C. gigas, Bay of Brest 48°N

Exploring the effect of temperature change on the spatial distribution of benthic species with an IBM-DEB model

Yoann THOMAS, Alain Ménesguen, Cédric Bacher

Effects of seawater warming on marine organisms

Individual

- ✳ **Physiological performances** (growth, reproduction)
- ✳ **Phenology** (timing of ontogenic transitions)
- ✳ **Biogeography** (distribution)
- ✳ **Community composition** (biodiversity)

Ecosystem

Effects of seawater warming on marine organisms

Individual

- **Physiological performances** (growth, reproduction)
- **Phenology** (timing of ontogenic transitions)
- **Biogeography** (distribution)
- **Community composition** (biodiversity)

Ecosystem

How to better understand the underlying processes?

in order to

anticipate future consequences on population distribution

Functional trait based species distribution model

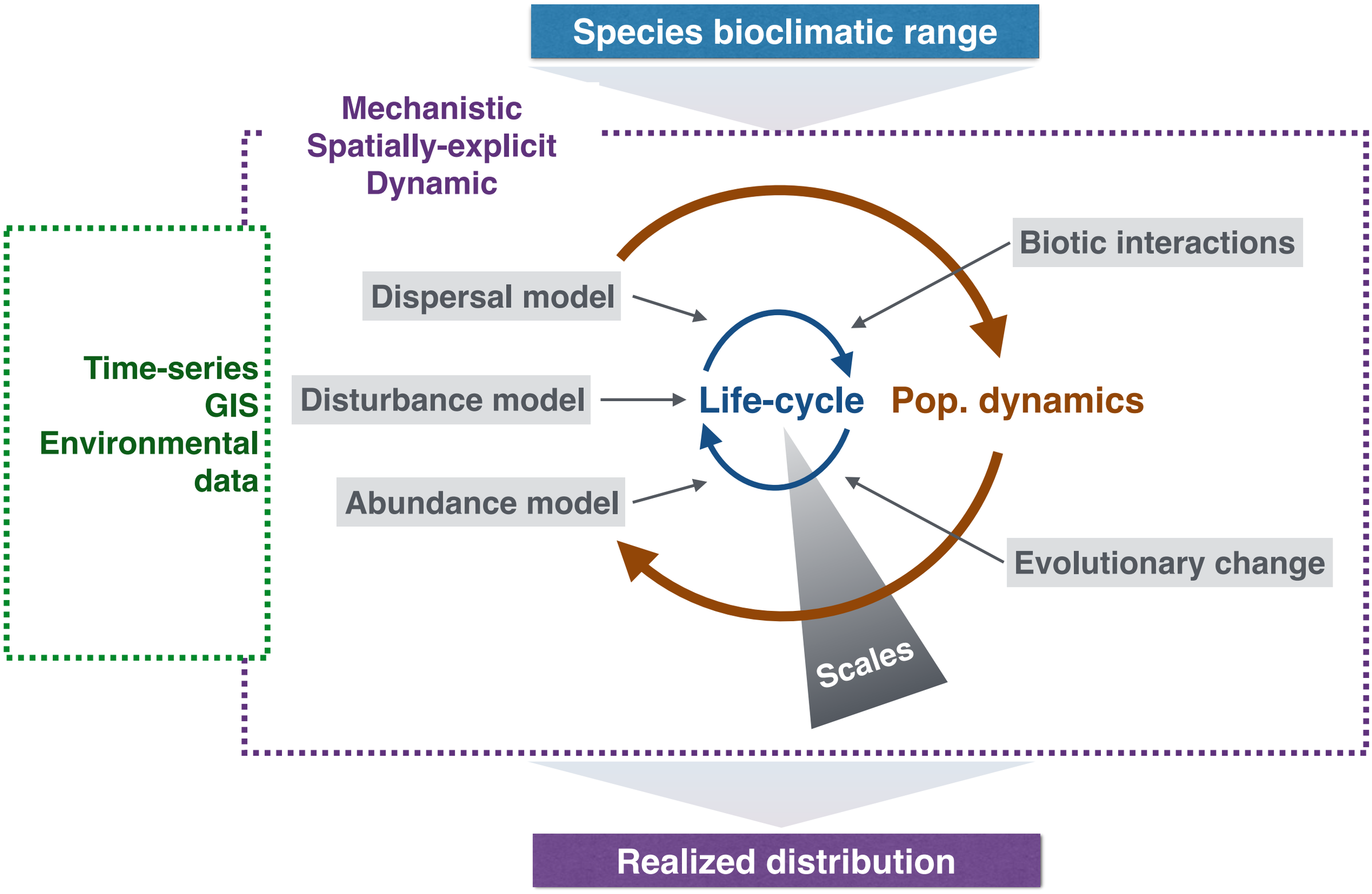
Species bioclimatic range

Mechanistic
Spatially-explicit
Dynamic

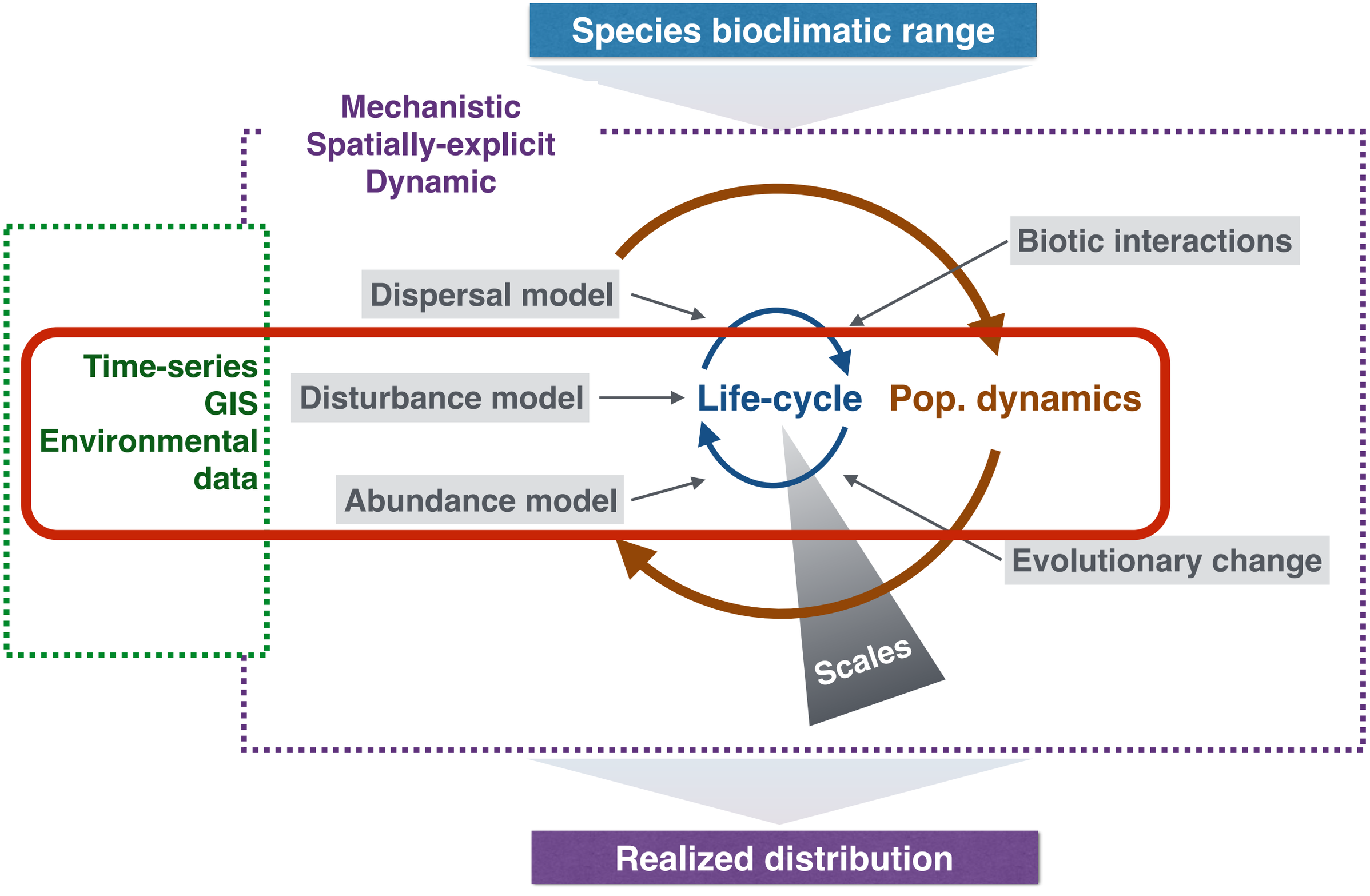
Time-series
GIS
Environmental
data

Realized distribution

Functional trait based species distribution model



Functional trait based species distribution model



Area & benthic species studied

✴ **Biogeographic boundary**

Pectinaria koreni : Jolly et al (2005**)**

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

Area & benthic species studied

✳ **Biogeographic boundary**

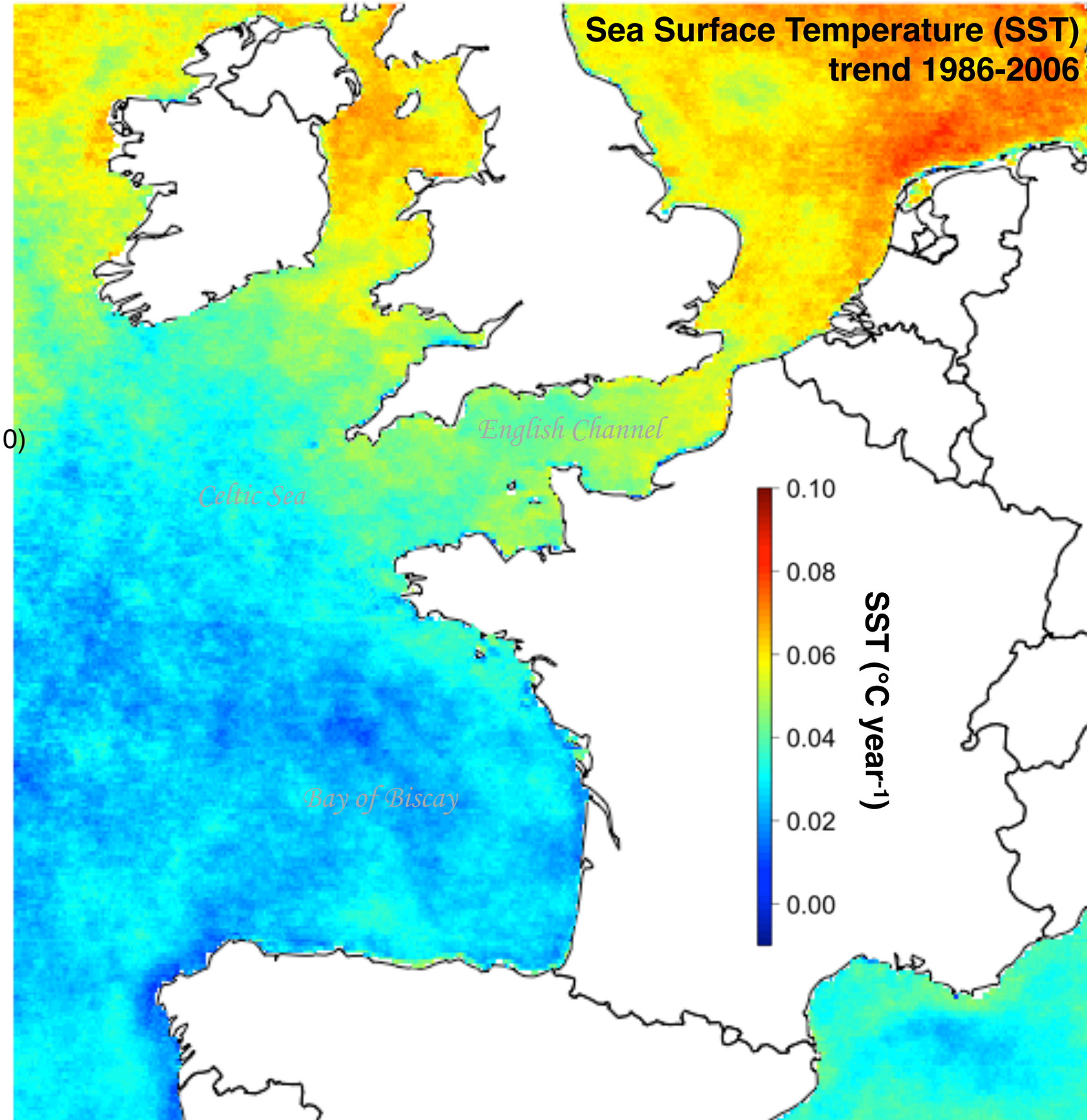
Pectinaria koreni : Jolly et al (2005**)**

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

✳ **Evidence of warming**

SST-satellite: Saulquin & Gohin (2010)



Area & benthic species studied

✳ **Biogeographic boundary**

Pectinaria koreni : Jolly et al (2005**)**

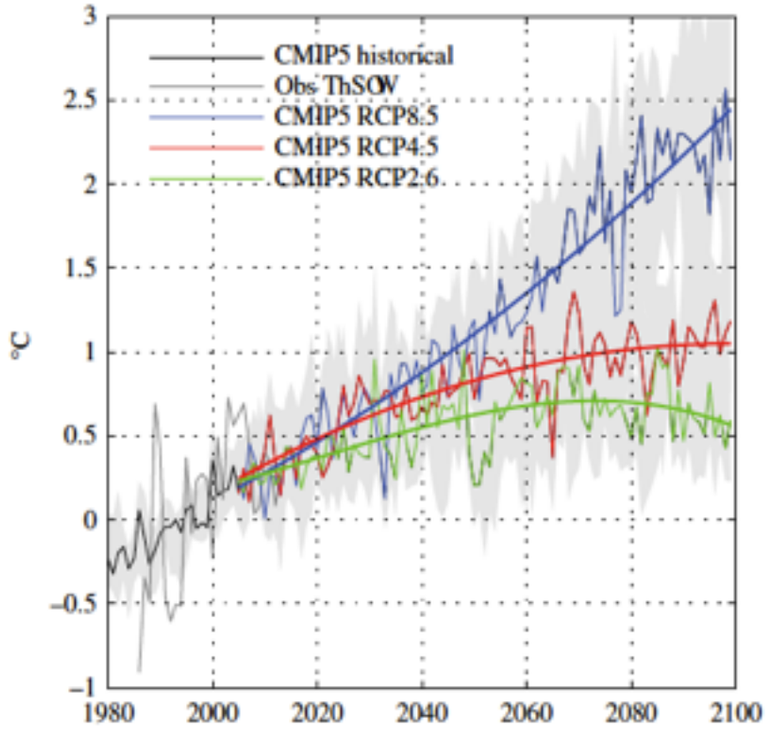
Mytilidae: Hilbish et al. (2012)

