10 years of Eel Restocking in France

&

Experience from the Loire river

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Interreg Atlantic Area European Regional Development Fund

EUROPEAN UNION

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Restocking : a key measure of the European Eel Management Plan

Objectives :

- Increase spawning biomass (e.g. silver eels) by restocking favorable habitats where the european eel populations are depleted
  - Reduce mortality & increase growth rate
- Mitigate the low connectivity of rivers by translocating glass eels upstream obstructions (chemical or physical)
- Choose favorable growth habitats that produce high quality spawners (low density, low mortality, good ecological status of the water)

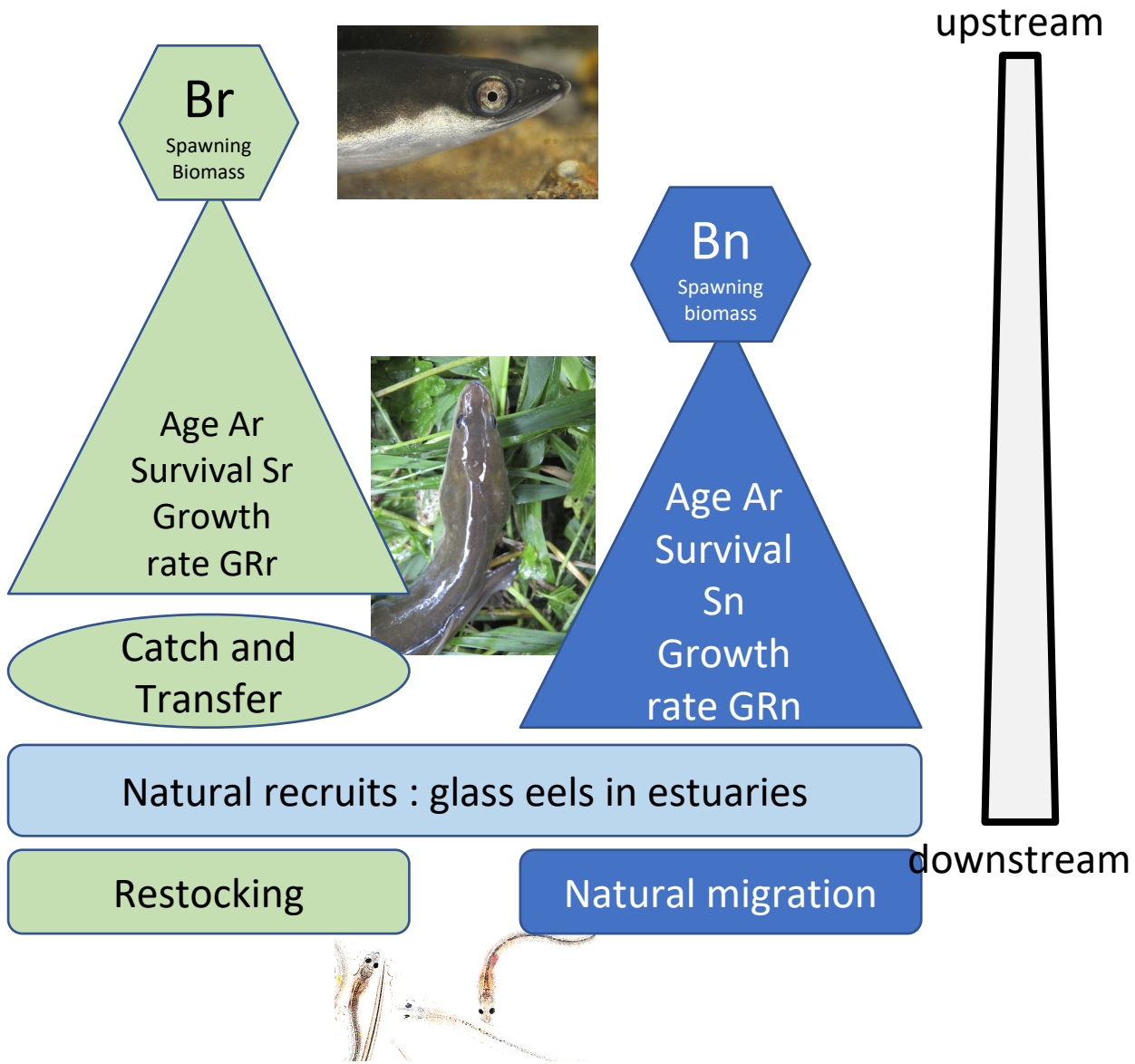
Main Pitfalls

- Is restocking an efficient measure to sustain eel stocks?
  - Long term experience throughout Europe… See Laurent Beaulaton's presentation
- Genetic pollution; evolutionary consequences ?
  - See Hermione Froelicher's presentation, and other literature.
  - → Favor intra catchment translocation
- Do translocated silver eels find there way to the spawning areas?
  - Studies converge to suggest that silver eels from restocking have similar migration behaviours and routes than naturally recruited silver eels.
  - → Limit long distance transfer.
- And what if we simply left glass eels migrate on their own ?
  - Comparison of restocked vs natural recruitment

Assessing the efficiency of restocking

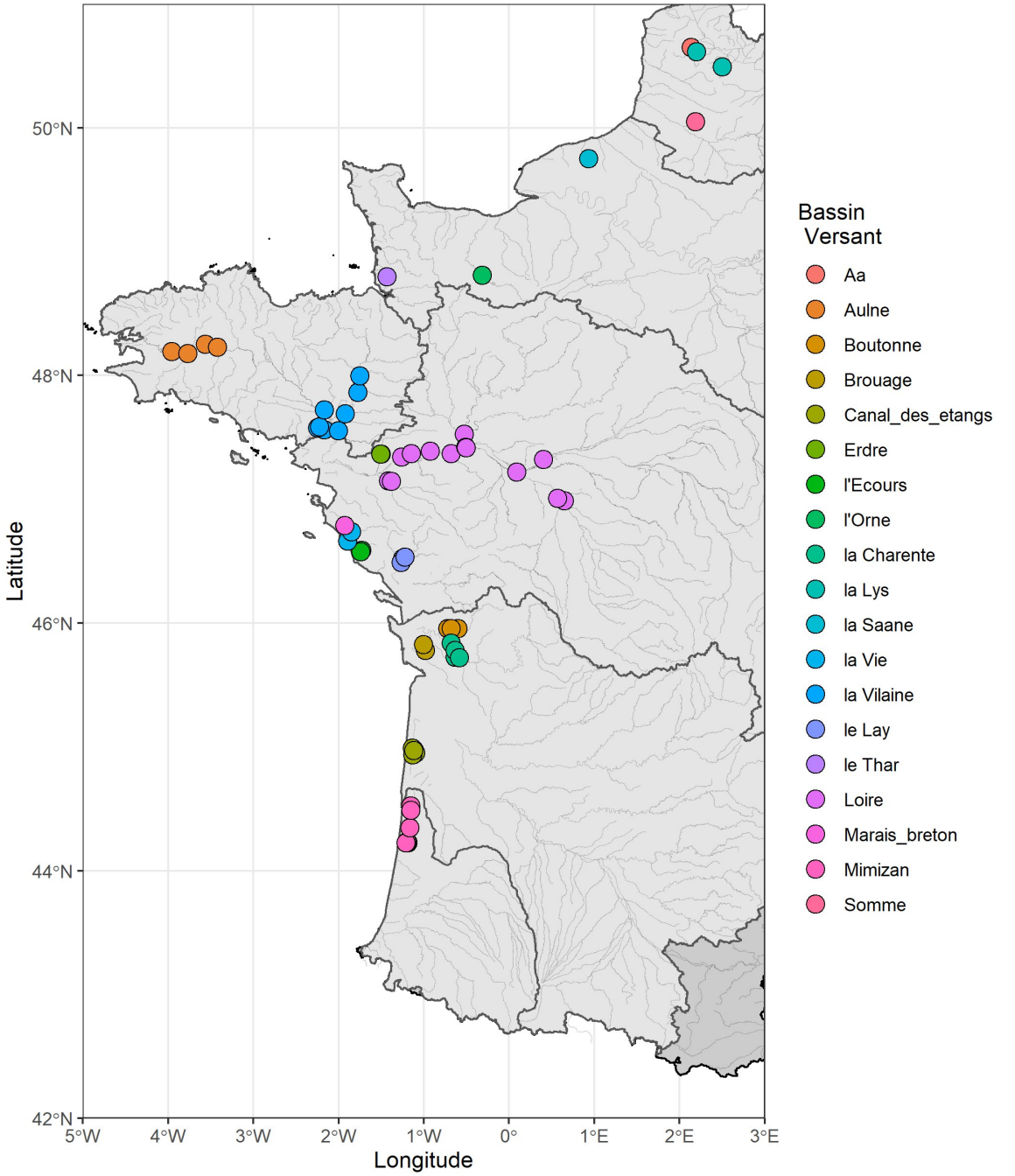
- Restocking is biologically efficient if :

1. Sr > Sn
2. GRr > GRn
3. Br > Bn



Restocking in France

- **72 (re)stocking projects**
- **88 M** glass eels transfered
- **19 Catchments**
- **6 Management units**
- Surveys at **6, 12 et 36 months after release**
- **2 M€ year^{-1} since 2012**



What is measured during the surveys?

