Exploring changes in the distribution of seabirds and cetaceans in the Bay of Biscay: relationship with local climate changes and regime shift

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INTRODUCTION

Oceano-climate changes have been demonstrated to affect marine populations, resulting in shifts in distribution or changes in abundance. Marine regime shifts have been detected in all ocean basins, particularly in the late 1980s (Beaugrand *et al.*, 2015). These shifts are likely to cause permanent changes in ecosystems.

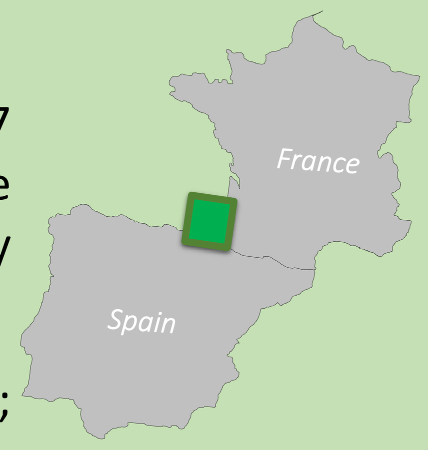
The Bay of Biscay is an important hotspot for marine biodiversity encompassing both cold and warm-temperate water species. A multivariate oceano-climatic index, called the South Biscay Climate (SBC), has been developed to study climate variations in the southern Bay of Biscay (Hémery, *et al.* 2008).

METHODS

SBC index: 36 initial variables describing the oceanic and atmospheric conditions and characterizing the four annual seasons in the study area

Biological data: long-term dataset from 1976 to 2023 (115,586 data) of 17 regular seabirds and cetaceans using a standardized monitoring based on line transects from ships (Castège & Hémery, 2009) and focused on the south of the Bay of Biscay.

Statistical approach: Mann-Kendall test; Principal Component Analysis; Sequential T-test Analysis of Regime Shifts (Rodionov, 2004); QGIS (3.34.14-Prizren)

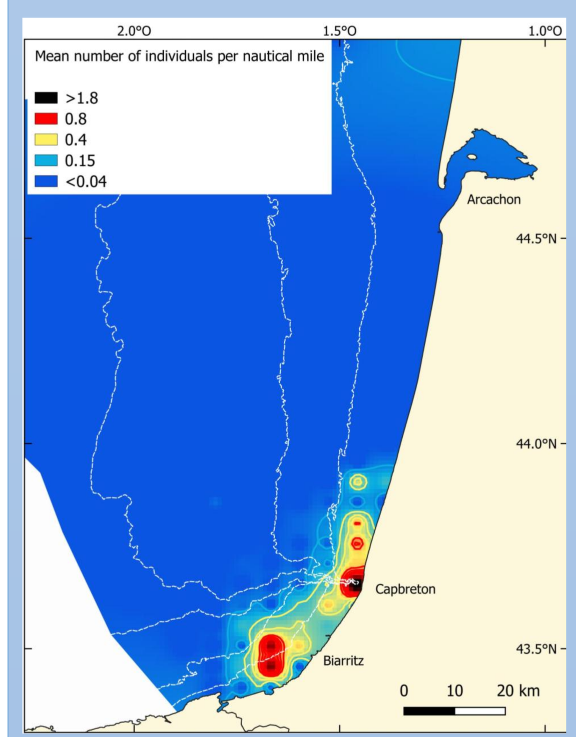
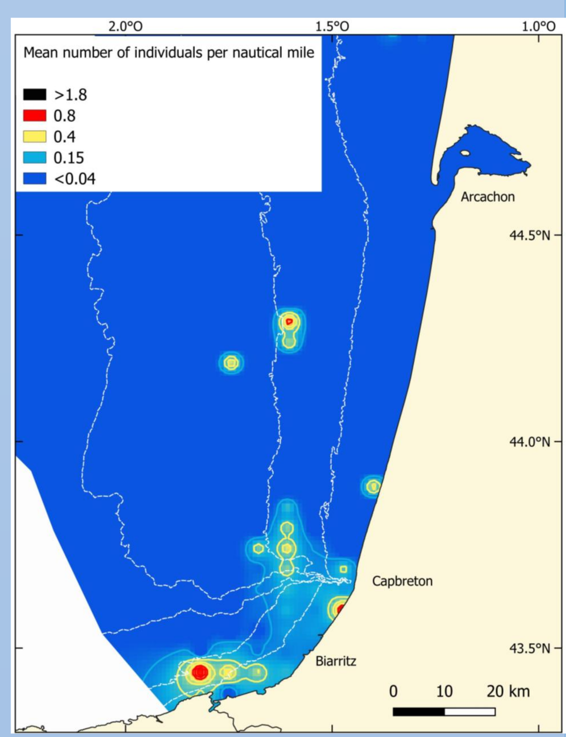


