Pérégrination d'un modèle alose au rythme d'une méthode ABC

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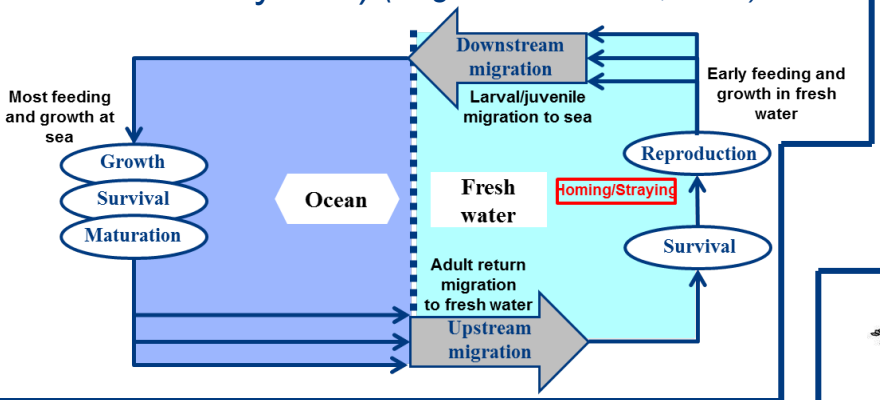
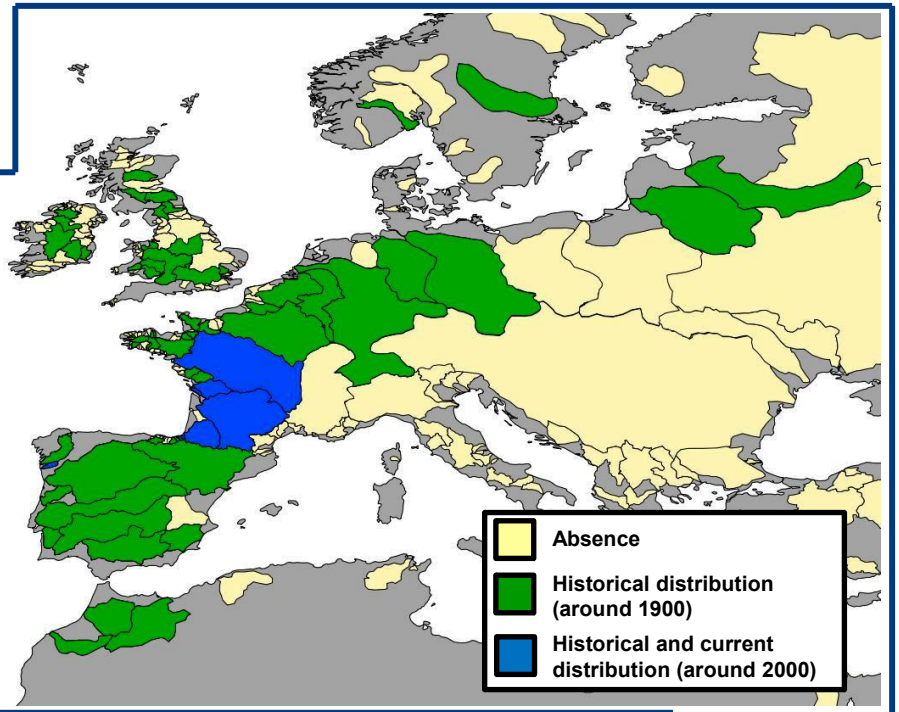
Context: allis shad, *Alosa alosa*, an endangered species ?

Anadromous species maturing at sea and spawning in rivers (approximately between 3 and 6 years) *(Baglinière and Elie, 2000)*



High patrimonial value and past high economic importance *(Castelnaud et al., kmae 2001)*

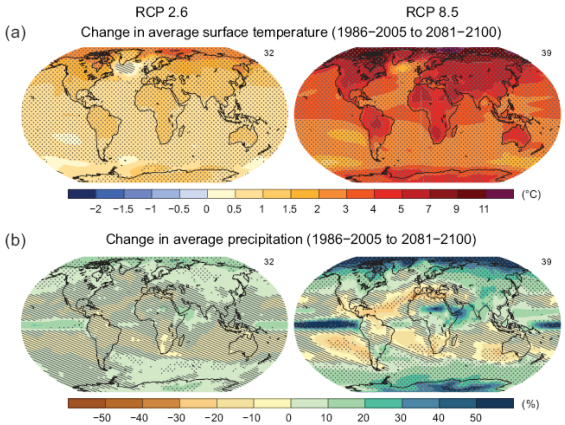
- Originally distributed along the Atlantic coast from Norway to Morocco *(Baglinière and Elie, 2000)*
- Its distribution area decreased considerably since the middle of the 20th century (overfishing, dam construction, pollution…) *(Limburg and Waldman, Bioscience 2009)*
- Current IUCN status: Least Concern…



Lassalle, PhD 2008

Context: a global changing environment, an additional pressure for the species…

"Recent climatic and atmospheric trends are already affecting species physiology, distribution and phenology" (Hughes, TREE 2000)



(IPCC, 2013)

Climate change
(warming,
precipitations modification,
sea level rise,
ocean acidification…)

might affect

- **Species physiology** *(e.g. Daufresne et al., PNAS 2009)*
- **Species phenology** *(e.g. Graham and Harrod, J. Fish. Biol 2009)*
- **Species distribution** *(e.g. Perry et al., Science 2005)*

A first study using **empirical species distribution models** (correlative approach) showed a **sensitivity of diadromous fish to climate modifications** and potential changes of suitable habitats for almost all the European diadromous fish in 2100 *(Lassalle and Rochard, GCB 2009)*

