

## INTRODUCTION

Accurate species identification is crucial for effective fisheries management, particularly for cryptic species with overlapping ranges and similar morphologies. Misidentification can lead to the overexploitation of sympatric populations due to inaccurate estimates of exploitation rates derived from catch data.

A notable example of such a challenge is represented by the commercially important black (*Aphanopus carbo* Lowe, 1839) and intermediate (*A. intermedius* Parin, 1983) scabbardfish two sympatric species distributed throughout the Atlantic Ocean.



## MORFOLOGICAL IDENTIFICATION

*Aphanopus carbo*

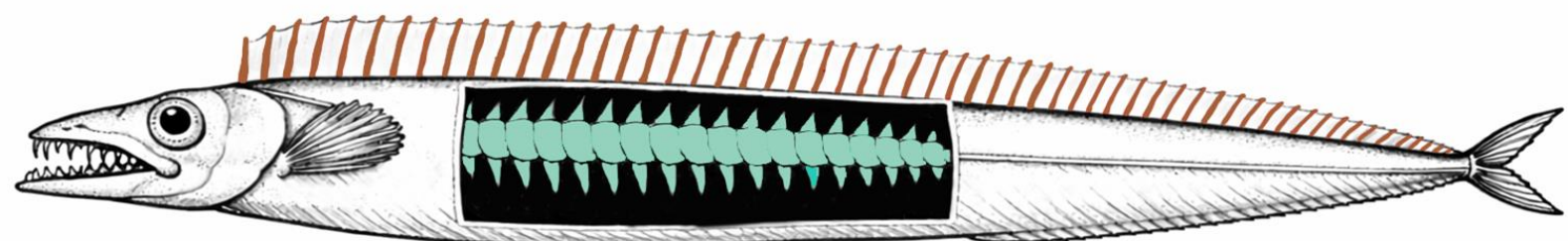
*Aphanopus intermedius*

90-96 Dorsal fin elements

