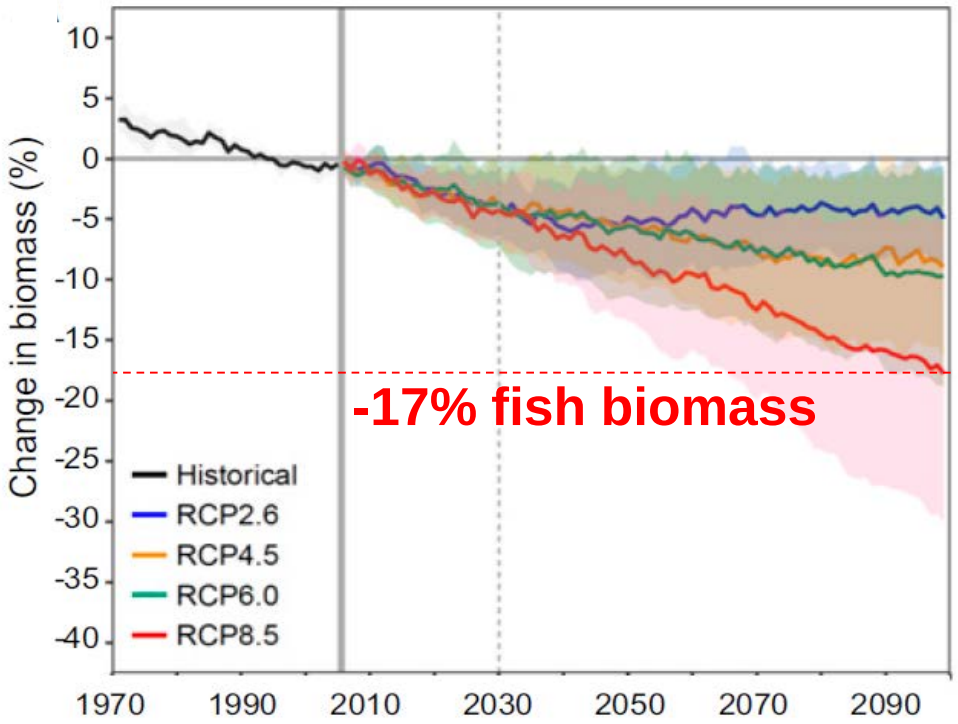
PNAS

Global ensemble projections reveal trophic amplification of ocean biomass declines with climate change

Heike K. Lotze[a,1], Derek P. Tittensor[a,b], Andrea Bryndum-Buchholz[a], Tyler D. Eddy[a,c], William W. L. Cheung[c], Eric D. Galbraith[d,e], Manuel Barange[f], Nicolas Barrier[g], Daniele Bianchi[h], Julia L. Blanchard[i,j], Laurent Bopp[k], Matthias Büchner[l], Catherine M. Bulman[m], David A. Carozza[n], Villy Christensen[o], Marta Coll[g,p], John P. Dunne[q], Elizabeth A. Fulton[j,m], Simon Jennings[r,s,t], Miranda C. Jones[c], Steve Mackinson[u], Olivier Maury[g,v], Susa Niiranen[w], Ricardo Oliveros-Ramos[x], Tilla Roy[j,y], José A. Fernandes[z,aa], Jacob Schewe[l], Yunne-Jai Shin[g,bb], Tiago A. M. Silva[r], Jeroen Steenbeek[p], Charles A. Stock[q], Philippe Verley[cc], Jan Volkholz[l], Nicola D. Walker[r], and Boris Worm[a]

2019

FISHERIES & MARINE ECOSYSTEM FISH-MIP MODEL INTERCOMPARISON PROJECT

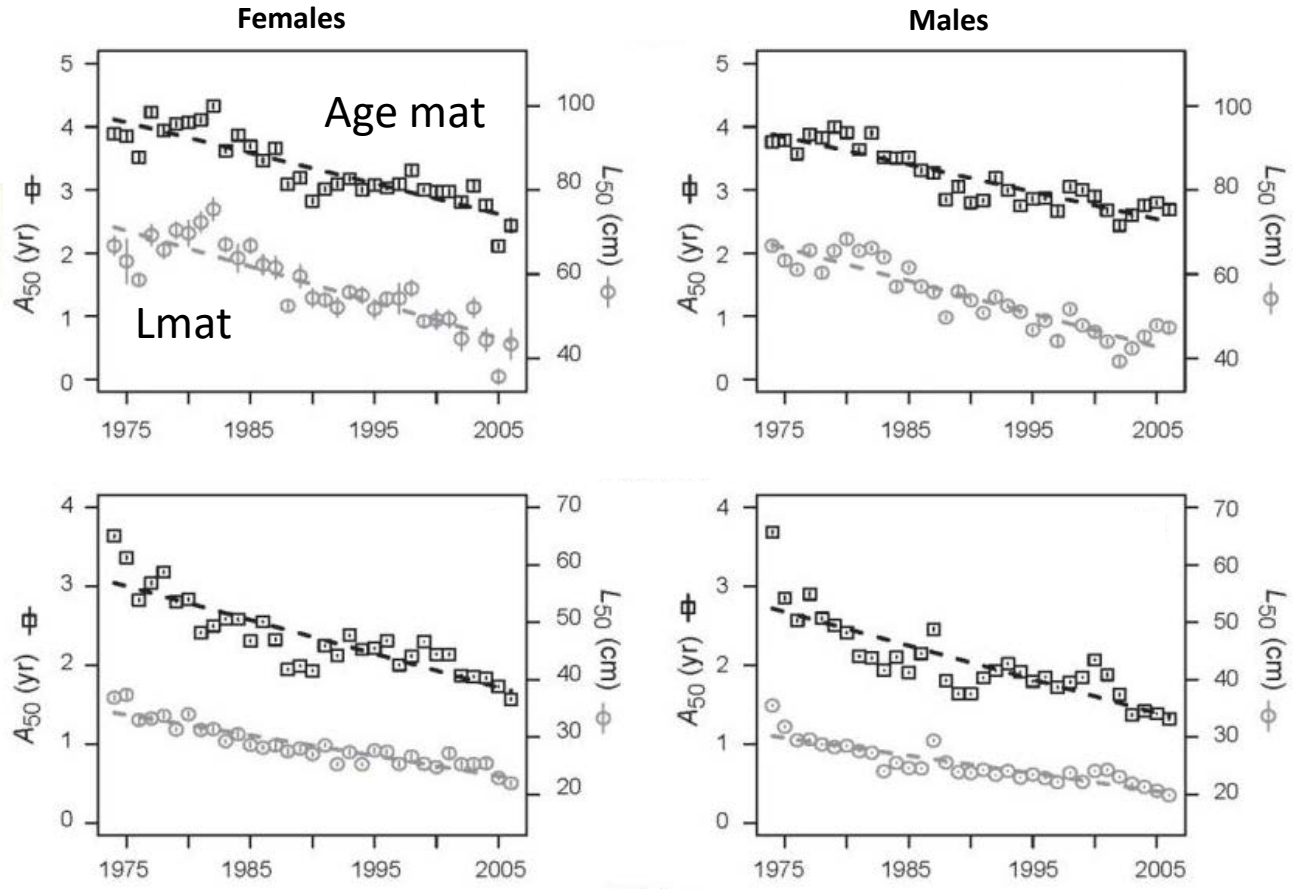


- What about the synergistic effects of climate change and fishing on marine biodiversity?
- What about the role of fish adaptation and evolution on multidecadal scales?

Marine populations adapt to global changes through the modification of their traits including their life-history and physiology (via phenotypic plasticity or evolution)

Cod

Haddock



NORTH SEA (Marty et al. 2014)

Exploited fish evolved towards small-bodied, early-maturing, highly-fecund life-histories

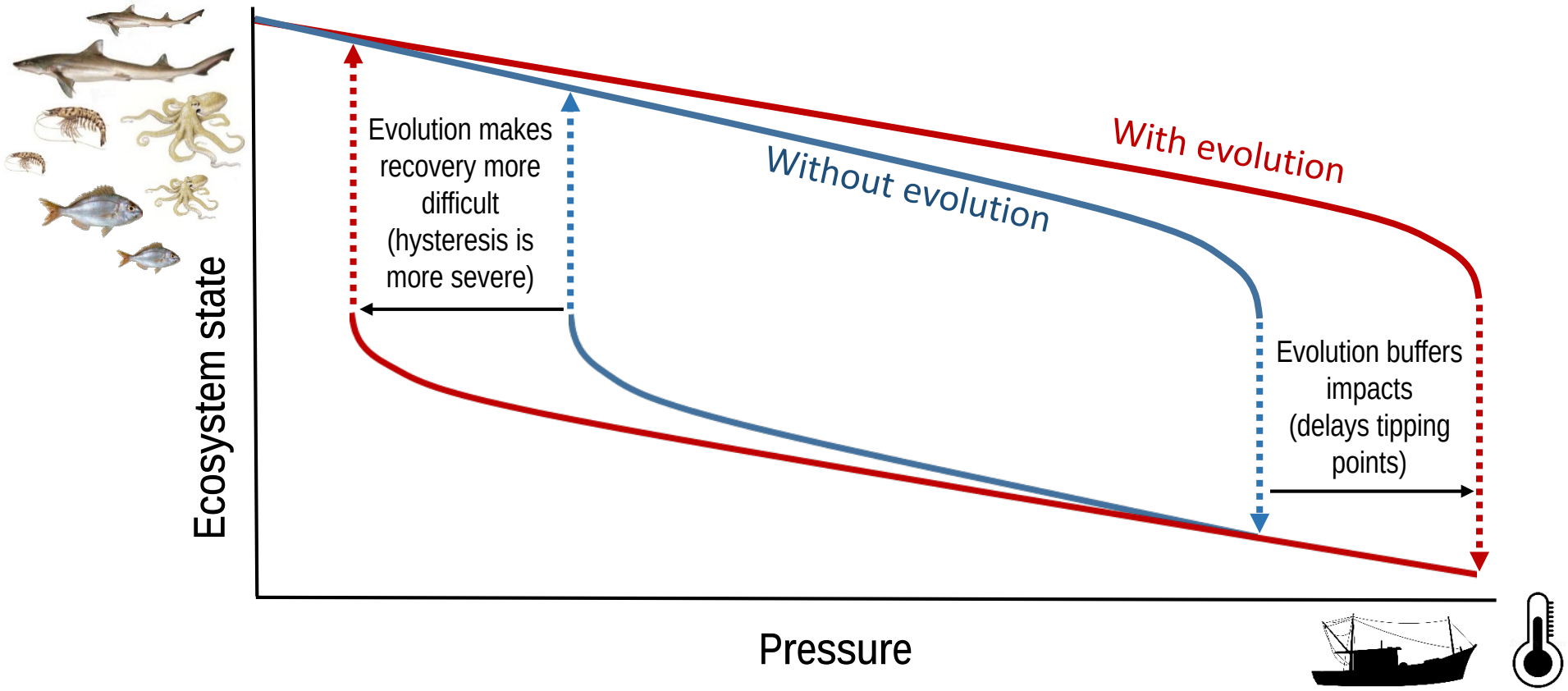
Marine populations adapt to global changes through the modification of their traits including their life-history and physiology (via phenotypic plasticity or evolution)

Result from the interplay between **selective pressures**  and **trade-offs** in energy-allocation between growth and reproduction.

Tend to maximize individual fitness, BUT **intensive fishing favors genetic drift** by diminishing effective population size**. This, together with selection, erodes genetic diversity** and thus decreases the evolutionary potential of populations.

Question

Will eco-evolutionary dynamics dampen (evolutionary rescue) or worsen (evolutionary trap) global change impacts on future marine fish biodiversity and its sustainable use?



Adapted from
Shin et al. 2019
IPBES GA Chapter 4

Objectives

Project future

- **intra-** and **inter-specific biodiversity dynamics** in marine **fish communities**
- their effects on **ecological and economic sustainability of fisheries**
- under scenarios of **fishing and climate change**

1. **develop a cutting-edge evolutionary-ecosystem model** focused on fish communities that accounts for fish genetics, physiology and life-history traits
2. **co-create scenarios with various stakeholders:** choose a set of future policy and fisheries management options to be tested in the context of climate change scenarios. **Downscaling** global scale scenarios to the regional/local scale.
3. **quantify the economic costs and tradeoffs to fishers** incurred by fishing- and climate-induced eco-evolutionary dynamics of fish communities that take place in some of the world's most productive and valuable marine fisheries.
4. **Project future marine biodiversity and fisheries economic pathways** under combined climate and fishing scenarios, gaining insights for both **biodiversity conservation and sustainable development of fisheries**
5. **address the synergistic and/or antagonistic ecological, evolutionary and economic impacts** of **climate change and fishing**, thus increasing the realism of future projections

Case studies

SOMBEE will conduct its work in **six regional marine ecosystems**, with important contrasts in oceanography and ecology, history of fisheries, socio-economics, and management and policy frameworks.

