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Towards effective management of Malta's marine waters

SEABIRD FIELDWORK REPORT 2021

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This report is Result 2 of the

TENDER FOR THE ESTABLISHMENT AND IMPLEMENTATION
OF A LONG-TERM MONITORING STRATEGY
FOR BREEDING SEABIRDS IN MALTA

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Contents

Objective and Result of the Report

This report demonstrates the result of the implementation of the monitoring processes for the three breeding seabirds in Malta, *Puffinus yelkouan, Calonectris diomedea and Hydrobates pelagicus* during part of the 2021 breeding season, building on the monitoring programme for seabirds as reported by Malta in 2015 pursuant to the MSFD, and in continuation of the data collection processes undertaken to date in Malta for the purpose of the EU Birds Directive 2009/147/EC and the MSFD 2008/56/EC.

As the main result, the report intends to present the methods and results of the 2021 monitoring period for the three breeding seabirds in Malta (*Puffinus yelkouan, Calonectris diomedea* and *Hydrobates pelagicus melitensis*). It addresses part of the data collection requirements of the EU Marine Strategy Framework Directive 2008/56/EC for seabirds and the EU Birds Directive 2009/147/EC during the breeding periods of the seabirds as covered by the duration of the contract. From the results, shortcomings and lessons learnt and together with the previous assessments, this fieldwork report provides a baseline and foundation, required for the development of a long-term monitoring strategy for seabirds in Malta.

Deadline for this report, deliverable 2 of the tender for the establishment and implementation of a long-term monitoring strategy for breeding seabirds in Malta (Reference number: GF/ Admin/48/2020), is the 15th of September 2021.

The relevant fieldwork period covered by the tender at hand is a proportion of the 2021 breeding period of three Maltese seabird species, in detail April 15 to July 14, 2021. Part of the activities were extended to August 14, 2021, specifically the assessment of the chick survival rate of *C. diomedea* until this cut-off date.

The fieldwork monitoring presented here links the data collection processes of the 2021 breeding season to the requirements as stipulated by the EU MSFD (Article 11 MSFD) and BD (Article 12 BD). The fieldwork, data collection and assessments presented here build on processes carried out in Malta to date to ensure continuity of data collection and comparability with past datasets. This is especially important to achieve reliable trend data as stipulated by the Birds Directive.

The Report at hand is presenting and putting into context all results of the monitoring of parts of the 2021 breeding season as a step towards the aim to develop a viable and robust long-term monitoring strategy for Maltese seabirds.

Monitoring effort during the 2021 breeding period

In the period between 08-03-2021 and 14-08-2021 the seabird monitoring team spent 620 hours in the field. Depending on the activities carried out as work also involved various conservation actions, these hours were at least partially utilized for the collection of data relevant for the report at hand. In the period between May 15 and August 14, 348 hours were carried out exclusively for work on the tender itself, 61 hours were part of the After-LIFE work of LIFE Arċipelagu Garnija (LIFE14 NAT/MT/991) while 211 hours were carried out as part of LIFE PanPuffinus! (LIFE19 NAT/MT/000982).

The total effort amounts to an estimated minimum of 1860 to 2480 person hours in the field, calculated with an average of 3-4 people (range: 2-8) in the field at each given visit.

Abundance/ breeding population size and trends

Population abundance and trends of the Yelkouan Shearwater *Puffinus yelkouan*

Methods: The breeding population size/ abundance was assessed combining a variety of methods as no one singular method is suitable to be applied across all colony sites. Furthermore, combining methods allows for increasing confidence by cross-checking the results of the different methods. Data for the population size estimate for the tender at hand were gathered over part of the 2021 breeding period and spanned from May 15 to July 14. Complementary data had been collected earlier in the same breeding season. Data collection and analyses followed the methodology for the previous MSFD assessment in 2019 for comparability. All methods used are explained in detail in Austad et al. (2019) and entail a combination of a general colony assessment, thermal imaging counts, camera traps, sound recorders (ARUs) and a capture-mark-recapture setup (CMR) at selected sites.

Colony monitoring with Automatic Sound Recorders (ARUs)

Automated sound recorders have been placed repeatedly at similar locations within Yelkouan shearwater colonies in the Maltese islands since 2018. In 2021, 10 devices were deployed at Yelkouan shearwater colonies, but due to battery failure, sufficient data was only obtained from 8 devices. Deployment of ARUs was planned for the following sites and outcome of 2021 deployment is as follows:

- Rdum tal-Madonna – MT0000009 One unit Deployed & Analysed
- Majjistral – MT0000024 Two units Deployed & Analysed
- Ċumnija - MT0000024 One unit deployed & Analysed
- Selmunett – MT0000022 One unit deployed but insufficient data obtained
- Cominotto – MT0000017 One unit Deployed & Analysed
- Comino – MT0000017 One unit deployed & Analysed
- Ta’ Isopu One unit deployed & Analysed
- Ras in-Newwiela – MT0000027: One unit deployed and analysed
- Miġra l-Ferħa - Ras ir-Raħeb – MT0000032 – Not deployed during Yelkouan Shearwater season due to insufficient number of units and short timeframe of monitoring period

- Għar Lapsi – MT0000031 - Not deployed during Yelkouan Shearwater season due to insufficient number of units and short timeframe of monitoring period
- Blue Grotto & Wied Babu – One unit deployed but insufficient data obtained

Here we test whether bioacoustic indices derived from the growing dataset of sound recordings can be used to detect trends in colony size.

Automated Sound Recorders (ARUs) were placed on ledges as close to the cliff top as possible and not next to any nest. This deployment strategy aims at predominantly recording birds in flight around the colony and avoiding strong influence on recordings from stationary birds in nests directly adjacent to ARUs. However, due to topography, access or vulnerability to theft, ARUs were placed within the colony at colonies such as Rdum tal-Madonna, Rdum id-Delli, Cominotto and Ta' Isopu. Nevertheless, even at these sites ARUs were not placed in immediate vicinity to any nest.

While ARUs had been in place in many sites over the years, our analyses focus on seven selected sites for this analysis, each one providing data for at least 3 seasons with ARU placement in the same location. Therefore, it is not only important that the 2021 data was obtained, but that previously collected data from LIFE Arcipelagu Garnija was available for these selected sites. Further, in view of limited resources (ARUs), and the timing of the tender at hand, colonies with least overlap with *C. diomedea* were given priority of selection. While the ARU deployment on St Paul's Island has been at the same site between 2018 to 2021, insufficient data was obtained in 2019 and 2021 due to loss of the device and battery failure respectively. Therefore, the site was omitted from further analysis. Data from Ras in-Newwiela was not included in this analysis due to the high spatial and temporal overlap of *P. yelkouan* with *C. Diomedea* within the recording period.

All ARUs utilized in this study were WildLife Acoustics SM04s. All ARUs were set on 0 db gain to reduce effect of wind and wave noise and 24kHz recording frequency. ARUs recorded 5 minutes every 30 minutes throughout the night (5 minutes ON; 25 minutes OFF).

Due to various logistical challenges the recording times of ARUs at different locations and years was not identical. Figure 1 shows the number of recordings obtained from different ARUs over the breeding seasons 2018 to 2021.

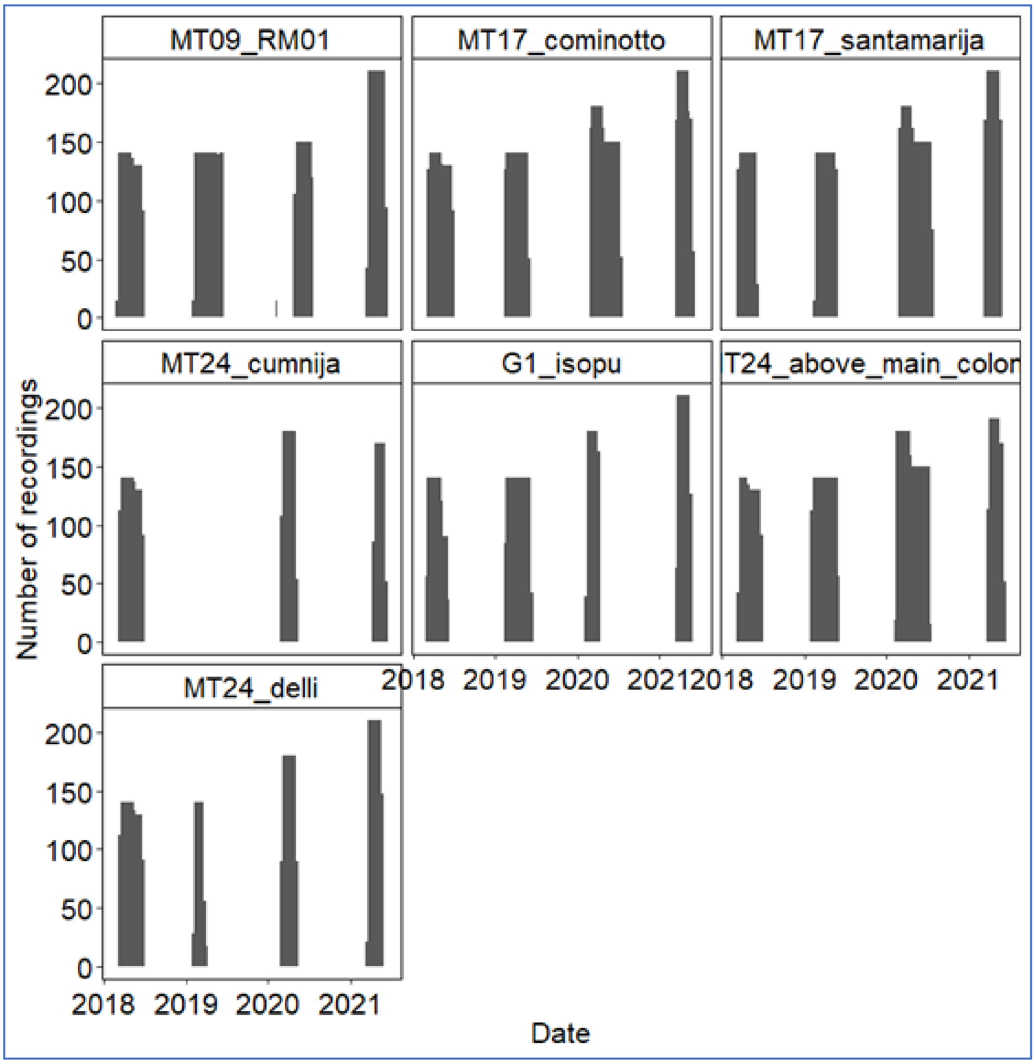

Fig. 1: Number of sound recordings obtained from ARUs for *P. yelkouan* over the breeding seasons 2018 to 2021.

There is large variation in shearwater calling rates over the course of the season, with moon phase, time of night, and weather conditions - among others - accounting for the variation. We selected a period spanning over three moon cycles from each season when devices were active. These were: 2018-03-08 UTC–2018-06-05 UTC; 2019-02-28 UTC–2019-05-28 UTC; 2020-02-28 UTC–2020-05-27 UTC & 2021-03-13 UTC–2021-06-10 UTC. Thus, sound data from overall 360 nights across the periods above was analysed.

Recordings from these selected dates were filtered down to those between 19hrs and 03hrs UTC (21:00 to 05:00 CEST). Removal of recordings when wind speeds was above 25 km/hr left 5683 recordings for final analysis, evenly distributed across all 7 ARUs. Filtering out recordings at higher wind speeds was carried out to avoid the most extreme effects of wind, and subsequent wave noise.

The ‘soundecology’ package was utilised to analyse the sound recordings. Bioacoustic Index (BIX) and Acoustic Diversity Index (ACD) were calculated for each 5-minute sound recording. For the latter index three separate indices were calculated at different sensitivity thresholds (-20, -30, and -50 dB). A graph of the correlation of these three ACD indices with BIX by ARU (shown in different colours) is presented in Figure 2. **There is low correlation between the BIX and ACD, indicating that the two indices measure different aspect of the soundscape. The higher correlation is found between ACD at -50dB and BIX (r=0.3669), but this still considered a weak positive relationship.**

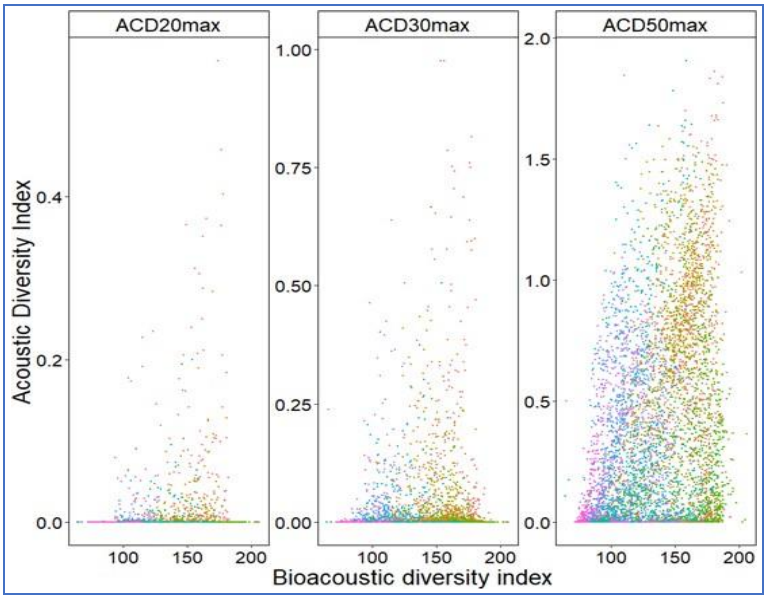

Fig. 2: Acoustic diversity index versus Bioacoustic diversity index (BIX) by ARU (shown in different colours) at three different ACDs.

