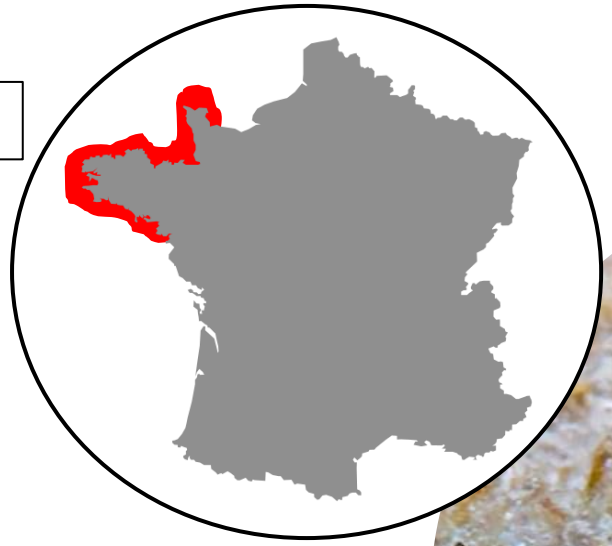
Population genetic structure of natural and hatchery-raised populations of European abalone *Haliotis tuberculata tuberculata*: lessons for future restocking and stock-enhancement

Ronan Le Gall, Pierre Chauvaud, Sabine Roussel, Eric Pante, Amélia Viricel & Grégory Charrier

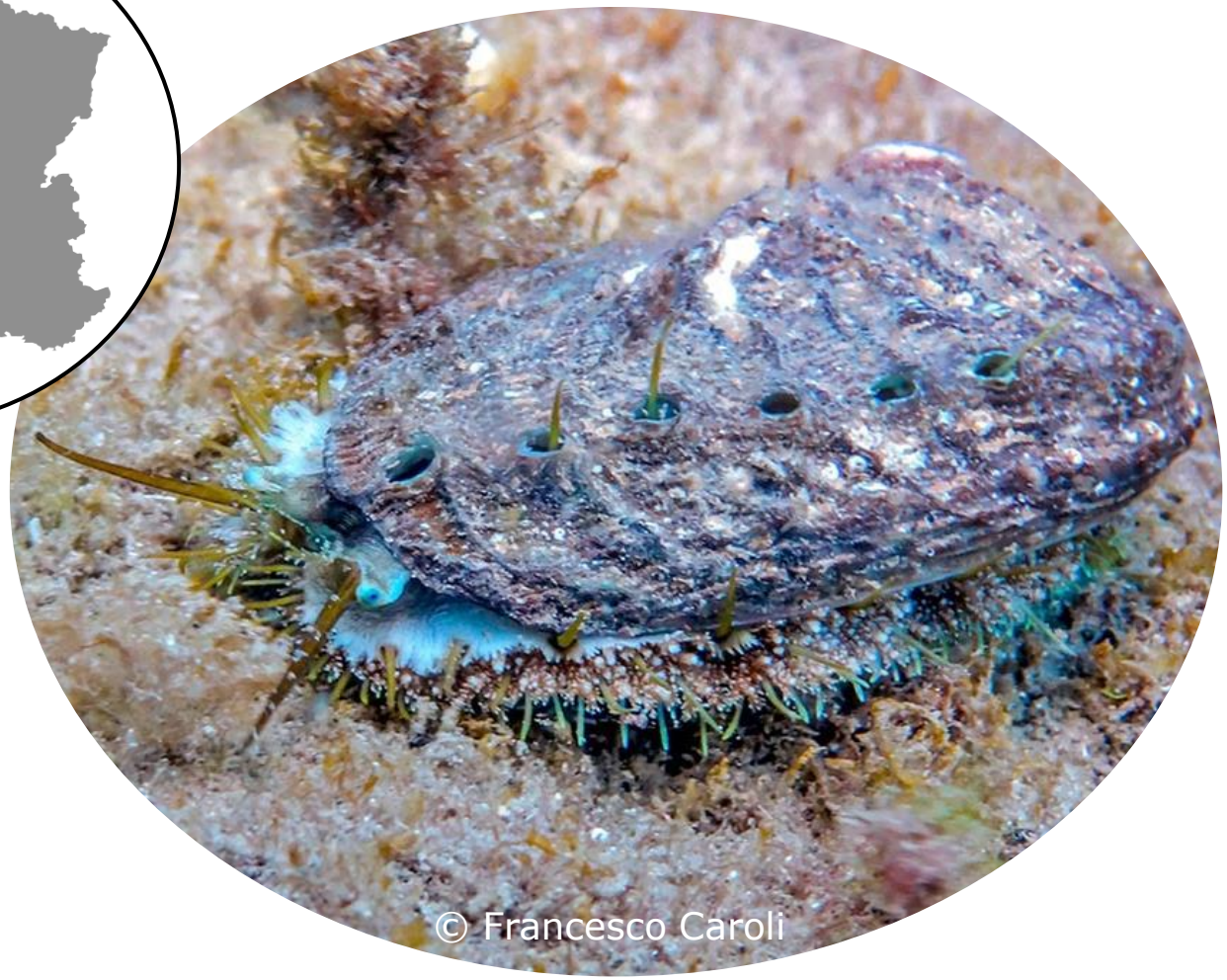
Abalone Symposium, Auckland, New Zealand
02 March 2023

PhD financing: 50% ARED UBO - 50% UBO EDSML

Location



Haliotis tuberculata tuberculata



Nicolas et al., 2002; Huchette et al., 2005; Lessard and Campbell, 2007; Travers et al., 2009; Lorenzen et al., 2012; Lachambre, 2017; Roussel et al., 2019

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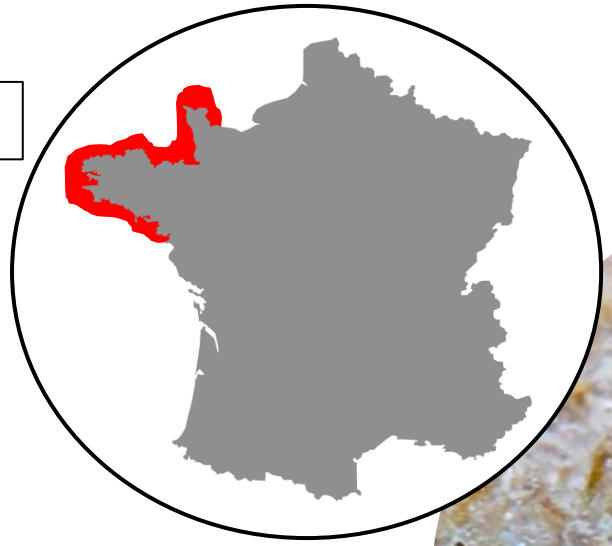
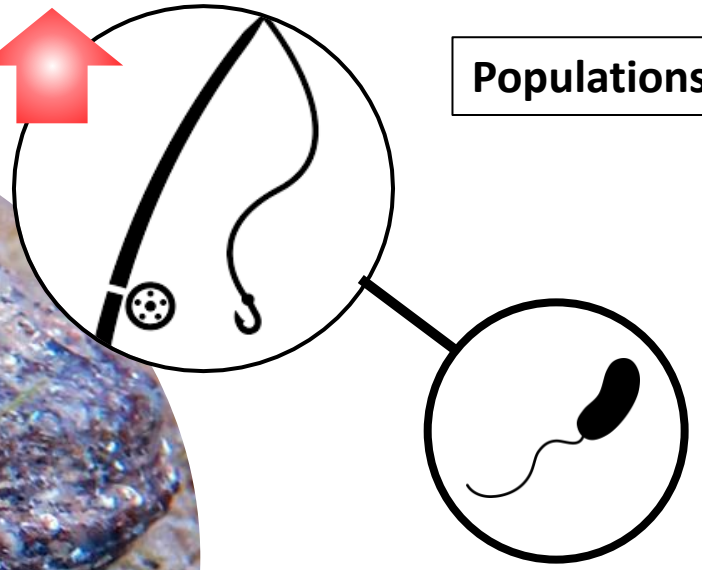


Populations decline



Vibrio harveyi

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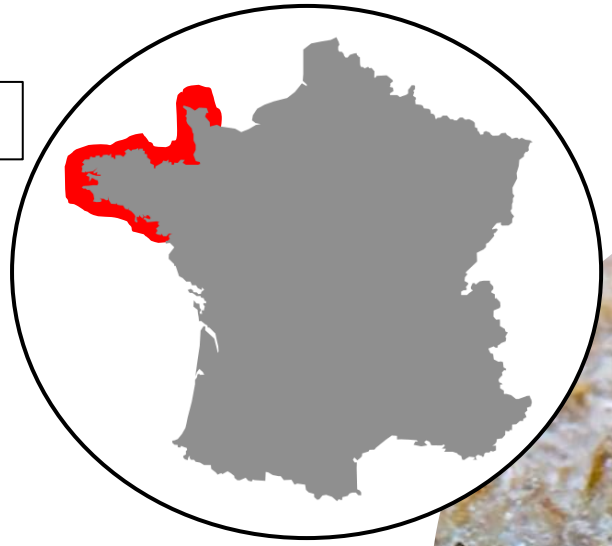

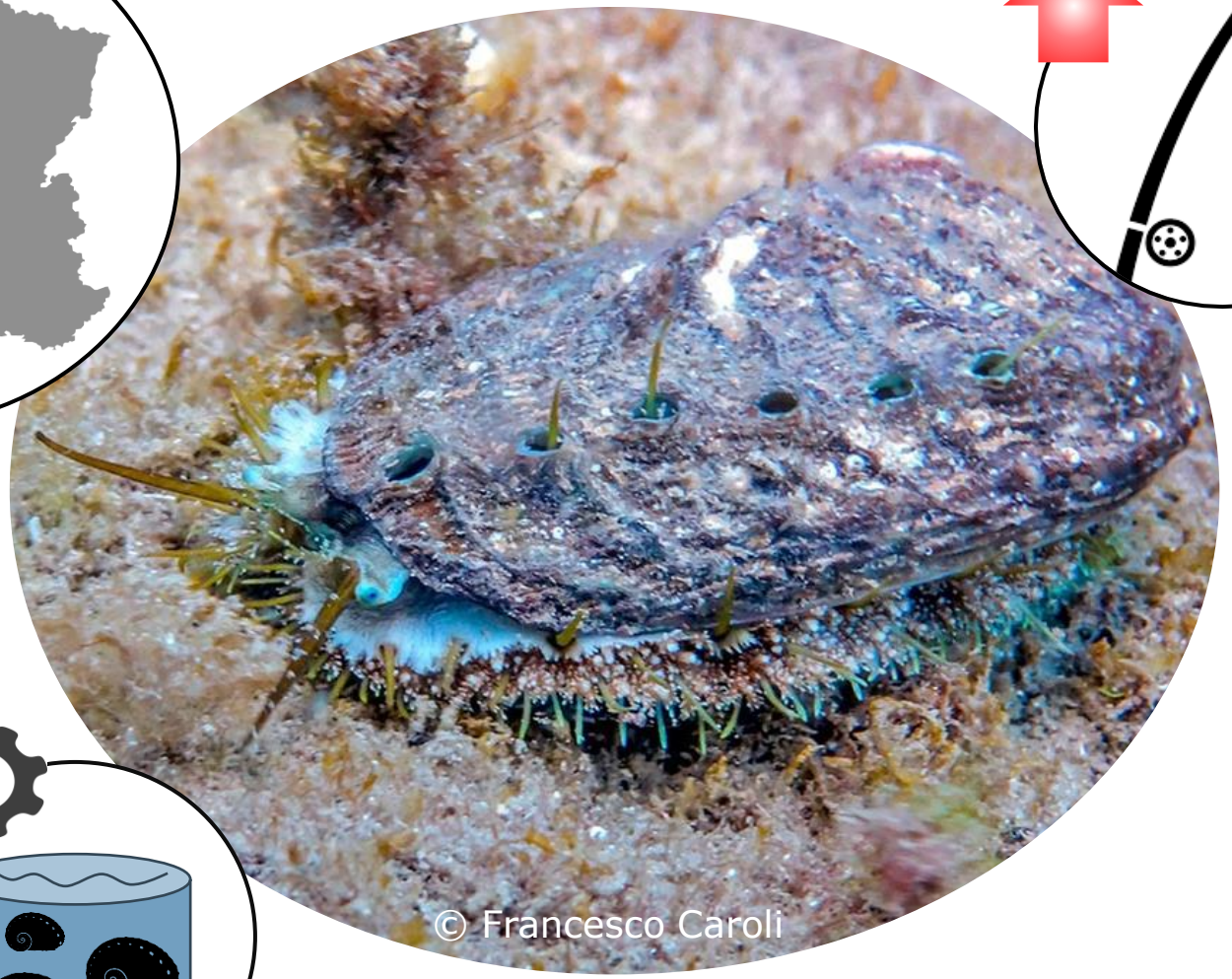

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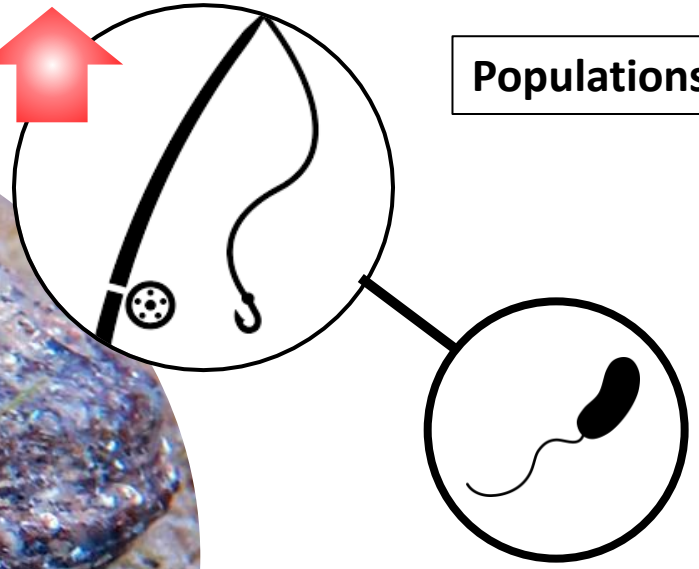
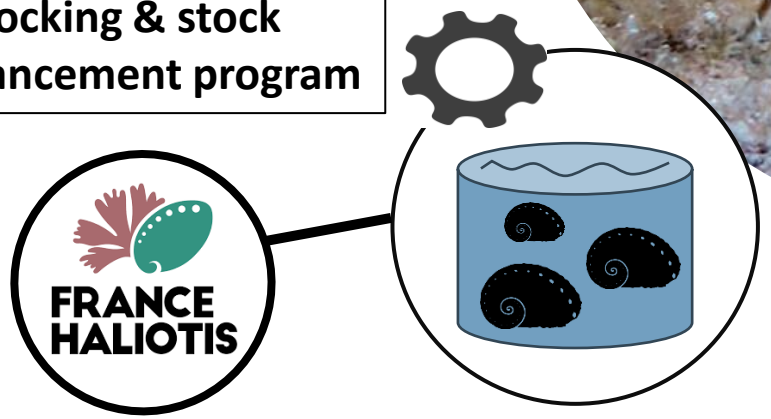


