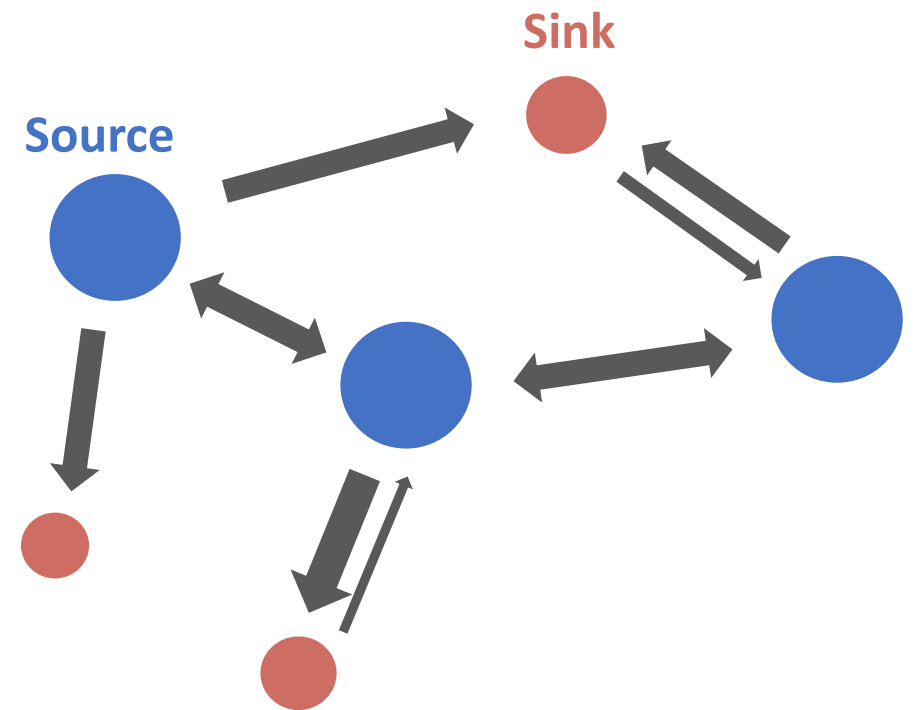


Spatial dispersal

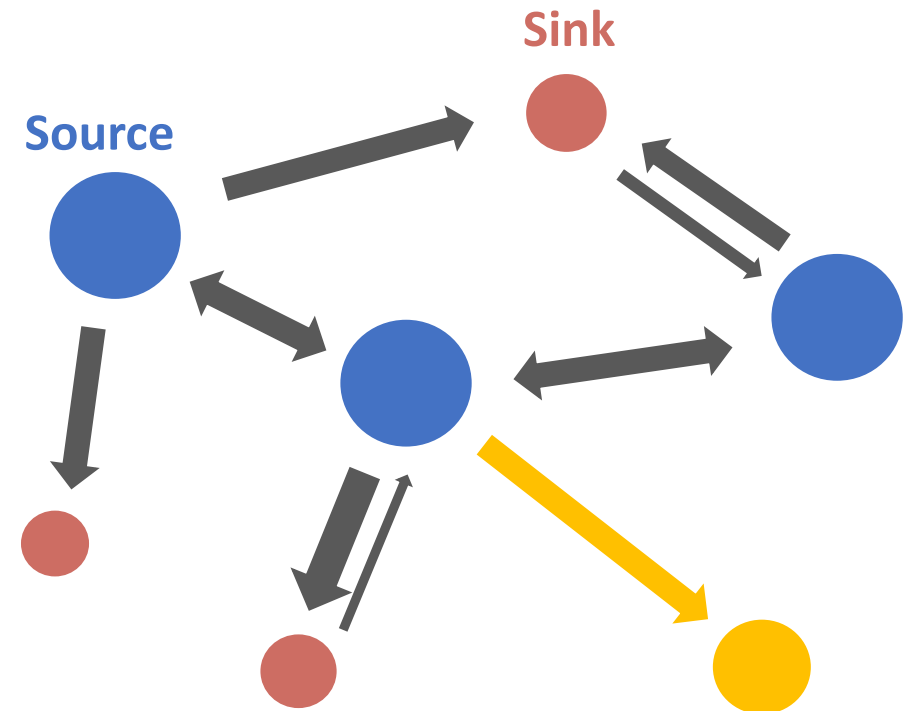
« any movement of individuals with potential consequences for gene flow across space » (Ronce, 2007)



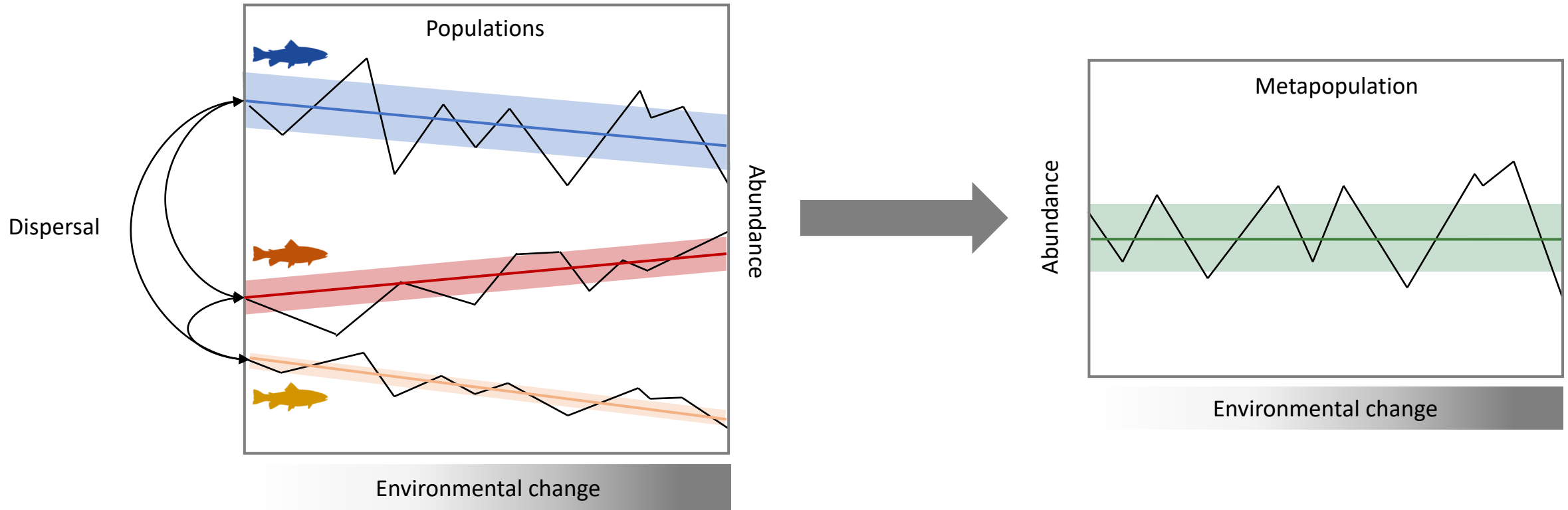
Spatial dispersal

« any movement of individuals with potential consequences for gene flow across space » (Ronce, 2007)

- Colonization of new habitats
- **Rescue effects** (Carlson et al, 2014):
 - Demographic rescue
 - Genetic rescue
 - Evolutionary rescue



↗ stability and persistence



Biocomplexity at different levels:

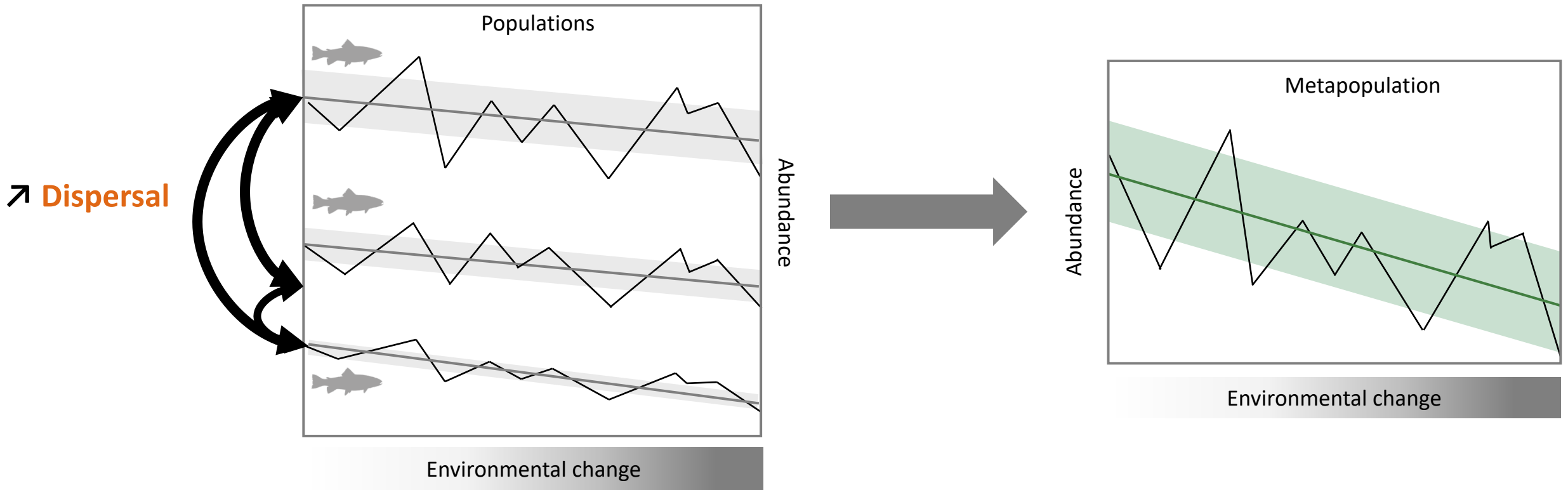
- phenotypes and genotypes
- population dynamics (asynchrony)

↳ Diversity of responses to environmental changes

↗ stability and persistence

= **Portfolio effect (PE)**

(Schindler et al, 2015)



↘ **Biocomplexity** at different levels:

- phenotypes and genotypes homogenization
- synchronyzation of populations dynamics

↪ **Homogenization** of responses

↘ stability and persistence
= **“anti-rescue”** effects
(Harding and McNamara, 2002)



Philopatry

Conservation Genetics (2005) 6:823–842
DOI 10.1007/s10592-005-9042-4

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Asymmetric gene flow and the evolutionary maintenance of genetic diversity in small, peripheral Atlantic salmon populations

Sofia Consuegra^{1,4,*}, Eric
¹Institute of Zoology, Zoological
Fisheries Research Service, Pilsen
Sciences, University of Wales Sw
St. Andrews, St. Andrews, Fife, K
449; Fax: +44-1334-463-443; E-

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Atlantic salmon straying from the River Imsa