Travers

③ North Sea

Shin

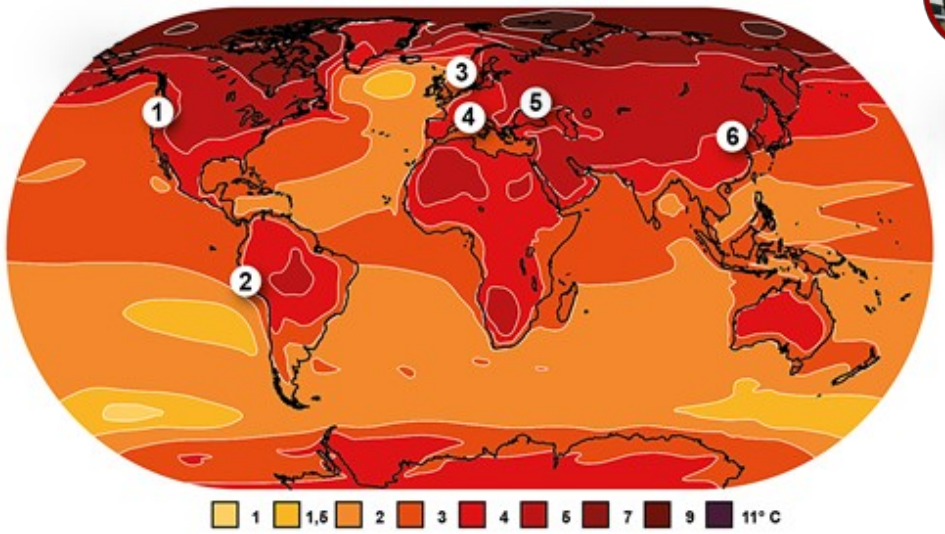
④ Gulf Of Lions

Akoglu

⑤ Black Sea

Fu

① Pacific Coast of Canada



Change in average surface temperature 1986-2005 to 2081-2100, RCP8.5 (IPCC AR5)

Tian

⑥ Yellow Sea

Alegre

② Northern Humboldt

Halouani

Gulf of Gabes

Halouani

English Channel

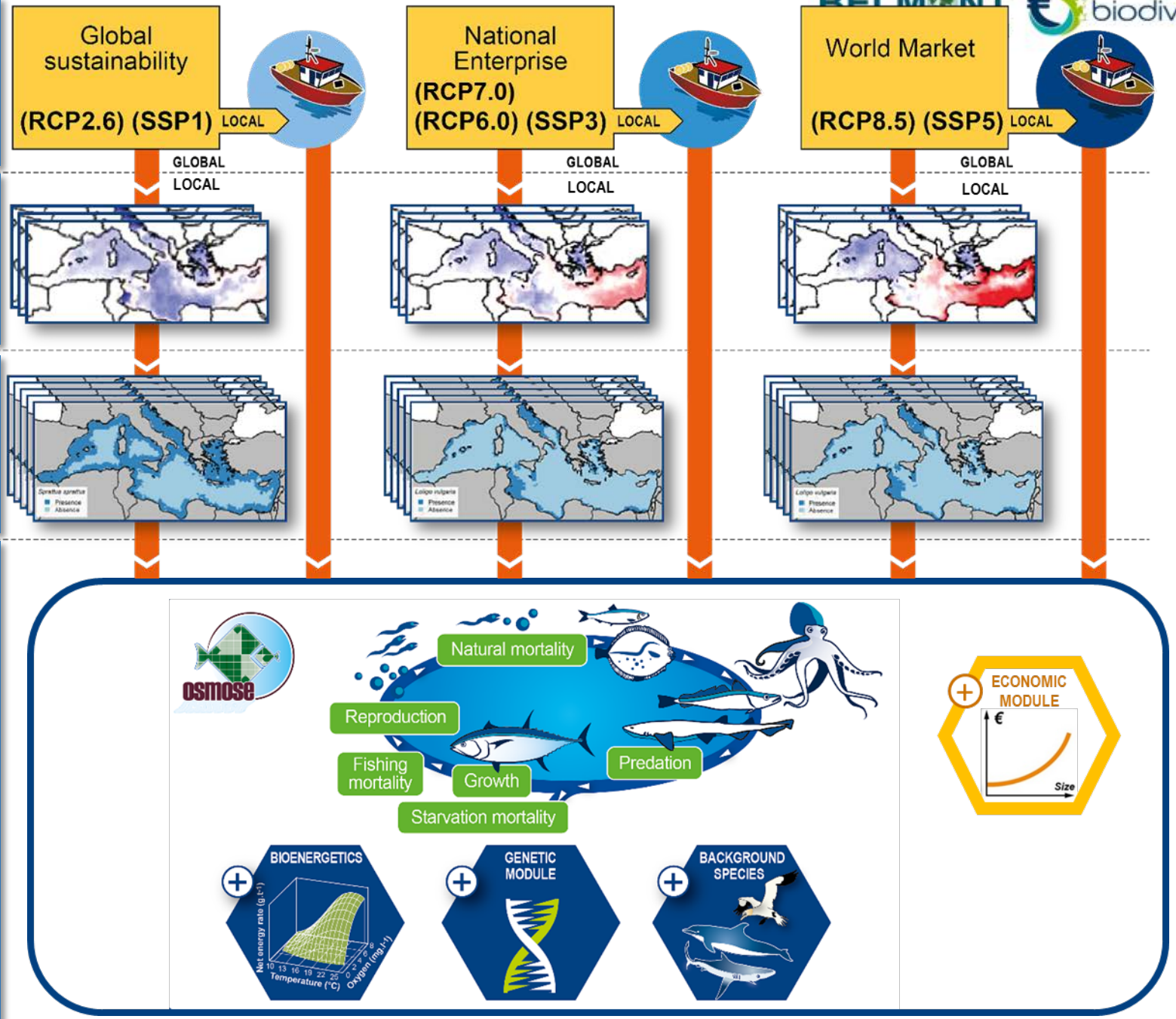
Global approach

Global climatic & socio-economic scenarios

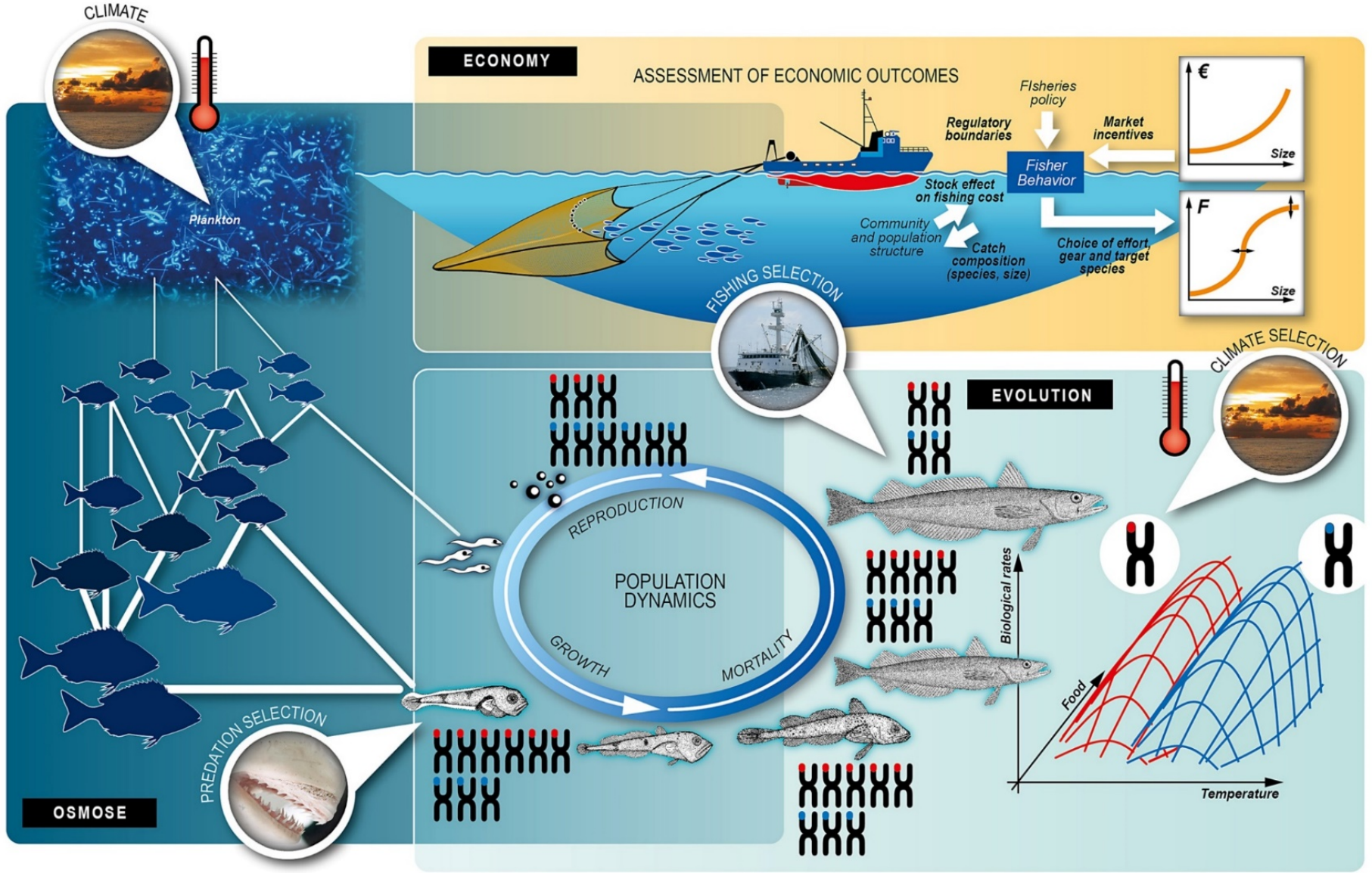
Downscaling of scenarios

Species distribution models

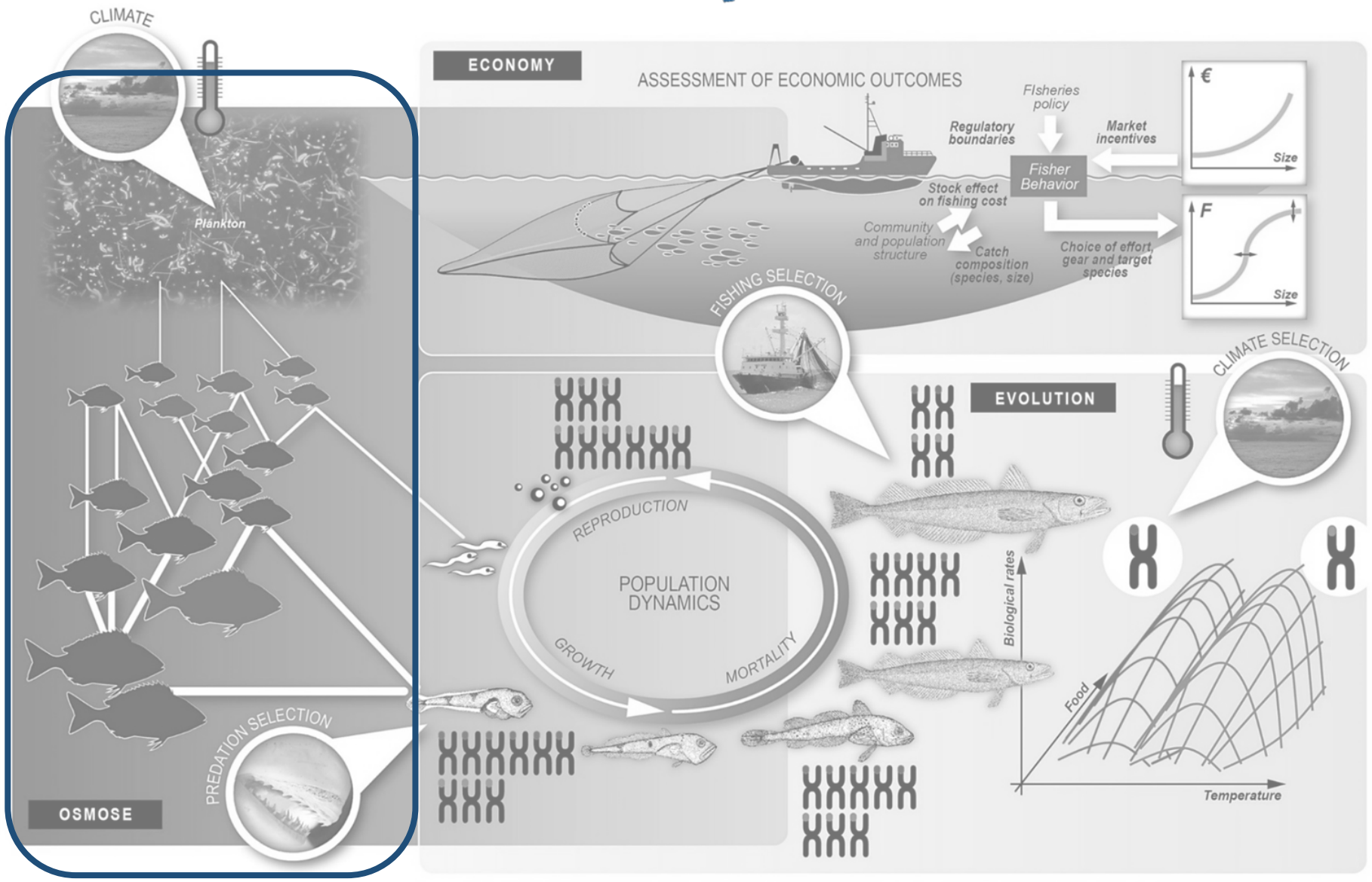
Evolutionary-ecosystem model
- Genetics
- Physiology
- Life-history traits
- Population
- Community
- Food web



