Do juvenile sole belong to mixed spawning populations?
Tracing juvenile flatfish arriving at the Belgian nursery using genomics and otolith shape

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BACKGROUND

Belgians consume on average 10 kg fish/year/capita amounting to some 136,000 tonnes/year. Sole is a national food item, but its abundance in the North Sea is decreasing due to heavy fishing. Recruitment has varied a lot through time. Stock managers and decision makers need to differentiate populations to (1) better assess stock status, to (2) enforce fishing regulations and to (3) address mislabelling and illegal fishing.

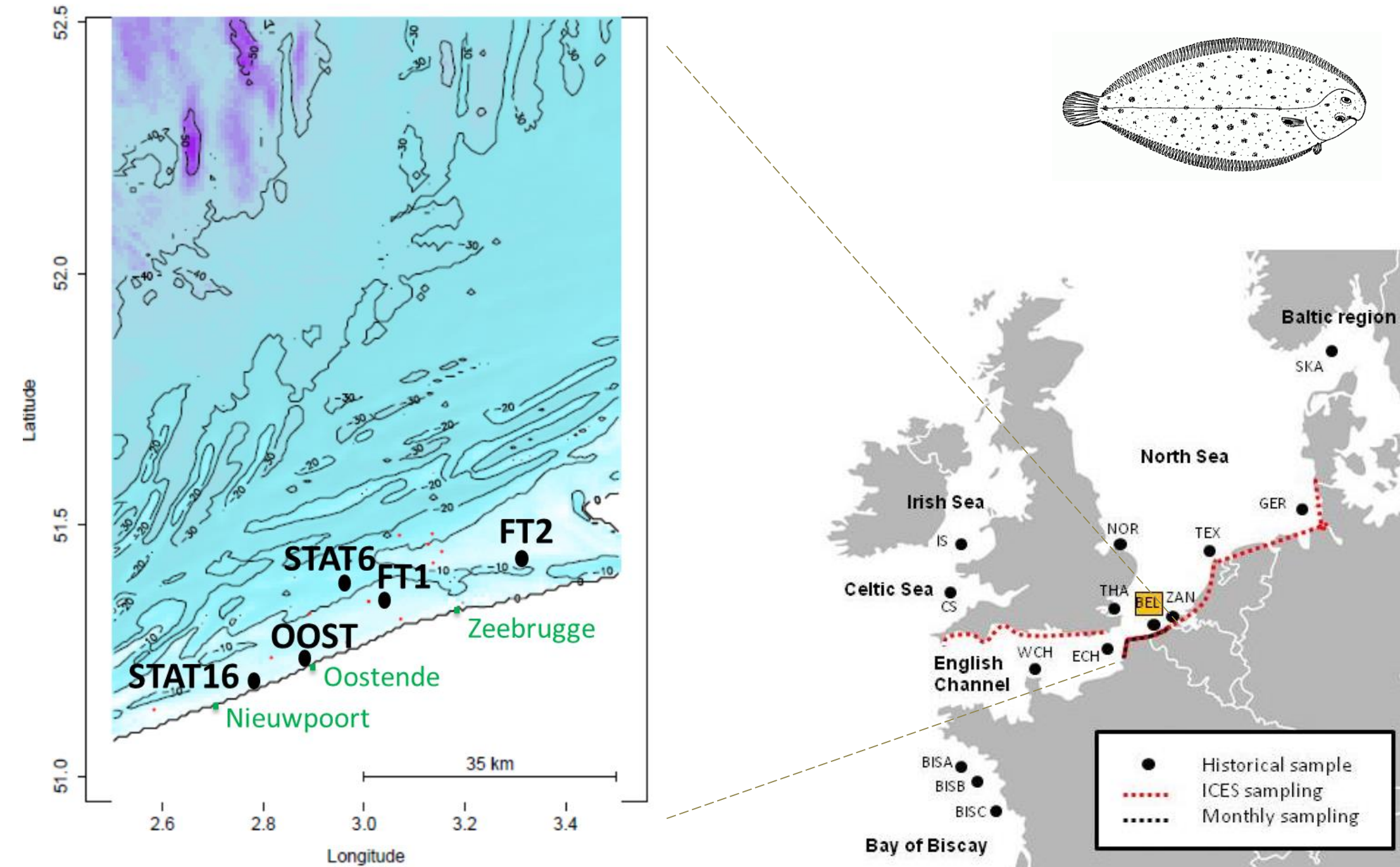## FINE SCALE SAMPLING of FLATFISH JUVENILES

Fig. 1: Map of the sampling locations of sole samples to produce genetic baselines over the past 10 years. Isobath every 10 meters.

