Light pollution impact on “tubenose” seabirds: an overview of areas of concern in the Maltese Islands

Picture taken by Paolo Nespoli from the International Space Station (ISS). Available at http://www.nightearth.com/

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Summary

Seabirds of the Order Procellariiformes are known to be highly affected by light pollution near their breeding colonies. One of the main consequences is the phenomenon of young birds being disoriented by artificial light sources and ending up stranded inland.

Although the subject demands further insight, light pollution might be having a very relevant impact on populations of three seabird species in Malta: the Yelkouan Shearwater (*Puffinus yelkouan*), the Scopoli's Shearwater (*Calonectris diomedea*) and the European Storm-petrel (*Hydrobates pelagicus*).

In this document, as an update to a previous report by Raine *et al*. (2007): "*Light pollution and its effect on Yelkouan Shearwaters in Malta; causes and solutions*", we assessed the magnitude of the issue as based on cases reported by the public to BirdLife Malta over the past 36 years.

Main hotspots of the island were identified, with our results indicating an apparent relation between the number of stranded birds in a given area along with the levels of light pollution and the vicinity and scale of a seabird colony.

Given the importance of Malta for populations of these species within the Mediterranean, we encourage the respective authorities to take immediate actions to apply corrective measures in identified troublesome areas as well as adopt the necessary policy to prevent the further sprawl of light pollution through careful planning. Indirectly the anticipated long-term effect of such measures would be less strandings and a decreased mortality of especially young seabirds susceptible to disorientation. Moreover less light pollution will decrease disturbance at nesting colonies and in conjunction with other conservation measures possibly encourage recolonisation of deserted colonies.

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1. Introduction

One of the recognised threats that Procellariiformes (“tubenose” seabirds, eg. shearwaters, petrels and albatrosses) face during their reproductive season is the effect of nocturnal light pollution at or in the vicinity of their nesting colonies (Podolsky *et al*. 1998, Day *et al*. 2003, Fontaine 2011).

As with many other organisms, the effects of light pollution on seabird colonies are possibly not fully understood (Rich & Longcore 2006, Hölker *et al*. 2010*a*,*b*). However a minimum of two main impacts can be recognised, as based on our limited records from the Maltese Islands.

The prime and most serious impact is that related to the abandonment of colonies. To date, Malta’s tubenose species colonies are confined to cliff areas with a degree of limited human disturbance, with research at colony sites pointing to some of them having been abandoned in past decades as a result of intensified human activity (Sultana *et al*. 2011). Being active at colony sites during the night, tubenose species have adopted this behaviour to avoid predation, relying on the cover of darkness to visit their nesting areas (Montevecchi 2006). Light pollution originating from urbanised areas of the coast disturbs this fundamental need to visit their colonies. Nest abandonment as a result of such has been recorded (Wolf *et al*. 1999), while in Malta the abandonment of whole breeding colonies is also attributed to light pollution (Sultana *et al*. 1975).

The second impact relates to the disorienting effect that light pollution has on immature individuals that disperse for the first time from their colonies (Le Corre *et al*. 2002, Raine *et al*. 2007, Rodríguez & Rodríguez 2009). Juvenile tubenoses, especially on their early flights have been reported to feel attracted and disoriented by artificial light sources, misleading them from going back to their colonies at night and often causing them to end up stranded on land or colliding against tall structures (Montevecchi 2006, Miles *et al*. 2010). This phenomenon, known as ‘fallout’ (Reed et al. 1985, Ainley *et al*. 2001) has been documented by BirdLife Malta over the past few decades and fallout or ‘stranding’ events appear to be pronounced at coastal development areas which bring about a significant increase of nocturnal light pollution.