RESULTS & DISCUSSION

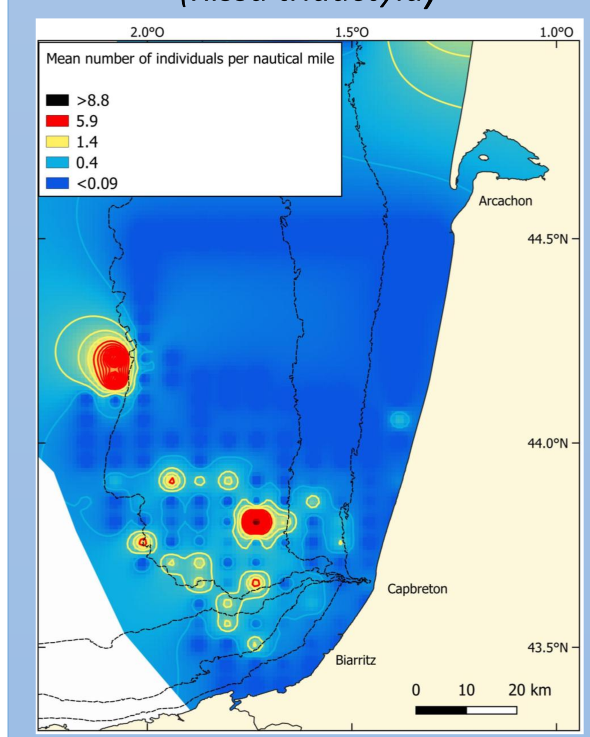
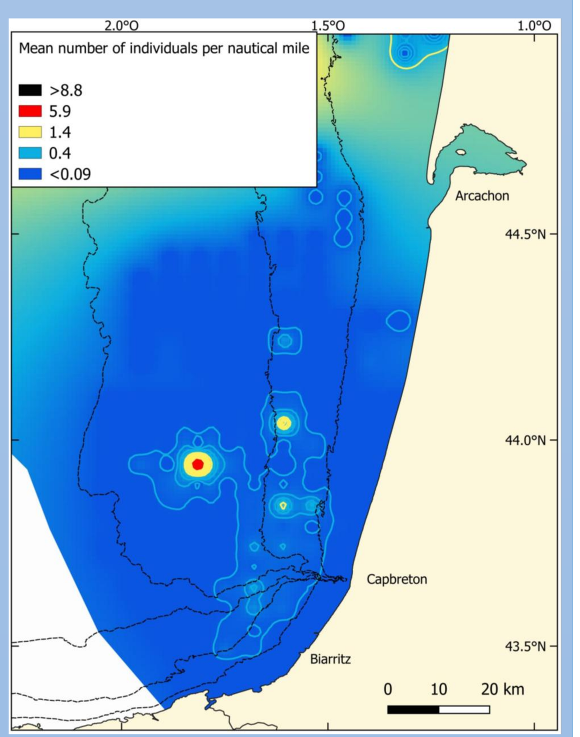
Spatial distribution of cold –temperate water species