OBJECTIVES

1. Compare **population structure** at **large and small-scales** using:

   (1) Genomics

   (2) Otolith shape

2. Determine **the spawning population of origin of juveniles** arriving on the Belgian nursery grounds
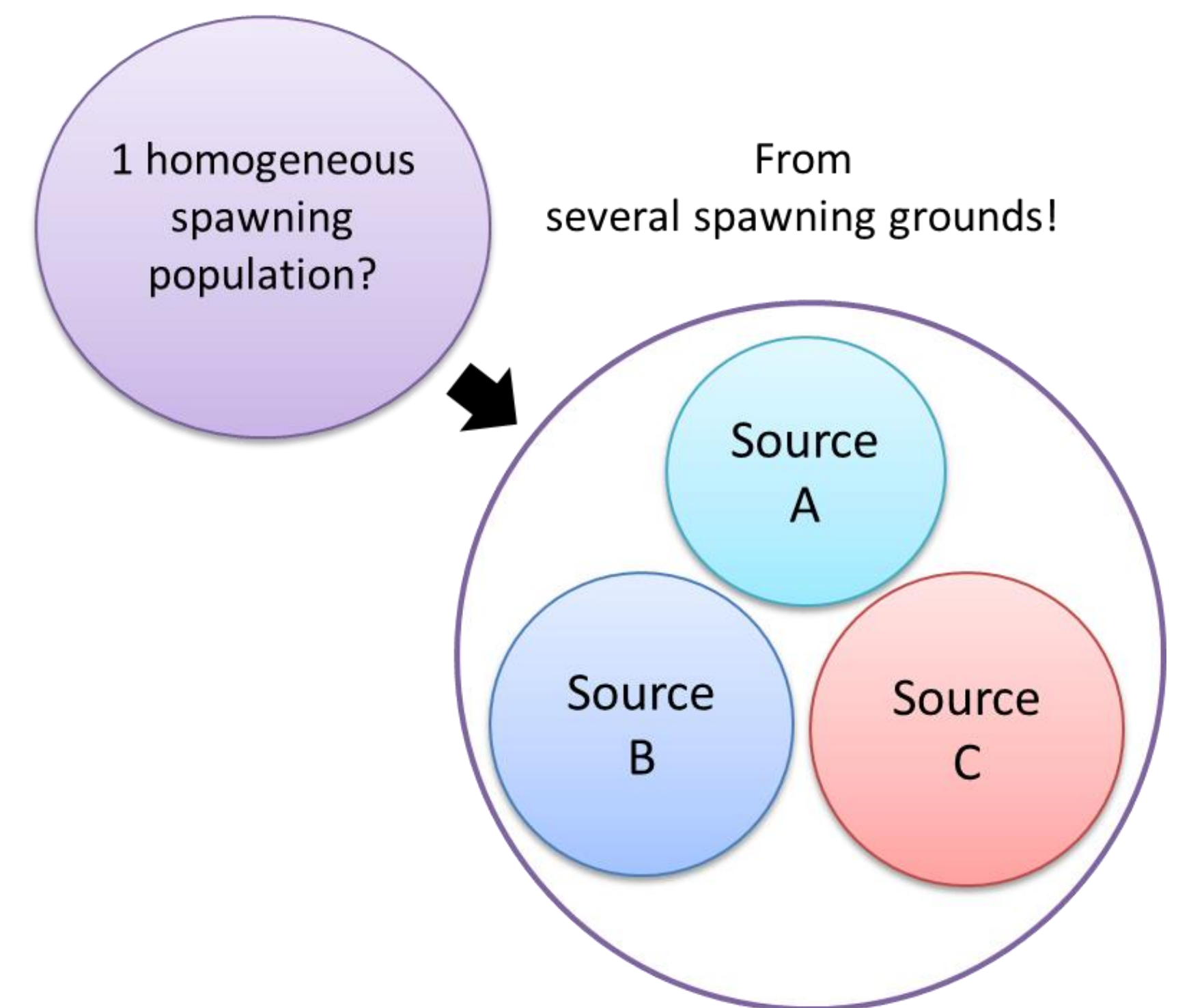

Fig. 2: What is the spawning ground (= source) of juvenile sole arriving at the Belgian nursery?

