Seabird drift as a proxy to estimate surface currents in the western Mediterranean?

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1. Introduction

Seabird trajectories can be used as proxies to investigate the dynamics of marine systems and their spatiotemporal evolution. Previous studies have mainly been based on analyses of long range flights, where birds are travelling at high velocities over long time periods. Such data have been used to study wind patterns (e.g. Felicísimo *et al.*, 2008; Weimerskirch *et al.*, 2016). Areas of avian feeding and foraging have also been used to study oceanic fronts (Haney & McGillivary, 1985) and the transitional region between the ocean and atmosphere (*De Monte et al., 2016)*. On the other hand, Miyazawa *et al* (2015) showed an improvement in their ocean model after assimilating **seabird** and ship drift data in the sea of Japan.

Objective: To investigate **seabird drift as a proxy for sea surface currents** in the western Mediterranean Sea.

Final goal: To contribute to our understanding of marine systems' dynamics **and** their spatiotemporal evolution.

2. Data

- **Seabird data:** The data from two campaigns was analysed. One of them was part of the research project LIFE 04NAT/ES/00049 - IBA Marinas, in which GPS devices were installed on 6 Scopoli's shearwaters (*Calonectris diomedea diomedea*) individuals at the Aire Island (southeast of Menorca) in late Summer 2007. The other was part of the research project LIFE+INDEMARES and GPS devices were installed on 24 individuals at Columbretes Islands in late Summer 2012. (fig. 1) The GPS devices provided their location at 5 minutes intervals.
- **Wind:** We used the Cross-Calibrated Multi-Platform version 2 (CCMPv2) gridded surface L3 ocean vector wind analysis product[1]. It has a temporal resolution of 6 hours and spatial resolution of 0.25º.
- **ADT:** Absolute Dynamic Topography (ADT) maps were obtained by adding the Mean Dynamic Topography (MDT) to the Sea Level Anomaly (SLA) downloaded from the Copernicus Marine Environment Monitoring Service (CMEMS) website. SLA data consists of reprocessed observations (L4 gridded maps) of which daily means with a spatial resolution of 0.12º are retrieved.[2]
  - From this ADT data Finite Size Lyapunov Exponents (FSLEs), were computed at 1/64º (Hernández-Carrasco *et al.*, 2011).
  - The eddy tracker (Mason *et al.*, 2014), was also applied to the ADT data.

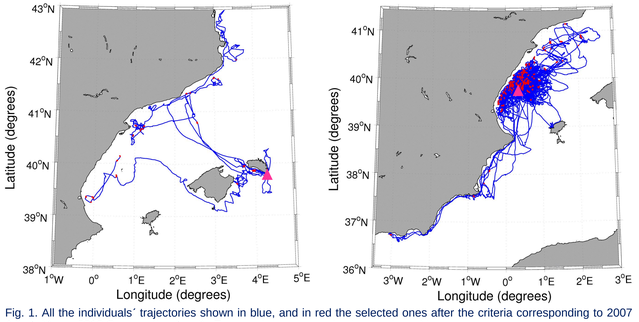
3. Methodology

Louzao *et al*. (2009) classified the behaviour of this species into 4 categories on the basis of both the apparent flying speed (m/s) of GPS-tracked birds and the visual inspection of trips:

- **Resting on water: < 0.5**
- Feeding: 0.5 - 2.8
- Searching: 2.8 - 4.2
- Traveling: > 4.2

We focus on the **'slow-moving'** periods when the individuals are resting on the water surface:
- **Velocity:** < **0.5 m/s**

Other criteria used:
- **Distance from colony: > 5 km**
- **Trajectory duration: > 2 hours**



In fig. 1 we show the trajectories of the 2 campaigns analysed. All the available trajectories are shown in blue. In red we show the selected ones after applying the criteria explained in the blue box above.

Fig. 1. All the individuals' trajectories shown in blue, and in red the selected ones after the criteria corresponding to 2007 Aire (left) and 2012 Columbretes (right). The pink triangle indicates the location of the colony.

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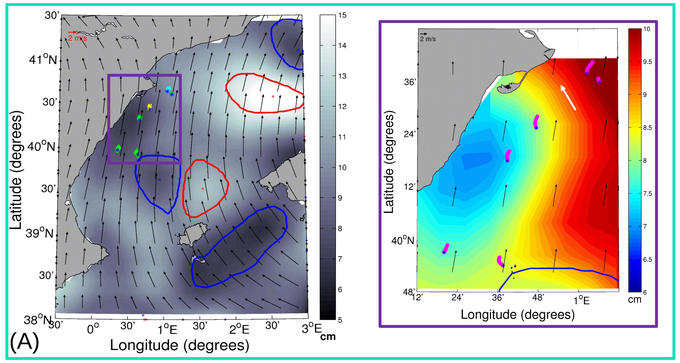
4. Results

The selected trajectories were compared to the ADT and wind fields to try and relate the trajectories' path to different processes. In table 1 we show the global statistics and in fig. 2 an example of wind and geostrophic current-driven trajectories. Lastly in fig. 3 we compare the histogram distribution with FSLEs.