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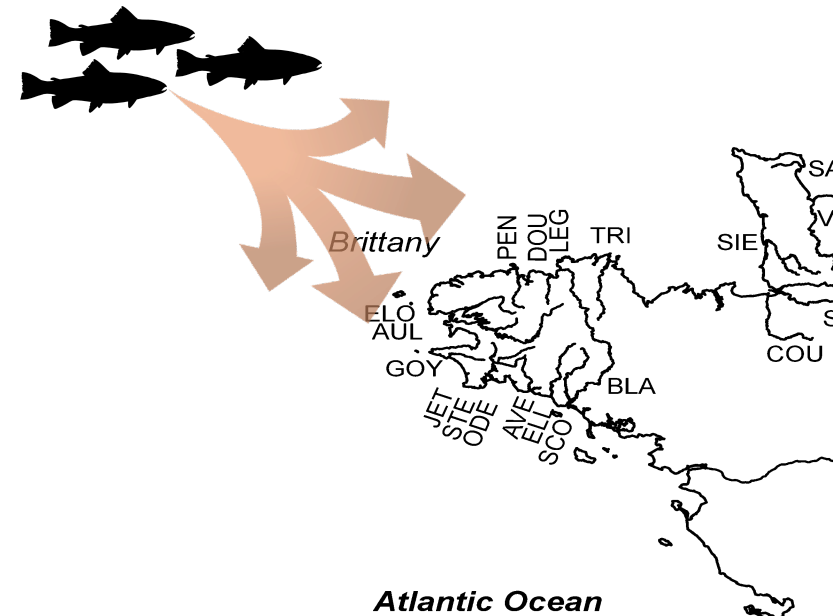
Norwegian Institute for Nature Research, Dronningensgt. 13, P. O. Box 736 Sentrum,
N-0105 Oslo, Norway

FISH and FISHERIES, 2007, **8**, 297–314

A metapopulation perspective for salmon and other anadromous fish

Nicolas Schtickzelle^{1,2} & Thomas P. Quinn²

¹Biodiversity Research Centre, Université Catholique de Louvain, 4 Place Croix du Sud, B-1348 Louvain-la-Neuve, Belgium; ²School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195-5020, USA





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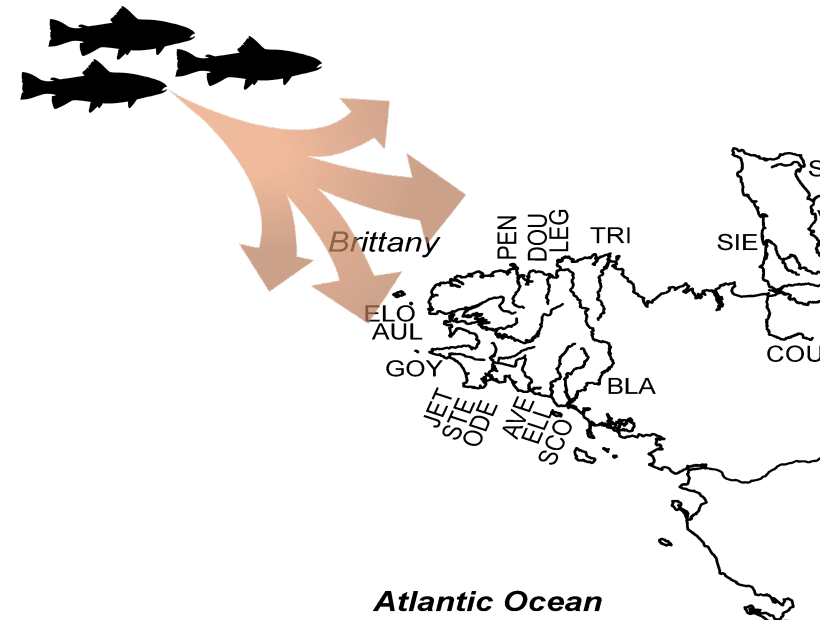
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- **Dispersal** rate: ~ 10% (Keefer & Caudill, 2014 for review)
- Mechanisms poorly known
- Dispersal = « straying »

↳ not considering potential consequences!
(demographic / phenotypic / genotypic)





Philopatry

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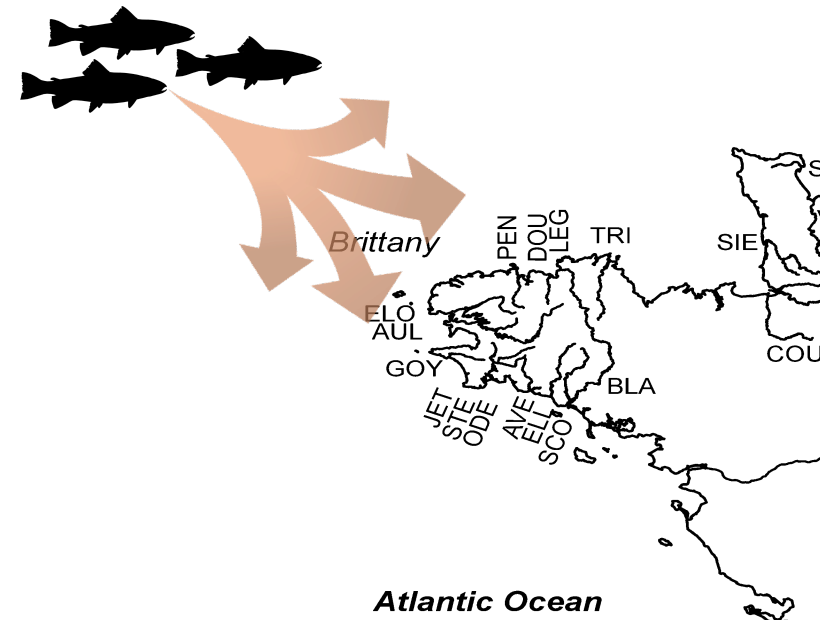
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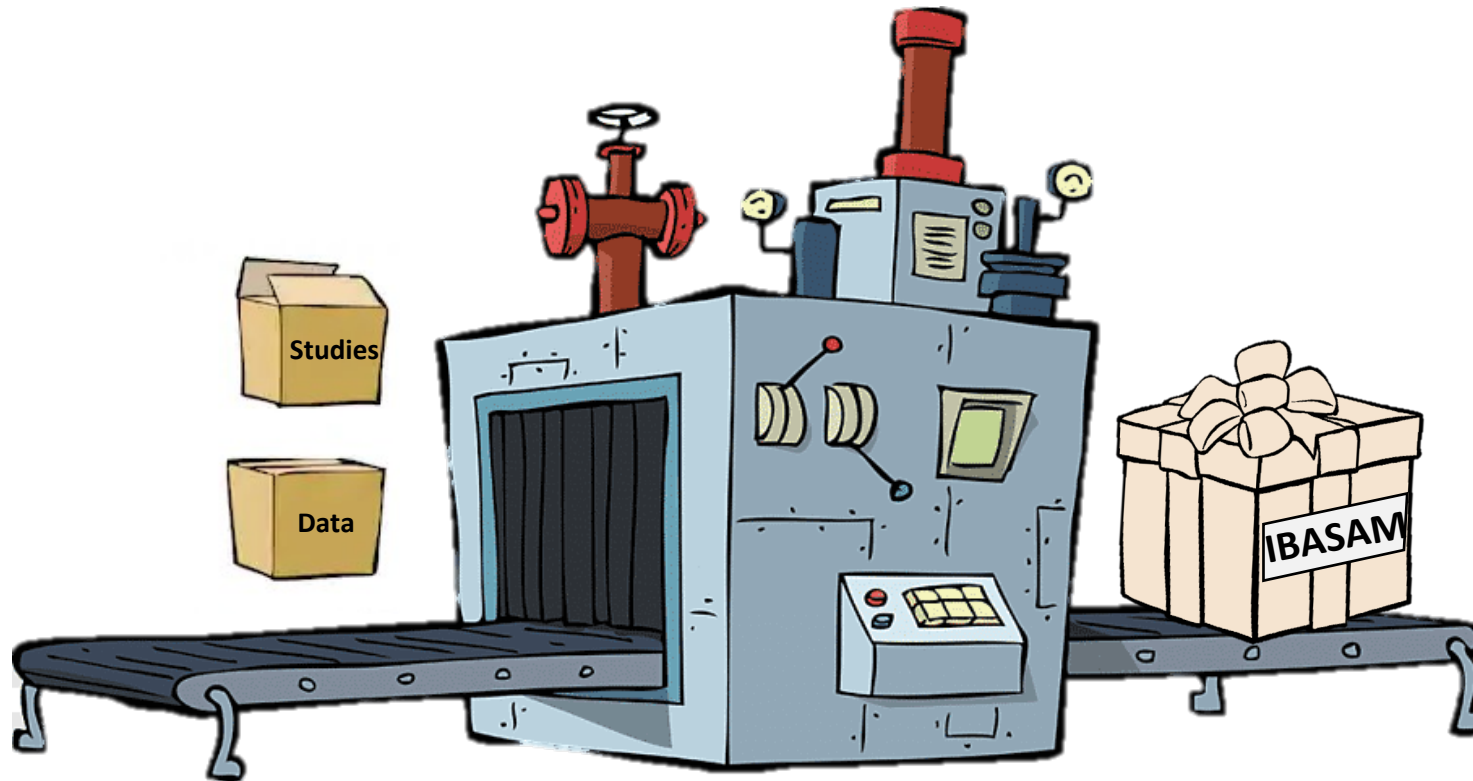
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(demographic / phenotypic / genotypic)



Explore the role of dispersal in Atlantic salmon metapopulation response using a portfolio approach

IBASAM

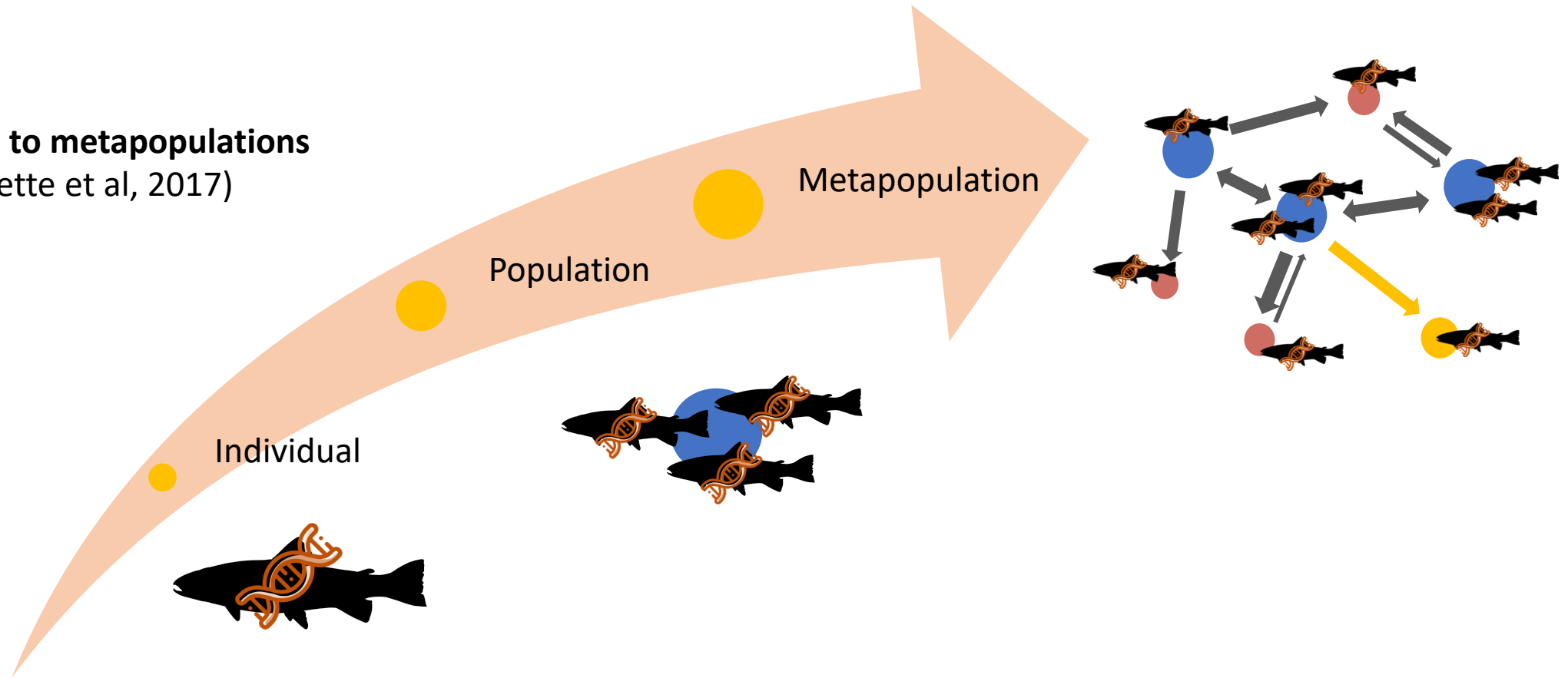
Individual-Based Atlantic Salmon Model
: a demo-genetic individual-based model for a single population (Piou & Prévost 2012)



