Using Otolith Phenotipic Variability to Infer Potential Population Differences of *Scomber colias* in the Northeast Atlantic and Mediterranean Sea

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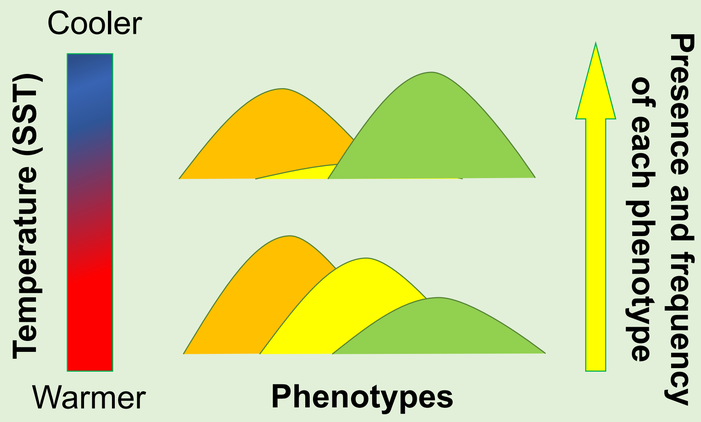
BACKGROUND

In the last decade there has been a growing interest in the Atlantic chub mackerel, *Scomber colias*, due to a noticeable expansion of this species in the East Atlantic Ocean from areas of greater abundance off northwest Africa to Atlantic Iberian waters and the Mediterranean Sea (ICES, 2021).

To implement sustainable management measures in the current global warming situation it is crucial not only to identify biologically-meaningful management units, but also to understand otolith morphological variability along its geographic distribution areas.

We analysed the otolith shape variability in *S. colias* considering four origins in as one metapopulation.

THEORETHICAL FRAMEWORK



MATERIALS & METHODS

- A total of **1835 otoliths** from 4 origins (3 in the C-N East Atlantic Ocean and 1 in the Mediterranean Sea).
- **Contour otolith analysis:** 4th Wavelet transform of normalized distance to the centroid was used. 512 cartesian coordinates were used to discretize the shape contour.
- **Analytical procedure:**
  - ⇒ All the individuals were analysed as a single pool to detect how many phenotypes are present in each region.
  - ⇒ Principal component analysis (PCA) to reduce the wavelet function.
  - ⇒ To remove the effect of fish size using the residuals of the common within-group slopes of the linear regressions of each component on total length, building a new PCA matrix.
  - ⇒ To obtain the optimal clustering algorithm using Partitioning Around Medoids (PAM) with *optClus* package in R-environment (R Core Team, 2021).

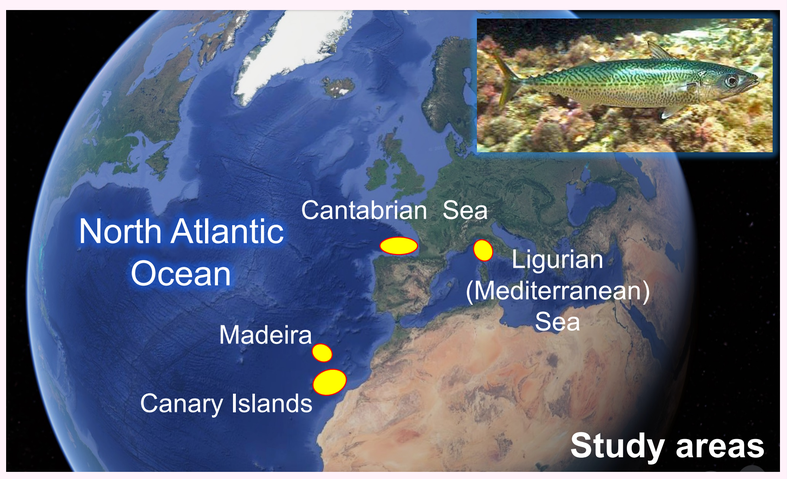


Table 1. Summary of statistical descriptives of total length (TL, mm) by origin.