In 2020, in order to establish whether there is a relationship between number of shearwater calls in recordings and BIX and ACD indices obtained from the same recordings, the number of Yelkouan shearwater calls in 41 five-minute recordings were counted by a human observer. The recordings were selected for the count using stratified sampling on the sound index values of the whole dataset, to ensure all ranges of the indices were covered. The selected recordings included 4 recordings which had been recorded at wind speeds greater than 25km/hr. Counts of calls were made by single observer, to avoid observer bias, using headphones while viewing spectrograms on a PC screen. The results show a strong positive correlation between especially ACD30max and number of Yelkouan shearwater calls (r=0.71), in comparison to for example ACD50max (r=0.41). However, as the plot in Figure 3 shows some recordings in which calls were detected by a human observer, had a ACD30 index value of zero. On the other hand, filtering recordings to those at wind speeds less than 25km/hr does not seem to improve the relationship (r= 0.68).

However, for the Bioacoustic index (BIX), using solely data with wind speeds below 25km/hr does indeed improve slightly the relationship between the Bioacoustic index and the number of counted Yelkouan shearwater calls (unfiltered: r= 0.45 and filtered: r=0.47). This becomes more obvious in the plots when the 4 recordings with wind speeds higher than 25km/hr, which have high BIX but no shearwater calls detected by a human observer, are filtered out Figure 4. **Therefore, the correlation between acoustic indices and number of calls counted by a human observer confirms the importance of removing recordings at windspeeds of more than 25km/hr and using both BIX and ACD30 indices for further analysis.**

In order to test whether acoustic indices can explain variation in colony size between sites a RandomForest model was run with colony size as the dependent variable. Sound recordings used for this model were filtered down to those recorded at windspeeds of less than 25km/hr to reduce the effect of wave and wind noise. Despite the acoustic indices not fully capturing the variation in Yelkouan shearwater calls counted manually, especially BIX is an important descriptor variable (Figure 5). The other explanatory variables were wind speed, moon illumination (as indicated by proportion illuminated and its elevation angle) and ACD at 30dbfs. However, overall, the model explains 12.2% of the variation in colony size. Low model explanation of the dependent variable indicate that further unmeasured variables might affect colony size and its relationship with acoustic indices. Moreover, it is likely that despite filtering to below 25km/hr wave and wind noise still have an effect on recordings taken the proximity of Yelkouan shearwater colonies to the sea. Sea swell might not be fully captured by the wind variable but is much less readily measured.

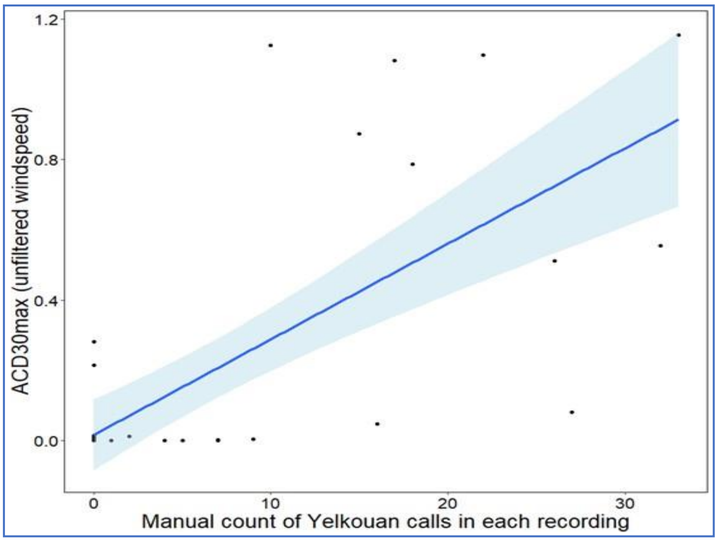

Fig. 3: Unfiltered recordings at ACD30 versus calls detected by a human observer.

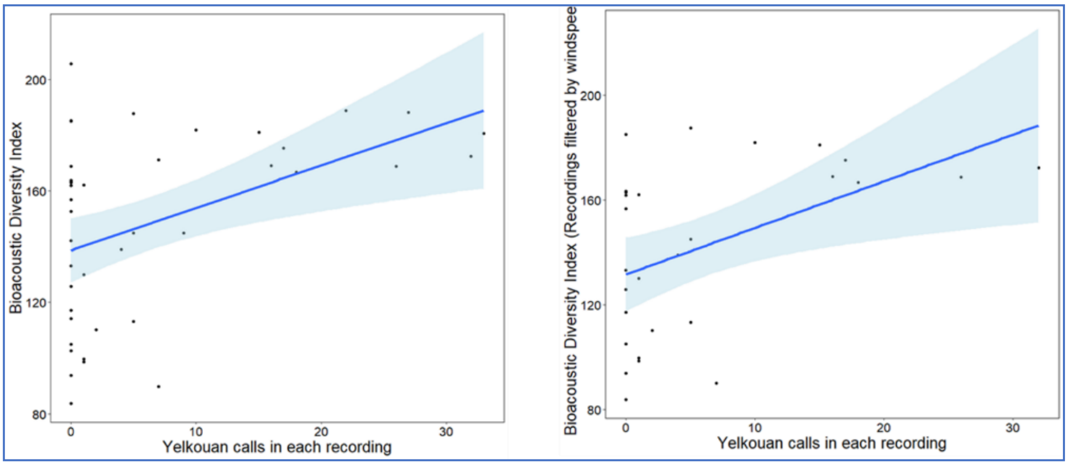

Fig. 4: BIX of unfiltered (left) and filtered (right, with windspeed >25km/hr filtered out) recordings versus calls detected by a human observer.

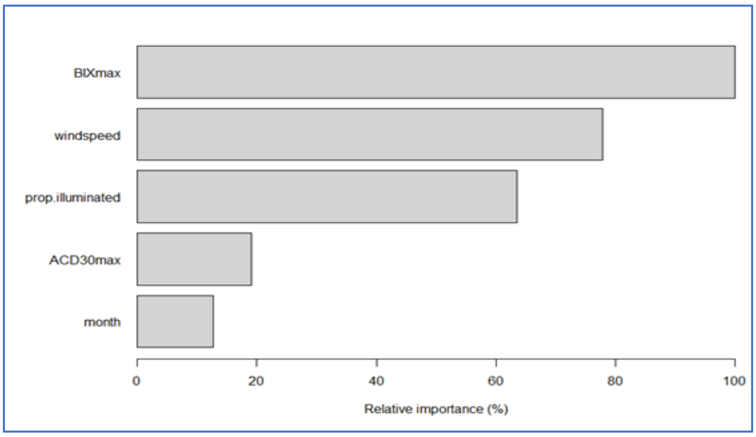

Fig. 5: Relative importance of descriptor variables including BIX in the explanation of *P. yelkouan* colony size variation by the RandomForest model.

In the RandomForest model, colony size estimates of 2018 were used as a baseline to predict variation from that baseline for each of the following years (2019-2021). The results have to be interpreted with caution, especially due to the relatively low percentage of variation that is explained by the model. However, there does not seem to be a general and apparent trend in variation as compared to the 2018 colony size. Prediction error (i.e. variation from baseline), was calculated by dividing colony size predicted in the RandomForest model by the colony size estimates from 2018.

Figure 6 provides a visual comparison of the Bioacoustic Diversity Index by ARU and year, where each colony is ranked according to the median index value. Whilst slight increases and decreases are noted through the median index values at the different colonies, the long boxplot tails point out at the large variation of the results across the sites and the years. Furthermore, the prediction error values (Table 1) are consistent without evident trends in changes from the baseline colony size. **For this reason, no general trend is currently apparent for the four years period (2018-2021)**[1]. **Additional years and potentially more devices deployed at additional sites are required to be able to infer trends of colony size bioacoustically in the future.**

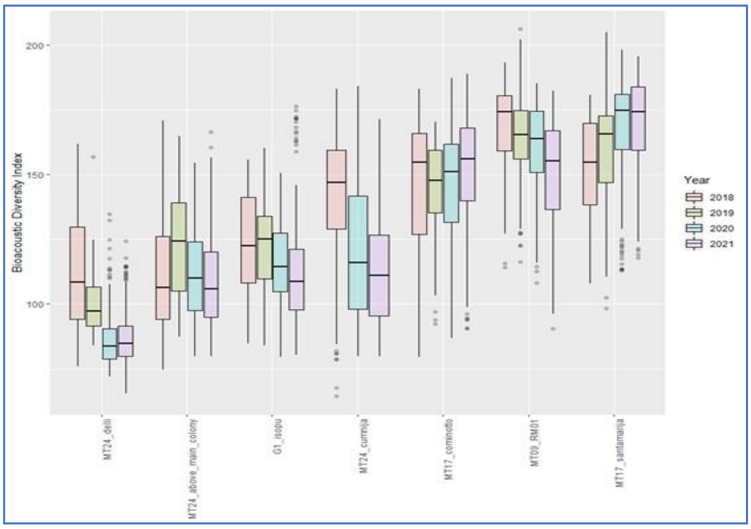

Fig. 6: Median index value of Bioacoustic Diversity Index (BIX) by ARU and year for 2018 to 2021.

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[1] In addition, a linear mixed effect model with site as random effect, found year to have a coefficient -estimate of -2.8735 which on the scale of the variable is probably not noteworthy. This result further supports the inference of no evident trend recorded for the time period studied.

***Tab. 1:** Predictions of population sizes per site from the Randomforest algorithm run on sound index data of 7 ARUs deployed in 2018 to 2021, with 2018 population size estimates as a baseline*

N2K site, colony location	Year of assessment	Predicted colony size	Baseline colony size	Prediction error
MT0000009 Rdum tal-Madonna, RM01	2018	53.99253	44	1.2271029
	2019	55.36890	44	1.2583841
	2020	56.16770	44	1.2765386
	2021	60.95239	44	1.3852817
MT0000017 Cominotto	2018	90.60047	98	0.9244946
	2019	94.86820	98	0.9680429
	2020	96.04537	98	0.9800548
	2021	91.70367	98	0.9357517
MT0000017 Comino, Santa Maria caves	2018	68.93627	65	1.0605581
	2019	68.82348	65	1.0588228
	2020	67.47230	65	1.0380353
	2021	68.23173	65	1.0497190
MT0000024 Cumnija	2018	60.11656	38	1.5820148
	2020	66.89513	38	1.7603982
	2021	75.22215	38	1.9795302
G1 (not N2K) Ta' Isopu	2018	70.09426	40	1.7523565
	2019	70.44812	40	1.7612029
	2020	69.43988	40	1.7359971
	2021	66.72134	40	1.6680335
MT0000024 Majjisral, above main colony	2018	182.19109	261	0.6980501
	2019	189.52432	261	0.7261468
	2020	195.59193	261	0.7493944
	2021	194.25170	261	0.7442594
MT0000024 Majjistral, Rdum id-Delli	2018	62.35286	13	4.7963736
	2019	43.85680	13	3.3736001
	2020	30.32588	13	2.3327602
	2021	34.21672	13	2.6320552

Capture-mark-recapture CMR

The breeding population size was assessed by means of CMR and population modelling in accessible sub-sites of the following four areas inside Natura 2000 sites and including Malta's two major colonies for the species (in bold): **L-Irdum tal-Madonna (MT0000009)**, Cominotto (MT0000017), St Paul's Island (MT0000022), **Majjistral (MT0000024).**

A repeated setup with captures of mainly incoming birds at fixed locations in the first half of the night was used to obtain abundance estimates for the species via a capture-mark-recapture (CMR) study. Depending on the topography of the site, birds were caught by hand or by mist nets. Each captured bird was fitted with a uniquely numbered ring for individual identification, essential for the CMR analysis. If a captured bird was already bearing a ring, it was regarded as recapture and the present ring number was recorded. Only adult birds (at least in their 2nd calendar year) were considered in the analysis.