IBASAM

Individual-Based Atlantic Salmon Model
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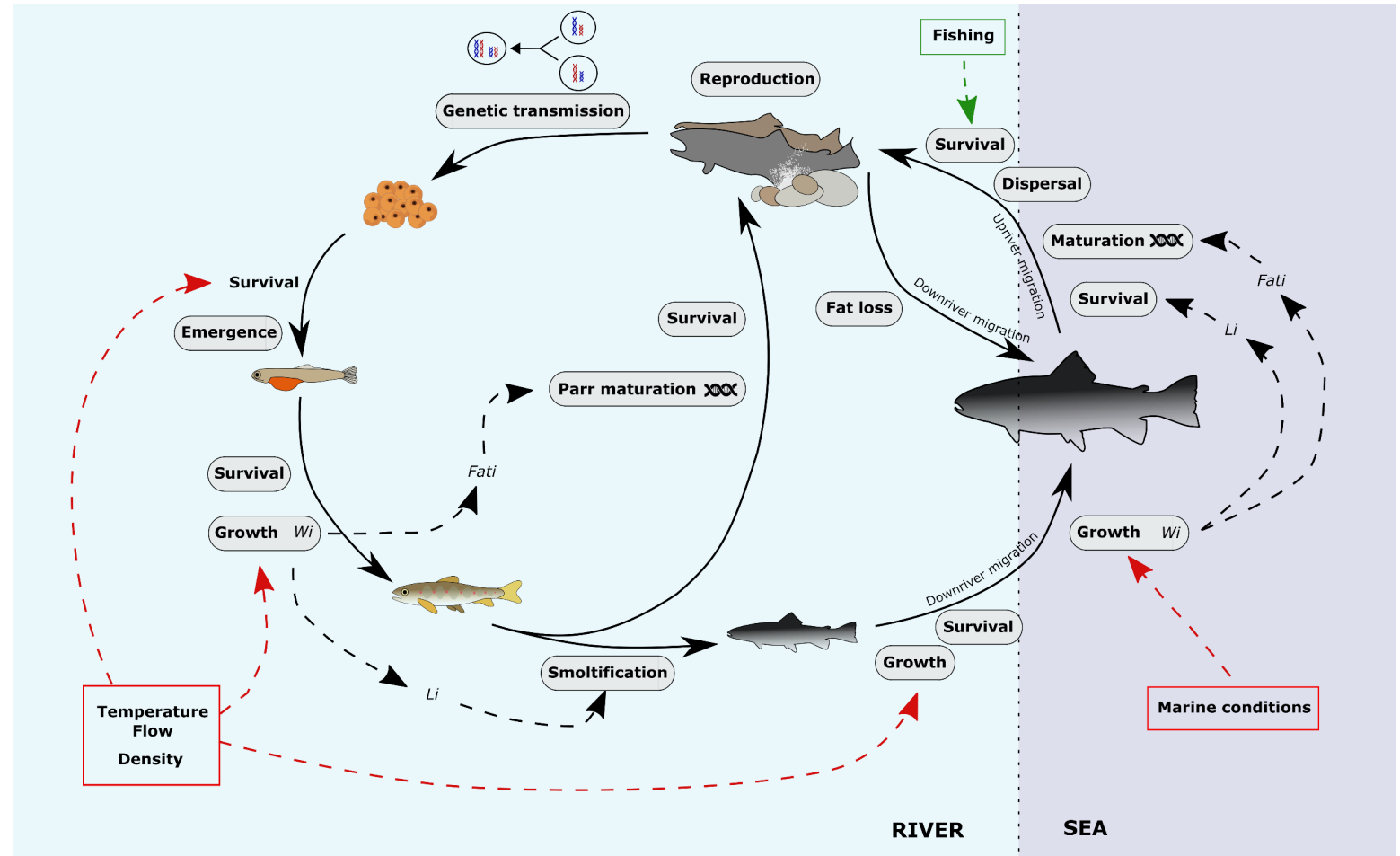
From genes to metapopulations
(Baguette et al, 2017)



IBASAM

Individual-Based Atlantic Salmon Model
: a demo-genetic individual-based model for a single population (Piou & Prévost 2012)

- Eco-evolutionary processes:
 - **Environmental** effects (density, temperature, fishing)
 - Individual response to environmental change: **phenotypic plasticity**
 - Traits genetic basis and transmission: **genetic adaptation**



METHODS

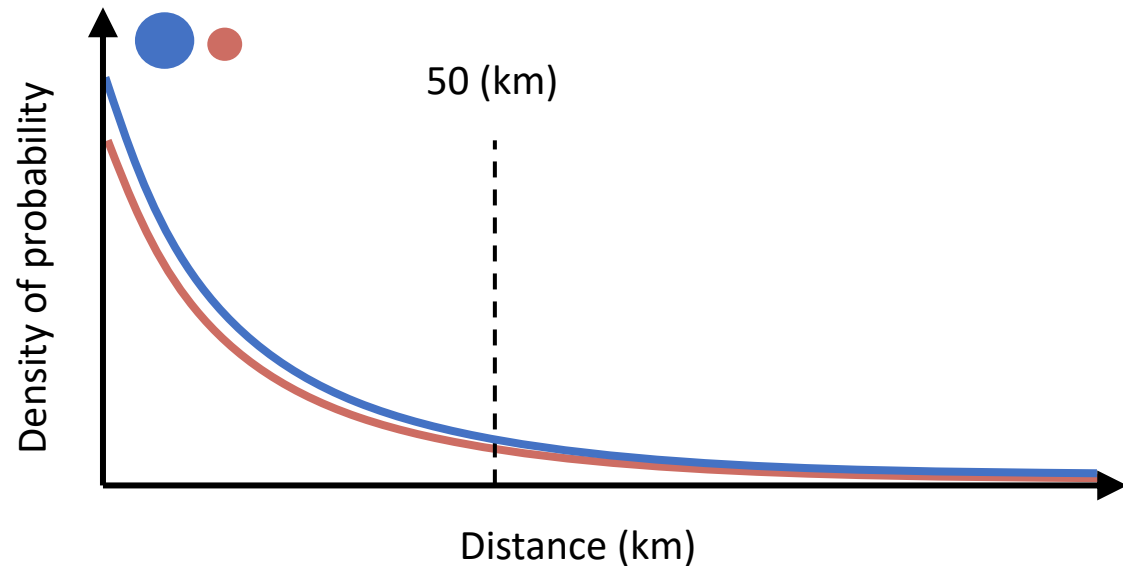
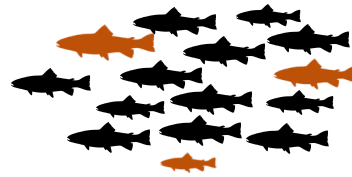
Salmon metapopulation modeling

MetaIBASAM

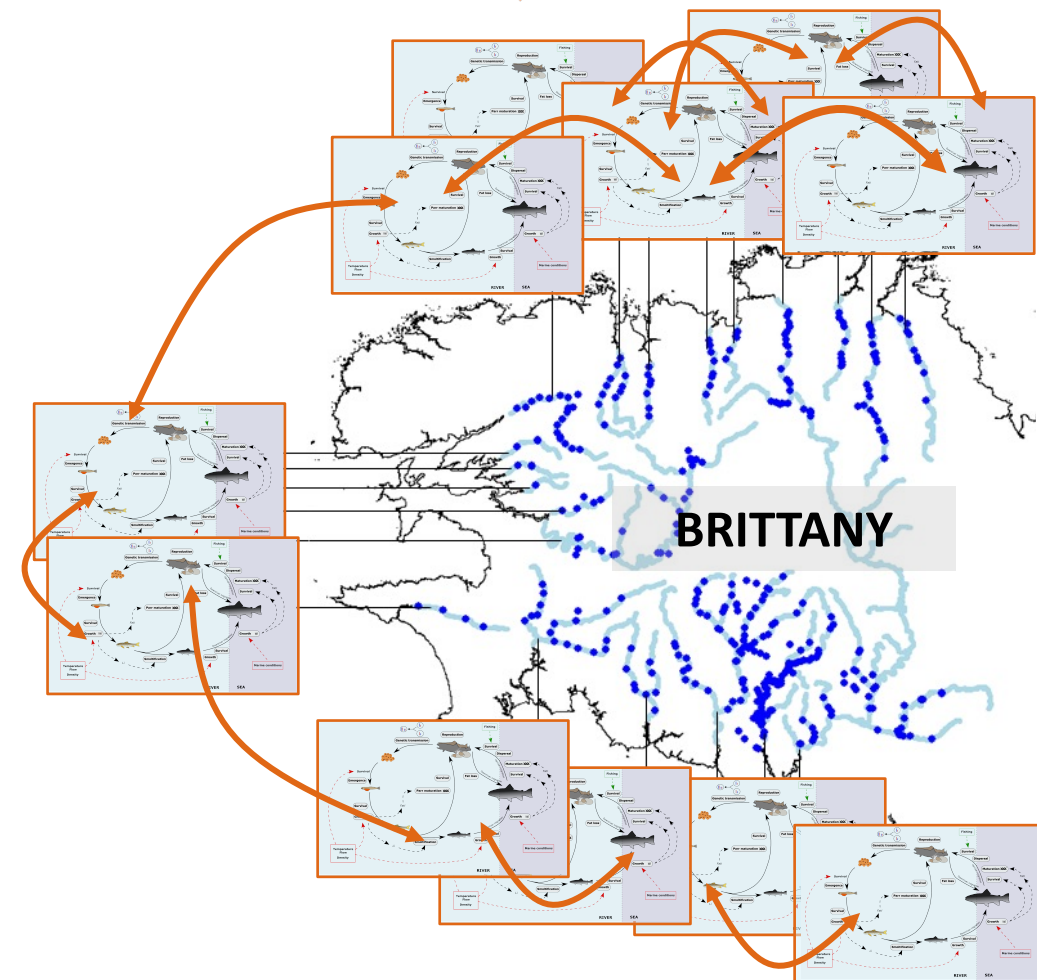
a spatially structured version of IBASAM

Dispersal modeling assumptions:

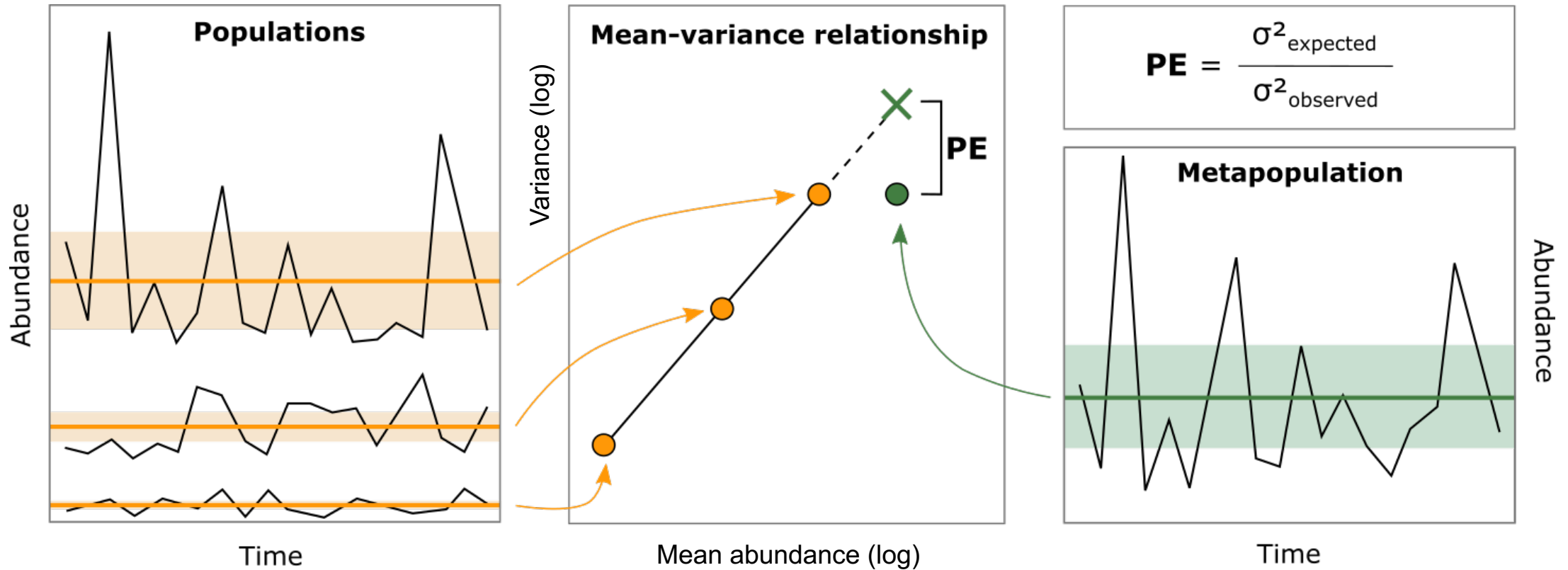
- Constant over space (populations) and time
- Not phenotypically or genotypically determined
- Choice of destination population based on distance and attractivity



FRANCE

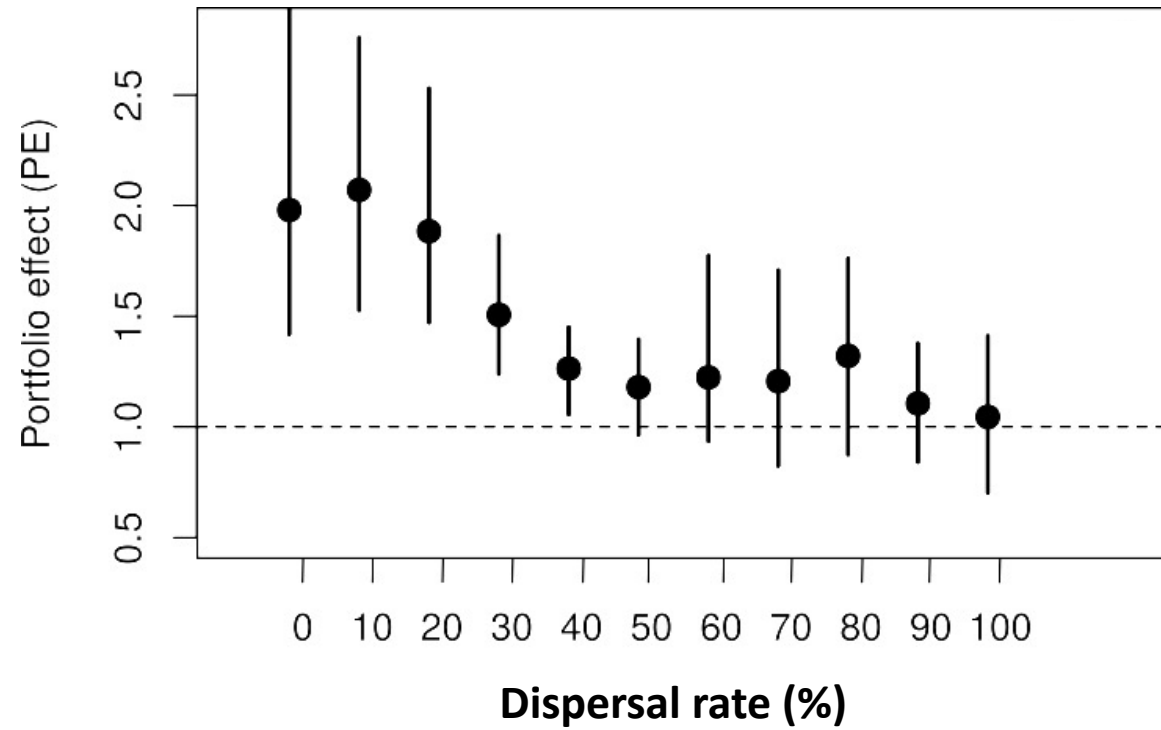


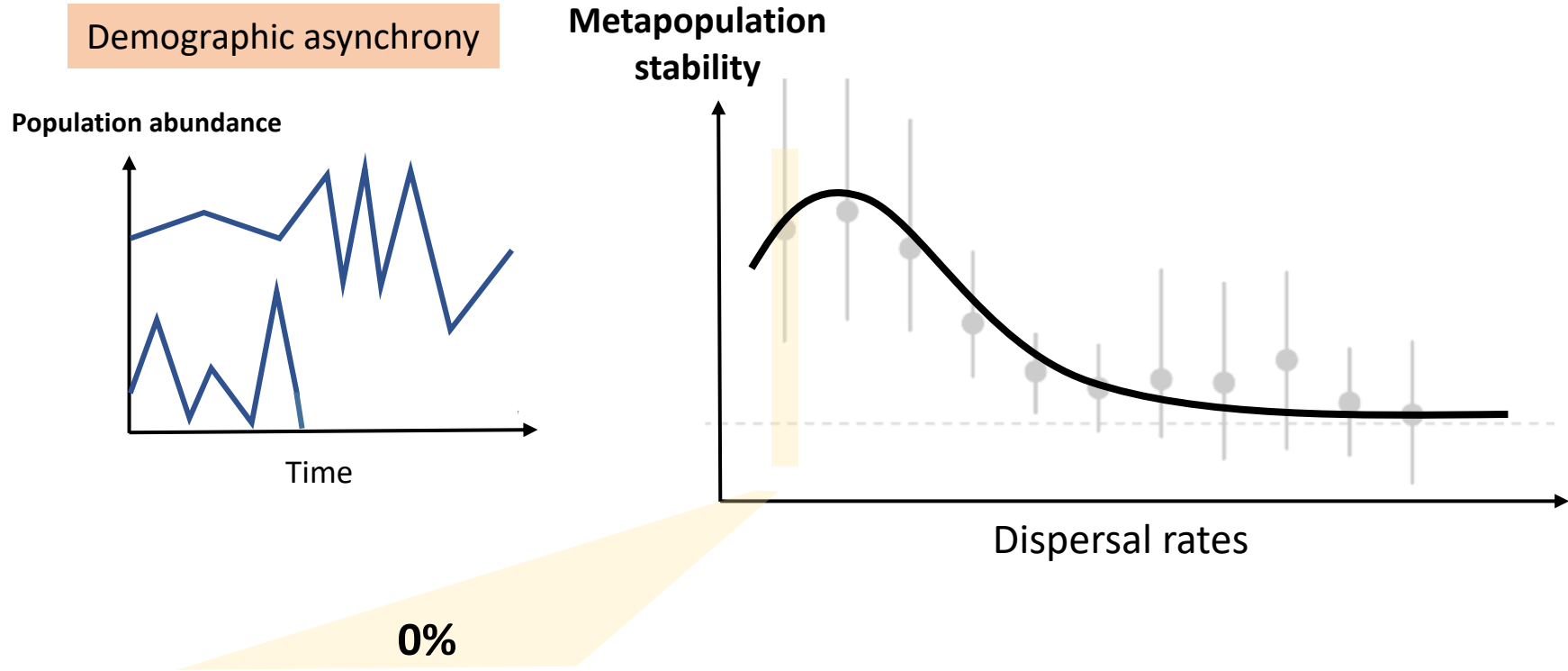
BRITTANY



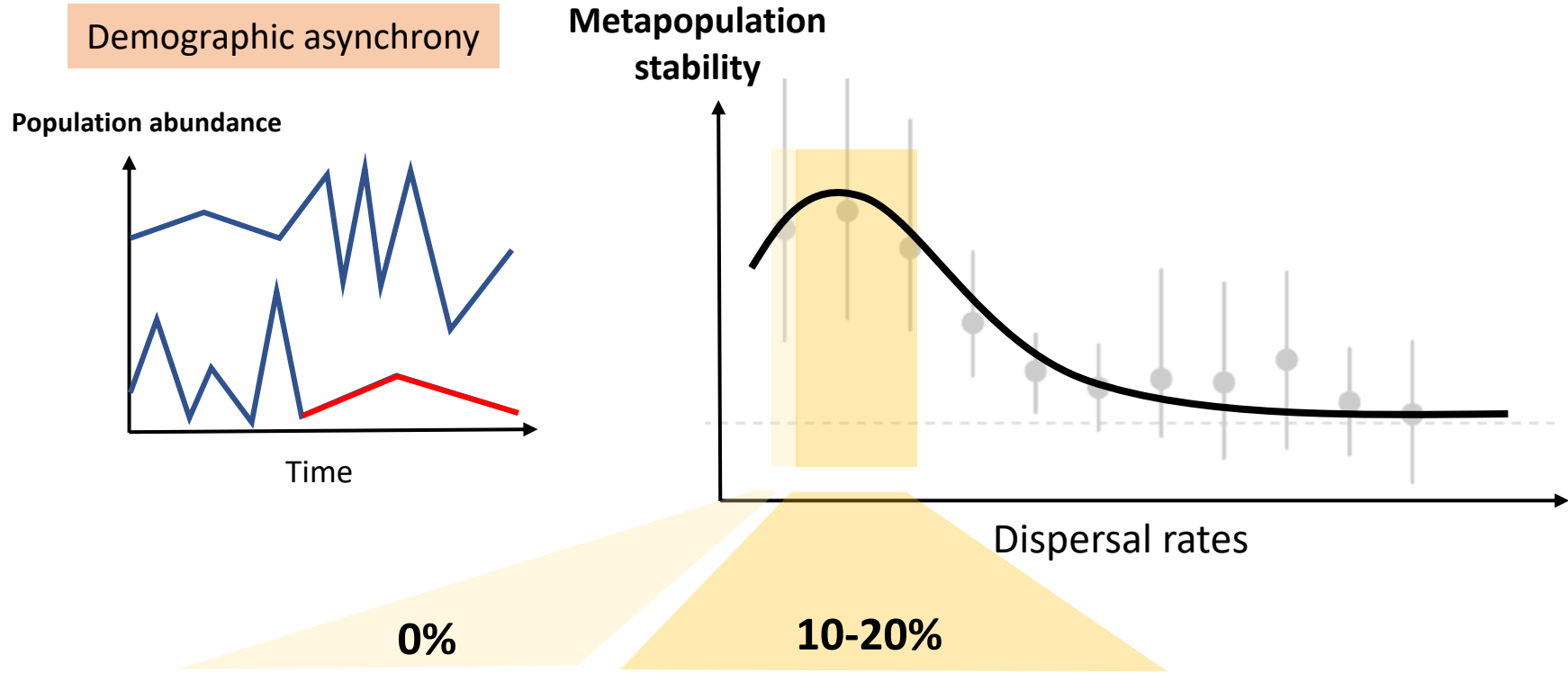
- $PE > 1 \rightarrow$ Metapopulation more stable than expected
- $PE < 1 \rightarrow$ Metapopulation less stable than expected

