Rafting behaviour of Yelkouan Shearwater *Puffinus yelkouan* breeding at Rdum tal-Madonna, Malta

André Raine, Helen Raine, Ana Meirinho & John J Borg

Introduction

The Yelkouan Shearwater *Puffinus yelkouan* is listed as Near Threatened under the IUCN Red List (IUCN 2010). Malta holds internationally important breeding populations of this species, with between 1,660 and 1,980 breeding pairs, equating to approximately 10% of the world population (Borg *et al.* 2010). The largest colony in the Maltese islands is found at Rdum tal-Madonna, in the north-east of Malta, which is designated as a Special Protection Area (SPA) for this species. As this area holds over one-third of the Maltese population, the site has been the subject of a four year EU LIFE project, focussed on the conservation of the species on land and at sea. As part of the project, intensive work was carried out using a range of telemetry techniques to ascertain important marine areas for this species.

This paper examines one aspect of this research – the identification of rafting areas for Yelkouan Shearwater during the breeding season, specifically birds nesting at the colony located at Rdum tal-Madonna in the north of the island. In Malta, Yelkouan Shearwaters begin returning to their nesting sites in October, with egg-laying beginning in March. Chicks hatch in late April and by late July the last juvenile birds have fledged (Borg *et al.* 2010). Rafting behaviour is common amongst shearwaters during the breeding season, with adult birds often forming large aggregations in the waters near to their colonies in the hours before darkness prior to returning to their nest sites. It is not clear why these birds form rafts and some scientists have hypothesised that this behaviour may have developed to reduce the chances of predation of birds returning to nest sites, with the birds remaining in their rafts until nightfall and the cover of darkness (Klomp *et al.* 1992). Alternatively, it could be because birds which are away for several days at distant food sources cannot time their returns precisely, so assemble to wait until it is safe to return to the nests in groups (Warham 1990). Rafts of Cory's Shearwaters *Calonectris diomedea* offshore from colonies in Malta can be very large, with the rafts of this species off Ta Cenc (one of the largest colonies) often numbering in the 1,000s in summer (Bonavia *et al.* 2005). Rafts of Yelkouan Shearwaters tend to be smaller and less obvious than those of the Cory's Shearwater. Consequently, they are often overlooked and limited data is available.

This paper considers data collected from data loggers on the location of rafting sites for Yelkouan Shearwaters breeding at Rdum tal-Madonna prior to returning to their nest sites after nightfall. Rafting sites at other times of the year or for other reasons, such as prior to the breeding season, at offshore feeding sites, or in the post-breeding season moulting period are not included here.

Methodology

Back-mounted GPS data loggers, manufactured by Technosmart, were deployed on adult Yelkouan Shearwaters during the breeding seasons of 2008 and 2009. GPS data loggers were encased in water-proof plastic and then affixed with duct tape to the back feathers in a series of thin strips. The loggers were attached as low down the back of the bird as possible but above (and out of the way of) the preen gland. The sensor of the data logger was kept facing upwards to effectively receive data. Data loggers weighed 12g and were fitted to birds up to a maximum of 3.2% of their body weight. It should be noted that each bird was presumed to be carrying a 60g fish meal based on the average weight of a fish meal carried by adults (*unpublished data*) and this was subtracted from the total weight of the bird prior to assessment of whether it was of sufficient weight to safely carry a tag. Furthermore, only birds in accessible or visible nests were used for the study to (i) confirm that the birds were definitely breeding, (ii) increase the chances of recapture and (iii) minimise disturbance to other breeding birds.

Data loggers can be set to different recording frequencies (from once a second up to once an hour or an even longer duration), but have limited battery power and a trade off has to be made between duration of battery and number of signals. Different recording frequencies were therefore trialled before the tags were fitted and it was decided that hourly and half hourly recording was the most effective use of battery, especially during the early part of the breeding season when the birds were spending considerable time in the burrows which depleted battery power without signals being obtained. The majority of tags were programmed for hourly recording, as a precautionary measure to ensure maximum battery length.