96-102 Dorsal fin elements

97-100 Total vertebrates

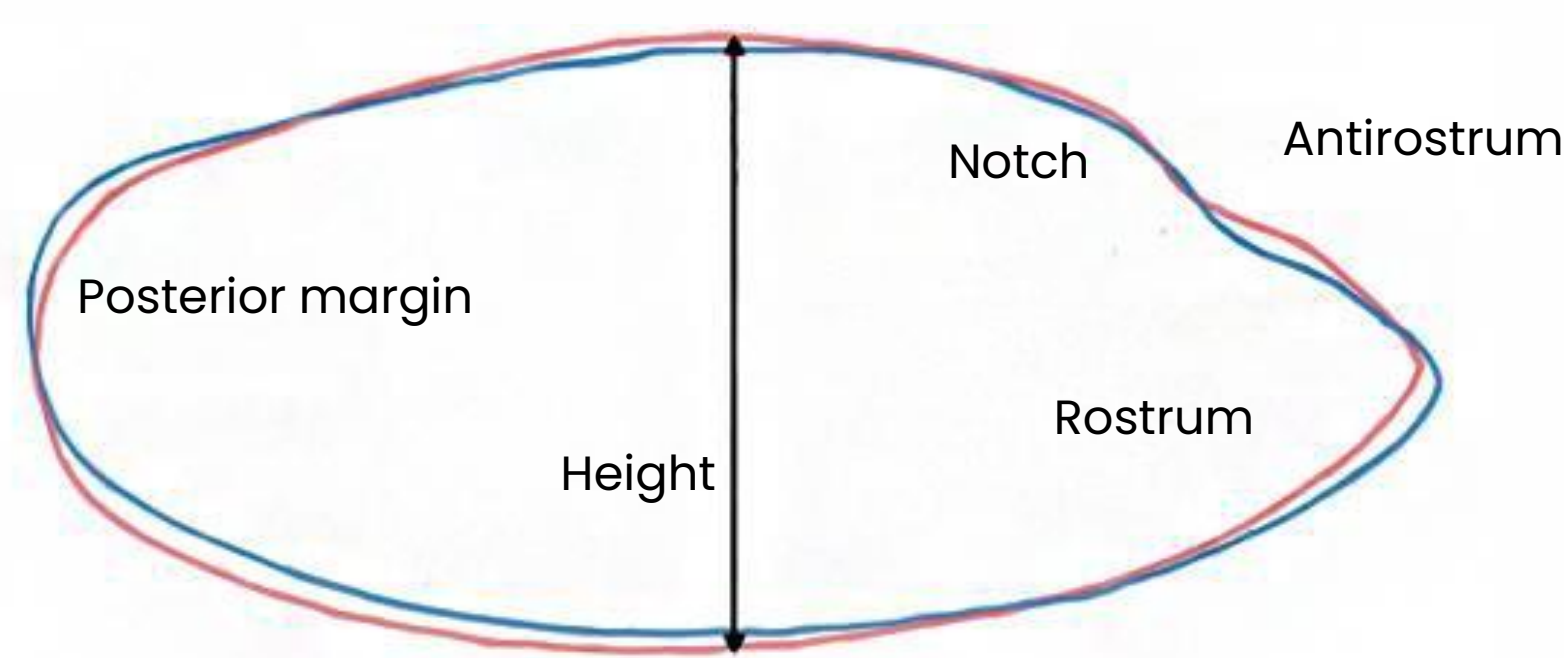
102-108 Total vertebrates



## OTOLITH IDENTIFICATION

Mean otolith shape of genetically identified *Aphanopus carbo* (red) and *A. intermedius* (blue), reconstructed using wavelet analysis to represent the average phenotype in the northeastern Atlantic. Although both species showed a broadly similar otolith outline, differences were evident in three key regions:

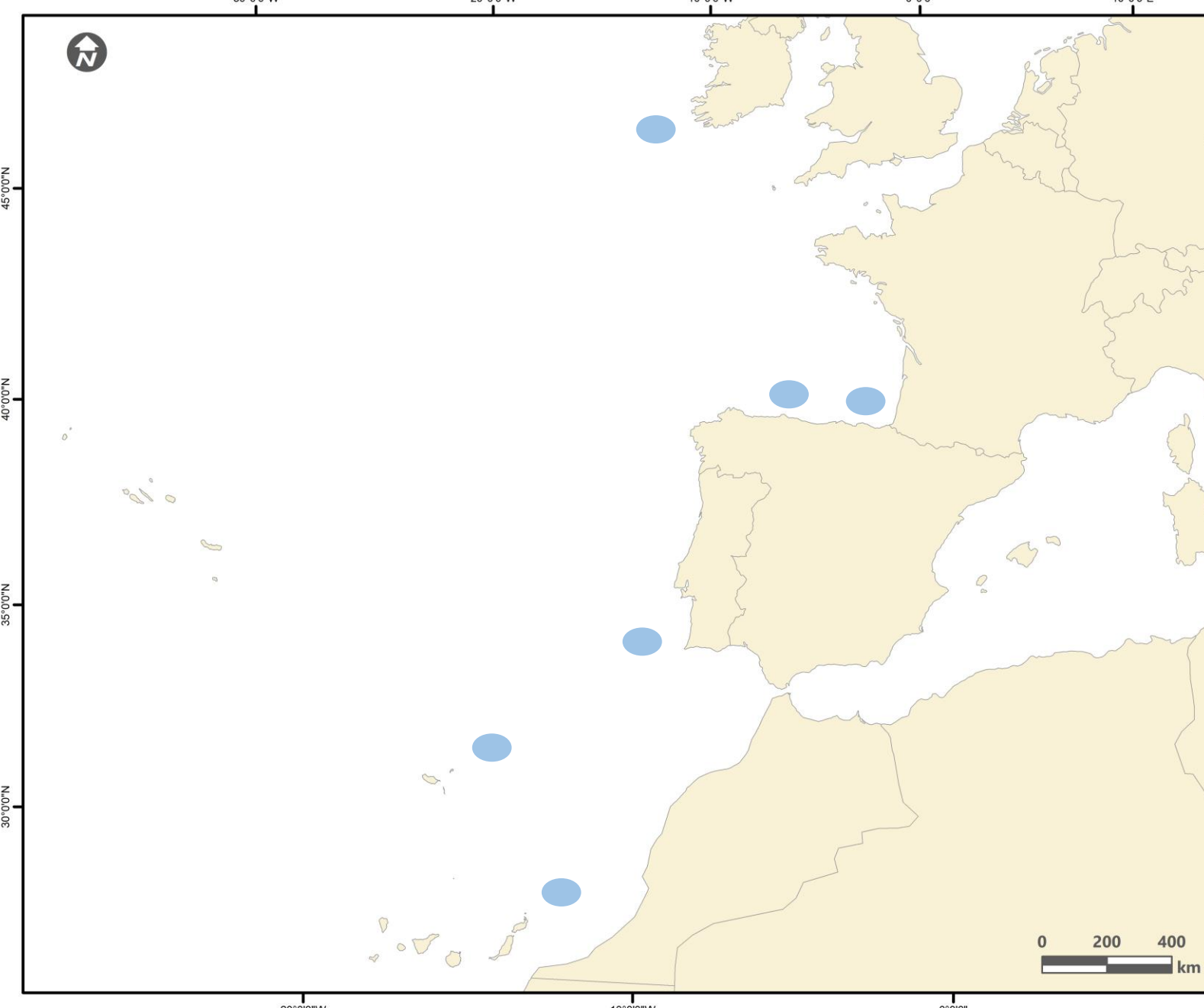
- Antirostrum/notch: more pronounced and deeper in *A. carbo*.
- Height: thinner and more elongated in *A. intermedius*.
- Posterior margin: rounded in *A. carbo*, oblique in *A. intermedius*.



