Towards spatial life cycle modelling of eastern Channel sole

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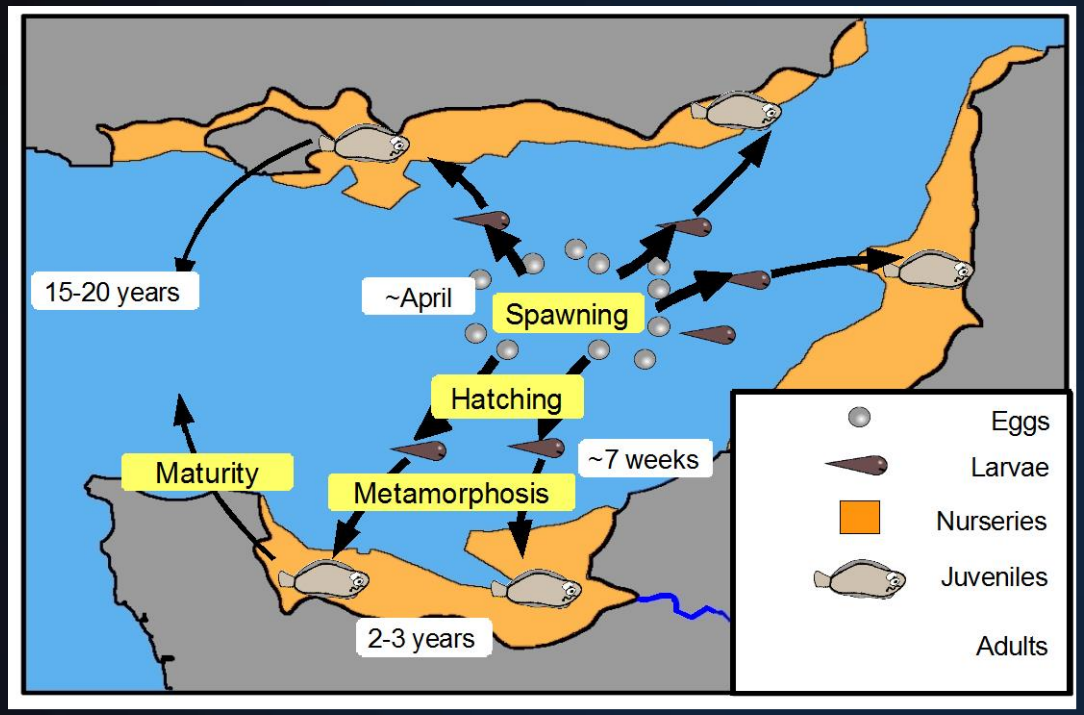
Spatialization of adults ?

- So far (justified) focus on early stages
- Adult spatial structure = missing link towards full understanding of marine population functioning (e.g. adult spatial distribution at the time of spawning may condition larval supply)
- Local actions (e.g. fishing/nursery areas) may have local/global consequences depending on population spatial functioning
- Opens the way to realistic spatial scenarios with assessment of local/global impacts → Ecosys. Approach
- Need to move from theoretical models to real-world case studies

Relevance to case study : sole in VIId



Eastern channel

Solea solea

- Well studied commercially important population (much scientific background, long time series)
- Nursery-dependent species with 5 well known coastal/estuarine nurseries
- Indices of very limited early stages connectivity between regions (Rochette 2012)
- Coastal (i.e. regional) fisheries
- Limited adult movement