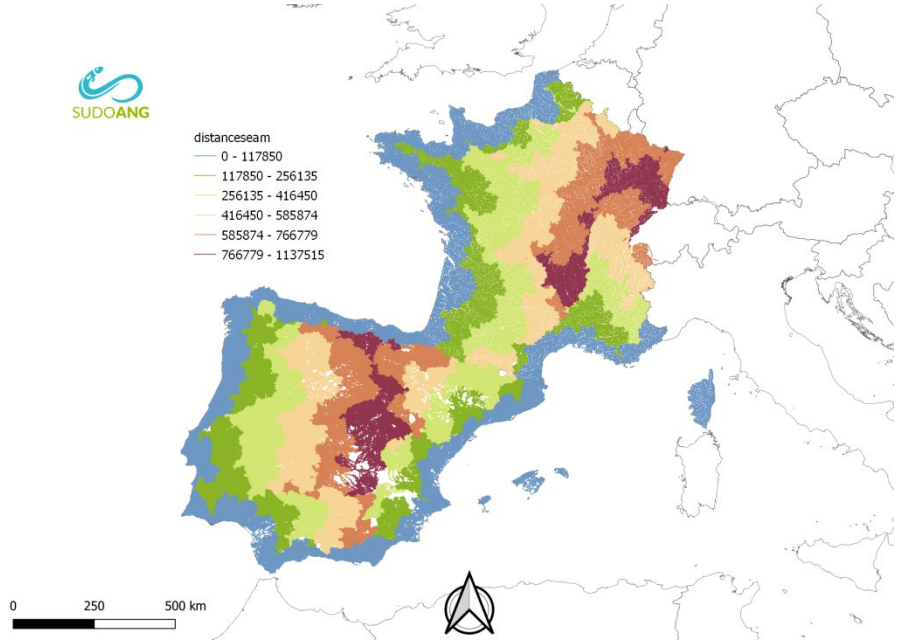
- Early stage 6 months survival (experiments Fish Pass)
- After 6, 12, 36 months
    1. Abundance indices.
    2. Contribution of restocking to the population (Alizarine stains in otoliths).
    3. Total length, Age, Growth Rate
- Comparisons between catchments and « survival indices »
- No information about density

Density estimates

SUDOANG

Attribute database

- Distance to the sea and the source
- Number of dams
- Temperature



Briand et al., 2021

A decade of 36 months surveys

Percentage of restocked eels over time : Example of the Aulne River

Modeling percentage of restocked eels

Percentage of restocked eels = f ()~

Time
Distance to the sea
River width
∑ hight of dams
Year
Week
Fishing method
River Basin

Modeling percentage of restocked eels

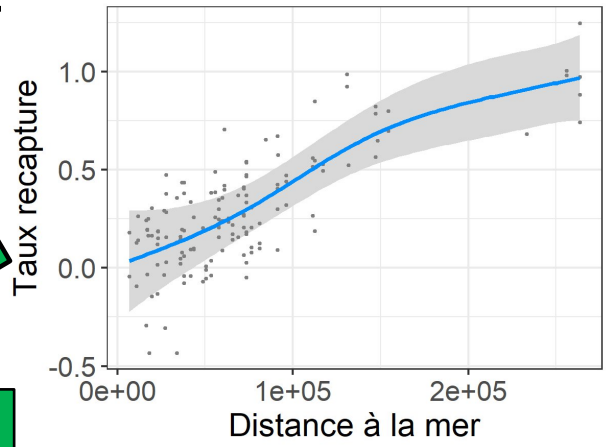
*Percentage of restocked eels = f ()^*

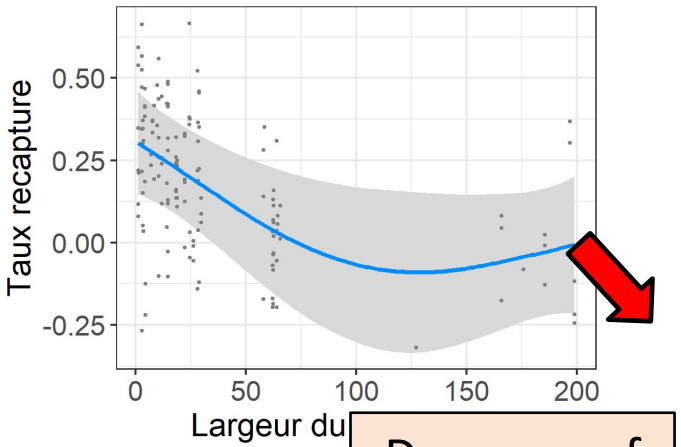
R^2=65%

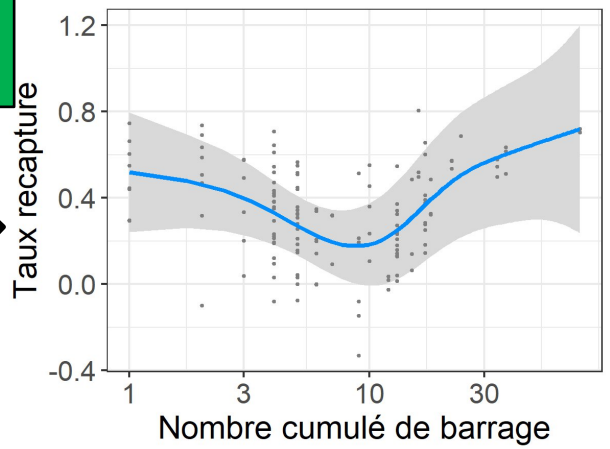
Significant
Non significant

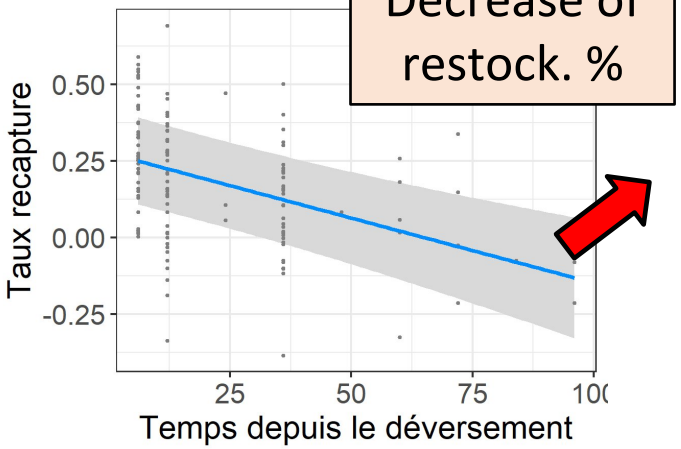
Time
Distance to the sea
River width
∑ nb of dams
Year
Week
Fishing method
River Basin