Vibrio harveyi

Restocking & stock enhancement program



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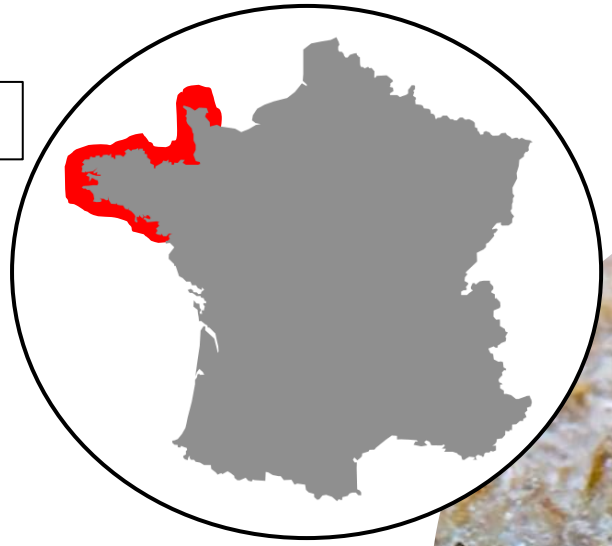

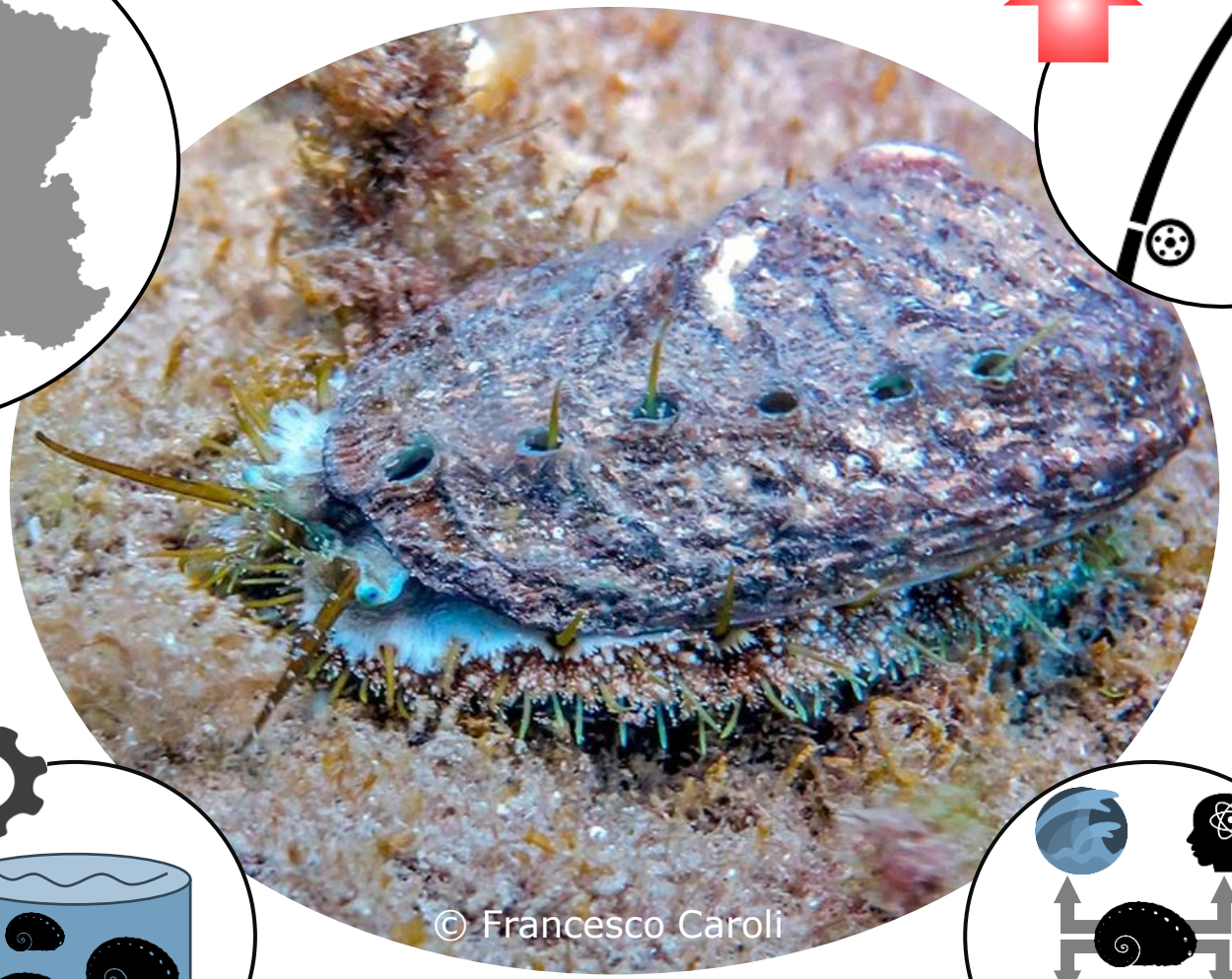

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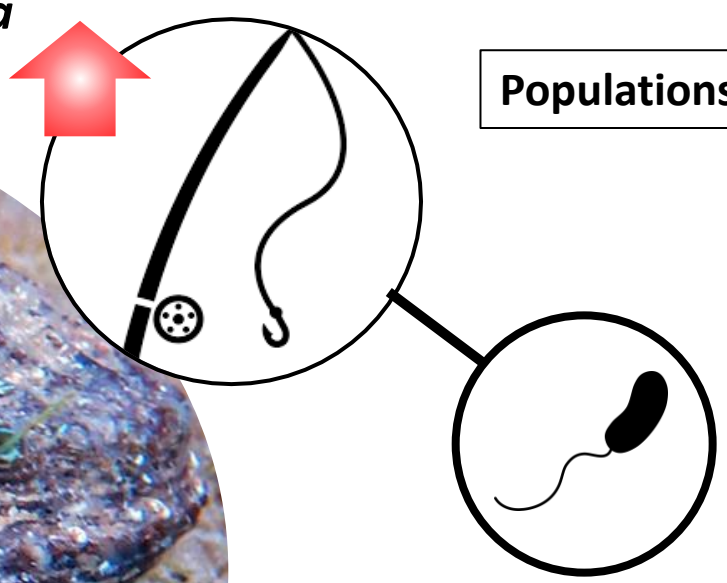

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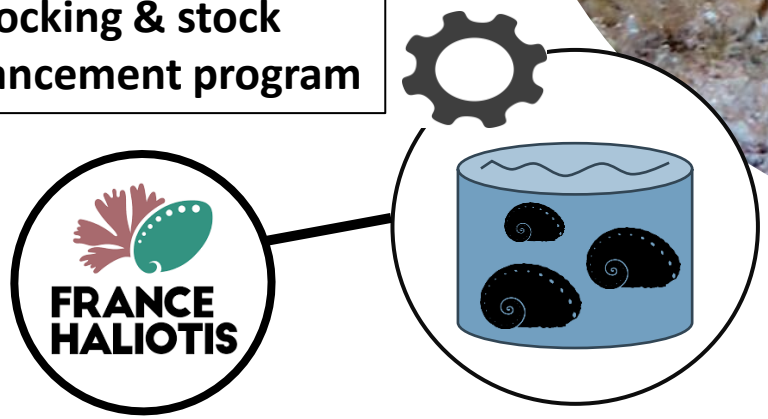
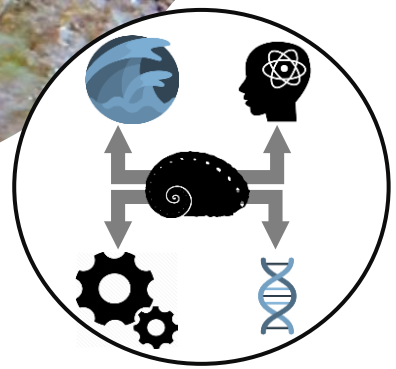


Levels of Study



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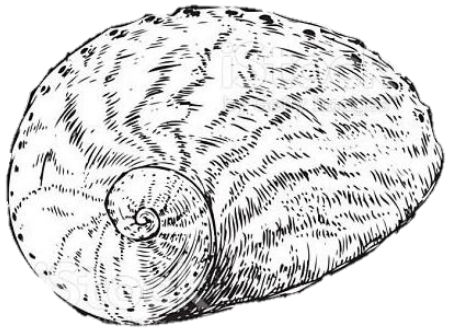
Genetics

- **Need to limit genetic differentiation** between wild & hatchery individuals

Study natural genetic structure



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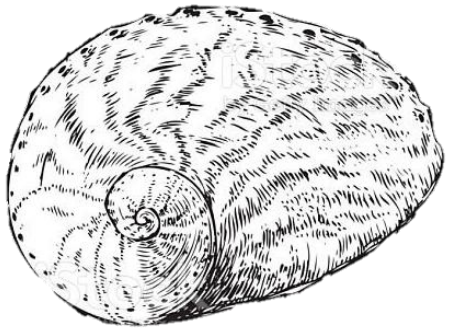

Genetic drift in hatchery

↑ **Genetic differentiation** between wild & hatchery

Release: **Potential Impact** on wild population

↓ **Reduce local adaptation** to local environmental pressures

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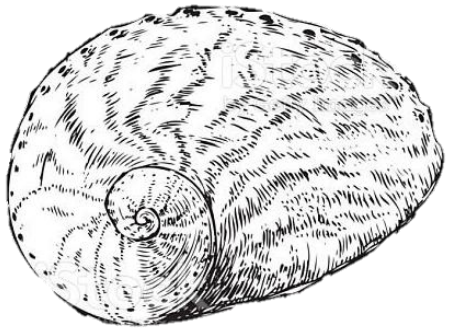

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Aims:

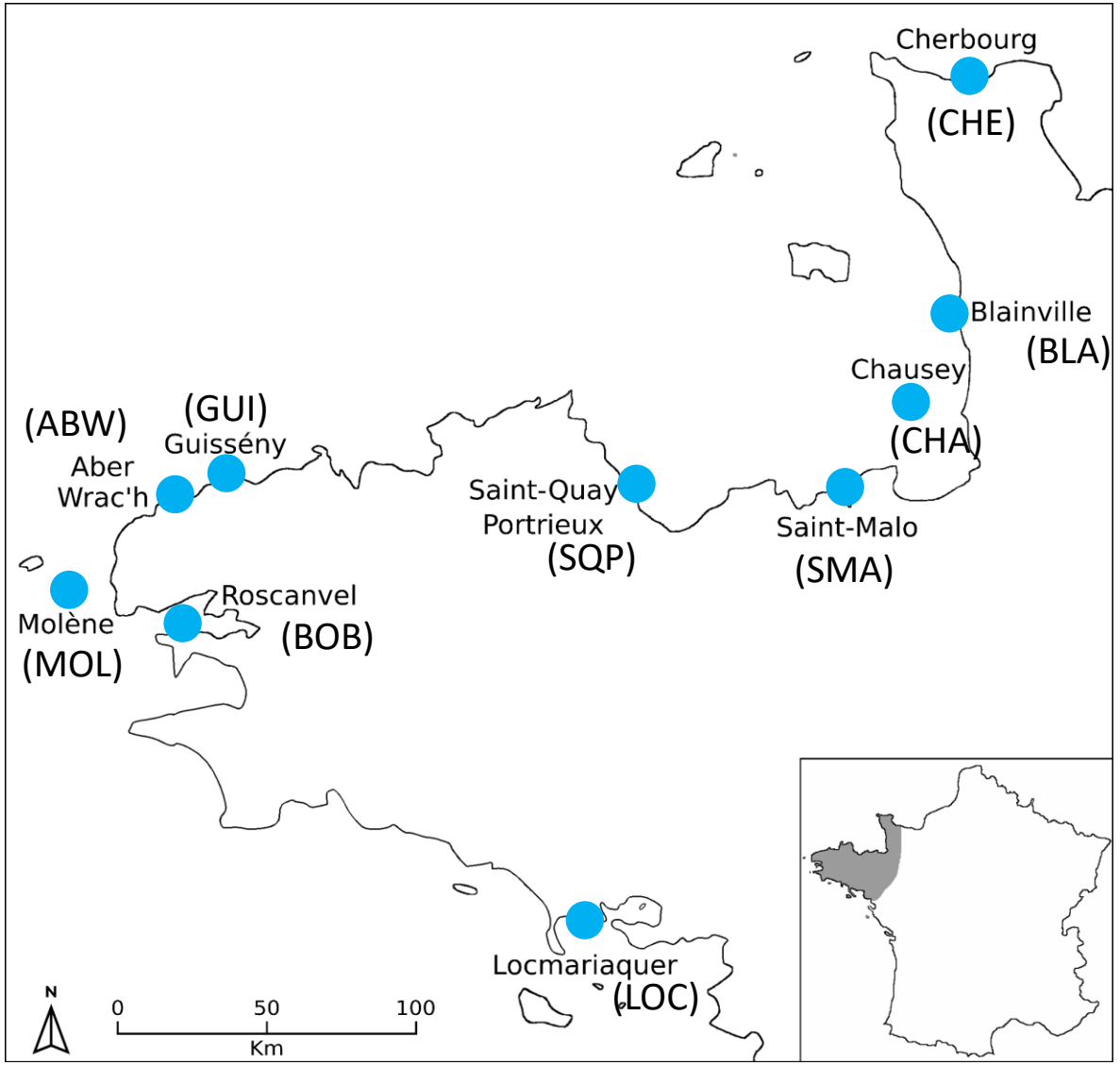
- Identify genetic structuring along French coast
- Assess genetic diversity of hatchery-reared individuals and compare with natural populations