The current Maltese socioeconomical growth model, established in the early years of the 1980s and continued over the last decades, relied on tourism-oriented urbanisation as a way of development. As a result it has led to a very fast and insensitive occupation of the territory, relegating the Maltese natural landscape to a secondary marginal portion of the country. Light pollution is only one of the many negative consequences of this model, which affects avifauna and the environment as a whole. Although now we know much more about the effect of urban development on our wildlife and the frame of conservation and legislation has evolved, this model, far from being reverted, still seems to be the standard for future planning in the country, indirectly encouraging the problems of light pollution and the already dramatic impact on seabirds.

This report aims to present an understanding of the most problematic coastal areas, which as a result of light pollution have ended up in numerous seabird strandings, in particular those of the Yelkouan Shearwater (*Puffinus yelkouan*), the Scopoli’s Shearwater (*Calonectris diomedea*) and the European Storm-petrel (*Hydrobates pelagicus*). The results obtained are just an overview of a complex problem which would benefit from more research, but can well serve as a suitable insight on the effects of light pollution in the Maltese Islands and the need to take remedial action.

2. Method of analysis

In our attempt to assess the magnitude of the impact of light pollution on the three species of Maltese Procellariiformes, we have analysed the records of stranded birds at disposal of BirdLife Malta. These records, covering the period 1978-2013 (36 years), are based on stochastic reports mostly made by members of the public who encountered such stranded birds either in their private property or simply by chance along publicly accessible areas and reported them to the organisation.

BirdLife Malta has for various years been running a voluntary service for the collection of stranded and injured birds in order to assist as much as possible with the recovery and potential release of such birds in the wild. The reported cases document only seabirds encountered in urban areas on land for which the majority constitute juvenile birds with no specific ailments relating to causes other than being stranded on land or collision. Cases related to illegal killing (evident from injuries relating to lead-shot use or strangulation) have not been included as such cases cannot be correlated to light pollution.

For each stranding, BirdLife Malta has documented the location, date, species, age and identity of the reporter, among other potentially interesting details. In the majority of cases when stranded birds were reported early enough and were in good condition, birds were ringed and released, with the aim that any ring recoveries would ascertain that such birds manage to survive after such stranding episodes.

3. Results and discussion

Over the last 36 years a total of 120 cases of stranded birds have been reported to BirdLife Malta. **Table 1** shows the 44 different locations recorded, in order of the number of strandings and their relative percentage to the total.

Before the presentation and discussion of our results it is important to note that as a result of the methodology relying on random public reports, there is a certain component of uncertainty that might lead to an underestimation of the problem.

The number of strandings could be significantly higher than the ones we report taking into account the low probability of encountering such incidents in less urbanised and densely populated areas during the night. It is also likely that many strandings, although noted, are not reported to BirdLife Malta, either because these are handed over to government authorities, or else attempts might be made to keep these species in captivity for some reason or another. Keeping that in mind, these numbers can still serve as indicators of trends and put under the spotlight the most problematic aspects.

Table 1: Location and number of stranded bird cases reported to BirdLife Malta in the period 1978-2013. The table shows number of individuals by location and the percentage of total strandings.

Stranding location	N_o of birds	Yelkouan Shearwater	Scopoli's Shearwater	European Storm-petrel	% of total
Hal Far	16		16		13.33
Xlendi, Gozo	11		11		9.17
Cirkewwa	7	2	5		5.83
Birzebbuga	6	3	3		5
Bugibba	6	5	1		5
Ghadira Bay	5	4	1		4.17
Salina	4	4			3.33
Sliema	4	1	2	1	3.33
St Paul's Bay	4		4		3.33
Delimara Lighthouse	3			3	2.50
Ghar Lapsi	3			3	2.50
Gnejna Bay	3		3		2.50
Mellieha	3	2	1		2.50
Marsalforn, Gozo	3		3		2.50
Comino	3	2		1	2.50
Zurrieq	3		2	1	2.50
Ghajn Tuffieha	2		2		1.67
Golden Bay	2		2		1.67
Marfa	2	1	1		1.67
Qawra	2	1	1		1.67
Valletta	2	1	1		1.67
Mgarr, Gozo	2		2		1.67
Xewkija, Gozo	2		2		1.67
Xaghra, Gozo	2	1	1		1.67
L-Ahrax, Mellieha	1		1		0.83
Blue Grotto	1		1		0.83
Cospicua	1		1		0.83
Foresta 2000	1		1		0.83
Ghar Hasan	1		1		0.83
Manikata	1	1			0.83
Marsaxlokk	1		1		0.83
Naxxar	1	1			0.83
Pembroke	1	1			0.83
Rabat	1		1		0.83
Santa Venera	1	1			0.83
St Julian's	1	1			0.83
Swieqi	1		1		0.83
Tarxien	1		1		0.83
Xemxija Bay	1		1		0.83
Gharb, Gozo	1		1		0.83
Mgarr ix-Xini, Gozo	1		1		0.83
Ramla Valley, Gozo	1		1		0.83
Sannat, Gozo	1		1		0.83
Victoria, Gozo	1		1		0.83
TOTAL	120	32	79	9	