Model

Based on Rochette et al. 2013

Egg-to-metamorphosis IBM coupled with hydrodynamic model

Hydro-climate

→ *estimation of larval allocation amongst identified nursery areas*

Juvenile habitat suitability model

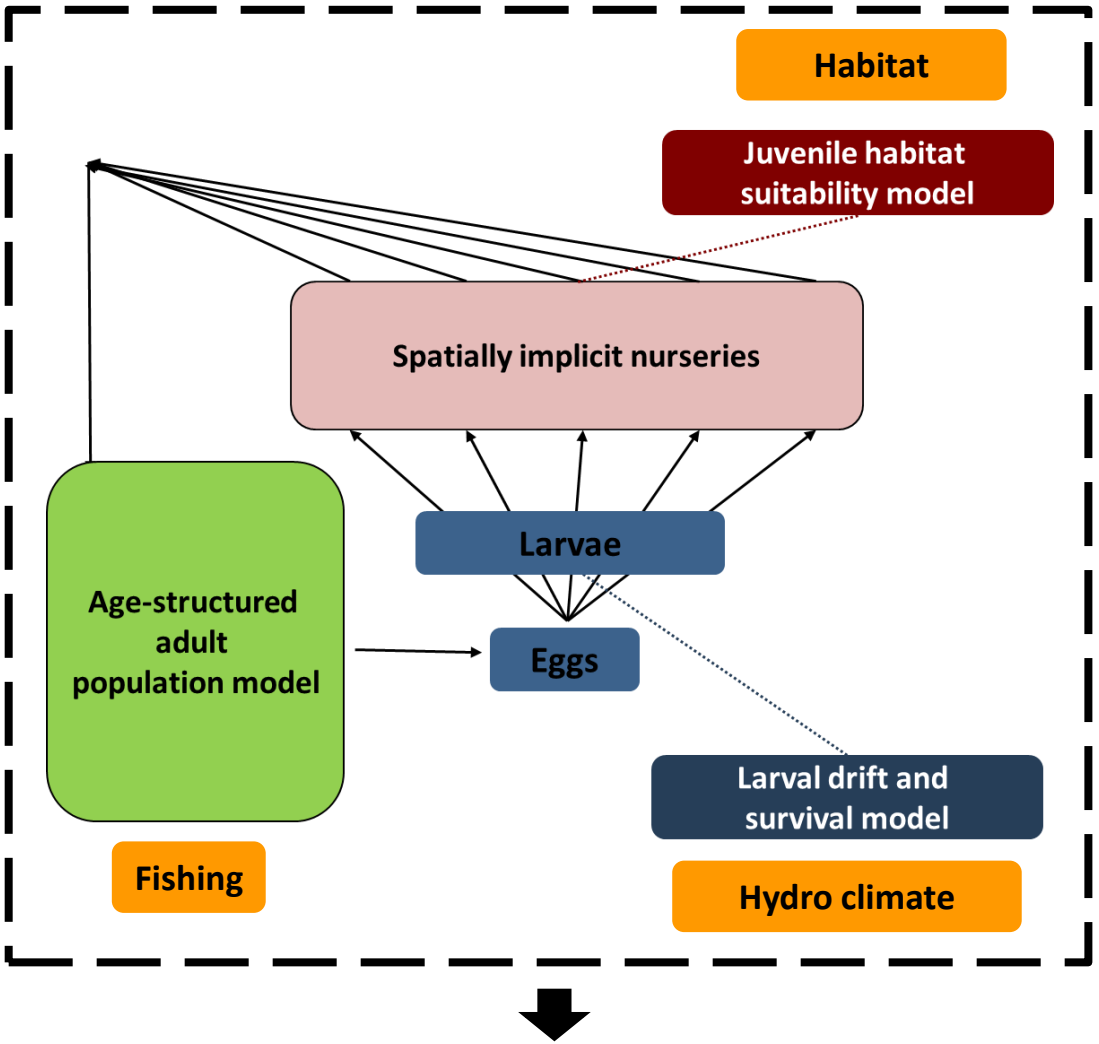
Habitat descriptors

→ *juvenile abundance indices in nursery areas*

Adult age structured model

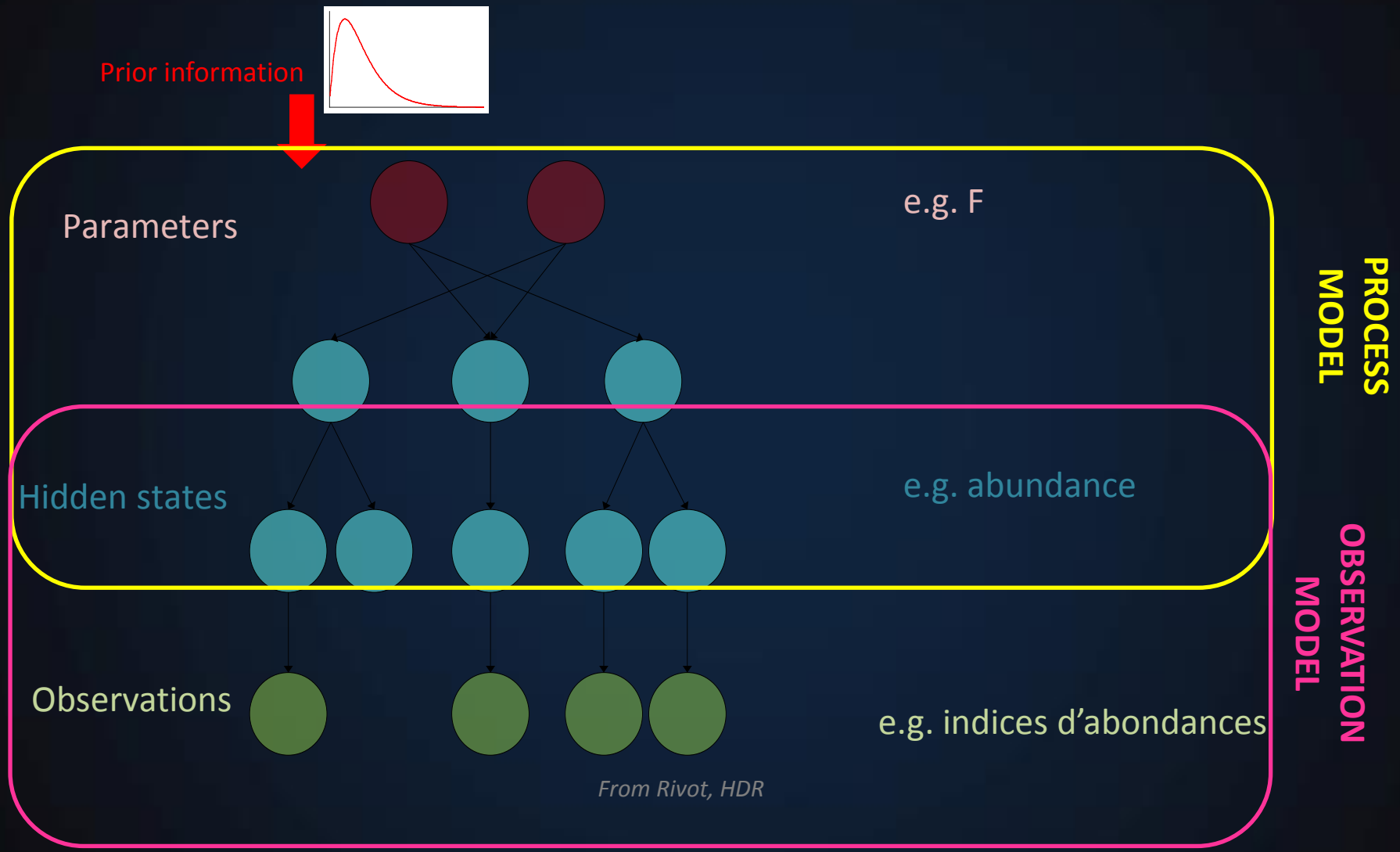
fishing & natural mortality

→ *commercial and scientific catches*

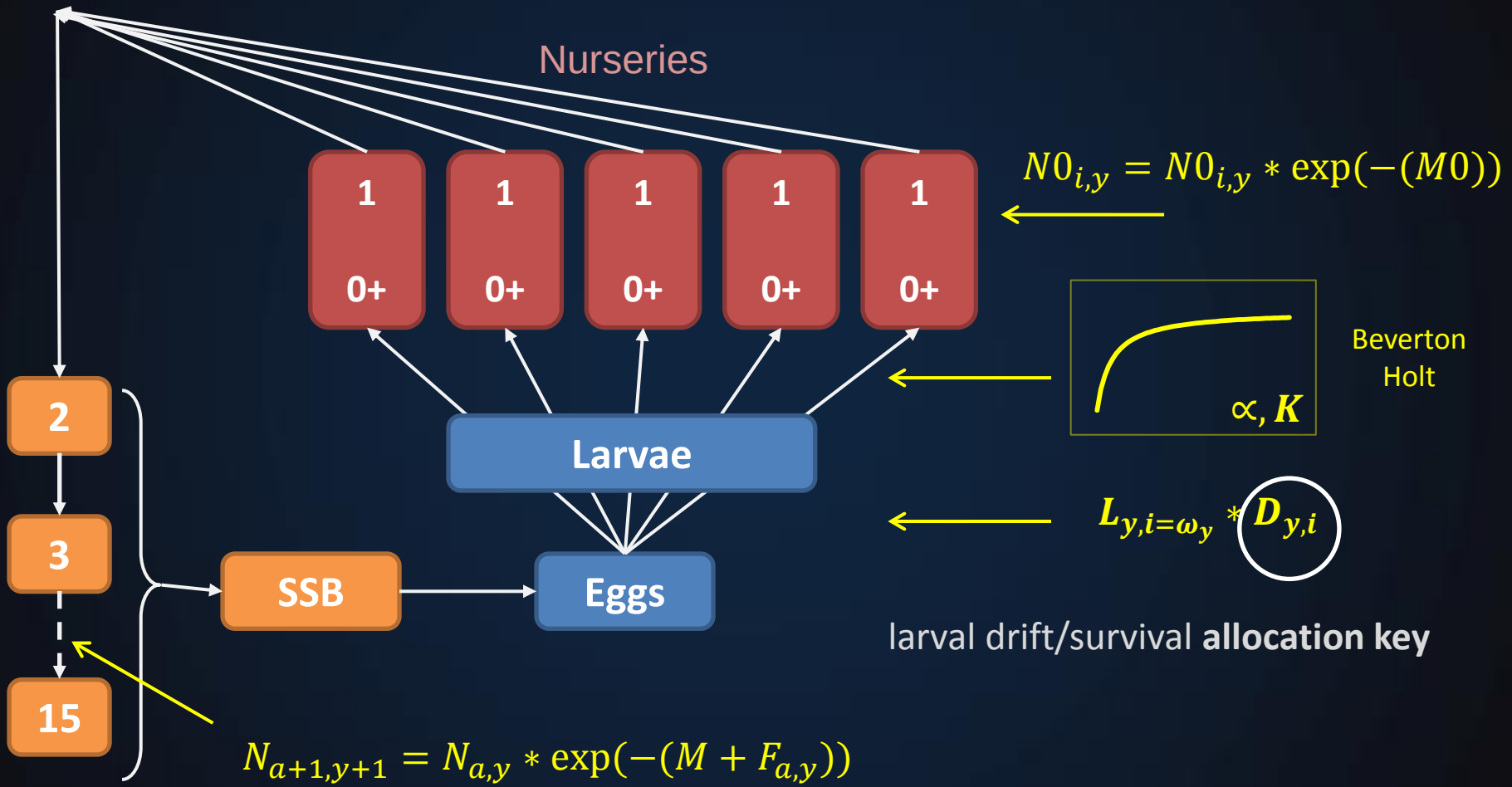


Hierarchical Bayesian Modeling framework

Hierarchical Bayesian Model

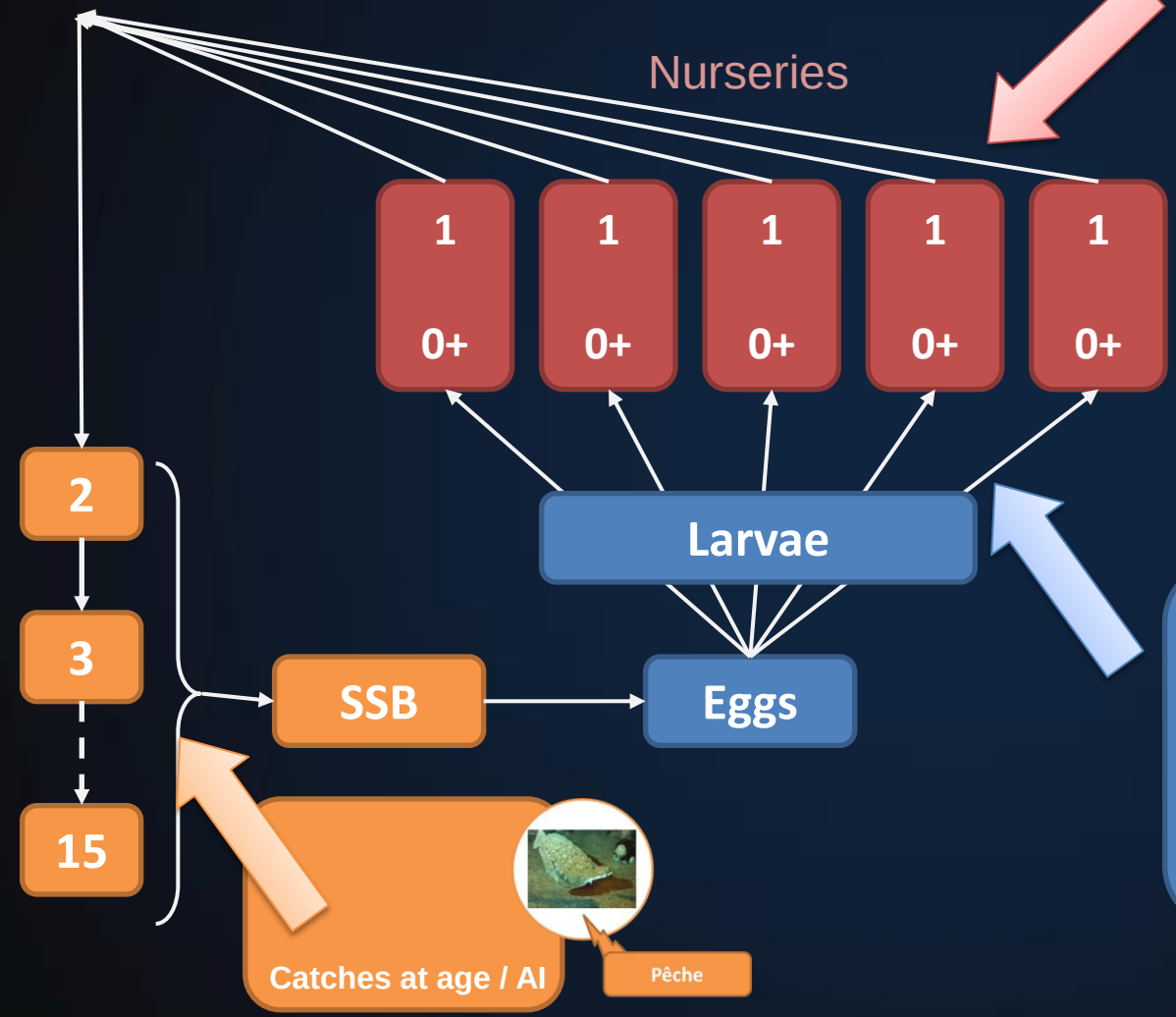


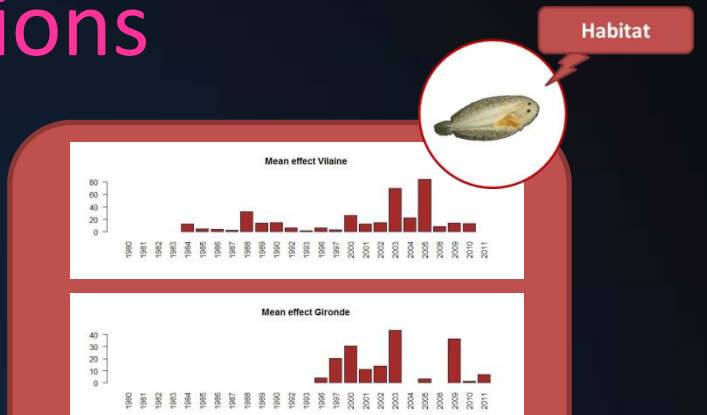
HBM : processes

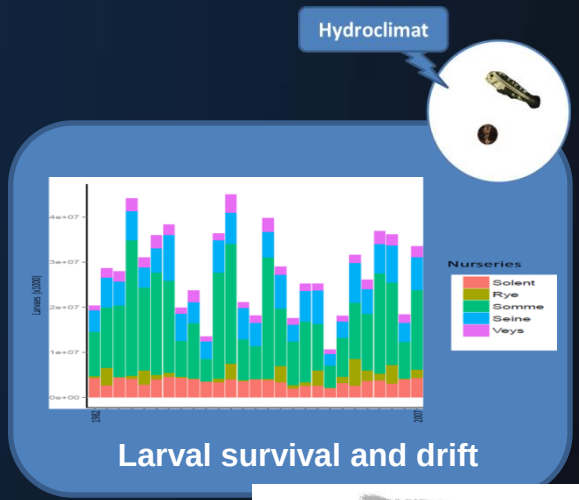


HBM : observations

1982 to 2011





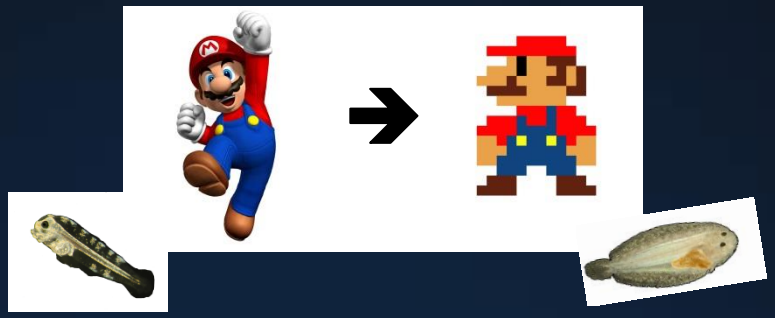


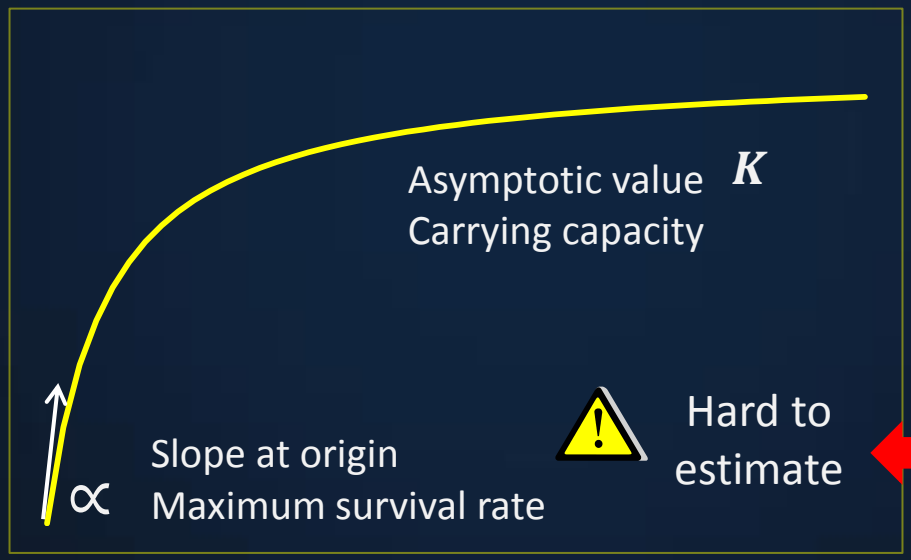
$$log(I_f) \sim Normal(log[q_f] * N * -0.5 * \sigma_f^2.\sigma_f^2)$$

$$D_{r,y,i} \sim Dirichlet(LKey_{r,y,i})$$

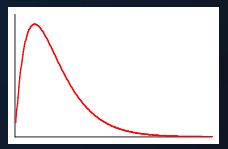
Density-dependence in nurseries

From 3D to 2D….