Origin	n	mean	sd	Min.	Max.
Ligurian Sea	271	289.4	47.4	180	410
Cantabrian Sea	499	305.0	40.3	180	384
Madeira	273	267.7	40.2	153	433
Canary Islands	792	251.1	32.1	145	375

RESULTS

High phenotypic variability in the otolith contour of *S. colias* for all the regions studied, which makes difficult the identification of general patterns (see some examples in Fig. 1).

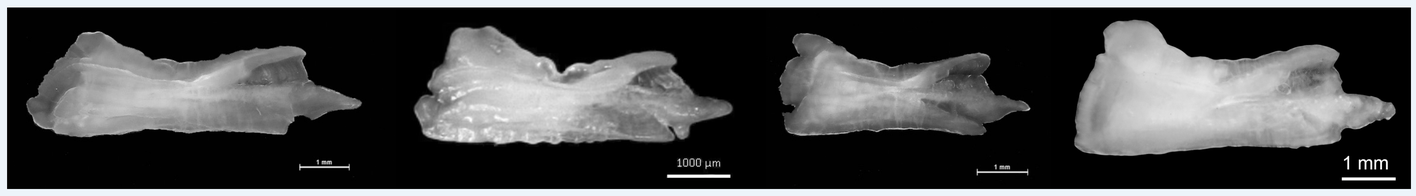


Figure 1. Different morphologies from enlarged to shorten otoliths with different shapes of dorsal/posterior margins (from left to right): concave/acute; V-shape/slightly acute; concave with a postero-dorsal projection/almost right; concave with a postero-dorsal projection/slightly acute.

Three clear phenotypes (Fig. 2) related to *antirostrum* size (A), dorsal and position of postero-dorsal projection (B), postero-ventral margin (C), and *colliculum* size (D) (Fig. 3).

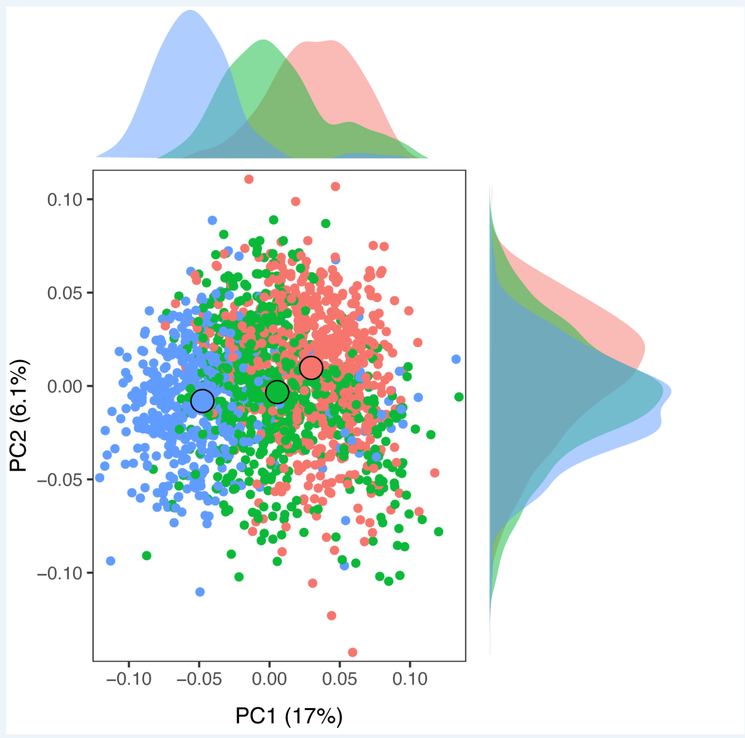


Figure 2. Morphospace illustrating the phenotypic distribution of otolith shape of *Scomber colias* from North Atlantic Ocean and Mediterranean Sea.