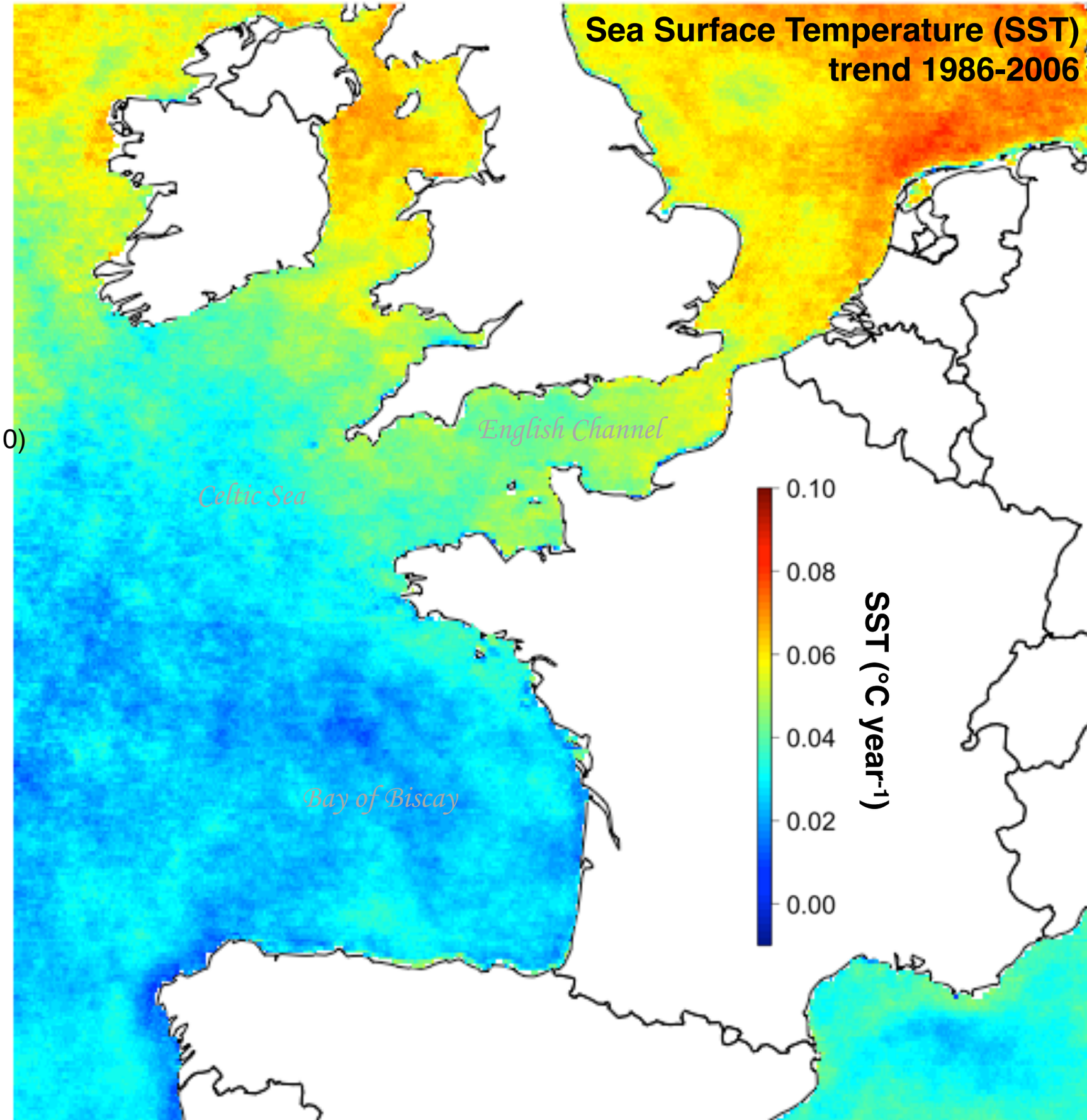
C. gigas: Thomas et al. (2016)

✳ **Evidence of warming**

SST-satellite: Saulquin & Gohin (2010)

CMIP5: L'Hévéder et al. (2016)





Area & benthic species studied

✳ **Biogeographic boundary**

Pectinaria koreni : Jolly et al (2005**)**

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

✳ **Evidence of warming**

SST-satellite: Saulquin & Gohin (2010)

✳ **Key species**

Fishing / Aquaculture

Biogeographic range

Invasive « feral » sp. (*C. gigas*)

Mytilus edulis

Crassostrea gigas

Mytilus galloprovincialis

Area & benthic species studied

✳ **Biogeographic boundary**

Pectinaria koreni : Jolly et al (2005**)**

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

✳ **Evidence of warming**

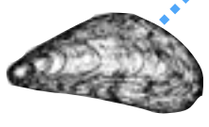
SST-satellite: Saulquin & Gohin (2010)

✳ **Key species**

Fishing / Aquaculture

Biogeographic range

Invasive « feral » sp. (*C. gigas*)



Mytilus edulis

Crassostrea gigas

Mytilus galloprovincialis

Area & benthic species studied

✴ **Biogeographic boundary**

Pectinaria koreni : Jolly et al (2005**)**

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

✴ **Evidence of warming**

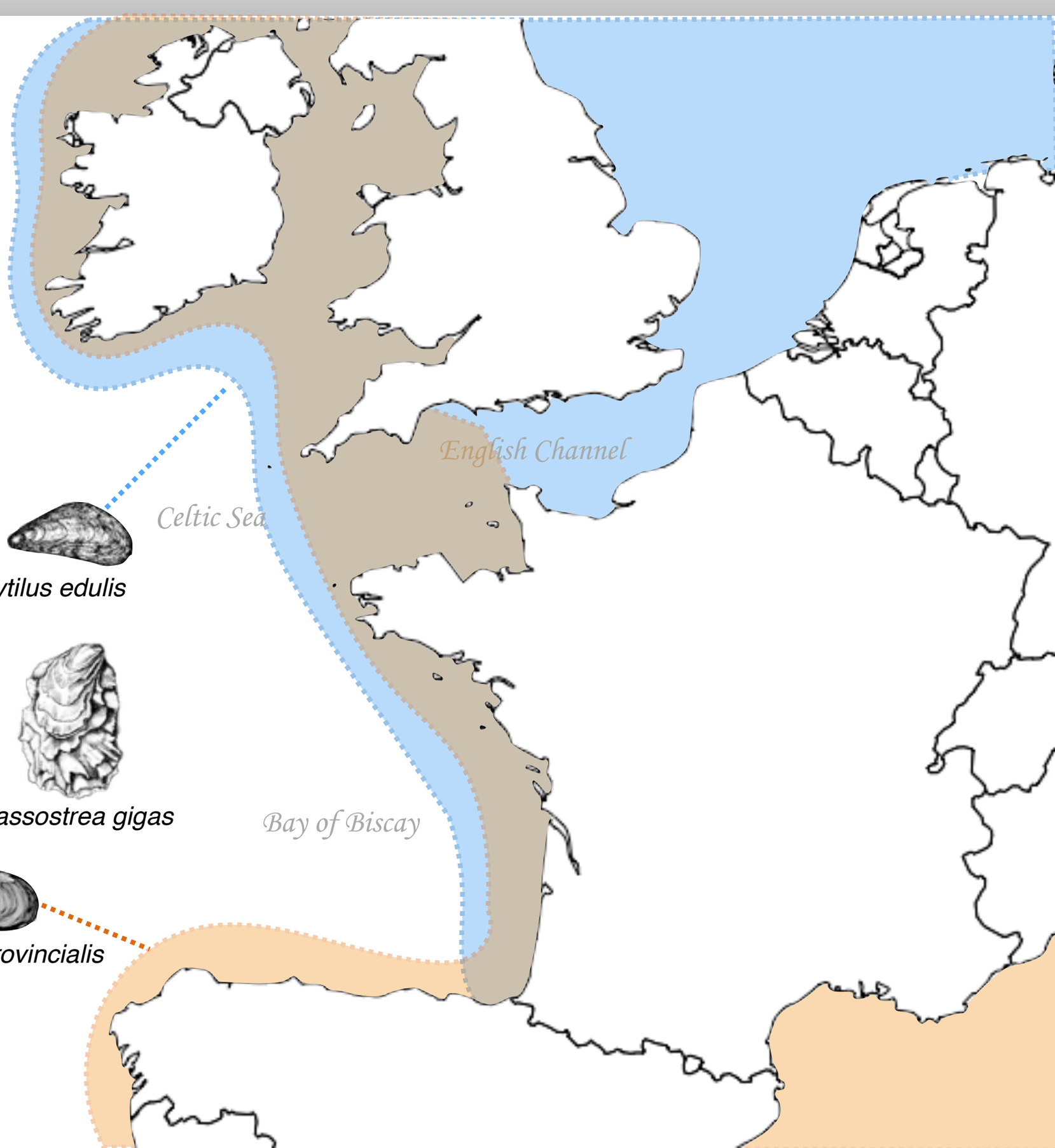
SST-satellite: Saulquin & Gohin (2010)

✴ **Key species**

Fishing / Aquaculture

Biogeographic range

Invasive « feral » sp. (*C. gigas*)



Mytilus edulis

Crassostrea gigas

Mytilus galloprovincialis

Area & benthic species studied

✴ **Biogeographic boundary**

Pectinaria koreni : Jolly et al (2005**)**

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

✴ **Evidence of warming**

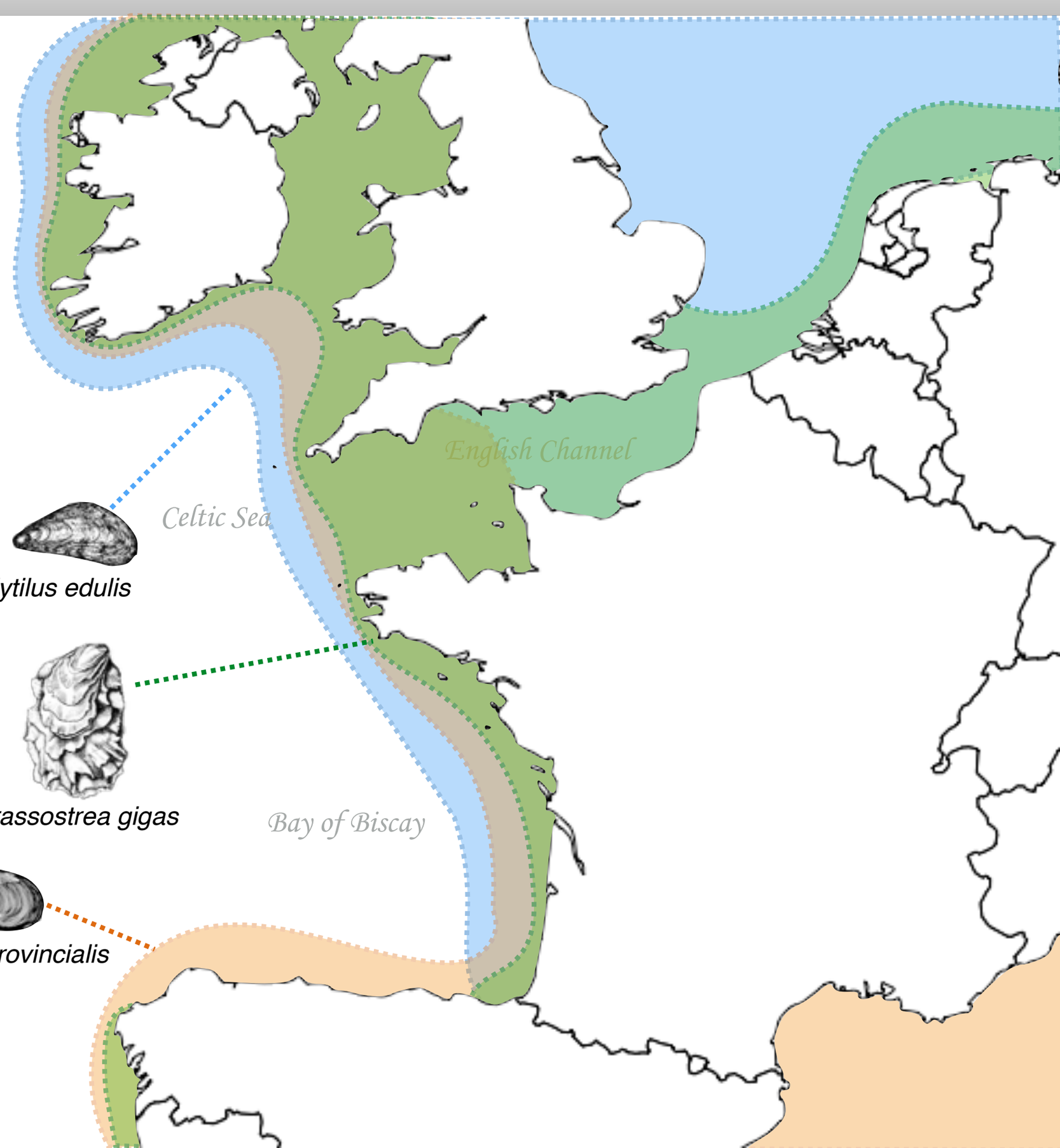
SST-satellite: Saulquin & Gohin (2010)

✴ **Key species**

Fishing / Aquaculture

Biogeographic range

Invasive « feral » sp. (*C. gigas*)



Mytilus edulis

Crassostrea gigas

Mytilus galloprovincialis

Area & benthic species studied

✳ Biogeographic boundary

Pectinaria koreni : Jolly et al (2005)

Mytilidae: Hilbish et al. (2012)

C. gigas: Thomas et al. (2016)

✳ Evidence of warming

SST-satellite: Saulquin & Gohin (2010)