Increase of Restock. %





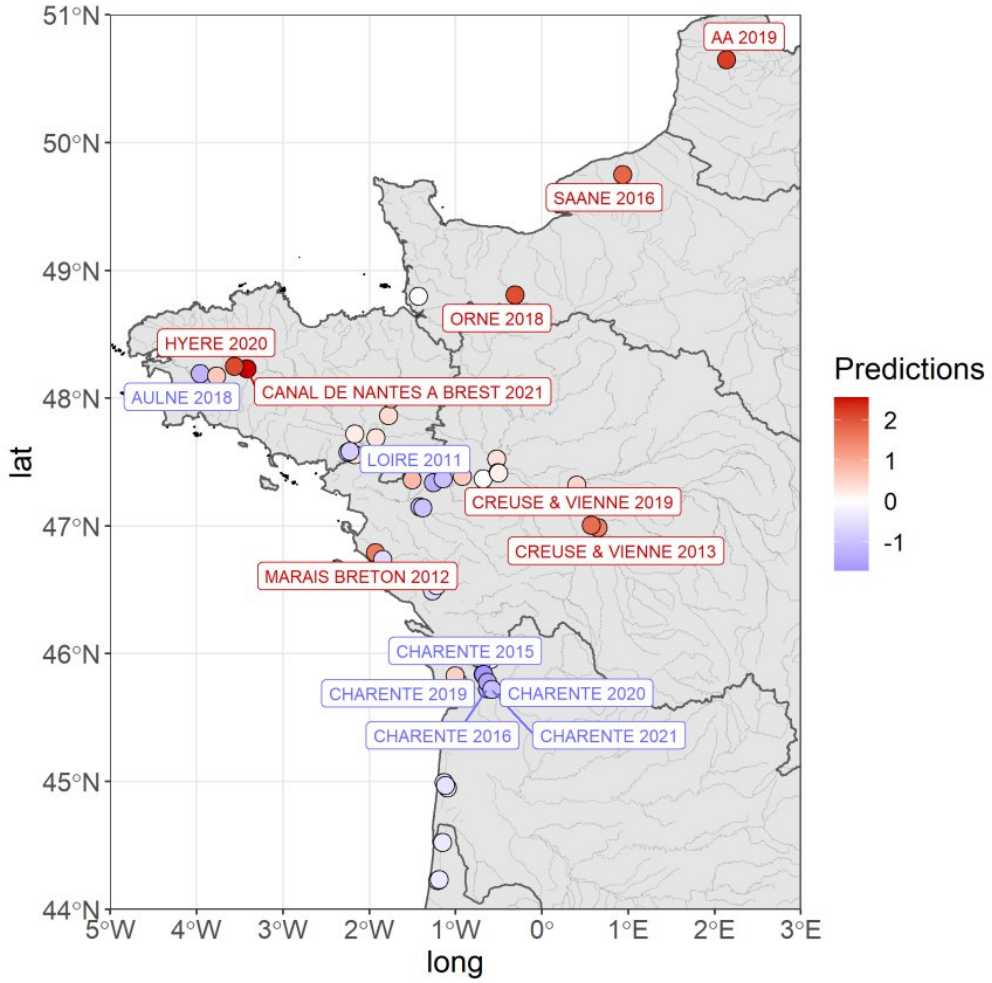




Decrease of restock. %

Mapping percentage of restocked eels in the population

Variabilité spatiale du taux de recapture

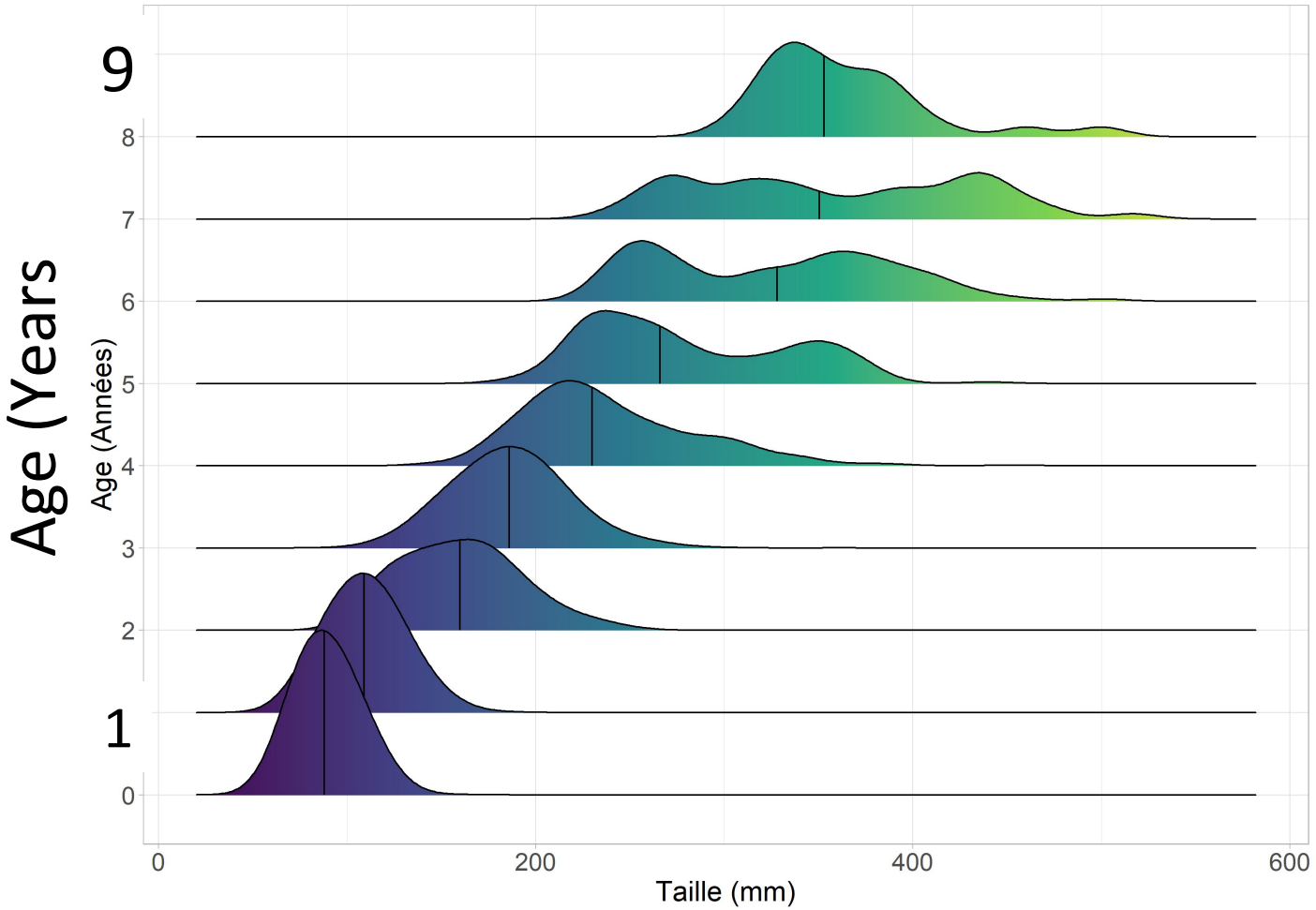


+High % **North and upstream rivers**

+Low % **downstream** and **in the South, in particular in the Charente**

Growth rate

Size Age relation ship from ~8000 otoliths



Modeling the growth rate distribution

Age at a given length

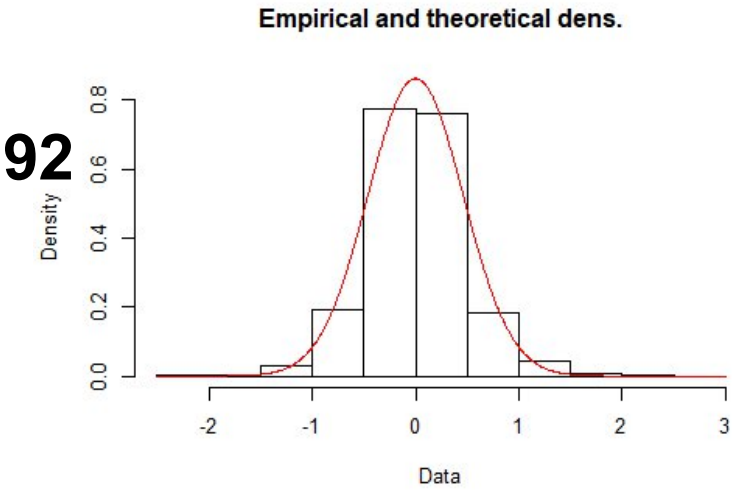
Distance to the sea
River width
Restocked or not
Management unit
River basin
Year of the survey
Week of the year