Metapopulation stability
(over 50 years)





- Asynchrony
- High risk of extinction of small populations

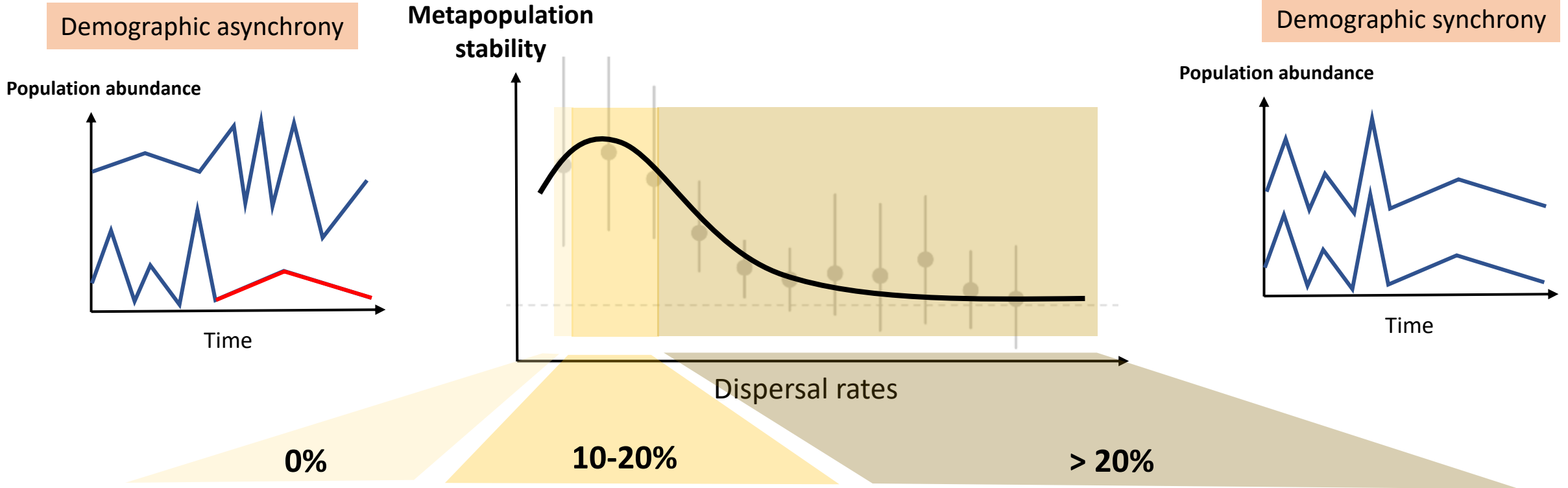


- Asynchrony
- High risk of extinction of small populations

- Demographic rescue of small populations
- Optimum ?

RESULTS

Effect of dispersal on metapopulation stability



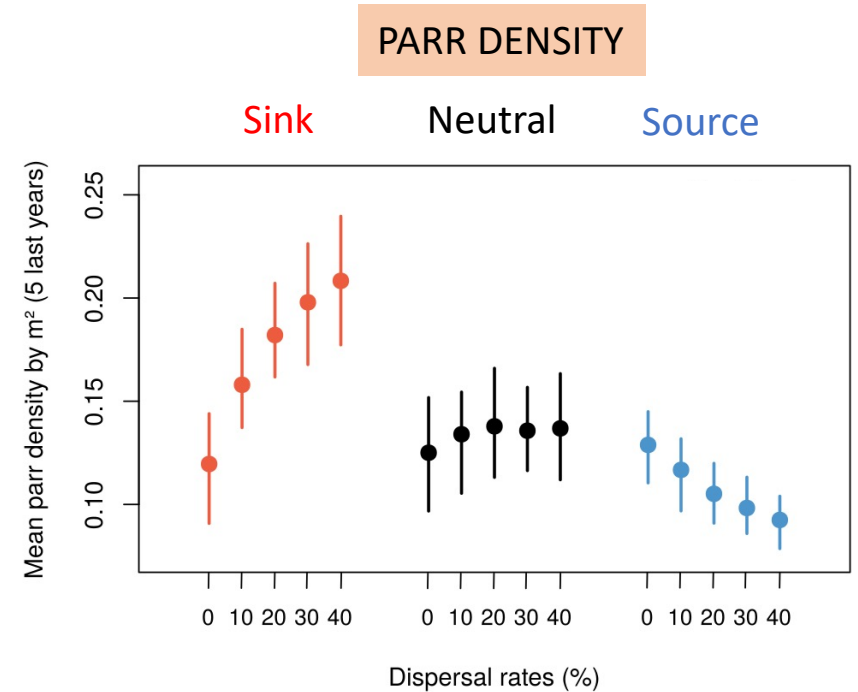
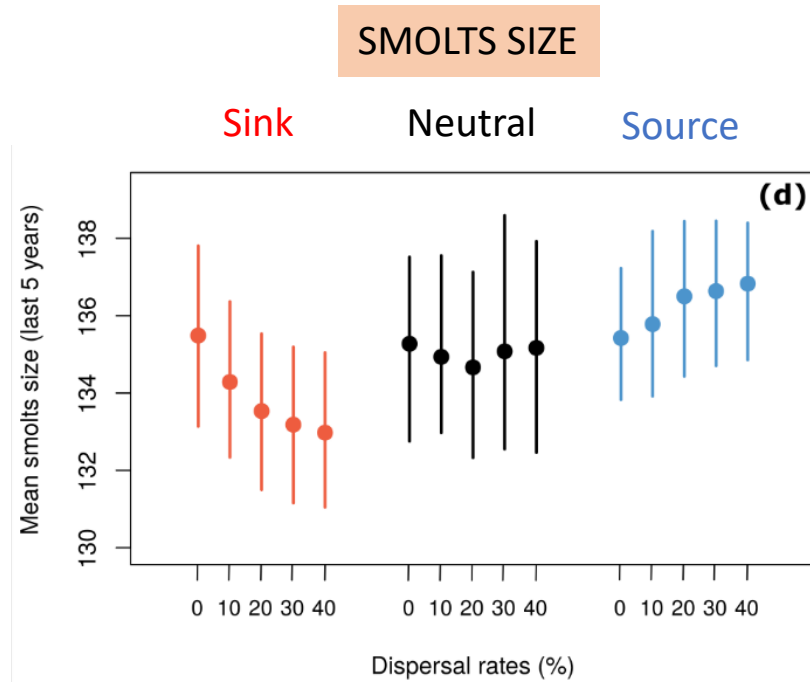
- Asynchrony
- High risk of extinction of small populations

- Demographic rescue of small populations
- Optimum ?

- ↗ ↗ synchrony
- Demographic decline of source populations

RESULTS

Phenotypic and genotypic consequences of dispersal on local populations



- No genetic change with dispersal (not shown)
- But consequences on **phenotypes** (e.g. smolts size)
 - Change of parr density
 - Density-dependent growth

→ Impact on **life-history traits** ?

AGE AT SEA MATURITY

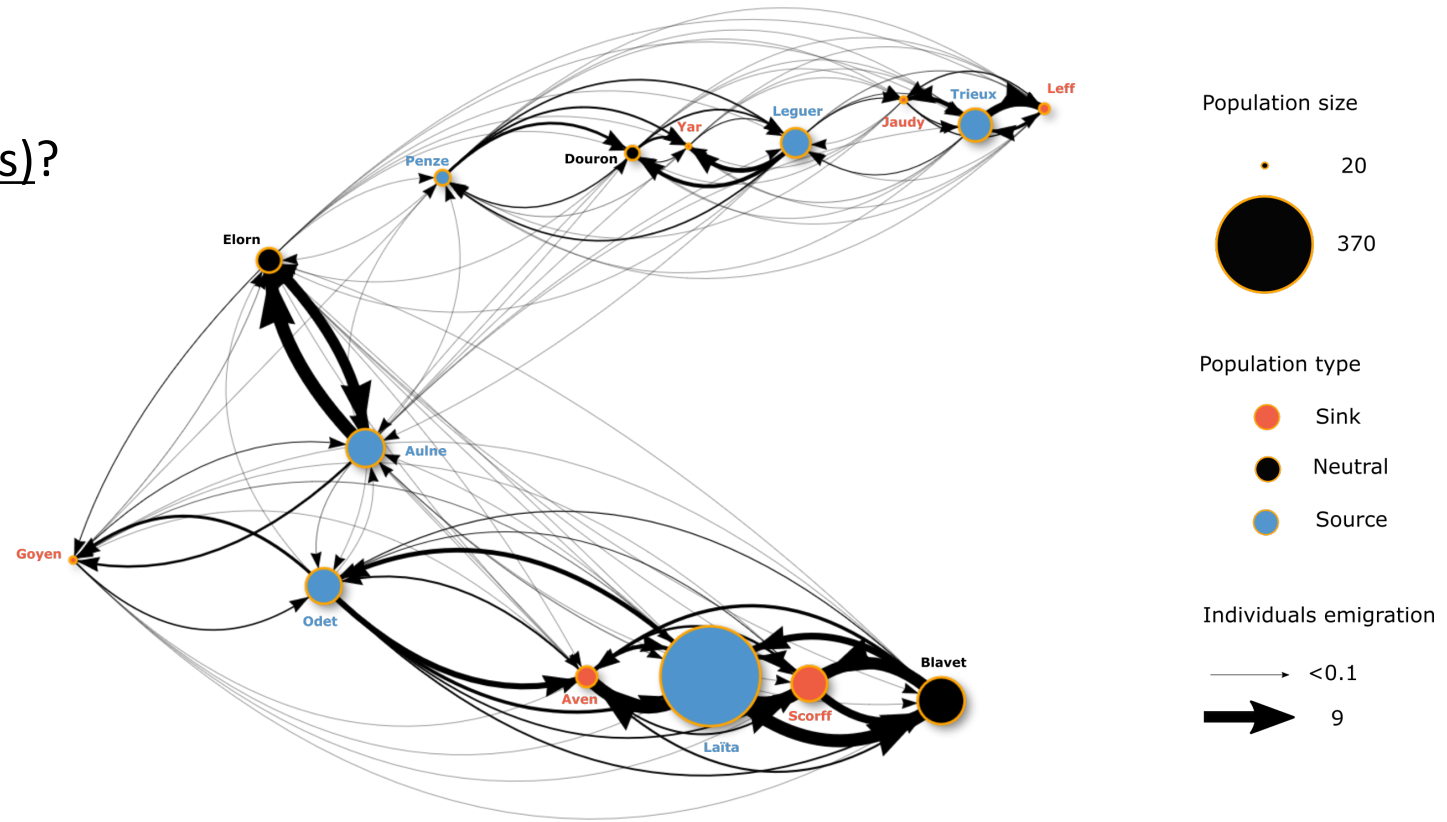
|| NEXT STEPS

- Role of dispersal in a context of climate change

|| NEXT STEPS

- Role of dispersal in a context of climate change
- What if non random dispersal (genetic basis)?