Before the regime shift | **After the regime shift**

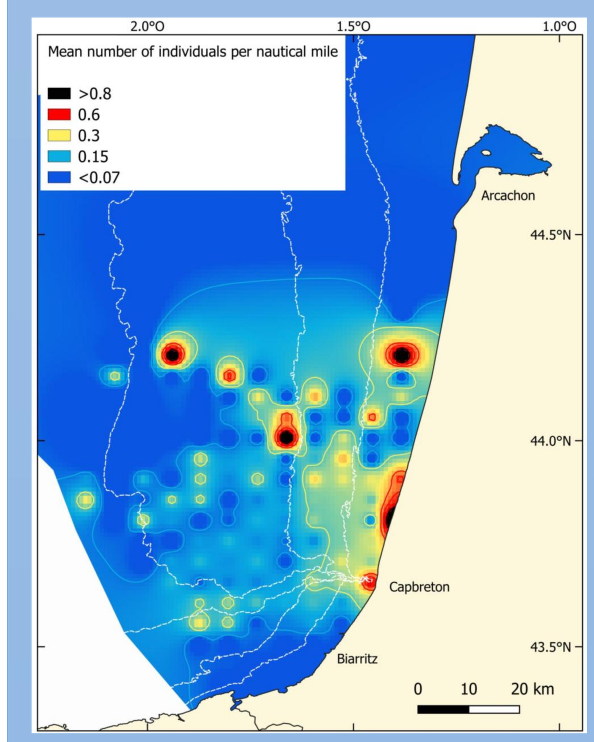
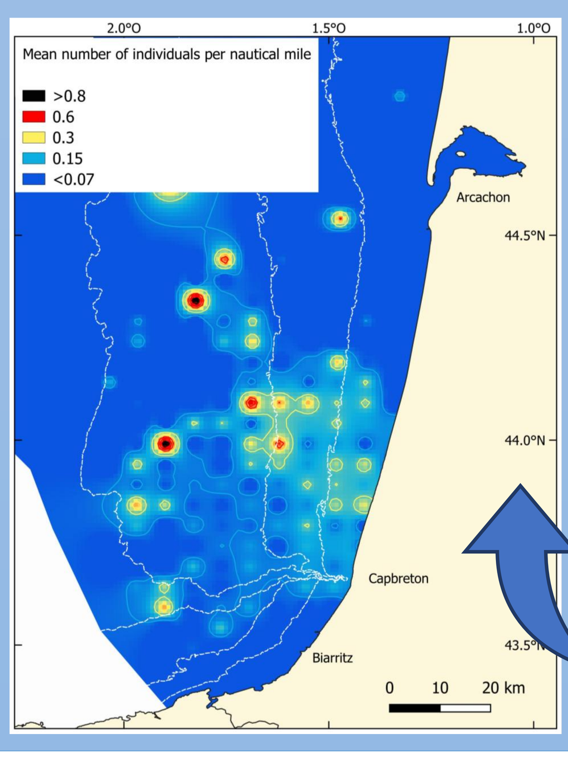
Razorbill
(Alca torda)

Kittiwake
(Rissa tridactyla)