A total of 42 data loggers were deployed on breeding birds at Rdum tal-Madonna in 2008 and 2009, between the months of April and June. Rafting locations were identified using two different analyses, and were considered to be any point where the bird was travelling at a speed of less than 2.5km/hr. In the first analysis, all locations under 2.5km/hr within a 7km radius of the colony were plotted. Only those points within a 7km radius of the colony were used, to exclude rafting sites of birds not returning to their nest site, as rafts of birds feeding at sea for several days could be 100s of kilometres away from land. A 7km radius was also identified as the 75% kernel limit for rafting data points – a method used by other authors to define the limit (BirdLife International 2010). This analysis would however potentially weight the key rafting areas towards birds with multiple points, so to control for this a second analysis was also carried out. In this case, the very last point registered by the data logger before the bird returned to its nest site was used. This resulted in each foraging trip being represented by a single point, thus ensuring that all trips had equal weight. This also identified the key rafting areas for birds immediately prior to their return to the nest. The speed of the bird at each of these points was also considered to ascertain whether the point indicated a rafting bird or not. Those with a speed below 2.5km/hr could safely be considered to be rafting at such slow speeds.

Results

Of the 42 data loggers deployed, useable data was recovered from 24 birds (representing 31 trips) – other tags failed to collect data due to technical problems or became water-logged. Due to the limit imposed by battery power, several of these loggers stopped collecting data before the birds returned to the nest and thus rafting data could not be extracted from them. Data on rafting site locations was identified for 15 birds. In the first analysis, a total of 138 rafting locations, up to the maximum distance from the colony of 7km, were identified for all birds combined (Figure 1). The majority of rafting sites were situated in a band of sea directly opposite the colony, across the waters off the eastern end of the Malta-Gozo Channel and up to the south-eastern tip of Gozo. The average distance (±SE) to the colony of these locations was 3.1 ± 0.2 km (min 0.7km, median 2.8km, max 7.0km).

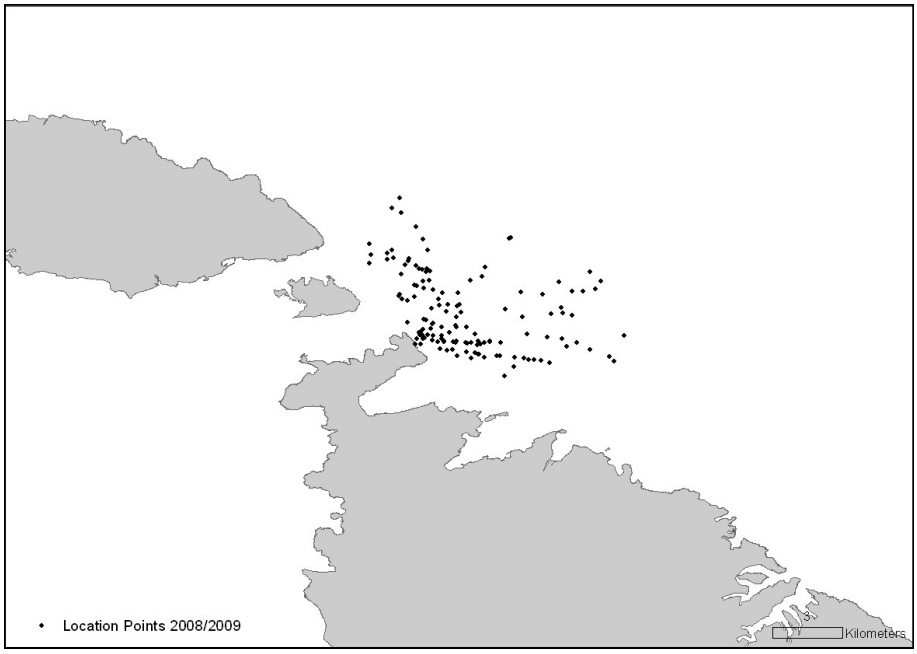

Figure 1. All rafting locations of Yelkouan Shearwater nesting at Rdum tal-Madonna in 2008 and 2009 from GPS data logger fixes up to 7 km from colony. Multiple points can be represented by a single bird.

The timings of rafts were also considered. Birds were found to predominantly raft between 19:00 and 03:59, with 92.8% of rafts occurring during this period (Figure 2) and over two-thirds (68.1%) found between 21:00 and 02:59. Only 5 points (3.6%) occurred after 03:59 and birds were not recorded rafting near the colony during the day (between 10:00 and 18:00), presumably as the birds were at favoured fishing sites far offshore.