3.1 Identifying seabird stranding hotspots

For better identification of problematic hotspots based on the number of reports, some of these locations can be aggregated in zones by proximity and the urban continuum they represent along the coast (Figures 2, 3, 4).

The top five hotspots with most seabird groundings can be recognised as summarised in Table 2.

Table 2: Top 5 hotspots for stranded bird cases reported to BirdLife Malta in the period 1978-2013

	Hotspot	No reports	% of total
1	Hal Far/Freeport area	23	19.17
2	Qawra/Bugibba/St Paul's Bay area	16	13.33
3	Xlendi, Gozo	11	9.17
4	Cirkewwa/Paradise Bay area	7	5.83
5	Mellieha/Ghadira Bay area	6	5

Hal Far/Freeport Area

According to our analysis the Hal Far/Freeport area is the worst hotspot for stranded seabird reports accounting for more than 19% of the total cases documented in the country over the past 36 years.
If the country as a whole had seen a drastic change on urbanisation and light pollution in the 80's, the case of south-west of Malta is especially notorious. Since the building of a foundry in 1982 in Hal Far, a whole industrial state has been developed around the old RAF airfield in the consequent years, transforming the area from a quiet coastal habitat, well suited for seabirds, to a highly active settlement too close to the colonies. A bit further south, in 1988 the shipping area of Freeport started operating, bringing similar consequences for seabirds. Both events are most likely to be linked with a very negative impact on tubenose species, as reported with the case of Scopoli's shearwater decrease in the late 1990s, mentioned in Sultana et al. 2011.

Qawra/Bugibba/St. Paul's Bay area

Bugibba and the whole urbanised area around St. Paul's Bay account for the second worst hotspot for seabird strandings, with the area being a standard example of the Maltese model of urban development aforementioned. The zone that was highly developed in the 1980 decade is now densely populated and has a waterfront packed with numerous hotels and other businesses aimed for the tourism industry that stay well lit and operating at night. This activity produces an intense glare effect that reaches even the northern cliffs of the island.

Xlendi area, Gozo

Very similar to St. Paul's Bay case in Malta, the coastal area of Xlendi, Gozo is a bay with a lit promenade and several hotels that has been increasingly urbanised over the past years. The zone has gathered a total of 11 reports exclusively on Scopoli's Shearwaters (Fig. 3), representing more than a 9% of the total strandings.

Cirkewwa/Paradise Bay Area

Although far from densely populated areas, the highly active ferry terminal in Cirkewwa and the hotel establishments around Paradise Bay generate on their own a sufficient amount of light pollution to make the area a hotspot of reported cases.

Mellieha/Ghadira Bay Area

Interestingly enough Mellieha/Ghadira Bay area ranks among the top 5 hotspots with a 5% of the records. Although the area concentrates a significant area of land designated protection (Ghadira Nature Reserve and Foresta 2000 site SAC/SPA), the tourist settlements, the roads around the bay and the tradition of lighting up churches and other historical buildings in the area, seems to be affecting seabirds.