The GR3D model

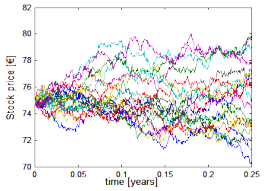
"The GR3D model, a tool to explore the Global Repositioning Dynamics of Diadromous fish Distribution", ***Rougier et al., Ecol. Model. 2014***

We developed a **mechanistic modelling approach** aiming at assessing diadromous fish local persistence, global persistence and potential evolution of their distribution area in the context of climate change: the **GR3D model**

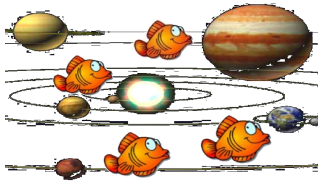
- Model developed in Java using the SimAquaLife framework (individual-based toolkit for aquatic life simulation) *(Dumoulin, 2007)*
- Mechanistic simulation model

Individual-based

Stochastic



Spatialy explicit

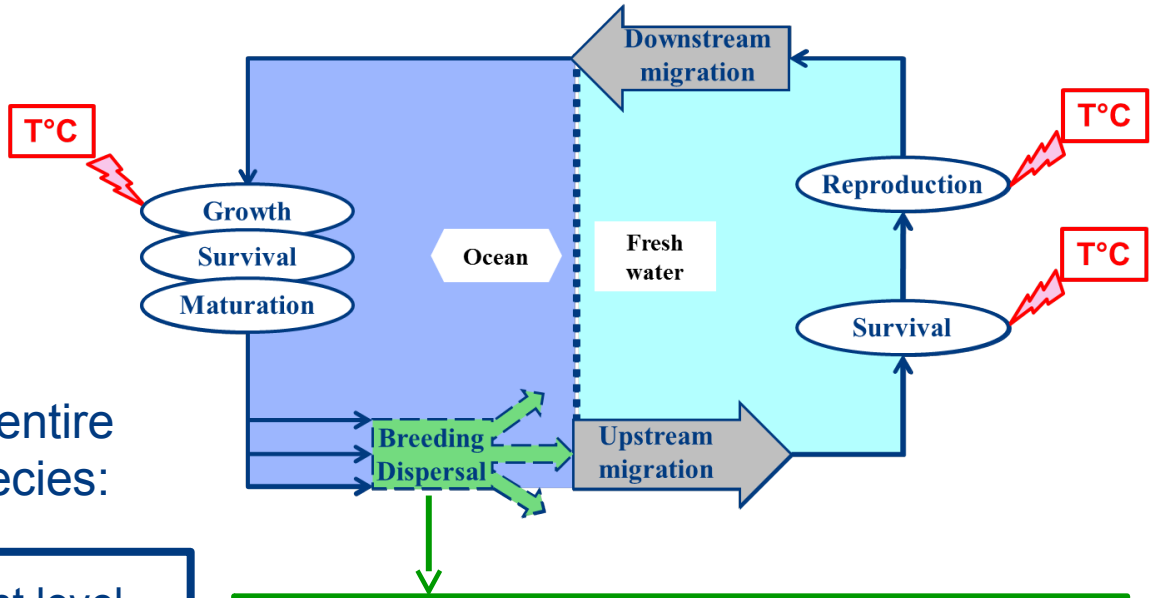


- Generic model designed to potentially work on several species (including virtual species) using a life-trait database of European diadromous fish (TraitDiad 1.0; *Rougier, PhD 2014*)

- Model incorporating an original dispersal process and including explicitly environmental effects in processes

The GR3D model

"The GR3D model, a tool to explore the Global Repositioning Dynamics of Diadromous fish Distribution", ***Rougier et al., Ecol. Model. 2014***



The GR3D model covers the entire life cycle of any anadromous species:

Six biological processes with different level of complexity in terms of parameters number *(total of 42 parameters)*

Three processes are directly linked to water temperature

The breeding dispersal process concerns strayed spawners (*i.e.* not doing homing) that choose a reproduction basin according to:

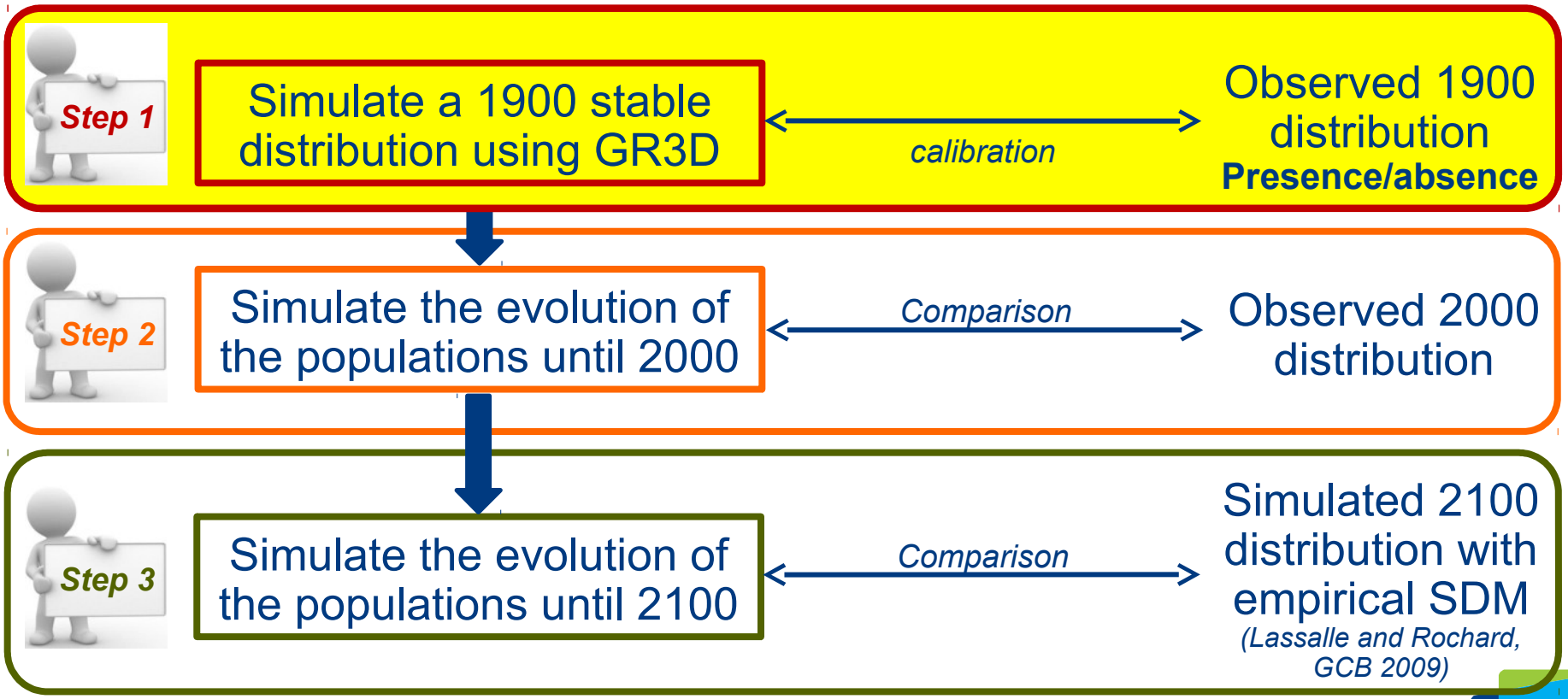
its accessibility
~ dispersal distance + fish length
(Slone, Ecol. Mod. 2011) (McCauley and Mabry, TREE 2011)