For the second analysis, the last rafting location of each trip was plotted. Of these, all locational points except one had a speed of less than 2.5km.hr, with a single point between 2.5 and 10 km/hr. The latter point is likely to have been that of a rafting bird (perhaps while sitting on waters under the influence of a strong current) but may also have been a bird in flight. It has been retained in this analysis based on the criteria outlined in the methods. These locations are presented

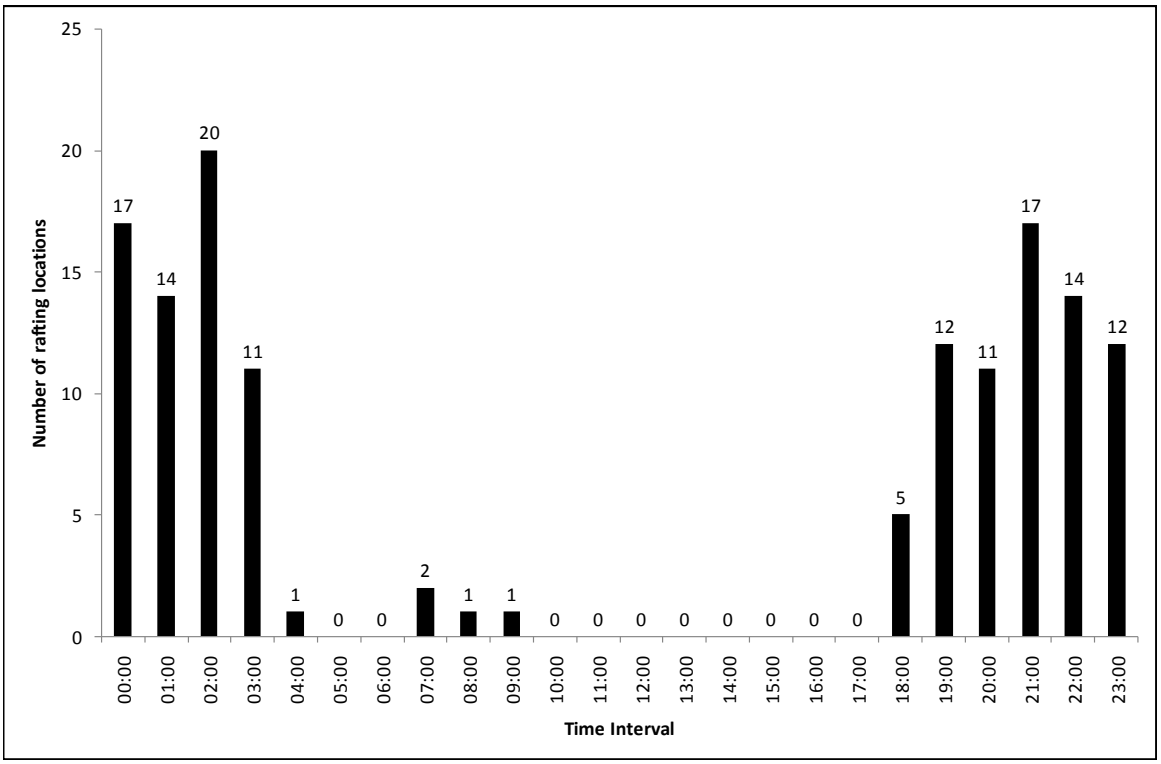

Figure 2. Timings of all rafting locations of Yelkouan Shearwater nesting at Rdum tal-Madonna in 2008 and 2009 from GPS data logger fixes up to 7 km from colony.