Although the correlation between heavier light pollution and the number of seabird stranding cases is well documented (Raine et al., 2007, Rodríguez *et al*. 2012), there might be other considerations to take in account while identifying the underlying causes for a higher occurrence of standings at a certain location. Specific characteristics of the location need to also be considered such as the distance and size of the nearest breeding colony or the chances of a member of the public passing by and finding the bird, which factor may increase the likelihood of a stranding being documented.

As an example, while a big part of the colonies of the two species of shearwaters happen to be mostly along the western coast of the island of Malta, reports are much rarer on the western side compared to the east coast (Fig. 2, 3). It is true that the east coast is in fact more polluted by light, but this is closely linked to the higher population density and occupancy of the territory, meaning that chances might be that grounded shearwaters in the west are less likely to be found and reported by the public.

3.2 Is light pollution becoming an increasingly concerning problem?

Trends in the number of reported cases over the years, as shown in Figure 1, support the hypothesis of a connection between the increasingly urbanised and light polluted Maltese nightscape and the amount of birds that end up stranded inland. Especially remarkable is the huge rise of incidents in the early 2000’s. While the concrete causes for this change are unknown and might include multiple variables, light pollution related events are most likely to play a big part in the origin of the problem.

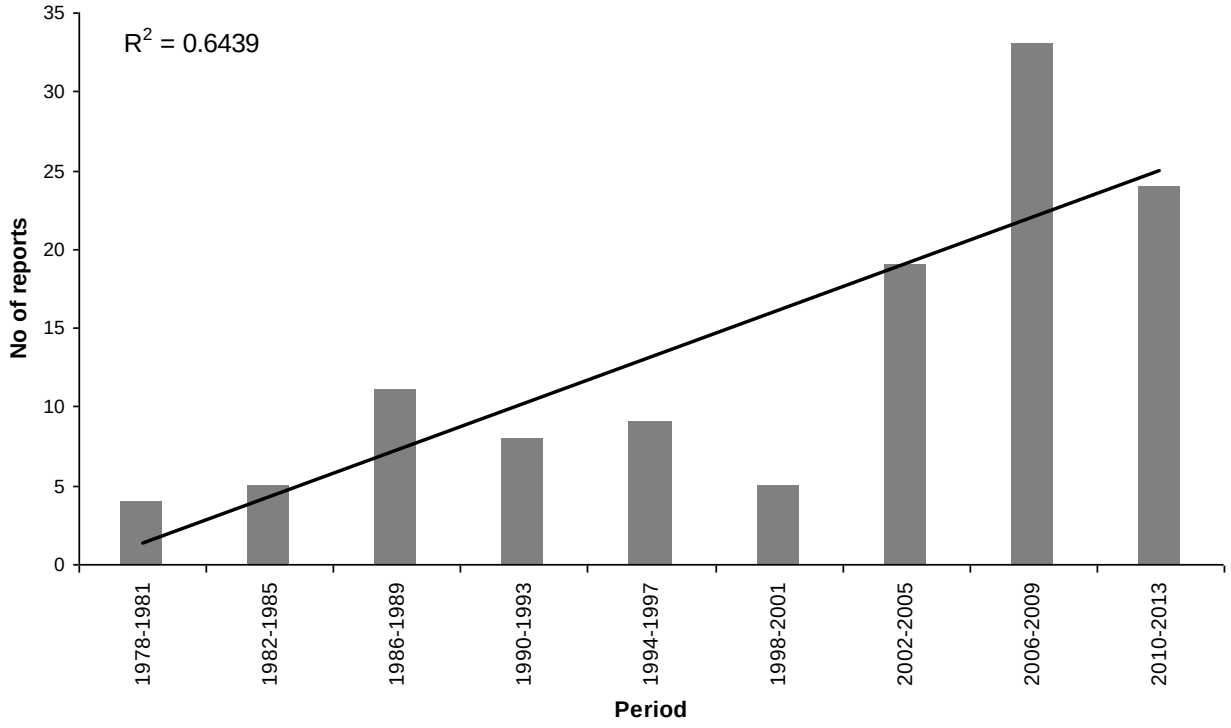

Figure 1: Number of reports of stranded bird cases reported to BirdLife Malta in the period 1978-2013. For a better reading of the trend line the cases are clustered in 4 year periods.

