Sighting data analysis and habitat preferences of blue, fin, humpback and sei whales in the Azorean "Triangle"

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EC-55

36TH EUROPEAN CETACEAN SOCIETY CONFERENCE
NAVIGATING WATERS OF CHANGE
AZORES 2025

Introduction

In **spring**, the waters surrounding **Pico**, **Faial**, and **São Jorge**—collectively known as the "**Triangle**" in the central group of the archipelago—serve as an **opportunistic foraging habitat** and migratory corridor for the **blue whale** (*Balaenoptera musculus*, abbreviated Bmu)[1], **fin whale** (*Balaenoptera physalus*, Bph)[1], and **humpback whale** (*Megaptera novaeangliae*, Mno)[1]. The **sei whale** (*Balaenoptera borealis*, Bbo) is primarily considered a traveler in the study area during spring[2], though feeding behavior has been observed in summer[3].

Materials and methods

Sightings were recorded by **CW Azores** (CetaceanWatching Lda) during **whale watching trips** conducted from **Pico Island** between **April and September from 2010 to 2024**, except 2020, when operations were suspended due to the COVID-19 pandemic. Given the **opportunistic nature of the dataset**, yearly **Encounter Rate** (**ER**) was calculated for each species to account for **observational effort**. Environmental variables associated with sightings included **Chlorophyll-a** (**Chl-a**), **Sea Surface Temperature** (**SST**), **depth**, **latitude** and **longitude**. To evaluate **habitat preferences** among the four balaenopterid species, analyses included **box plots**, **variance partitioning**, and **PERMANOVA**.

Results

SIGHTINGS AND ERs

A total of **1266 sightings** were recorded across **3194 trips**, including 298 blue whales, 537 fin whales, 149 humpback whales and 353 sei whales (Fig. 1). **ERs for blue and fin whales increased until peaking in 2018 and 2017, respectively, followed by a sharp decline**. A **partial rebound in blue whale ERs** was observed in subsequent years. Humpback whale ERs remained highly variable until 2021, after which they rose substantially, peaking in 2024. Sei whale ERs exhibited pronounced peaks in 2022 and 2024.

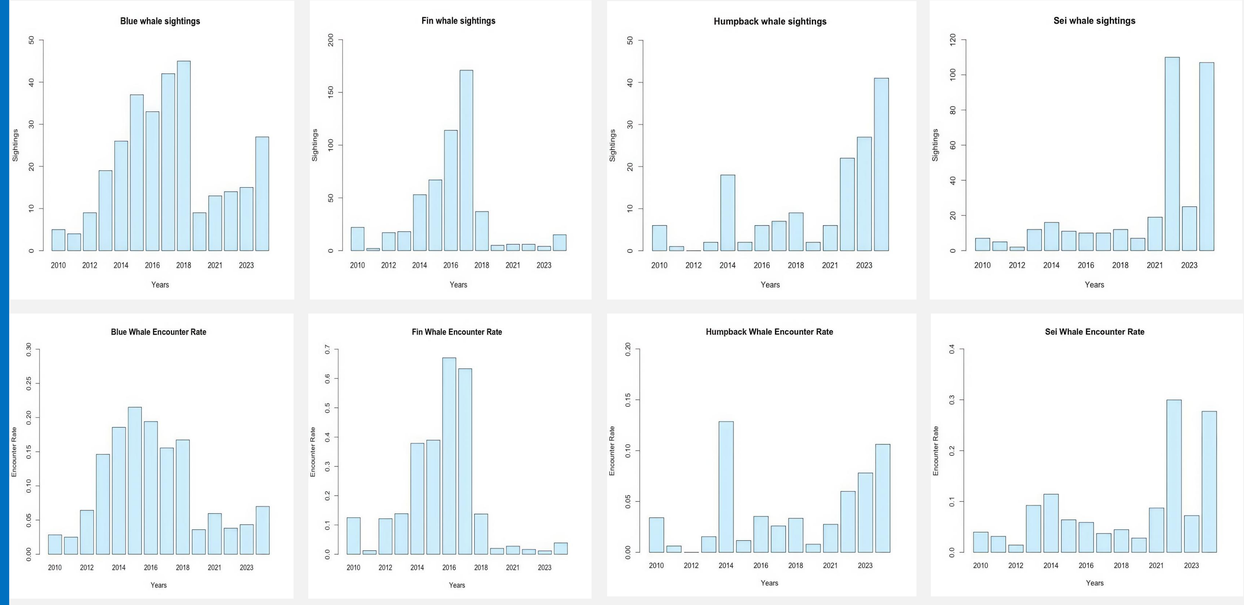

Fig. 1. Yearly sightings (top) and ERs (bottom) for the four balaenopterid species.