CONNECTIVITY MEASURES THROUGH (1) GENOMICS

LARGE EUROPEAN SCALE – ADULTS – 200 SNPS

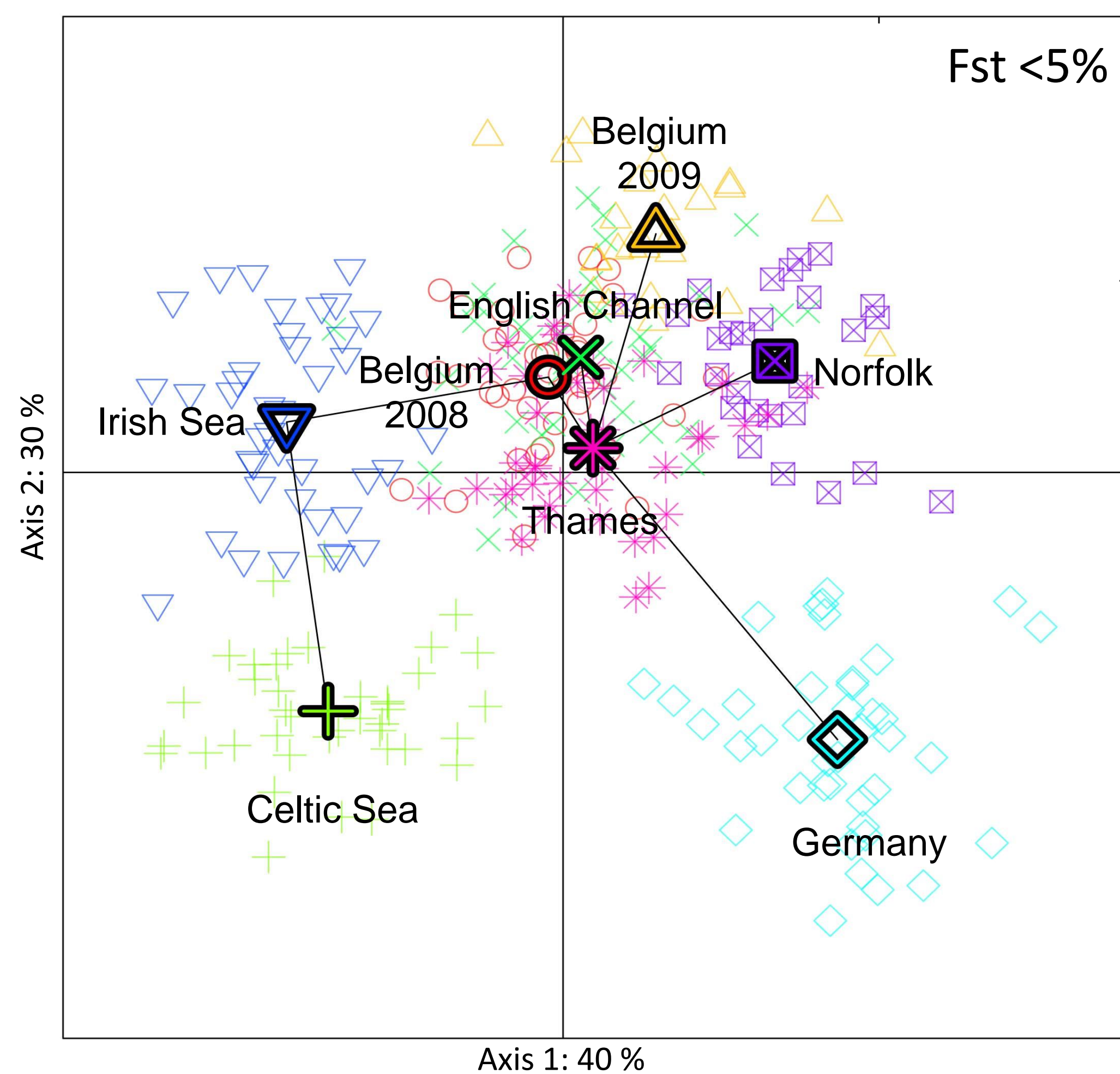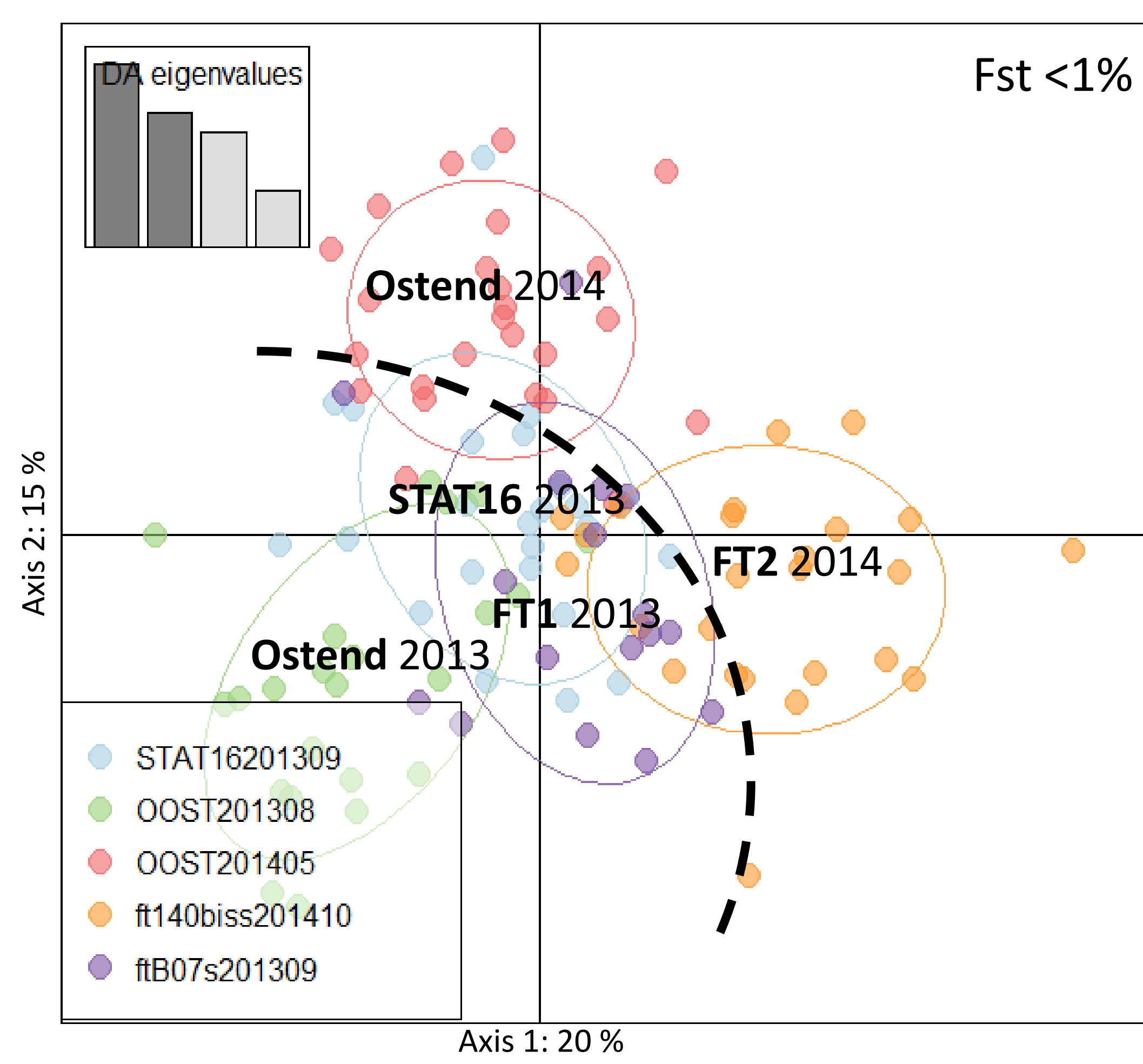### BELGIAN SCALE – JUVENILES – 450 SNPs