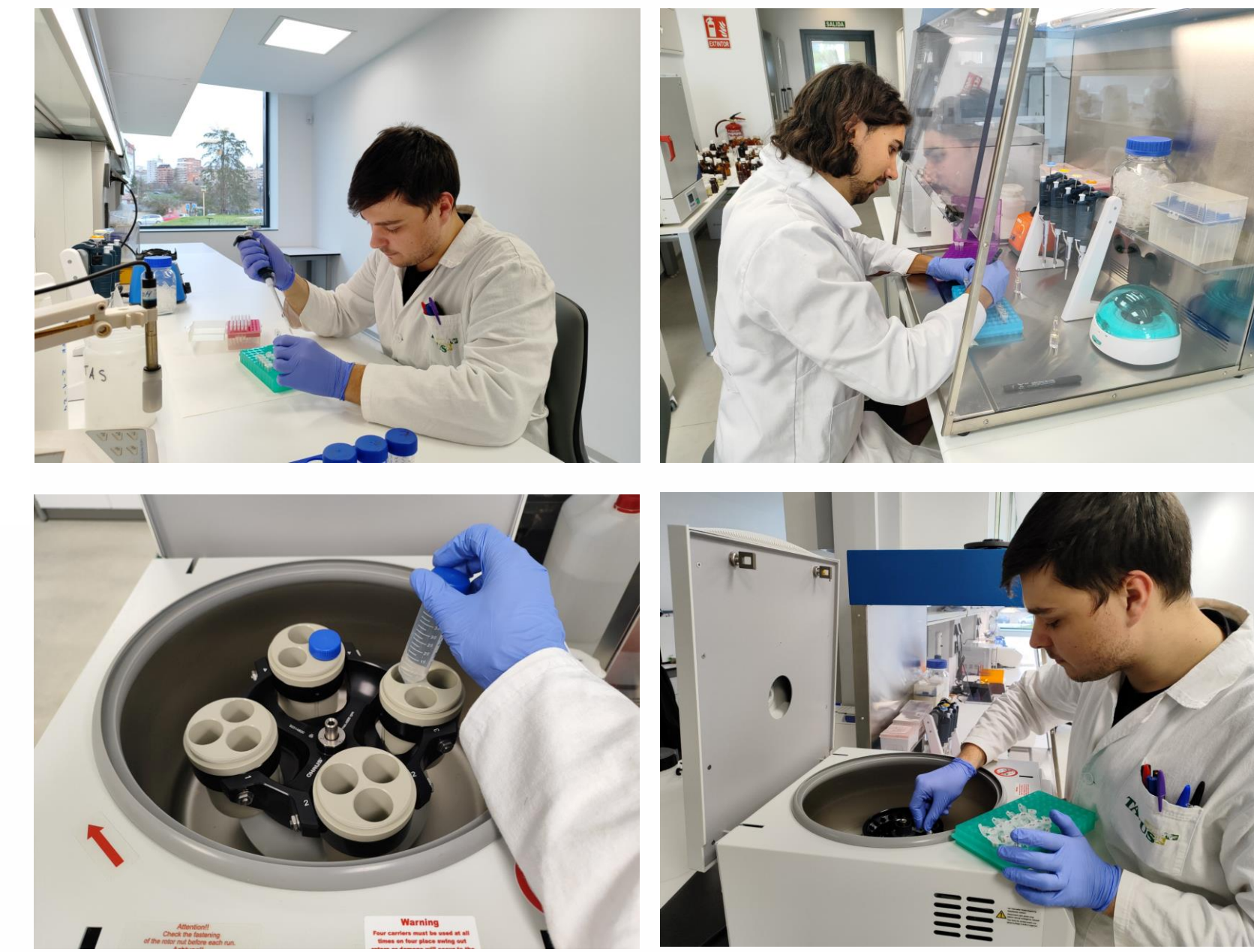