ENVIRONMENTAL VARIABLE ANALYSIS

Environmental data analysis revealed **similar depth and Chl-a ranges** across all species (Fig. 2). SST varied among species, with **blue whales** exhibiting the **most restricted range (16-17 °C)** (Fig. 2). Longitudinal ranges largely overlapped, while fin and humpback whales displayed broader latitudinal distributions than blue and sei whales (Fig. 2). **PERMANOVA** (Table 1) identified statistically significant differences in all environmental variables between species ($F = 64.522$, $p < 0.001$). **Principal Coordinates Analysis (PCoA)** showed **similar habitat preferences** for blue, fin, and humpback whales, with **greater overlap between fin and humpback whales than either species had with blue whales**. Sei whales exhibited **distinct habitat preferences compared to the other balaenopterids** (Fig. 3), a result supported by variance partitioning analysis ($F = 6.1209$, $p = 0.00039$); they were observed **feeding on Longspine snipefish** (*Macroramphosus scolopax*) **in summers 2021 and 2022**.

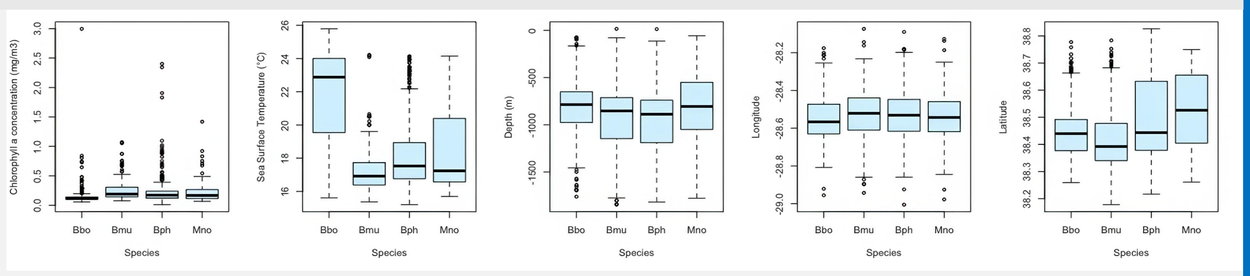

Fig. 2. Boxplots illustrating differences in habitat preference for the four species.

PERMANOVA ANALYSIS	D.f.	Total Sum of squares	R^2	F	Pr(>F)
	3	2741.5	0.12772	64.522	0.001
VARIANCE PARTIONING	**D.f.**	**Partitioned Sum of Squares**	**Mean Square**	**F**	**Pr(>F)**
	3	52.1	17.3696	6.1209	0.0003918

Table 1. PERMANOVA results and variance partitioning analysis of environmental variables.

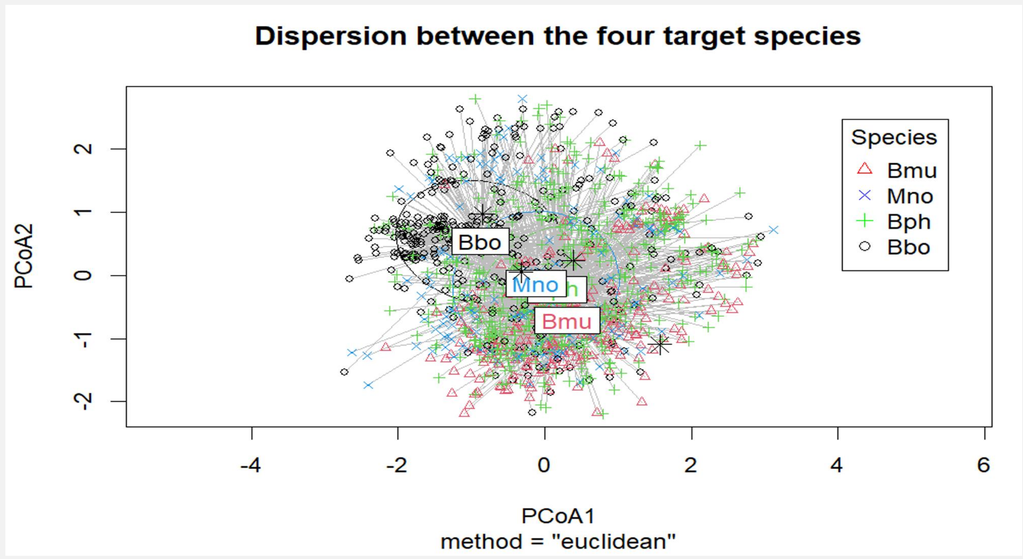

Fig. 3. PCoA showing habitat differentiation among the four target species.

Conclusions

Blue, fin, and humpback whales showed similar environmental and spatial preferences, suggesting partial ecological niche overlap. Blue whales had the narrowest environmental range, with their presence **strongly influenced by SST**, limiting them to **spring months**. Fin and humpback whales demonstrated **broader environmental adaptability**, while sei whales occupied a **distinctly separate ecological niche**, particularly favoring warmer waters. They primarily appeared as **travelers in spring**, while recent observations documented **summer feeding behavior**. Interpretation of ER trends requires further study and analysis.

Acknowledgements

A heartfelt thanks to all CW Azores staff, students, interns and volunteers for the invaluable support.

References

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