✳ Key species

Fishing / Aquaculture

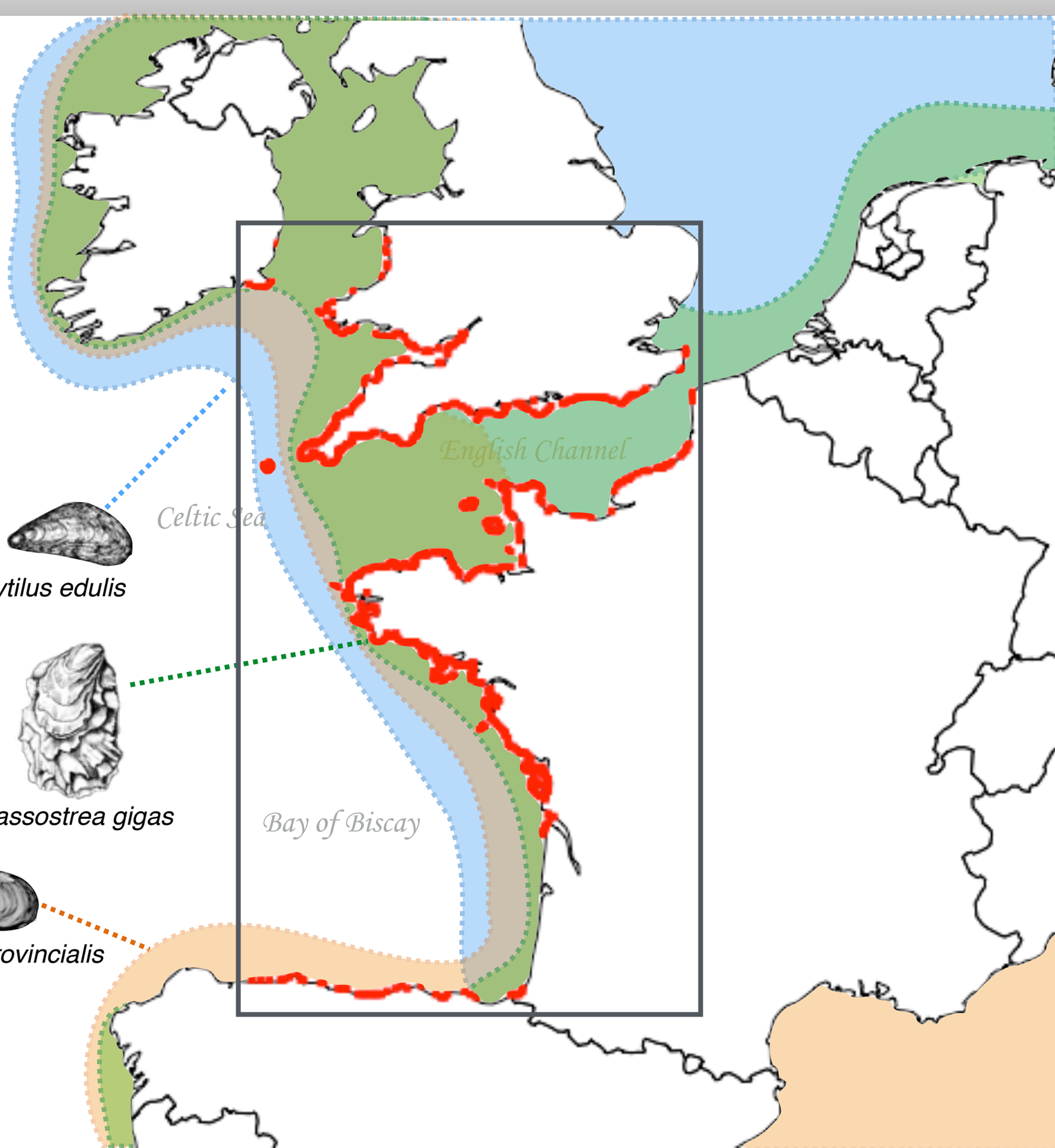
Biogeographic range

Invasive « feral » sp. (*C. gigas*)

✳ Habitat selection

Rocky-shore

EUSeaMap - EMODNET*



Mytilus edulis

Crassostrea gigas

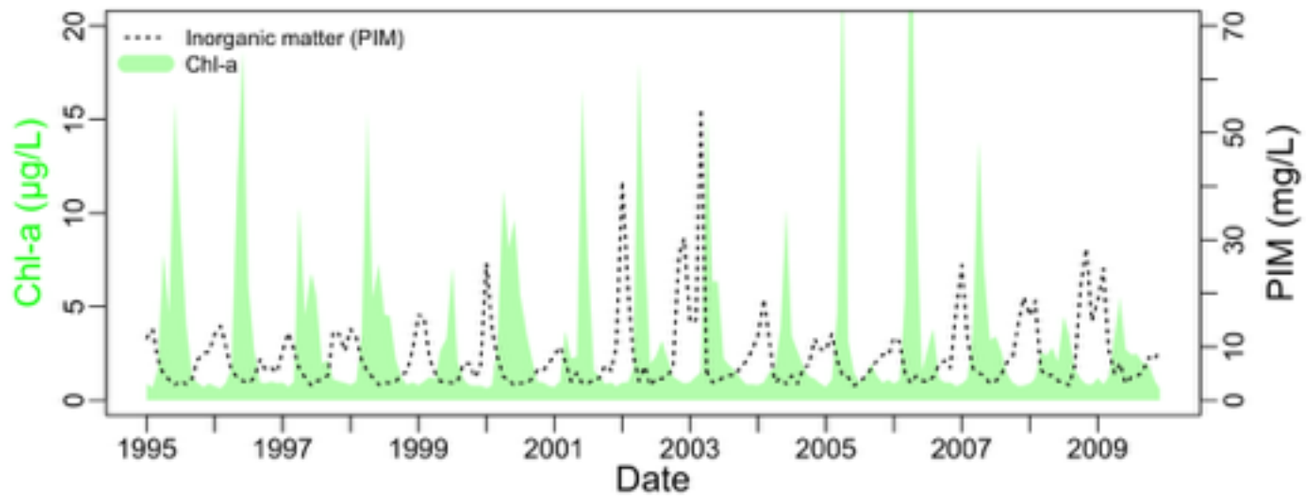
Mytilus galloprovincialis

*http://www.emodnet.eu/seabed-habitats

Climatic scenarios

FOOD

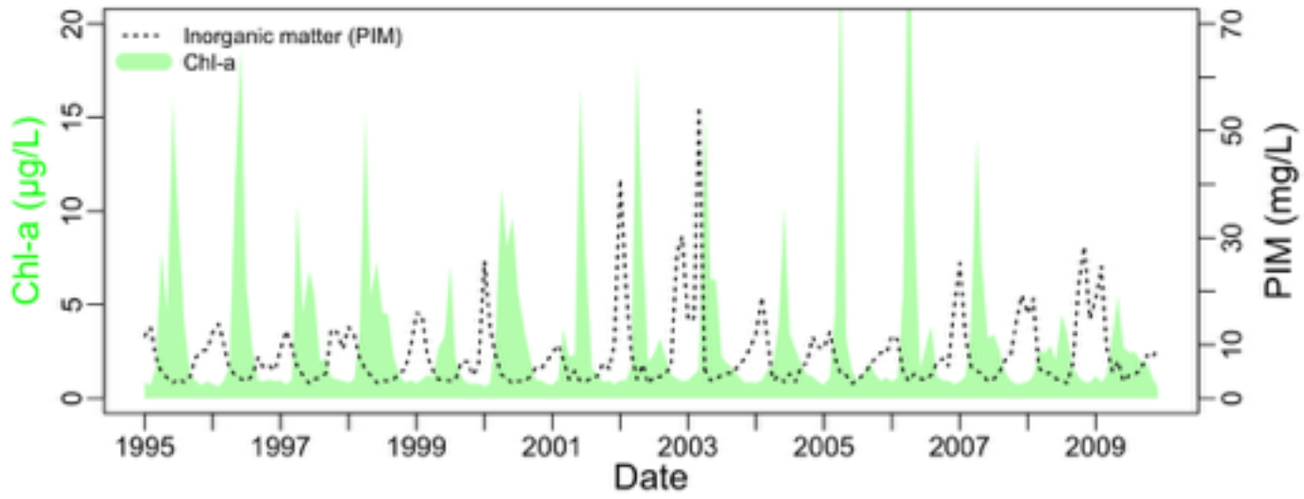
Monthly mean over 15 years of remote-sensing observations (PIM, Chl-a)

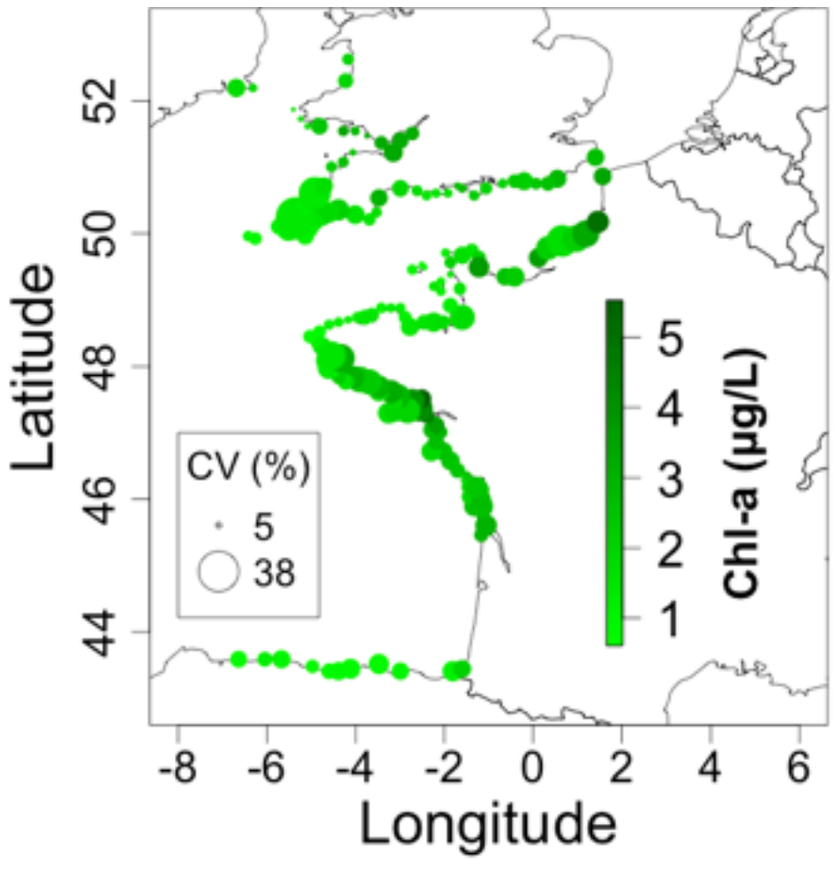


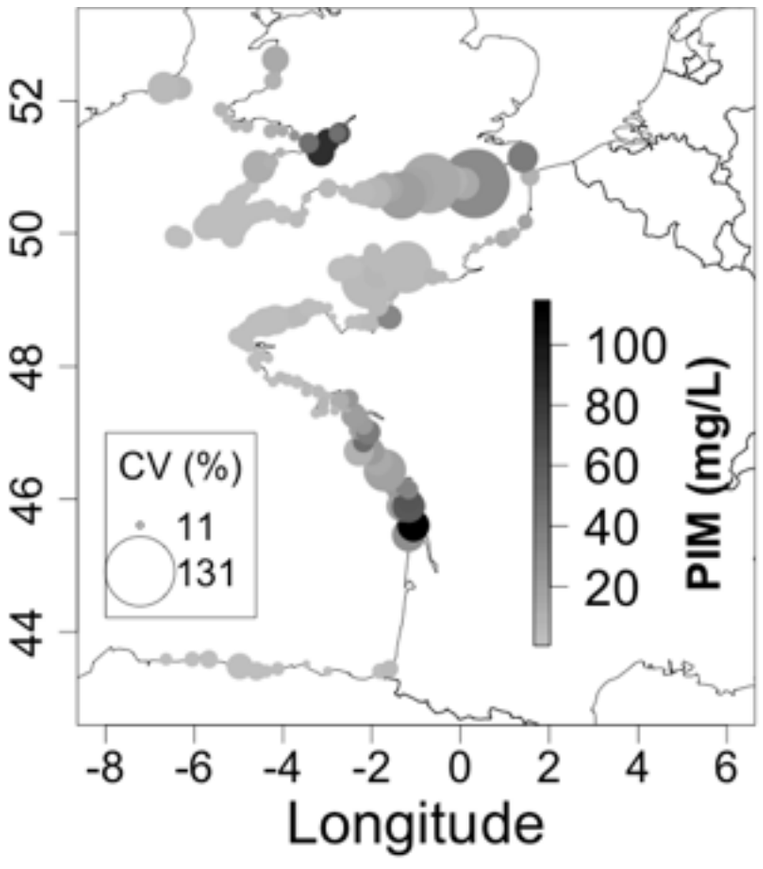
Climatic scenarios

FOOD

Monthly mean over 15 years of remote-sensing observations (PIM, Chl-a)



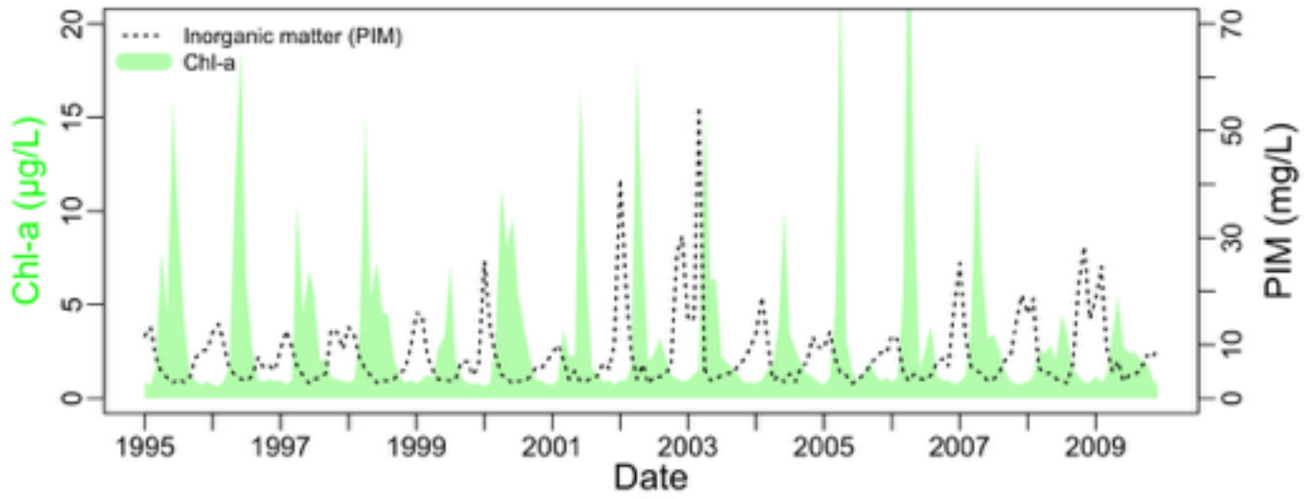




Climatic scenarios

FOOD

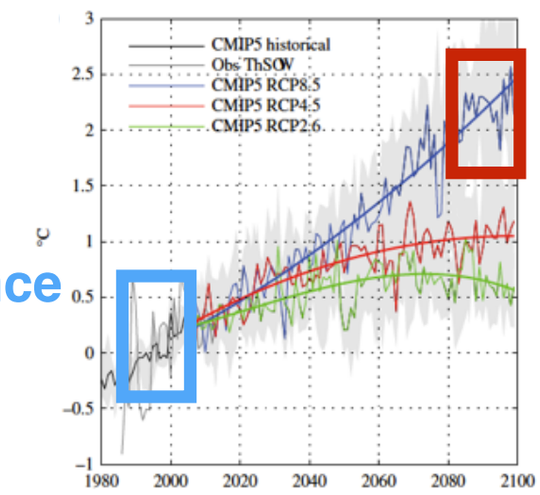
Monthly mean over 15 years of remote-sensing observations (PIM, Chl-a)



TEMPERATURE

Two scenarios of monthly SST from RCP8.5 simulations (model CNRM-CM5)