its attractiveness
~ watershed area
(Barinaga, Science 1999; Jessop, AFS 2003)

The case-study

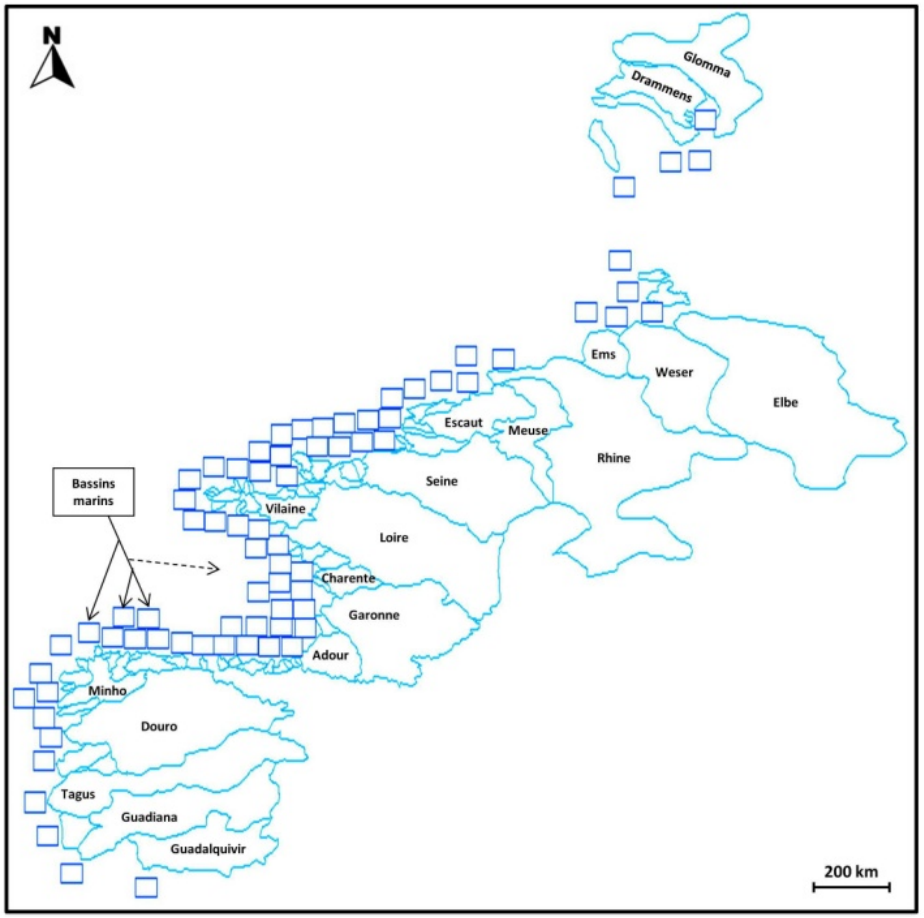
How to use GR3D to study the future of allis shad ?

The model could help to understand the evolution of the distribution area of the species between 1900 and 2000 and could give some clues about its evolution until 2100 ***(Rougier et al., in prep)***