Table 1. Trajectories' statistics for both campaigns.

Total number of trajectories (post-criteria)	Trajectories associated to:		
	Wind	Geostrophic currents	Other
144 (22 individuals)	71 (49%)	21 (15%)	52 (36 %)

Example of trajectories associated to **wind**:



Example of trajectories associated to **geostrophic currents:**

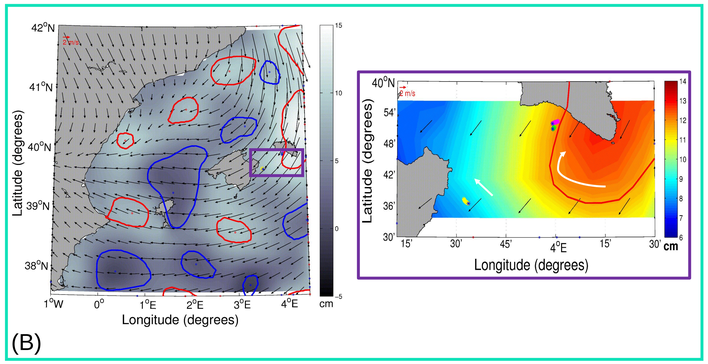


Fig. 2. Snapshot of the ADT (background) and wind (black arrows) fields with the corresponding trajectories on the 28/08/2012 of the Columbretes campaign (A) and on the 08/08/2007 of the Aire campaign (B). Trajectory starting point is shown with a blue asterisk. Trajectories in different colour correspond to different individuals (except if trajectories shown in magenta, that means all individuals are of the same colour for clarity). The eddies detected by the eddy tracker are shown with the blue/red contours (cyclone/anticyclone). The dot shows the position of the centre of the eddy. Left: General overview. Right: Zoom of the region marked with a purple rectangle on the left panel. White arrows indicate the direction of the geostrophic current.

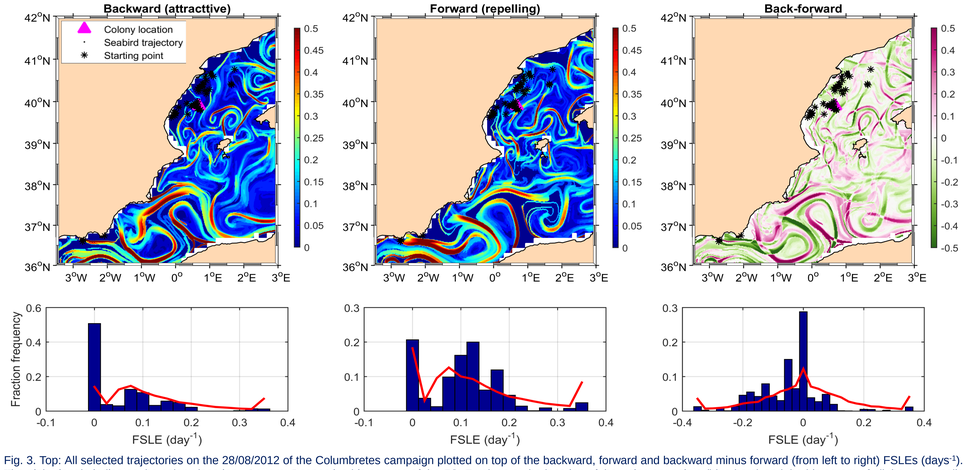


Fig. 3. Top: All selected trajectories on the 28/08/2012 of the Columbretes campaign plotted on top of the backward, forward and backward minus forward (from left to right) FSLEs (days^{-1}). The pink triangle indicates the colony location. Bottom: Respective histograms of the FSLE values at the location of the trajectory points (blue bars) and the histogram of all the top panel's region (red line).

5. Summary and perspectives

- We have analyzed **144 trajectories** corresponding to **'slow moving' periods** recorded by GPSs attached to individuals of the species *Calonectris diomedea* (Scopoli's shearwater) for late Summer 2007 and 2012. The trajectories are compared with ADT, FSLE and wind.
- Preliminary results show that the trajectories followed mainly the wind direction (49%), although **we also found significant correlations with geostrophic currents** (15%).
- Future work:
  - Apply these analyses to other campaigns and other seabird species.
  - Further analysis of FSLEs results.
  - Compare with HF radar data if available.

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