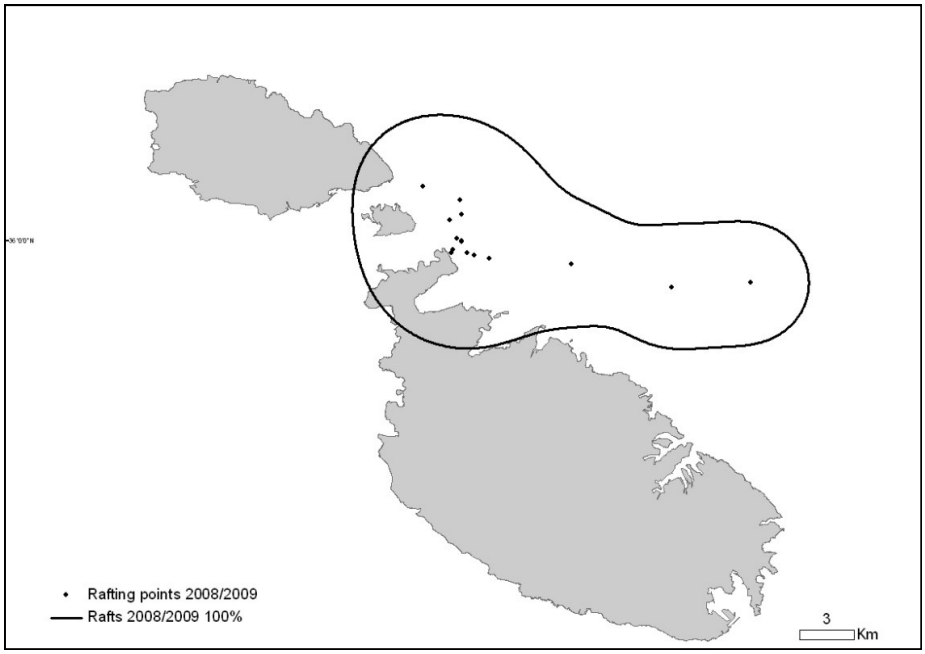

Figure 3. Rafting locations of Yelkouan Shearwater nesting at Rdum tal-Madonna in 2008 and 2009 from GPS data logger fixes. Each point represents a single trip. The 100% kernel limit is also shown on the map.

in Figure 3, while Figure 4 shows an expanded view of the waters immediately off-shore from Rdum tal-Madonna where the majority of rafts were located.The vast majority of individual birds (80.0%) for which a rafting location was identified were found to raft in the waters adjacent to the colony up to 4.5km offshore. The average distance of a rafting site to the breeding colony in this analysis was 3.7 ± 1.2km (min 0.2km, median 2.0km, max 16.6km). The vast majority of these rafting sites were situated directly opposite the colony, with a smaller number in the waters off the eastern end of the Malta-Gozo Channel.

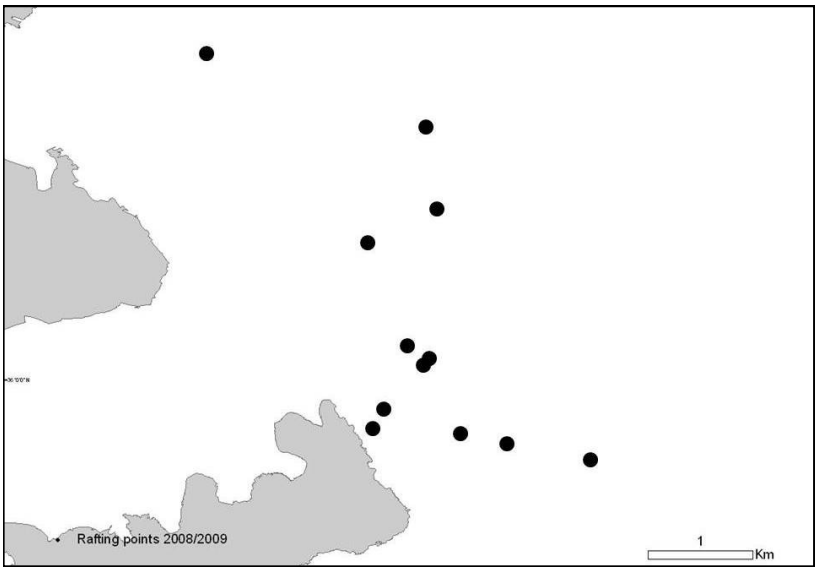

Figure 4. Map showing the majority of rafting sites as pinpointed from GPS data loggers. Each point represents a single trip. These positions are the last known rafting location of the bird before it entered the nest.

Discussion

Fixes from the data loggers show that the majority of tagged Yelkouan Shearwaters returning to their nest sites rafted in the waters directly opposite the Rdum tal-Madonna breeding grounds and the eastern end of the Malta-Gozo Channel. Two analysis were used; (i) all rafting sites for tagged birds within a 7km radius of the colony, where multiple points could be the same bird and (ii) last recorded point by the logger before the bird went to the nest, where all trips were thus given equal weight. The average distance of rafting sites from the colony were 3.1 ± 0.2km (first analysis) and 3.7 ± 1.2km (second analysis). As this was the case for every bird that had been tagged and which provided data on rafting locations, it is therefore reasonable to assume that the vast majority (if not all) of birds breeding at Rdum tal-Madonna use this area to raft prior to returning to nest sites. It was also found that there were multiple rafting points for many of the birds, showing that individuals often rafted in several locations within the area of sea immediately off of Rdum tal-Madonna before returning to their nests.