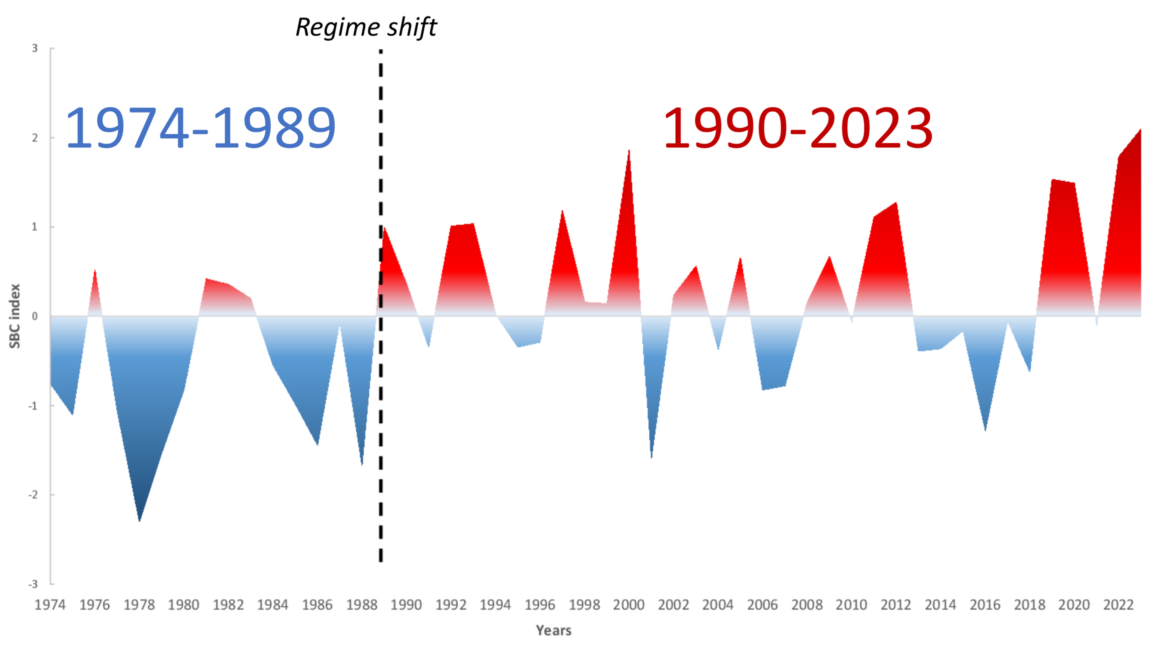



Great skua
(Stercorarius skua)

Oceano-climatic changes

- **The SBC index increased significantly between 1976 and 2023** ($\tau = +0.259$; $p=0.008$)
- **A Regime shift was detected in 1989** ($p < 0.001$)



Temporal variations of the SBC index over the period 1974-2023 (data were normalized to mean= 0 and SD= 1). Positives values of the index are in red and negatives values in blue. South Biscay Climate index between 1974 and 2023

Overall changes in species' abundances

- **Decrease in at-sea abundance of several cold-water species**
- **Increase in at-sea abundance of warm-water species adapted to warm waters**

Species	Trend 1976-2023 (Mann-Kendall τ and p-value)
Cold-temperate and polar waters species	
Hydrobates p. pelagicus	**-0.348 (0.001)**
Rissa tridactyla	**-0.291 (0.006)**
Stercorarius skua	**-0.282 (0.007)**
Hydrocoloeus minutus	+0.116 (0.289)
Alca torda	+ 0.17 (0.114)
Morus bassanus	**+0.206 (0.045)**
Species without thermal preference	
Larus fuscus	-0.09 (0.357)
Ardenna grisea	-0.053 (0.642)
Globicephala melas	+0.154 (0.164)
Thalasseus sandvicensis	+0.173 (0.110)
Uria aalge	**+0.231 (0.025)**
Warm-temperate and tropical waters species	
Larus michahellis	**+0.551 (<0.001)**
Ichthyaetus melanocephalus	**+0.518 (<0.001)**
Puffinus mauretanicus	**+0.490 (<0.001)**
Delphinus delphis	**+0.417 (<0.001)**
Tursiops truncatus	**+0.409 (<0.001)**
Calonectris borealis/ diomedea	+0.028 (0.819)

Trends in seabirds and cetaceans' abundances (1976-2023). All p-values are indicated in brackets; bold characters indicate statistically significant results ($p< 0.05$)