The case-study

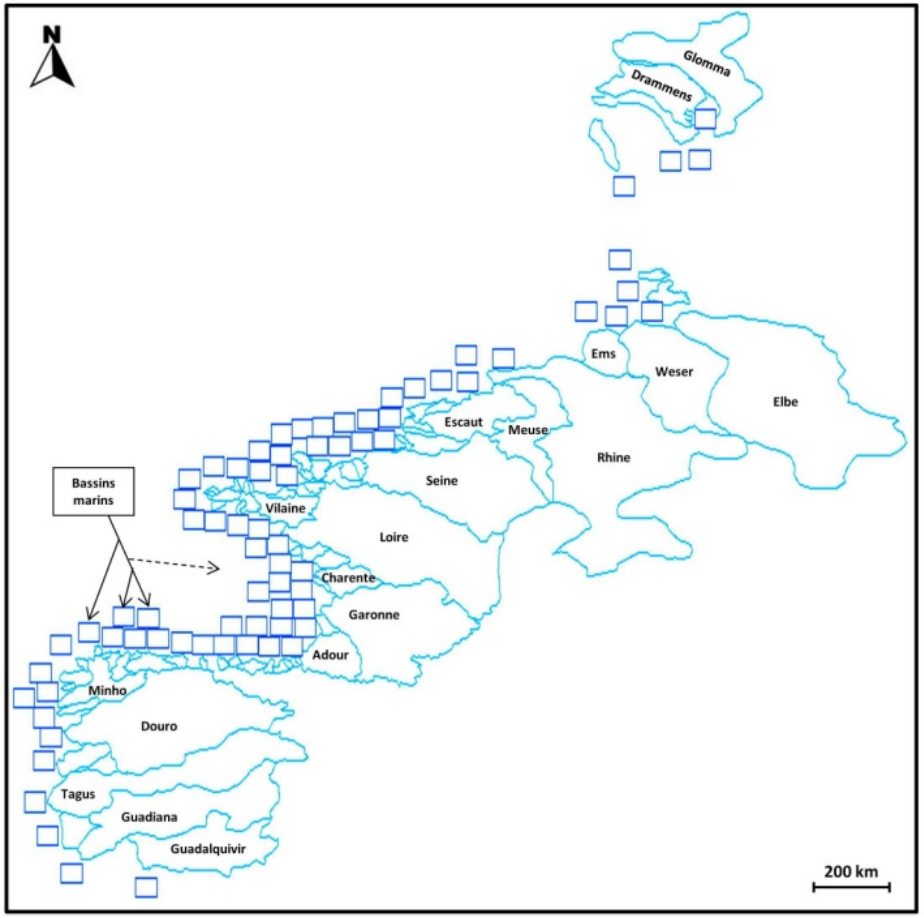
Study case: Environment, time and initialization



- Environment with 73 river basins of the European Atlantic coast
- Model parameterization with allis shad life traits
- Initialization: same amount of juveniles in each river basin
- Simulation lasting 100 years with constant environmental conditions

Model calibration

Elements required for calibration:



- Definition of output(s)
- Selection of model parameters to calibrate
- Use of a recent Approximate Bayesian Computation (ABC) algorythm adapted to complex model (Lenormand et al., 2013)

Model calibration

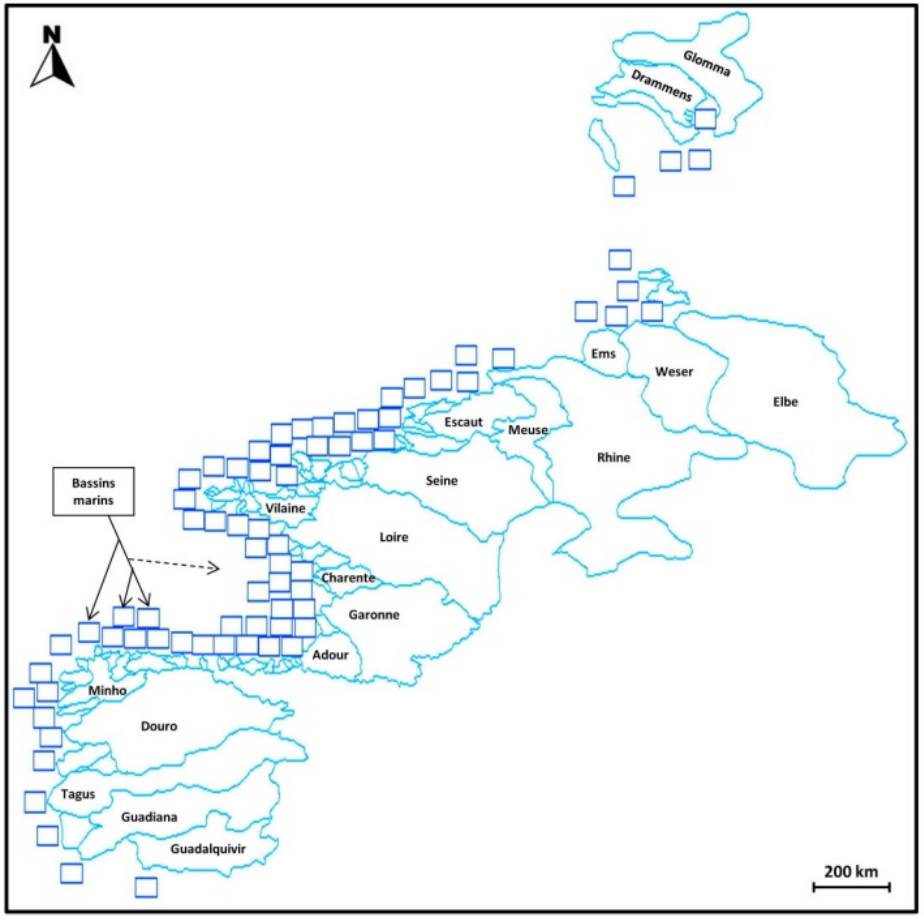
ABC algorythm with the Lenormand method (Lenormand et al., 2013) **and the EasyABC package** (Jabot et al., 2014) :

➡ Definition of the:

- Selected parameter(s) prior distribution(s)
- Output(s) target value(s)
- Initial number of simulations
- Percentage of the best simulations to keep
- Number of simulations at each new step
- Stopping criterion of the algorithm

Model calibration

1st attempt of calibration:



→ Definition of a single and simple output: Kappa index (*i.e.* similarity index from Cohen (1960))…