Reference

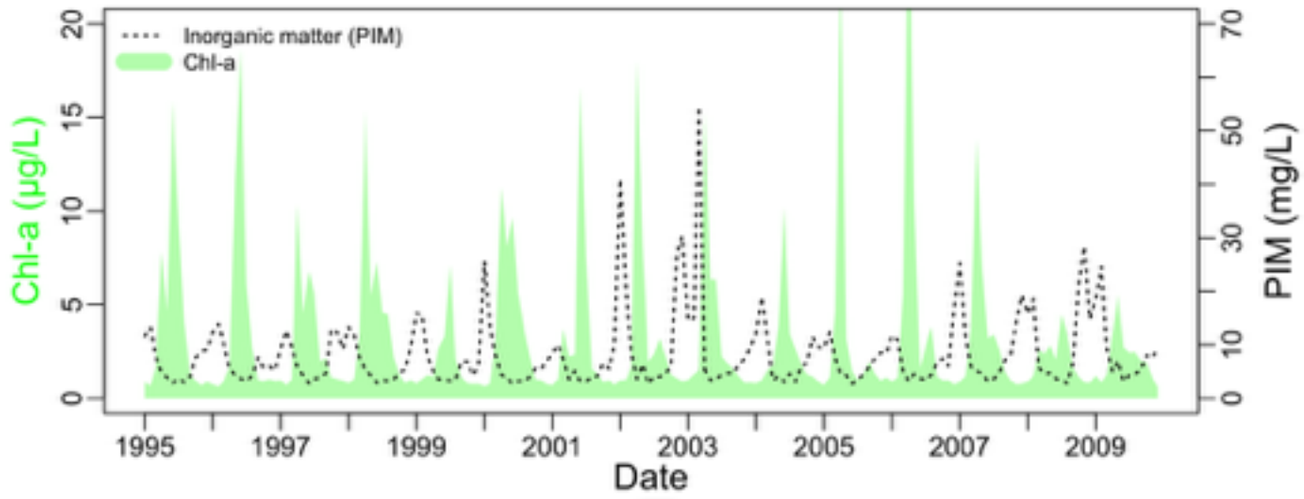


Projected

Climatic scenarios

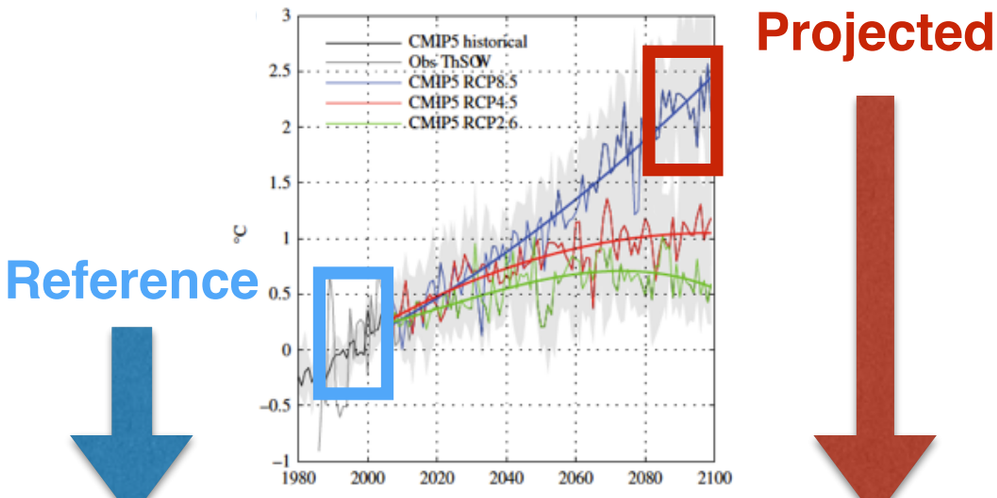
FOOD

Monthly mean over 15 years of remote-sensing observations (PIM, Chl-a)



TEMPERATURE

Two scenarios of monthly SST from RCP8.5 simulations (model CNRM-CM5)



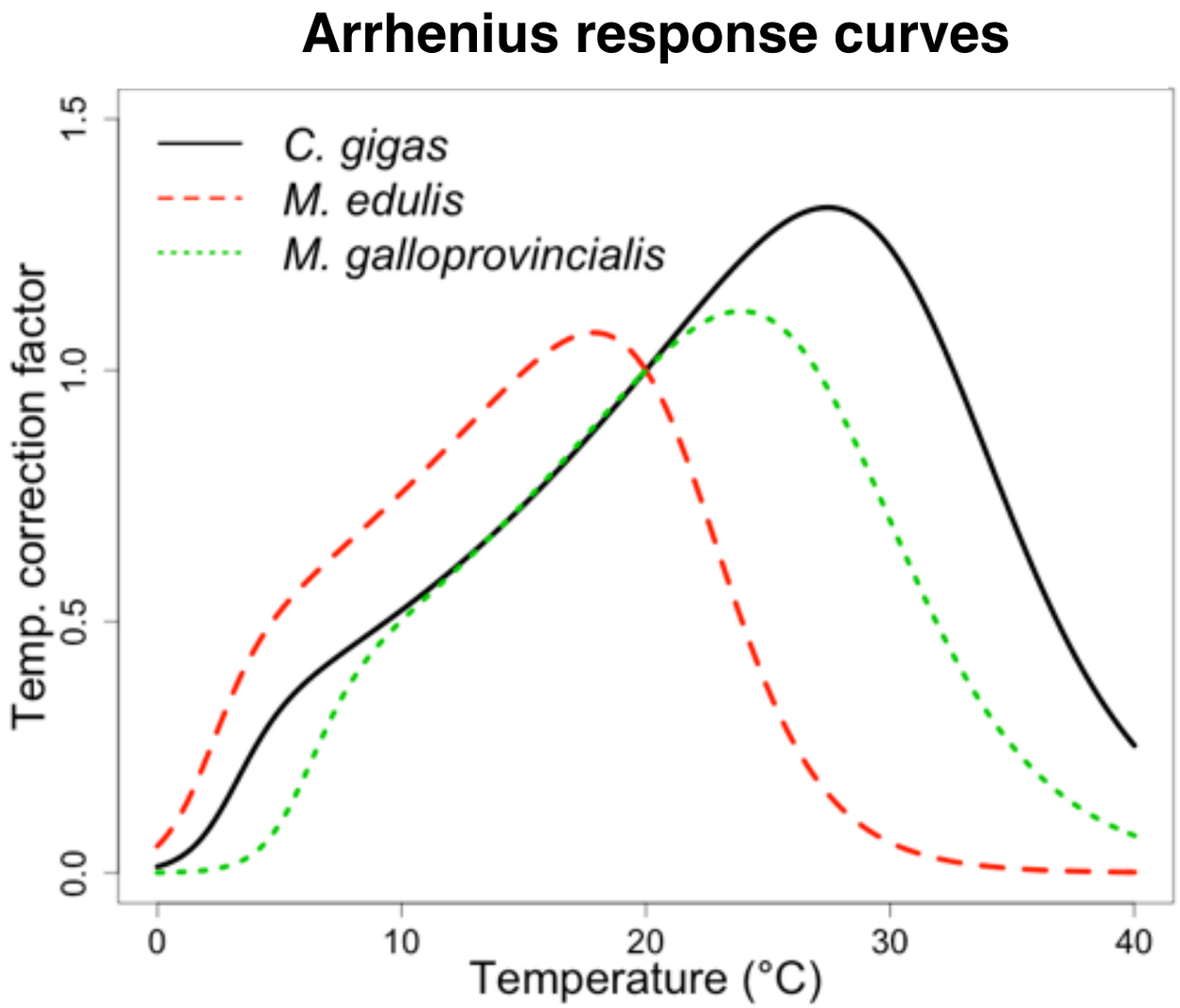
OUTPUT

DEB-IBM population dynamics modelling

Individual yearly growth

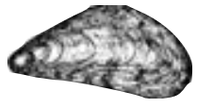
Population growth rate (PGR) and reproductive traits over 45 years of simulation

Species-specific thermal tolerance



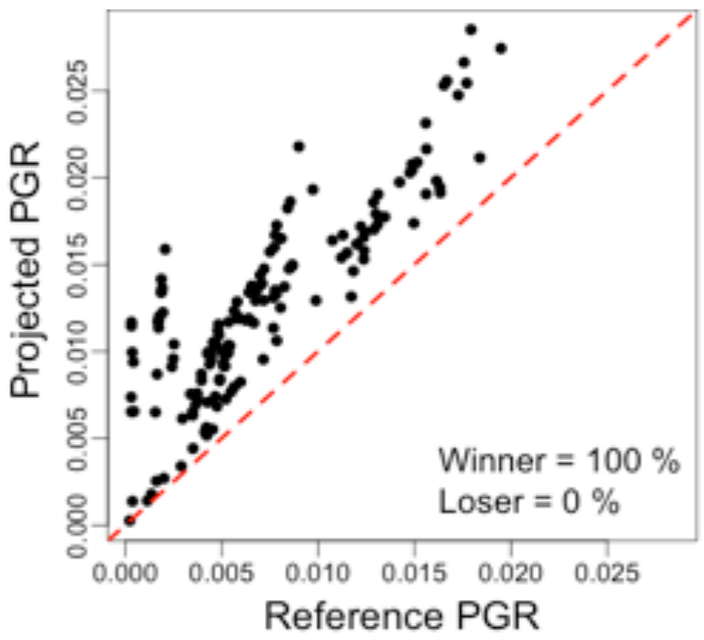
Response of populations growth rate (PGR) to warming

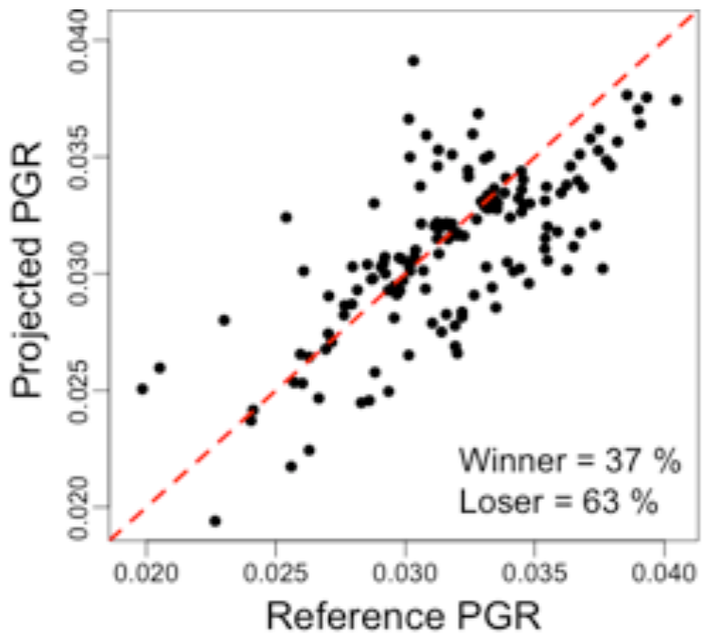
C. gigas

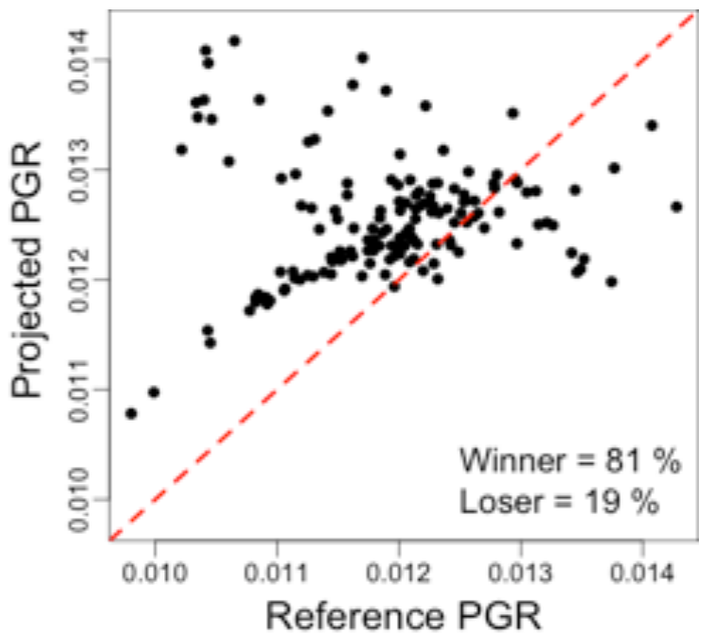


M. edulis

M. galloprovincialis

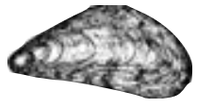






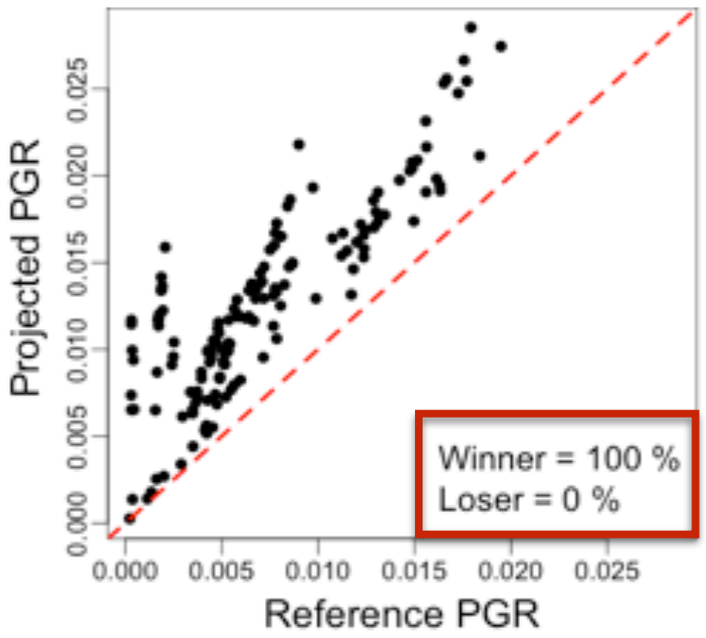
Response of populations growth rate (PGR) to warming