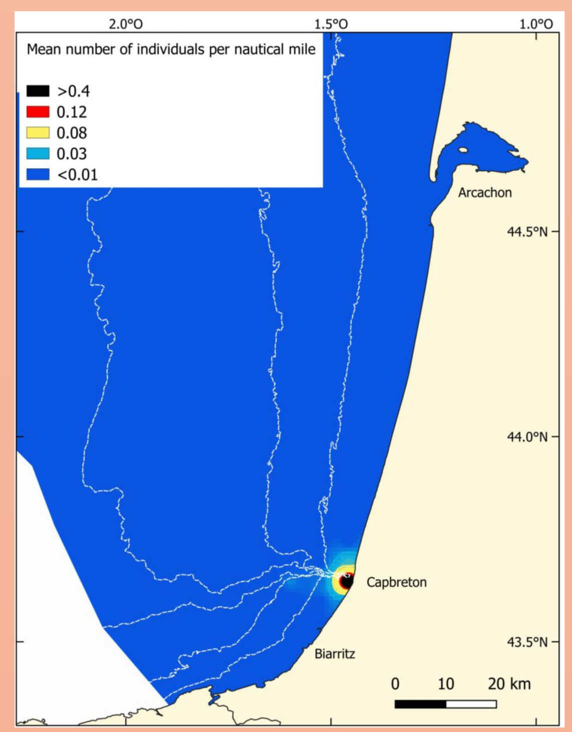
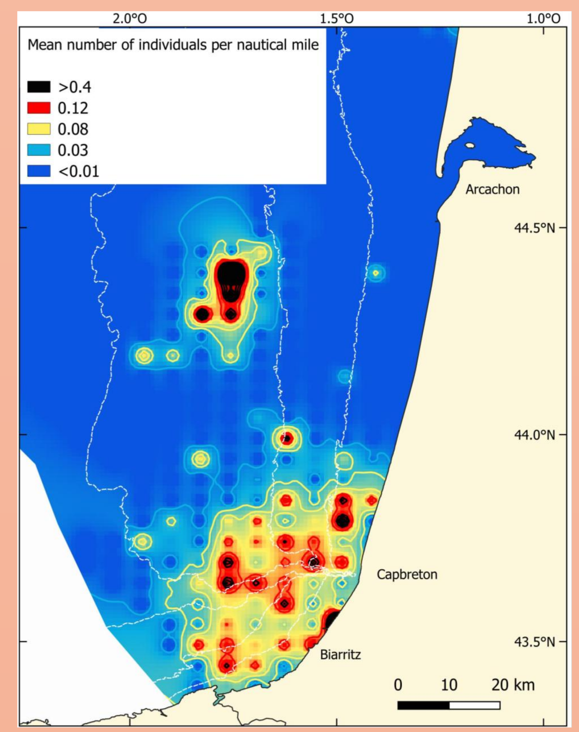
Changes in species' spatial distribution since the regime shift of 1989

- **Cold-water species have generally occupied the same key areas, though in lower numbers.**
- **Warm-water species have expanded their geographic range.**

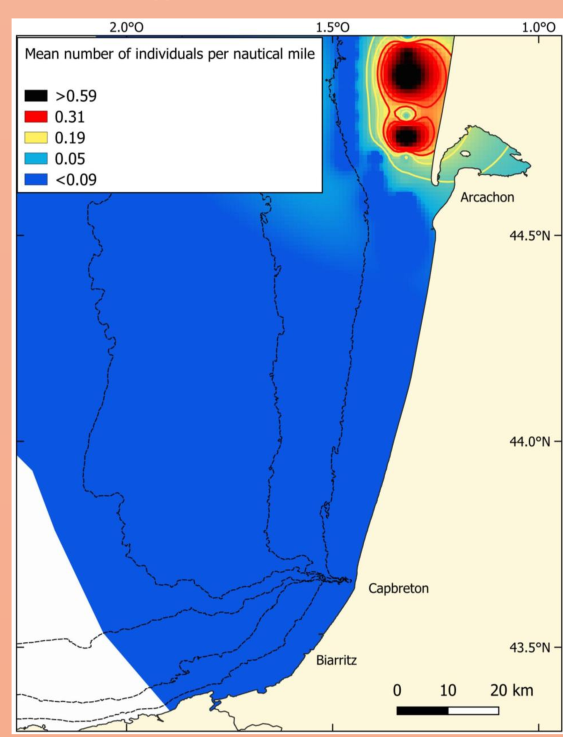
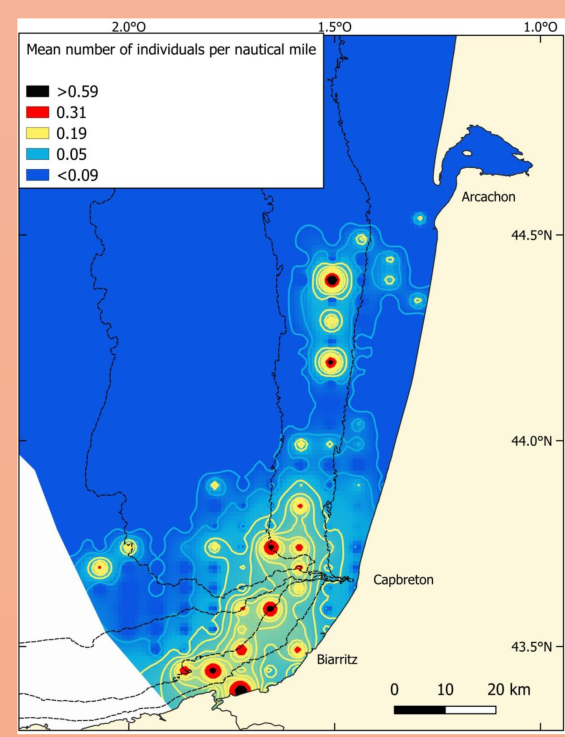
Spatial distribution of warm –temperate water species