→ Selection of 4 parameters according to my model knowledge…

Model calibration

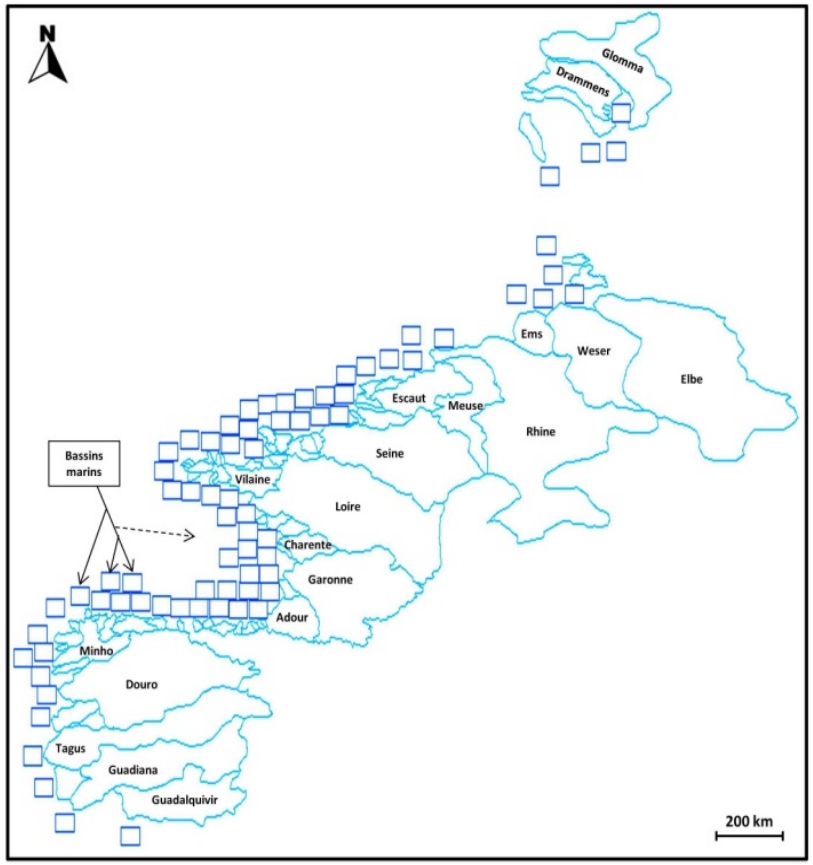
1st attempt of calibration:

But not useless !!!

- Identification of some beugs in the EasyABC package…
- Problem with NA values…
- Kappa index… bof bof…

Model calibration

Definition of 2 new outputs based on the observed distribution:



At the end of the simulations, we defined a probability of presence of the species in each river basin:

$$p_{pres,j} = \frac{N_{rep,j}}{10}$$

Number of reproductions in the basin j during the last 10 years of simulation

Computation of our first summary statistics:

$$SS_1 = \sum_{i \in p} \log\left(P_{pres,i} + \delta\right) + \sum_{i \in a} \log\left(1 - P_{pres,i} + \delta\right)$$

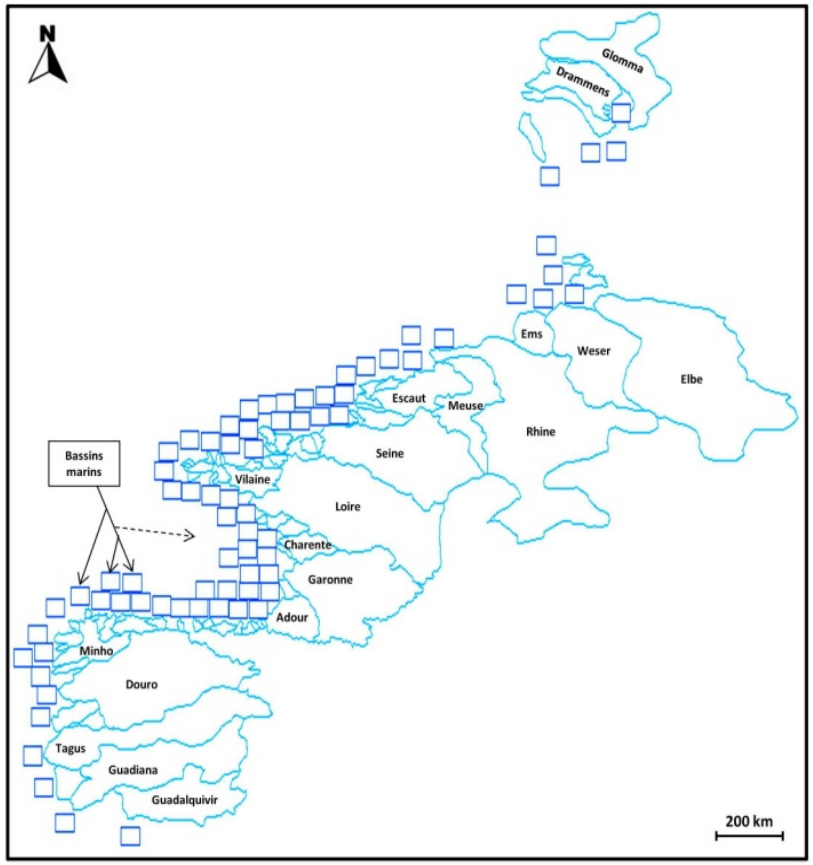
Basins with an observed <u>presence</u> in 1900

Basins with an observed <u>absence</u> in 1900

Objective: maximize SS1 (i.e. target value = 0)

Model calibration

Definition of 2 new outputs based on the observed distribution:



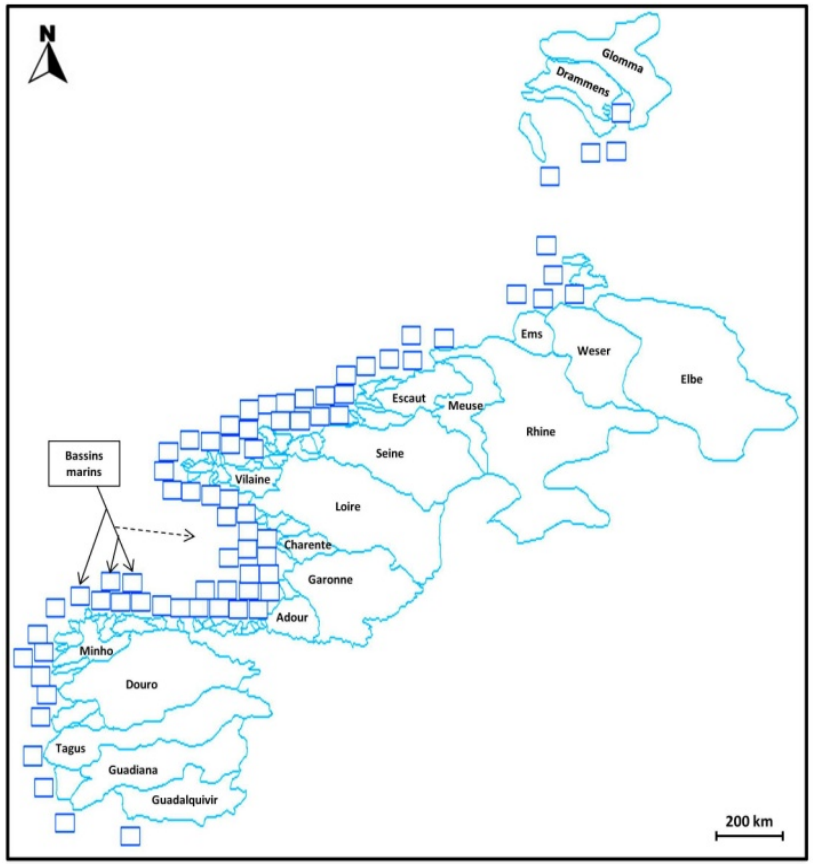
For the second summary statistic, we just record the latitude of the northern populated basin at the end of the simulations

$$SS_2 = maxLat$$

Objective: reach the observed value (i.e. target value = 53.55)

Model calibration

Definition of a 3rd output based on an observed pattern:



We recorded in each river basin *j* the mean age of first spawner during the 10 last year of simulation

$$\overline{SpAge}_j$$

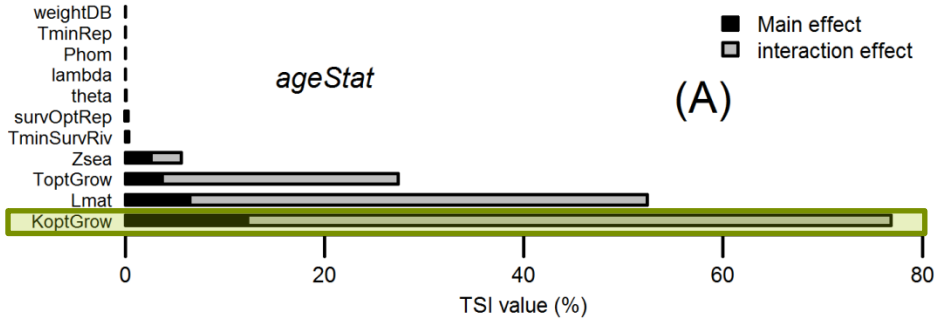
Computation of our third summary statistics:

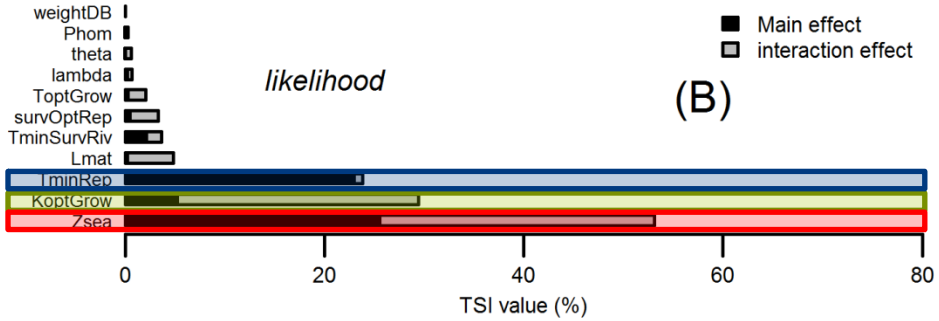
$$SS_3 = \sum_i \left(\overline{SpAge}_i - 5 \right)^2$$

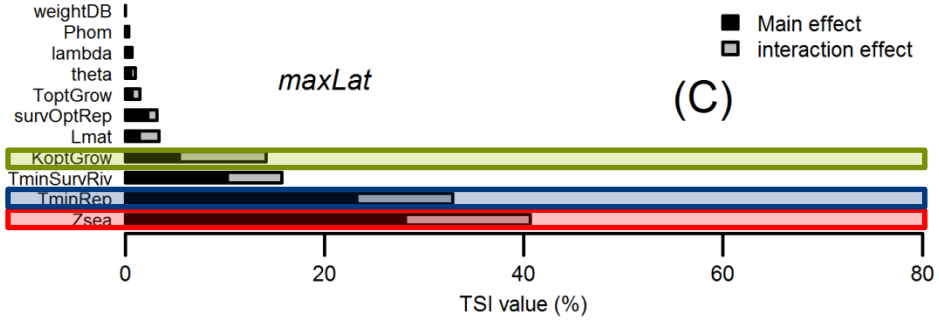
➡ Objective: minimize SS3 (i.e. target value = 0)