Price, 1984; Bell et al., 2008; Laikre et al., 2010; Rhode et al., 2012; Morvezen et al. 2016; Grant et al., 2017

Sampling

Wild Population

- **429** Individuals
- **10** sites
  - **Covers natural range** of the subspecies
- **Several cohorts** sampled



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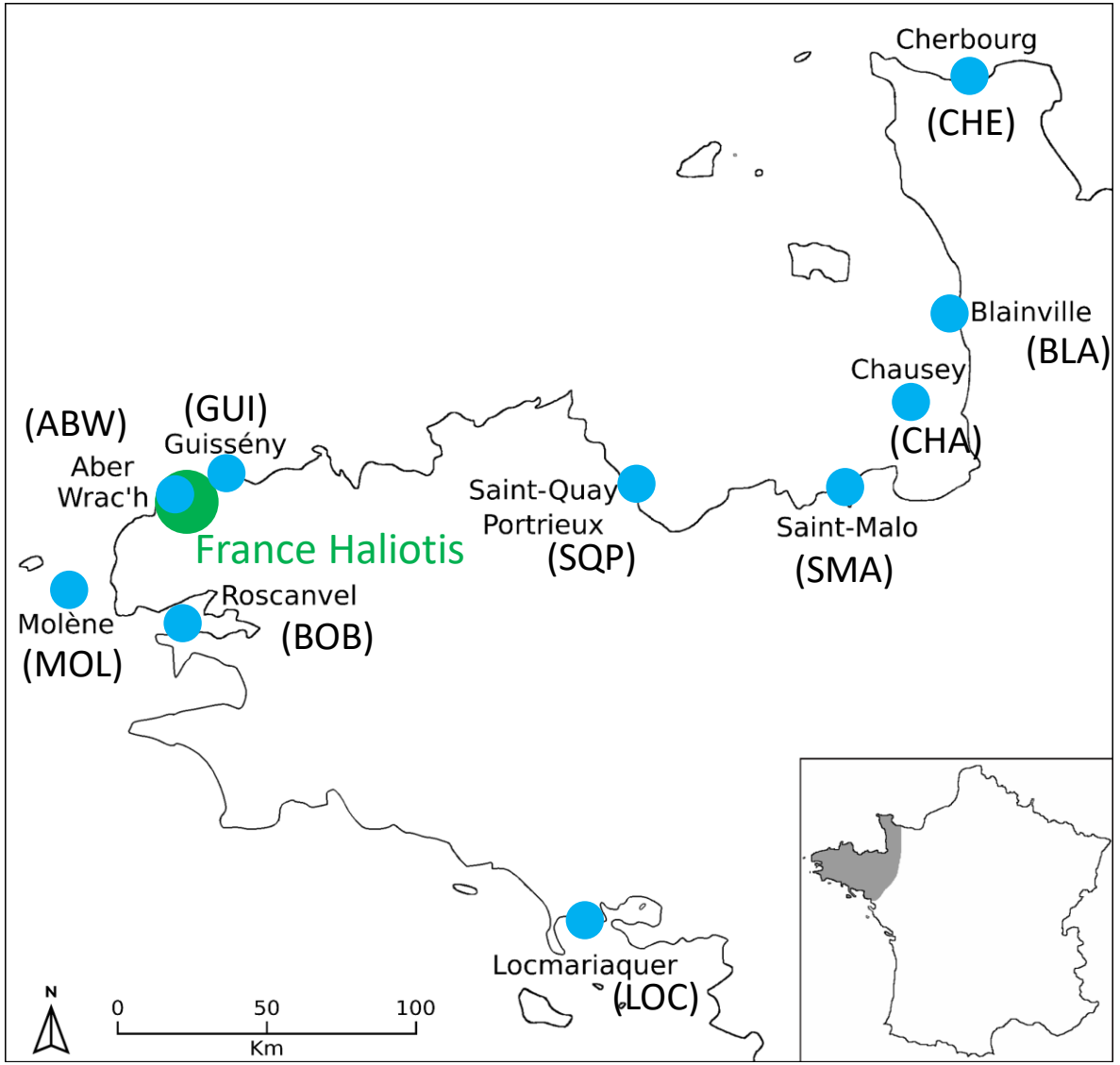
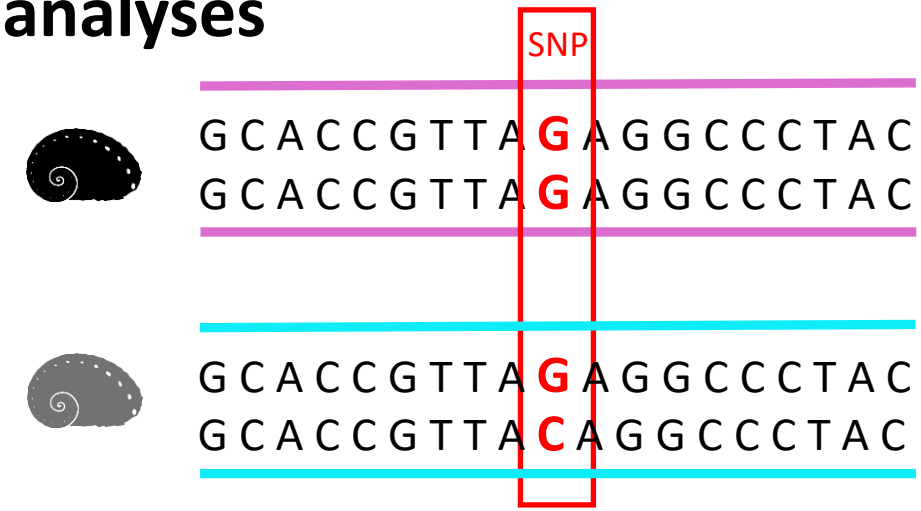
Hatchery Samples

- **467** Individuals
- France Haliotis
- **14** subgroups
  - **3rd to 5th generation in hatchery** (selection program)



SNP selection and laboratory genetic analyses

- **Single-nucleotide polymorphism (SNP)**
  - Variations of one single base pair throughout the genome



Harney et al., 2018

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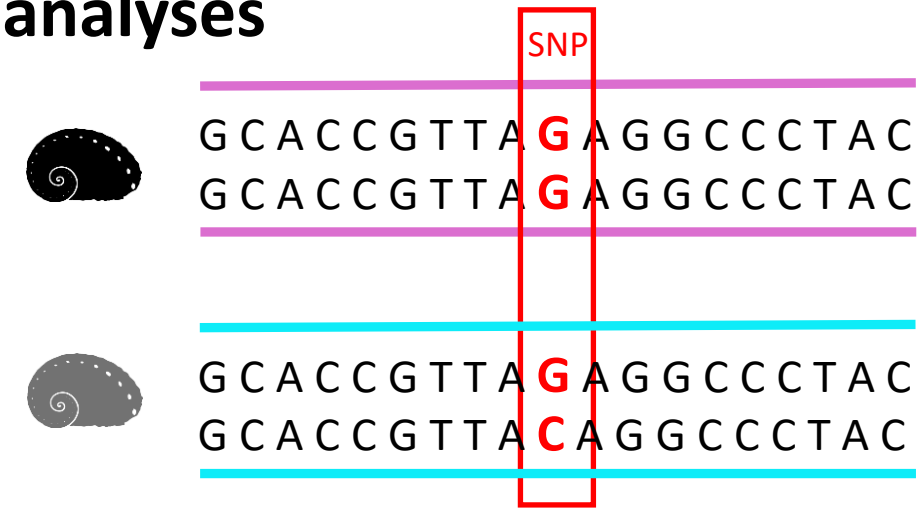

Genotyping using **Kompetitive Allele Specific PCR assays** (KASP) by LGC Genomics

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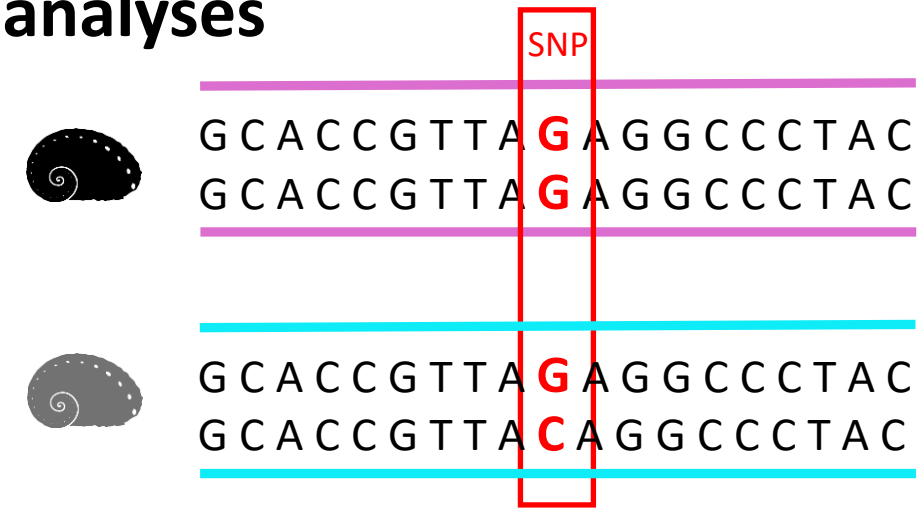
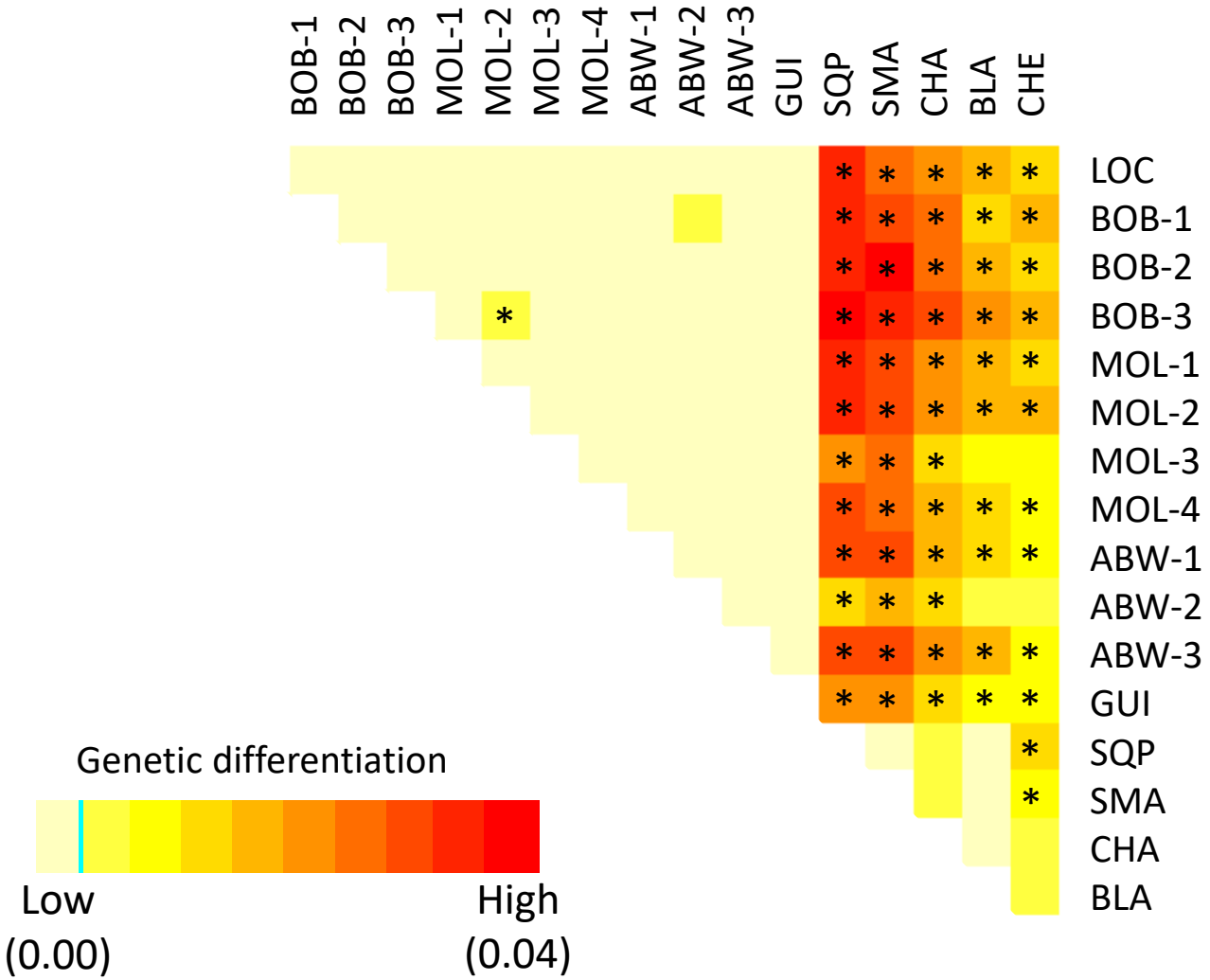