Prior information



Integrating a priori information on α

If I have seen further than others,
it is by standing upon the
shoulders of giants.

Sir Isaac Newton

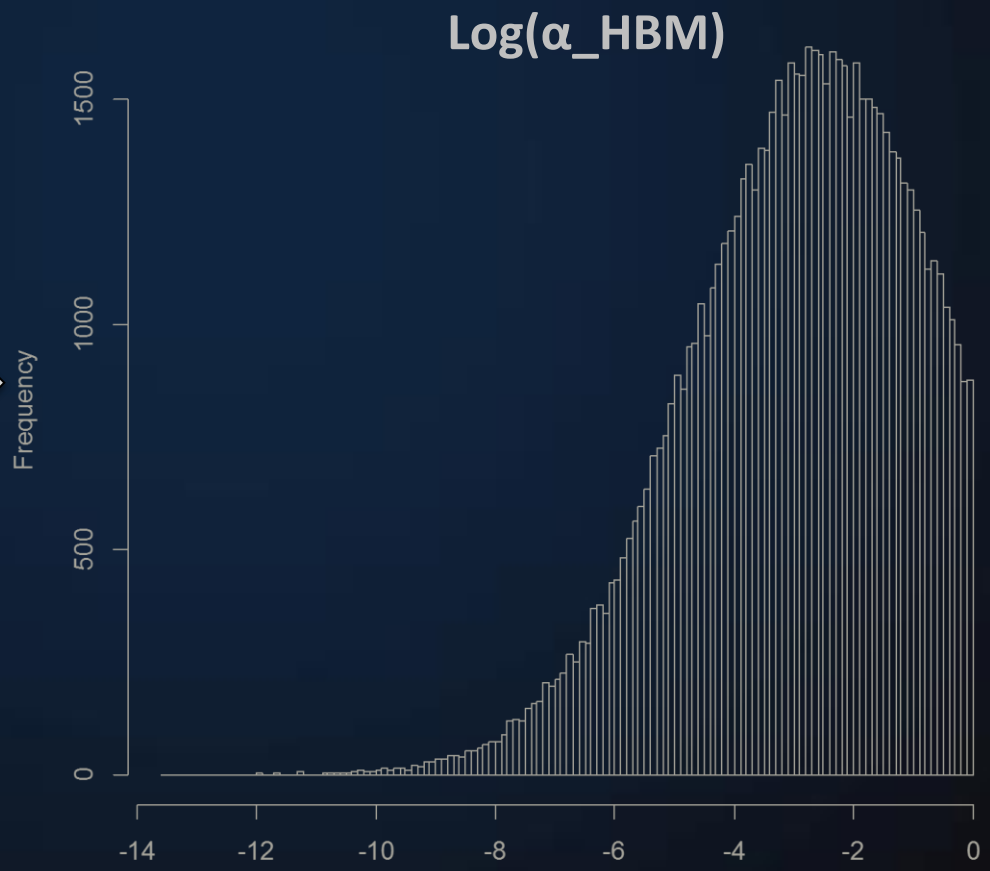
Archambault et al 2014.

Meta-analysis of stock recruit relationships in flatfish

α_metanalysis

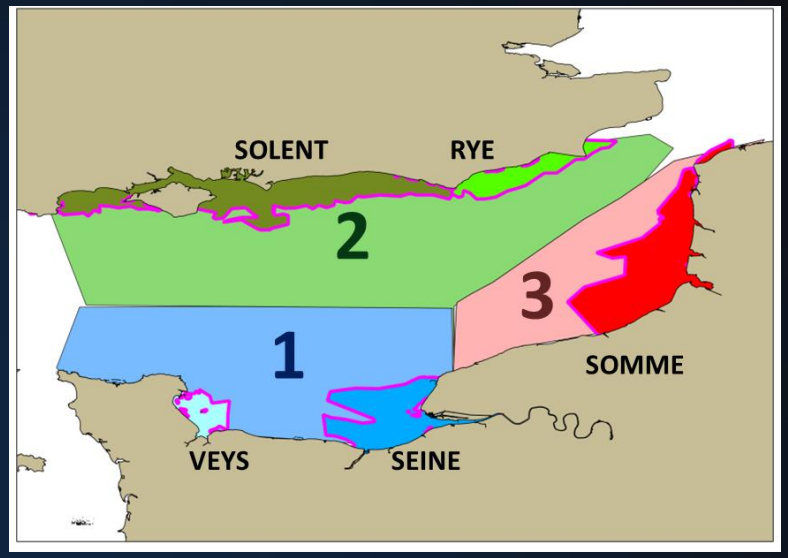
transformation

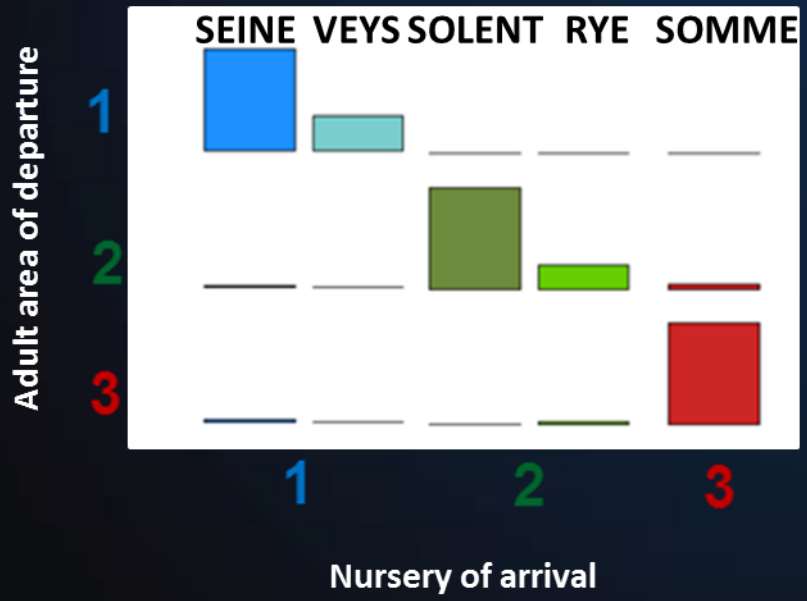
VIId sole life history



Back to regionalisation

- Definition of 3 regions
  - 1 : Veys/Seine (1 spawning ground)
  - 2: UK (2 spawning grounds)
  - 3: Somme (3 spawning grounds)



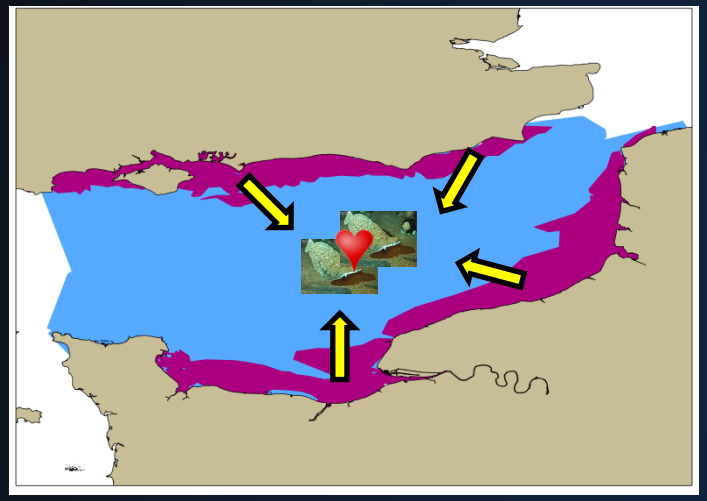


Rochette et al. 2012 + comm. pers. Baulier Savina

- **Larval retention** between spawning areas and adjacent nurseries

Two alternative scenarios

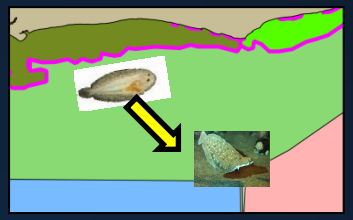
NON SPATIAL



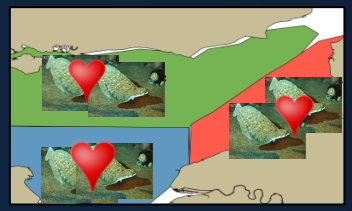
One **panmictic** population :

- Juveniles migrate to the **global population**
- Adult repartition at reproduction follows **observed eggs map**