Modeling framework

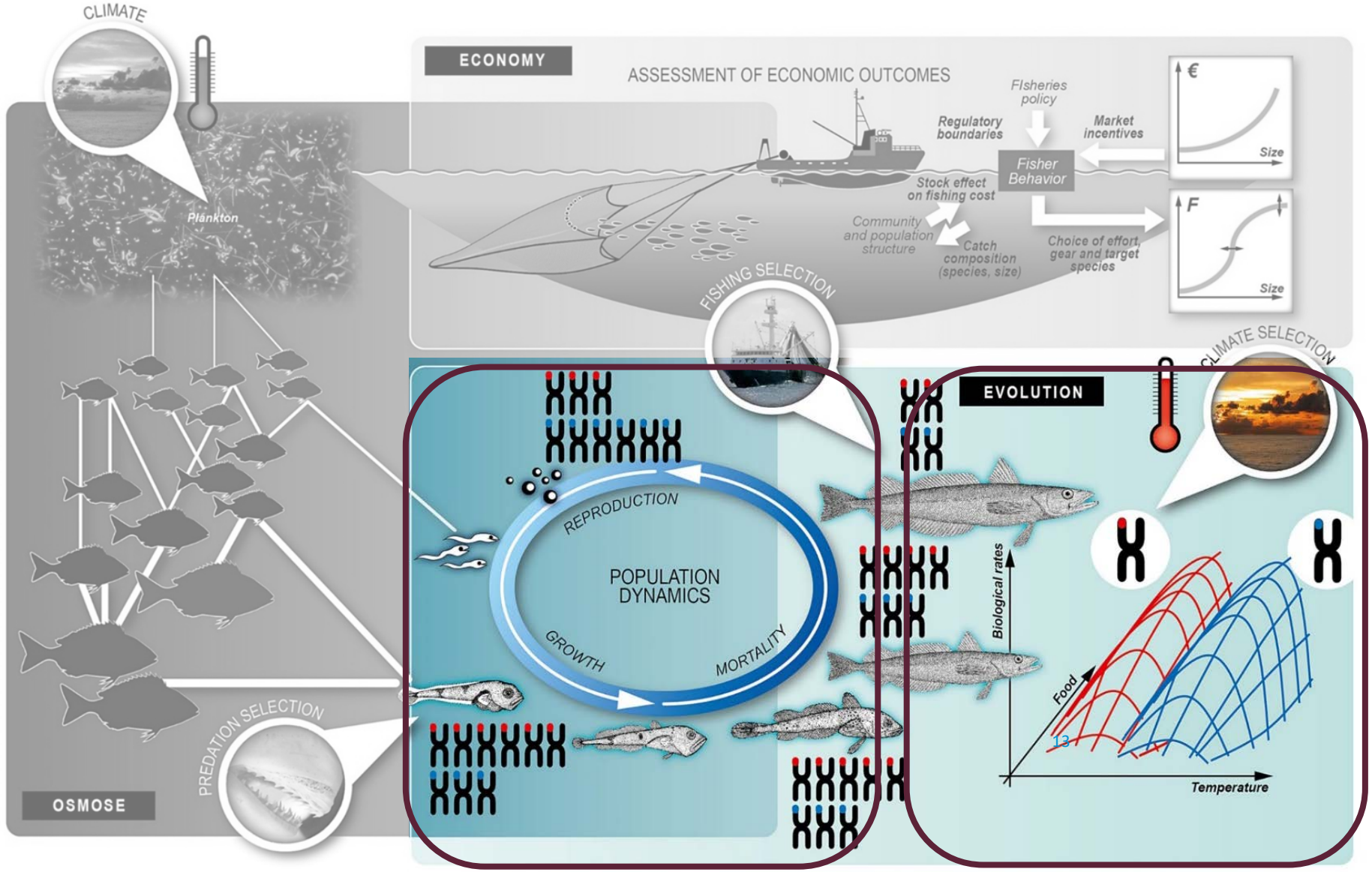


Modeling framework



OSMOSE
Multi-species model

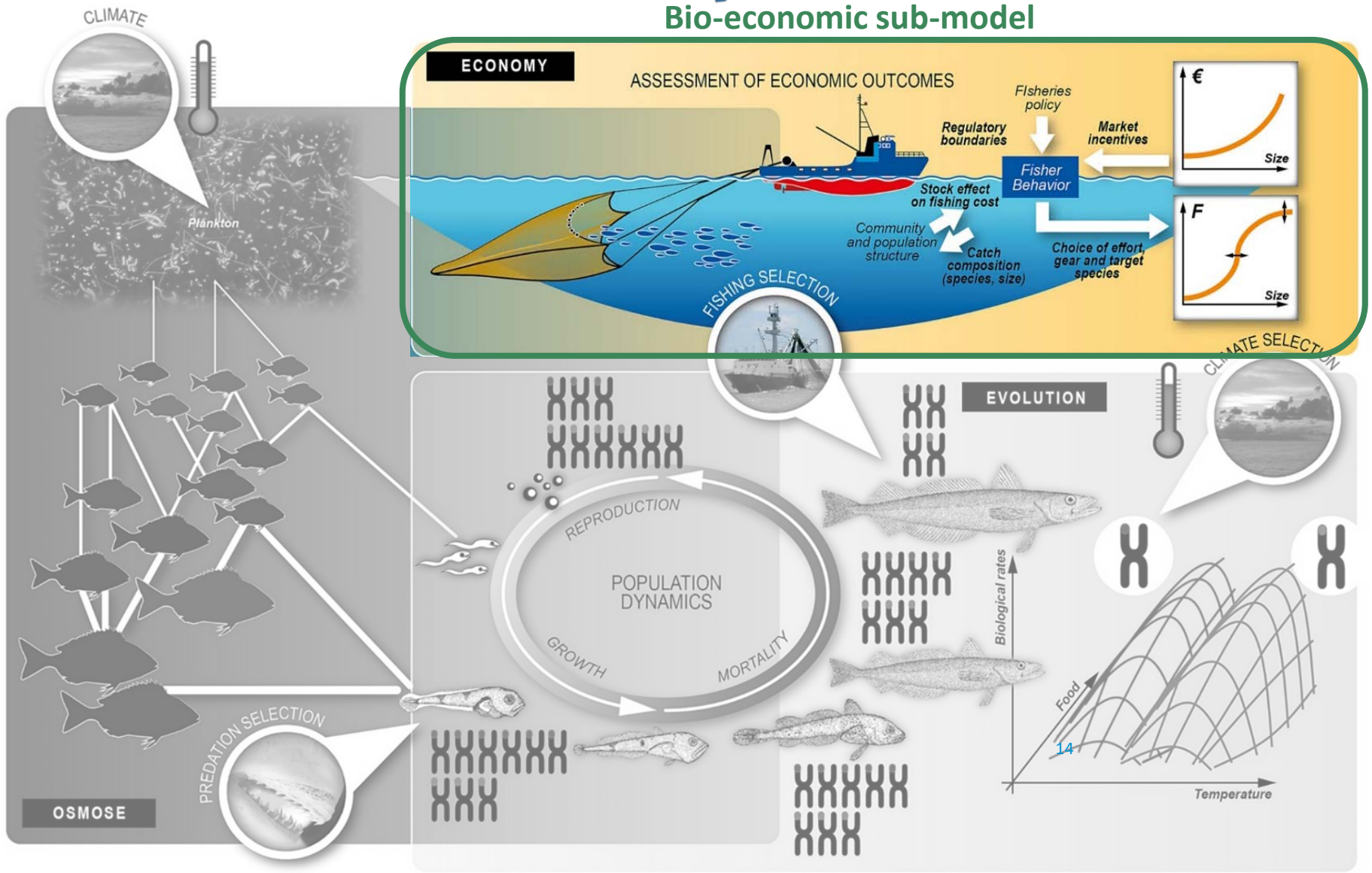
Modeling framework



Evolutionary sub-model **Bioenergetic module**

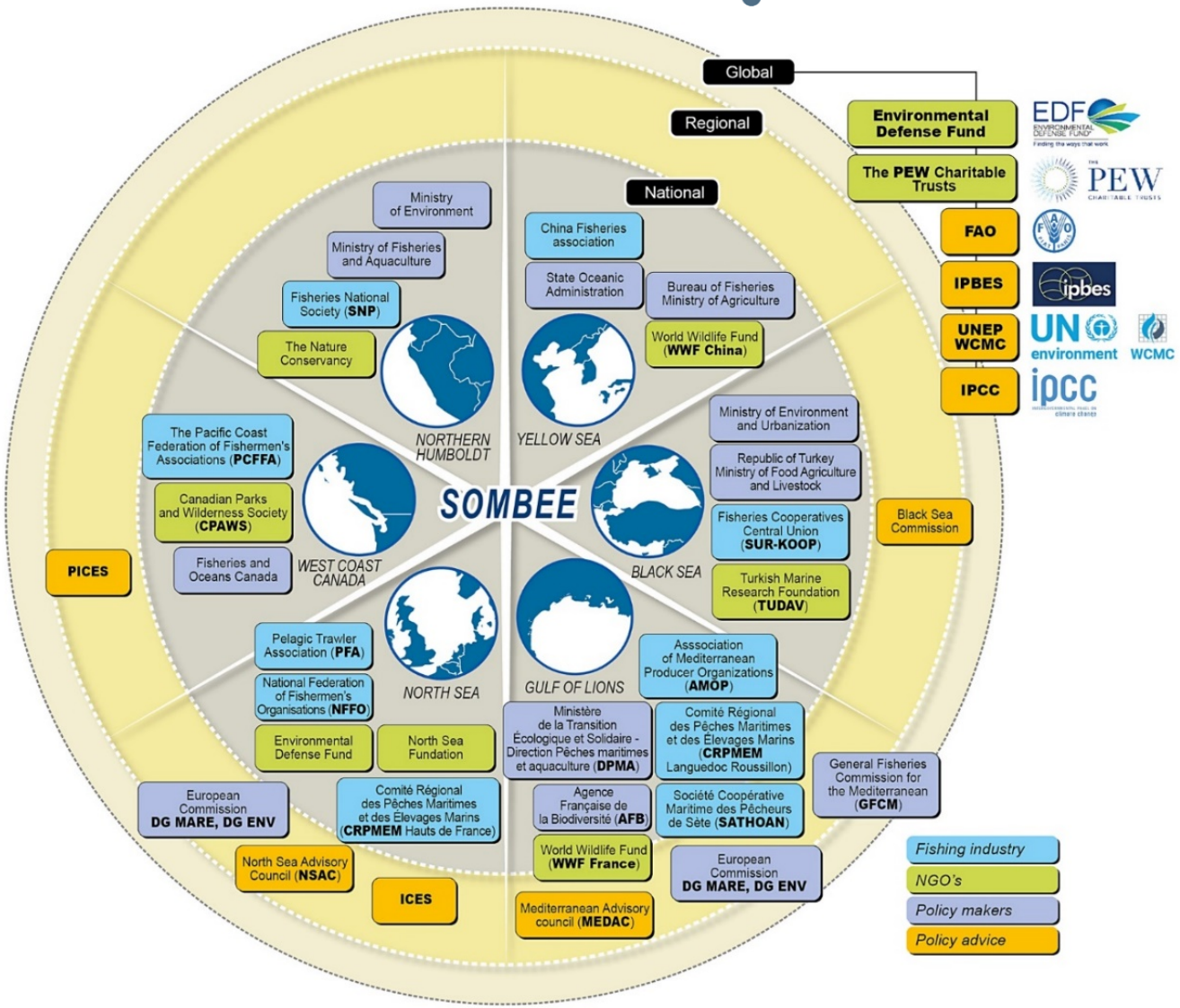
Modeling framework

Bio-economic sub-model



Co-building policy-relevant scenarios

With various groups of stakeholders…



OSMOSE Model
English Channel case study

Ghassen Halouani, Yunne Shin, Bruno Ernande, Morgane Travers

BELMONT FORUM
NORTH WESTERN WATERS ADVISORY COUNCIL
biodiversa
26th November 2020