The areas covered for the CMR include the two most important colonies of *P. yelkouan* in Malta, Rdum tal-Madonna (MT0000009) and Majjistral NHP (MT0000024). At least two nocturnal visits were carried out at each accessible sub-site of these areas in the period March 10 to June 30.

The initial plan was to include a small accessible sub-colony in Wied Babu (MT0000024) in the CMR analyses and population modelling, especially with the aim to distribute the selected colonies more widely from a geographic perspective (Wied Babu is the only colony of *P. yelkouan* monitored via CMR situated in the south). However, CMR at the site did not reveal sufficient data and therefore Wied Babu was excluded from the current assessment. Nonetheless, the colony can be included in the assessments in coming years when more data will be available.

Across all sites, BirdLife Malta's Seabird team captured 2981 individual Yelkouan Shearwaters in 7923 capture events between 2012 and 2021. Out of these data, only capture events of adult individuals from four selected sites were utilized for the population modelling. For the 2021 breeding period this resulted in the selection of 936 capture events of 605 adult individuals at four sites: 55 events at Saint Paul's Island, 118 at Cominotto, 362 at Rdum tal-Madonna and 401 at Majjistral NHP. Statistical models were applied to CMR data to investigate abundance as well as adult survival rates (see in relevant section below) within these four colonies between 2013-2021, following the same methodology as for the 2019 MSFD assessment (Austad et al. 2019; Kéry & Schaub, 2011). Figure 7 presents the results of the population modelling for all four selected sites for the last 9 years.

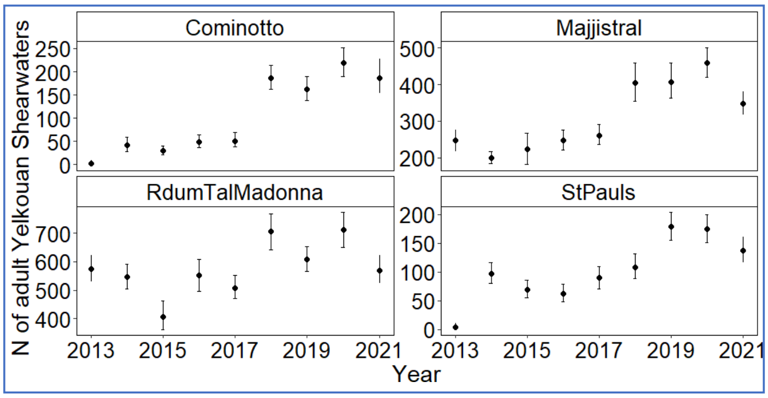

Fig. 7: Population numbers by CMR for *P. yelkouan* at four colonies in the period 2013 to 2021.

The apparent increase in population abundance at all four sites from 2018 onward can to a large extent be attributed to the start of predator control at these sites, except for Rdum tal-Madonna where IAS control had been carried out in previous years already and where this apparent increase is less pronounced. To some degree it may also be attributed to an increase in monitoring effort specifically at Majjistral and Cominotto. During the last four years in which rodent control has been carried out at all four sites and in which CMR effort has remained on a comparable level, the population appears to be fluctuating. However, abundance estimates for 2021 for all four sites appear low, especially for the two major colonies Rdum tal-Madonna (MT0000009) and Majjistral NHP (MT0000024) and future assessments will indicate whether the populations are indeed fluctuating or actually rather showing a short-term decline.

Assessment of the *P. yelkouan* population abundance/ size by additional methods

Apart from the use of ARUs and the CMR approach, the entire Maltese breeding population was also assessed further by means of 17 Trail Cameras and 2 land- and vessel-based audio-visual (thermal imaging) counts covering all known colonies in the period between 10.03.2021 and 15.06.2021.

Trail camera imagery set-up and results

A total of 17 camera traps (Bushnell Trophy Cam HD) were deployed in communal nest entrances of accessible *P. yelkouan* colonies. The bird activity in image data was manually counted to estimate the number of breeding pairs specific to that burrow/cave or simply to determine the presence of Yelkouan Shearwaters. All camera trap locations per Natura 2000 site covered in 2021 are shown in Table 2.

Camera traps are fitted with a motion sensor that triggers the camera to take an image as soon as any movement is detected. An integrated infrared flash without visible glow was used to avoid disturbing nesting birds at night. The number of nights cameras were recording varied depending on the frequency that the cameras were triggered by bird activity. Birds in images were counted manually, assigned to three categories: IN (entering the cave), OUT (leaving the cave) and Total (All, including those with undetermined direction). In previous years a positive relationship between the number of birds counted and the number of images was found. Therefore, in subsequent years, including 2021, a maximum of 10 nights were analyzed per cave, selected by the highest number of images. 5 of these nights were selected to be in the early chick rearing period, considered as 26th April to 30th May, if the camera was functioning in this period. The early chick rearing period is counted distinctly because counts during this time might be more accurate with adult birds entering directly to nests to feed nestlings. During the mating period in comparison, higher movement in cavity entrances might inflate counts. On the other hand, counts in the chick rearing period are expected to be higher than those made in the incubation period due to more frequent colony attendance by adults in the chick rearing period.

Only categories IN and OUT are shown in Figure 8. The sum for each category was noted separately per night and cave and used to obtain an estimate of the minimum number of breeding pairs for each cave.

Table 2 summarizes the minimum number of pairs as revealed by counts from trail camera images of incoming and leaving birds, following the methodology in Austad et al. 2019.

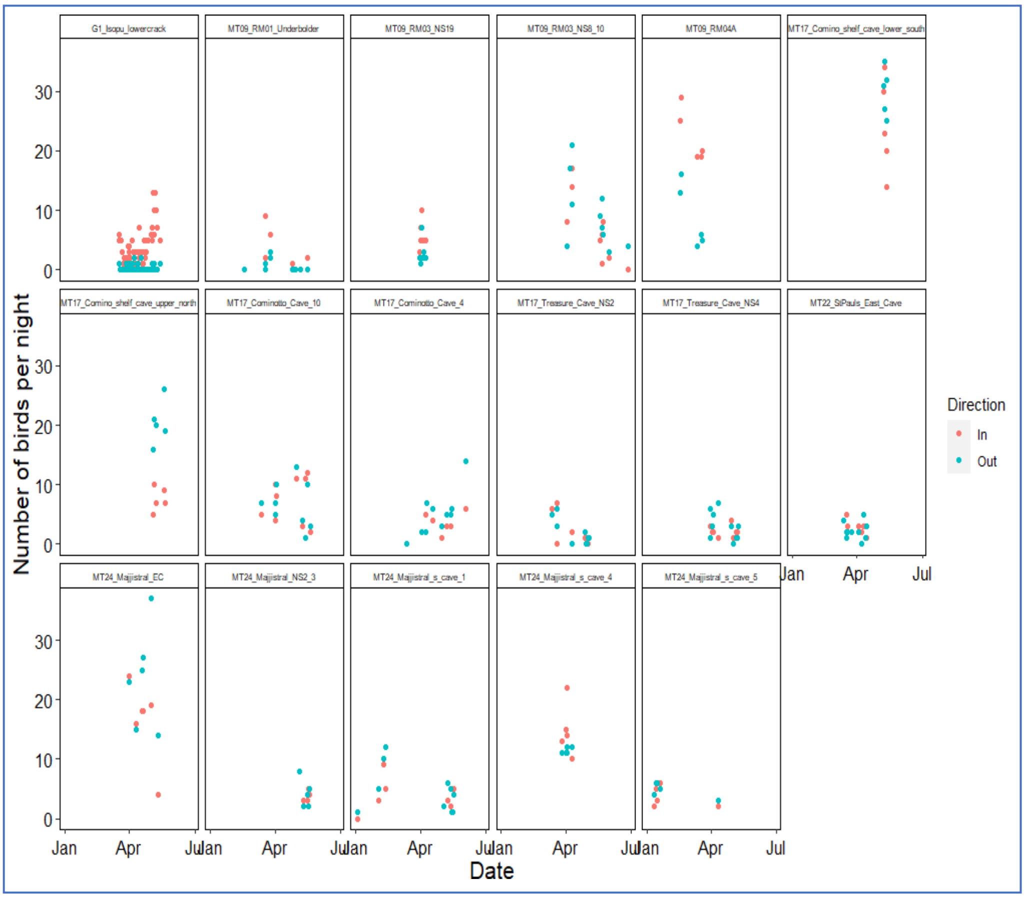

Fig. 8: Counts of incoming (in) and leaving (out) adult *P. yelkouan* per camera trap and date.

Tab. 2: *Camera trap locations in N2K sites, minimum number of pairs per location during chick rearing period and the entire available period as revealed by camera trap imagery.*

N2K site number	Location	Min number of pairs chick rearing period	Min. number of pairs entire available period
NA	G1 Isopu, lower crack	13	13
MT0000009	RM01 under bolder	2	9
	RM03_NS19	-	10
	RM03_NS8_10	12	21
	RM04A		29
MT0000017	Comino shelf cave, lower south	35	35
	Comino shelf cave, upper north	26	26
	Cominotto cave 10	13	13
	Cominotto cave 4	6	7
	Treasure cave NS2	2	7
	Treasure cave NS4	4	7
MT0000022	St Paul's Island east cave	-	5
MT0000024	Majjistral EC	37	37
	Majjistral NS2_3	8	8
	Majjistral_s_cave_1	6	12
	Majjistral_s_cave_4	-	22
	Majjistral_s_cave_5	-	6

Thermal imaging and audial counts

Counts at night using a thermal imaging camera (FLIR) at inaccessible colony entrances as well as audio-visual assessments from RIB, were limited by the late start of the monitoring with respect to the Yelkouan Shearwaters breeding period. These assessments, ideally carried out only for *P. yelkouan* and earlier in the season, had to be in fact combined with the visits for the assessment for *C. diomedea*. On few occasions a thermal imaging camera mounted on a tripod and directed at the cliff face or cave entrances was recording activity in 30 min intervals to collect additional data on abundance of colonies in inaccessible cliff faces. The footage was analyzed by first dividing the cliff face into sections/cave entrances and then counting individuals entering per section within 5-minute intervals. The number of incoming birds was counted to obtain a minimum number of breeding pairs for each monitored site (Table 3). Additionally, *P. yelkouan* detected opportunistically visually via hand-held thermal imaging camera or audial detection of calls during *C. diomedea* monitoring surveys later in the season were utilized for abundance and range assessments. *P. yelkoaun* and *C. diomedea* are distinctly different in size and flight characteristics, which is evident also when viewed in the thermal imaging camera at suitable range. The calls are different and can be distinguished by a human observer. Distinction was made directly in the field.

Table 3: *Results from P. yelkouan counts entering caves and inaccessible cliff faces from thermal imaging footage, recorded from fixed points for extended periods with camera mounted on tripod.*

N2K site number	**Location**	**Date & Time**	**Number of birds entering as counted in FLIR footage**
MT0000009	Inaccessible section between RM05GC & RM05BT	2021.04.29 21:09 – 23:00	12
	RM03 upper	2021.05.31 21:30 – 22:45	7
MT0000017	Cominotto Cave 5 to Cave 8 (inc. inaccessible ledges)	2021.05.27 21:08 – 23:10	36
	Cominotto inaccessible cliff east of cave 1	2021.05.03 20:42– 21:55	5
	Cominotto inaccessible cliff east of cave 1	2021.05.17 21:44 – 23:36	11
MT0000024	Majjistral Upper inaccessible	2021.05.07 20:46 – 22:49	43
	Majjistral Upper inaccessible	2021.05.16 21:02-23:02	30

Puffinus yelkouan **population abundance estimates by integration of methods**

The population abundance estimates followed Austad et al. (2019). For all accessible colonies, each colony is subdivided into subsites based on different ledges, caves and burrows. All encountered cave entrances and nest sites are assessed for the presence of Yelkouan Shearwater footprints, faeces, smell and/or visible nests with adults (incubating) or chicks. Population estimates, with lower and upper estimates, are assigned to each subsite according to the different methods most suited to each subsite.

For each colony, the estimates of each subsite were summed to give the total estimate for the colony. This results in a higher resolution and accuracy compared to estimating the population on the colony level.