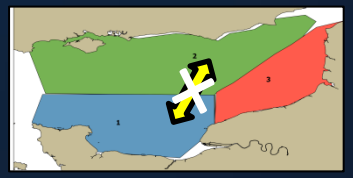
SPATIAL



- Juveniles from a given nursery migrate to the **adjacent** adult zone



- Adults reproduce in spawning areas **within their respective zone**

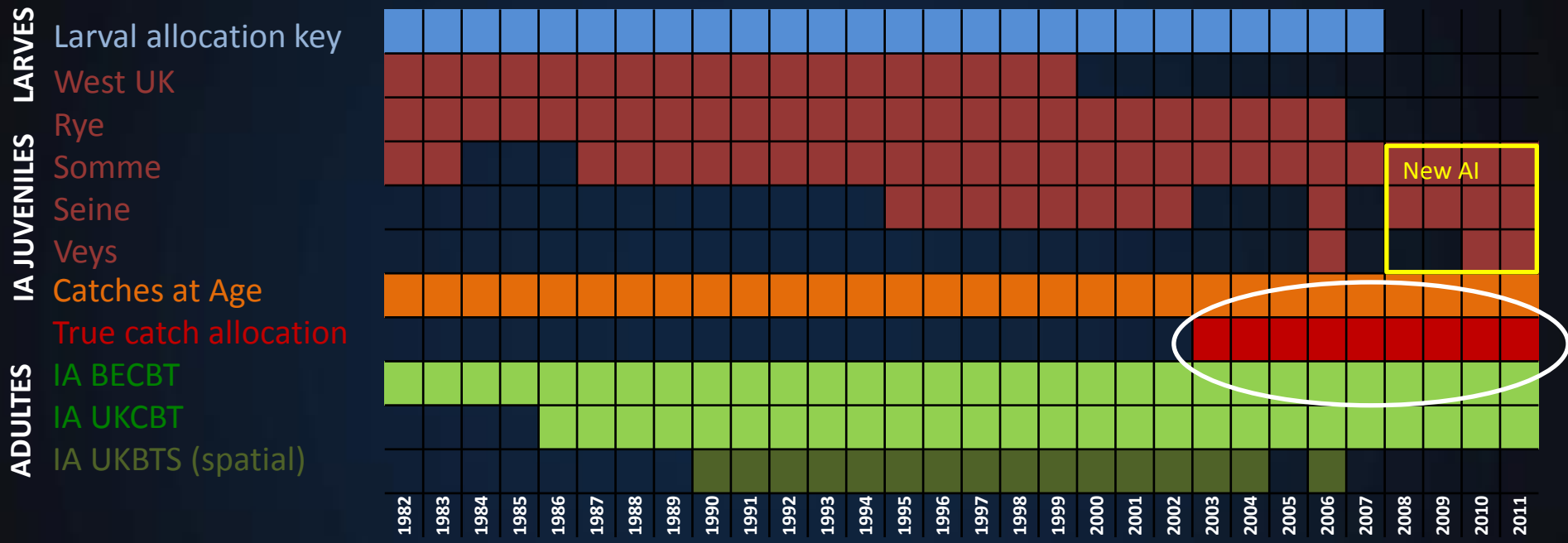


- **No adult movement** between zones

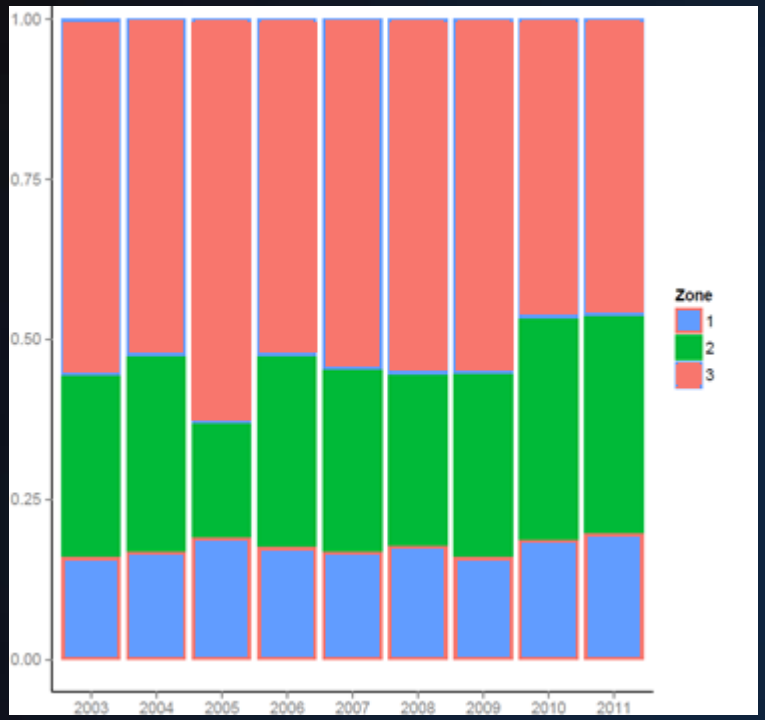
➔ **Mixing between zones** intervenes solely through (limited) **larval dispersal**

+ IA spatial
+ Spatialized catches

Data sources



« Spatialazing » catch data



Ratio of catches (weight) over the 3 regions since 2003

- **True** spatial catches (in **weight** only) since 2003
- Relatively **stable ratio** among regions since 2003

2 hypotheses

➔ Identical catches **age structure** among regions

➔ Pre-2003 **spatial repartition of catches similar** to 2003-2011

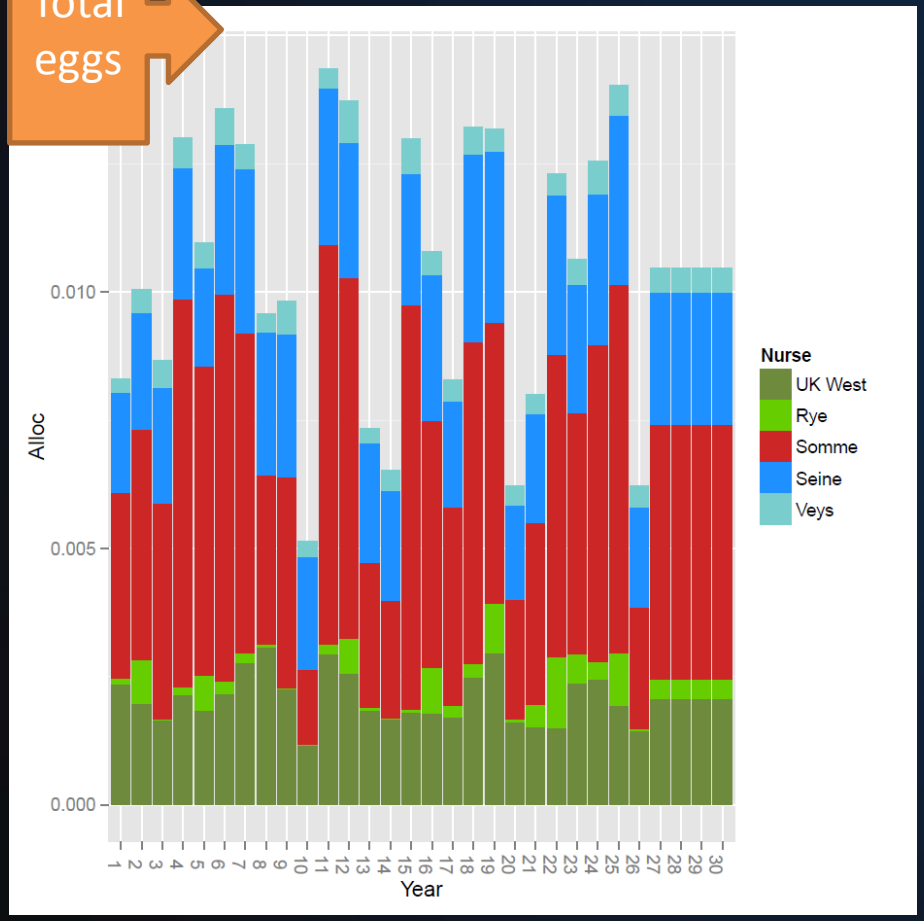
Two alternative scenarios : consequences on larval survival and dispersal