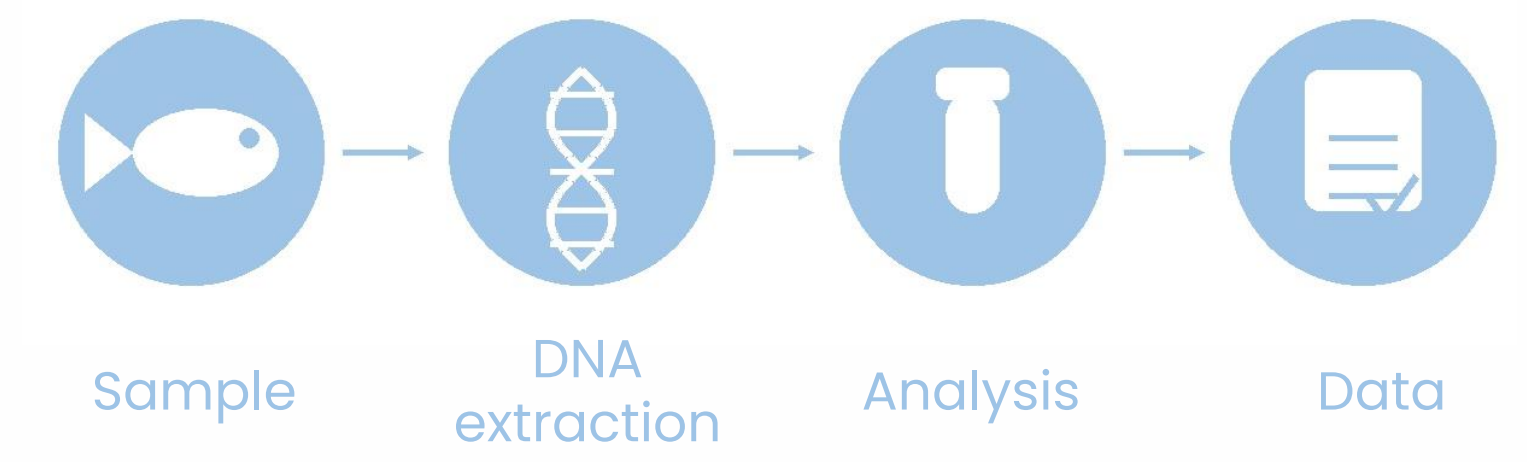
*Aphanopus carbo*