Each subsite where the topography allows (some areas are complex boulder screes where 2D imagery is not suited) is photomapped with photos showing large proportion of colonies. Images Annex 1 Fig 1 to 3 provide example images of photomapped cliff faces. Further photomapping will take place to close any existing data gaps. For this work a drone is required but was not available during the short contract period due to changes in license legislation. Methods deployed at subsite-level specifically included nest counts where these are visible, number of fledglings ringed, CMR of adults entering nesting sites, counts from trail camera imagery and nocturnal visual counts of adults entering inaccessible subsites using thermal imaging equipment. For widely dispersed burrows with low number of pairs where CMR or trail camera are not cost efficient, occupancy was confirmed using visual and olfactory cues and low estimates were assigned. Analysis of call recordings are used to cross-check estimates derived from the other methods employed within the range of the ARUs. Large differences as defined by expert judgement on a case-by-case basis,- between colony size estimates predicted from acoustic indices and those estimated from other methods would indicate potential over or under-estimation of colony size as obtained by other methods.

For completely inaccessible colonies, estimates are largely less accurate and are based on methodologies that can be applied on a larger scale, mainly audio-visual counts, and surveys caried out from land or sea. To improve accuracy in such colonies, more ARU devices could be deployed. However, safe locations for winter deployment (November to January) need to be identified in mixed colonies to cover periods when *P. yelkouan* are vocal and *C. diomedea* are absent. Moreover, computer software using machine learning is required to separate out waves noise which is especially prevalent in this period and causes biased results.

Table 4*: Population estimates of P. yelkouan [in breeding pairs] per colony and Natura 2000 site per assessment period, data quality and preliminary trends since latest assessment (2019).*

N2K site	**Site name**	**Sultana et. al 2011**	**MSFD 1st assess. (2013)**	**MSFD 2nd assess. (2019)**	**MSFD 2021**	**Data quality 2021**	**Trend since 2019**
NA	G1 - Għar il-Mixta to D. Qorrot	50-80	-	50-80	40-60	Medium	-
MT0000037	G2 - W. Għasri to San Dimitri	-	0	10-20	10-20	Poor*	+/-
MT0000001	Għajn Barrani	20-30		10-25	10-25	Poor*	+/-
MT0000009	Rdum tal-Madonna	ca. 500	ca. 500	375-600	300-575	Good	-
MT0000016	Filfla	0	0	0	0	Good	+/-

MT0000017	Kemmuna	50-80	50-80	55-85	70-95	Good	+/-
	Kemunett			70-100	85-125***	Good	+
MT0000022	Selmunett	0	0	45-75	45-70	Good	+/-
MT0000024	Ċumnija	-	-	25-45	25-45	Medium	+/-
	Majjistral NHP	30-50	-	240-360	180-300	Good	-
MT0000027	Ras in-Newwiela	-	-	25-45	25-45	Poor**	+/-
	Ta'Ċenċ	150-300	150-300	150-300	150-300	Poor**	+/-
MT0000028	Xlendi - t-Ħajt, t.-Bardan - l. Ċnus			300-330	300-330	Poor*	+/-
MT0000029	Wardija			70-75	70-75	Poor*	+/-
MT0000030	Għarb	30-50		80-100	80-100	Poor**	+/-
MT0000031 & MT000032	Għar Lapsi & Fawwara			60-90	60-90	Poor**	+/-
MT0000031	Blue Grotto & Wied Babu			20-30	20-30	Medium	+/-
MT0000032	Fomm ir-Riħ	-	-	15-35	15-35	Poor*	+/-
	Miġra l-Ferħa	-	-	25-40	25-40	Poor*	+/-
	Dingli & Fawwara	180-300	100-200	80-100	80-100	Poor*	+/-
MT0000033 & MT0000031	Fulija to Ħal Far			90-100	90-100	Poor**	+/-
Totals		**1190-1680**	**1660-1980**	**1795-2635**	**1680-2560**	**Medium**	**- 3-7%**

**Not sufficiently surveyed in 2021 due to short-term period covered, so 2019 estimate is used*

***Not sufficiently surveyed in 2021, but estimate is based on a limited number of surveyed nests indicating that no apparent change in the few monitored nests was detected*

****Increase due to better assessment coverage with FLIR thermal imaging camera and trail cameras*

Trend symbols: - decline, + increase, +/- stable as compared to previous assessment

Short-term trend according to the Birds Directive (last 12 years)

In 2010, Sultana et al. (2011) estimated the total Maltese population at **1190-1680** breeding pairs. The first round of MSFD assessment stated the population to be **1660-1980** breeding pairs (Malta Environment and Planning Authority 2013), while the second MSFD assessment with data collected between 2016 and 2018 estimated the total population at **1795-2635** breeding pairs and concluded an increasing trend in line with the BD reporting (Epsilon 2019), without specifying the trend magnitude (Environment and Resources Authority 2020). The current assessment (2021) for the tender at hand estimates the total Maltese population of *P. yelkouan* at **1680-2560** breeding pairs. The apparent short-term increase in the population abundance between 2010 and 2021 by an estimated >40% can be mainly attributed to an increase in assessment effort, changes in assessment methodologies and hence an overall improvement of knowledge. Due to this strong bias in assessment effort it would be currently misleading to categorize trends according to the BD reporting requirements. Furthermore, the apparent increase can be partially explained by the implementation of predator control measures at Rdum tal Madonna (since 2007) and at three additional sites (since 2018), including Majjistral, St Paul's Island, Comino and Cominotto. Nest predation shortly after egg-laying can mean an abandonment of nest sites early in the season which then leads to an underestimation of breeding pair numbers.

Trend since the latest assessment in 2019

Estimated breeding pair numbers of *P. yelkouan* for 2021 are 3-7% lower as compared with numbers of the latest MSFD assessment in 2019. Good quality data showing a negative trend mainly originate from Rdum tal-Madonna (MT0000009) and Majjistral NHP (MT0000024). This is reason for concern as these are the largest and hence most important colonies in the Maltese islands and among the best managed when it comes to predator control. Future monitoring and assessment will reveal whether 2021 was a poor year for the species and whether this is part of natural fluctuation or indicative of a population decline.

Long-term trend (since 1980)

The previous assessment defined the long-term population trend of *P. yelkouan* in Malta as stable (Environment and Resources Authority, 2020). The total breeding population was estimated at more than 100 pairs by Bannermann & Vella-Gaffiero in 1976, but (Sultana, Borg, Gauci, & Falzon, 2011) interpret this as an underestimation. The same source states that the population was stable between 1970 and 1990 and the authors estimate the population at 1190-1680 pairs in 2010. Since then, increased effort, specifically as part of EU-funded projects, has led to increased knowledge and hence to an apparent increase in population numbers in the short-term. Furthermore, rodent control at one site since 2007 (Lago, Cabello, & Varnham, 2019) and at 3 additional sites from 2018 onward might have led to an actual population increase at these sites. However, the overall data quality appears currently to be too heterogeneous and poor to allow for a robust long-term trend estimate and categorizing according to the BD reporting requirements.

Conclusion for the population abundance or size and trends of *P. yelkouan* in reference to MSFD D1C2 and BD: As assessed for the 2021 breeding period, the Yelkouan Shearwater breeding population abundance/ size showed a decline, most clearly for the colonies assessed via CMR as compared with previous years that were surveyed with comparable effort. No trends can be currently inferred with the bioacoustic data collected in 2021 alone due to a late start of the tender as compared to the breeding period of the species and low number of ARUs. Additional years with higher effort (more sample points) that is adequately timed (earlier start) will allow to infer such trends for sites where CMR is not feasible.

It remains to be seen in future assessments whether the decrease in population abundance in 2021 is the start of a negative trend or just indicates a poor year in a fluctuating population scenario.

Taking a precautionary approach, a decline of 3-7% in two years (since the latest assessment in 2019 with comparable effort) can be extrapolated to 9-21% within the six years reporting cycle. Therefore, GES for the species is currently not reached (see also chapter on demography).

Population abundance and trends of the Scopoli's Shearwater *Calonectris diomedea*

Assessing the size of Scopoli's Shearwater colonies with Automated Sound Recorders (ARU)

ARU deployments

Here we test whether sound data collected at Scopoli's Shearwater breeding colonies are useful as a cross-check estimated colony population sizes obtained through other assessment methodologies. Moreover, whether such data can be used to predict population size estimates for 2021 and whether trend estimation from comparison with the previous year of assessment (2019) can be made.

Automated Sound Recorders (ARUs) were placed on ledges as close to the cliff top as possible and avoiding the close vicinity to any nest. This deployment strategy aims at predominantly recording birds in flight around the colony and avoiding strong influence on recordings from stationary birds in nests directly adjacent to ARUs. However, due to topography, access or vulnerability to theft, ARUs were placed within the colony at colonies such as Blue Grotto, Fungus Rock and Filfla. Nevertheless, even at these sites ARUs were not placed in direct vicinity of any active nest.

All ARUs used in this study were WildLife Acoustics SM04s, and 20 units were deployed at an average distance of 2.2 km, covering all the colonies in the Maltese Archipelago (Fig. 9). With a minimum distance of 0.89 km between the closest units, recording of the same calls was precluded. All ARUs were set on 0 db gain to reduce effect of wind and wave noise and 24kHz recording frequency. ARUs were set on a schedule to record 5 minutes every 30 minutes throughout the night (over a period of 7 hours: 9pm to 4am local time; 5 minutes ON; 25 minutes OFF).

All units deployed in 2021 were in in the same locations as compared to units deployed at for the sites in 2019. Slight changes (+/- 25m) were made at deployment of Dwejra (MT0000030) and Halfar (MT0000033). Due to different timelines set for the assessment periods by the Environment and Resources Authority, the periods of ARU deployments between 2019 and 2021 overlapped only partially. Figure 10 shows the number of recordings obtained by date from the 20 different ARUs over the first part of the 2021 breeding season.

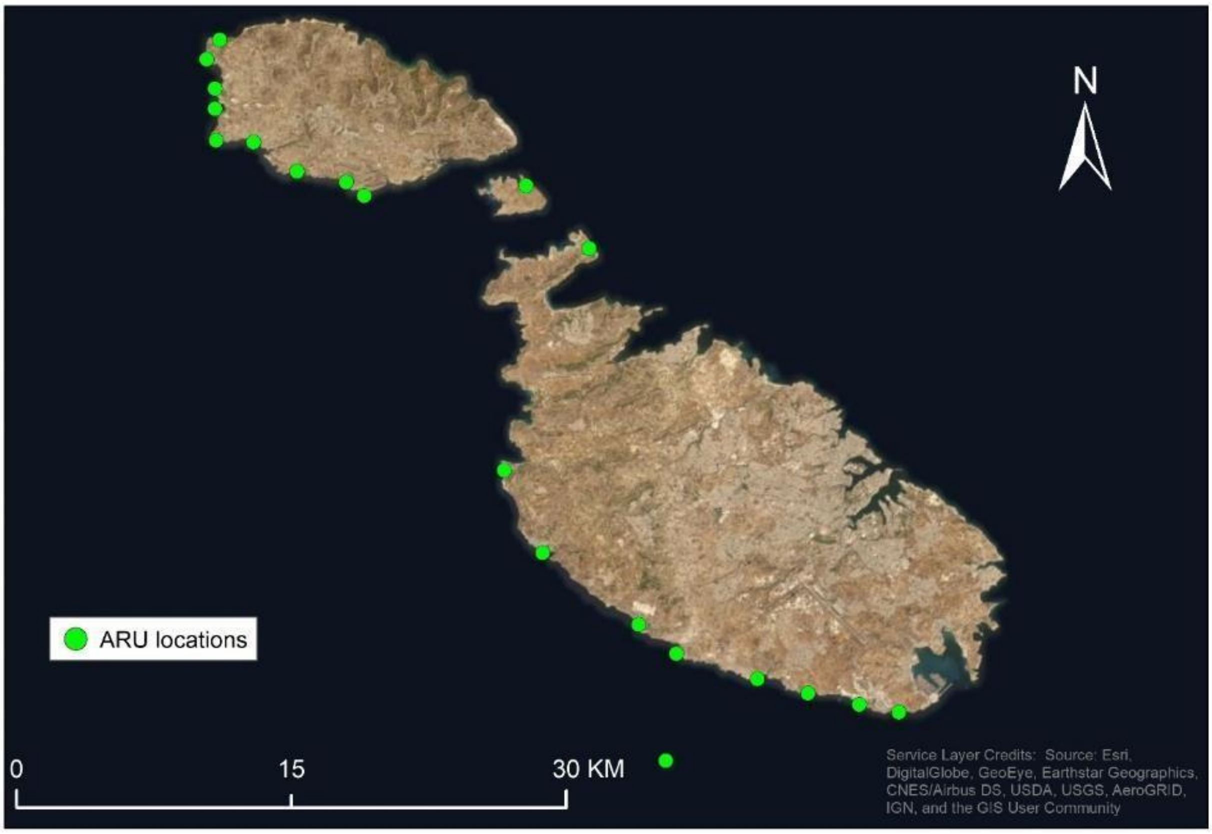

Fig. 9: Map of the 20 ARUs deployed in 2021 breeding season in *C. diomedea* colonies.