3.3 Stranding records for Yelkouan Shearwater

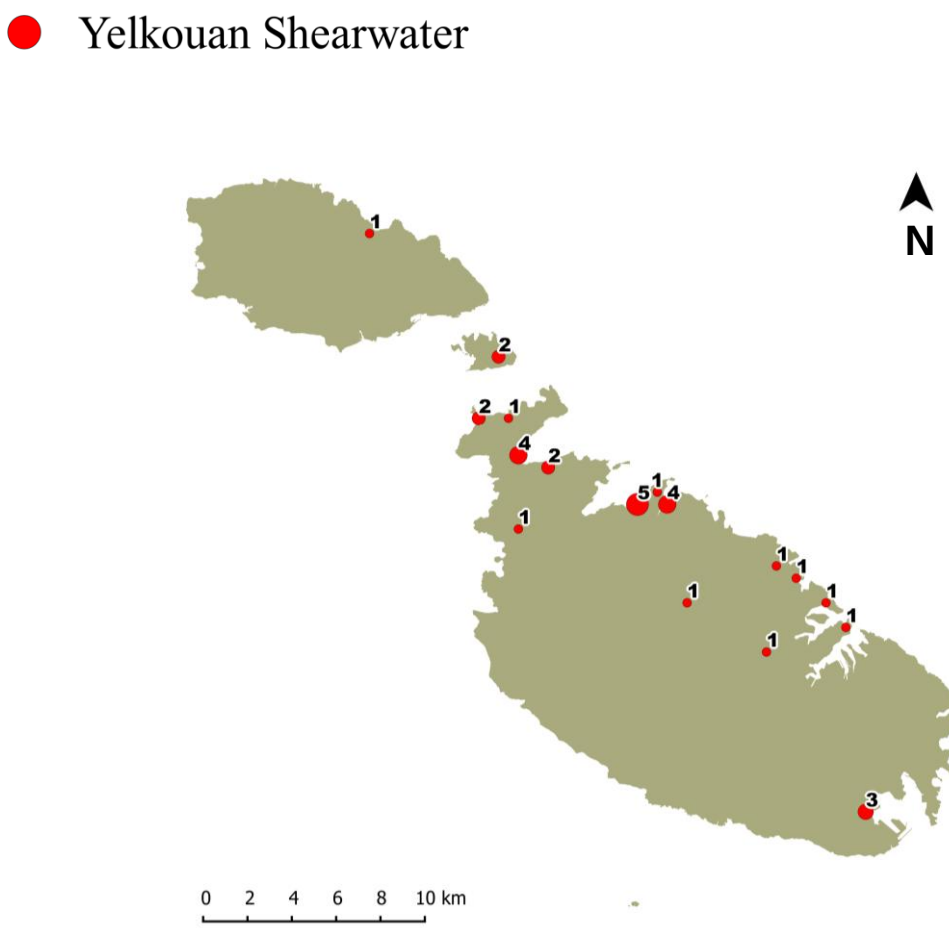

Figure 2: Location and number of grounded Yelkouan Shearwaters (*Puffinus yelkouan*) reported in the period 1978-2013

Main stranding hotspots for Yelkouan Shearwater groundings are concentrated in the north-east of Malta, mainly around St. Paul’s and Ghadira bay areas. Besides the especially worrying levels of light pollution previously mentioned, that originate from the Qawra/Bugibba/St. Paul’s Bay area, the proximity of this light-polluted area to the largest known colony of Yelkouan Shearwaters at Rdum tal-Madonna , located 5km away is without doubt a typical cause and effect scenario. As expected, a combination of high light pollution and the proximity to a large breeding colony seems to be the main cause of seabird grounding cases.