Model calibration

Selection of 3 parameters to calibrate using a global sensitivity analysis







Optimal growth rate

Mortality rate in sea

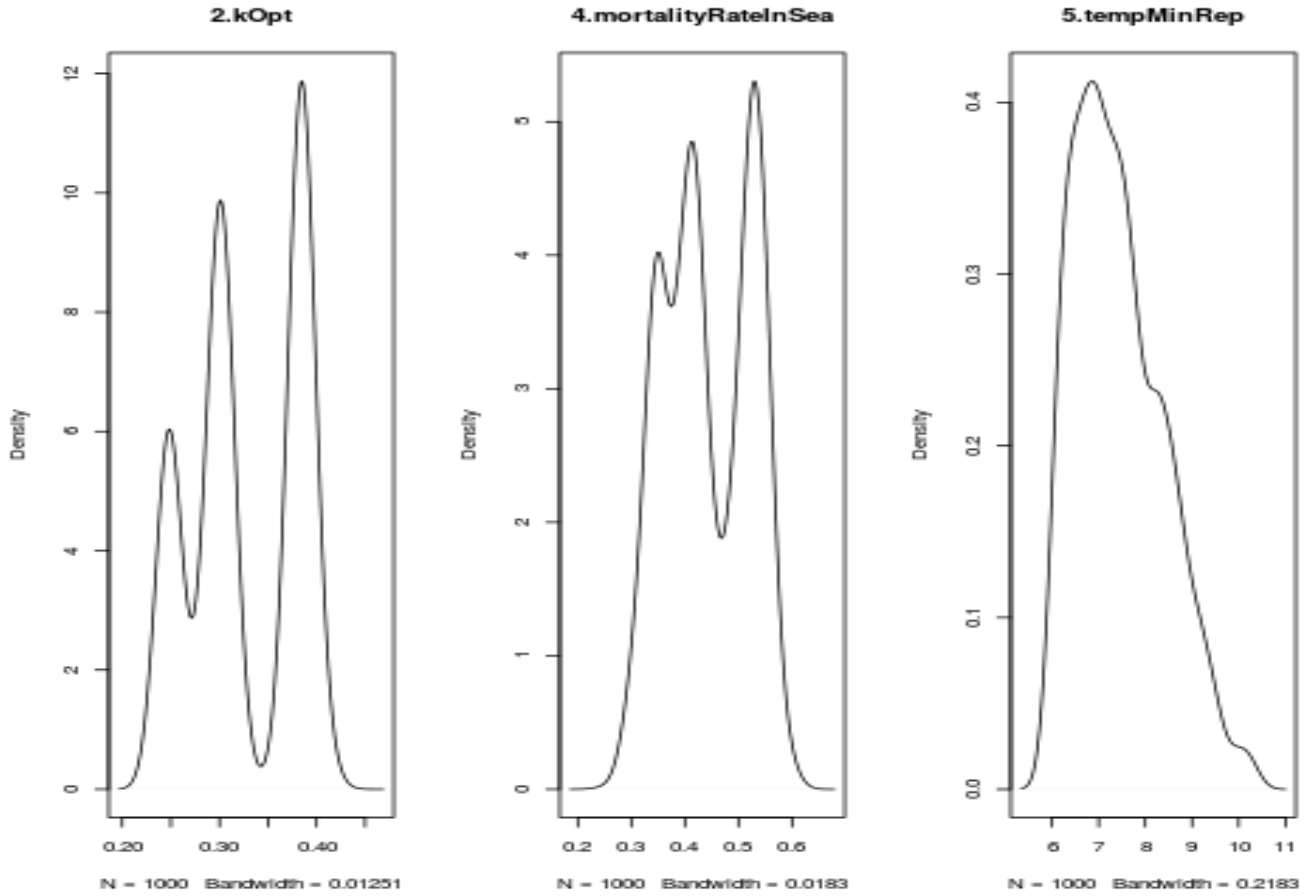
Minimal temperature for eggs survival

Model calibration

Number of initial simualtions: 4000 simuls (the best 1000 simuls were kept); Number of simulations at each step: 3000 simuls; stopping criterion: 0.01

Results

Algorithm converged after 136 000 simulations, *i.e.* 45 steps, *i.e.* 2,5 days



Conclusion/discussion

Jusque là, les résultats ne sont pas à la hauteur de mes attentes…

Des pistes pour améliorer:

- Difficulté dans le choix (problème d'interactions) et le nombre de paramètres à optimiser…

- Difficulté dans la définition des outputs à optimiser…

- Difficulté dans le choix des prior par rapport aux min-max de l'AS…
- Désaccord avec les posterior de certains paramètres… Dois-je les fixer ? Dois-je restreindre les priors ? Cas notamment du paramètre TminRep…

- De part ma connaissance du modèle, j'ai déjà une bonne idée des paramètres influents les outputs et de valeurs vraisemblables pour ces paramètres…
- Dois-je abandonner l'idée de la calibration du modèle sur ce cas d'étude…?

Thank you for your attention…

Contacts:

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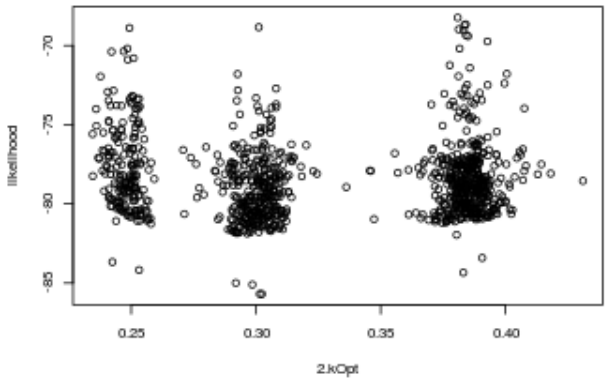
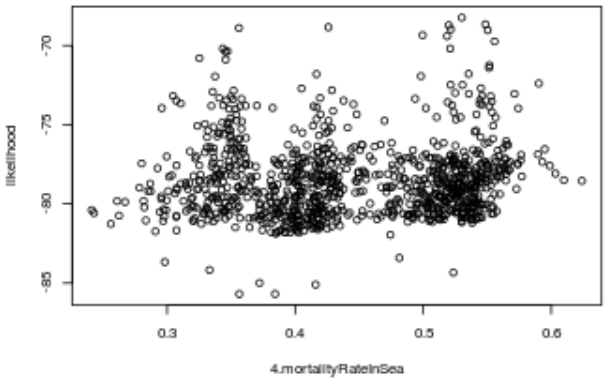
Simulations stats at step 045