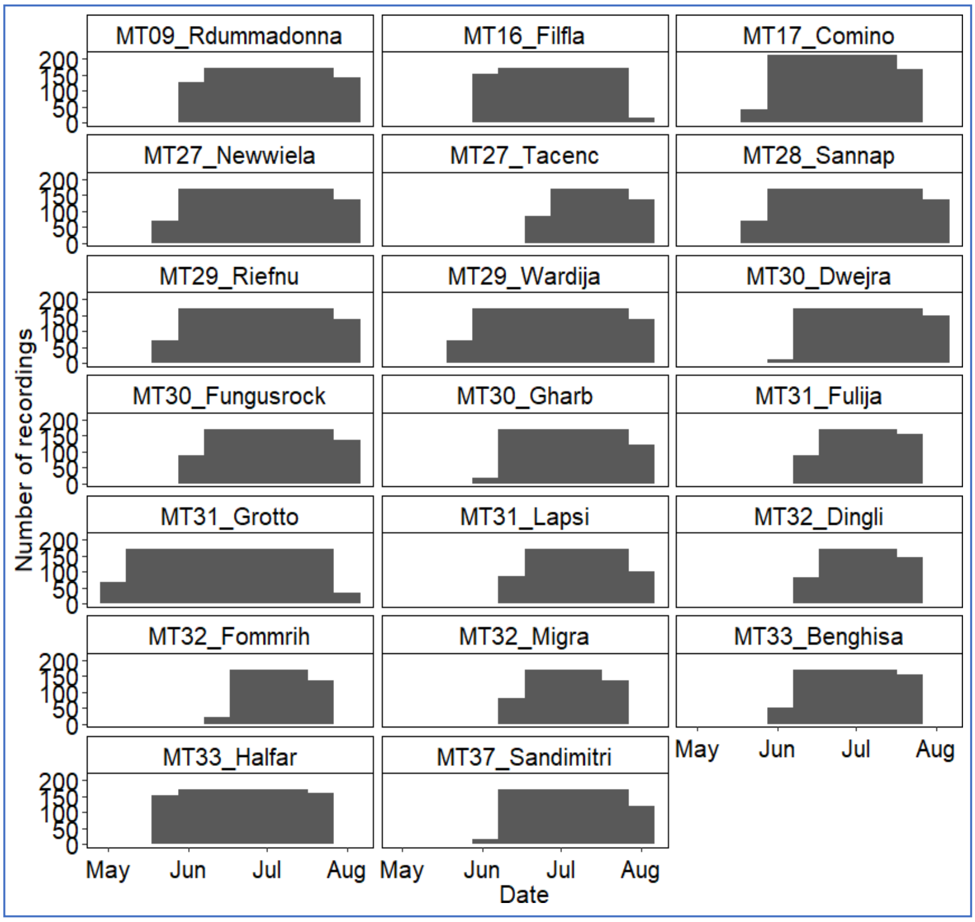

Fig. 10: Total number of recordings obtained by date from the 20 different ARUs over the first part of the 2021 breeding period.

ARU Data Processing

Due to effects of weather, breeding season phase and moon phase on calling activity we only analysed the data for the period when all ARUs were active. This limited the data we used to 39 monitoring nights from 2021-06-17 to 2021-07-26.

Recordings from these selected days were filtered down to those between 19hrs and 02hrs UTC (21:00 to 04:00 Maltese summertime). Removal of recordings when wind speeds were over 20 km/hr left 9546 recordings for final analysis, evenly distributed across all 20 ARUs. Filtering out recordings at higher wind speeds was carried out to avoid the most extreme effects of wind, and subsequent wave noise.

The ‘soundecology’ package was utilized to analyze the sound recordings. Bioacoustic Index (BIX) and Acoustic Diversity Index (ACD) were calculated for each 5-minute sound recording. For the latter index three separate indices were calculated at different sensitivity thresholds (-20, -30, and -50 dB).

A graph of the correlation of these three ACD indices with BIX by ARU (shown in different colours), is presented in Figure 11. There is relatively low correlation between the BIX and ACD, indicating that the two indices measure different aspects of the soundscape. The higher positive correlation is found between ACD at -50dB and BIX (r= 0.5880).

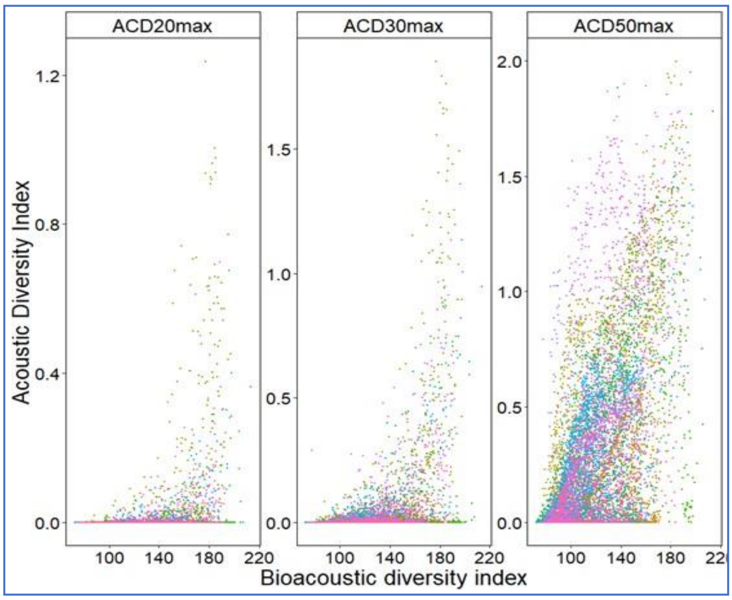

Fig. 11: Acoustic diversity indices versus BIX by ARU (shown in different colours) at three ACD.

ARU Results and their interpretation

Figure 12 provides an initial visualisation of the Bioacoustic Diversity Index by ARU, where each colony is ranked according to the median index value. Generally, the results are in line with the assumption that at larger colonies higher acoustic indices are recorded (e.g. Ta’ Cenc, Gharb). However, as expected, two colonies (Filfla and Fungus Rock) in which ARUs were placed within the colony and not on the cliff top, had the highest median recorded BIX values. This applies as well to Ghar Lapsi, which has a higher measured acoustic index than expected for its estimated colony size. Moreover, the Bioacoustic Diversity Index used here measures the intensity and frequency of sound signals but does not recognise Scopoli’s Shearwater calls from other sounds in the soundscape. Therefore, for example European Storm-Petrel calls might contribute to higher indices measured for recordings from Filfla. This is the only colony where this species occurs at an abundance and density high enough to possibly have an effect. While the calculation of BIX was limited to sound signals above 500 Hz, which should reduce the effect of low frequency sounds we cannot exclude the effect of wave noise entirely either. Wave noise might have a larger effect on recordings from ARUs closer to the sea.

Scopoli's Shearwater nest density might also affect this analysis in that a higher concentration of birds breeding within the recording distance of ARUs would produce higher indices compared to a larger but less dense colony. It is also not known at what distance from their nests Scopoli's Shearwaters call when in flight. For example, the ARU on Fungus Rock is likely to have recorded birds nesting on the adjacent cliffs of Wardija and not only breeders from Fungus Rock. Likewise, the ARU at Ras in-Newwiela (MT30_Newwiela), might have recorded birds on their way to the larger colony at Ta' Cenc cliffs.

It follows that it not possible to differentiate between calling activity of breeding adults and non-breeding prospectors. Therefore, colonies with larger numbers of visiting non-breeders might have higher indices than would be expected for just the number of breeding pairs. The behaviour of prospecting birds in shearwater species is poorly known.

Nevertheless, despite these sources of variation, the data collected is suitable for model fitting as described in the section below.

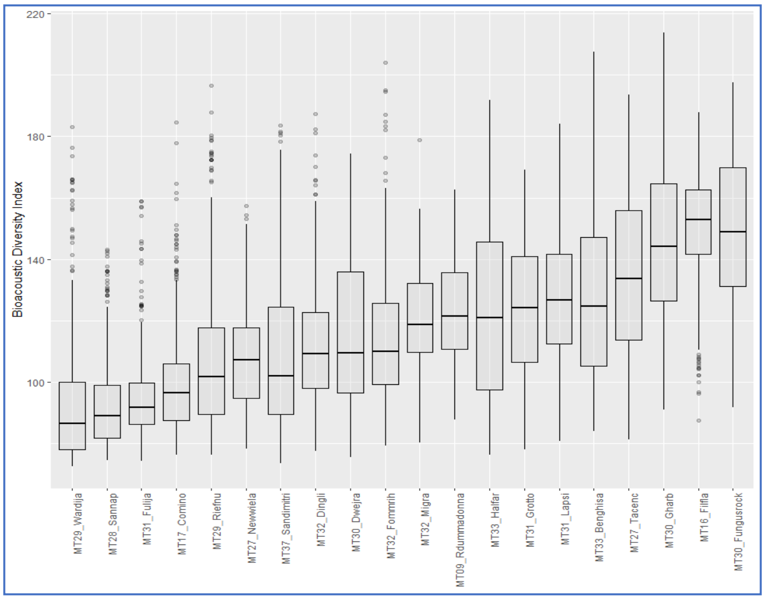

Fig. 12: Median index value of the Bioacoustic Diversity Index (BIX) by ARU at each *C. Diomedea* colony site.

Testing whether sound recorder data can be used to predict population size estimates taking previous estimates as a baseline

In order to predict the 2021 colony size, we used the latest available Scopoli's Shearwater estimates from 2018 as a baseline. The average of upper and lower estimates was used. The number of breeding pairs ranged between 25 and 1250. From the 2018 data, we only used the estimates for small enough ranges, in order to avoid specifying colony sizes which were completely outside the recording range of ARUs. Additionally, we included an estimate for Fungus Rock based on nest counts in the period 2018-2021, at 60-90 pairs.

We ran a RandomForest model with temporal predictor variables including wind speed, moon illumination (as indicated by proportion illuminated and its elevation angle) and the sun's elevation angle (lowest values for the middle of the night), as well as the BIX and ACD at 50Dbfs indices. Windspeed and BIX were the two variables which explained most of the variation in the model (Figure 13). Overall, the model explained 28.8% of the variability in colony size.

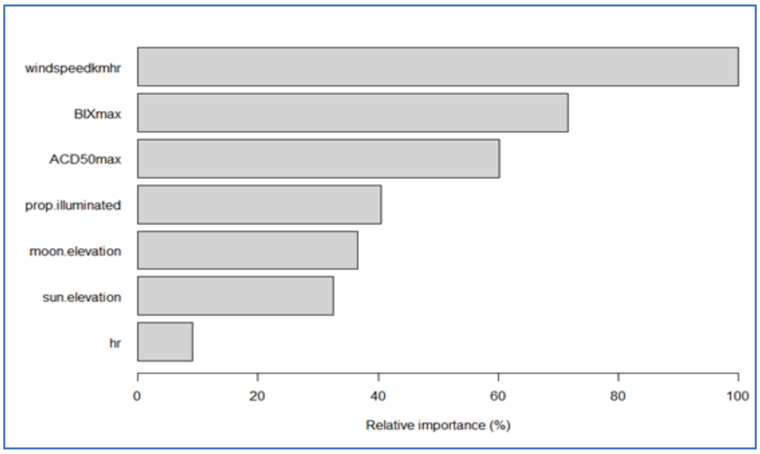

Fig. 13: Relative importance of descriptor variables including BIX in the explanation of *C. Diomedea* colony size variation by the RandomForest model.

To inspect visually the relationship of windspeed and BIX with the dependent variable (colony size), we created partial dependence plots (Figure 14). These plots show, as expected, a positive relationship for BIX with colony size, but no such relationship for windspeed. On the contrary, low wind speeds seem to have a bigger influence on the model, perhaps because shearwater calls are recorded more efficiently in these conditions.