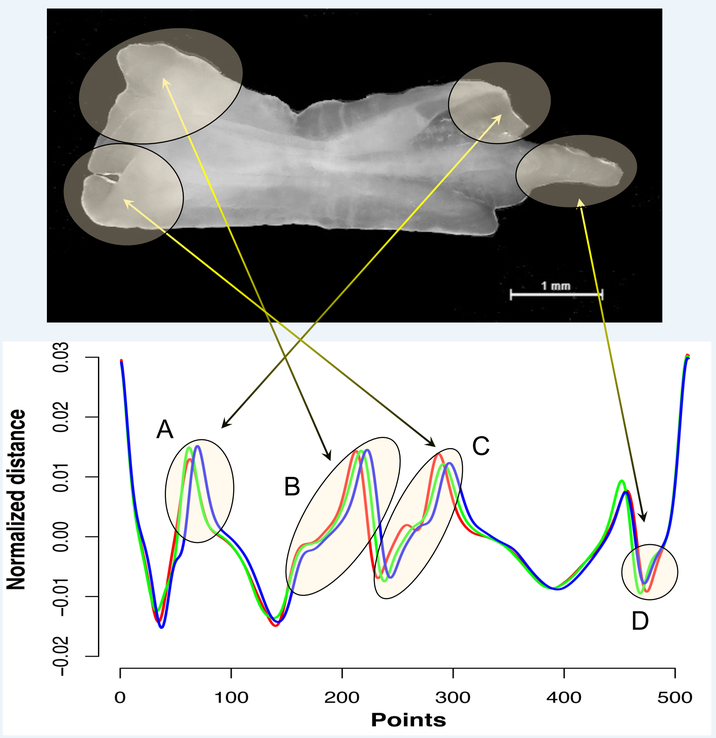
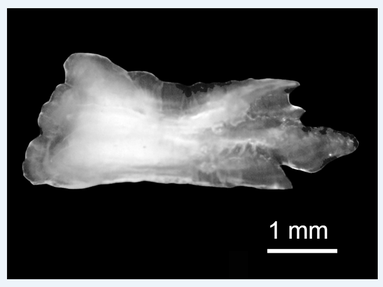
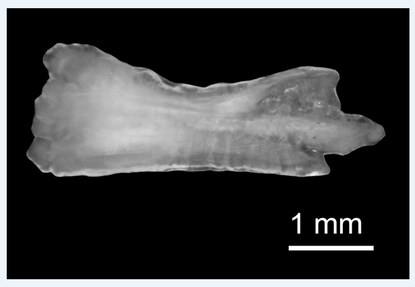


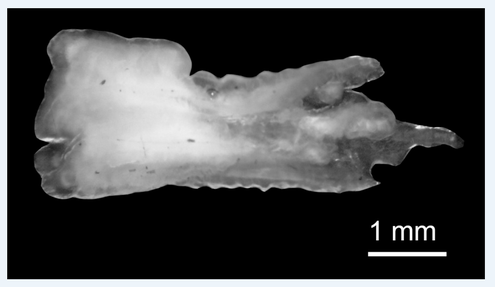
Figure 3. Otolith contours illustrated by the wavelets 4th of *Scomber scolias* from North Atlantic Ocean and Mediterranean Sea. Red, M1; green, M2; blue, M3.



Phenotype 1. *Antirostrum* few developed, dorsal margin strongly inclined, posterior-ventral margin strongly angled and wider *colliculum*.



Phenotype 2. *Antirostrum* slightly developed, dorsal margin inclined, posterior-ventral margin slightly angled, and *colliculum* wider.



Phenotype 3. *Antirostrum* developed, dorsal margin with step, posterior-ventral margin few angled, and *colliculum* narrow and elongated.