OSMOSE

Object-oriented Simulator of Marine Ecosystems

www.osmose-model.org

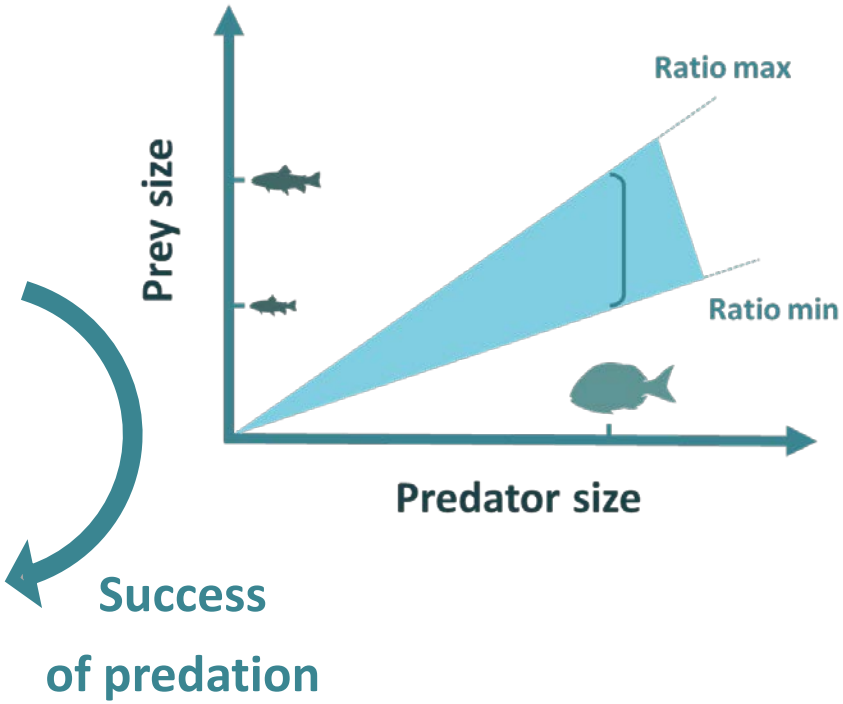
Main assumptions

- Individual based model
- Spatialized tropho-dynamic model

Opportunistic predation :

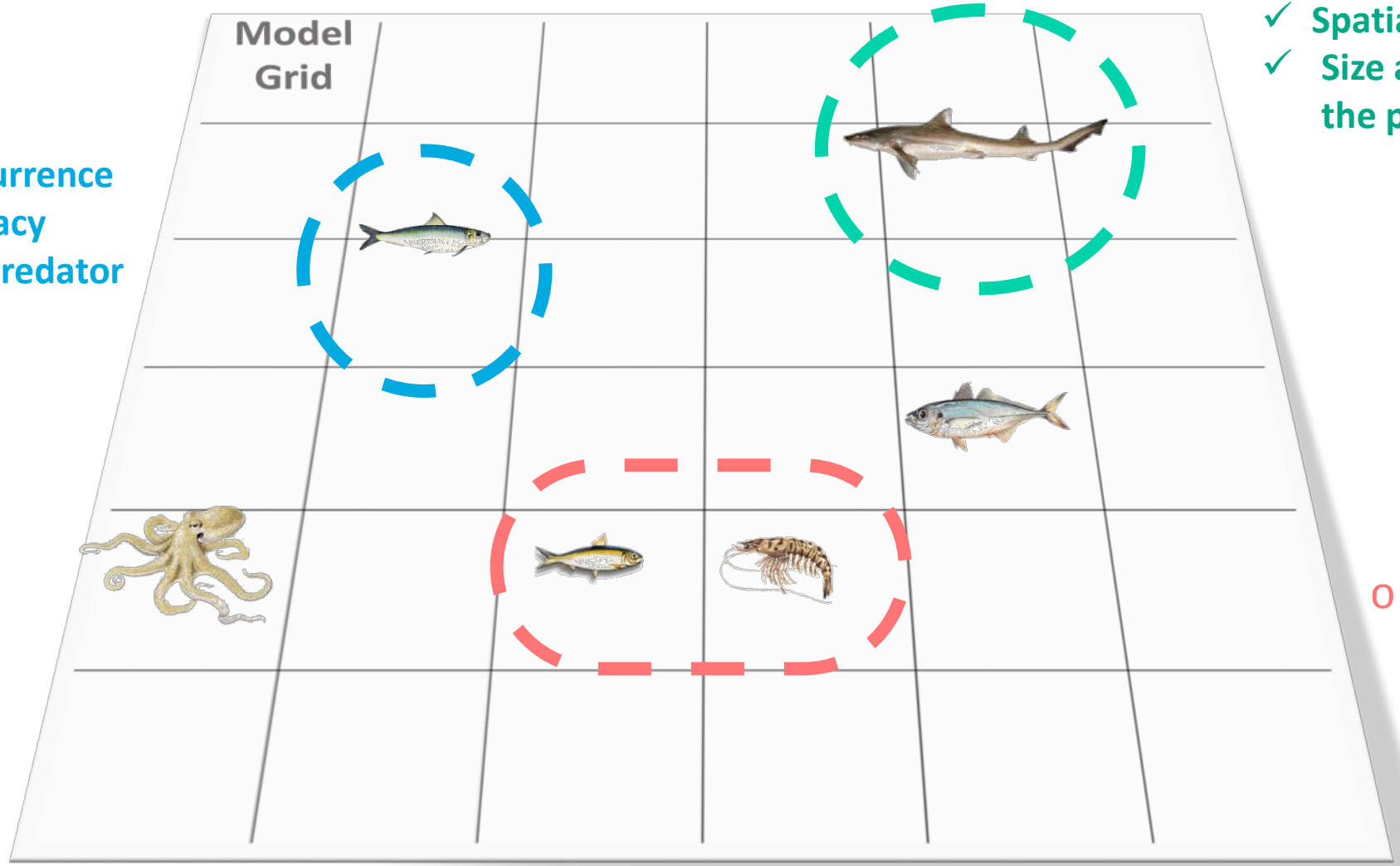
- Size selection
- Spatio-temporal co-occurrence

- Growth
- Mortality
- Reproduction
- …



OSMOSE Model

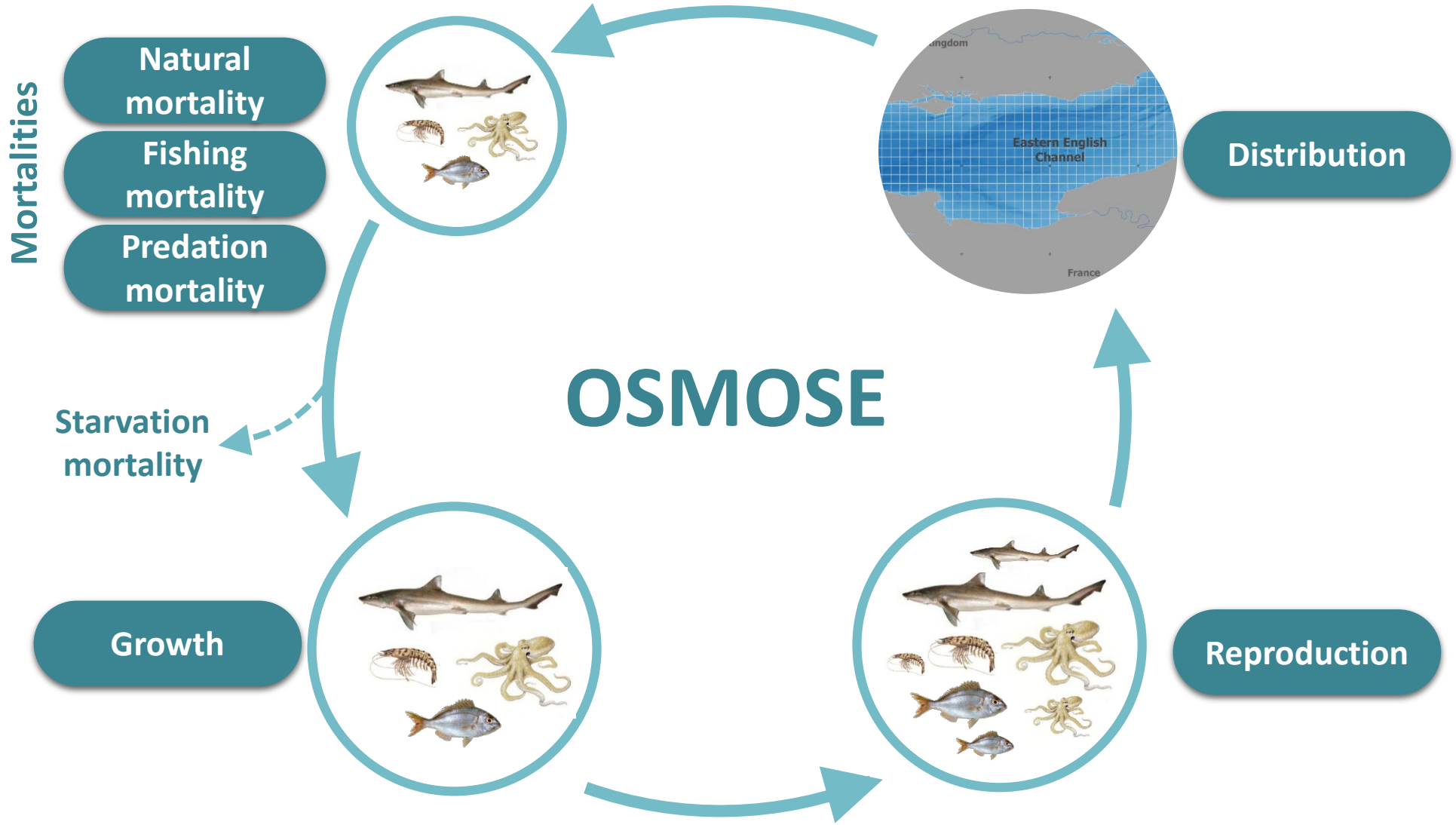
- ✓ Spatial co-occurrence
- o No size adequacy between the predator and its prey