Fig. 3 and 4: Discriminant Analysis of the Principal Components (DAPC) on the genetic data based on 200 SNPs markers in 10 adult sole sampled at the European scale (left) and 450 SNPs in 114 juveniles sampled at the Belgian scale (right)

Overall statistical assignment power between populations is 70% at the European scale (Fig. 3) and much lower at the local scale (35%, Fig. 4).
Populations remote from the Southern Bight are genetically distinct. Locally, 114 juveniles have been ananlyzed using ddRAD sequencing. We obtain a low pairwise Fst between neighboring fish populations (<1%). The strongest structure suggests inter-annual variability which is supported by the model of Lacroix et al. 2013.

More markers and more individuals needed!

To improve resolution, combine genomic measures with otolith shape and microchemistry. Different time scale of connectivity.
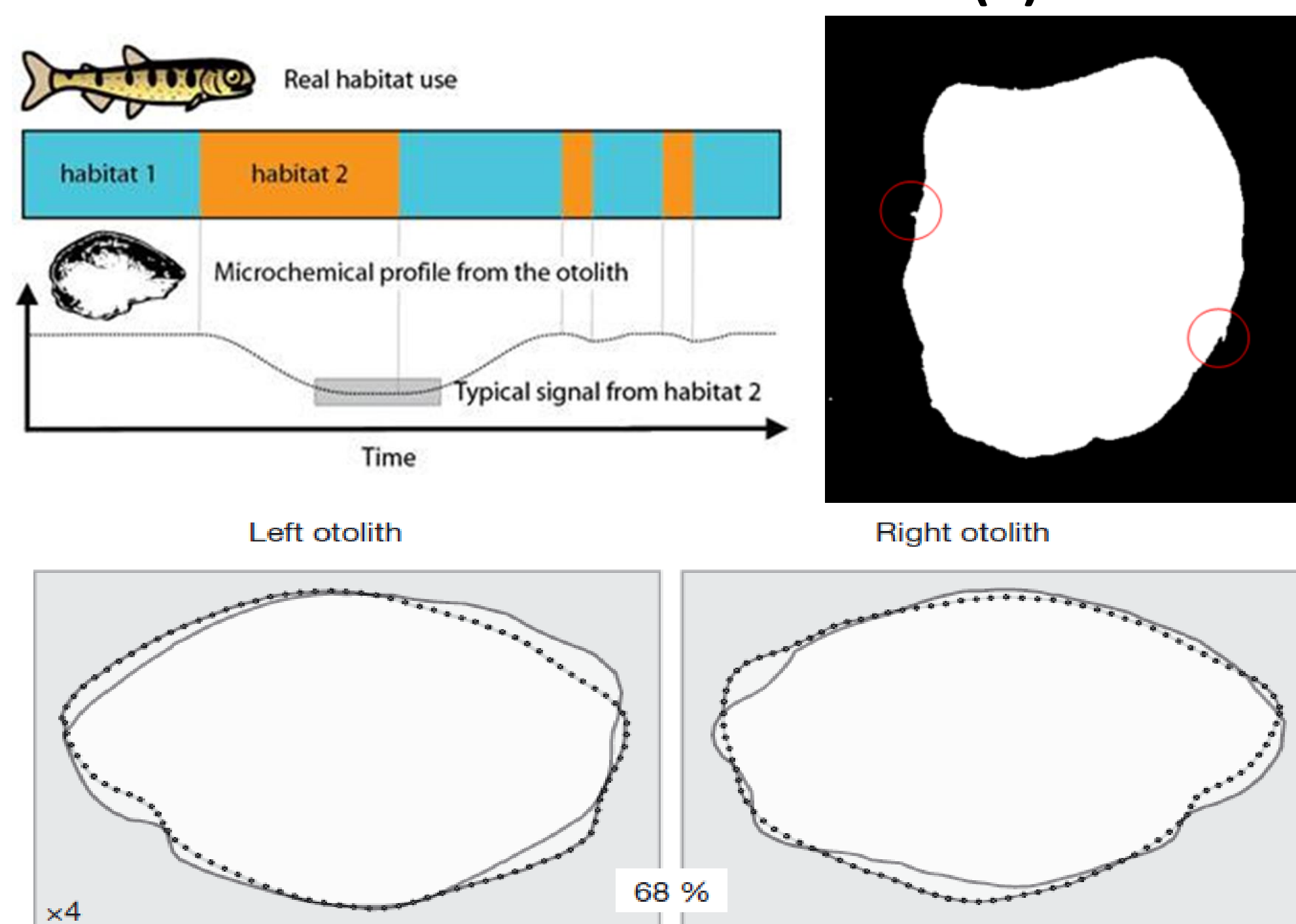
CONNECTIVITY MEASURES THROUGH (2) OTOLITH SHAPE