Considering the timings when birds rafted, the vast majority of rafting locations occurred during the hours of darkness - between 19:00 and 03:59. Only 5 rafting locations (3.6%) were recorded after 03:59 and no rafts were recorded in the vicinity of the colony between 10:00 and 17:59, when the birds were out at sea fishing. The timings also suggest that while all of the birds rafted in the area at night prior to returning to their nests, some birds also rafted in the area after leaving their nest site and before returning to offshore feeding grounds. It is possible that this was so that birds could gather in flocks before heading out to sea. While this behaviour was less frequent, it is thus apparent that some early morning rafting also occurs in the vicinity of the colony.

These results compare well with a land-based study carried out on shearwater rafts by Sultana & Borg (2000) and Wigmore (2008) who found that the inshore waters opposite Rdum tal-Madonna were particularly important for rafting Yelkouan. It has also been noted that many adult birds returning to their nests had wet belly feathers when caught by field workers (both during the LIFE Project and in previous studies), suggesting that they had been rafting close to the colony prior to flying up to their nest sites. The authors have also personally observed rafting Yelkouan Shearwaters within 2.5km of the colony, including a raft of over 35 birds recorded on the 19th May 2009 (AR pers obs). Four raft sites were also identified during LIFE project boat-based observations between 2007 and 2009 (unpublished data). These rafts included 30 birds located 5.1km directly off of Rdum tal-Madonna, and three single rafting birds between 5.5 and 5.9km from the colony. It should be noted that these boat based observations took place during daylight hours with the result that they would have missed the majority of rafts, which as the analysis has shown occur from late afternoon and during the hours of darkness.

It is therefore evident from this study that the waters adjacent to Rdum tal-Madonna from the shore up to at least 7km represent a critically important area for Yelkouan Shearwaters breeding in this internationally important colony, with a concentration of rafting sites within the first 4km from the colony. The waters off the eastern end of the Malta-Gozo Channel are also evidently of importance to these birds as well.

Any developments in the area (such as the offshore wind farm that has been proposed for Sikka l-Bajda, which falls within the rafting zone) should therefore take this into account, especially in light of the fact that the Rdum tal-Madonna site is classified as a Special Protection Area under European Union law for the two nesting shearwater species (Cory's Shearwater also breed at Rdum tal-Madonna. Using data loggers, the LIFE project also identified this area as an important commuting route for birds entering and leaving the colony, meaning that birds are constantly moving back and forth through the area (unpublished data). It is not known what impact human disturbance would have on rafting Yelkouan Shearwaters, such as the presence of a series of large wind turbines from the proposed Sikka l-Bajda offshore wind farm project.

The proposal of an offshore wind farm at Sikka l-Bajda should therefore be considered carefully in light of the results of this study, as it is now evident that this area is critically important for rafting shearwaters from the Rdum tal-Madonna SPA. Any studies on the potential effects of such a development would therefore need to utilise appropriate methodologies if they were to accurately consider the impact of a windfarm on the rafting behaviour of Yelkouan Shearwaters from the colony. The use of tracking techniques, such as the data loggers used in this study, would provide the most reliable sources of data. Surveys from land would not be appropriate for such studies as they would almost certainly miss the majority of activity at such a distance away from the land (Sikka l-Bajda lies between 2 and 4km from Rdum tal-Madonna, and is thus beyond the effective range for land-based surveys). This is particularly true in the low light conditions when birds are concentrating in rafts, with the results of the study showing that rafts predominantly occur in the hours of dusk and darkness. Counts occurring during the afternoon would therefore miss the majority of rafts. It is also imperative that these studies would be carried out over several years and throughout the full breeding season (October to July), to take into account temporal fluctuations in usage. Most critically, sea-based counts within Sikka l-Bajda of calling birds would also need to be undertaken during the hours of darkness because, as shown in this study, the vast majority of rafts occur during this time and would be completely missed by diurnal studies. Likewise, studies should be carried out to ascertain other potential sources of disturbance, such as the impact of tankers bunkering in the waters off Rdum tal-Madonna, as their bright lights may have a negative impact on these light-sensitive birds.

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André Raine - c/o BirdLife Malta 57/28 Triq Abate Rigord, Ta'Xbiex, Malta. andre.raine@birdlifemalta.org
Helen Raine - c/o BirdLife Malta 57/28 Triq Abate Rigord, Ta'Xbiex, Malta. helenleach2002@yahoo.co.uk
Ana Meirinho - ana.meirinho@spea.pt
John J. Borg - National Museum of Natural History, Vilhena Palace. Mdina, Malta. john.j.borg@gov.mt