NON SPATIAL

1991 egg maps

SPATIAL

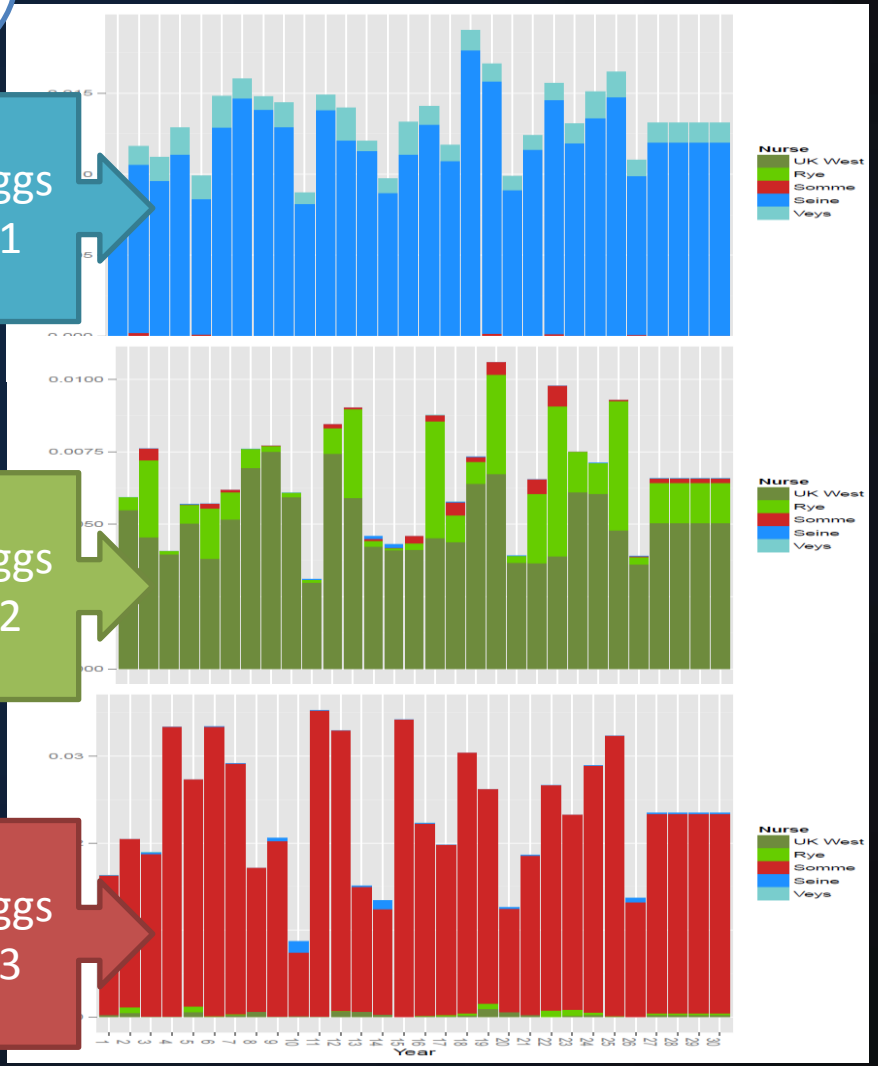
Total eggs



Eggs 1

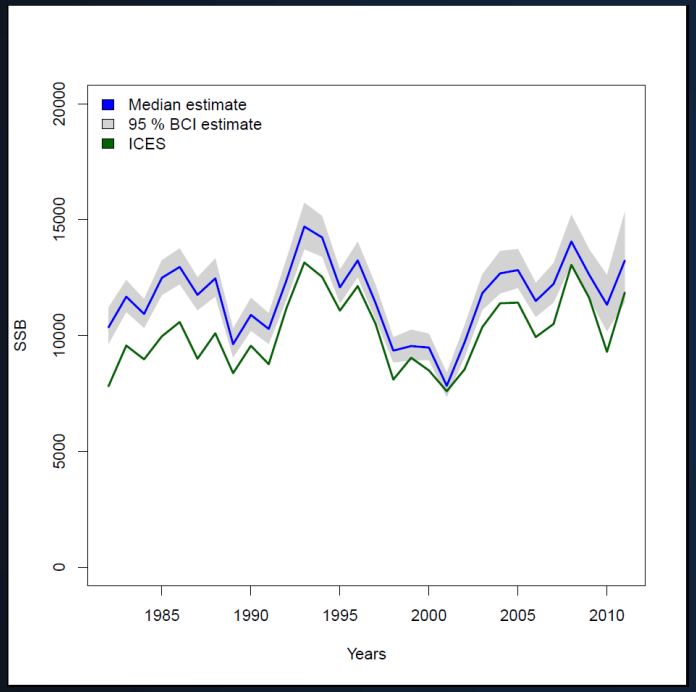
Eggs 2

Eggs 3



Results : SSB estimates

NON SPATIAL



Consistent with ICES

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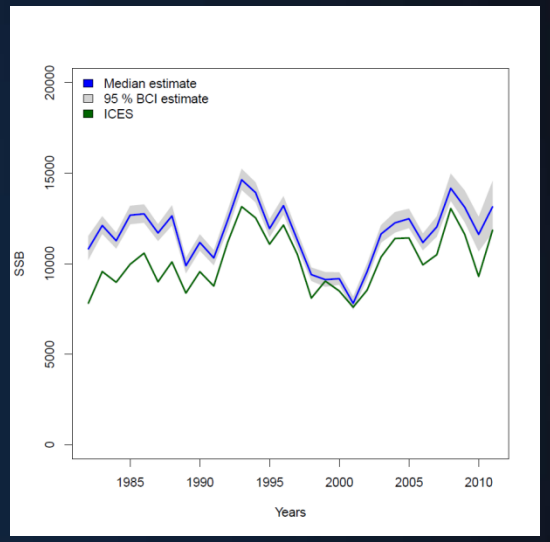
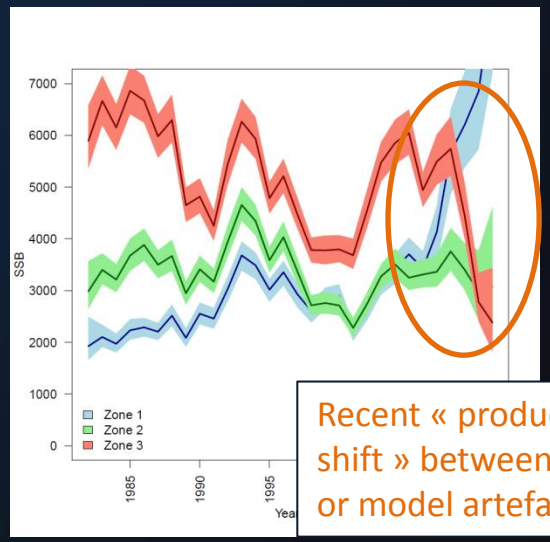
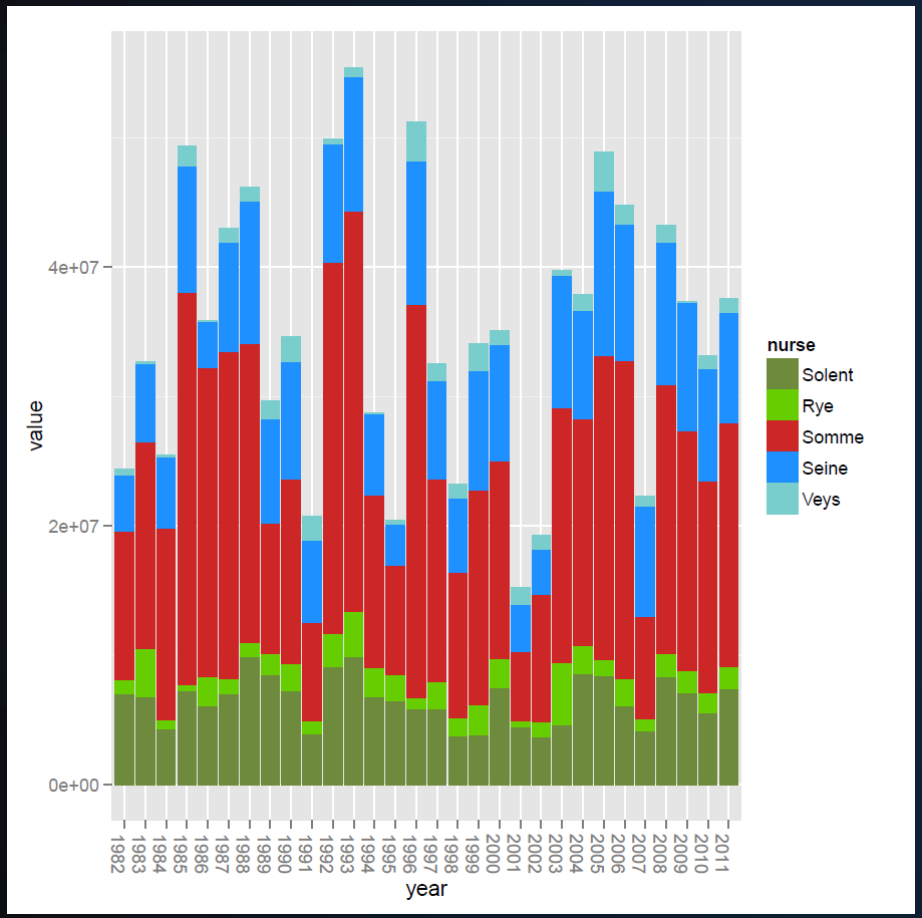




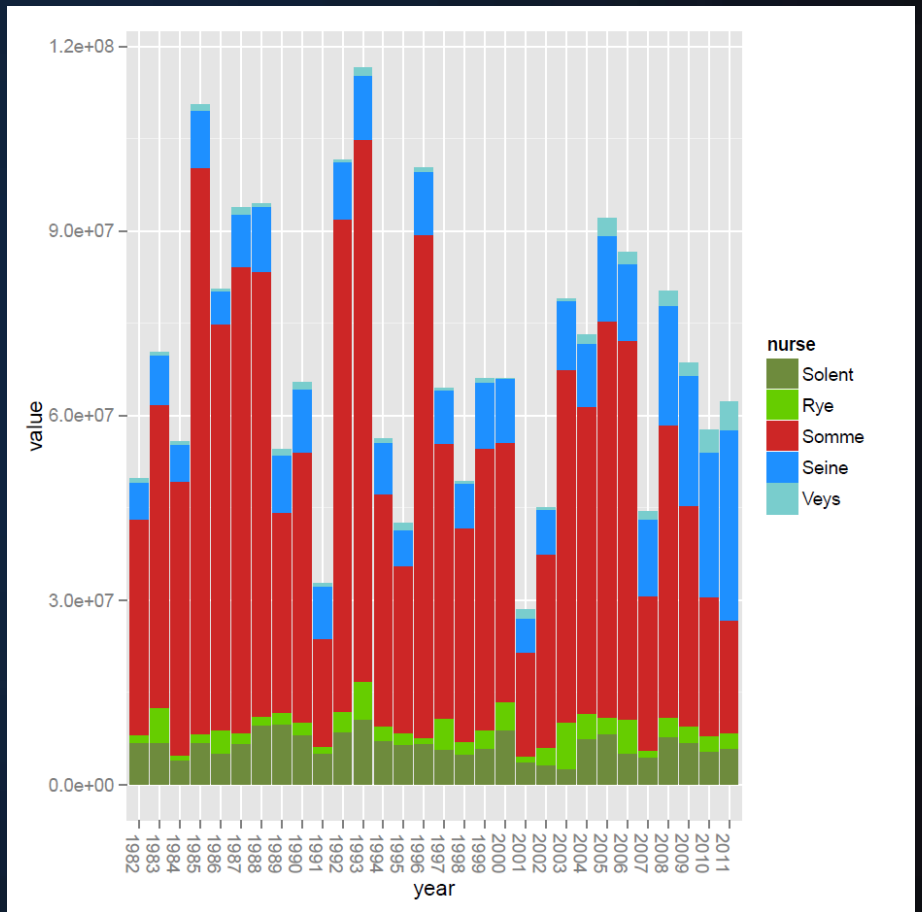
Recent « productivity shift » between regions or model artefact ?

Results : larval allocation

NON SPATIAL



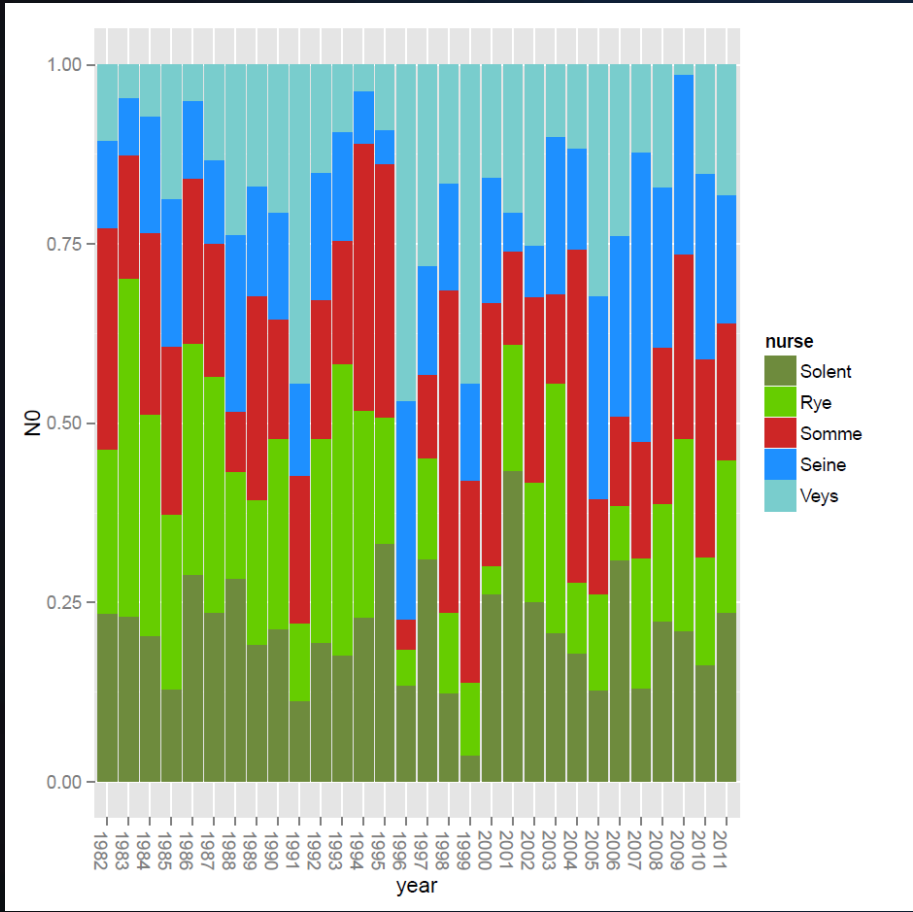
SPATIAL



Small contributions differences – higher input from Somme in spatial scenario

Results : nurseries contribution to population ➔ Past proportions of Age 0 per nursery sector