It is interesting to note that despite other smaller colonies of Yelkouan Shearwater scattered around the western coast of Malta and Gozo, reports of strandings close to these areas are rarer. This scenario fits in our hypothesis of the existence of underreported areas. While it’s true that there is less light pollution on the western side of Malta and Gozo, due to these areas being less populated compared to the east, stranded birds are less likely to be found in rural areas and therefore might not be reported.

3.4 Stranding records for Scopoli’s Shearwater

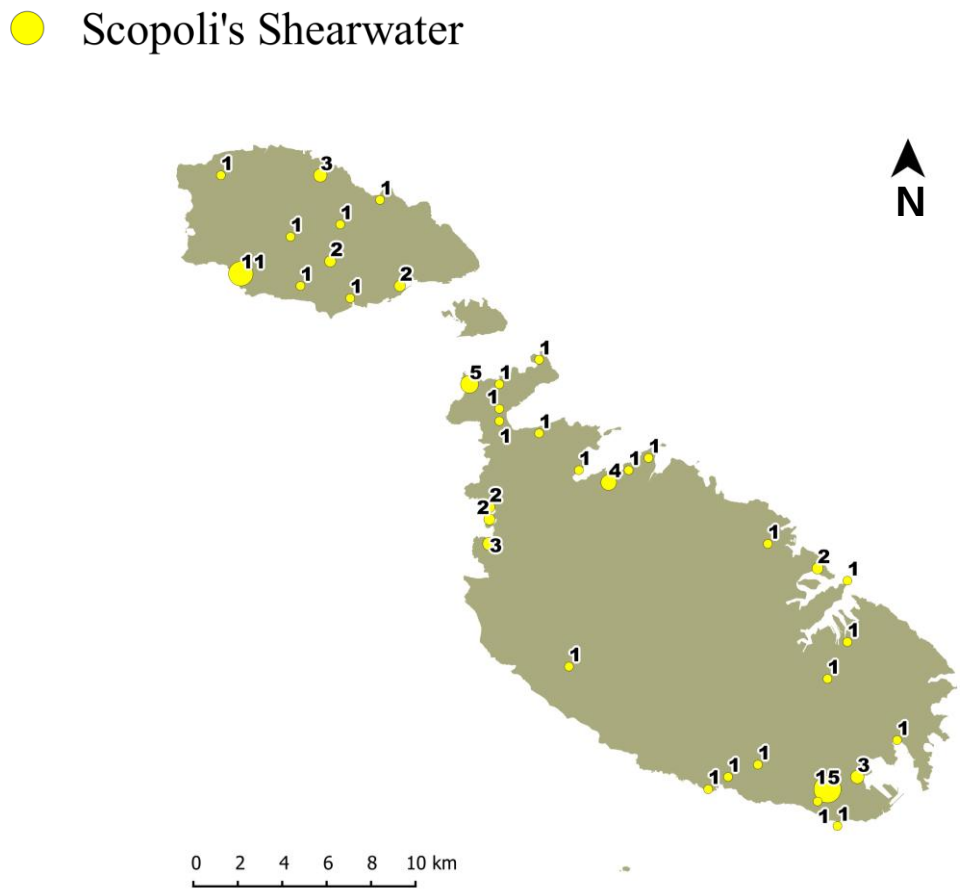

Figure 3. Location and number of grounded Scopoli’s Shearwaters (*Calonectris diomedea*) reported in the period 1978-2013.

Scopoli’s Shearwater cases represent the majority in terms of quantity of stranding cases of the three seabird species of study, amounting to 65% of the total cases reported over all of the Maltese Islands.

The reasons behind the higher amount of strandings of this species compared to the Yelkouan Shearwater, for example, could be various.