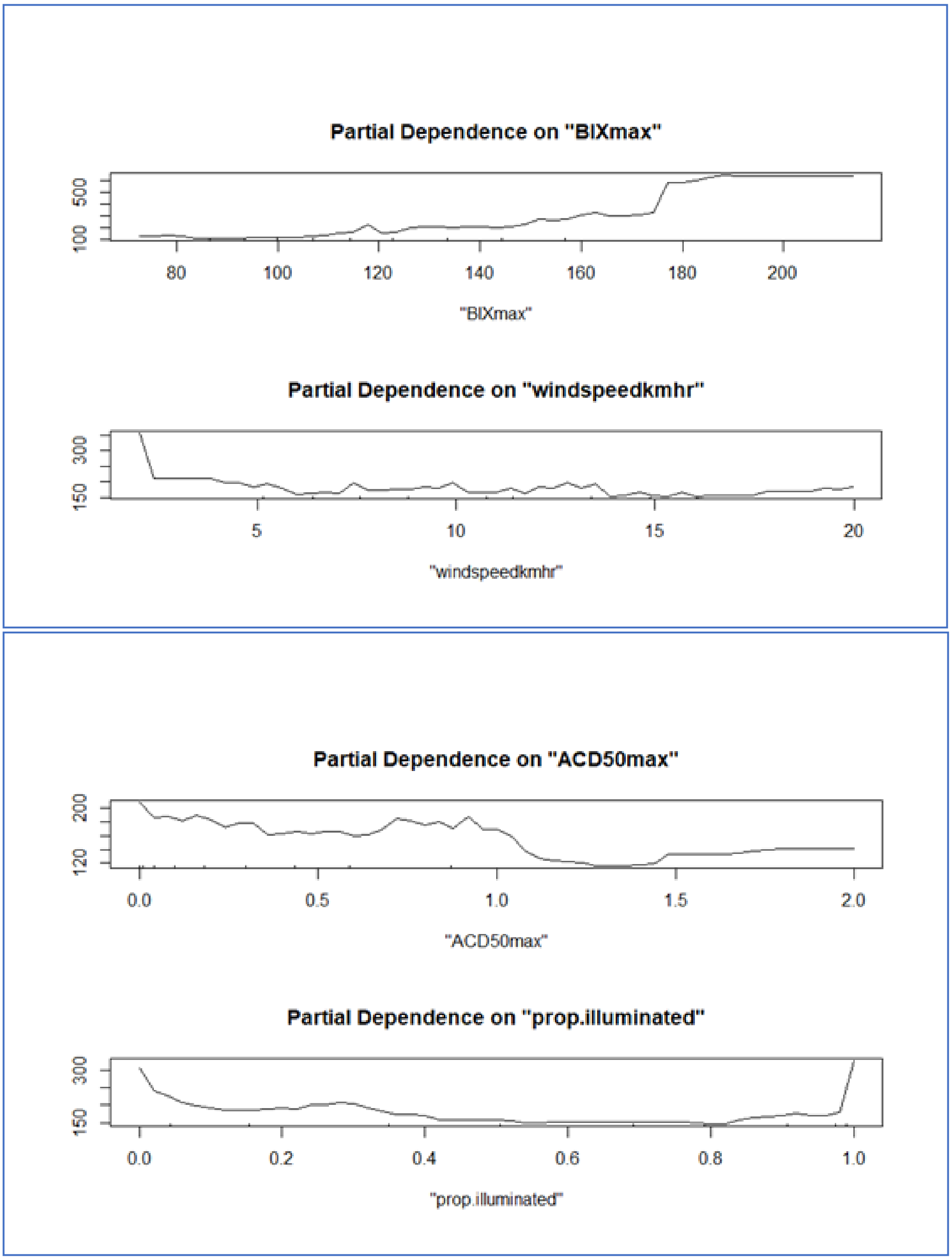

Fig. 14: Partial dependence plots of the dependent variable 'colony size' on BIXmax, windspeed, ACD50max and moon illumination.

We predicted colony size using this model for all the colonies monitored by ARUs. Prediction error was calculated by dividing colony size predicted in the RandomForest model by the colony size estimates specified for some of the ARUs.

Predictions of 2021 population size from the Randomforest algorithm were run on 2021 sound index data (BIX) and using previous (2018) population size estimates as a baseline. Results are seen in Table 5.

***Tab. 5:** Colony size predicted from RandomForest model based on BIX of ARU deployed for C. diomedea during the 2021 breeding period and using 2018 estimates as a baseline.*

N2K site	ARU	Predicted colony size	Baseline colony size (2018 estimate)	Prediction Error
MT0000009	MT09_Rdummadonna	78.23864	35	2.2353898
MT0000016	MT16_Filfla	198.36149	175	1.1334942
MT0000017	MT17_Comino	70.86623	38	1.8649007
MT0000027	MT27_Newwiela	78.52038	28	2.8042994
MT0000027	MT27_Tacenc	833.82830	1250	0.6670626
MT0000028	MT28_Sannap	192.80692	215	0.8967764
MT0000029	MT29_Riefnu	155.29675	NA	NA
MT0000029	MT29_Wardija	164.41975	NA	NA
MT0000030	MT30_Dwejra	172.06017	NA	NA
MT0000030	MT30_Fungusrock	142.12516	75	1.8950022
MT0000030	MT30_Gharb	270.11958	NA	NA
MT0000031	MT31_Fulija	123.79413	NA	NA
MT0000031	MT31_Gharlapsi	127.23023	110	1.1566384
MT0000031	MT31_Grotto	75.12255	40	1.8780638
MT0000032	MT32_Dingli	124.57708	110	1.1325189
MT0000032	MT32_Fommrih	90.66280	63	1.4390920
MT0000032	MT32_Migra	142.08926	125	1.1367141
MT0000033	MT33_Benghisa	185.52067	NA	NA
MT0000033	MT33_Halfar	195.34300	NA	NA
MT0000037	MT37_Sandimitri	82.66591	25	3.3066365

The model output presented in Table 5 provides a more useful ranking of (predicted) colony size due to the successful relation of BIX to estimated colony size rather than BIX being interpreted as a stand-alone measure. However, predicted colony sizes arising from the RandomForest model should not necessarily be interpreted as standalone updates of estimated colony size.

In 2019, 20 ARUs were deployed at the same locations as those used in 2021. However, deployments took place later, mostly in August 2019. Thus, due to variation in calling activity across the breeding season, we only compare sound indices of 6 ARUs which were active in the same periods in both years. Results are shown in Table 6.

The plot in Figure 15 compares the ranked Bioacoustic Diversity Index by ARU for each year, where each colony is ranked according to the median index value. The difference recorded at Hal Far might be due to the slight change in device deployment site.

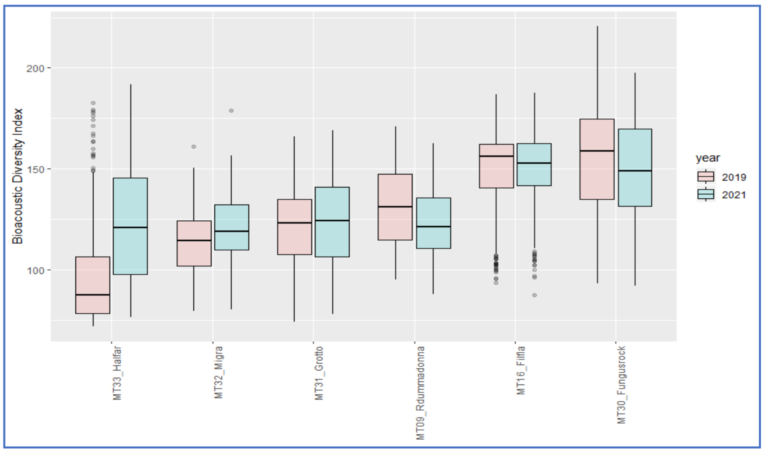

Fig. 15: Median index value of Bioacoustic Diversity Index (BIX) for six ARUs during two C. Diomedea breeding season assessments (2019, 2021).

We ran the RandomForest model above but with data from these 6 ARUs from both 2019 and 2021. In addition to the same parameters, we added year but we do not expect this to be an important explanatory variable since baseline colony size (the dependent variable) for both years was the same. We kept the same baseline population size for both years since we want to test whether ARU data can detect any changes between years.

The model explained 56% of the variance in colony size, with both BIX and ACD at 50dbfs being the most important variables. As expected, year was relatively unimportant (Figure 16).

The larger amount of data (2 months of recordings instead of only one) certainly helps in adding prediction power. The predicted population size for each year (Table 6) reflects the similarities in the BIX values. Furthermore, the prediction error values (Table 6) are consistent without evident trends in changes from the baseline colony size With only two years of data and only 6 ARUs suitable for comparison, estimating a statistical trend is not reliable. **However, these results indicate that it is a potential method to infer trends if all ARUs are deployed in the same period and location over multiple years.**

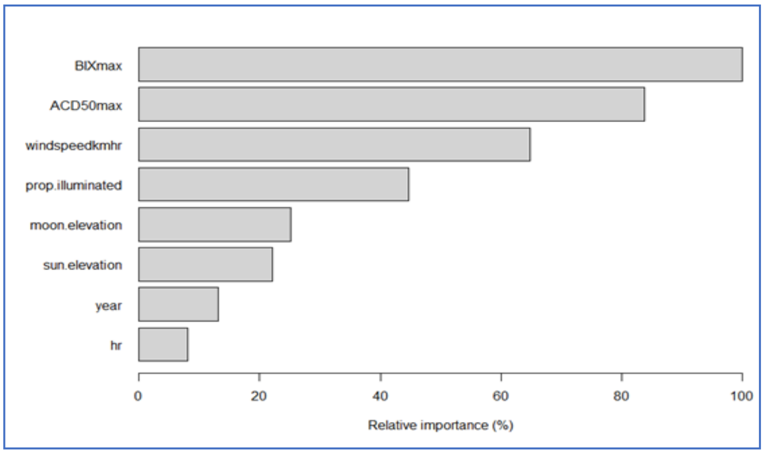

Fig. 16: Relative importance of descriptor variables including BIX in the explanation of *C. diomedea* colony size variation by the RandomForest model; as Figure 14, however, model run for 6 ARUs with two years' worth of data available (2019, 2021).

Tab. 6: *Predictions C. diomedea population sizes from the Randomforest algorithm run on BIX and ACD50 from 6 ARUs deployed in 2019 and 2021, using previous (2018) population size estimates as a baseline. Relative importance of predictor variables in this model is hsown in Fig. 16.*

ARU	**year**	**Predicted colony size**[2]	**Baseline colony size (2018)**	**Predictione rror**
MT09_Rdummadonna	2019	52.94693	35	1.5127695
	2021	46.51424		1.3289783
MT16_Filfla	2019	153.74507	175	0.8785433
	2021	158.17706		0.9038689
MT30_Fungusrock	2019	79.59054	75	1.0612072
	2021	81.44229		1.0858973
MT32_Migra	2019	114.36409	125	0.9149128
	2021	114.10819		0.9128655
MT31Grotto	2019	50.16422	40	1.2541055
	2021	49.48342		1.2370856
MT33_Halfar	2019	89.12479	NA	NA
	2021	86.52695		NA

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[2] Predictions are based on RandomForest models, complex data algorithms, the outcomes of which will vary depending on what data is included. In model behind results in Table 5, only 2021 data was included, and 20 sites were considered. In model behind results in Table 6 it is two years of data (2019, 2021) but 6 sites. These differences in data inputs in the underlying models explain the difference in predicted estimates for the same sites and same years as shown in the two tables (e.g. Tab 5 Rdum tal-madonna 2021 = 78.23; Tab 6 Rdummadonna 2021 = 46.51).

Assessment of the *C. diomedea* population abundance/ size by additional methods

Trail camera imagery

During the assessment we located few locations that were suitable for deployment of trail cameras to inform population estimates of *C. diomedea*. The species does not utilise communal burrows with relatively small cave entrances, which can be covered with a trail camera, to the same degree as *P. yelkouan*. Therefore, the method has been shown to be less suitable for assessments of *C. diomedea*. Nonetheless, three trail cameras were deployed with the aim to inform population estimates, one of which malfunctioned. A second camera, placed at Rdum tal-Madonna, did not capture any *C. diomedea* entering the cave. The third trail camera had been set up in a cave entrance on Fungus Rock. The maximum number of birds moving in or out in any one night was 5 *C. diomedea*. 32 nights were analysed for this camera, between 03rd June and 2nd August.

Audiovisual counts including thermal imaging

All thermal imaging surveys for this species were made in relation to boat- or land-based surveys aiming at identifying nesting sites and breeding range. Therefore, a scanning method was deployed during these surveys. On a survey at Ghar id-Dwieb on 26/07/2021, a fixed section of cliff was surveyed, but no birds were seen landing within the time of survey (21:08 to 22:00). At the same time a maximum of 10 *C. diomedea* were seen flying within 3-minute intervals.