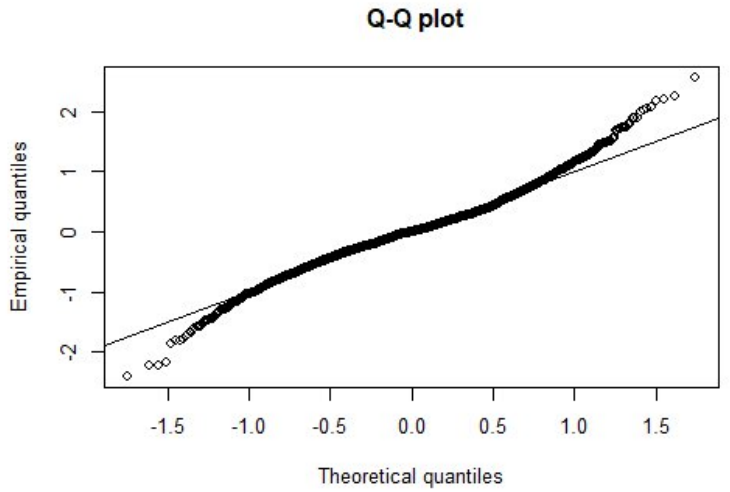
Modeling the growth rate distribution

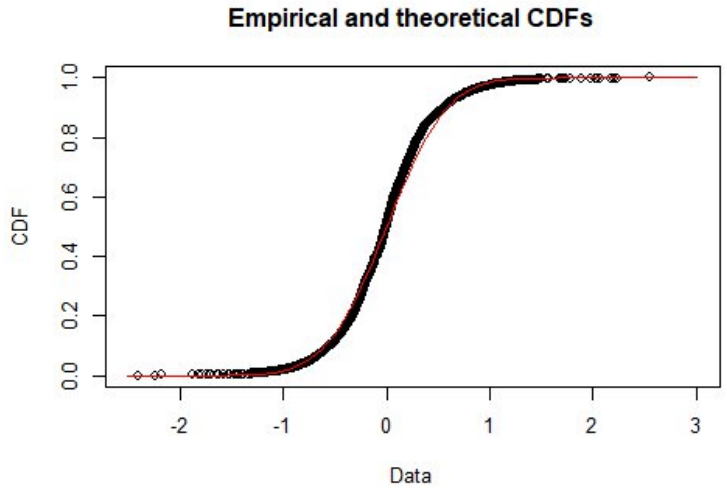
Age at a given length **R2 = 0,92**

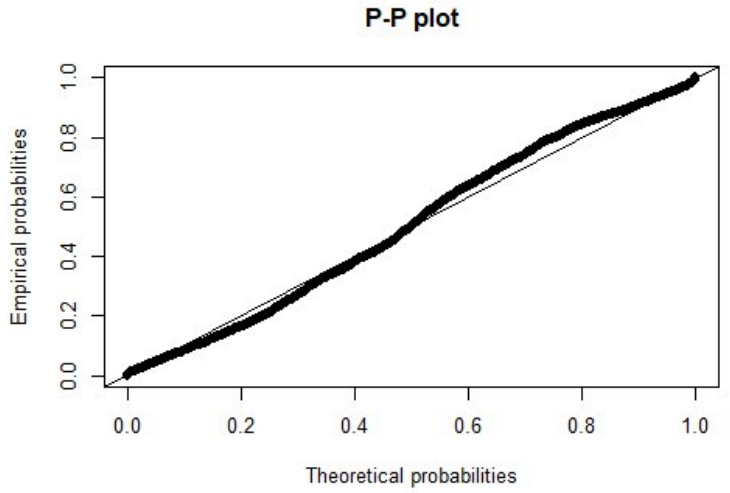
Distance to the sea
River width
Restocked or not
Management unit
River basin
Year of the survey
Week of the year