Before the regime shift | **After the regime shift**

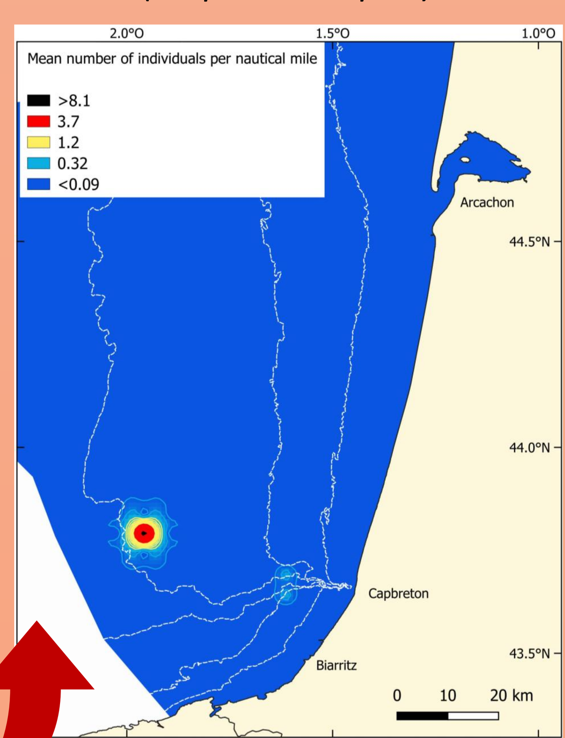
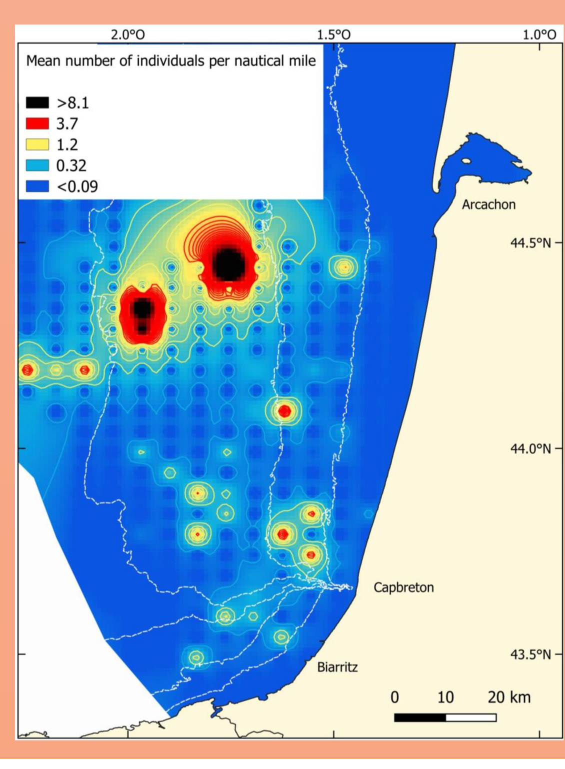
Mediterranean gull
(Ichthyaetus melanocephalus)

Balearic shearwater
(Puffinus mauretanicus)

Common dolphin
(Delphinus delphis)

CONCLUSION

Following the regime shift of 1989, **changes in the abundance and distribution of seabirds and cetaceans at sea were observed.**

Most species demonstrated a **spatial fidelity within specific areas.**

These data are essential to **enhance the management of marine protected areas** and demonstrate the necessity to update them in light of climate change impacts.

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