- ✓ Spatial co-occurrence
- ✓ Size adequacy between the predator and its prey

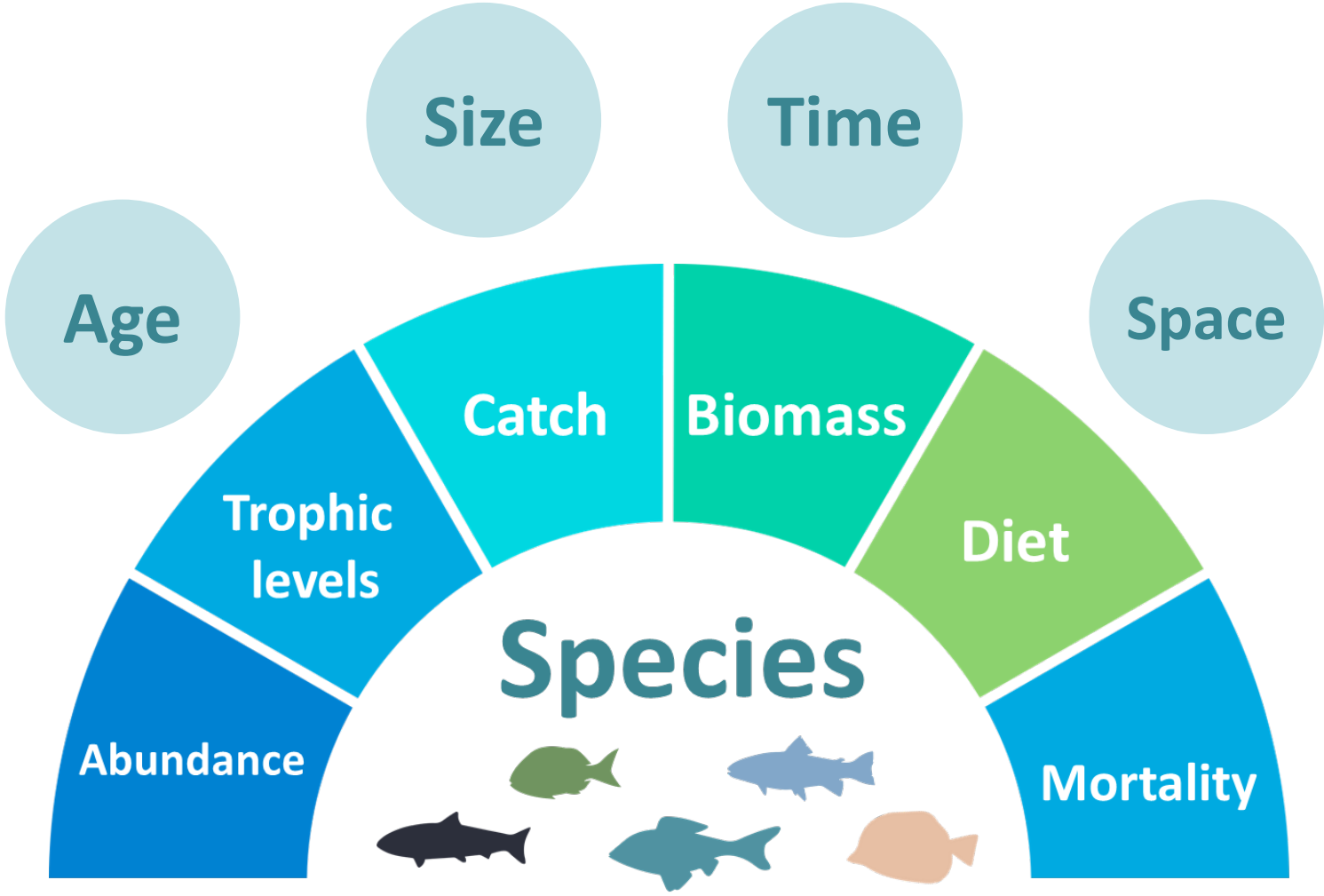
- o No spatial co-occurence

OSMOSE Model

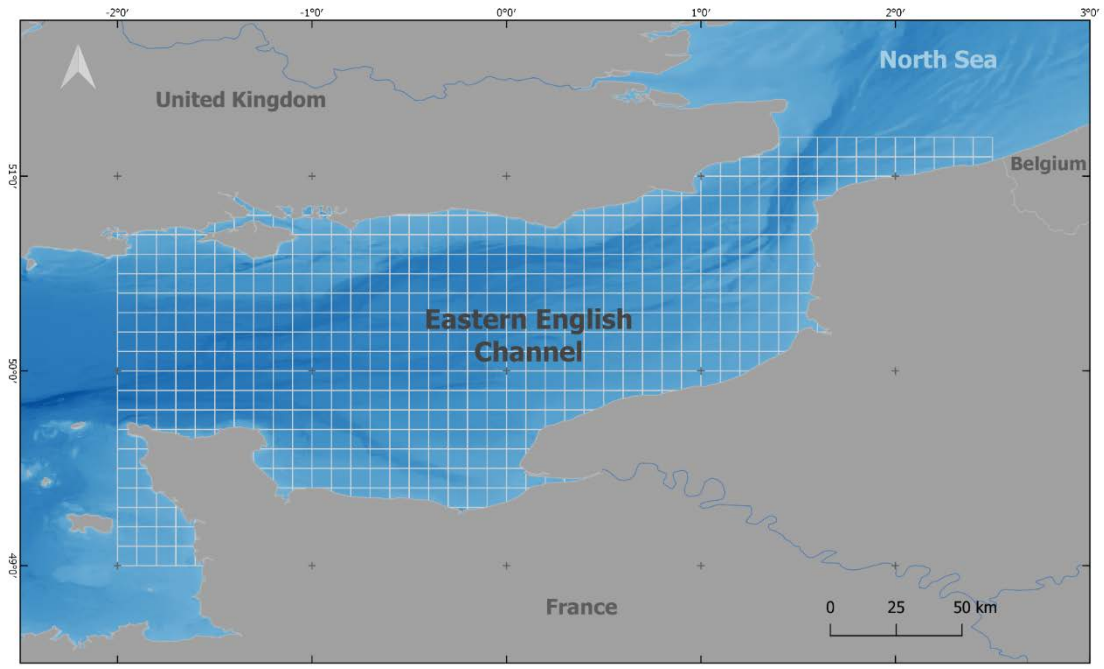


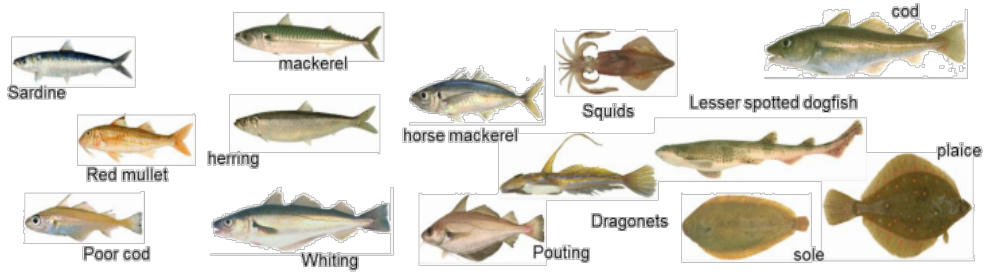
OSMOSE Model

Outputs



English Channel case study





- **14 Species** (~90% of landings)
- **5 Planktonic groups** (ECO-MARS-3D)
- **5 Benthic groups** (structured by size)

Ecological Modelling 410 (2019) 108800

Contents lists available at ScienceDirect

Ecological Modelling

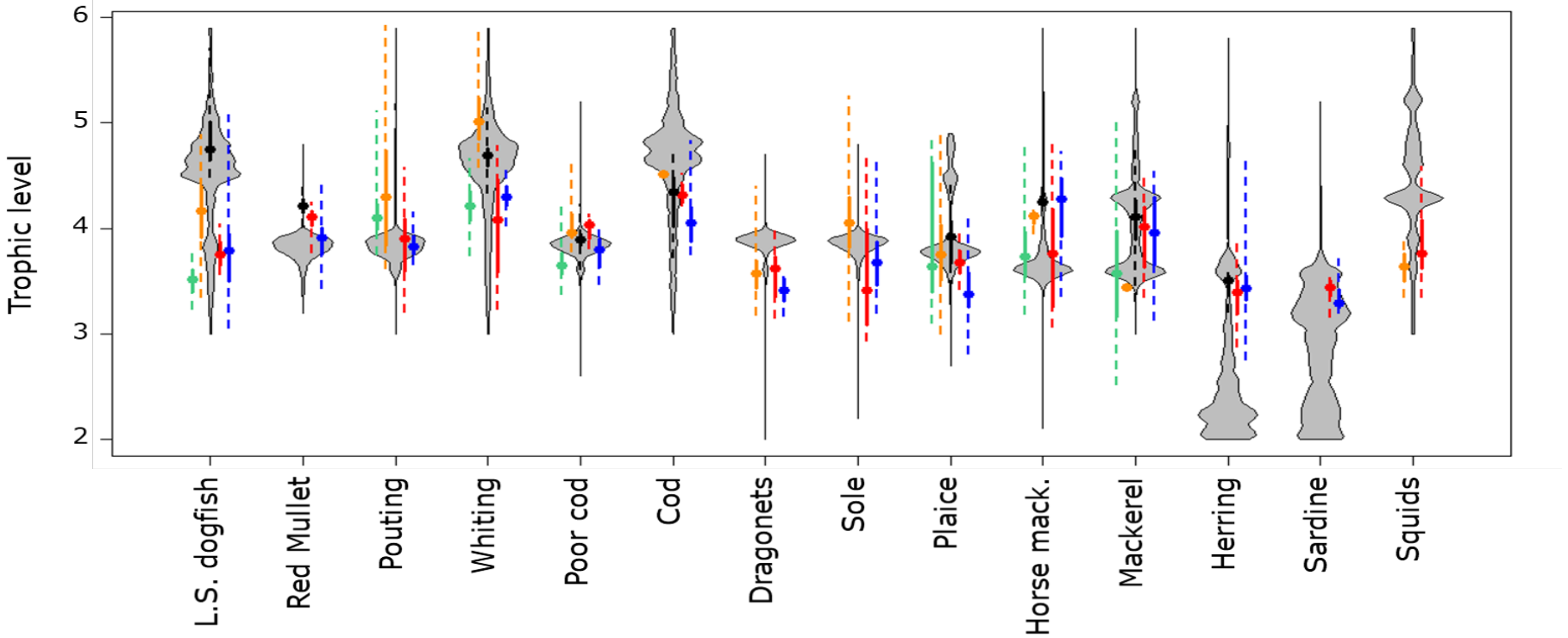
journal homepage: www.elsevier.com/locate/ecolmodel

Emergence of negative trophic level-size relationships from a size-based, individual-based multispecies fish model

Morgane Travers-Trolet[a,b,*], Franck Coppin[a], Pierre Cresson[a], Philippe Cugier[c], Ricardo Oliveros-Ramos[b], Philippe Verley[d]

English Channel case study

Model validation



Cresson et al. (2017)
Jennings and van der Molen (2015)

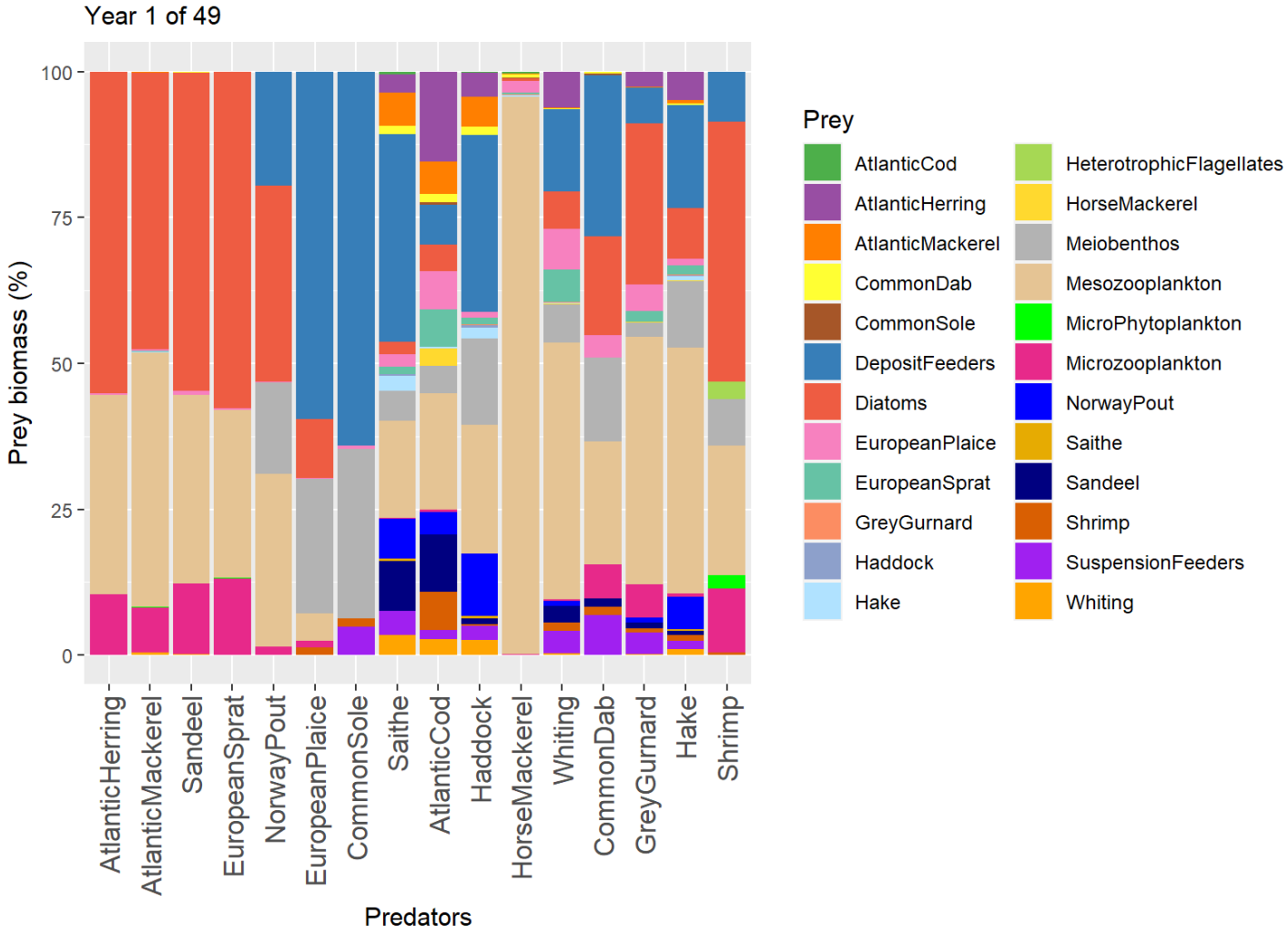
Cresson et al. (2018)
Kopp et al., (2015)