Genotyping using **Kompetitive Allele Specific PCR assays** (KASP) by LGC Genomics

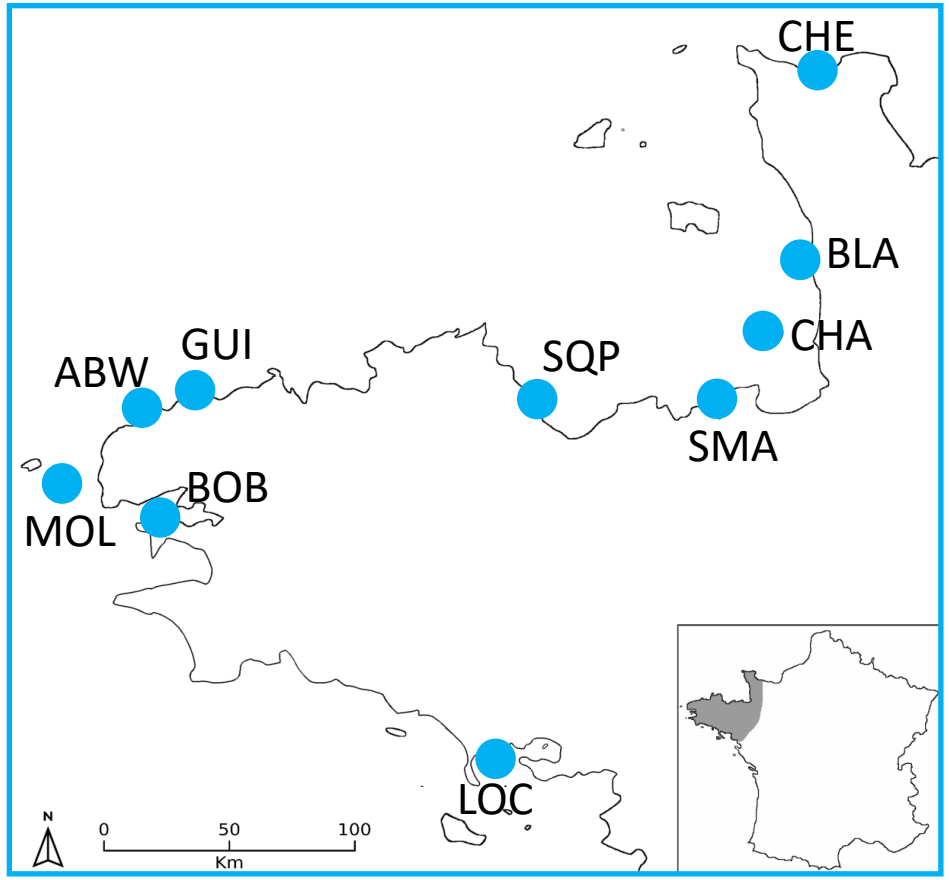
- **158 bi-alleic nuclear SNPs**
  - Filtered to keep only neutral markers for connectivity analysis
  - Using Hardy-Weinberg Equilibrium, Linkage Disequilibrium, Outliers
    => 147 SNPS

Harney et al., 2018

- **Index of genetic differentiation (Pairwise Fst)**



*P-value<0.05



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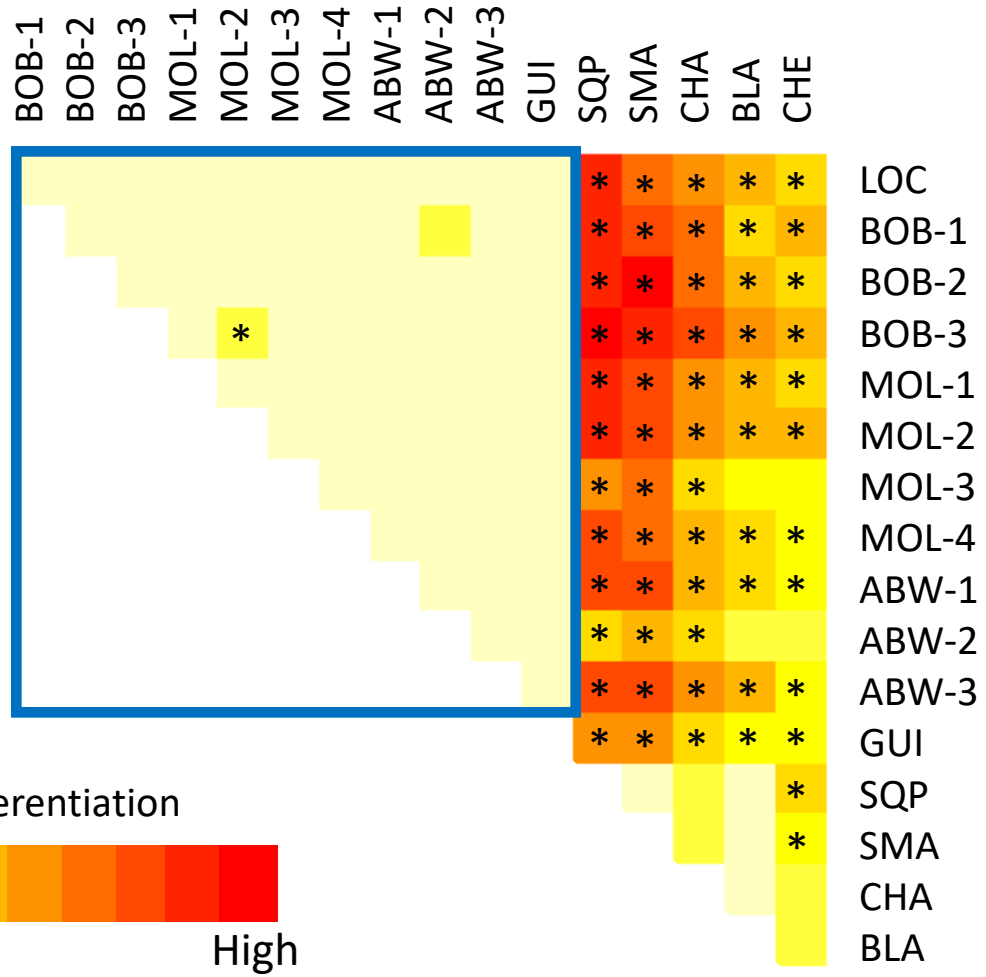

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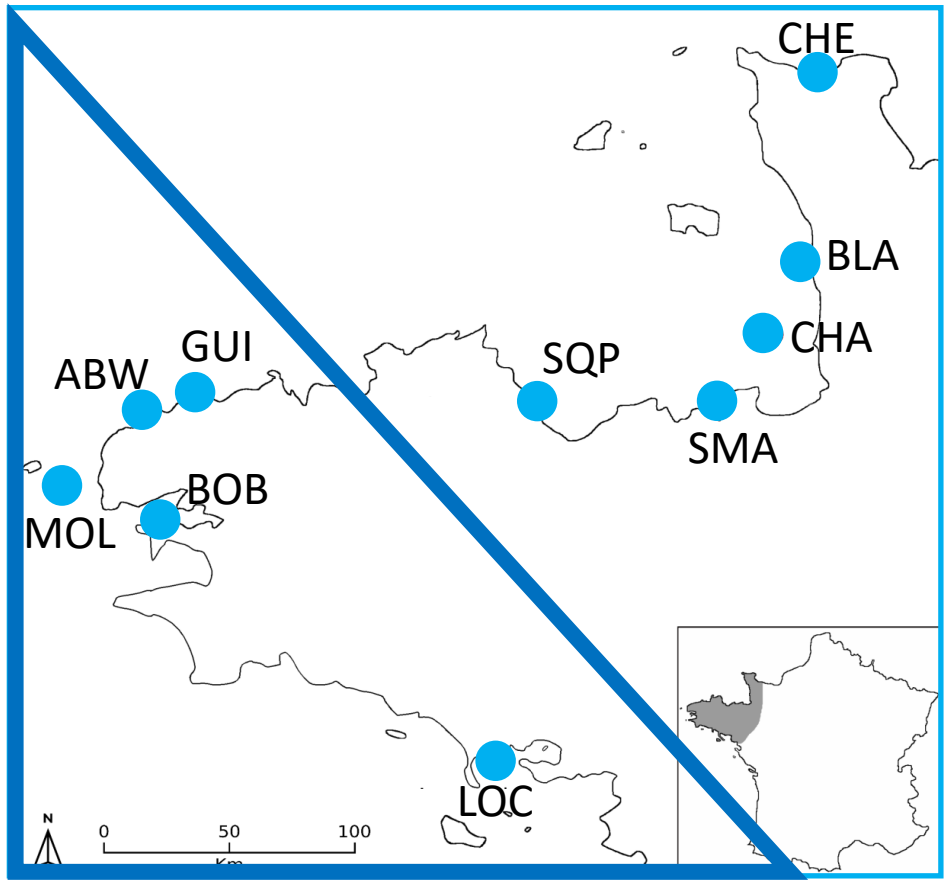

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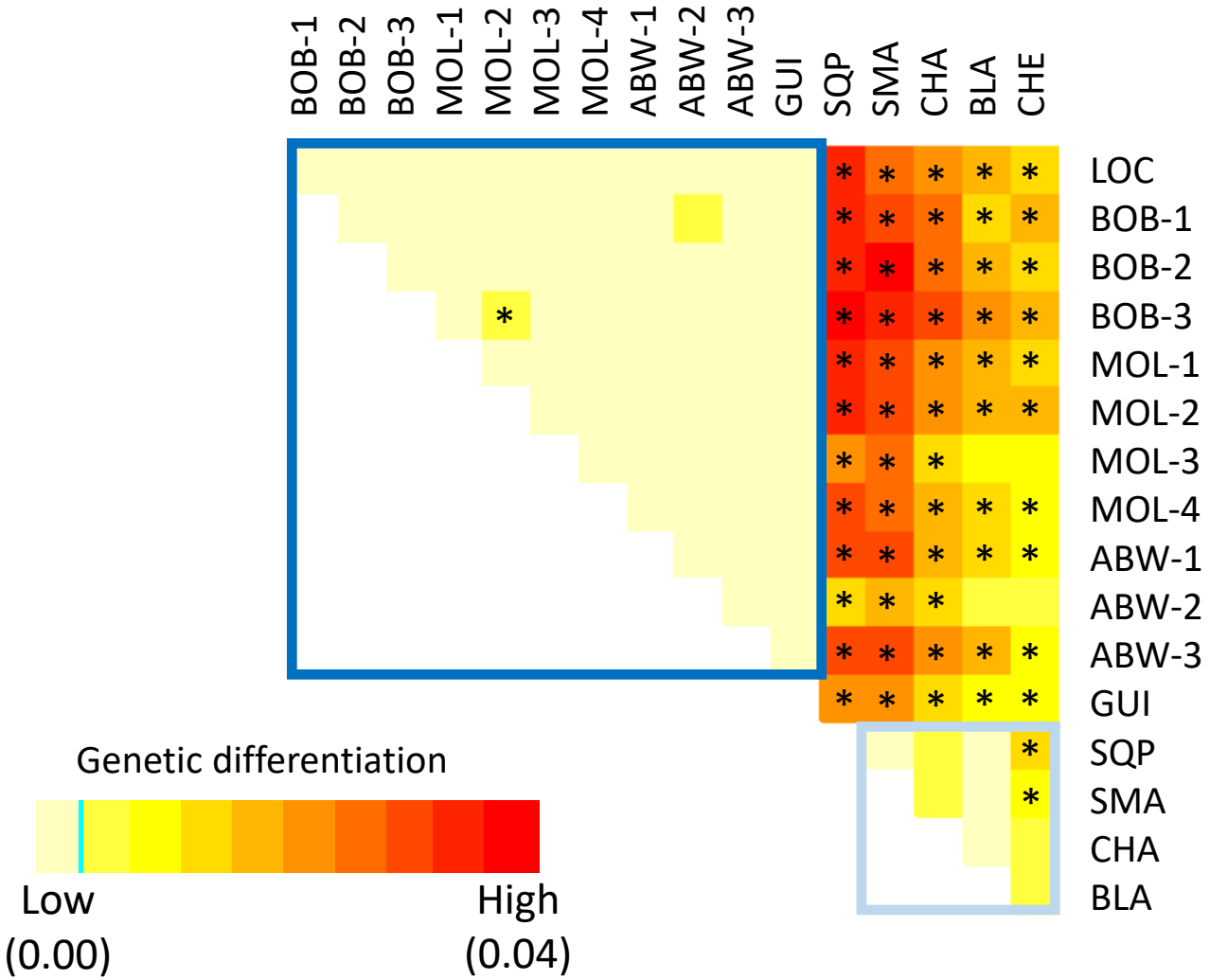