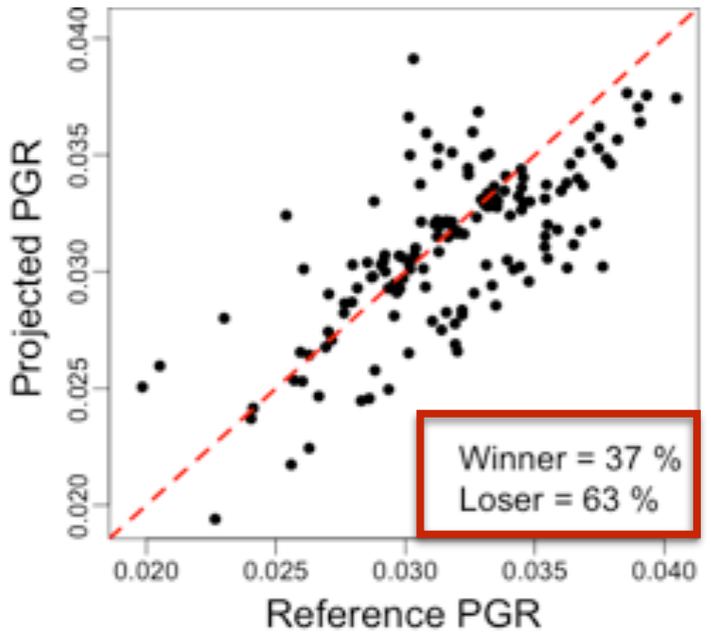
C. gigas

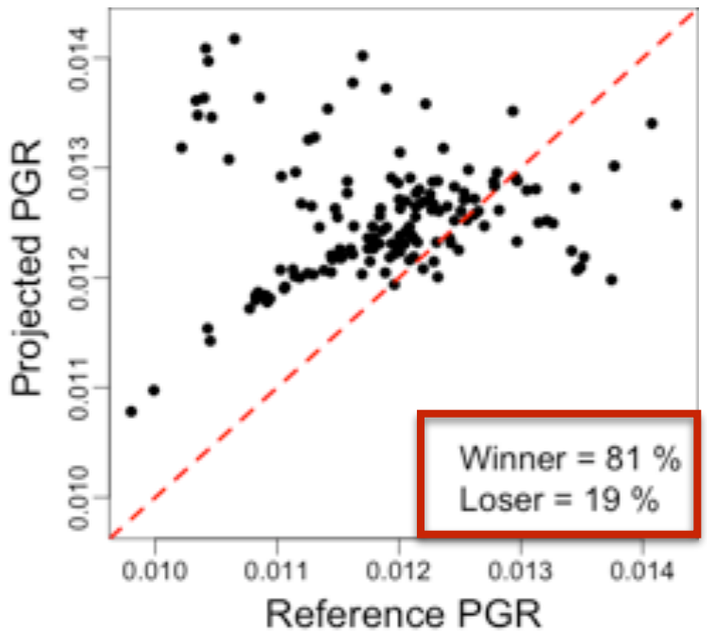


M. edulis

M. galloprovincialis

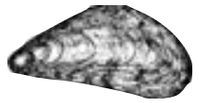






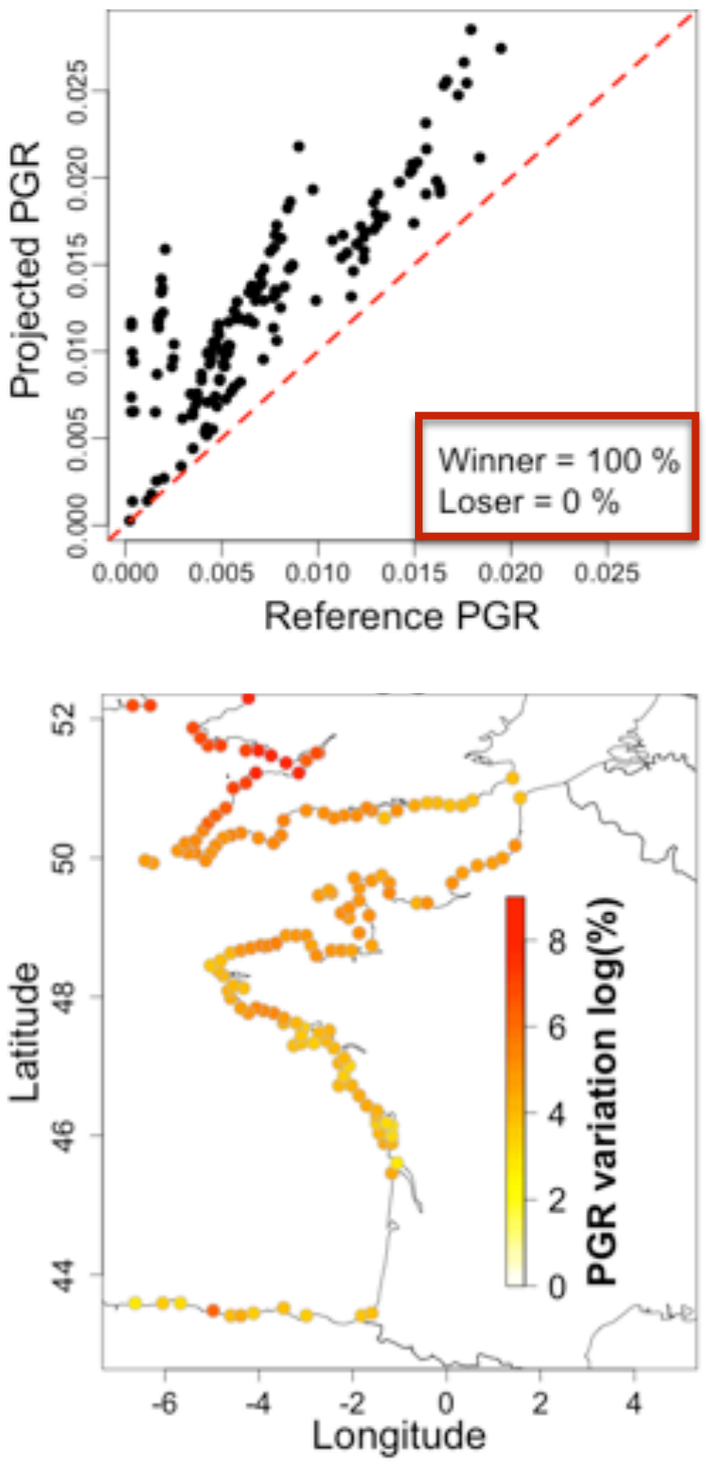
Response of populations growth rate (PGR) to warming

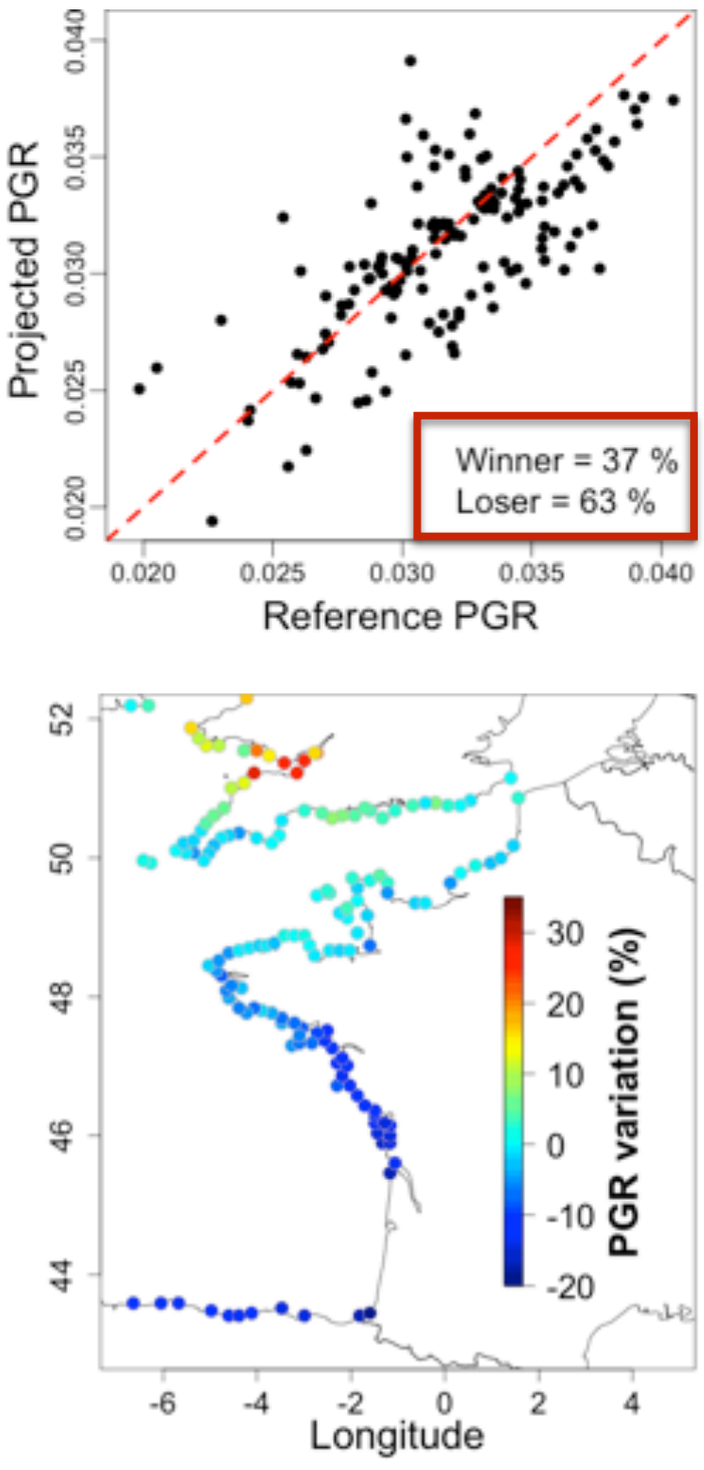
C. gigas

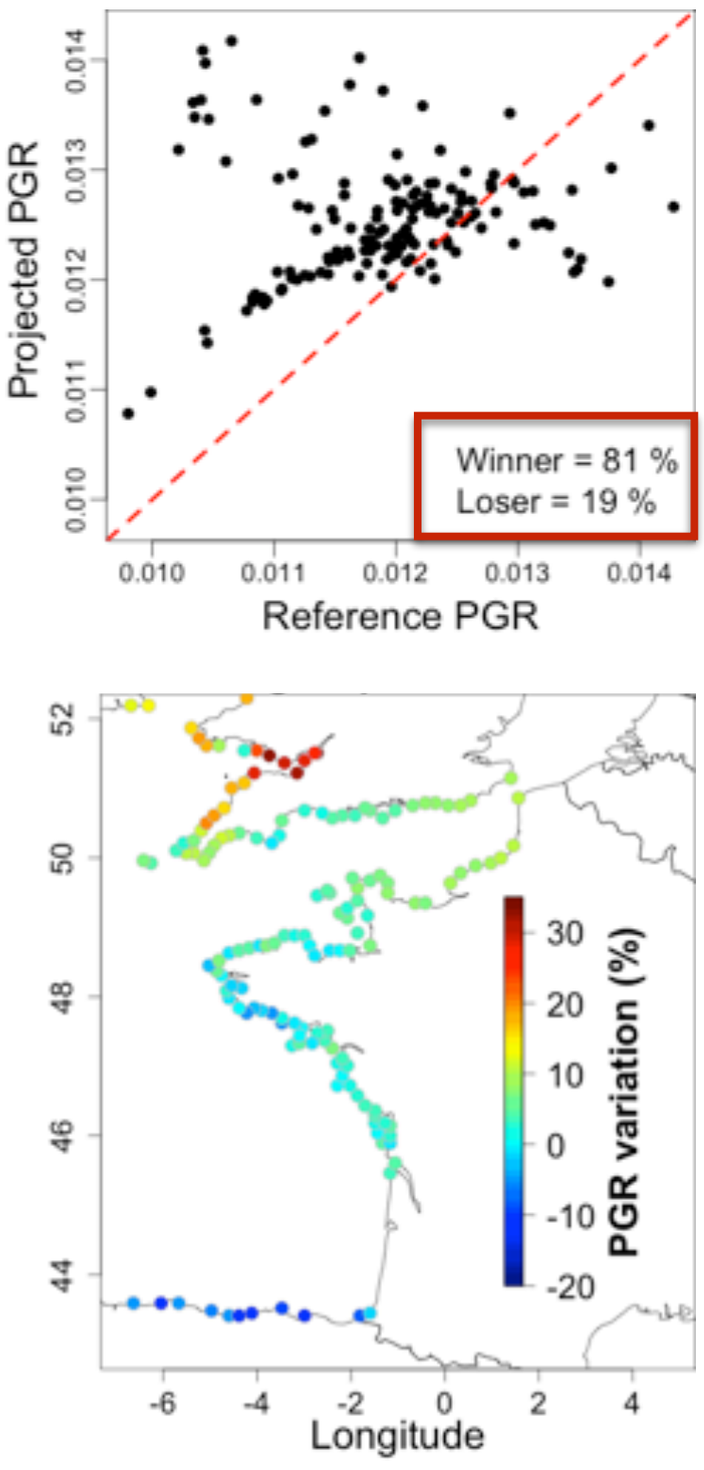


M. edulis

M. galloprovincialis

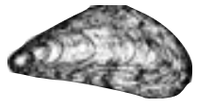






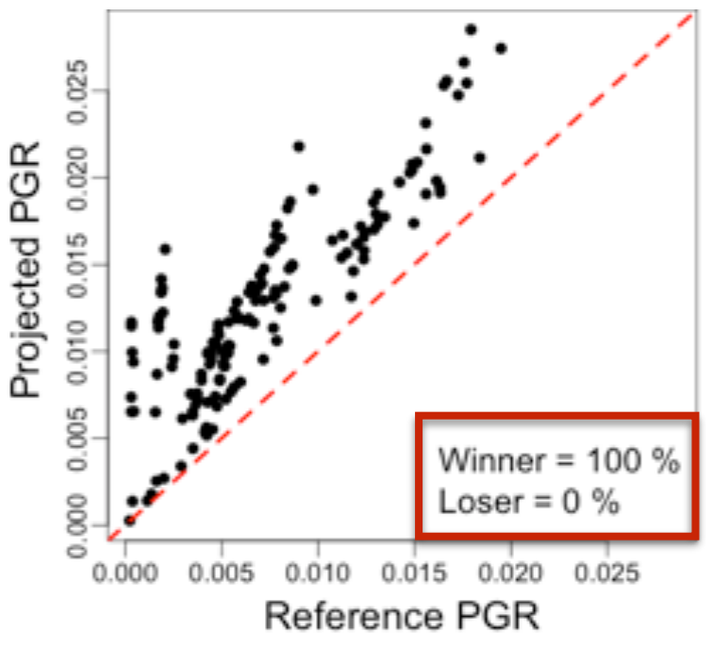
Response of populations growth rate (PGR) to warming