According to Sultana et al. (2011), Scopoli’s shearwaters amount to circa 5,000 breeding pairs. This is much higher compared to estimates of around 1,100 – 1,600 pairs of Yelkouan Shearwaters. Therefore the higher number of strandings could be a simple reflection of the fact that Scopoli’s Shearwater populations are more numerous.

A closer look at the hotspots reveals that the highest number of strandings occur in proximity of the larger colonies of the species. Ta’Cenc, in the south-western coast of Gozo, holds the biggest colony of Scopoli’s in the country with 1,000 estimated pairs and it is located very close to Xlendi Bay, second area in number of cases for the species. Similarly Hal Far and its vicinities rank as the main hotspot and predictably, the zone holds a high number of pairs, around 800, this being the second largest colony after the Xlendi/Ta’ Cenc area.

3.5 Stranding records for European Storm Petrel

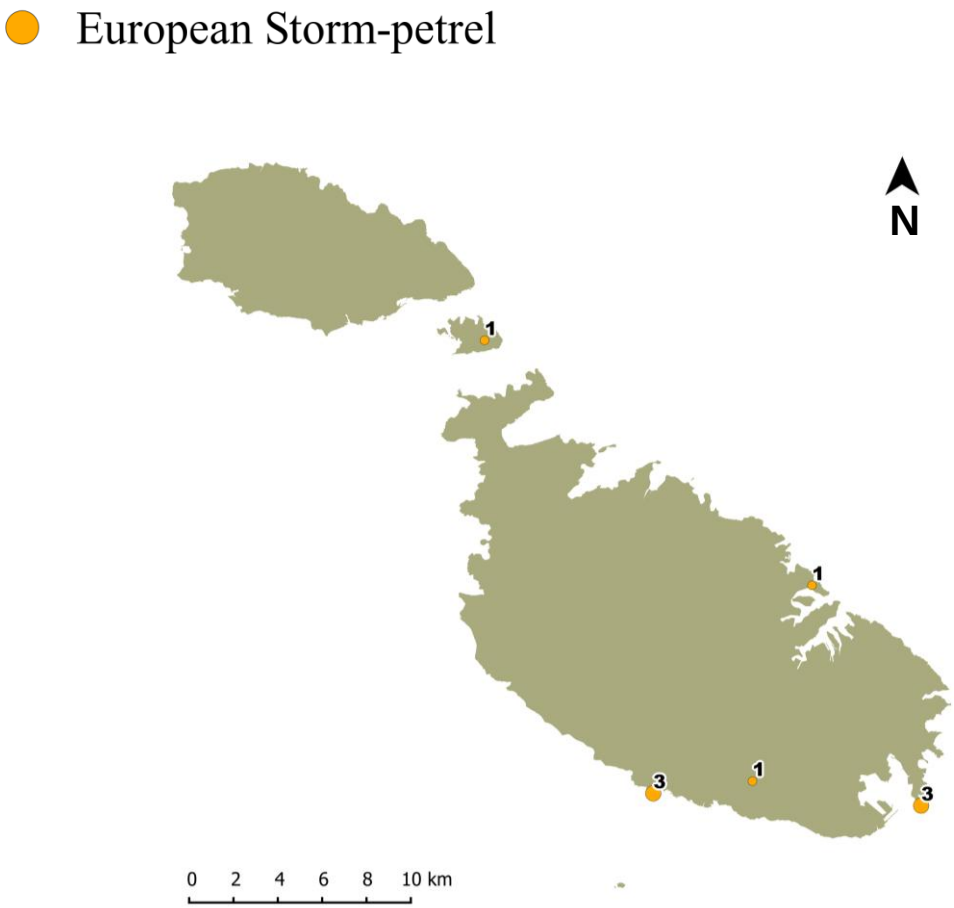

Figure 4. Location and number of grounded European Storm-petrel (*Hydrobates pelagicus*) reported in the period 1978-2013.

As based on BirdLife Malta records and compared to the other two species, the number of grounded Storm Petrels seems to be very low. However various studies document the effect of light pollution on similar species, especially reporting the strong attraction of young individuals for artificial light sources (Imber 1975, Telfer *et al*. 1987).