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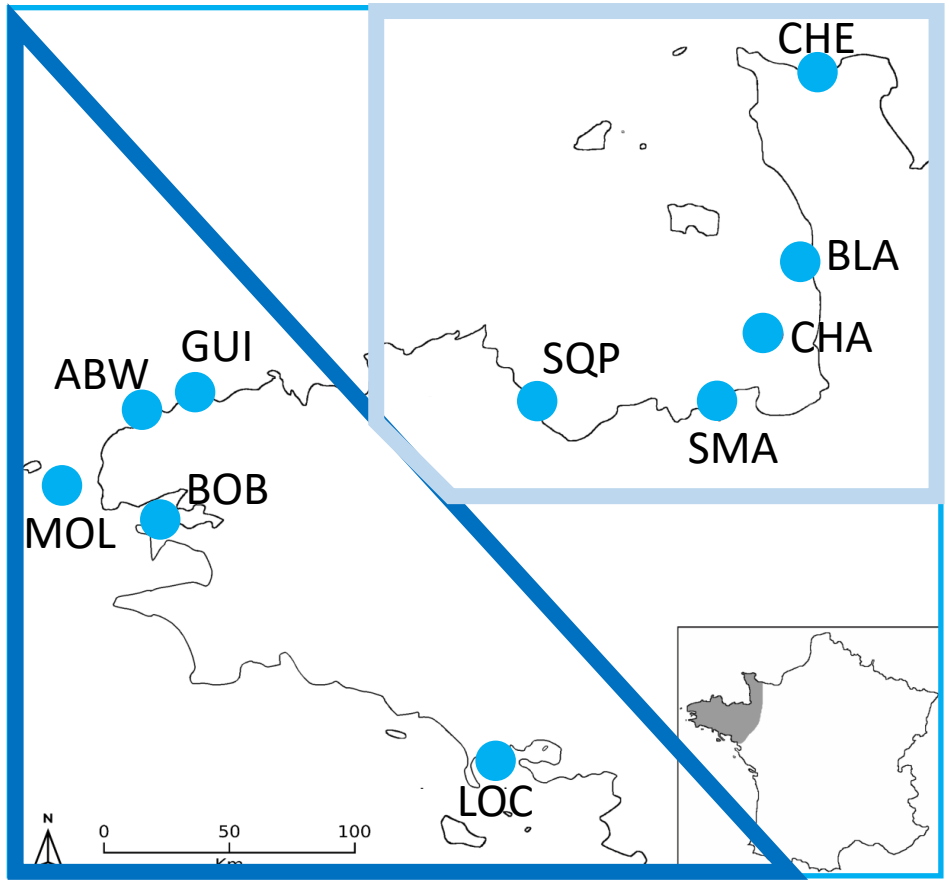

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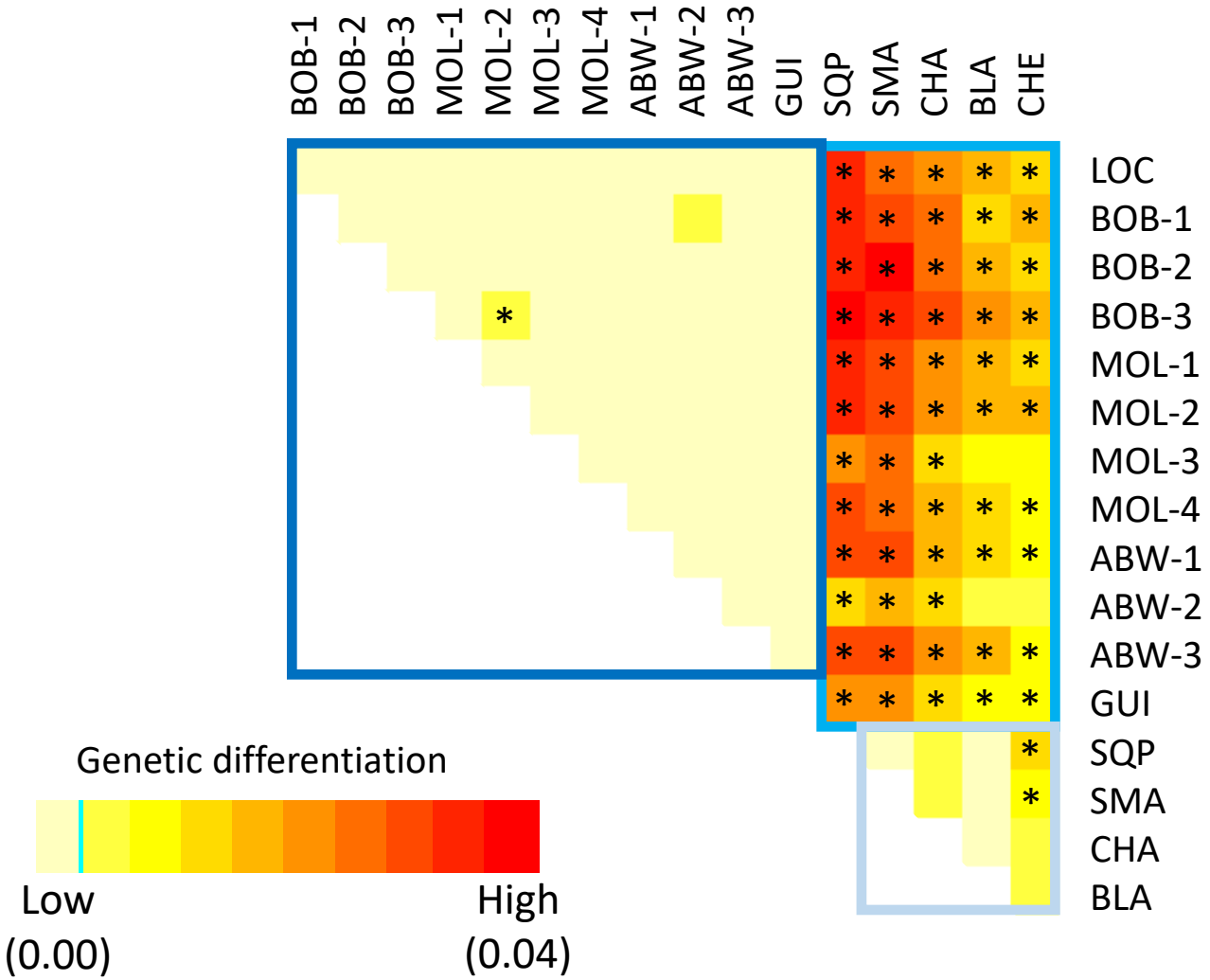

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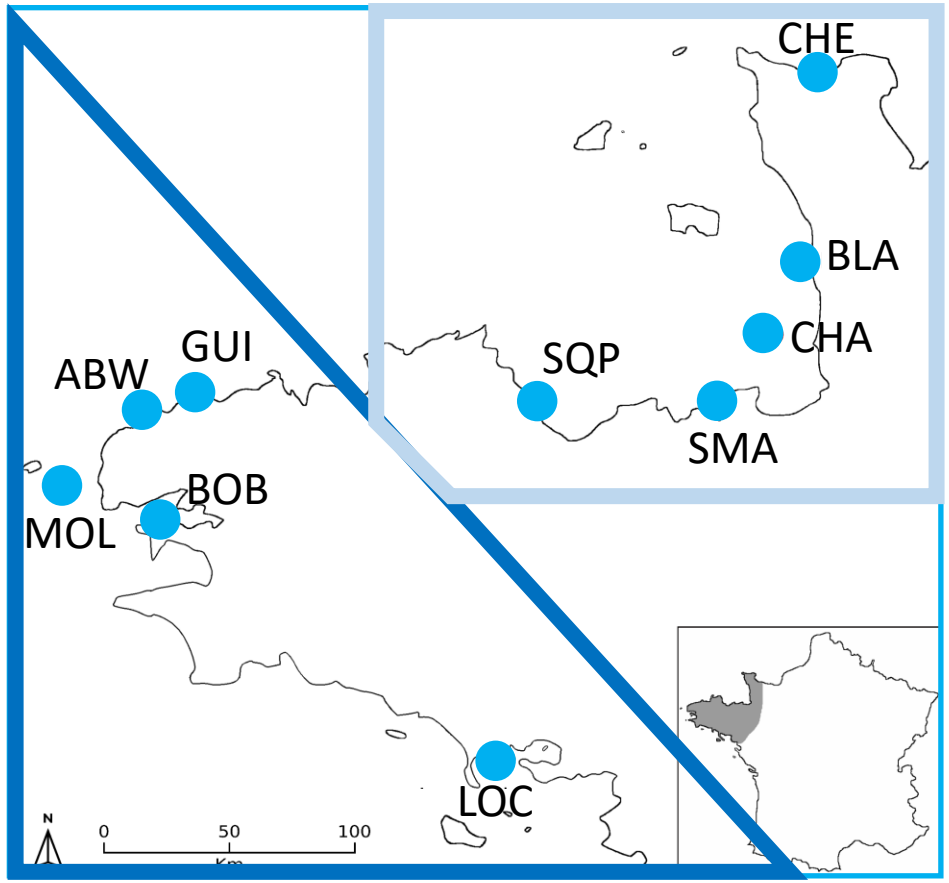
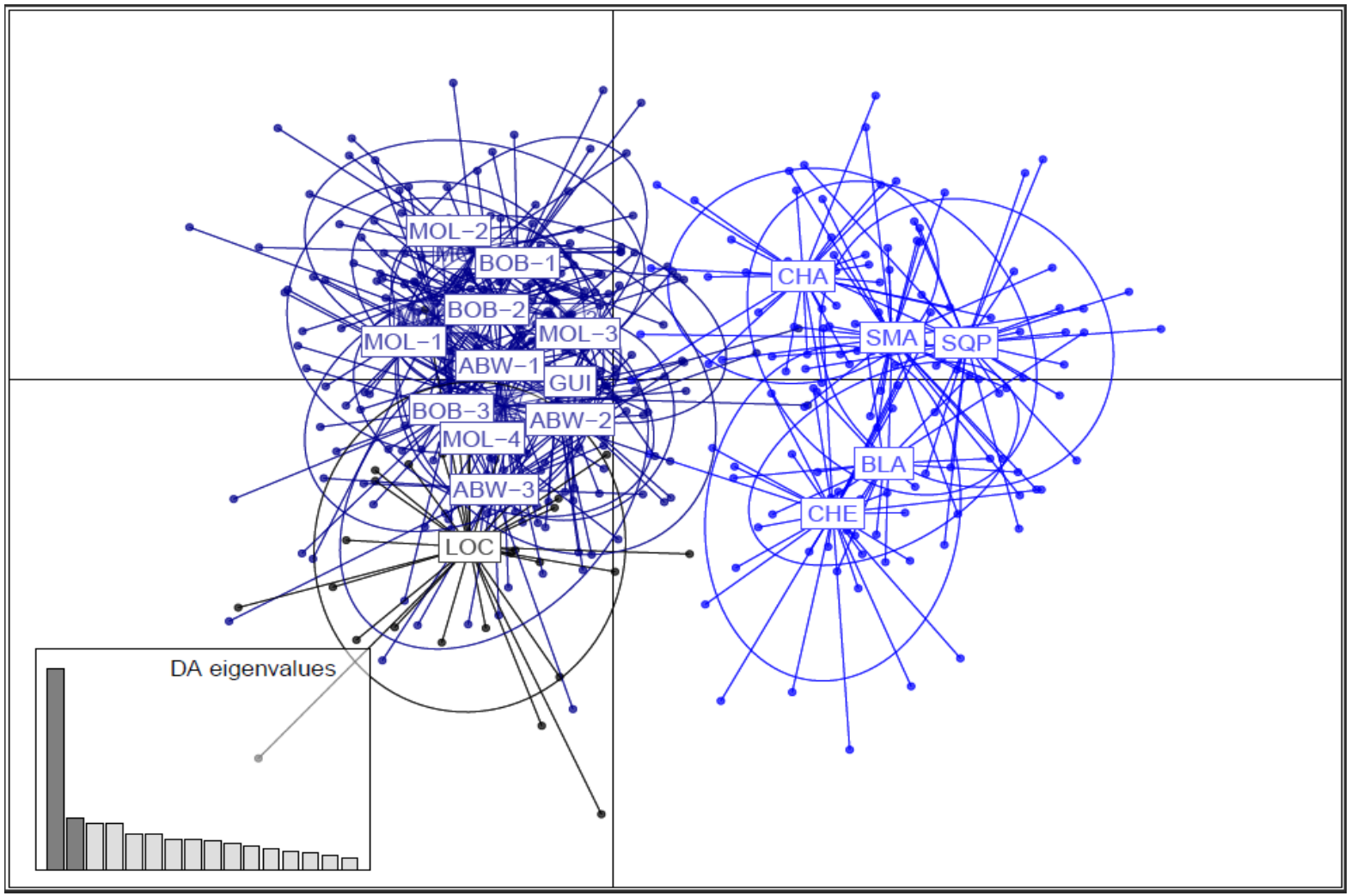
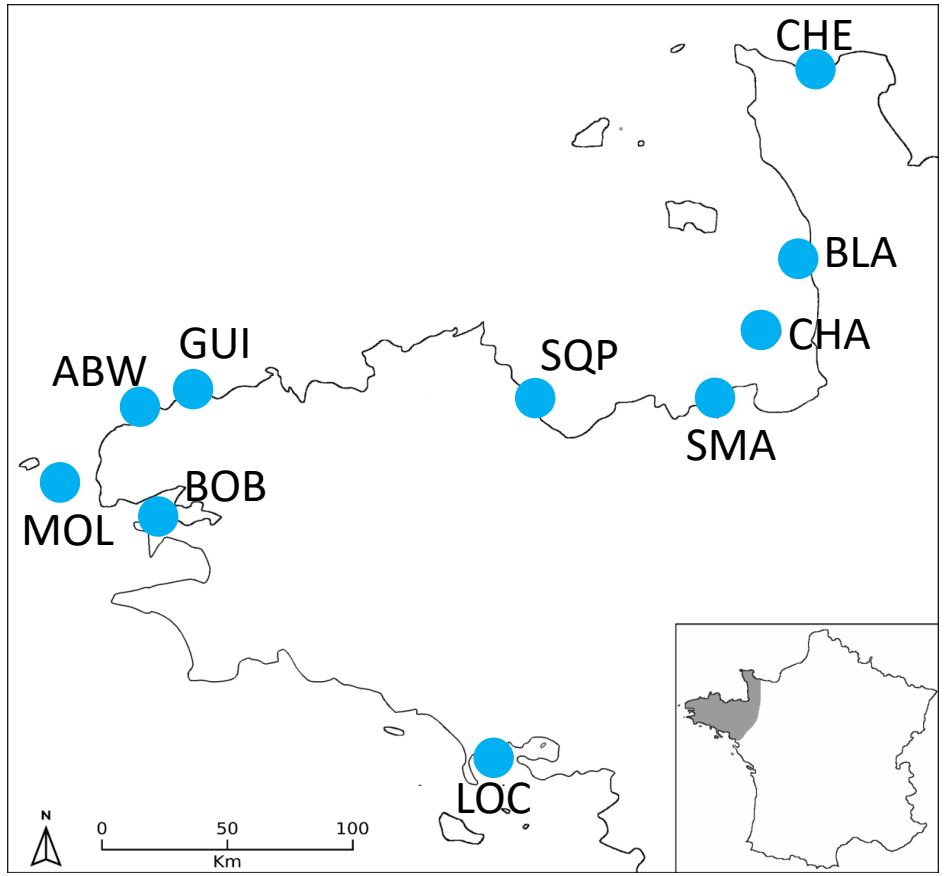