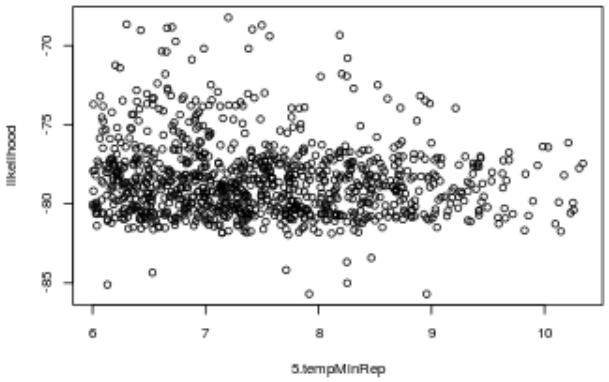
likelihood / 2.kOpt



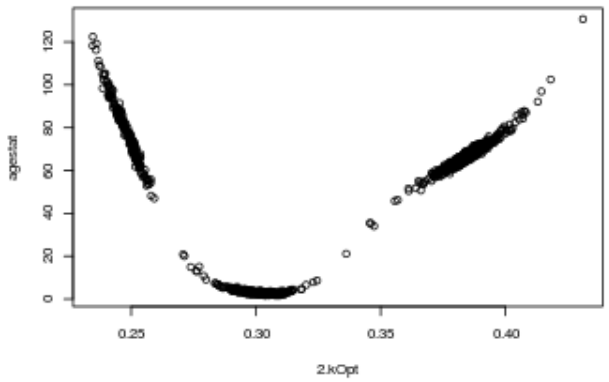
likelihood / 4.mortalityRateInSea



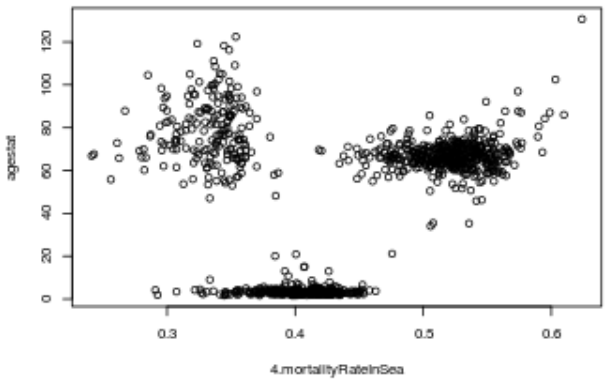
likelihood / 5.tempMinRep



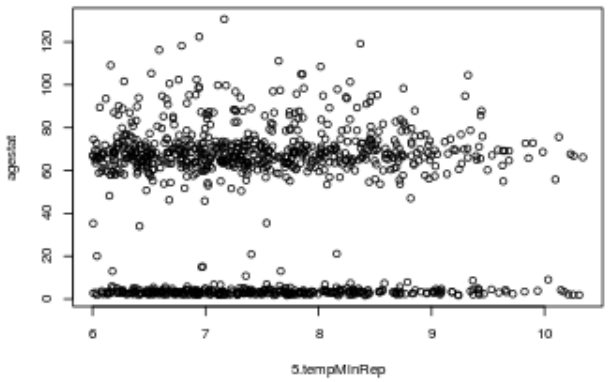
agestat / 2.kOpt



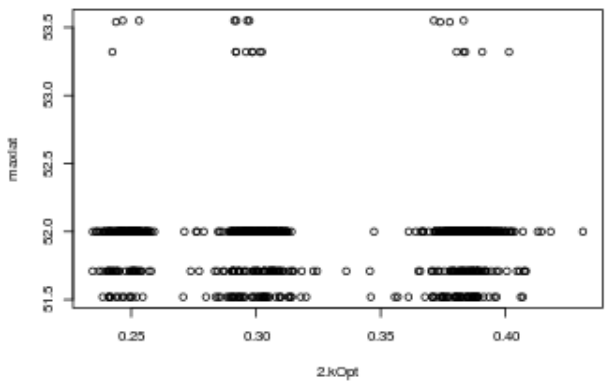
agestat / 4.mortalityRateInSea



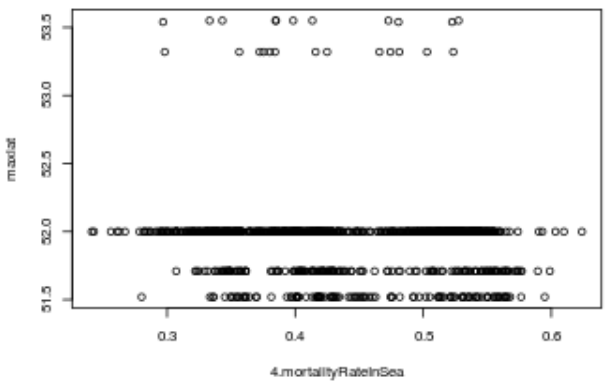
agestat / 5.tempMinRep



maxlat / 2.kOpt



maxlat / 4.mortalityRateInSea



maxlat / 5.tempMinRep