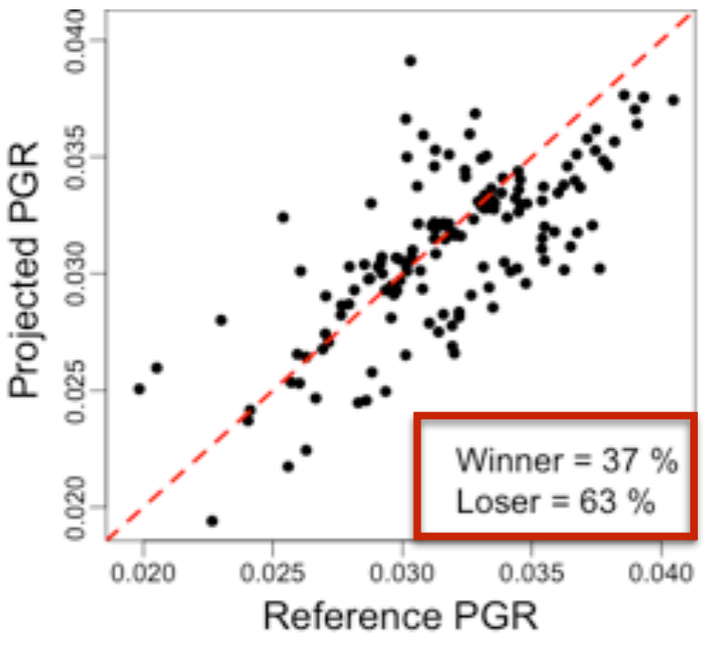
C. gigas

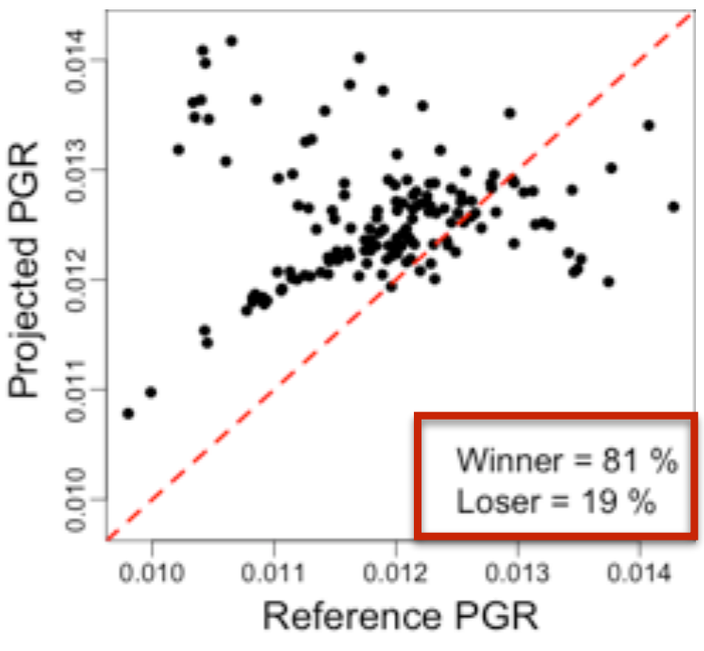


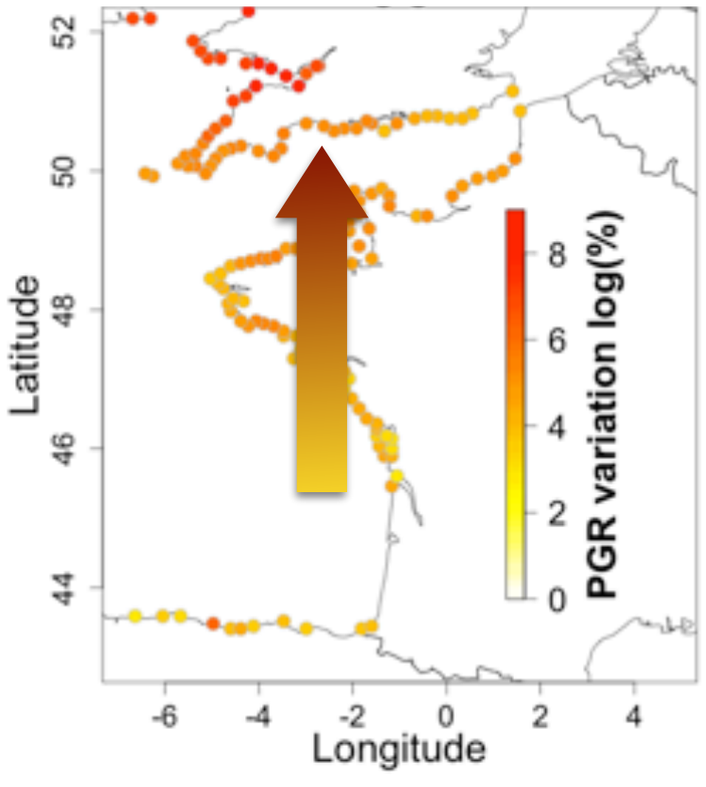
M. edulis

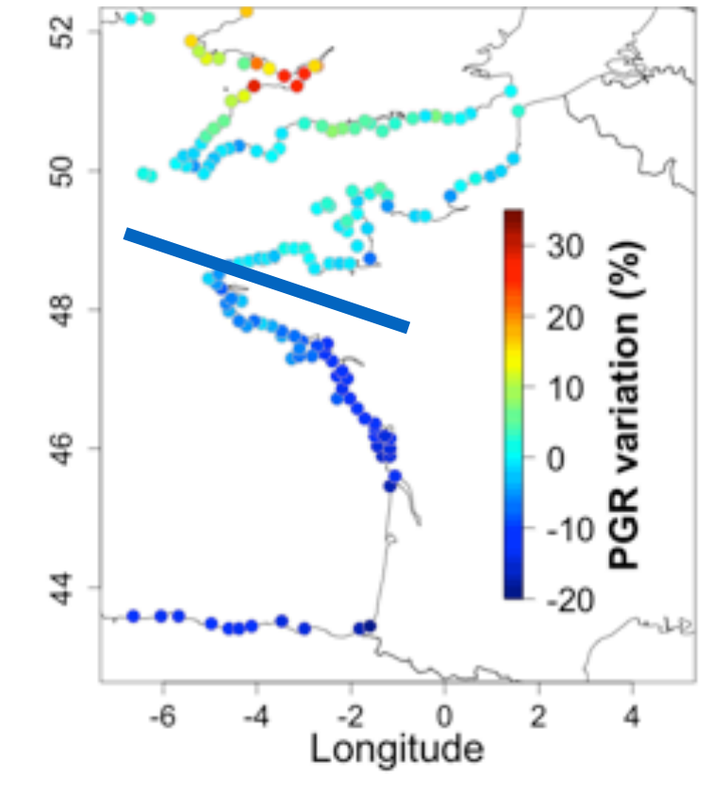
M. galloprovincialis

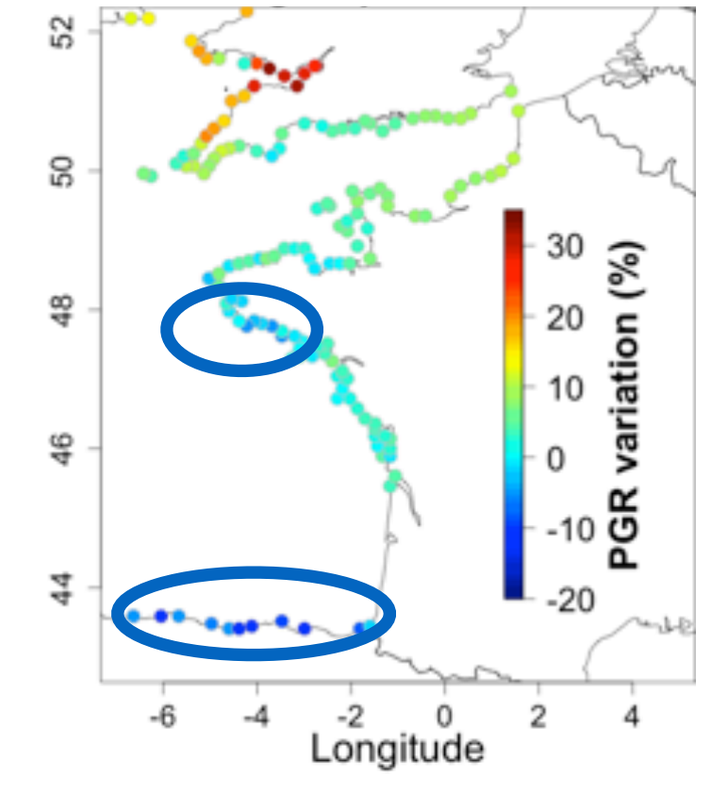




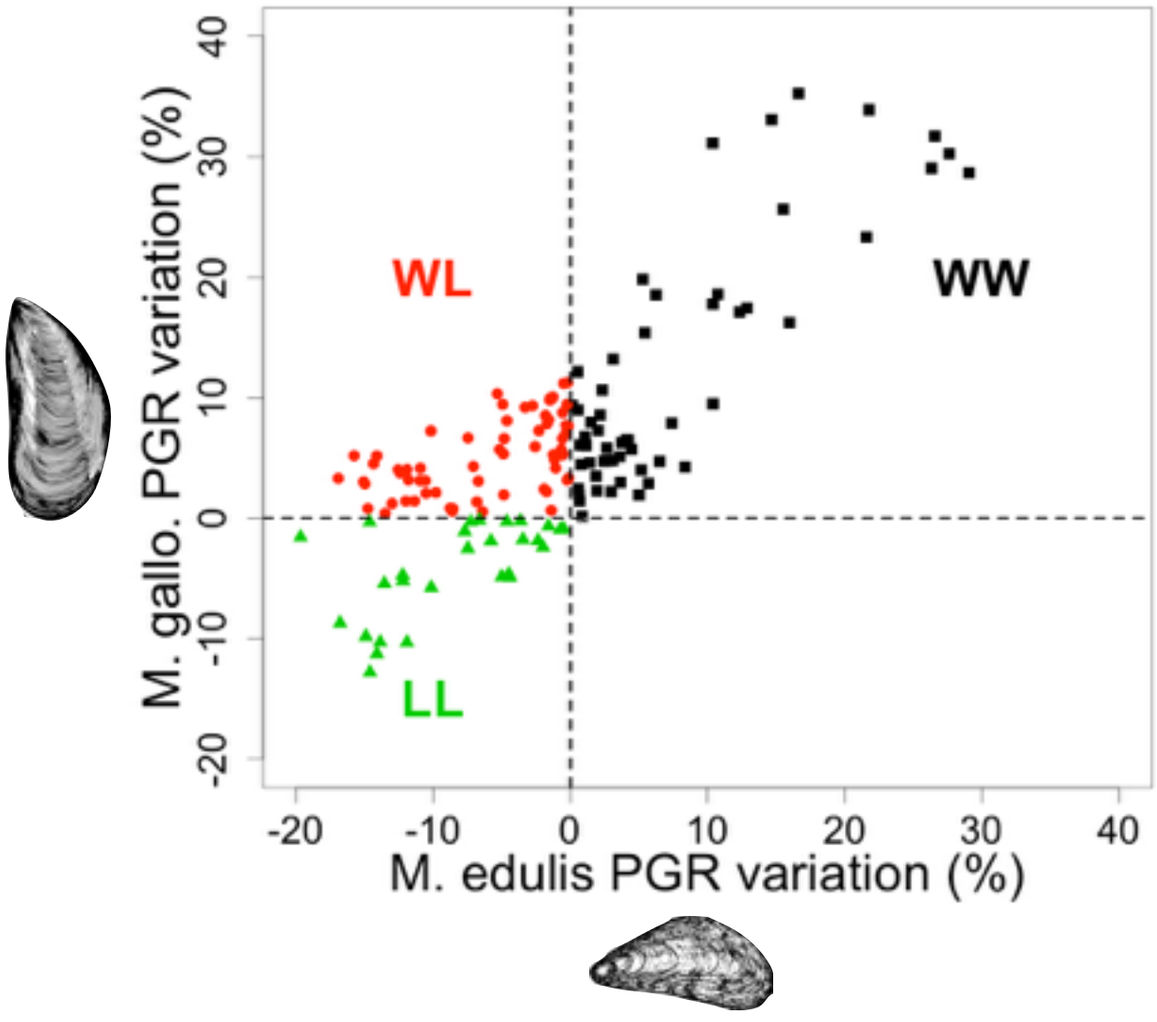




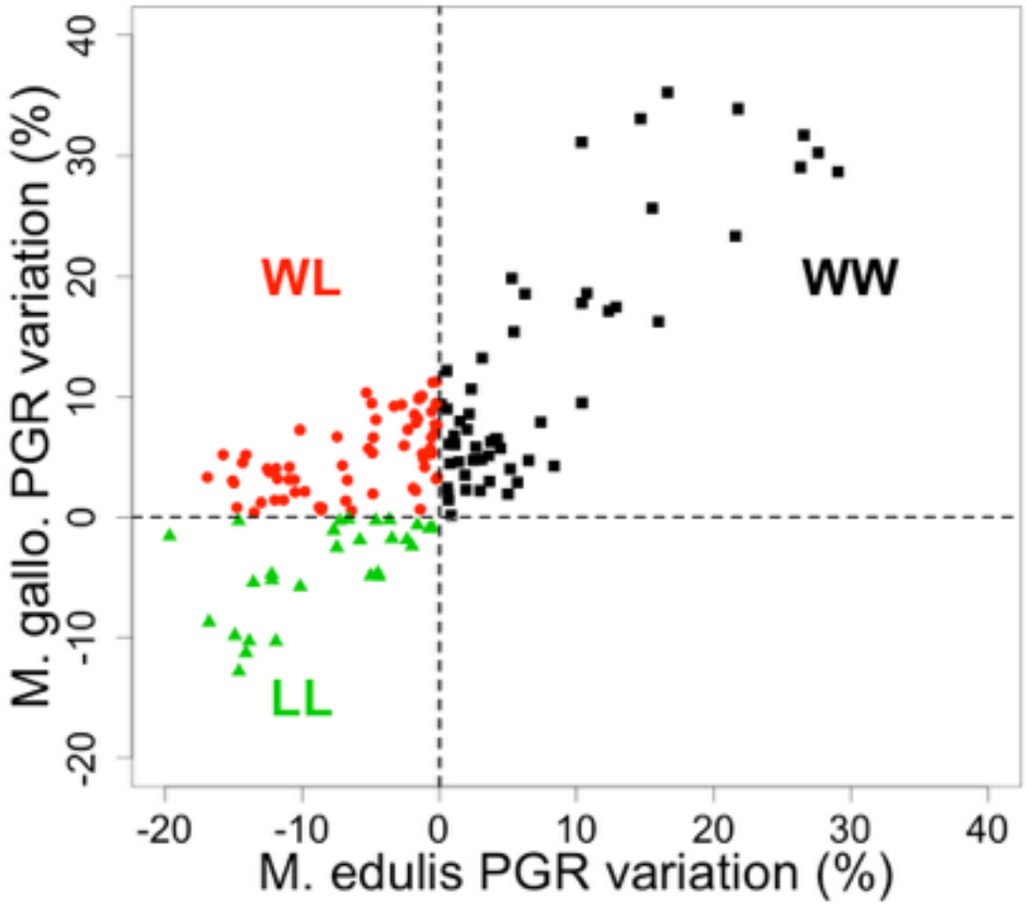




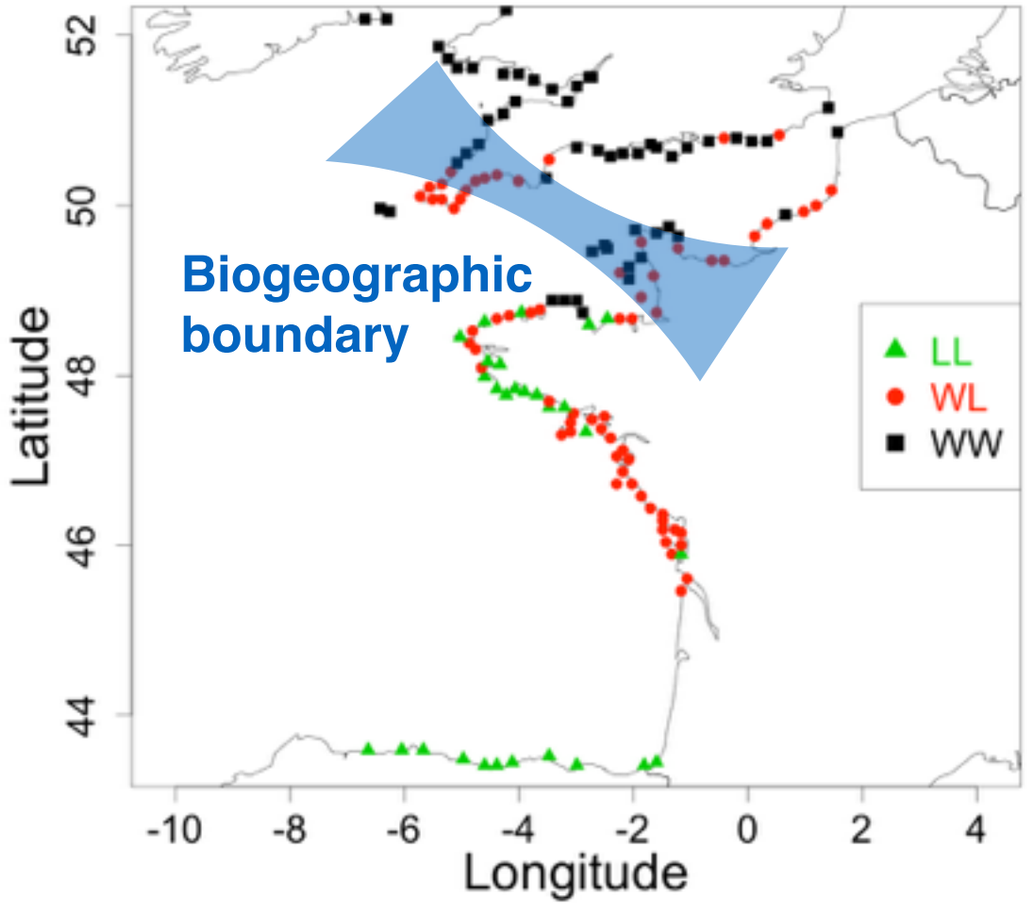
Identification of biogeographic boundaries