- **Discriminant Analysis of Principal Components** (DAPC)





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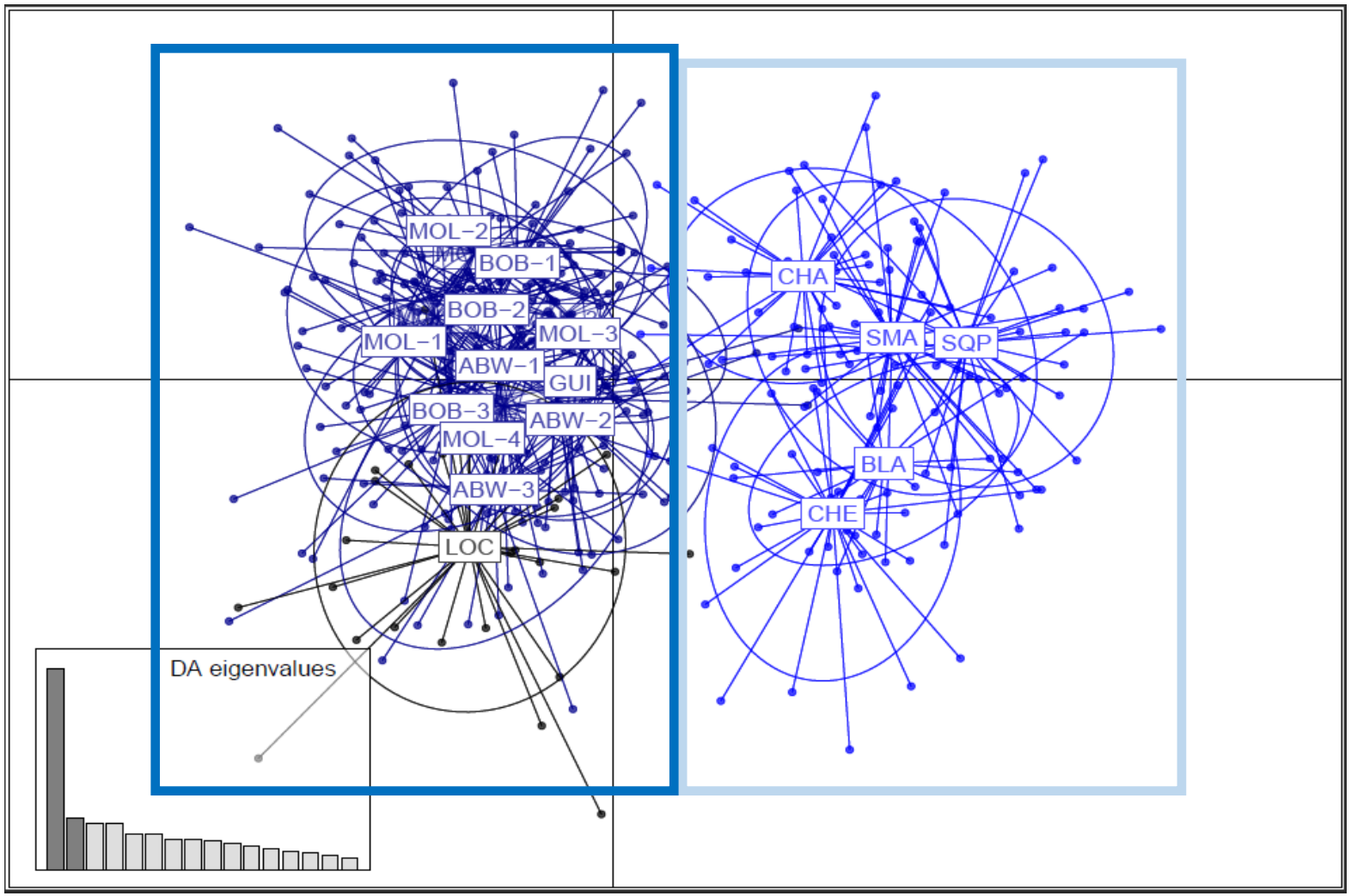
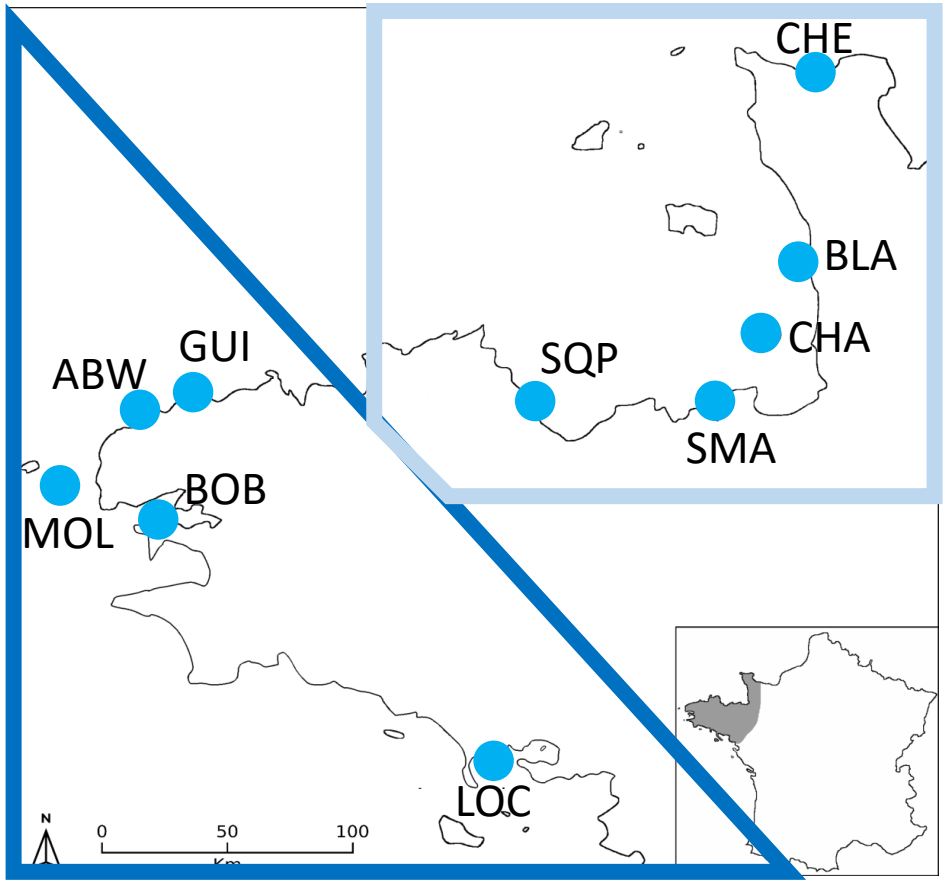




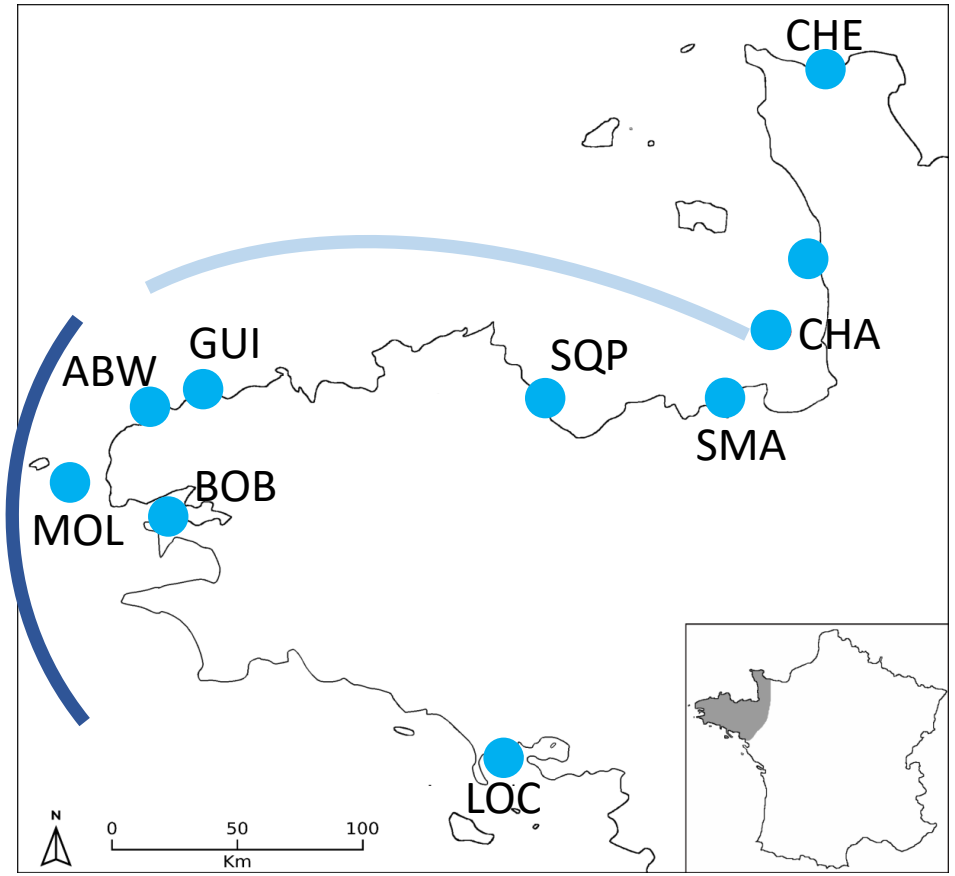
Structure North/South

- **Similar pattern found in many invertebrate species**:

Great Scallop
(*Pecten maximus)*
*(*Handal, 2019)

Polychaetes
(*Pectinaria koreni*, *Owenia fusiformis)*
(Jolly et al., 2005; Jolly et al., 2006)

Edible Cockle
(*Cerastoderma edule*)
(Vera et al., 2021)