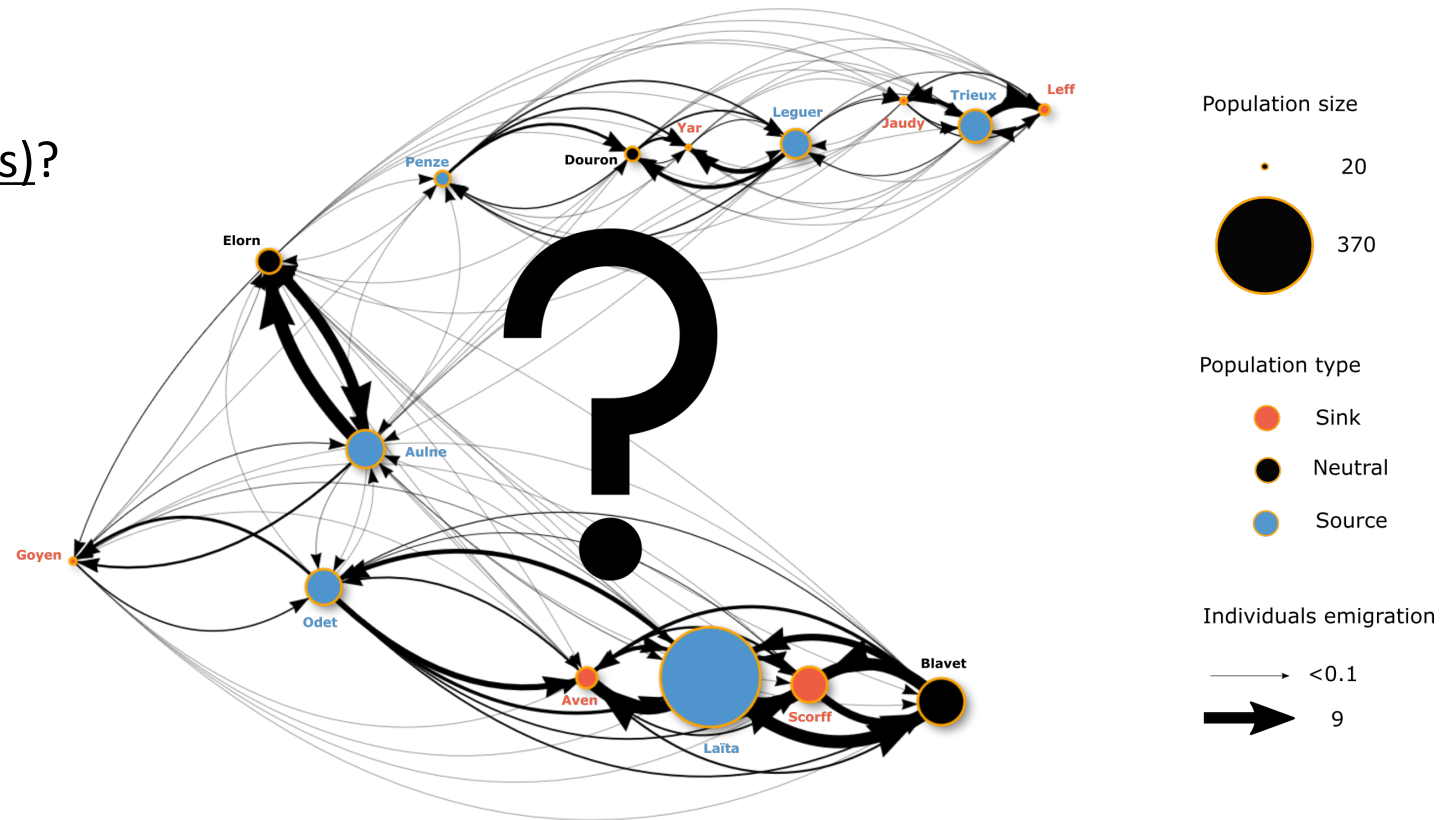
Spatial structure of the Brittany metapopulation



|| NEXT STEPS

- Role of dispersal in a context of climate change
- What if non random dispersal (genetic basis)?
Spatial structure?

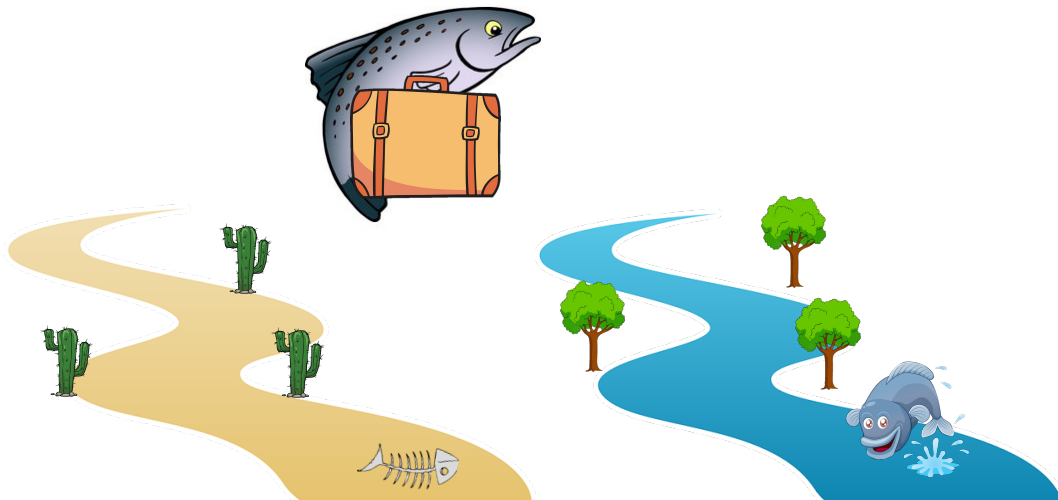
Spatial structure of the Brittany metapopulation



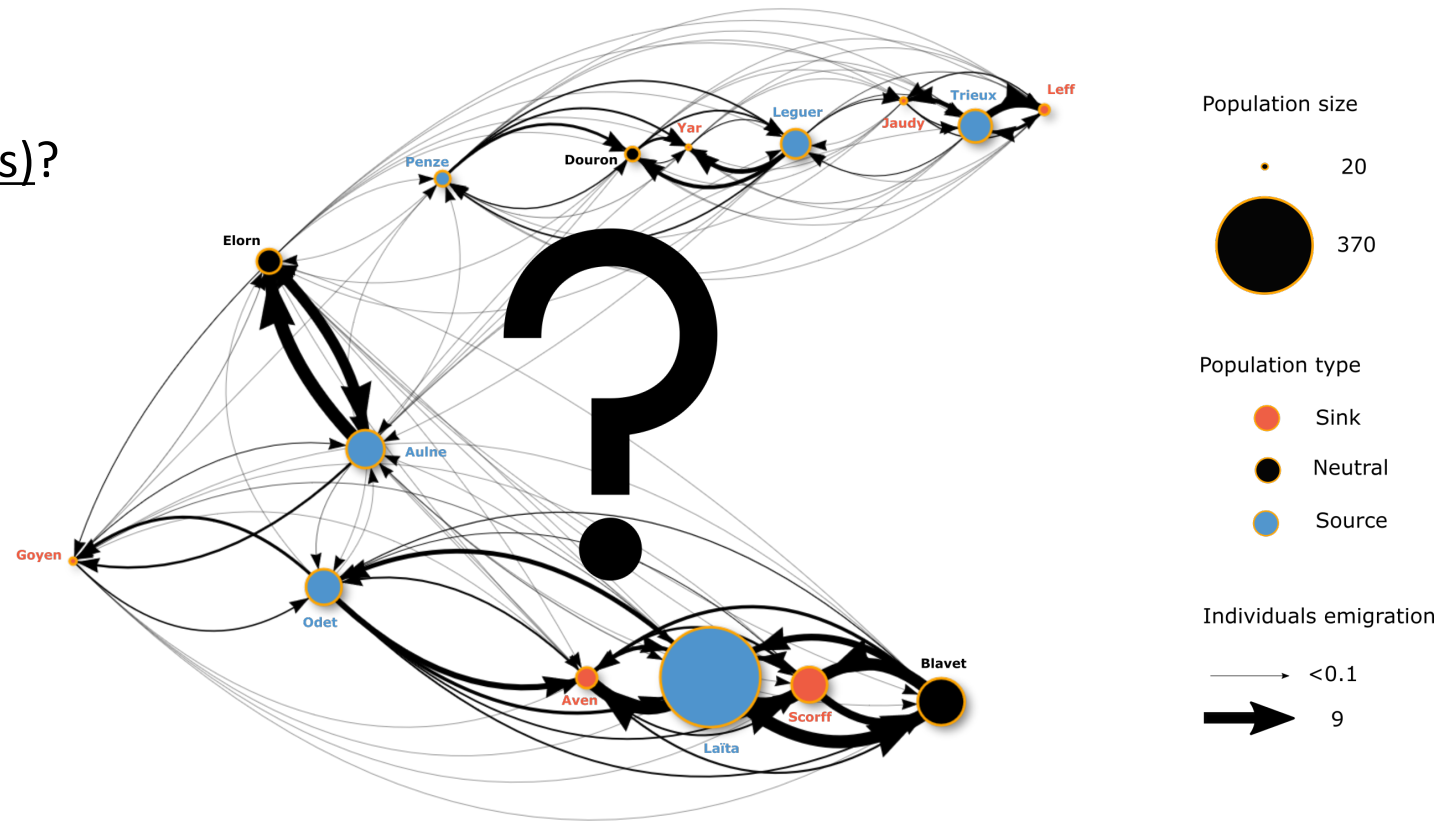
|| NEXT STEPS

- Role of dispersal in a context of climate change

- What if non random dispersal (genetic basis)?
Spatial structure?
Response to climate change?



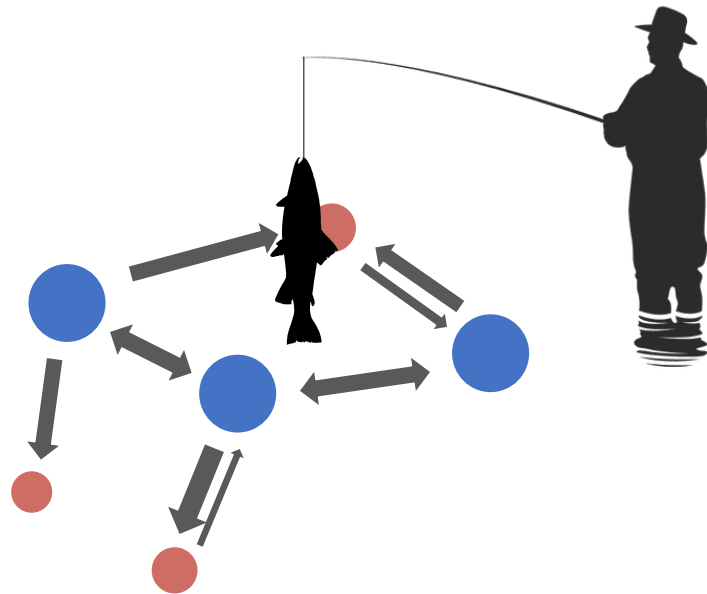
Spatial structure of the Brittany metapopulation



|| NEXT STEPS

Fisheries management in the context of spatially structured populations

- Brittany: local fishing with population-based conservation limits
- What are the best management strategies fostering metapopulation **and** local populations persistence and diversity ?