Mialet et al. (2017)
Travers (2019)

(Morgane Traves pers. comm)

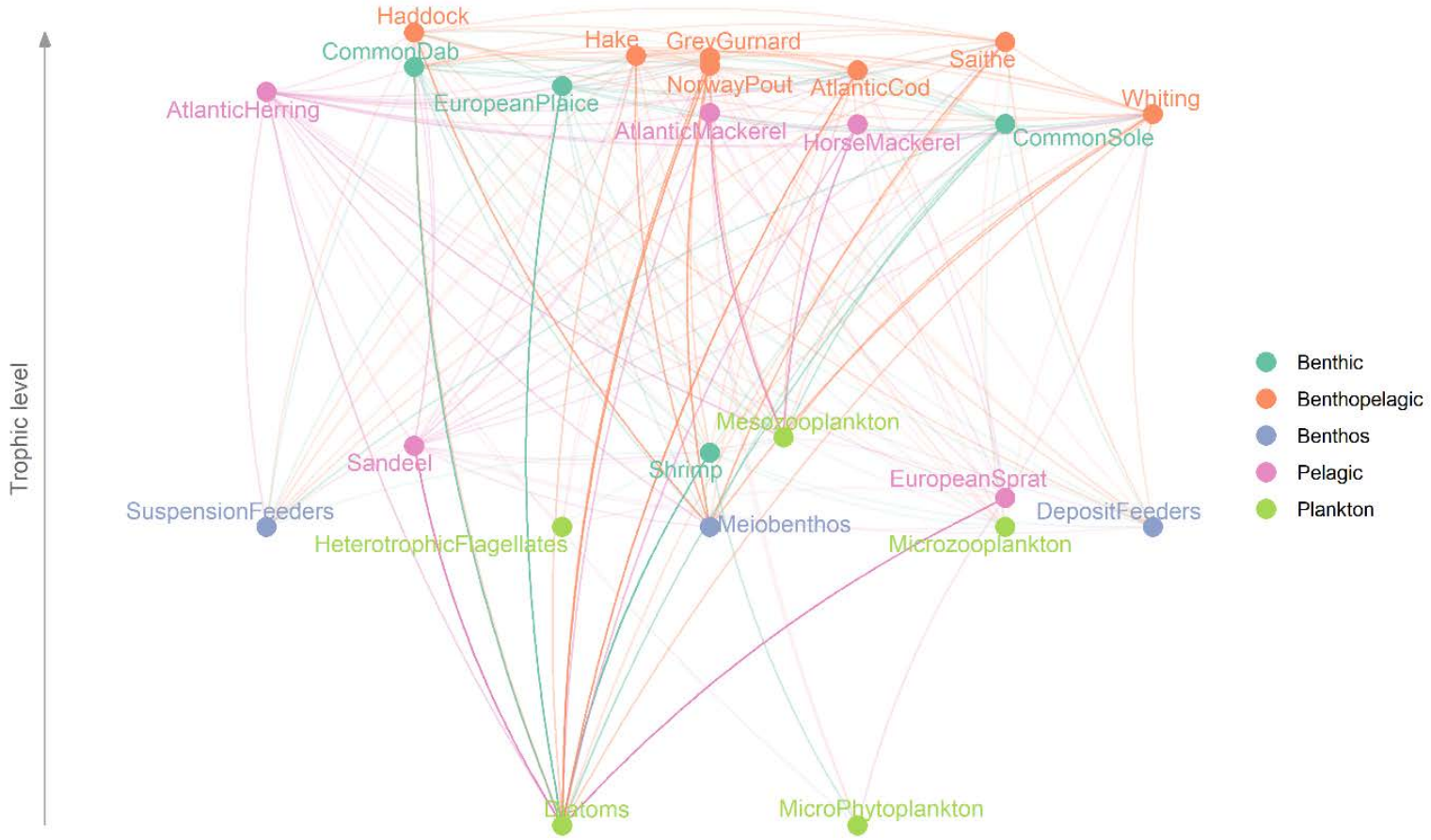
English Channel case study

Diet composition



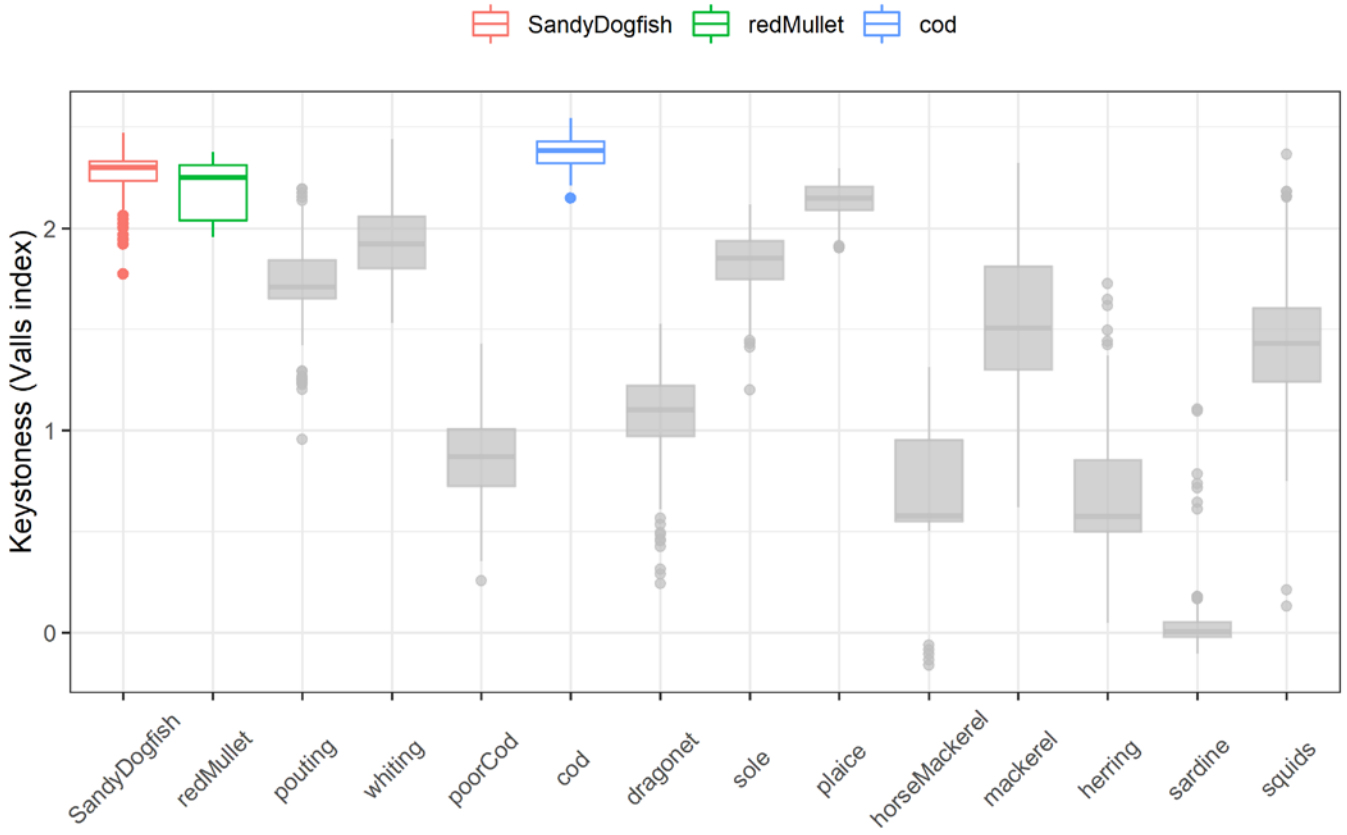
English Channel case study

Food web



English Channel case study

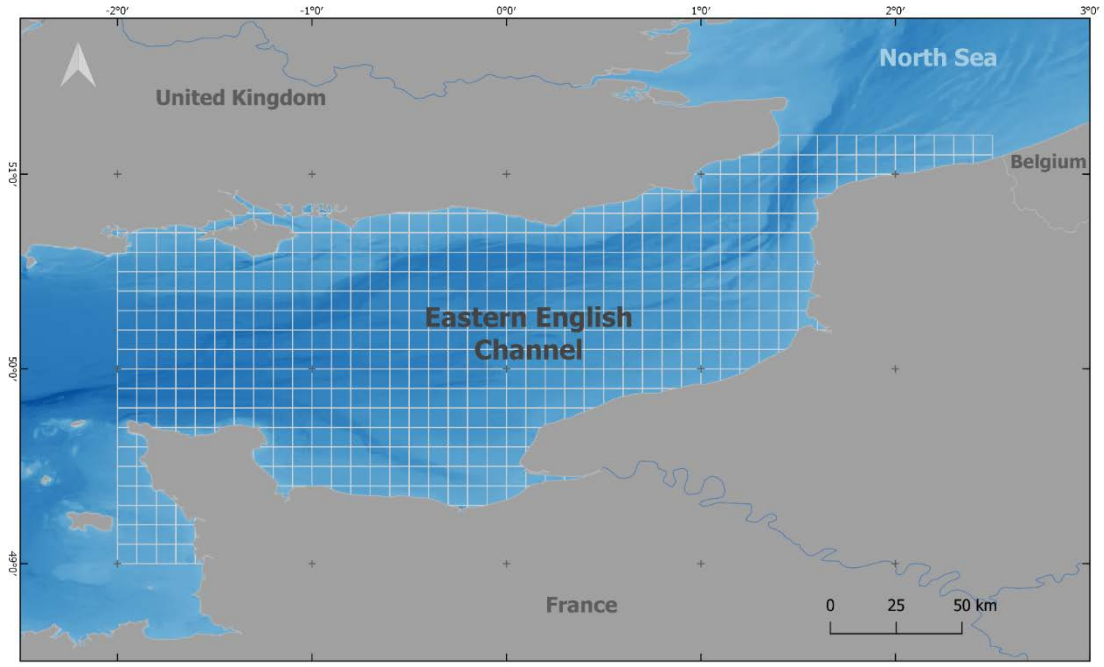
Ecological Network Indicators

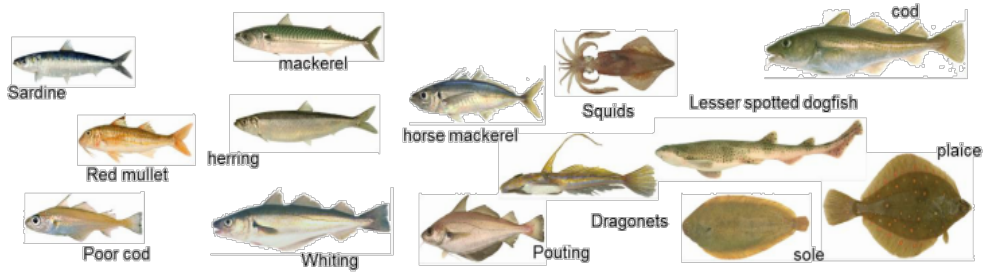


Keystone index

Identifies the species with low biomass that have a disproportional effect on the ecosystem