Significant
Non significant

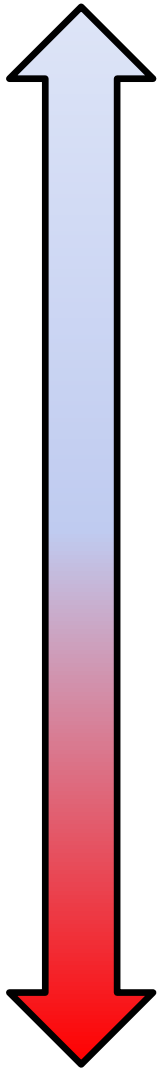


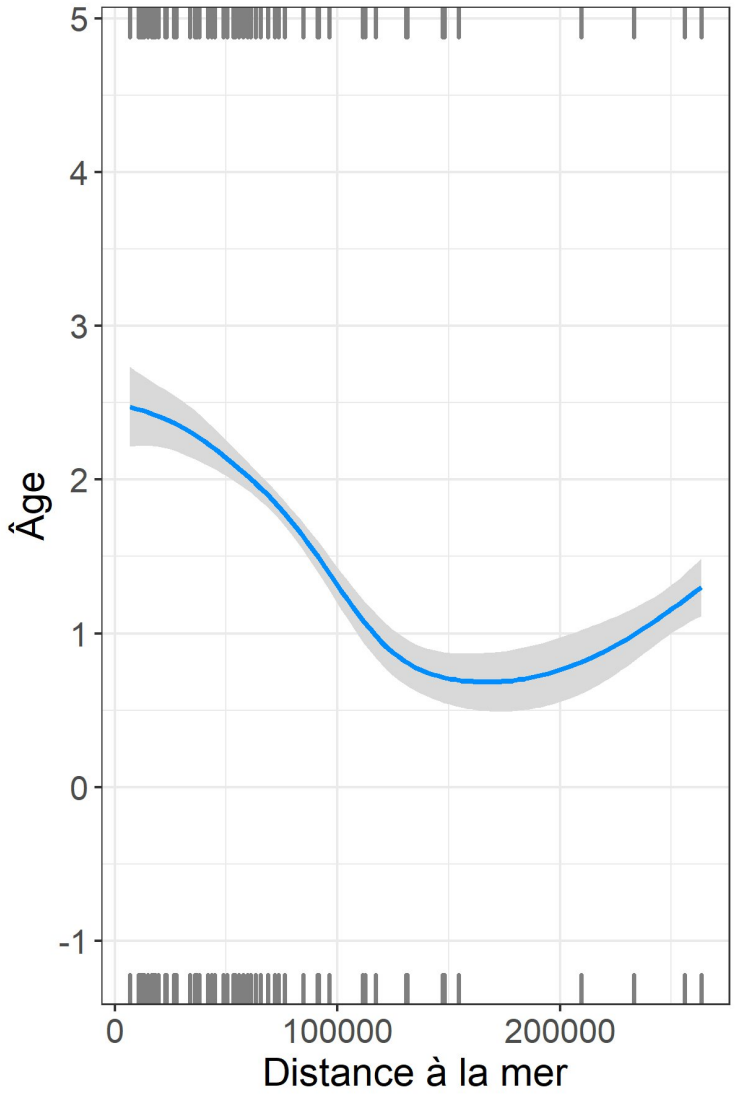


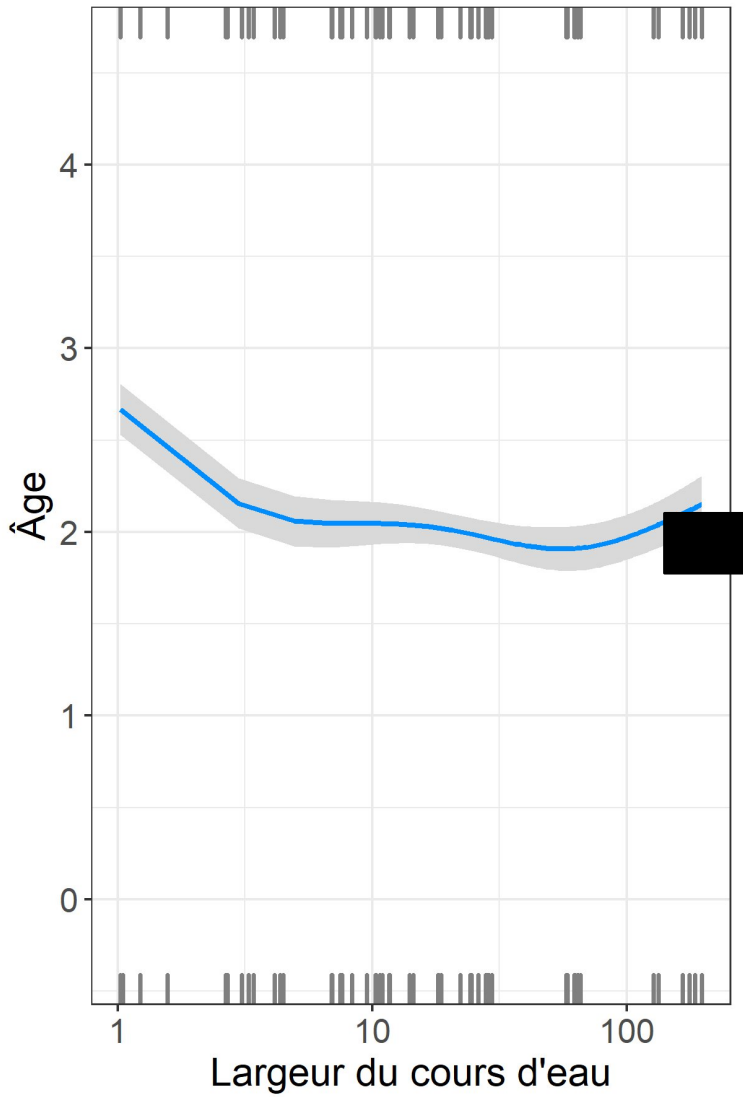




Growth rate increases with the distance to the sea



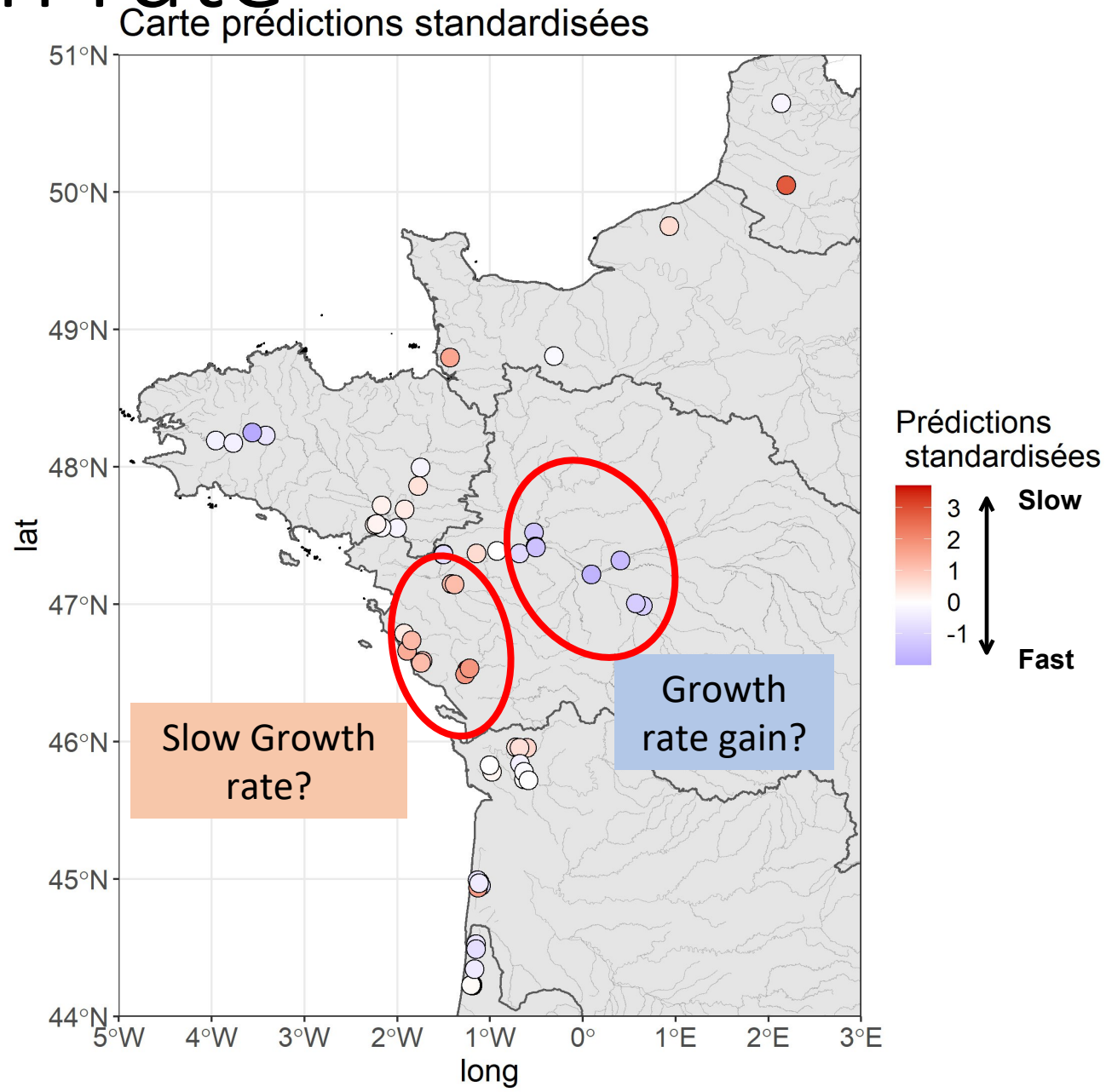




Growth is ~twice faster upstream

Mapping the growth rate

Growth rate increases with the distance to the river mouth and decreases with the river width



1st Conclusions and Hypotheses

- Growth rate is negatively related to distance to the sea and is low in some river basins (especially northern ones)
- Proportion of restocked eels increases with the distance to the sea
- Density of eels globally drops with the distance to the sea and with the cumulated hight and number of dams (EDA model, Sudoang)
- There is a negative relation between density, natural recruitment strength and growth rate and survival.

Simulations to estimate the spawning biomass gain of restocking

- Still in progress !
- First tentative results !!!

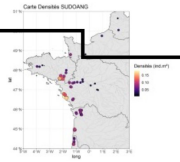
Number of eels from recruitment in the Loire

- **Assumption**: In downstream areas, density is high, growth rate low and mortality are higher than in upstream areas.
- Glass eels naturally settle in the boundaries of high density areas or are blocked downstream obstructions to migration where density is high, growth rate is low due to competition and survival low
- Restocked eels are translocated to low density areas were growth and survival are more favourable.
  - High mortality : Z = 0,60
  - Low mortality: Z = 0,20

Methodological Flow Chart

1

Densités Estimées SUDOANG

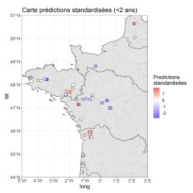


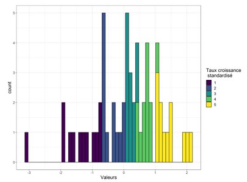
Attribution d'un taux de mortalité [0.17-0.7] relatif au taux de croissance

Modèle Du taux de croissance sur petites tailles (pas de dimorphisme) R^2=85.6%

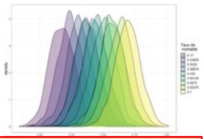
Variabilité spatiale du taux de croissance

Attribution d'un taux de mortalité [0.17-0.7] Relatif aux densités

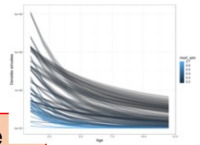




Situation repeuplement
Moyenne des taux de mortalité + Etablissement distributions de valeurs (Sd = 0.1)



Situation forte motalité
r constant = 0.7



Tirage aléatoire de 100 taux de mortalité par simulation

Simulation des densités repeuplement
Nb A… 1…0.9… NB civelle (…
mortalité)

Simulation des densités statu-quo

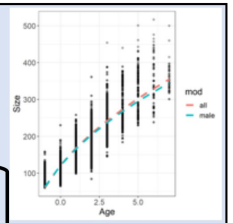
Mâle:6-7-8 ans
Femelles:10-11-12

Inclusion du sexe-ratio
relatif densités
Faibles densités 90/10
Fortes densités 50/50