Identification of biogeographic boundaries

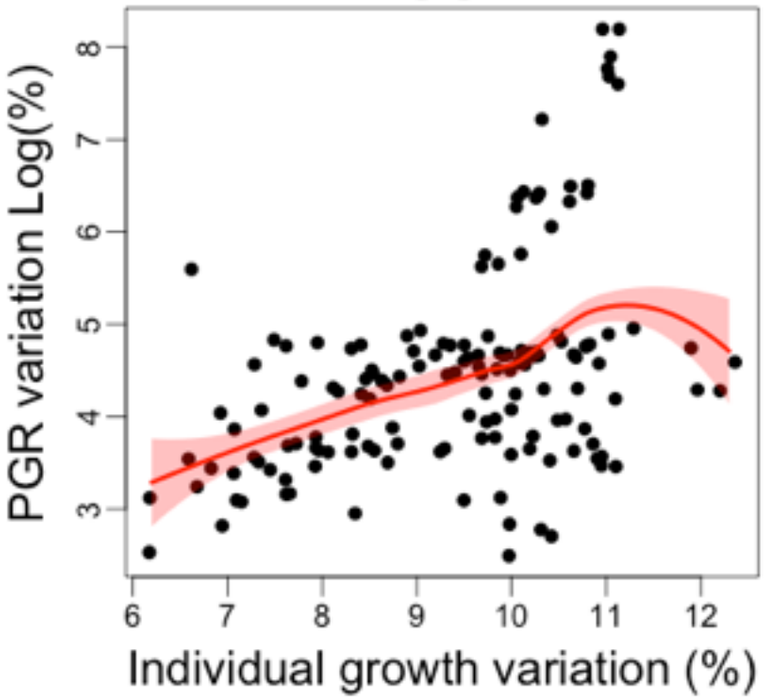


Shift in populations response

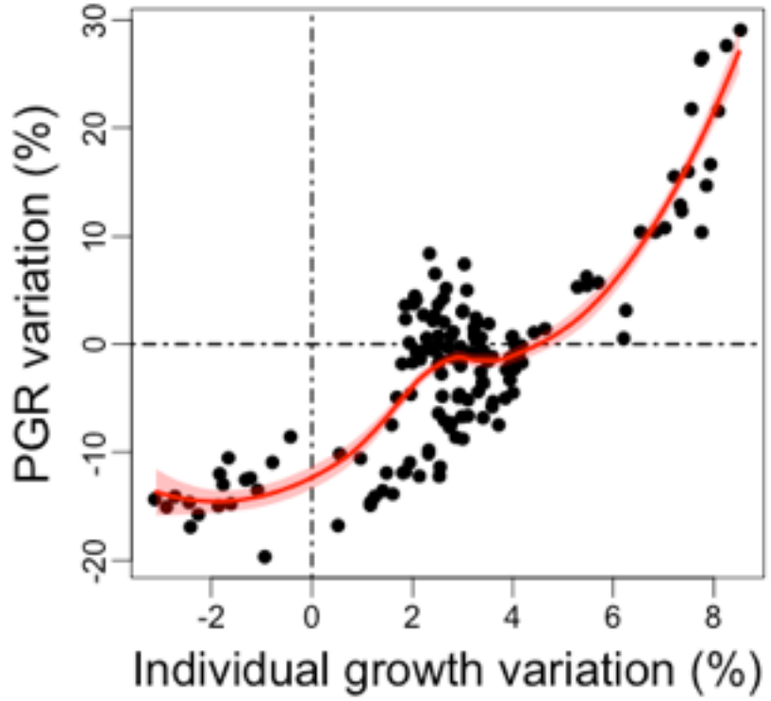


Individual *vs* population response

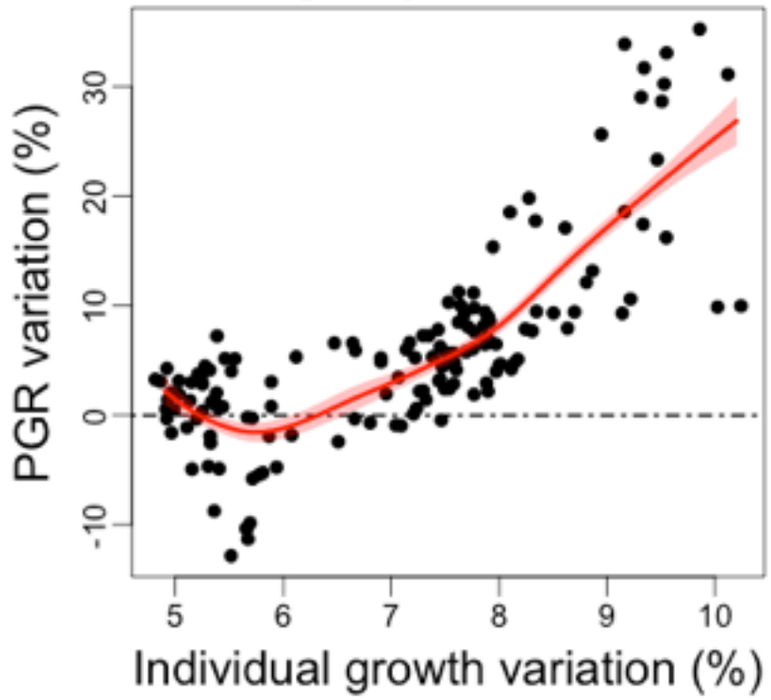
C. gigas



M. edulis

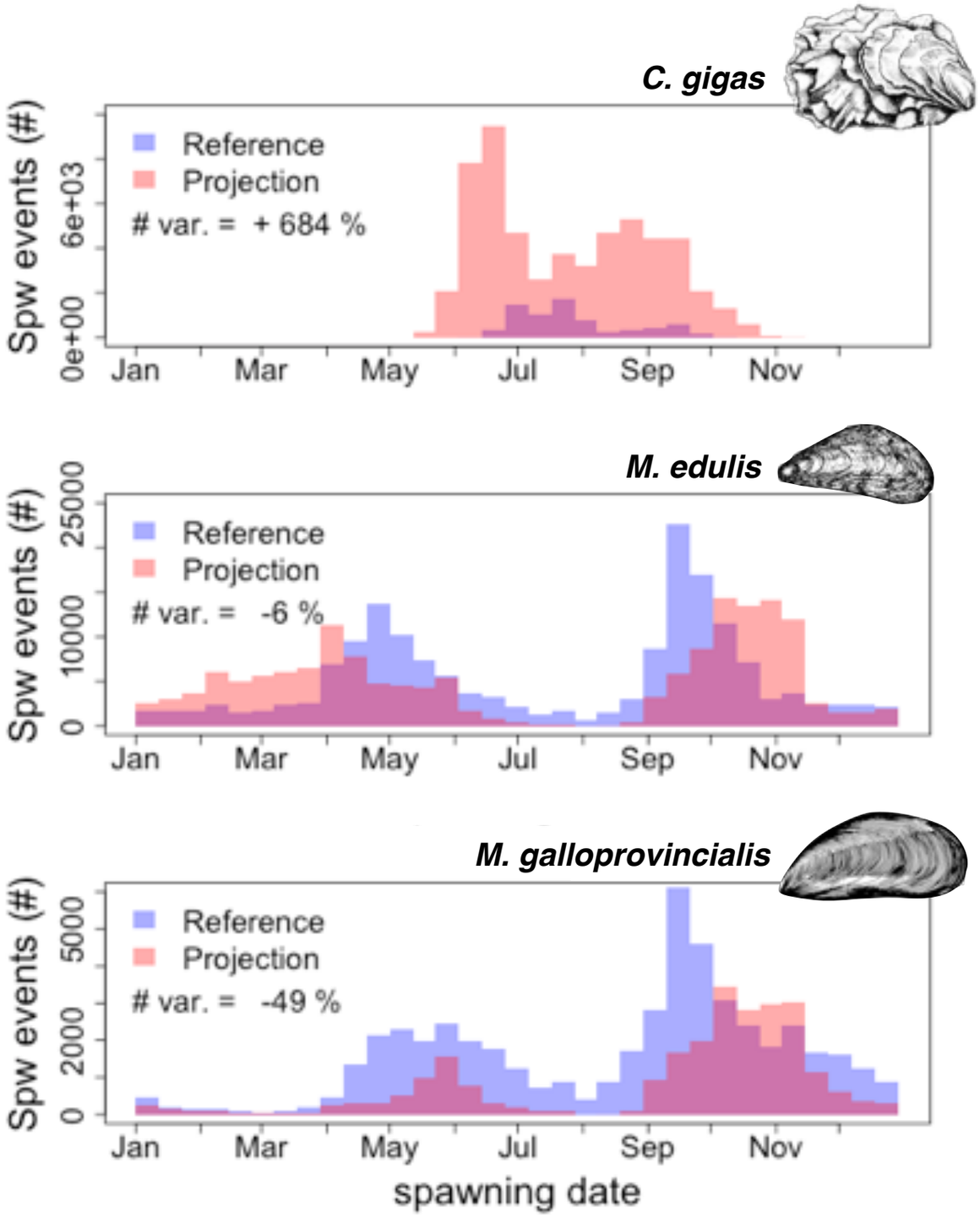


M. galloprovincialis

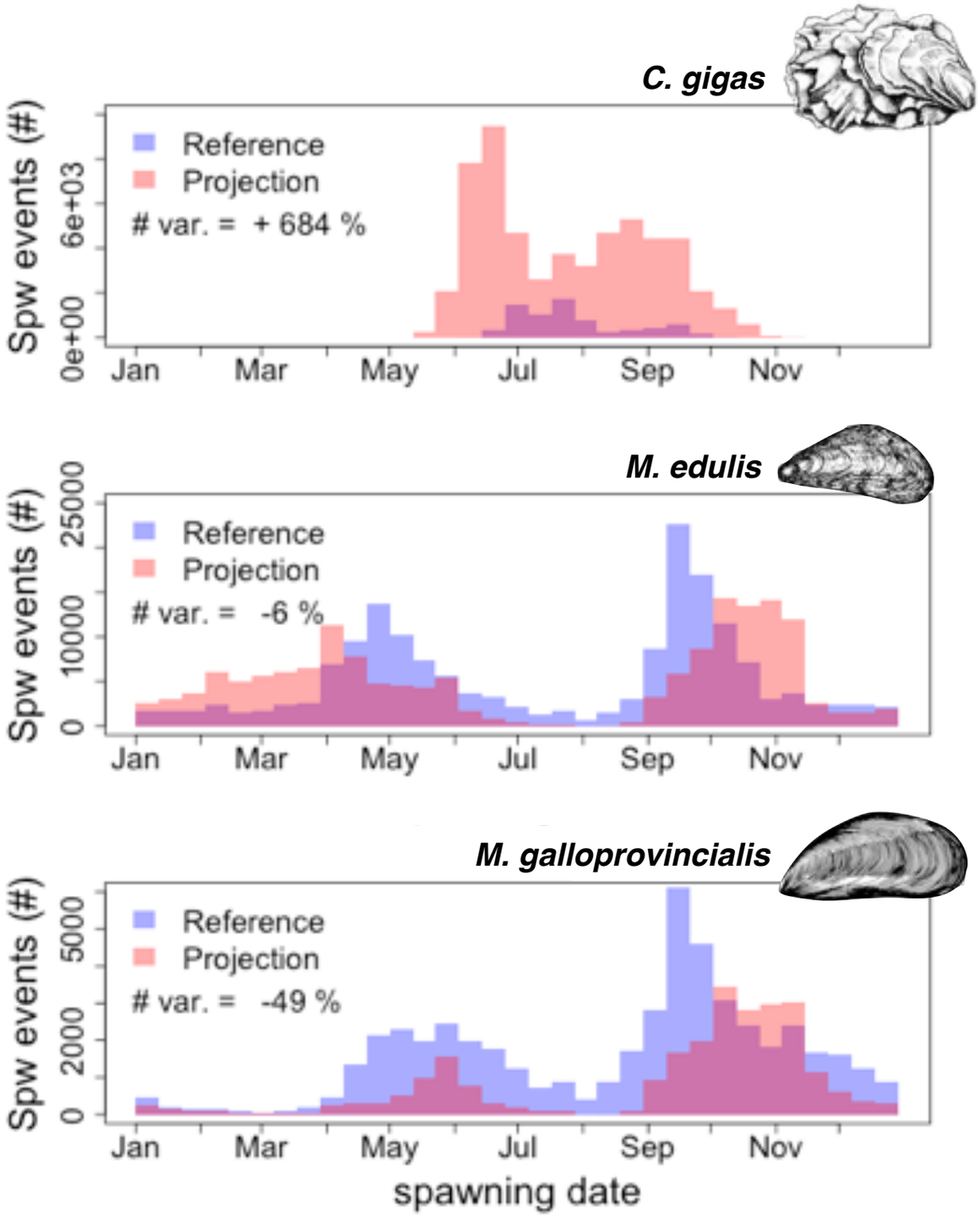


Nonlinearity between individual and population response

Reproductive traits



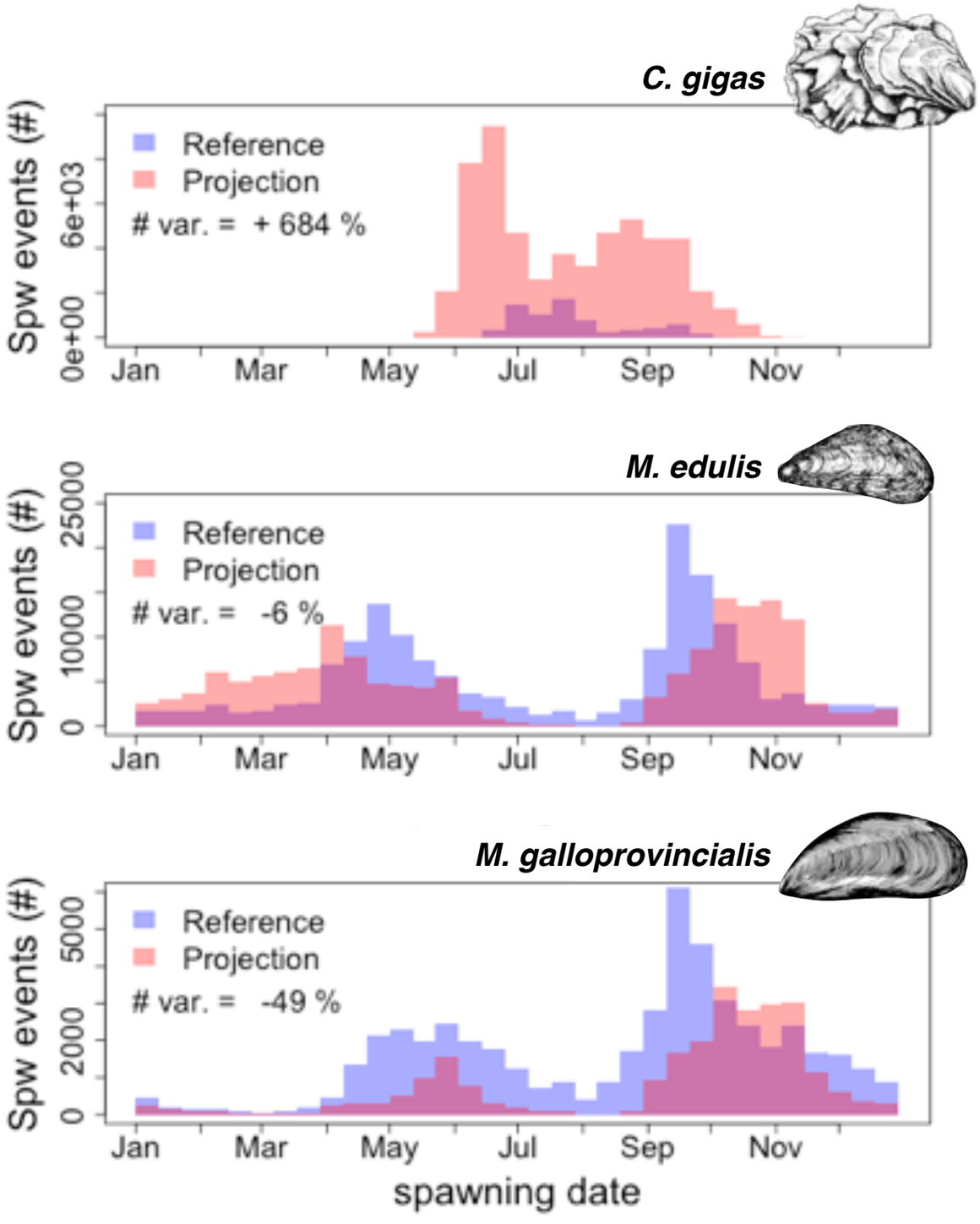
Reproductive traits

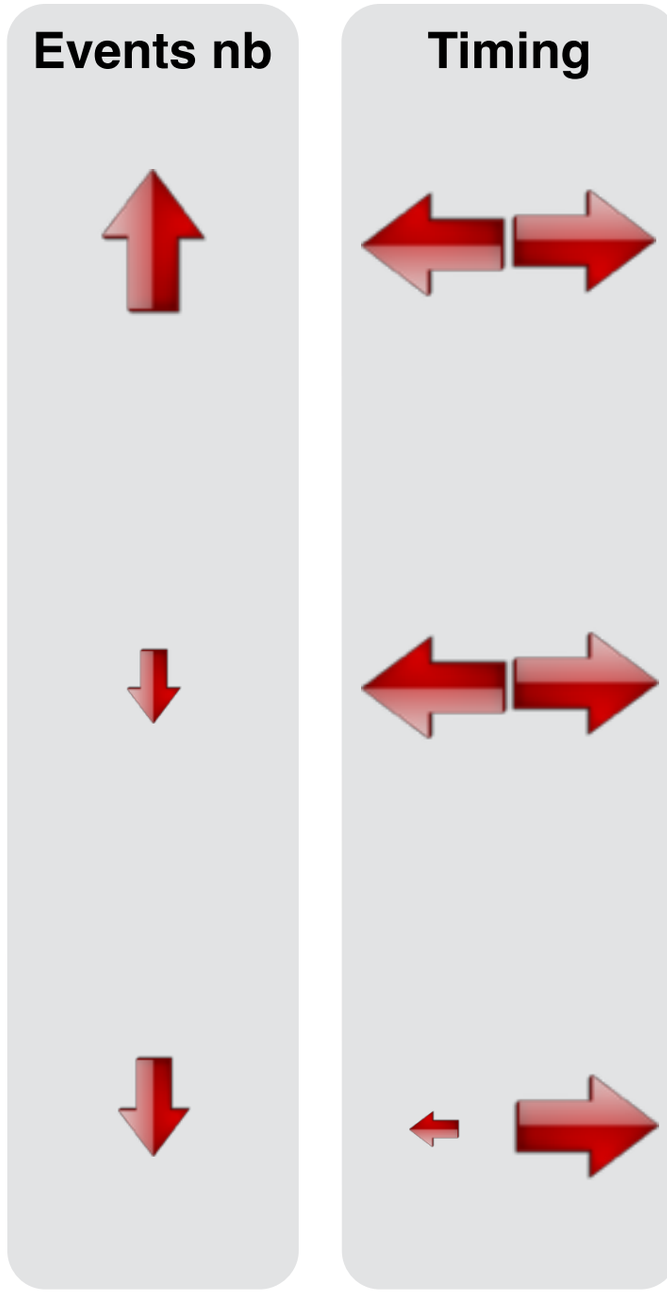


Events nb

Fecundity variation

Reproductive traits





Take-home messages

Effect of global warming on species biogeographic range (Winner/Loser)

➡ **Polward extension** of the species range and southward contraction for mussels

➡ Identification of a **biogeographic boundary** for mussels population growth potential

Population niche vs. species thermal tolerance