Fig. 5: Otolith shape and microchemistry concept and example of shape asymmetry between left and right otolith in Solea solea (figures from Vignon and Morat 2010)
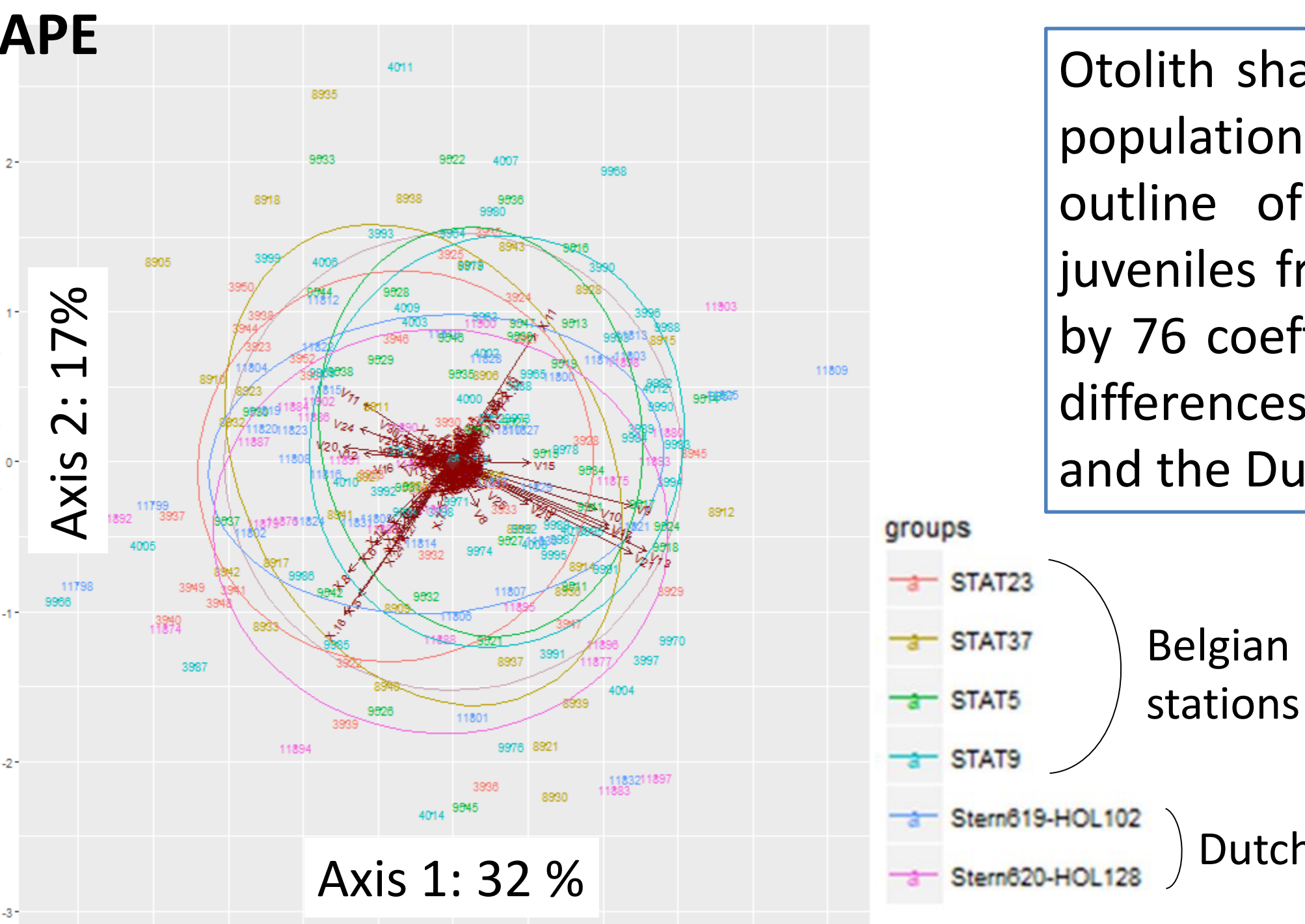