Estimation gain de biomasse:
Dens estimée * masse ind

Estimation de la Taille pour âge donné

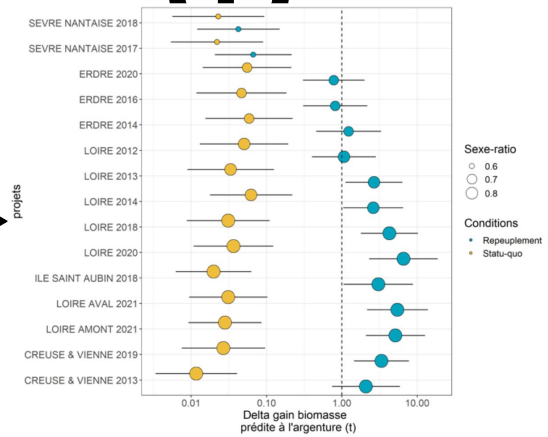
Modèle de Von Bertalanffy R^2=0.88



2

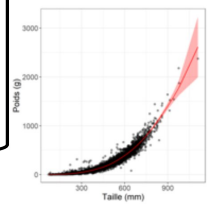
Sous estimation évidente
Envisager de prendre valeurs issues de la littérature

3



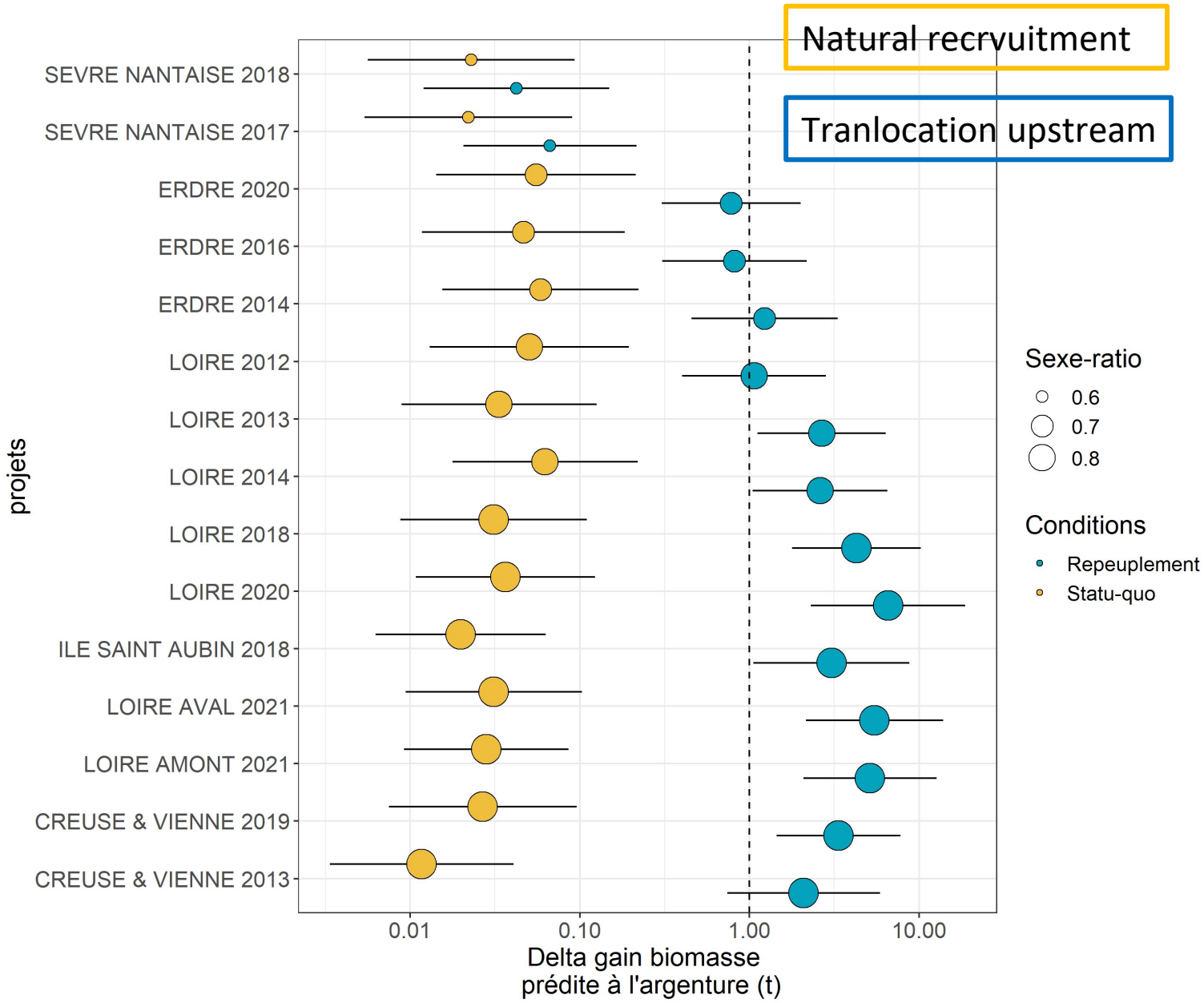
Estimation de la masse Pour une taille donnée

Modèle Log-linéaire R^2=0.97



Tentative comparison of silver eel biomass : restocked vs natural recruitment

- If glass eels recruit naturally, they are blocked downstream and they settle in densely populated habitats. **The simulation predicts a production of 2.6 tons of silver eels**
- If glass eels are fished and transferred to lowly populated areas, **the model predicts** a **production of 64.5 tons of silver eels**



2d Conclusions and Hypotheses

- Tentative modeling still needs tuning and development
- Preliminary results suggest that
- Translocating glass eels to low density areas, with suitable habitat conditions helps :
    1. Increasing Spawning biomass
    2. Increasing proportion of females
    3. Improving recruit to sp
- Next step : what happens in catchments : needs to measure recruits to silver eel relationship

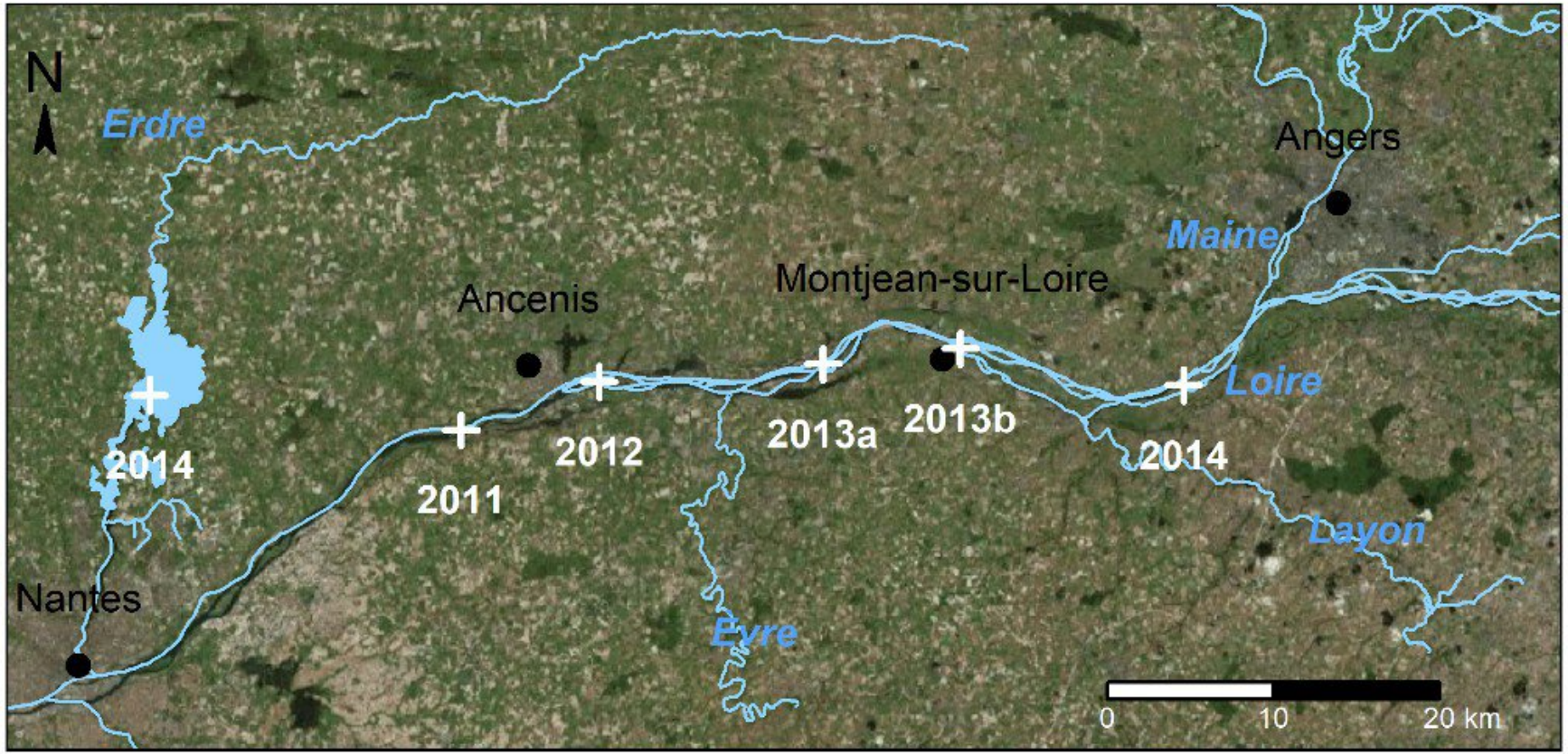
Measuring restocked glass eels (recruits) to silver eels in the Loire.