|| TAKE-HOME MESSAGES

- Straying **X**
- Dispersal **✓**



|| TAKE-HOME MESSAGES

- Straying **X**
- Dispersal **✓**

- Not a linear effect of dispersal on metapopulation stability:
rescue (low rates) and **anti-rescue effects** (high rates)
- Potential consequences of dispersal on **life-history traits** via density changes



|| TAKE-HOME MESSAGES

- Straying **X**
- Dispersal **✓**

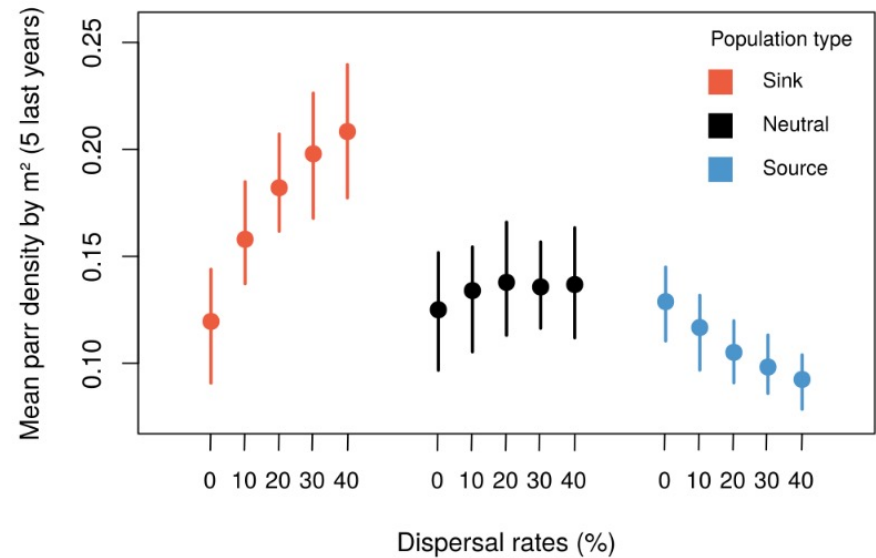
- Not a linear effect of dispersal on metapopulation stability:
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- Potential consequences of dispersal on **life-history traits** via density changes

- Lack of knowledge about mechanisms and rates of dispersal

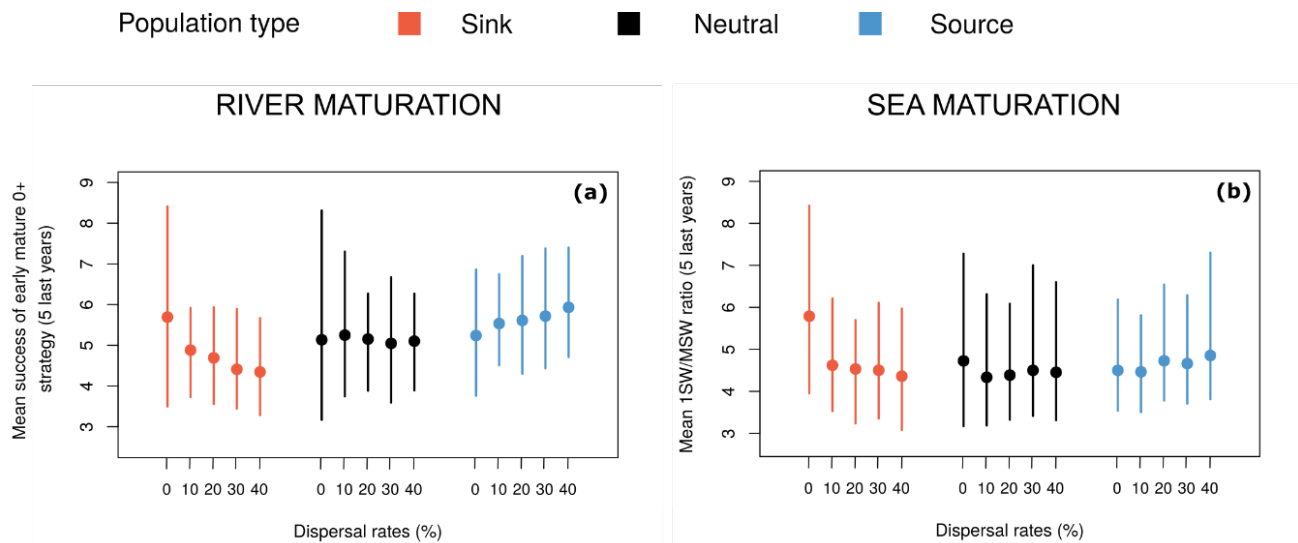
- Importance to consider spatial structure for **management**



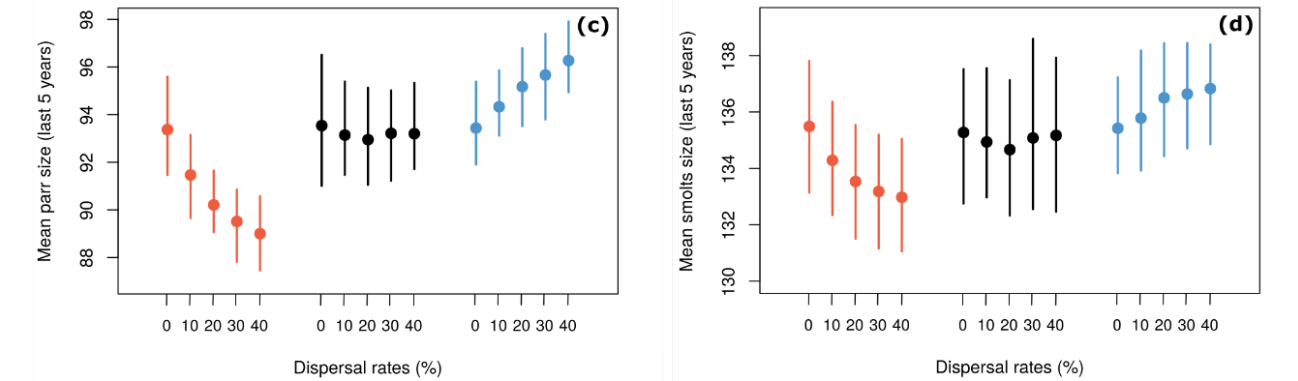
Thank you for your attention! Any question ?



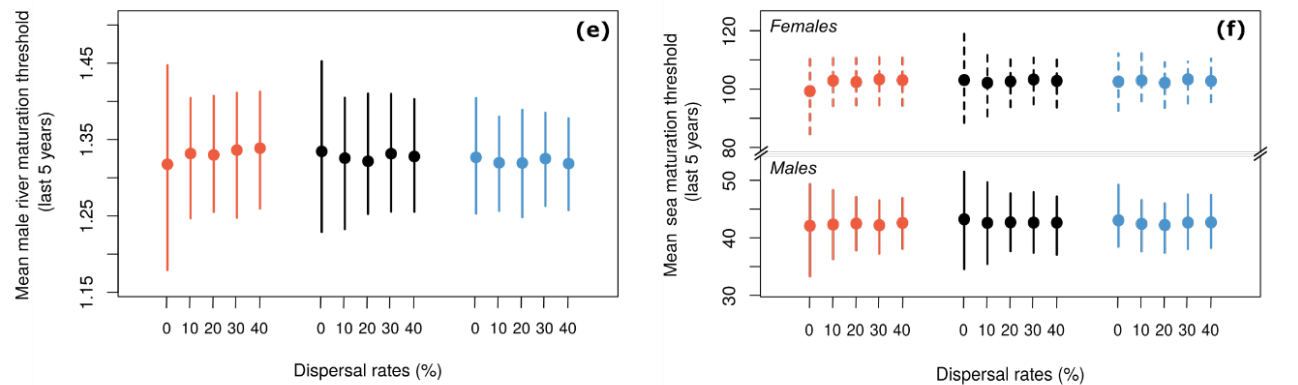
LIFE-HISTORY TRAIT
(AGE AT MATURATION)



PHENOTYPE
(JUVENILE SIZE)

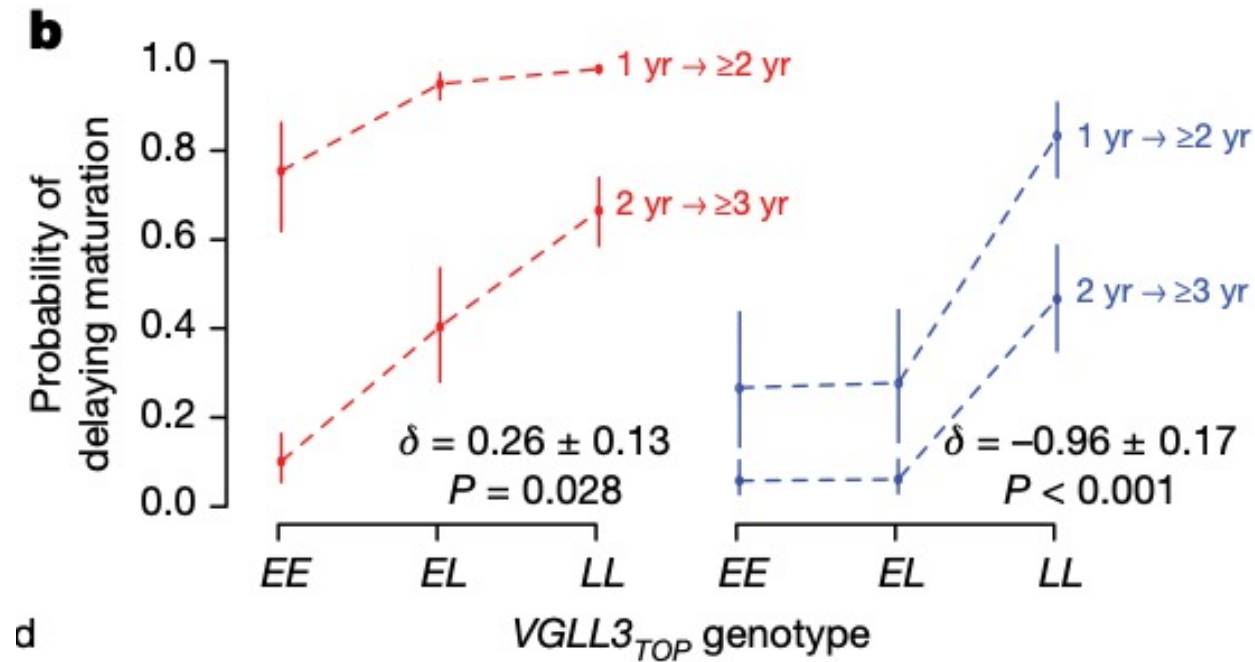


GENOTYPE
(MATURATION THRESHOLD)



Sex-dependent dominance at a single locus maintains variation in age at maturity in salmon

Nicola J. Barson^{1*}, Tutku Aykanat^{2*}, Kjetil Hindar³, Matthew Baranski⁴, Geir H. Bolstad³, Peder Fiske³, Céleste Jacq⁴, Arne J. Jensen³, Susan E. Johnston⁵, Sten Karlsson³, Matthew Kent¹, Thomas Moen⁶, Eero Niemelä⁷, Torfinn Nome¹, Tor F. Næsje³, Panu Orell⁷, Atso Romakkaniemi⁷, Harald Sægvog⁸, Kurt Urdal⁸, Jaakko Erkinaro⁷, Sigbjørn Lien¹ & Craig R. Primmer²



Axis 1: Role of biocomplexity and dispersal on metapopulation response to CC

How dispersal influences metapopulation **stability** ?

