

What Yelkouan shearwaters get up to when in the non-breeding period.

Where seabirds go after the breeding season has always been of interest to scientists. The non-breeding season is a critical period of the annual cycle, where individuals migrate to areas of seasonal peak resource abundance, balancing the energetic cost of travelling and the increased availability of food (Newton 2008). They often also moult flight feathers during the non-breeding period, and the growth of these feathers and the change in flight performance are other costs for migrating seabirds to consider and schedule in order to minimise overlap between energetically costly activities. Recent advances in biologging technology has increased the knowledge about the non-breeding period of seabirds (Yoda 2019). Several Procellariiformes (order including shearwaters and albatross) show intraspecific variation in non-breeding destinations and behaviours (Cherel et al. 2016; Fayet et al. 2017). These differences can occur between sexes, known as sexual segregation (Catry et al. 2006; Hedd et al. 2014). Sexual segregation in the non-breeding period can lead to the sexes being exposed to different levels of threats, such as bycatch (Cortés et al. 2018). Therefore, a sex could be more vulnerable and cause a skew in adult mortality, which has been recorded in declining seabird species (Gownaris and Boersma 2019).

Yelkouan shearwaters *Puffinus yelkouan* (Fig. 1) are a Mediterranean endemic seabird, classified as 'Vulnerable' to extinction by IUCN due to low adult survival (Oppel et al. 2011; BirdLife International 2018). Yelkouan shearwaters breed in burrows between February and July and are presumed to moult at the beginning of the non-breeding period. Two non-breeding strategies have been documented so far: either birds stay in the central Mediterranean or they head further east to the Black Sea (Raine et al. 2012; Péron et al. 2013).



Figure 1: Yelkouan shearwater at breeding colony in Malta, visiting the cliffs during the hours of darkness.

Photo by LIFE Arcipelagu Garnija

The aim of my study, in collaboration with University of Glasgow and BirdLife Malta, was to better understand the migratory strategies of yelkouan shearwaters, the schedule of

migration and moult, and the location of the non-breeding and moult areas. In addition, to see if there are differences between the sexes in these strategies.

Methods. Malta holds around 10% of the global breeding population distributed across a number of colonies around the archipelago. I studied Maltese yelkouan shearwaters in 2019 and 2020 in collaboration with the long-term monitoring study conducted by LIFE Arcipelagu Garnija. We captured 27 breeding yelkouan shearwaters from accessible nests in Malta in 2019 and equipped them with geolocator-immersion loggers (Fig. 2), which The Seabird Group partly funded to increase the sample size.



Figure 2: Deployment and retrieval of geolocators on the breeding yelkouan shearwaters. Squeezing into caves in the middle of the night to wait for them to return and feed their chick.

In 2020, a season constrained by the Covid-19 pandemic and spells of unfavourable weather conditions, 44% of the loggers deployed were retrieved. From these loggers, I estimated locations from the light curves with the R package FlightR (Rakhimberdiev et al. 2017) and removed locations around the equinoxes as latitude is unreliable during this period (Phillips et al. 2004).

Immersion data was categorised into wet (sitting on water), dry (flight or on land) and mixed activity (reflecting active foraging). Moulting birds are expected to show prolonged periods of high wet activity, due to the high cost of flight when replacing flight feathers (Gutowsky et al. 2014, Cherel et al. 2016). Proportion of time spent sitting on the water was modelled as a Generalised Additive Model with serial autocorrelation, from which the peak was taken as the mid date of flight feather moult.

When Did They Migrate and Moults?

Yelkouan shearwaters breeding on Maltese islands either staid in the central Mediterranean or migrated east. Moult occurred between August and October but varied between individuals. The first birds returned to the colony in October but others returned only in

January (Figure 3). Inter-individual variation did not appear to be related to either sex or destination.

What is their behaviour? Yelkouan shearwaters increased their time spent on the water's surface during the non-breeding compared with the breeding period due to relatively low energetic requirements while free from central-place constraints and chick provisioning (Mackley et al. 2010). Within the non-breeding period they spent more time sitting on the water during the night than during the day and then declined from November onwards as they returned to the colony.

Where Did They Go? All yelkouan shearwaters spent the non-breeding period either in the central Mediterranean or they travelled east to Aegean and Black Sea (Figure 3). Birds generally moulted on their way to their wintering grounds. No differences between sexes were discovered in either the moult locations or the entire non-breeding period. Further analysis of the data are underway to test whether the areas utilised during the non-breeding period have certain environmental characteristics that correspond to favourable prey species.