NON SPATIAL



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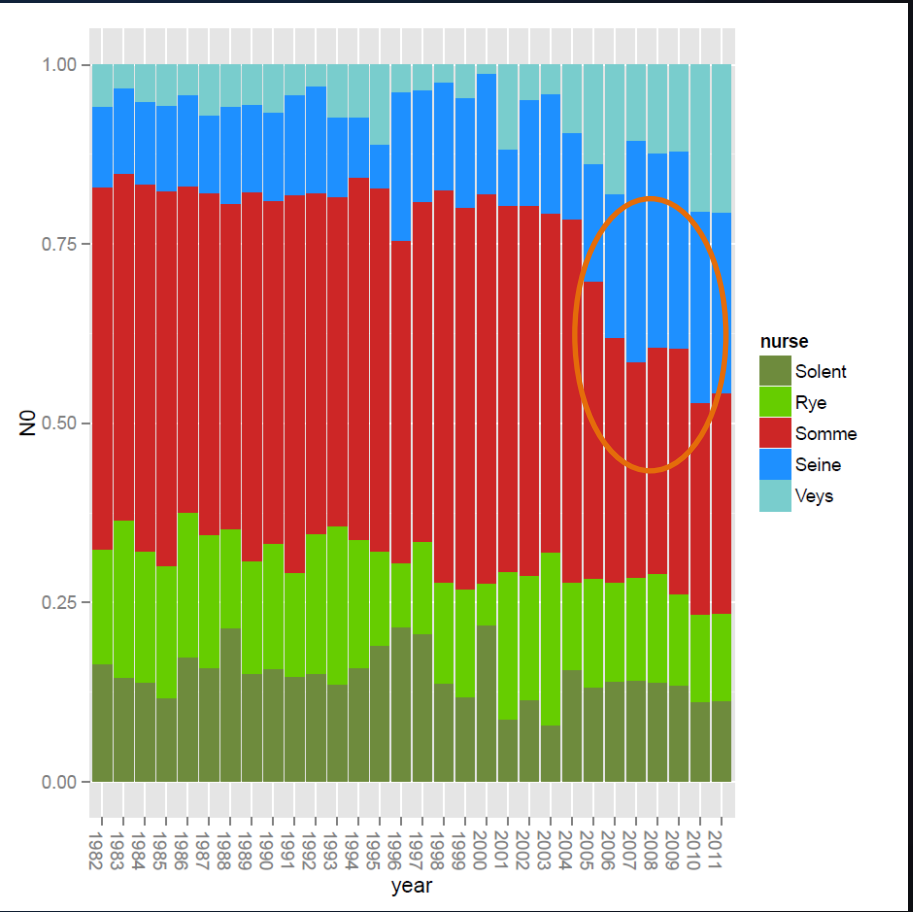
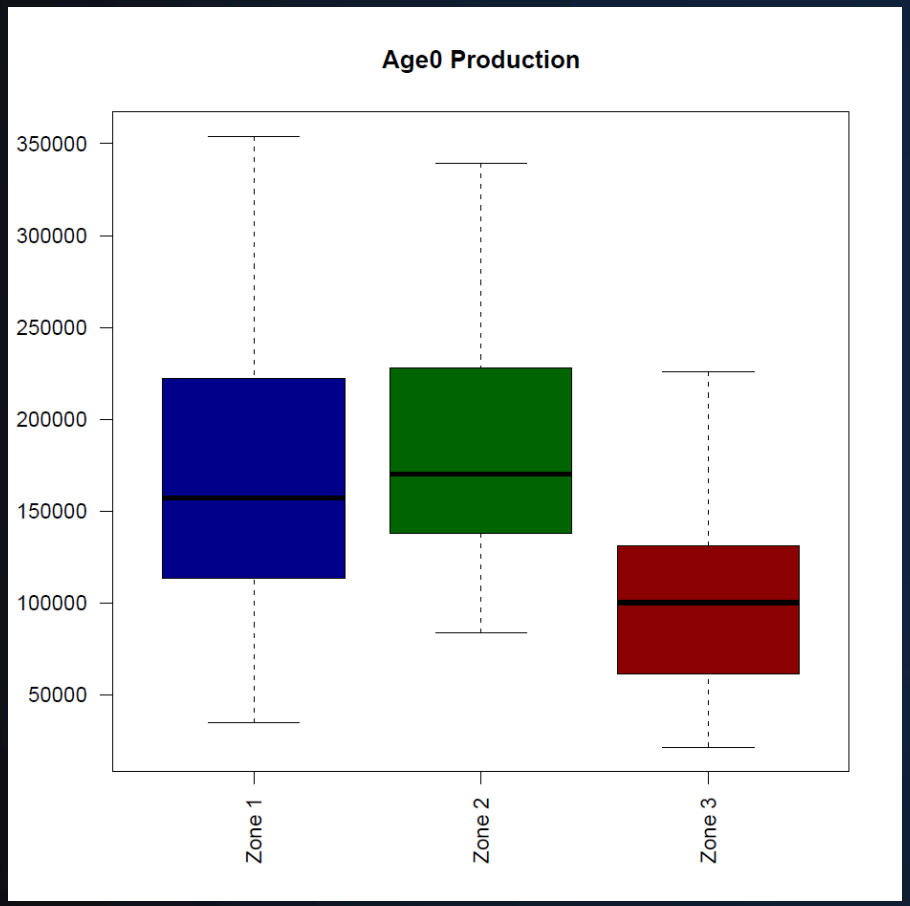


Much higher Somme contribution to population + less variability in spatial model

Results : nurseries contribution to population ➔ Past production of Age 0 per region

NON SPATIAL



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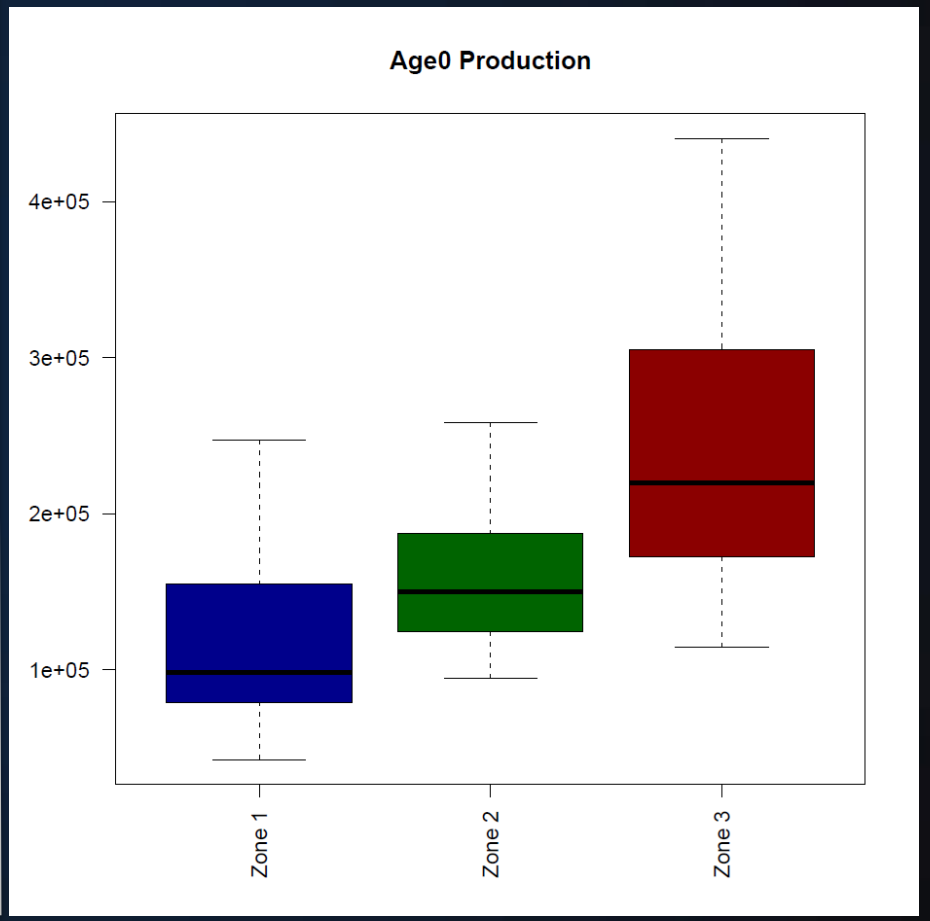

Much higher Zone 3 contribution to population in spatial model

Results : nurseries contribution to population parameters estimates

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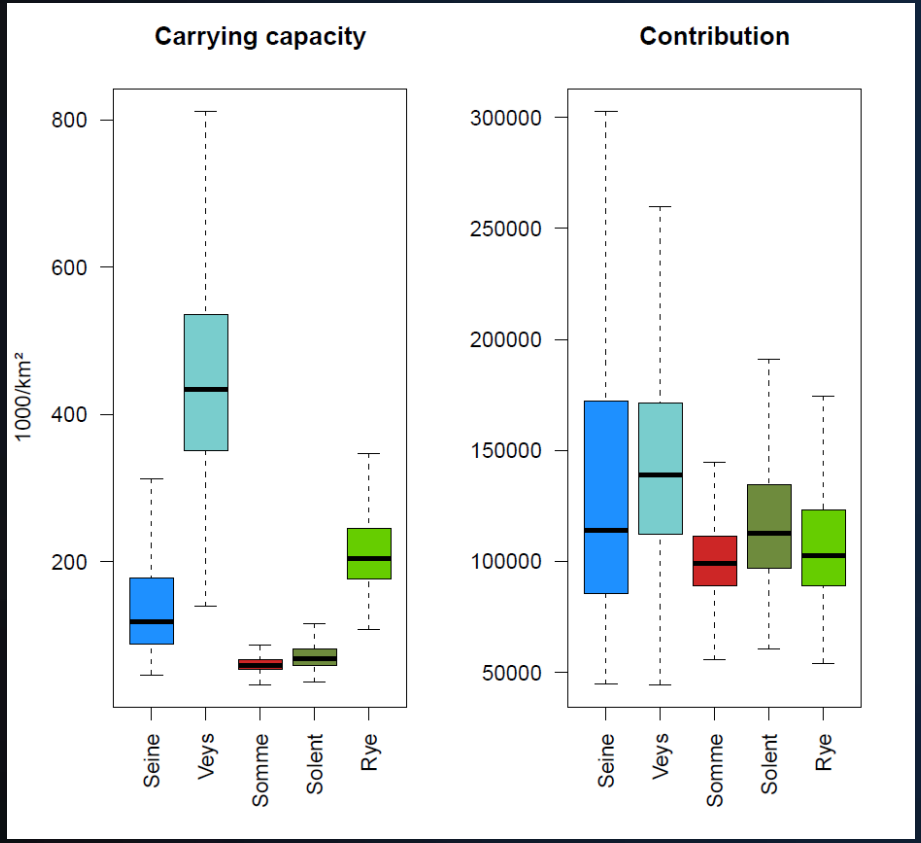