Restocking : 2011 – 2014
30% glass eels marked with Alizarine

9 632 000 glass eels in the Loire (2972 kg)

2 864 000 glass eels in the Erdre (824,8 kg)

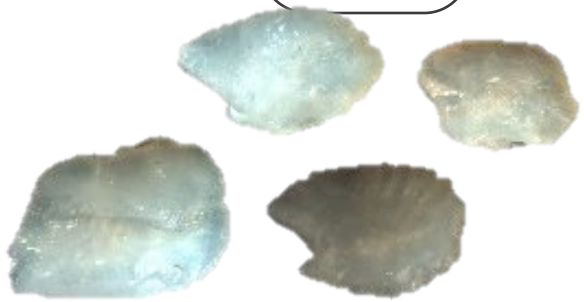
Silver eel runs : 2019
From 110 000 silver eels per year



Estimating the proportion of restocked silver eels

Sampling eels

Otolith extraction



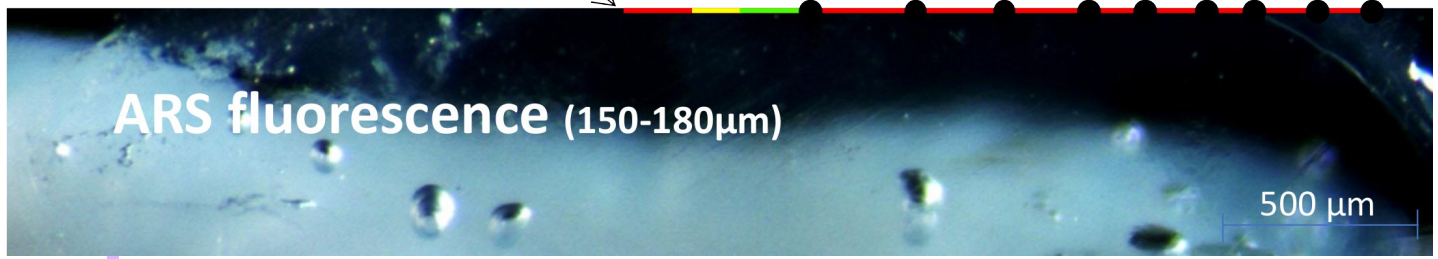
Age estimates

Recruitment

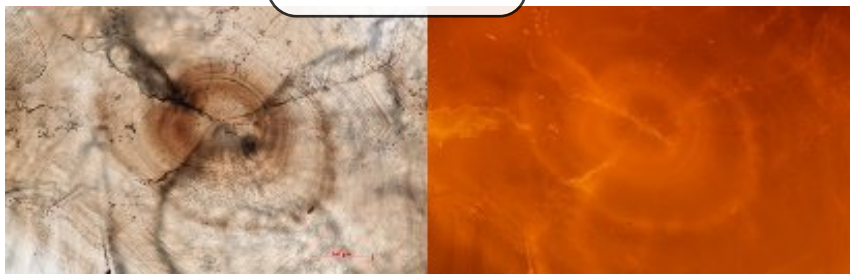
Continental age

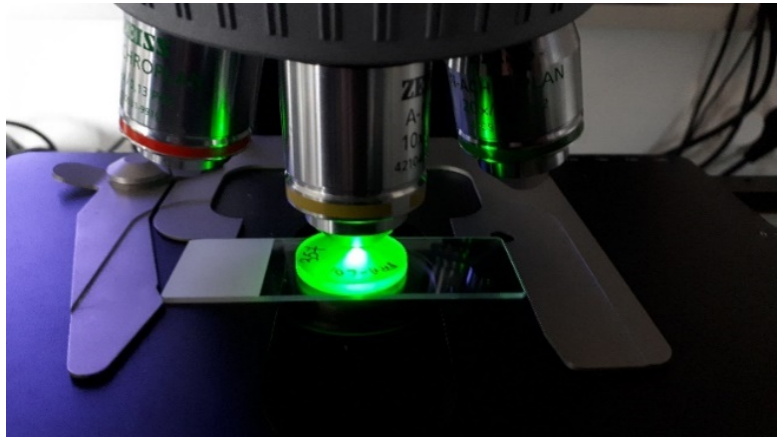
Nucleus

1 2 3 4 5 6 7 8 9

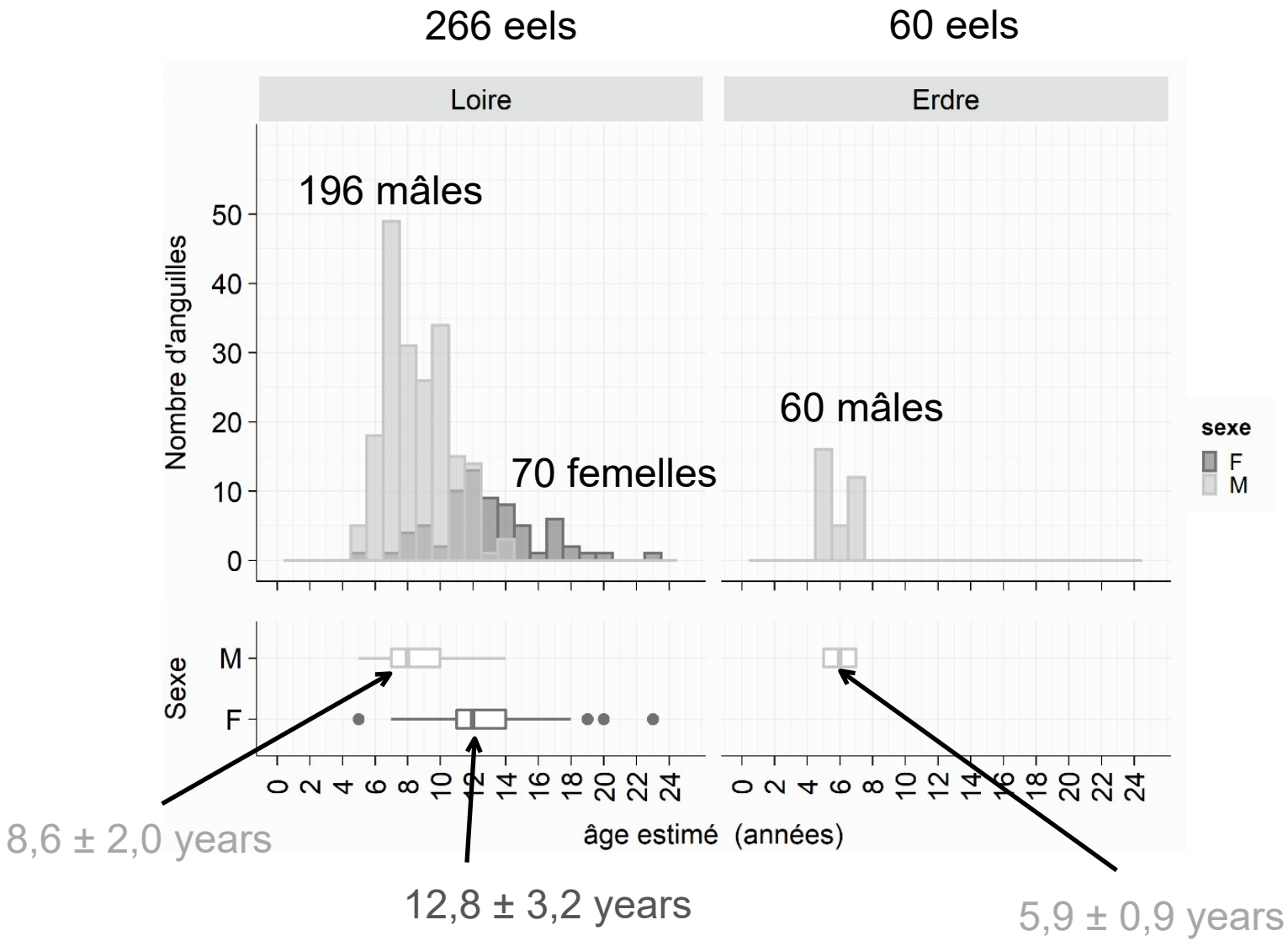


Fluorescence

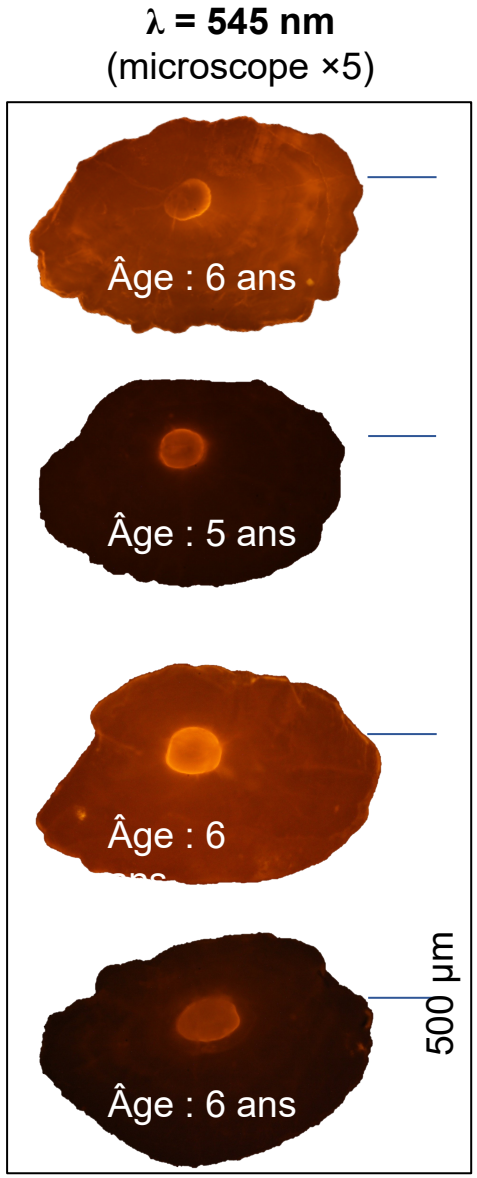


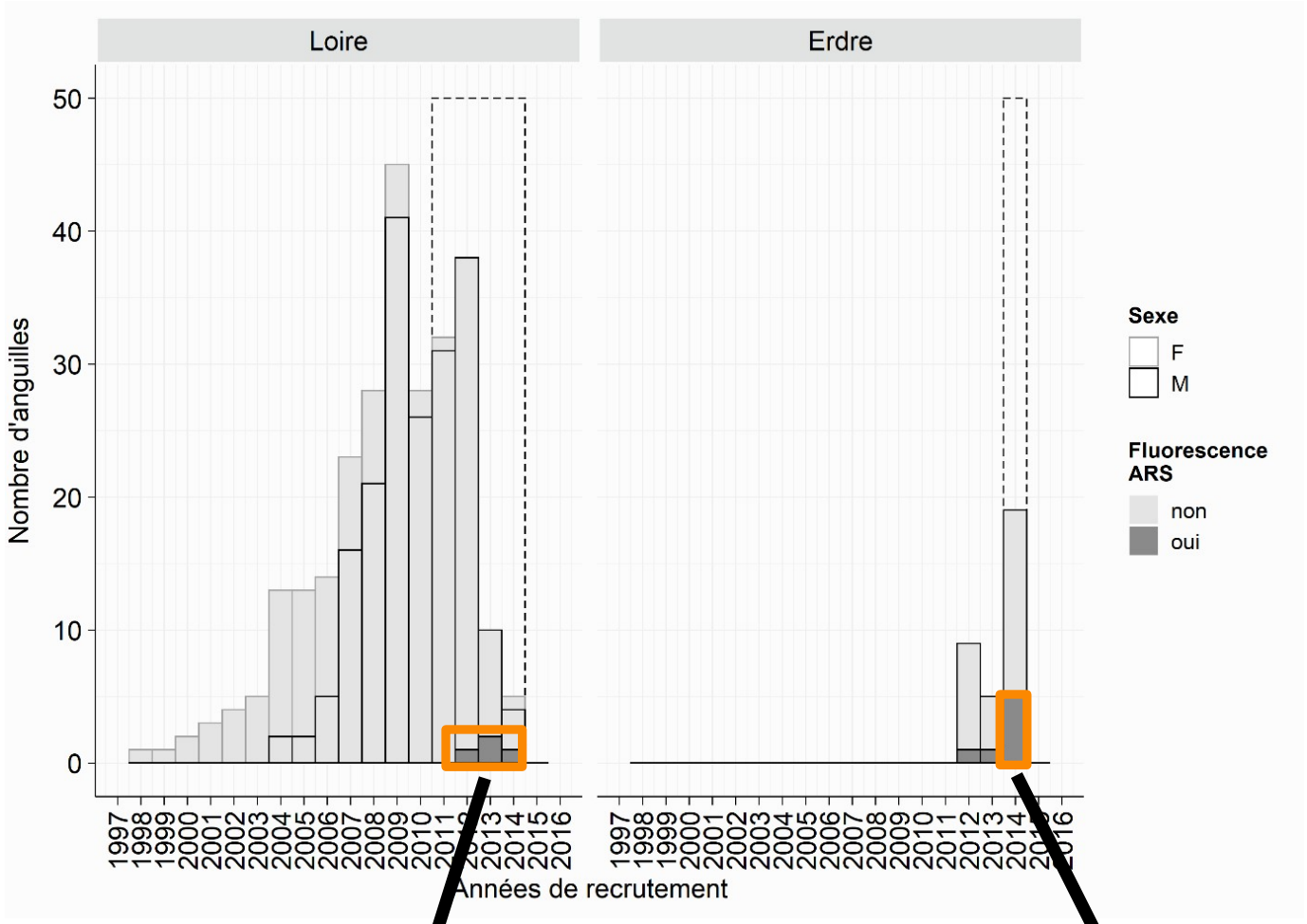


Ageing


266 eels
60 eels
Loire
Erdre
196 mâles
70 femelles
60 mâles
Nombre d'anguilles
0
10
20
30
40
50
Sexe
M
F
0 2 4 6 8 10 12 14 16 18 20 22 24
âge estimé (années)
sexe
F
M
8,6 ± 2,0 years
12,8 ± 3,2 years
5,9 ± 0,9 years

Percentage of restocked eels (ARS)





6,8% of the target cohort
5,75 ± 0,5 years

87% of the target cohort
6,29 ± 0,95 years

Final Conclusions - perspectives

- Results and analysis of the French Restocking programme still in progress
- Restocking protocole implemented in France :
  - Tranlocate glass eels within Eel Management Units (geographically constrained)
  - Translocate eels to high density areas, and low density areas
  - Efficient surveys
- Translocating glass eels to low density areas enable to:
  - increase spawning biomass,
  - Increase proportion of females,
  - Decrease mortality
- Need to include silver eels stage in the surveys to measure efficiency of restocking programmes.
  - Feasibility shown on the Loire River, the biggest in France !
  - 10 Eel index rivers in France
  - Modification of the survey methods to include silver eels ???

Bon voyage ! Thanks for your attention.

Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION

Bordeaux : 4-8 juillet 2022