➡ **Nonlinearity** between species tolerance and population response

- Various environmental trajectories
- Combining multiple stress (T°C, food)

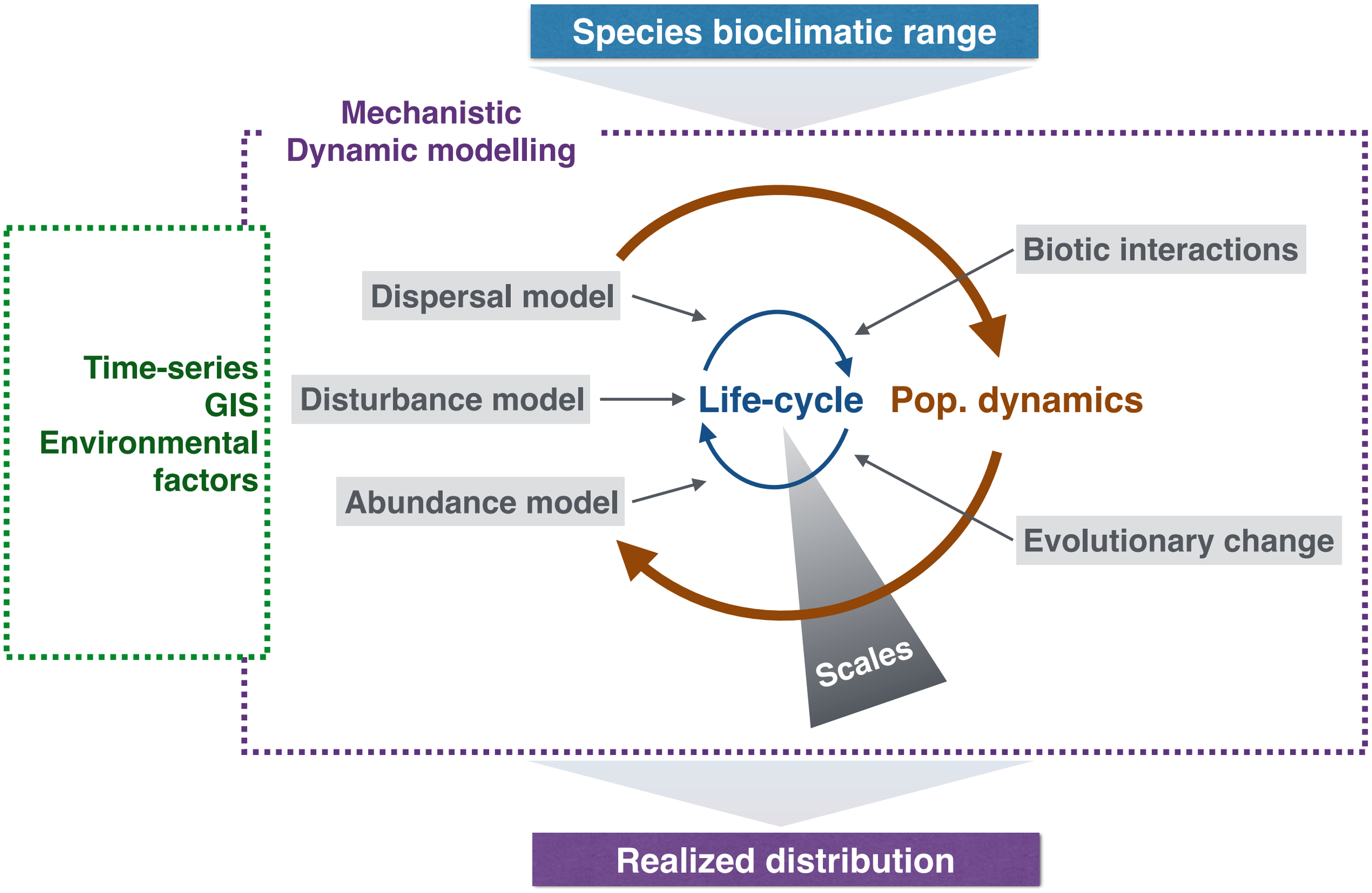
Population response driven by reproductive traits

➡ Significant **increase of reproductive potential** for oysters

➡ **Shifts** in spawning phenology

- Interaction between food & T°C ? (cf. Melaine's talk Thursday 10:00)
- Conséquences on larval growth, dispersal & connectivity patterns?

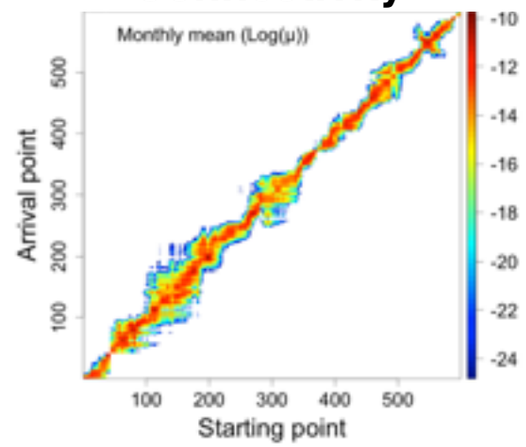
Current work & Next steps



Current work & Next steps

From fundamental to realized population niche under climatic scenarios

Connectivity



Agent-based platform
NetLogo

Dispersal model

Biotic interactions

Time-series
GIS
Environmental factors

Disturbance model

Life-cycle **Pop. dynamics**

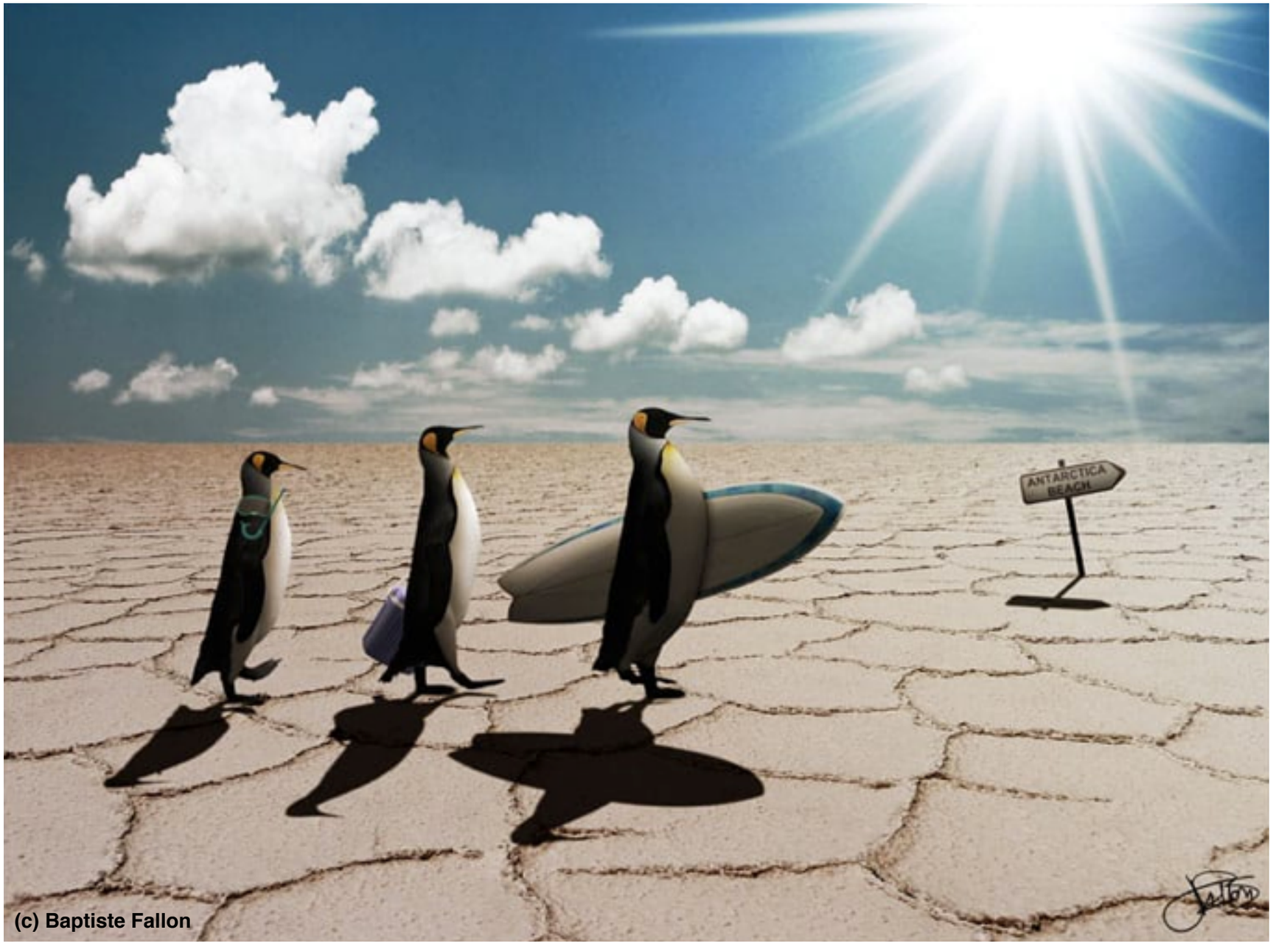
Abundance model

Evolutionary change

Scales

Realized distribution

Thank you



(c) Baptiste Fallon

RCP8.5 *vs* RCP2.6