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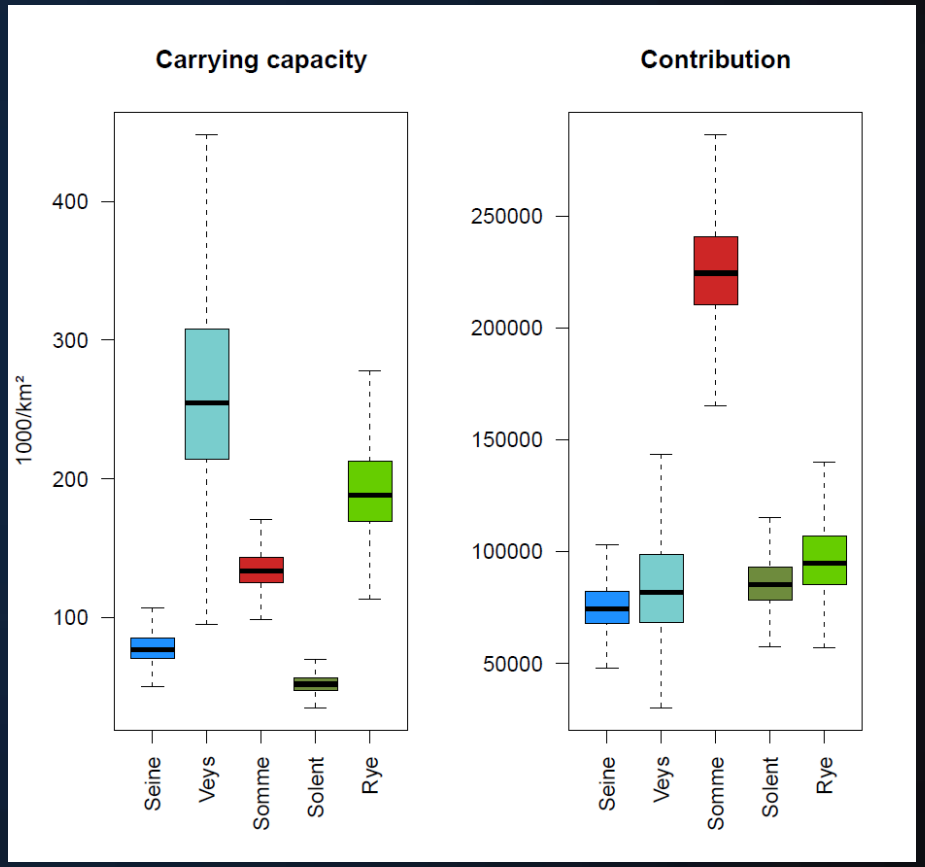
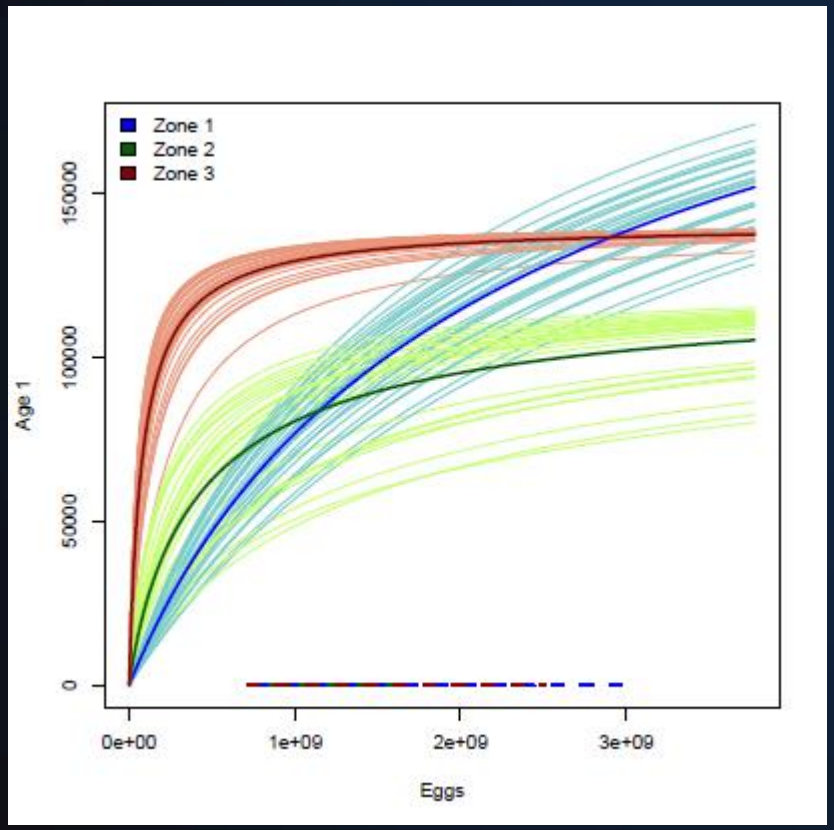
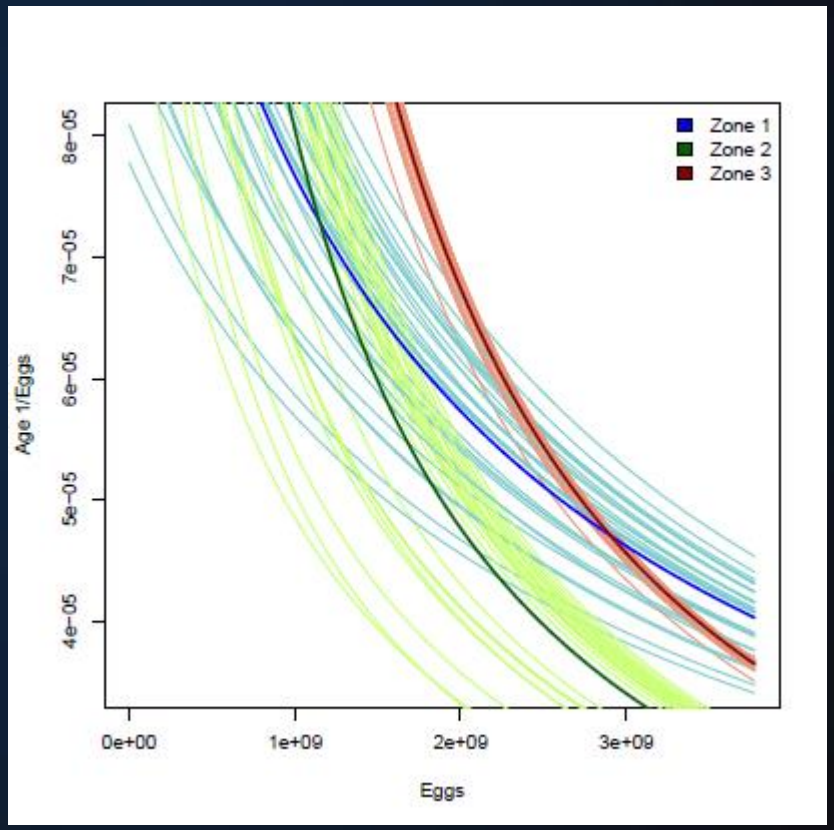


Possible differences between past production and parameters (K is maximum production/surface) I.e. veys