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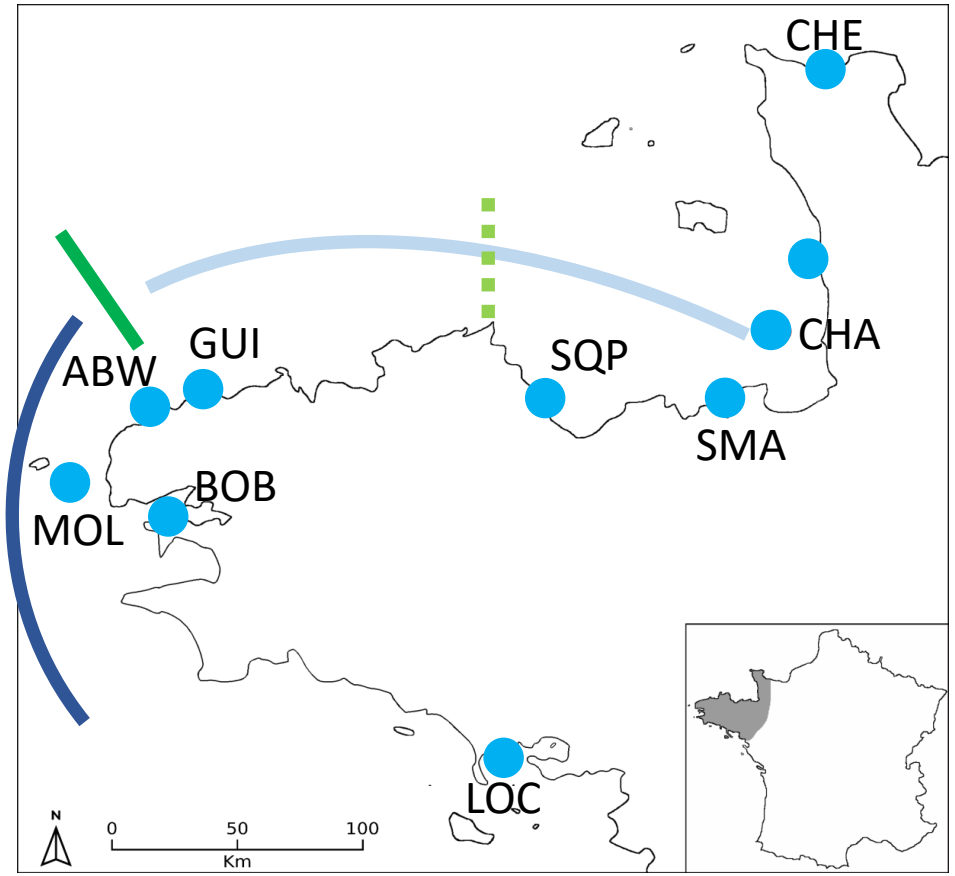

- **Possible barriers** (Ayata et al., 2010)**:**
  - **Ushant front**

	J	F	M	A	M	J	J	A	S	O	N	D
Seasonal Hydrodynamics					■	■	■	■	■	■		
Abalone Spawning						■	■	■	■			

  - **The Furrow of Talbert**

Jolly et al., 2005; Jolly et al., 2006; Ayata et al., 2010; Handal, 2019; Vera et al., 2021

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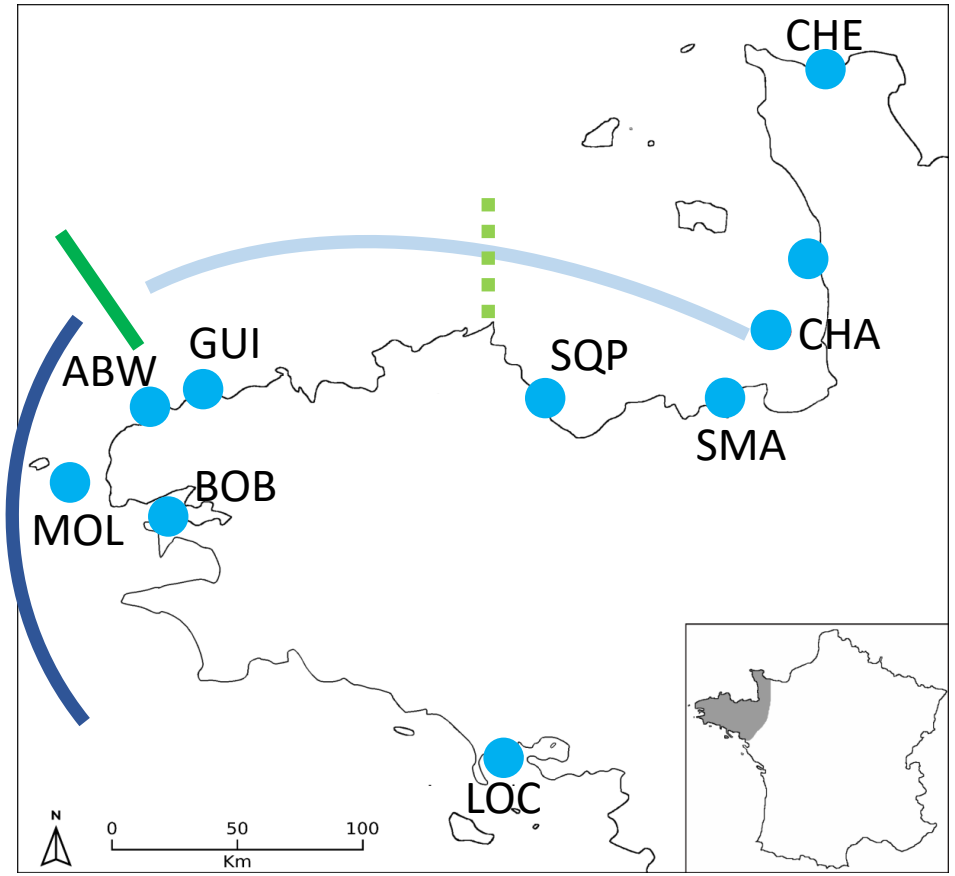

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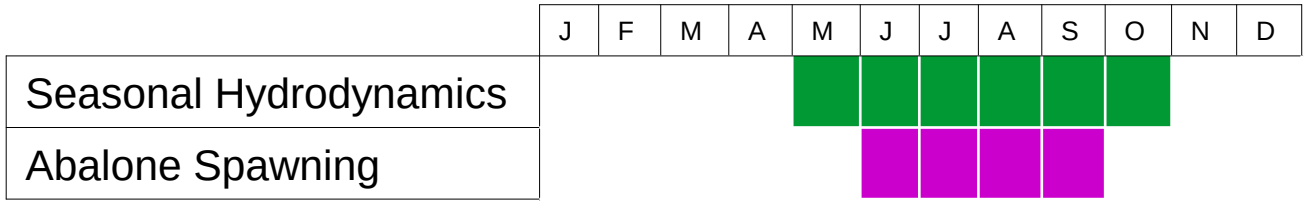
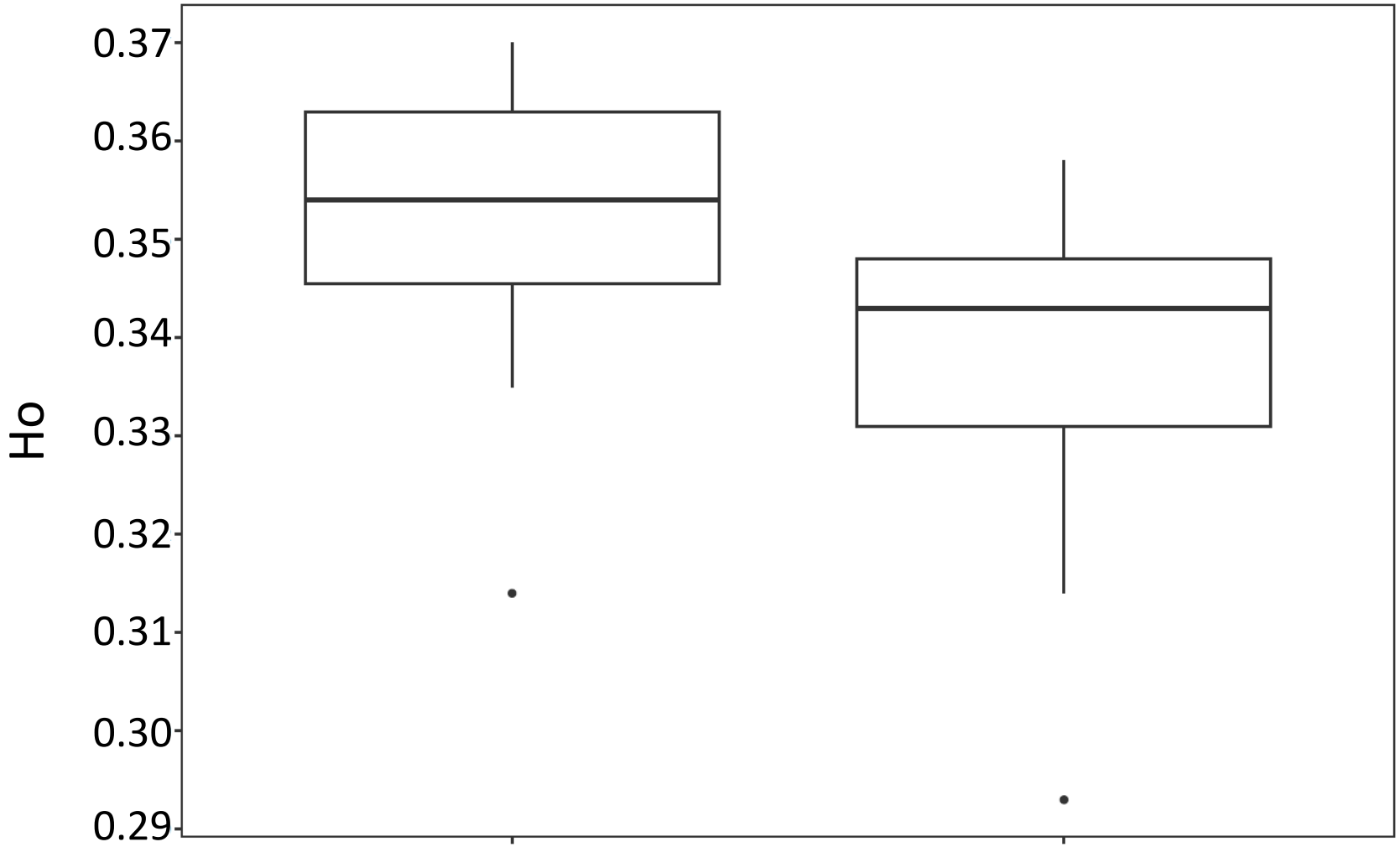


North/South differentiation

Broodstock must be chosen depending on the locality

Jolly et al., 2005; Jolly et al., 2006; Ayata et al., 2010; Handal, 2019; Vera et al., 2021

- Basic **population genetic statistics** (Ho)



Ho = observed heterozygosity, estimated from allele frequencies

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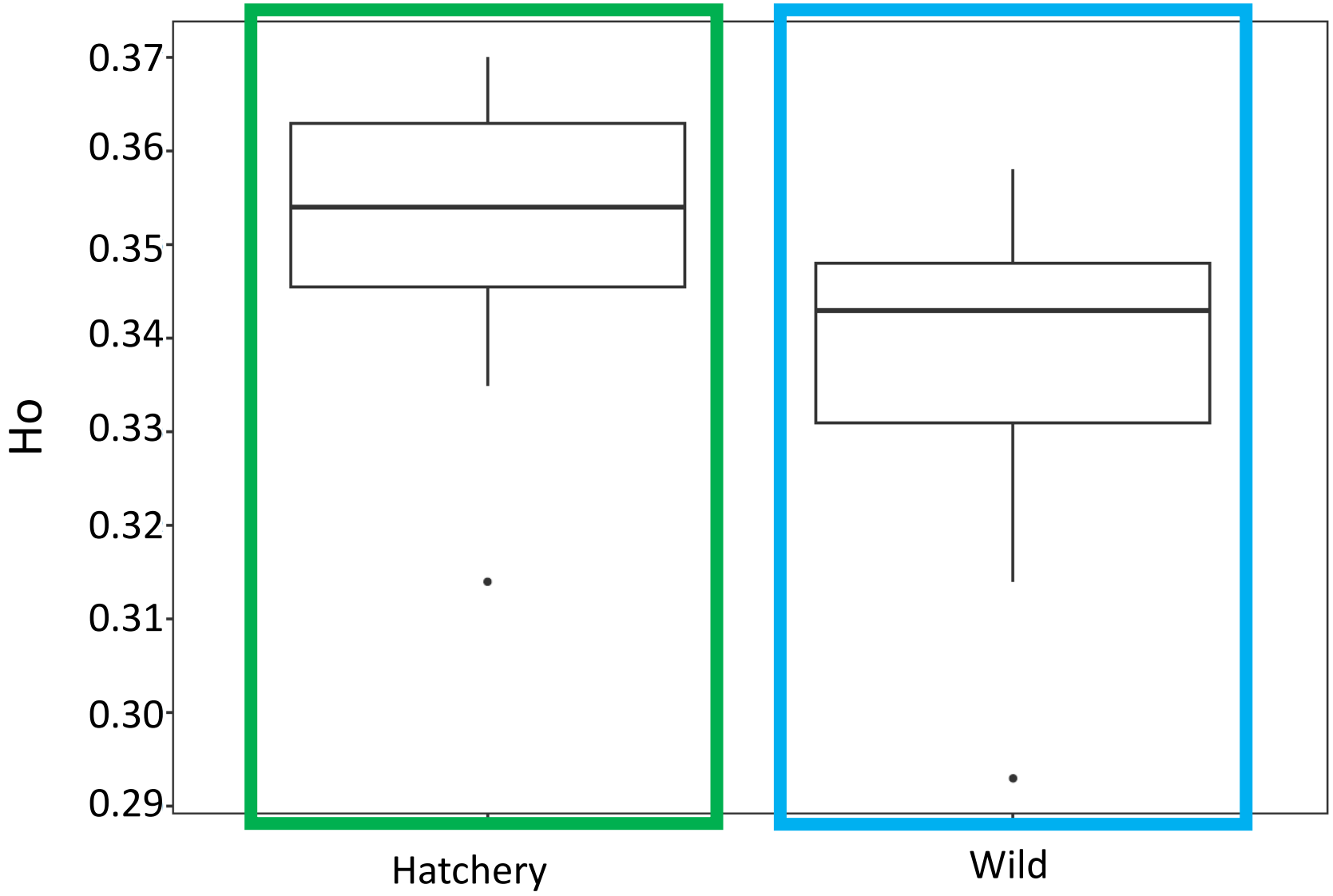