Fig. 6: Biplot of a Principal Component Analysis of otolith shape of juvenile sole described by 76 coefficients of Fourier series and each colour represents a sampling station

Otolith shape has became a common in fisheries to detect population structure. Fourier series are used to analyzed the outline of an otolith silhouette. Otolith shape of 300 juveniles from the Belgian and the Dutch coast is described by 76 coefficients of Fourier series. There are no significant differences in otolith shape of juvenile sole from the Belgian and the Dutch coast (Fig. 6). More data analysis is needed.

Numerous factors influencing otolith shape (Fig. 7)

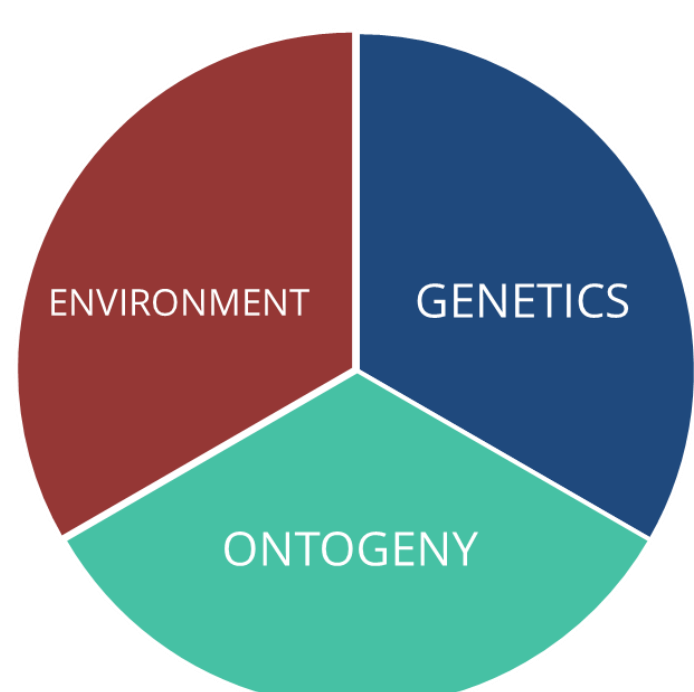Combine several measures on the **same individuals** to increase assignment power.

Fig. 7: Main factors influencing otolith shape and otolith microchemistry

There is no a priori knowledge on fish source population, so individual assignment to a spawning population requires Bayesian clustering.

Potential bias in otolith shape:
• Age of the fish => ontogeny
• Siblings => genetics

PERSPECTIVES

➤ **Add more information with new ddRAD libraries of Belgian and other potential North Sea sole spawning populations (Fig. 2 and 3)**
• Develop thousands of SNP markers using Next Generation Sequencing of part of the genome
• Select the markers that differentiate the spawning populations we want to trace the most

➤ **Trace fish movements with otolith microchemistry on the same populations**
• Age reading of larval and juvenile sole sagittae to determine dispersal pathways
• Select 15 chemical elements that differentiate the spawning populations we want to trace

OUTPUTS

• Spatial and temporal tracing of juvenile sole
• Increase enforcement capacity, detection of fraud and IUU fishing
• Improve management of stocks and certification of Marine labels to reward sustainable fishing

BIBLIOGRAPHY

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2) Vignon Matthias and Fabien Morat. « Environmental and genetic determinant of otolith shape revealed by a non-indigenous tropical fish ». Marine Ecology-progress Series - 411 (2010): 231-41.

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