English Channel case study





- **14 Species**
- **5 Planktonic groups** (ECO-MARS-3D)
- **5 Benthic groups** (structured by size)

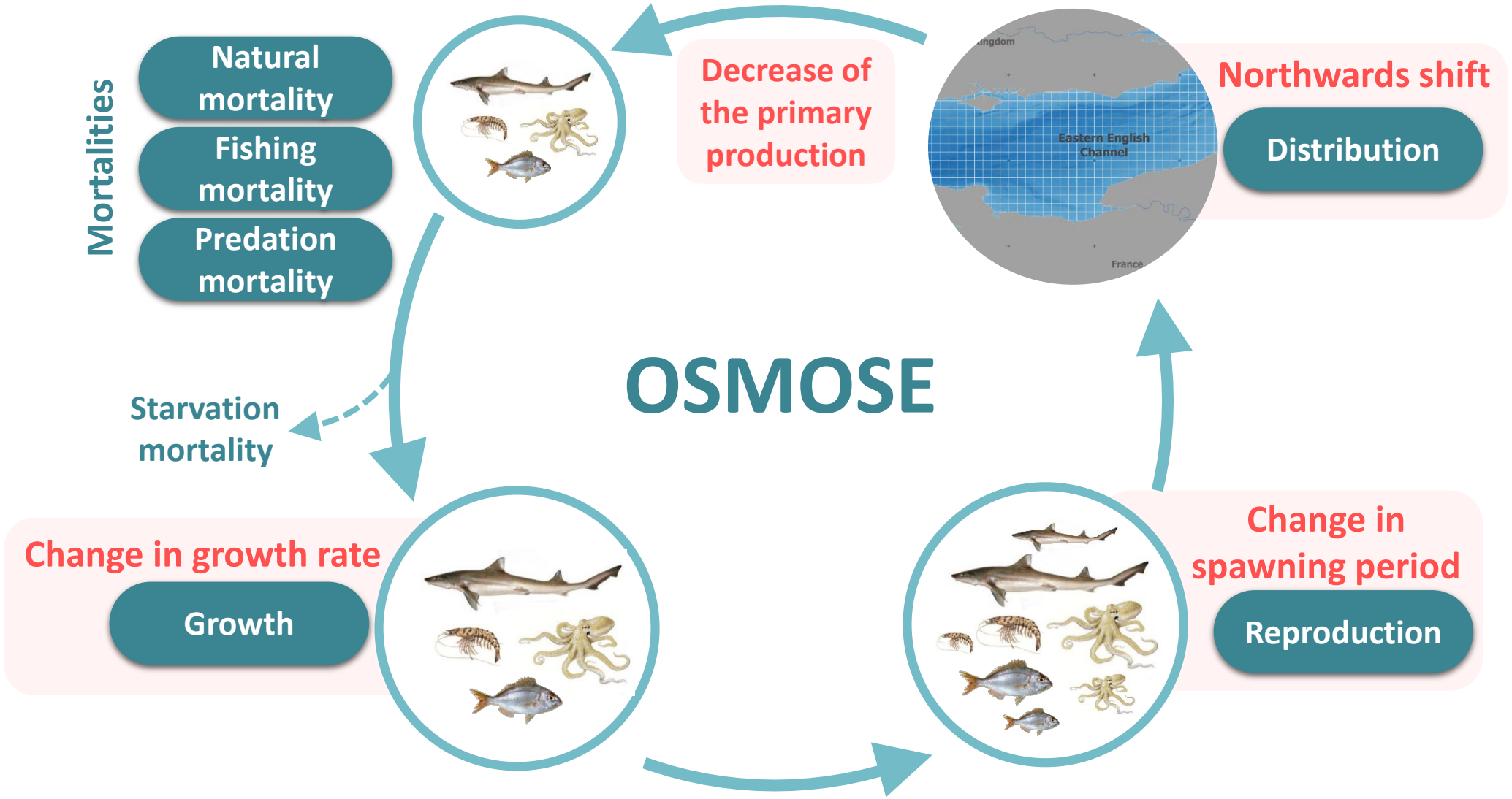
Simulation of RCP regional scenarios (RCP 4.5 and RCP 8.5) using the model POLCOMS-ERSEM

- Primary production
- Growth
- Spawing period
- Distribution

PML | Plymouth Marine Laboratory

(Morgane Traves pers. comm)

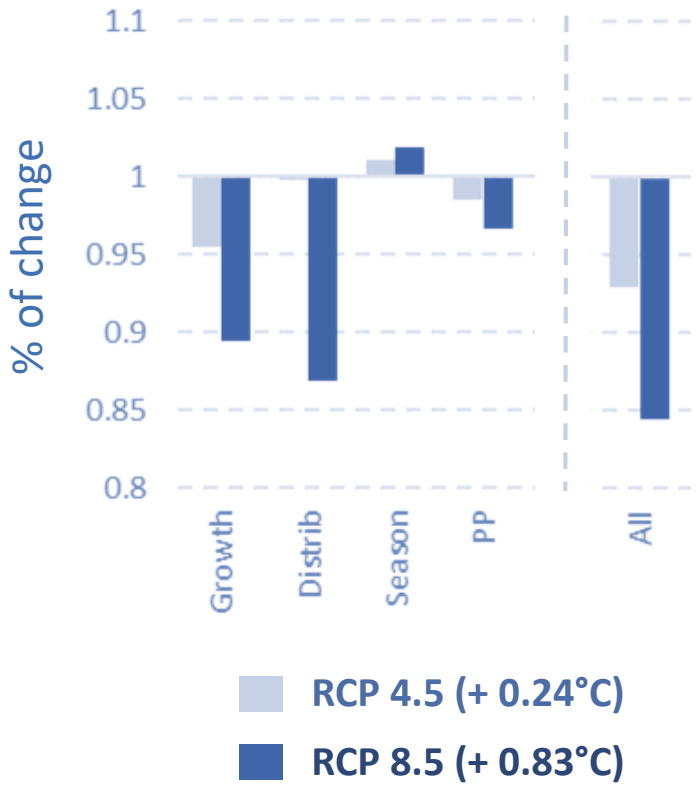
English Channel case study



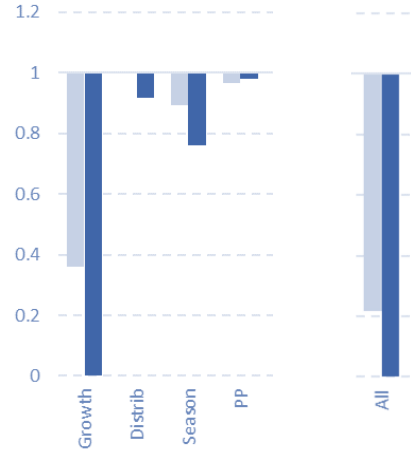
English Channel case study

Simple and combined effects of climate change

Total biomass



Whiting



Pouting

Horse Mackerel

Red Mullet

(Morgane Traves pers. comm)

English Channel case study

Climate change impacts on refrence points

Evolution of reference points (F and F_{MSY}) with climate change was compared across species

frontiers in Marine Science

ORIGINAL RESEARCH
published: 06 November 2020
doi: 10.3389/fmars.2020.568232

Check for updates

The Risky Decrease of Fishing Reference Points Under Climate Change

Morgane Travers-Trolet[1], Pierre Bourdaud[2], Mathieu Genu[3], Laure Velez[4] and Youen Vermard[1]*

[1] Ifremer, EMH, Rue de l'Île d'Yeu, Nantes, France, [2] Laboratoire des Sciences de l'Environnement Marin (LEMAR), IUEM Technopôle Brest-Iroise, Plouzané, France, [3] Observatoire PELAGIS, UMS 3462, CNRS-La Rochelle Université, La Rochelle, France, [4] MARBEC, Univ. Montpellier, CNRS, Ifremer, IRD, Montpellier, France

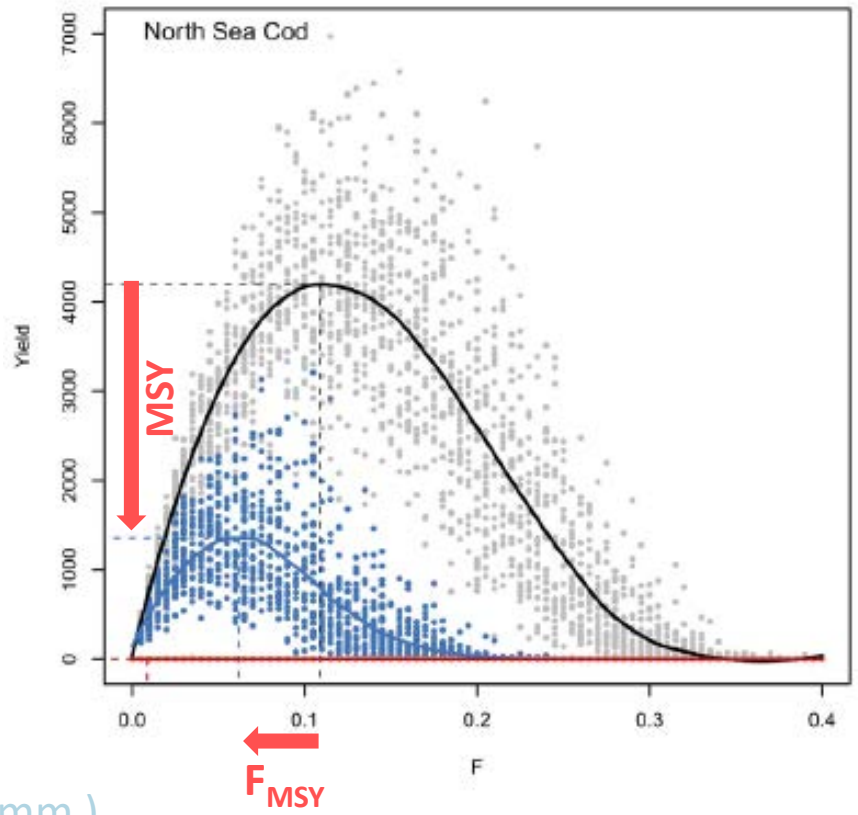
(Morgane Traves pers. comm)

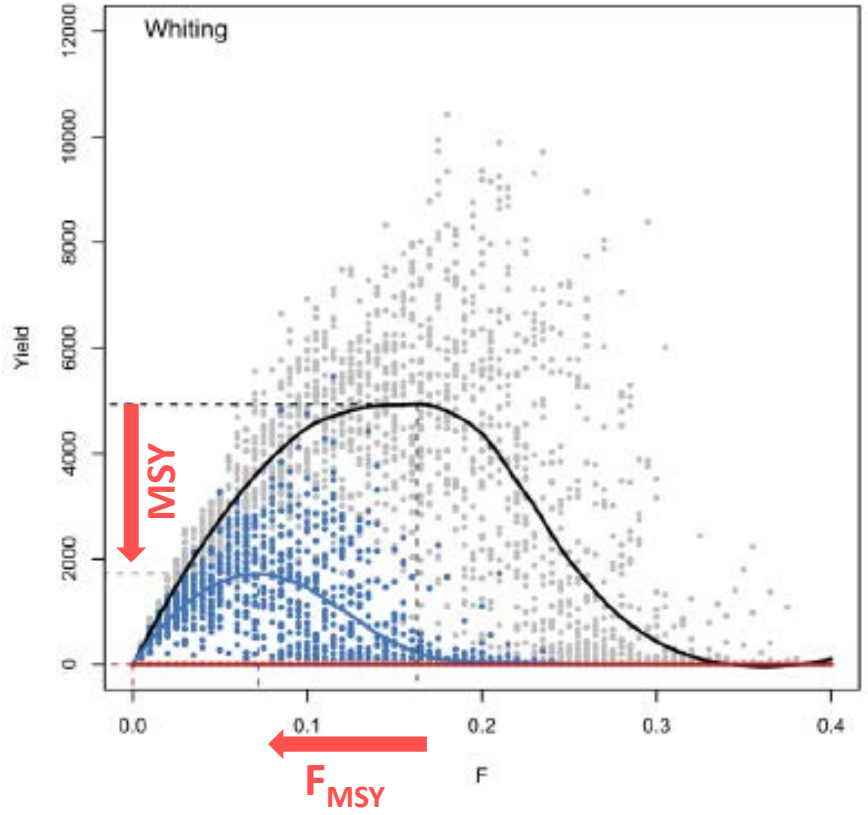
English Channel case study

Climate change impacts on reference points

Cold-water species are likely to have both MSY and F_{MSY} declining with climate warming.