Calonectris diomedea population abundance estimates by integration of methods

The predictions of the sound analysis from ARU recordings were used to adjust previous (2019) population estimates in the direction (larger or smaller) predicted by the analysis of 2021 sound recordings, while taking into account other sources of data such as nest counts and land-based survey counts. The 2021 assessment provides estimates at higher site-specific resolution than previous assessments, a step toward higher spatial resolution population estimation. Mainly site-specific ARU predictions were utilized to obtain these estimates. Additionally, due to an increased effort in 2021, better counts and spatial distribution of nests were obtained within various sub-colonies, achieved by intensive nest searches. These were photomapped on colony wide images where topography allowed. These nests counts were also incorporated into population estimates. Due to the limited timeframe of the tender and limited periods with suitable weather conditions, photomapping has not been completed for all sites. However, Annex 1 Fig. 4 to 6 at the end of the document provide examples for mapped colony sites.

In the case of Filfla, the number of birds ringed during multiple nocturnal visits was also taken into account, but this was the only site where CMR was carried out separate from a nest-based approach. Finally, we used data from audio-visual counts including thermal imaging during LBS or BBS at various sites to further complement sound analysis-based population estimates.

***Tab. 7**: Population estimates of C. diomedea [in breeding pairs] per colony and Natura 2000 site and totals, per assessment period and including data quality.*

N2K site	**Site name**	**Sultana et. al 2011**	**MSFD 1st assess. (2013)**	**MSFD 2nd assess. (2019)**	**MSFD/BD 2021**	**Data quality 2021**	**Method**
MT0000037	S Dimitri – W. il-Għasri	-	-	20-30	20-60	Medium	LBS, ARU
MT0000009	Rdum tal-Madonna	<100	NotSpecified	25-45	25-60	Medium	LBS, ARU
MT0000016	Filfla	200	200	150-200	150-200	Good	LBS, NS, ARU, ringing
MT0000017	Kemmuna	<100	NotSpecified	30-45	30-50	Poor	ARU
MT0000027	Ras in-Newwiela/West of Mġarr ix-Xini	1000	1000	20-35	20 - 50	Medium	NS, ARU
	Ta'Ċenċ			1000-1500	900-1400	Poor	ARU
MT0000028	Sannap	300	1350	200-230	180-230	Medium	ARU, BBS
MT0000029	Xlendi to Wied Riefnu	700		400-450	100-150	Medium	NS, ARU
	Wardija				100-150	Poor	ARU
MT0000030	Dwejra	350			80-160	Poor	ARU, NS
	Fungus Rock				60 - 90	Medium	NS, ARU
	Gharb			200-250	200-250	Medium	NS, ARU
MT0000031 & MT0000032	Ghar Lapsi & Fawwara	200	200	100-120	70-130	Medium	NS, ARU
MT0000031	Blue Grotto	<100	NotSpecified	30-50	30-50	Poor	ARU
	Fulija	800	800	250-300	70-120	Poor	ARU
MT0000033	Hal Far				80-160	Mediun	ARU, NS
	Benghisa				75–140	Medium	ARU, NS
MT0000032	Dingli	300	300	100-120	100-120	Medium	ARU,NS
	Fomm ir-Rih			45-80	45-80	Poor	ARU, NS

	Migra	250	250	100-150	90-150	Medium	ARU, NS
total		**<5,000**	**<5,000**	**2670- 3605**	**2425-3800**	**Medium - Poor**	

Short-term trend of *C. diomedea* according to the Birds Directive (last 12 years)

(Sultana et al., 2011) estimated the total Maltese population at less than 5,000 breeding pairs and the same number was given for the initial MSFD report (Environment and Resources Authority, 2020). (Raine, Sultana, & Gillings, 2009) had given more precise numbers at 4340 – 4860 pairs.

The second MSFD assessment estimated the total population at 2,670-3,605 breeding pairs and defined the trend as stable/declining (Environment and Resources Authority, 2020). The current assessment (2021) for the tender at hand estimates the total Maltese population of *C. diomedea* at **2425-3800** breeding pairs.

The short-term population trend (over the last 12 years) according to Art. 12 BD requirements is assessed as declining. The magnitude of the decline is 22% - 44% (as compared to numbers by Raine, Sultana, & Gillings, (2009))

Long-term trend (since 1980)

According to (Sultana et al., 2011), the breeding population of *C. diomedea* in the Maltese islands has shown a marked decline in some of the colonies. Unfortunately, the data quality regarding population estimates as since 1980 is poor. Therefore, the long-term trend is given as declining without providing a magnitude of this long-term decline.

Conclusion for the population abundance or size and trends of *C. diomedea* in reference to MSFD D1C2 (primary) and BD:

As assessed for the 2021 breeding period, the Scopoli's Shearwater breeding population abundance/ size is stable or declining as compared to the latest MSFD assessment and clearly declining, albeit relatively poor data quality, in the short term and long term. Future monitoring effort will show whether this trend continues, however, due to the short-term decline by approximately 30%, GES/ FCS for the breeding population of *C. diomedea* in the Maltese islands is currently not reached.

Population abundance and trends of the Med. Storm-petrel *H. pelagicus melitensis*

The breeding population abundance/ size was assessed by means of CMR with a focus on Malta's largest Storm-petrel colony. Situated on the islet of Fifla (Filfla u l-gżejjer ta' madwarha, MT0000016) it comprises of more than 97% of the known Maltese breeding population of the species. Most of the nest sites on the islet are well hidden in small crevices in the bolder scree and the vast majority of nests are neither visible nor accessible. Therefore, only an indirect method can be applied to estimate the breeding population abundance and size.

A repeated mist net set-up with fixed locations was used to obtain abundance estimates for the species via a capture-mark-recapture (CMR) study. Each captured bird was fitted with a uniquely numbered ring for individual identification, essential for the CMR analysis. If a captured bird was already bearing a ring, it was regarded as recapture and the present ring number was recorded. Only adult birds (at least in their 2nd calendar year) were considered in the analysis.

In a two-month period, between May 30 and July 29 2021, 12 overnight capture-mark-recapture sessions (occasions) were held on Filfla boulder scree. Each of the six sub-sites on the islet (North, North-East, South-East, South-West, West and North-West), were visited on two separate nights within this period. The set-up was identical with the one for the CMR carried out in 2019 and similar to the one carried out in 2013 (Austad et al. 2019).

The length of mist nets set up on each occasion and sub-site depended on the topography of the location and the number of licensed ringers present. For some sub-sites (North, North-East and South-East) two net locations (i.e. mist nets set up separately from each other) were used to increase the effort and coverage, depending on the number of licensed ringers available.

For each occasion in all years all hours of darkness, when the species can be found active in flight in the colony, were covered.

The similarity in the CMR setup and approach in all three years of assessment (2013, 2019 and 2021) means that data collected in each year is not only comparable but can be analysed together in a robust design model which has the potential to improve comparison (Kéry & Schaub, 2011). In such a model, each year is regarded as a primary occasion, with the different sessions held within a year regarded as secondary occasions. The robust design model utilised was a spatially explicit capture–recapture (SECR) model and therefore abundance estimates are given as density. We used the R package ‘openpopscr’ (Glennie & Borchers 2019) with data preparation carried out using R package ‘secr’ (Efford, Borchers, & Byrom, 2009). Finally, effort for each occasion and sub-site, in net length multiplied by hours, was controlled for in the robust design model as a covariate to the detection parameter.

For the spatial analysis carried out we just considered the part of the boulder scree of Filfla that provides actual breeding habitat for the species. This means that the spatially explicit density analysis was carried out on a polygon of 2.75 ha only and not the whole 3.92 ha surface area of the islet. It excludes the plateau and the outer rocks in the splash zone of the islet where Storm-petrels do not breed.

For the estimation of the population size in breeding pairs we followed the assumption that the overall population constitutes of up to 50% non-breeding individuals, including prospecting birds (Sanz-Aguilar et al., 2010). Therefore, the population numbers in individuals as revealed by the CMR and modelling approach were divided by four to obtain the population size in breeding pairs.

All analysis was carried out in RStudio linking to R 3.6.1 (R Core Team 2019).

Results of the CMR

In 2021, 5279 individuals were handled in 5377 detections (capture events), the majority of 3856 individuals being handled for the first time. 1423 individuals were recaptures from one of the previous years (1522 detections).

In 2019, 4445 adult individuals were handled; the majority of these being handled for the first time and ringed in 2019 (N=3497). Of the 5530 adult individuals handled in 2013, 376 individuals were recaptured in 2019 and 246 individuals in 2021. Out of the 5279 individuals that were detected in 2021, 513 individuals had also been detected in 2019. 52 individuals were detected in all three years of assessment.

The total dataset with combined 2013, 2019 and 2021 data contain 13897 individuals in 16604 detections. The average detection probability was relatively low, estimated at 0.004702254 (LCL: 0.003436018; UCL: 0.006438502).

A number of individuals were captured at different sub-sites on various occasions (n=37). This includes detections at different sites within and between years and indicates that birds move at least to some extent around the islet as they are prospecting or approaching their nest site. Figure 17 shows these captures at different subs-sites within each of the three assessment years and between them.

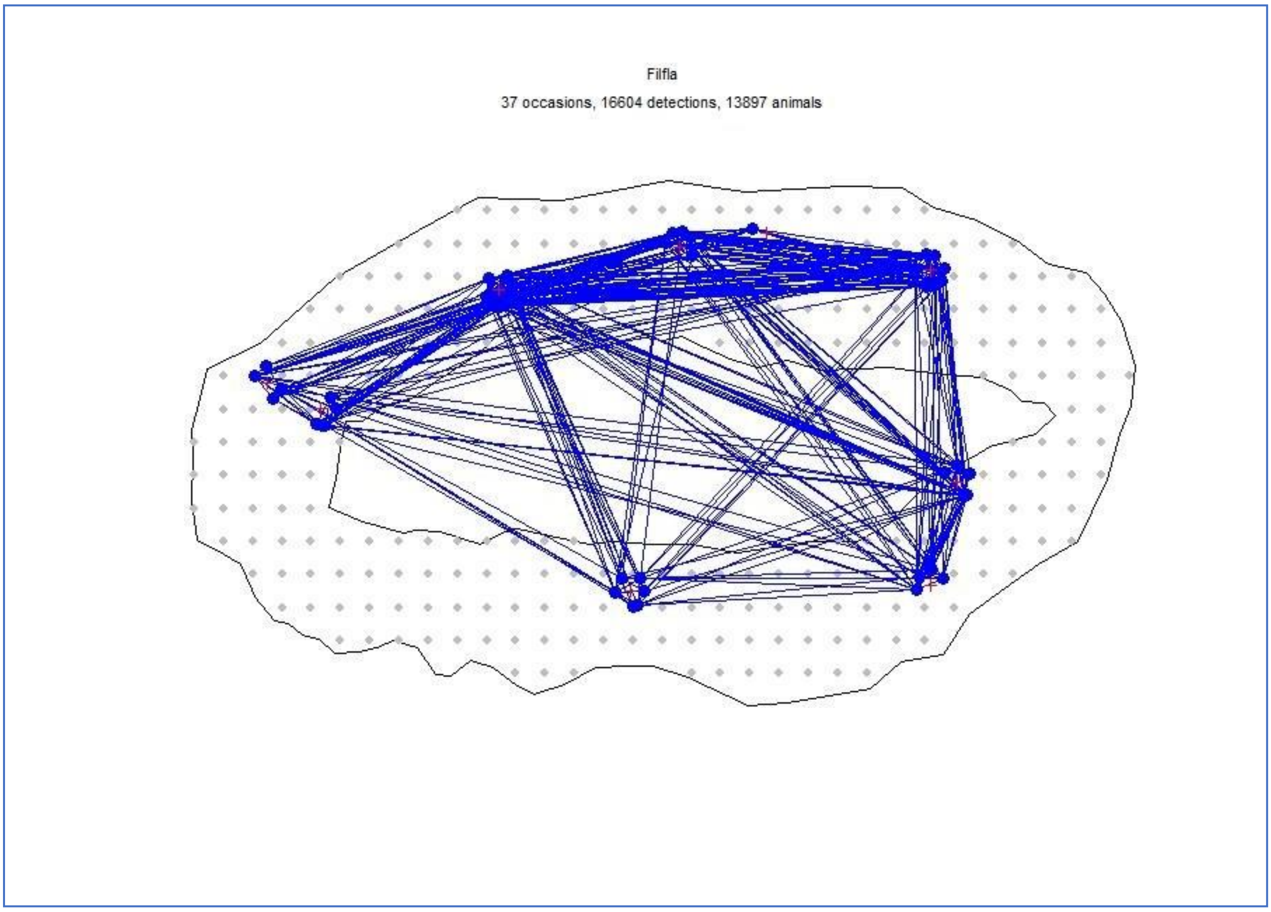

Fig. 17: The CMR Setup on Filfla with net locations in the boulder scree around the plateau (red xx). Blue lines indicate detections of individuals between mist-netting sites within and between all three years of assessment (2013, 2019, 2021).