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Hatchery genetic diversity

- **Retention of the genetic diversity** in hatchery-raised stock
  - **Similar between** wild & hatchery samples

- **Breeding protocol avoided any noticeable erosion**


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Harney et al., 2018

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Limits

- Ascertainment bias
  - Markers developped for parentage assignment (*Harney et al., 2018)*

Harney et al., 2018

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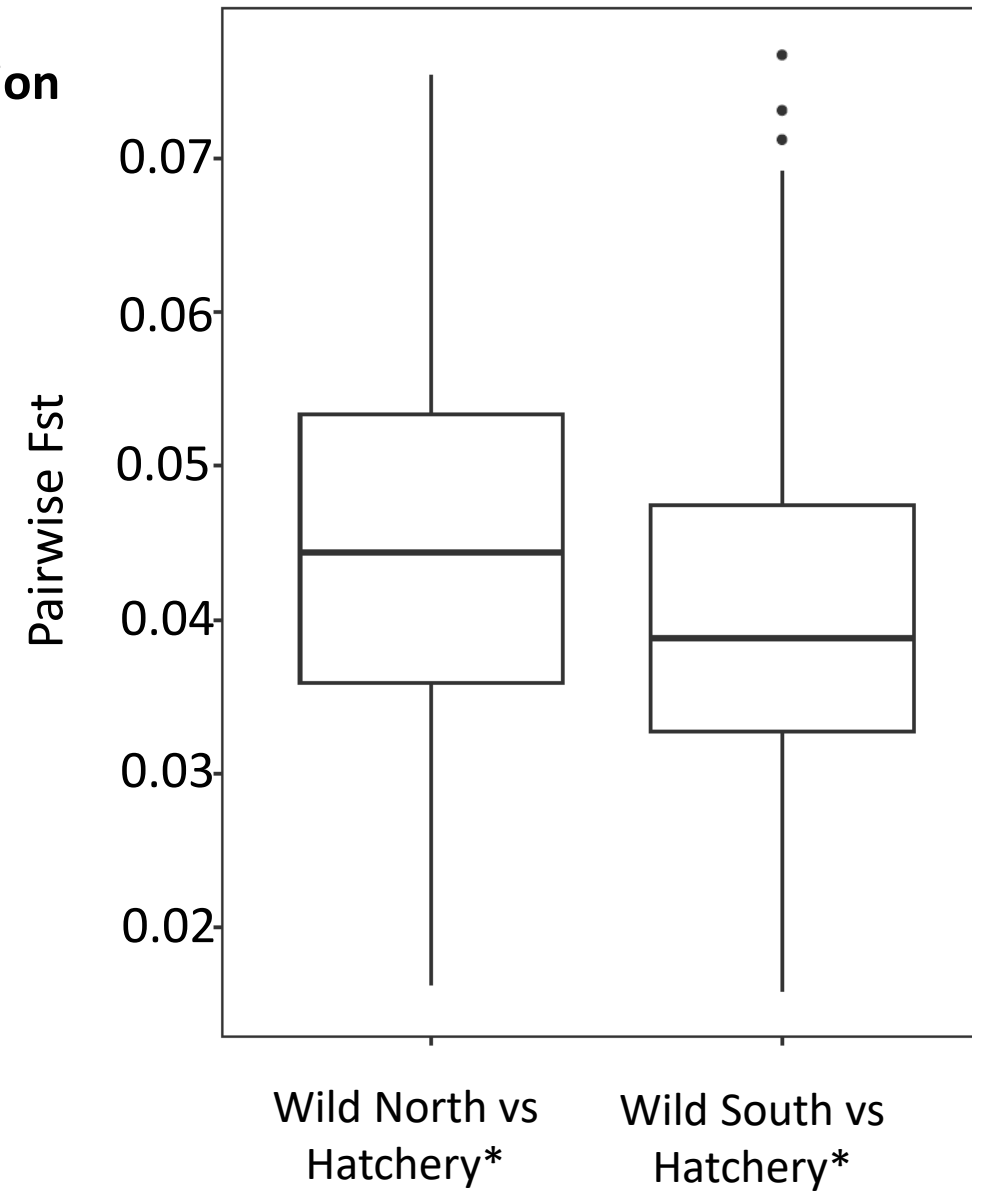

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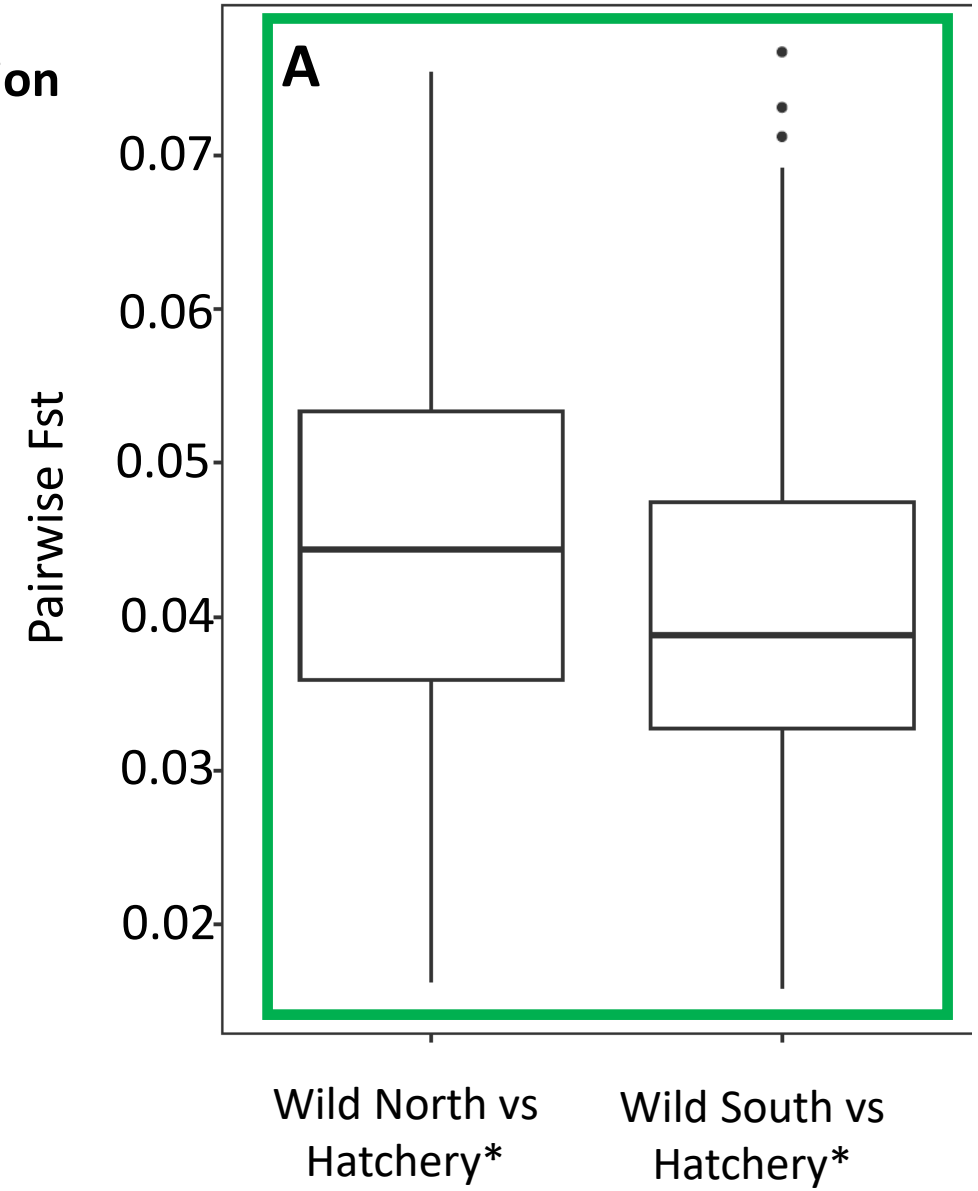
A = **Wild** populations /
14 **hatchery** subgroups



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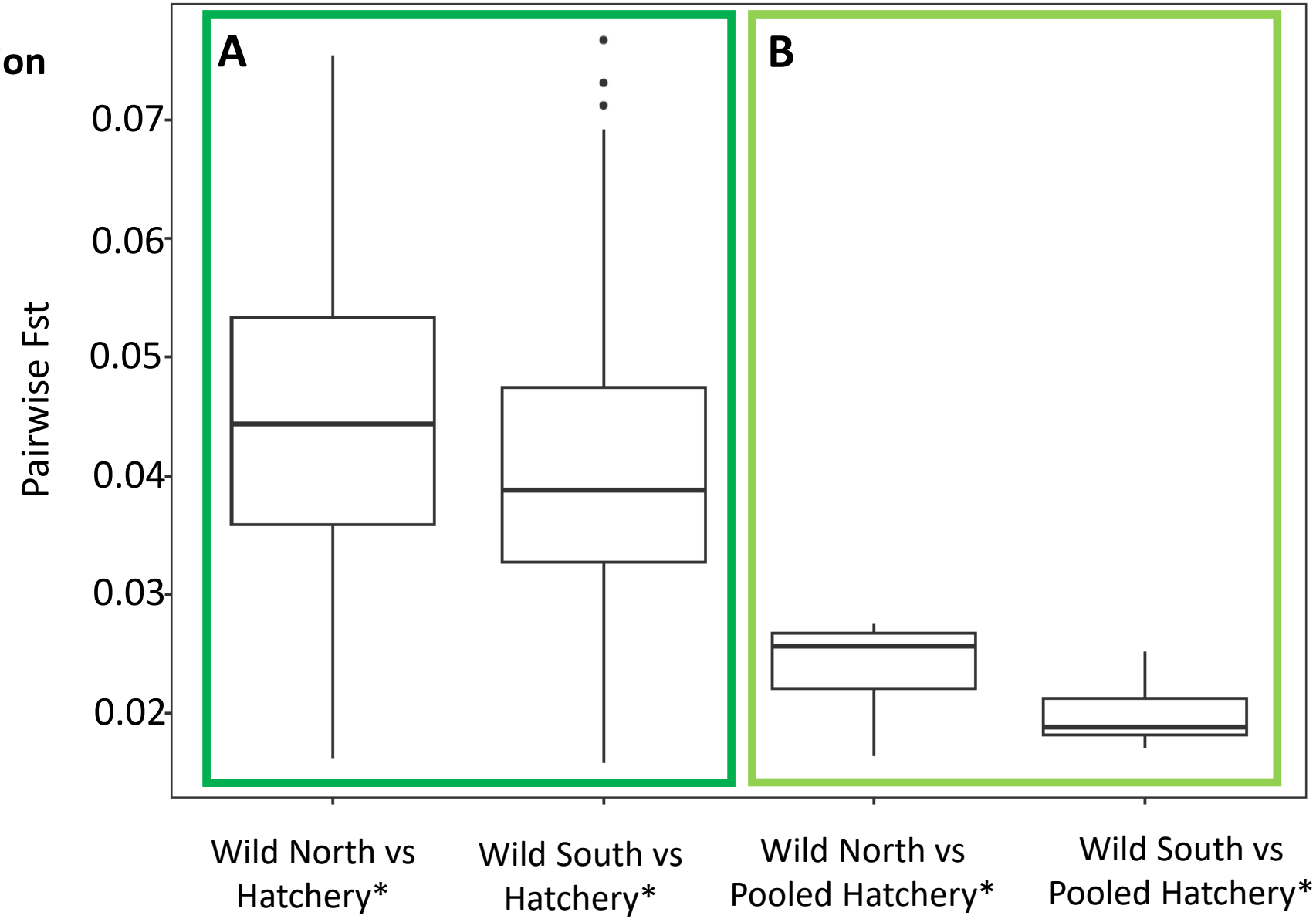
B = **Wild** populations /
Pooled all hatchery samples



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Differentiation Wild & Hatchery

- **Highly differentiated** wild and hatchery samples
  - Similar pattern found in *H. midae* in South Africa and *H. rubra* in Australia (Evans et al., 2004; Rhode et al., 2012)

- The **use of wild broodstock** and the **use of different cohorts from different parents** ensures to **minimize the loss of genetic diversity and adaptive potential** (Hornick & Plough, 2019)

Evans et al., 2004; Rhode et al., 2012; Hornick & Plough, 2019

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Breeding practices appropriate in France Haliotis

⚠ But strong differentiation suggests seeds **released should be composed of several cohorts/generation**

Evans et al., 2004; Rhode et al., 2012; Hornick & Plough, 2019

Now?

- **Local Structure between North and South**
  ↳ Spatial autocorrelation analysis to study recruitment patterns and gain a better understanding of connectivity (Miller et al., 2016)

Araki et al., 2007; Christie et al., 2014; Miller et al., 2016

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- **High genetic diversity in the hatchery**
  - ↳ Confirm it with the use of genomics tools for a more complete analysis

- **High differentiation between hatchery & wild**
  - Can it affect fitness? (Araki et al., 2007; Christie et al., 2014)
  - ↳ Compare responses of natural and hatchery population to environmental variability
    - Common garden experiment
    - **Poster**
      - ➡ ”Effect of domestication on the response of European Abalone to natural environmental variations and global change: a common garden experiment”

Araki et al., 2007; Christie et al., 2014; Miller et al., 2016

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Thank You!


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- Basic **population genetic statistics** (Ho, He)