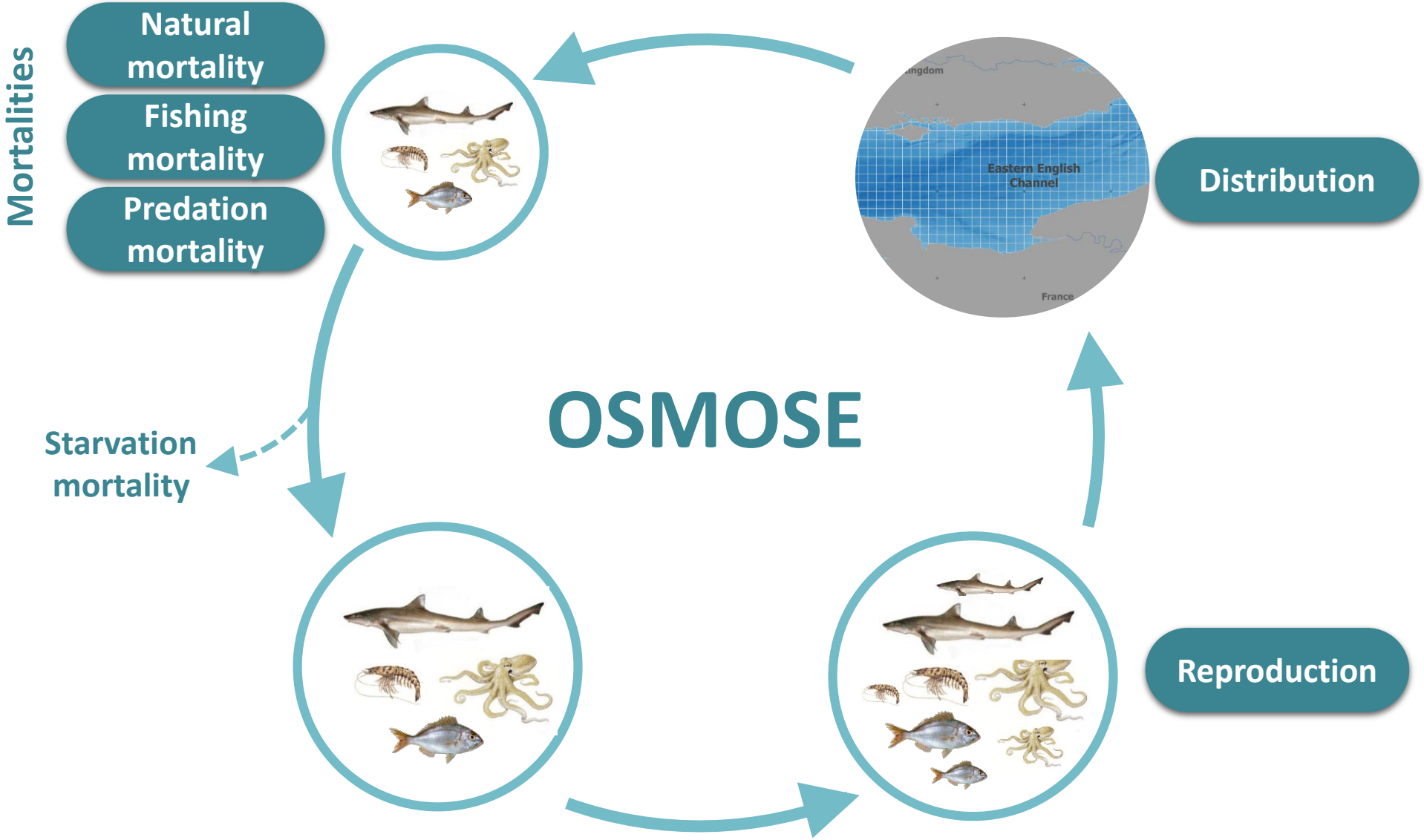
- **Historical conditions**
- **Climate change scenarios 4.5**



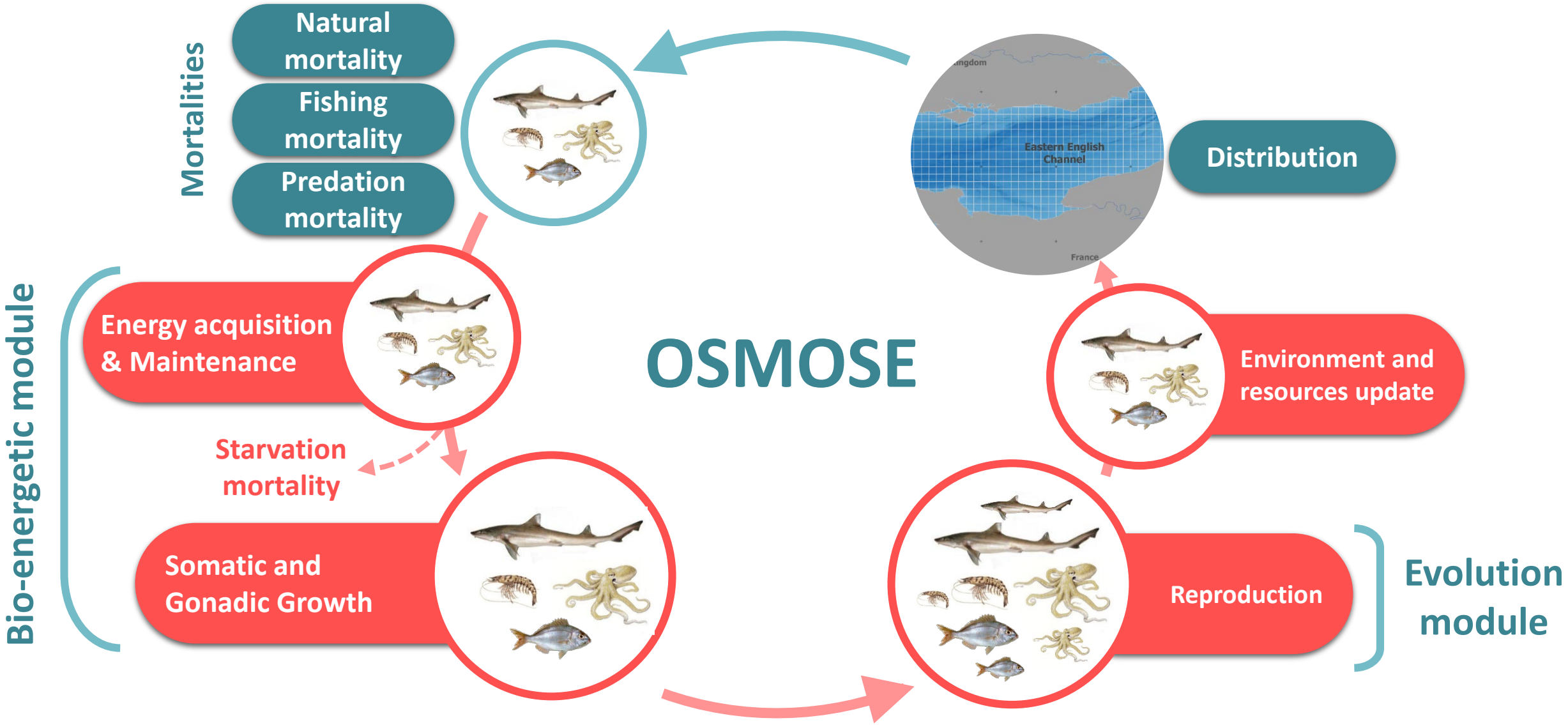


(Morgane Traves pers. comm)

OSMOSE Model



Ev-OSMOSE Model



English Channel case study

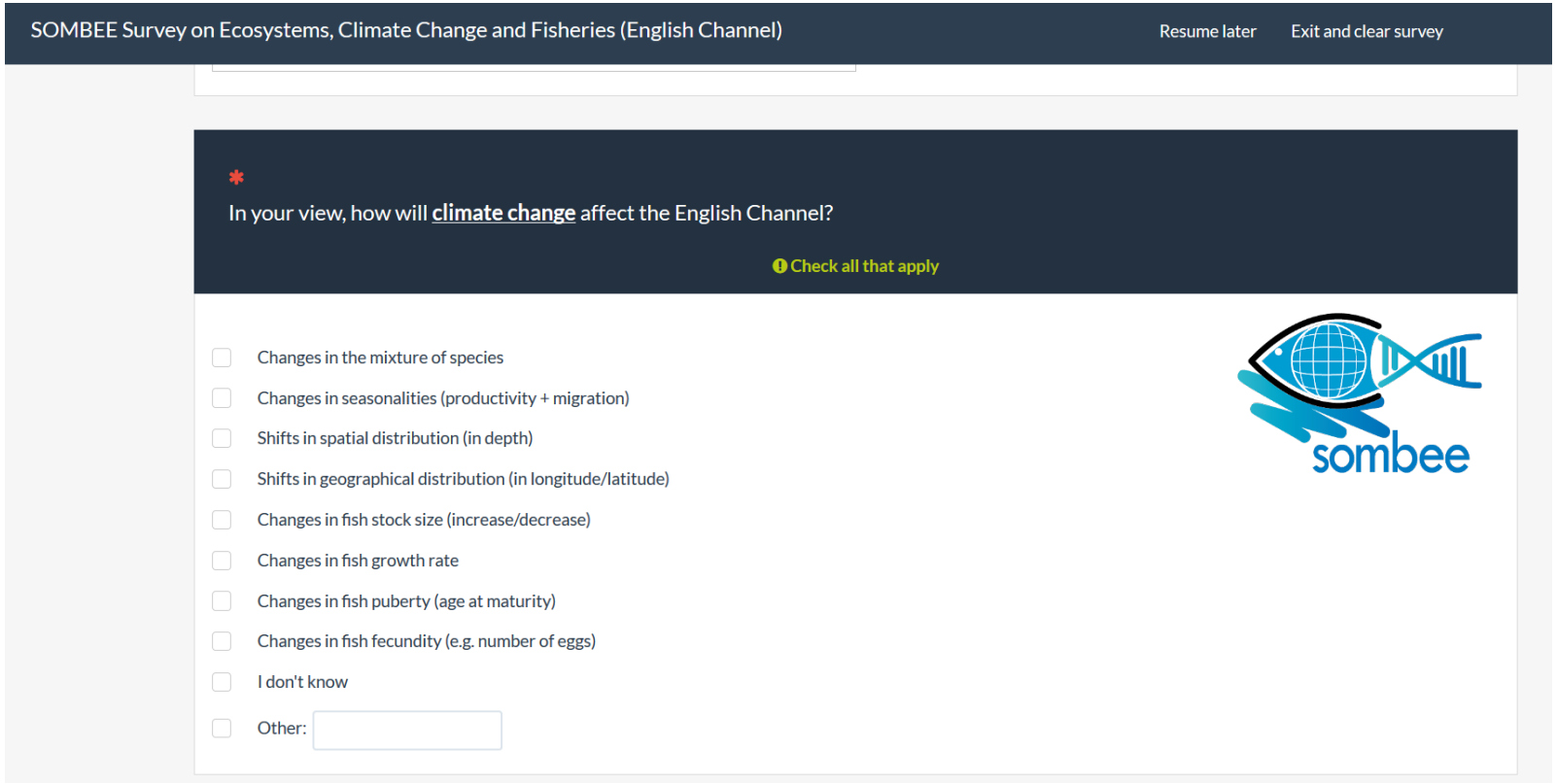
The overall objective of SOMBEE is to build future scenarios of marine biodiversity with emphasis on the effects of fishing and climate change.

sombee

English Channel case study

SOMBEE Survey on Ecosystems, Climate Change and Fisheries

How stakeholders perceive the effects of climate change and fisheries on fish resources ?



https://www.limesurvey.uni-hamburg.de/index.php/761917/lang/en/newtest/Y