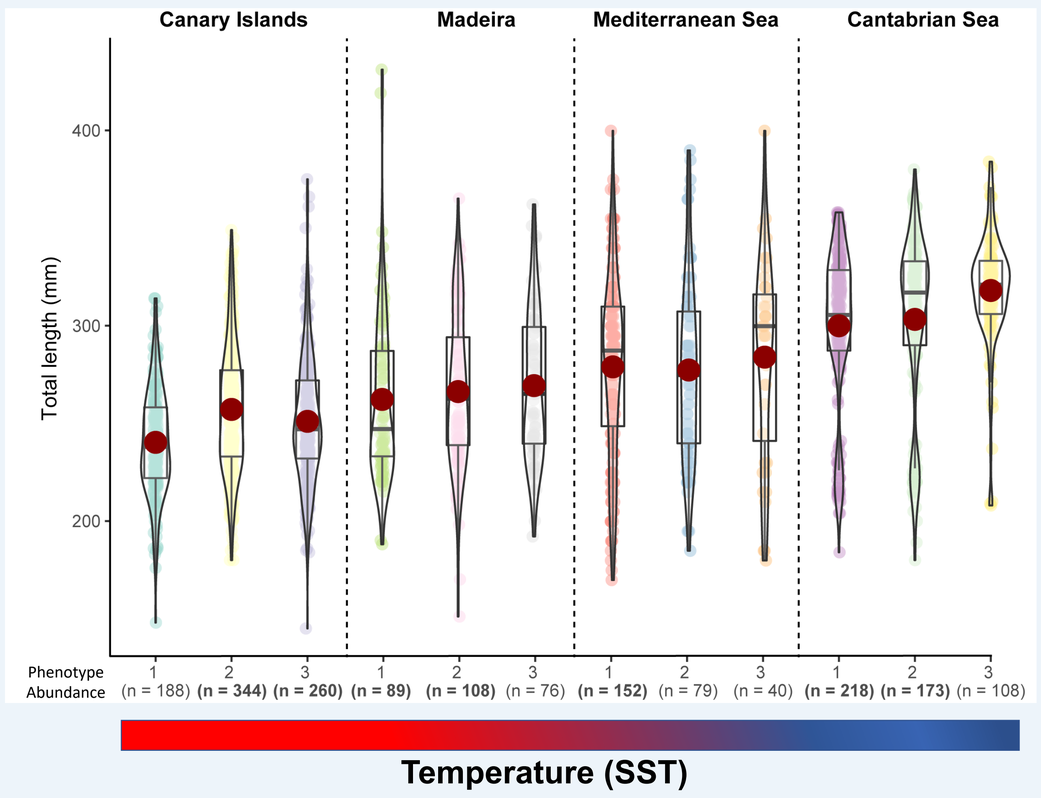
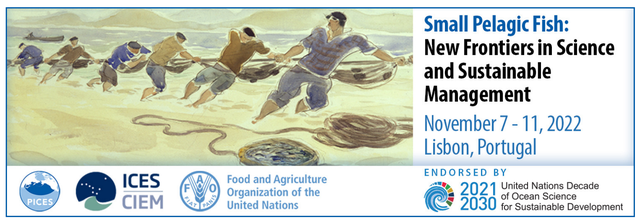


Figure 4. Mean fish total length (TL, in mm) of *Scomber colias* from North Atlantic Ocean and Mediterranean Sea, by otolith phenotype and region. In bold, the phenotypes more abundant in each region.

CONCLUSIONS

- ✓ All phenotypes are present in all regions, what emphasizes the possibility of one metapopulation.
- ✓ The more abundant phenotype changes depending on the region.
- ✓ The mean TL increases northwards through cooler waters (Fig. 4), independently of the phenotype.
- ✓ The abundance of each phenotype vary along geographical scenario. In warmer waters (the Canary Islands and Madeira) predominates the phenotype-2. By contrast, in cooler waters, the phenotype-1 is the most common.



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