While under-reporting of this species may be more pronounced owing to the small inconspicuous nature of the species, the colonies belonging to this species are very much limited in the Maltese Islands to the island of Filfla and isolated locations along the west cliffs of Gozo.

It is interesting to note though, how even with the limited amount of data at our disposal, results match our hypotheses and previous literature. One of the spots with multiple reports is on the area of Ghar Lapsi (Fig. 3), directly facing Filfla, one of the only two known breeding colonies of the species in the country, indicating again the susceptibility to the problematic in locations closer to the colonies. The other main spot being in Delimara responds to cases of collision with the lighthouse, a common phenomenon thoroughly reported and evaluated in previous works (Jones 2001).

4. Conclusions

Although limited, the data at our disposal is able to point two main aspects in the identification of problematic hotspots.

The first one, which can be described as the geographic susceptibility of the area for an incident to occur, has to do with the amount of birds potentially affected by the problem. The main hotspots tend to match areas close to where the largest colonies of at least one of the species are located. This effect which may seem very obvious needs to be properly highlighted as it provides a clear indication of what is the cause of insensitive coastal urbanisation close to seabird colonies. This puts in perspective **the high sensitivity of seabird colonies to light-pollution, not just necessarily at colony sites but even within an area of influence that may extend kilometres away**. Though different species may have different degrees of sensitivity and susceptibility to light pollution sources, it is evident that light pollution sources in proximity to seabird colonies results in juveniles becoming stranded on land.

The second outcome of the results relates to the overall amount of light pollution generated by highly urbanised coastal zones. It is very evident from our results that at some point in time, all well-lit coastal settlements in the country, either residential or industrial, have resulted in strandings. With the trend in strandings appearing to be one of an overall increase in recent years, this may well be an indicator of a situation where **light pollution is becoming worse as coastal development intensifies and increases along our coastline**. While indeed new major coastal developments are nowadays taking the matter into consideration, the situation definitely highlights the need for more action to reduce coastal light pollution from the identified hotspots in this report, which may demand a review of existing external lighting schemes at these areas.

In conclusion, the analysis carried clearly points to a **direct relation between the intensity of the source of the light pollution impact and its proximity to a seabird colony**. In order to be able to tackle the problem it is important to keep both factors in mind, and start taking early action in two directions: corrective measures to reduce existing light pollution levels and preventive measures that can prevent further damage.

Corrective measures to avoid light pollution phenomena such as over-illumination, glare or light trespass have been proposed in the past (Pace 2000, Raine *et al*. 2007) and involve simple and inexpensive technologies to give correct use to our light infrastructure, focusing it only for its purpose and rationalizing the amount of energy spent. These actions could not only improve the situation for the birds significantly, but also human health and on the medium-long term save energy cost and resources to the taxpayer (Pace 2002).

On the side of prevention, the problem must be acknowledged in balance with the capital role Malta plays in the conservation of these species in the Mediterranean. Judicious planning that can approach the problem from a serious scope is much needed to avoid making the same mistakes as those committed in the past. Any action taken in advance that can limit the amount of the impact of light pollution, especially in the identified hotspots and vulnerable areas will be crucial to safeguard the future of Malta's seabird colonies, and in economical terms will be especially cost-efficient for the future, preventing the need for conservation actions as a last resort.

This report, following an earlier one by Raine et al. (2007): "*Light pollution and its effect on Yelkouan Shearwaters in Malta; causes and solutions*"; should serve as an initial guideline to assess the growing light pollution problem in Malta and its impact on seabird colonies, revealing apparent causes and main hotspots to take in consideration.

While the subject demands more research, the present findings already indicate that **immediate action is required to reduce the existing levels of light pollution in the country – both from a preventive action**

limiting further urbanisation of coastal areas, and ensuring new developments in urban coastal areas adopt sensitive measures – to immediate remedial action at already developed problematic coastal areas.

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