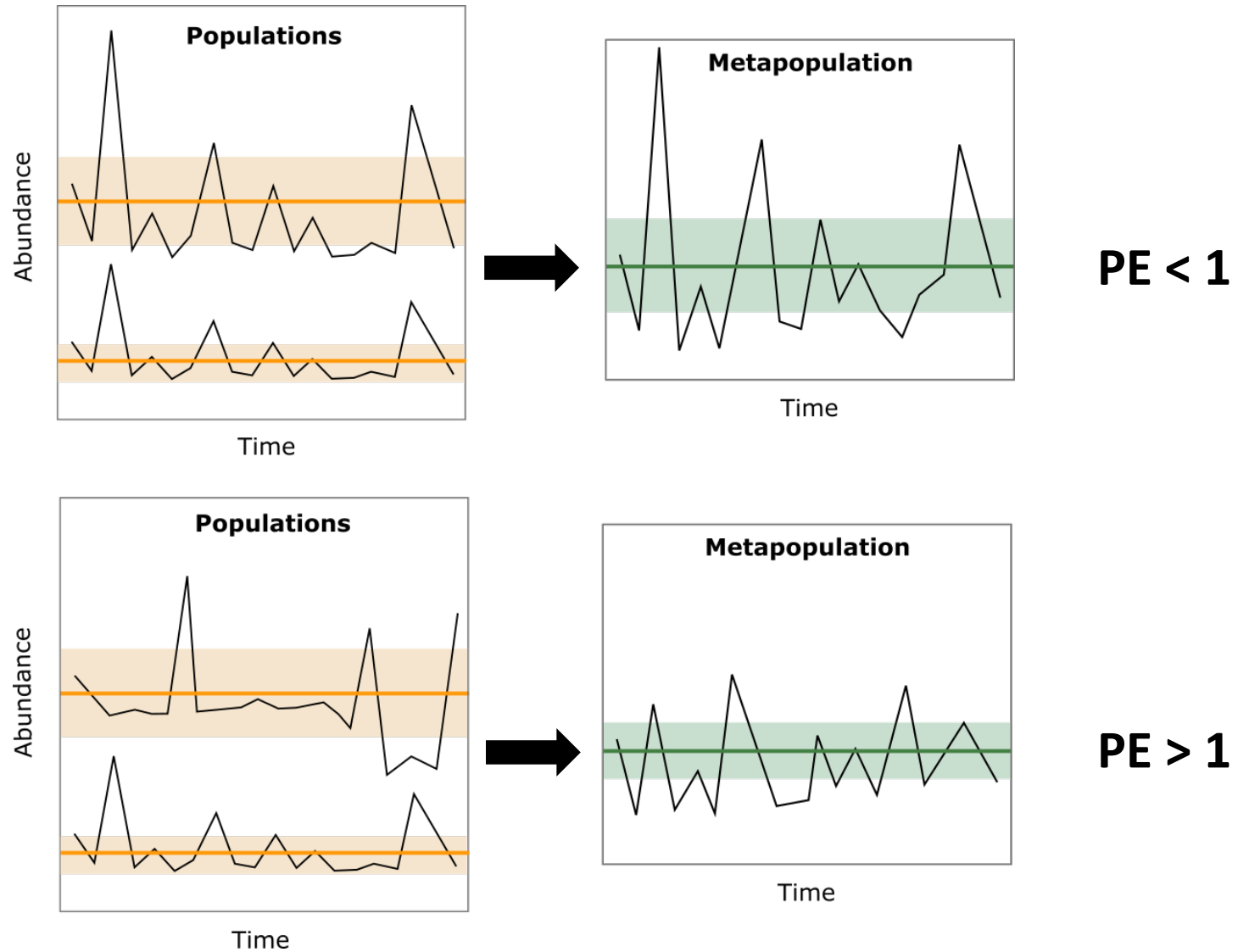
Synchrony = 1

- Populations highly synchronous
- Metapopulation size variable

$$\text{Synchrony} = \frac{\sigma_{\text{metapop}}^2}{\left(\sum_{\text{pop}_i} \sigma_{\text{pop}_i}\right)^2}$$

Synchrony = 0

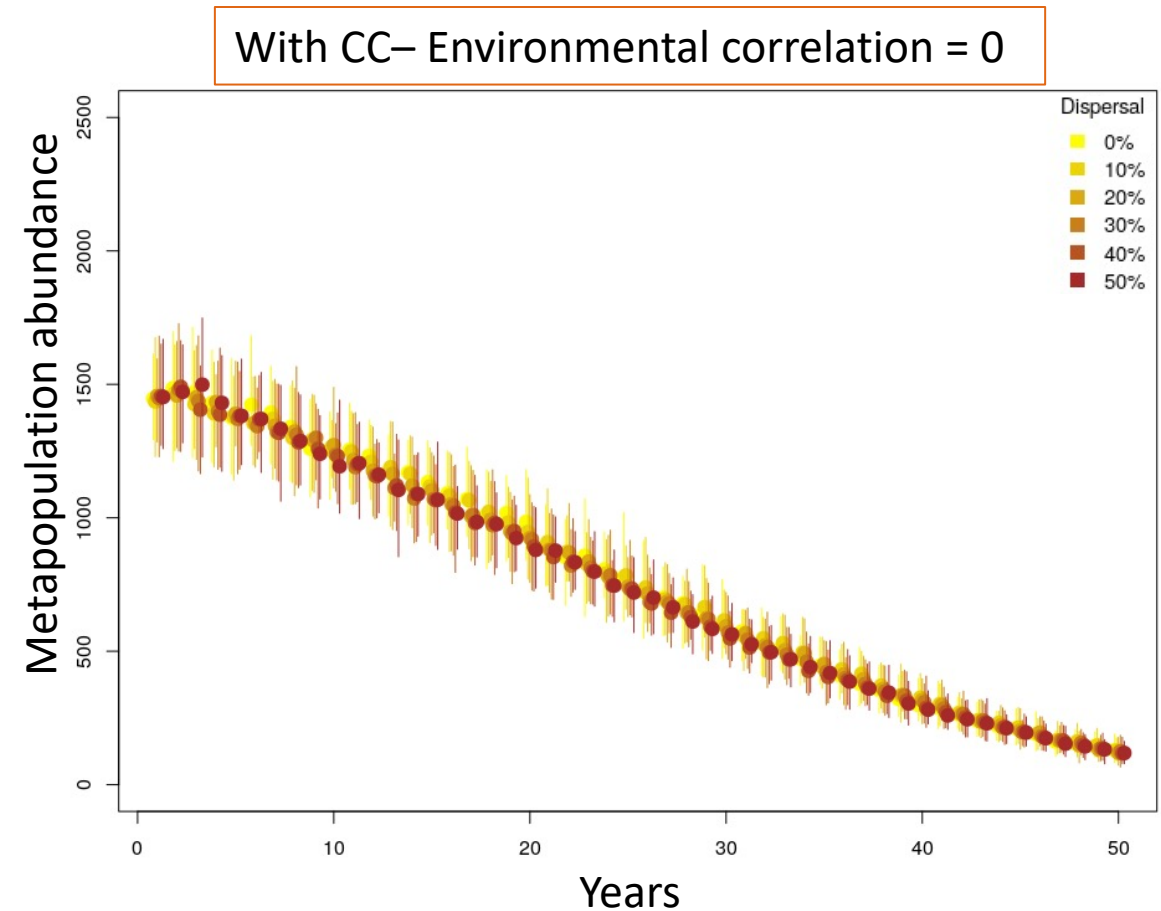
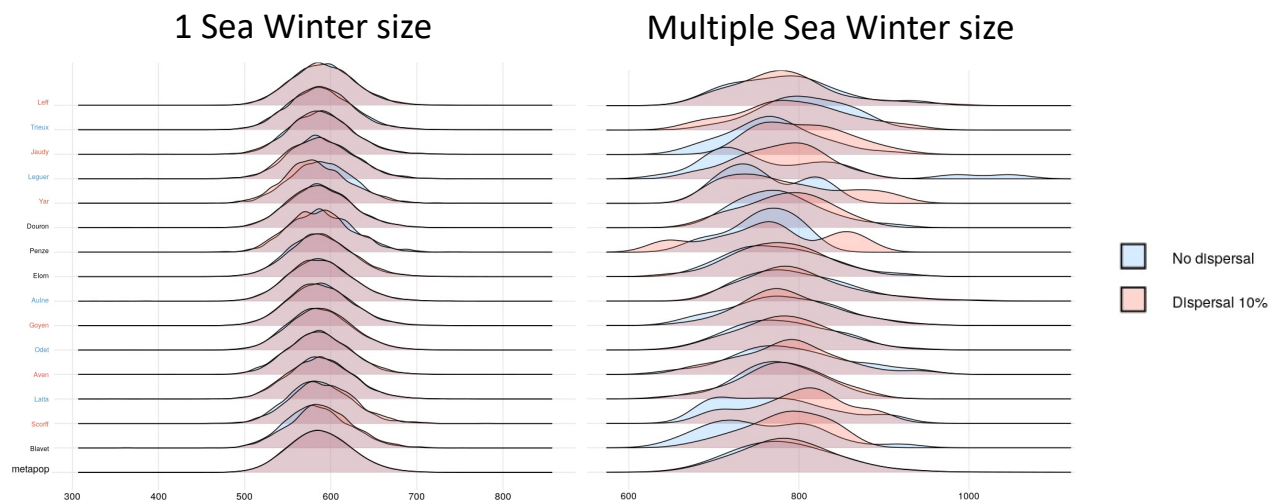
- Populations highly asynchronous
- Metapopulation size stable



Axis 1: Role of biocomplexity and dispersal on metapopulation response to CC

How climate change influences metapopulation **persistence** ?

- Dispersal does not influence **metapopulation persistence** facing CC
- BUT... has **local impacts** (populations persistence and density-induced phenotypic changes)
- AND...**No diversity** of phenotypic and genotypic characters between populations (all environmental conditions = Scorff)



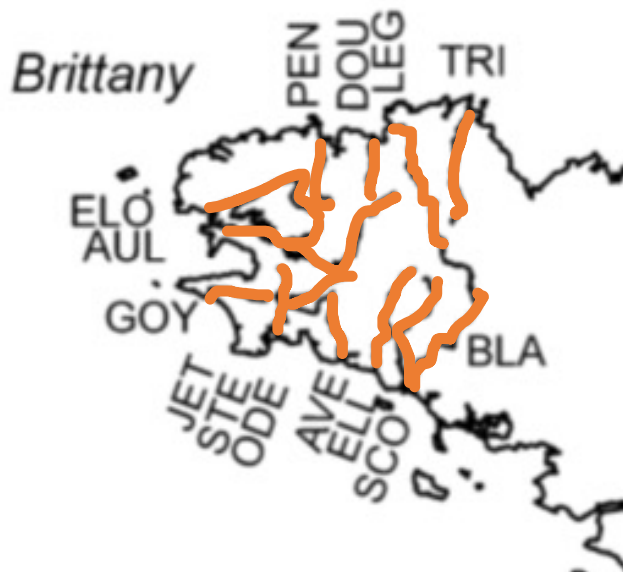
Axis 1: Role of biocomplexity and dispersal on metapopulation response to CC

B. Ongoing and upcoming work


What if environmental conditions were too similar in Brittany?

↳ Another case study: the Adour system


- Dendritic spatial structure
- Dispersal intra basin
- Higher environmental diversity (and biocomplexity ?)
 - Rivers differentially impacted by snow melt



↳ different patterns facing CC?



→ Model generalization

- Capsis software initiation 
- Meeting to build the model « architecture »