Results : estimating local potential productivities

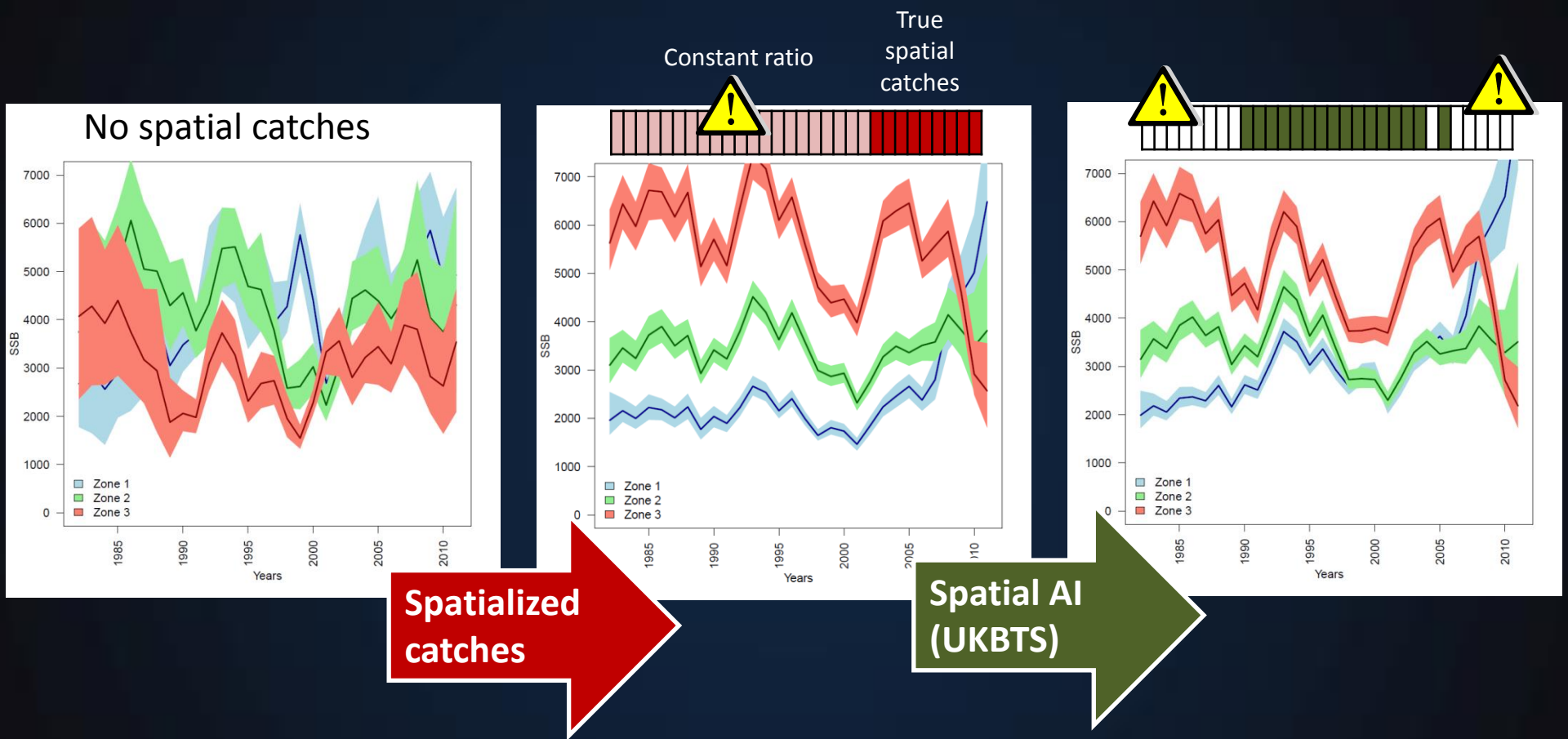


From eggs to Age 1

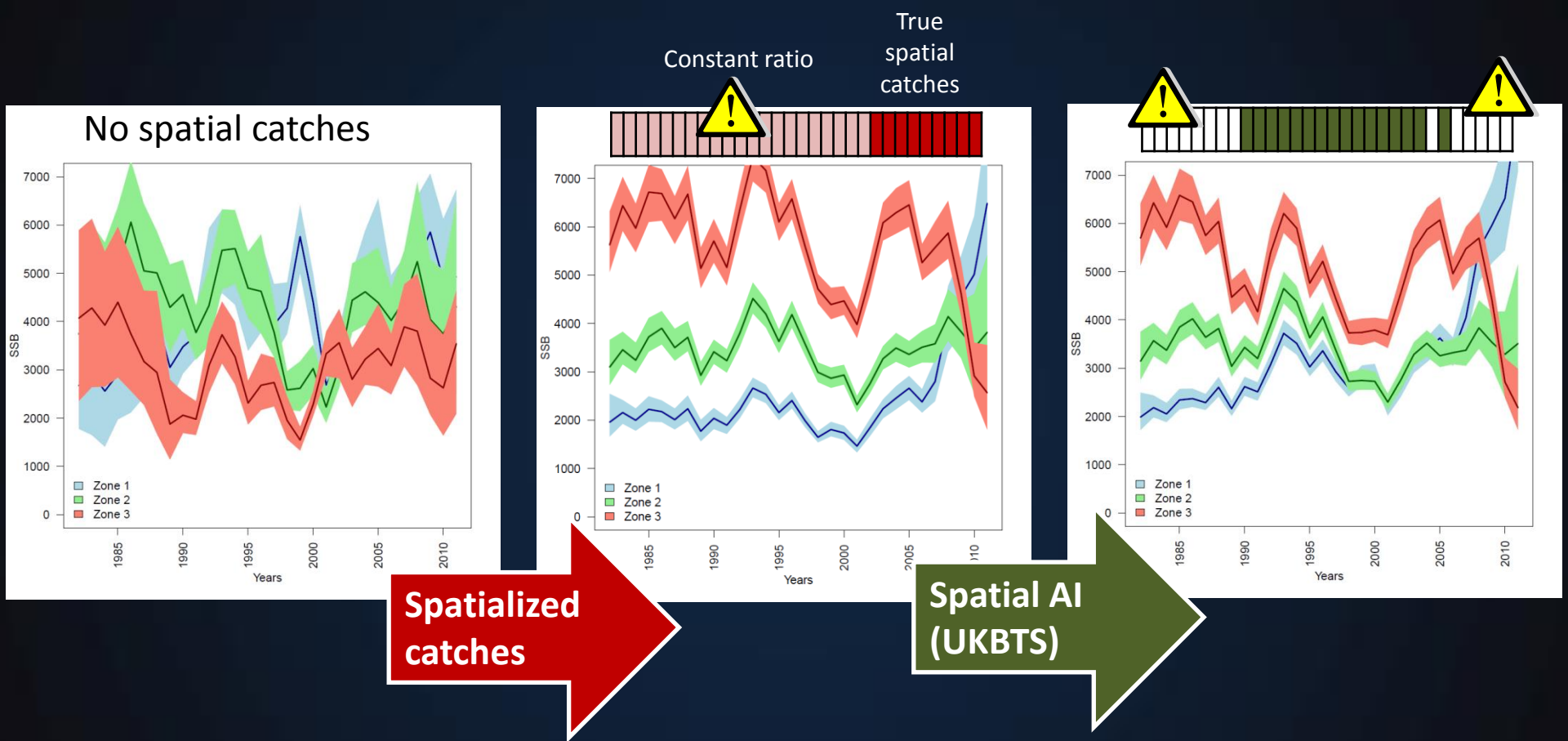


Survival

Contribution of the different data sources



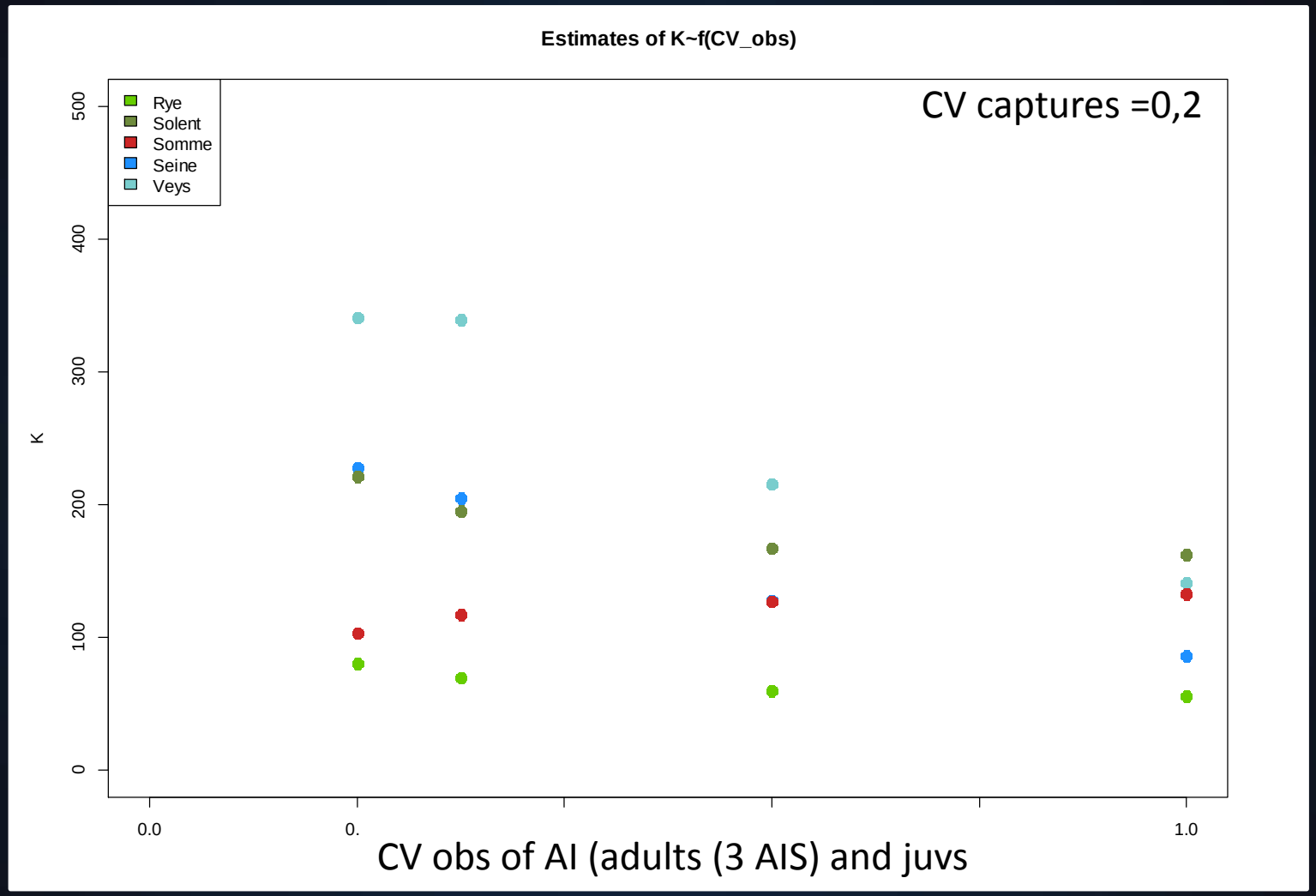
Contribution of the different data sources



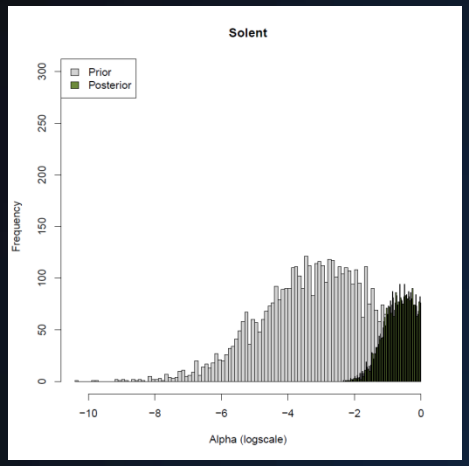
➔ We need data !

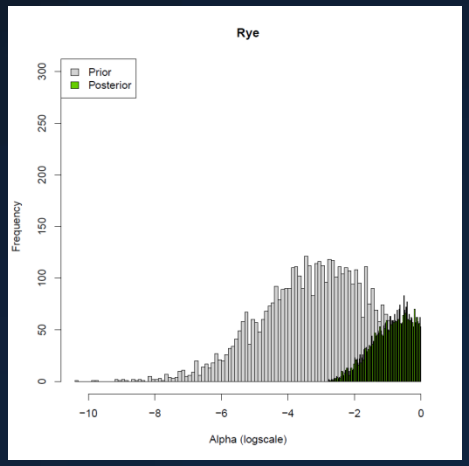
➔ Identification of data needs (e.g. past spatial catch reconstruction)

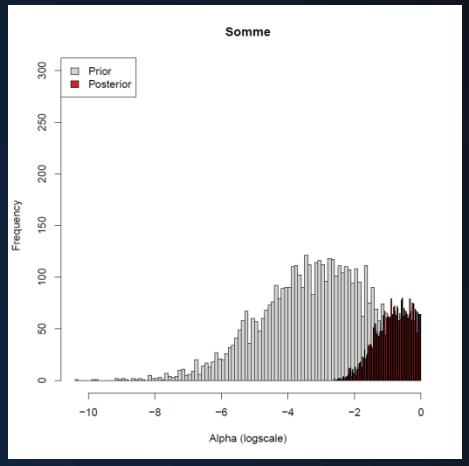
Sensitivity to observation error levels

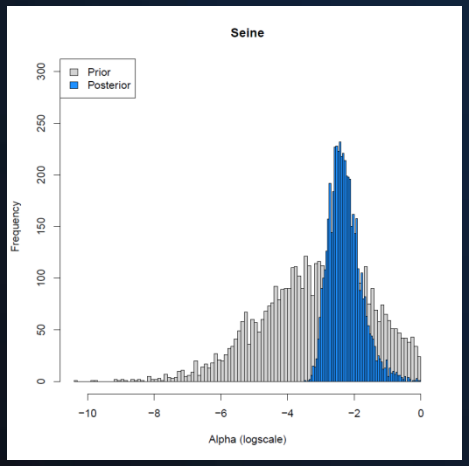


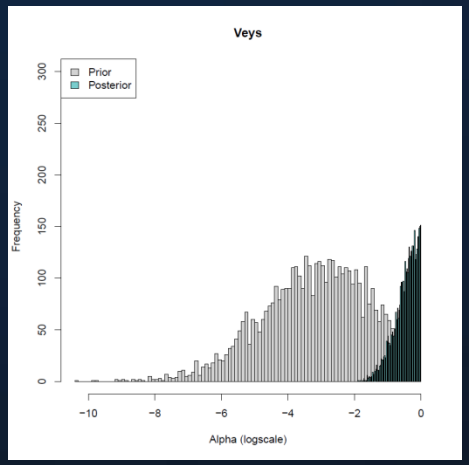
Informative prior ?











Spatialization of adults : room for improvement

- Generally, attempting to model full spatial functioning of population may **help to identifity specific needs** in data : e.g. on a specific sector/region, specific aspects (genetics, mark/recapture)

- In given case study, both spatial hypotheses are probably wrong, reality in between ? ➔ Easy to explore (e.g. migrations), hard to choose.

Spatialization of adults : new opportunities

- **Assessment of stock health at a finer scale** ➔ implication for regional fisheries. (e.g. recent drops in Somme region catches)
- Reevaluation/precisions of **habitat contributions** to population renewal
- HBM = ideal framework to integrate data, processes and prior knowledge in such cases
- Rooms for **spatial scenarios** (e.g. restauration/degradation of habitats) = Next and last step !

Scenarios

A2 → Diminution de la qualité et/ou surface des nourriceries. Surexploitation par la pêche.

B1 → Préservation et/ou restauration des nourriceries, exploitation au RMD.