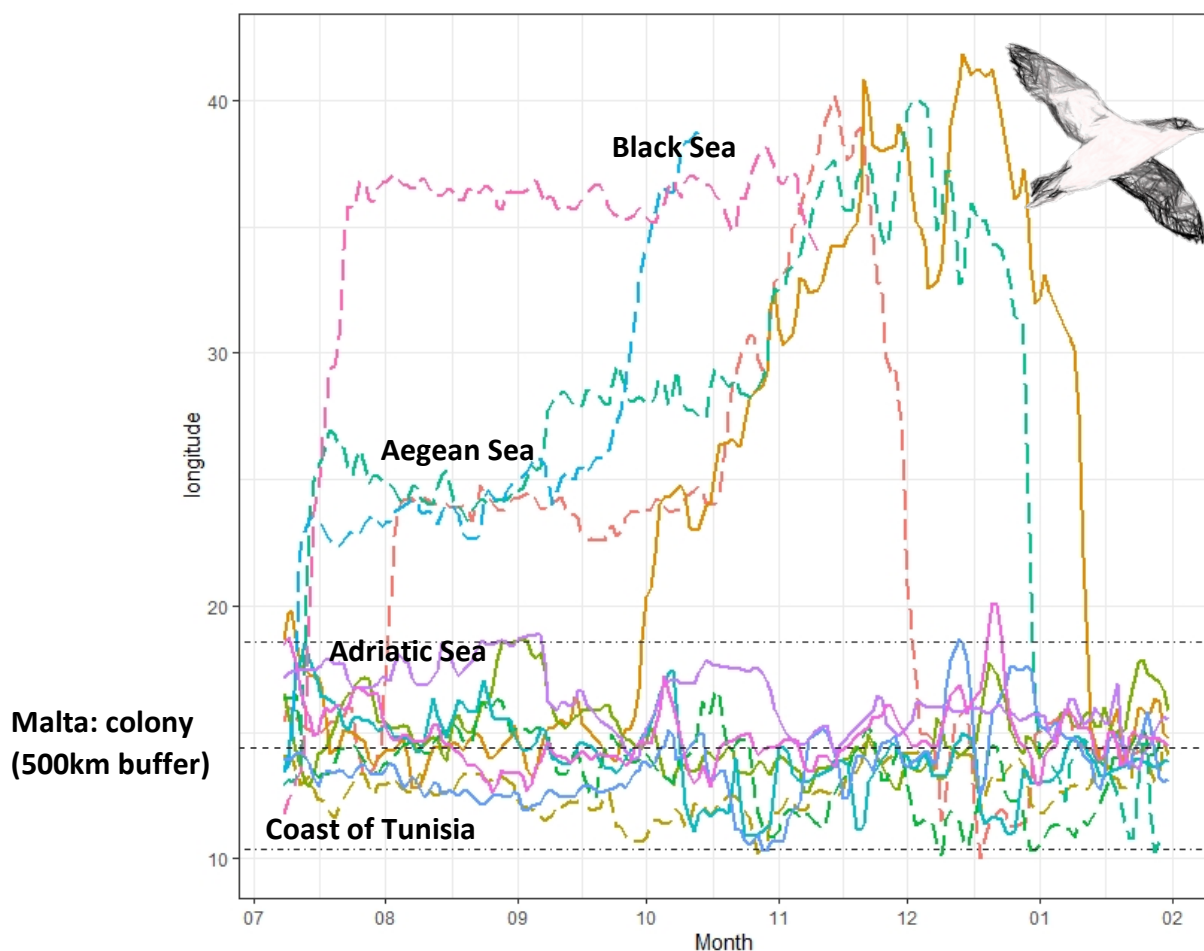


Figure 3: Longitudinal movements (unaffected by equinoxes) of the tracked Maltese yelkouan shearwater (n=12), demonstrating the West - East movements during the non-breeding period 2019-2020. Colours are individually tracked birds, with sex represented by line type (males = dashed line, females = solid line). The colony of Malta their 500km of known breeding foraging areas (Raine et al, 2012).

Further study. The areas utilised by yelkouan shearwaters during the non-breeding period, especially those that appear to contain a high density of individuals need to be considered as potential areas for protection. Though a larger sample size is needed, future research should investigate the potential threats such as bycatch in the areas identified in this study.

Loggers that have been retrieved this year have been redeployed on new birds and an effort will be made to recapture birds deployed in 2019 and 2020 in order to increase the sample size, fingers crossed for 2021!

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