*Aphanopus intermedius*

## MATERIAL AND METHODS

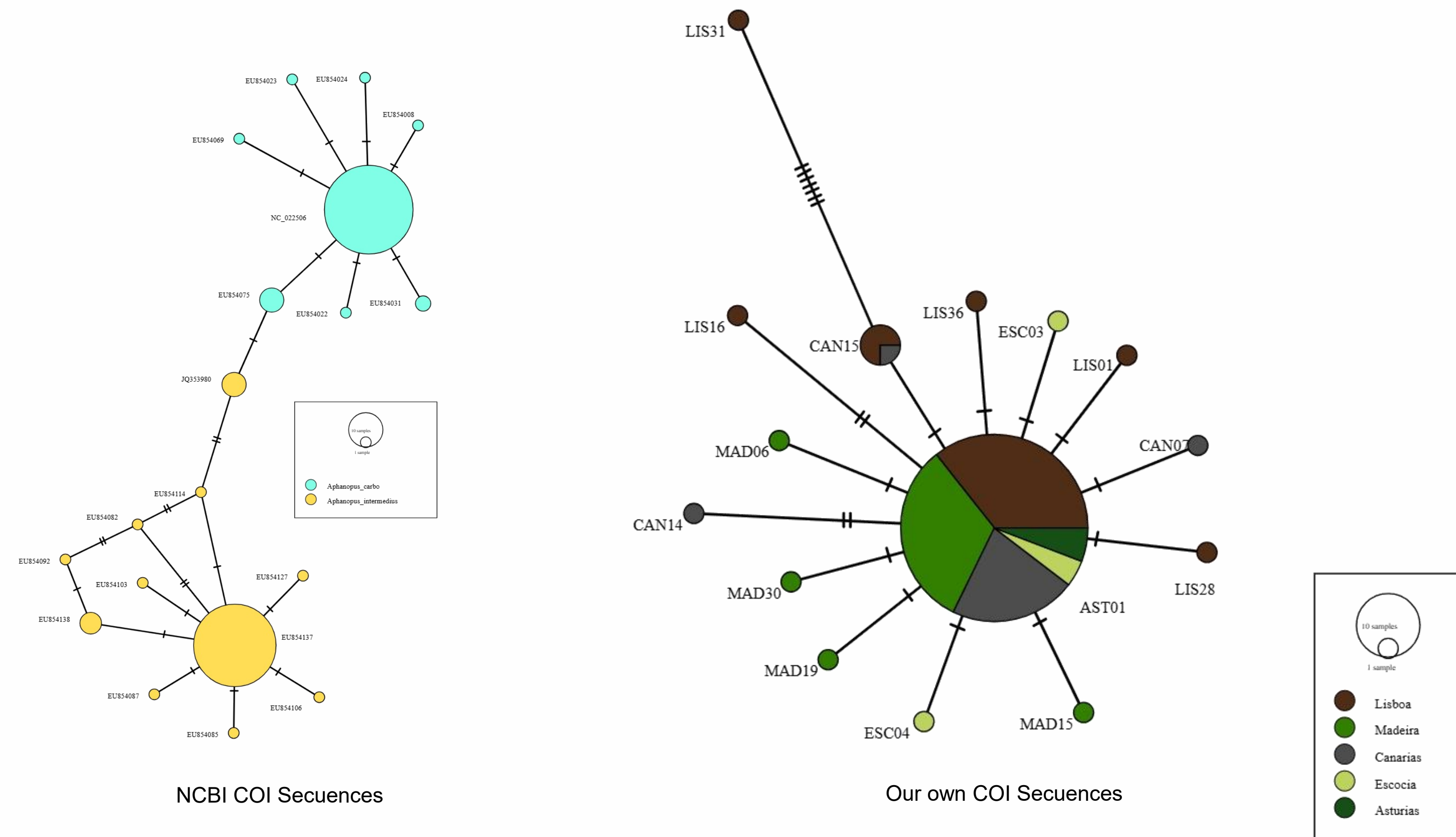


Location	Number of specimens
Madeira	32
Mainland Portugal	41
Canary islands	22
Scotland	6
Asturias	5
French	2



## GENETICS IDENTIFICATION

The results of the analysis suggest that *Aphanopus carbo* and *A. intermedius* represent two distinguishable mitochondrial lineages, as their haplotypes cluster into two differentiated groups. However, the separation between them is very small, being supported by a limited number of mutations and by an average genetic distance close to 1%. This level of divergence is low for mitochondrial sequences and, considering the estimated evolutionary rates for the COI gene in fishes, indicates that the separation between the two species likely occurred relatively recently in evolutionary terms.



## CONCLUSIONS

These species pose a major management challenge due to their high degree of similarity. To the naked eye, morphological differences between the two are virtually imperceptible, unless more detailed analyses of structures such as the vertebrae or the dorsal-fin spines are performed. A similar pattern is observed in otolith shape: although recent work has shown that wavelet-based approaches allow improved discrimination, the regions that differentiate the two species remain limited.

This morphological proximity is supported by the genetic results obtained from the haplotype analysis of Cytochrome Oxidase I (COI) gene sequences available in NCBI. This analysis reveals clustering into distinct groups, but separated by only a very small number of mutations, with a mean genetic distance close to 1%. In fishes, this value is consistent with an early stage of divergence, given that estimated average divergence rates range from 1 to 2% per million years.

Taken together, these results support the hypothesis that *Aphanopus carbo* and *Aphanopus intermedius* may be undergoing an early diversification process. However, accurately delimiting the extent and dynamics of this process requires a more comprehensive assessment that integrates additional lines of evidence (e.g., nuclear markers, genomic approaches, and broader geographic and sampling coverage). Such an in-depth characterization is essential to underpin management decisions based on appropriate biological units, minimize misidentification and estimation errors, and thereby reduce the risk of implementing inadequate measures that could result in excessive fishing pressure and potential depletion of their populations.

## REFERENCES

- Nakamura, I., & Parin, N. V. (1993). FAO species catalogue. Vol. 15.
- Vasconcelos et al. (2025). PLoSOne, 20(6). <https://doi.org/10.1371/journal.pone.0326199>