***Tab. 8:** Results of the CMR and robust design spatially explicit model for the Storm-petrel population on Filfla in three years of assessment; density estimate (ind/km2) with respective standard error (SE), lower confidence limit (LCL) and upper confidence limit (UCL)*

Year of CMR assessment	Density estimate [ind/km²]	SE	LCL	UCL
2013	1144000	28190	1090000	1201000
2019	1238000	31090	1179000	1300000
2021	**1667000**	**39870**	**1590000**	**1747000**

Tab. 9: *Results of the CMR and robust design spatially explicit model for the Storm-petrel population on Filfla in three years of assessment; population size, where LCL and UCL are lower and upper confidence limits respectively*

Year of CMR assessment	**Breeding population size [ad individuals, (LCL-UCL)]**	**Breeding population size [breeding pairs, (LCL-UCL)]**
2013	31460 (29975-33028)	7865 (7494-8257)
2019	34045 (32423-35750)	8511 (8106-8257)
2021	**45843 (43725-48043)**	**11461 (10931-12011)**

At each site and before each nocturnal CMR mist-netting session started, hence at sunset or dusk, 2 minutes of locally recorded Storm-Petrel calls were played using a portable speaker. Storm-petrels responding to playback were counted only on single occasions. At the time when playback took place, birds would be on the nest during the day and would not have entered the nest that respective evening. The method does not seem suitable for population assessment on Filfla, but could be trialled in the coming years earlier in the season (April – May), when in the pre-breeding period response might be more likely.

Assessment of Storm-petrel breeding population abundance in other Natura 2000 sites: All known Storm-petrel nesting sites apart from Filfla as well as all suitable Storm-petrel nesting habitats were visited twice at night by means of a RIB or abseiling and assessed with thermal imaging equipment (FLIR). Additionally, direct audio-visual, and olfactory cues indicating Storm-petrel presence were assessed during these nocturnal visits. Where suitable, automatic registration units were deployed.

Rdum tal-Madonna boulders at RM04/5 (L-inħawi tar-Ramla tat-Torri u tal-Irdum tal-Madonna, MT0000009)

Storm-petrels were confirmed to be breeding at Rdum tal-Madonna for the first time in 2013. The first record of an incubating bird was situated in the Yelkouan Shearwater colony section RM03. The overall colony size in the entire N2K site was estimated at 1-10 breeding pairs for the latest MSFD report, where breeding was confirmed in the section RM04C. Breeding was also confirmed during the 2021 breeding period as a begging chick was recorded in an area of boulders close to the sea between the section RM04 and RM05 on July 15. Overall, at least 5 adult Storm-petrels were registered at this site during a night visit on July 3rd: two of them captured by hand on the ground while leaving the colony at night, ringed and released, two more seen leaving the colony and one male purring from inside the colony under boulders. A trail camera was positioned in the area of nest sites on 15.07.2021 and retrieved on 05.09.2021 in order to improve the population abundance assessment. Out of 121 images taken during that period, 38 showed *H. pelagicus*. The population size for the 2021 breeding season remains conservatively estimated at 1-10 breeding pairs.

Ta' Ċenċ Storm-petrel Sea Caves (Rdumijiet ta' Għawdex: Ta' Ċenċ, MT0000027):

First mentioned in literature in 1746, the Ta' Ċenċ Storm-petrel colony was rediscovered in 1994 and estimated at a population size of 25+ breeding pairs (Sultana et al., 2011). During the monitoring efforts in previous years, it was found that the colony actually spreads over three sea caves in the area. The population size of the colony was estimated at 40-60 breeding pairs for the latest MSFD reporting cycle (Austad et al. 2019), assessed by means of thermal imaging counts and direct counts of visible nests. The colony was assessed with the same methodology during the 2021 breeding season and its size was estimated again at 40-60 breeding pairs.

Għar Jaħra (Rdumijiet ta' Għawdex: Il-ponta ta' San Dimitri sal-ponta ta' Ħarrux, MT0000030). The storm-petrel colony in a sea cave next to San Dimitri, Gozo, was discovered in 2014 (Metzger pers. obs.). Situated in the overhanging northern wall and roof of the sea cave, the actual colony is not accessible and in the years of assessment there were no visible nest sites that would allow for an adequate nest-monitoring. The colony was estimated to hold 50 to 70 pairs for the latest MSFD report (Environment and Resources Authority, 2020) and 50-70 breeding pairs in 2021, assessed via thermal imaging during two nocturnal visits each.

Tab. 10: *Estimated Storm-petrel populations for the 2021 breeding season as per Natura 2000 site.*

N2K site	**Location name**	**Population abundance estimates 2021 [breeding pairs]**
MT0000009	Rdum tal-Madonna	1-10
MT0000016	Filfla	10931-12011
MT0000027	Ta' Ċenċ Storm-petrel Sea Caves	40-60
MT0000030	Għar Jaħra, Għarb	50-70

Breeding population trend of *H. pelagicus melitensis*

The colony on Filfla comprises of more than 97% of the estimated breeding population of the Mediterranean Storm-petrel in Malta. Furthermore, past population assessments for the smaller colonies were only available for the Ta' Ċenċ colony. Therefore, only data from the Filfla breeding colony was utilized to assess short-term and long-term trends in population abundance.

Short-term population trend: Systematic CMR with spatially explicit modelling of population size is only available for three breeding periods within the last eight years, as opposed to a 12 years period stipulated for short-term population trend assessments according to the BD. This preliminary short-term trend for the Filfla population over the past eight years indicates a strongly positive trend in population abundance of **+45.7% (+45.5% to +45.9%)**. However, it must be pointed out that apart from the limited timespan for the short-term trend assessment, the magnitude of the trend can be easily overestimated due to extremely low detection probability estimates in CMR models (0.0047), which in turn are caused by few or no tertiary occasions per sub-site within seasons. More years of assessment are required to determine whether this is a true trend or whether the population shows a fluctuating trend.

Long-term population trend: Based on the numbers of Storm-petrels ringed during the first two years after the Filfla colony was discovered (1968-69), the population size was initially estimated at not less than 4,000 individuals. Later, the colony was estimated at 10,000 pairs (Sultana & Gauci 1970), without providing a range or an estimate of error, but it was noted that since the 1980s numbers were on the decline (Massa & Sultana 1993). In 2002 the number of breeding pairs on Filfla was estimated at a range between 5,000 and 8,000 pairs (mean 6,500), all numbers extracted from various sources in (Sultana et al., 2011). Due to differences in assessment methods and effort and an irregular and lower assessment frequency before 2013, long- term trends should be interpreted with extreme caution. Overall, the long-term trend of the Storm- petrel breeding population size on Filfla (since 1980) appears to be fluctuating by less than **±30%**, however the data quality for this long-term trend can be classified as poor (Figure 18).

Conclusion for the population abundance or size and trends *H. pelagicus melitensis* in reference to MSFD D1C2 (primary): As assessed for the 2021 breeding period, the Mediterranean Storm-petrel breeding population abundance/ size and trends indicate that GES for the Maltese population is achieved, and its overall long-term viability appears currently ensured. However, it must be pointed out that only the CMR data from the Filfla colony, comprising more than 97% of the estimated population, allow for robust population estimates.

Regarding population trends (short- and long-term) as a reporting requirement under the Birds Directive the trend for the species in Malta appears to be currently favourable.

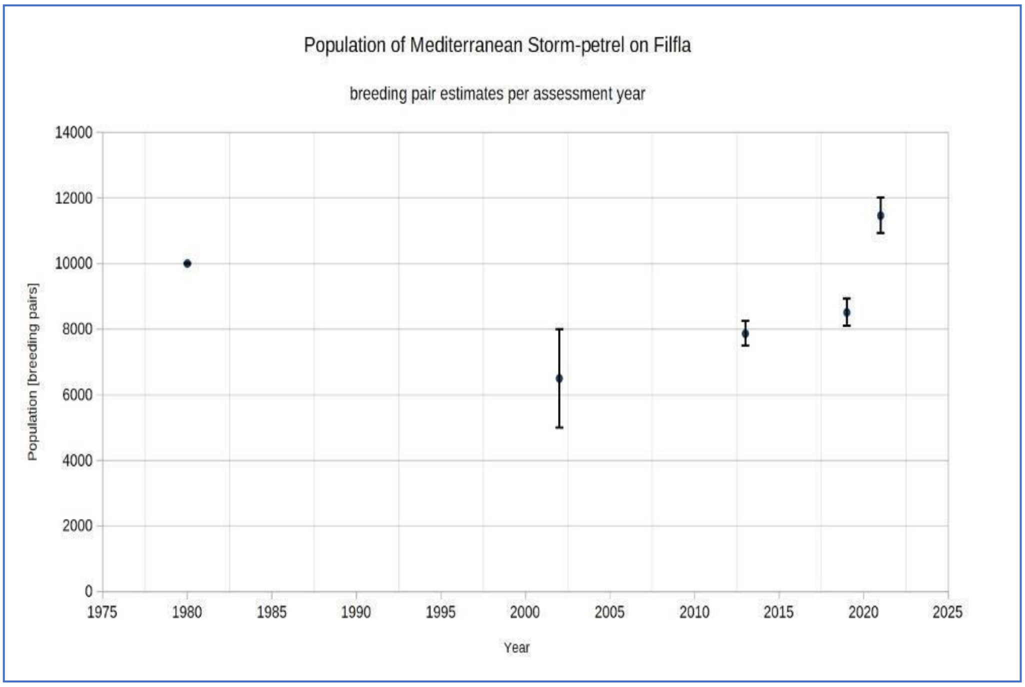

Fig. 18: Population estimates of the Maltese *H. p. melitensis* population [breeding pairs]. Comparable methodology has been only followed during the latest three assessments

Population demography

Adult annual survival rates

Annual survival rates of Yelkouan Shearwaters *P. yelkouan*

The adult annual survival rate of *P. yelkouan* in Malta had been assessed as 0.74 on average (95% confidence interval: 0.69–0.80) for the period between 1969 and 1994. It had been reported to have increased to 0.85, though with a larger range (0.58–1.0), for the period between 2007 and 2010 (Oppel et al., 2011). As part of the latest MSFD assessment cycle, annual adult survival probability across all colonies in which sufficient ringing effort took place was calculated at >0.7 for each year in the period between 2013 and 2019 (Austad et al. 2019). Except for two years (2017 to 2018 and 2019 to 2020), adult annual survival rates were below the value of ≥92%. A value of 92% or higher is deemed necessary for the species' recovery. It is published as the ten years goal to be achieved for the International Single Species Action Plan for *P. yelkouan* (Gaudard, 2018), as well as for the Maltese national species action plan, a deliverable of LIFE Arcipelagu Garnija (Sahin et al., 2020).

For the period between 2013 and 2021 the adult annual survival rates were re-assessed making use of the CMR model amended with data collected during the 2021 breeding period. CMR data were obtained from colonies situated in four Natura 2000 sites, including Malta's two largest *P. yelkouan* colonies (in bold); namely: **L-Irdum tal-Madonna (MT0000009)**, Cominotto (MT0000017), St Paul's Island (MT0000022), **Majjistral (MT0000024).**

The adult annual survival for 2021 was calculated at 0.75 (LCL: 0.70, UCL: 0.81). However, it can be expected that this value will increase to some extent with the next assessment as it can be assumed that not all individuals that were not detected (recaptured) in 2021 have died and that some of them will be detected in future assessments. In other words: the annual survival estimate of the latest assessment has to be lower, because some adults that were not handled in 2021 are still alive and will be recaptured in consequent occasions (years). For instance, in the latest MSFD assessment, adult annual survival was estimated for 2019 as just >0.7. It has increased to 0.84 (LCL: 0.78, UCL: 0.91) in the current assessment. The reason for this apparent increase is that individuals that have not been handled in 2019, have been recaptured alive in 2020 and/ or 2021. A similar increase in the adult annual survival rate can be expected for the 2021 breeding period when assessed in the coming years, however, it is unlikely that the value will increase above 0.9. Figure 19 summarizes the annual survival rates for the species from 2013 to 2021.

Irrespective of a lower value for the 2021 adult annual survival rates due to methodological constraints, it must be pointed out that the adult annual survival reaches satisfactory values ≥0.92 only in two (2018, 2020) out of nine years (2013-2021). A value of ≥0.92 is postulated as the ten years aim for the species in the International Single Species Action Plan for *P. yelkouan* (Gaudard, 2018) and in the National Species Action Plan (Sahin et al., 2020). It is deemed necessary to allow for a recovery of the population.

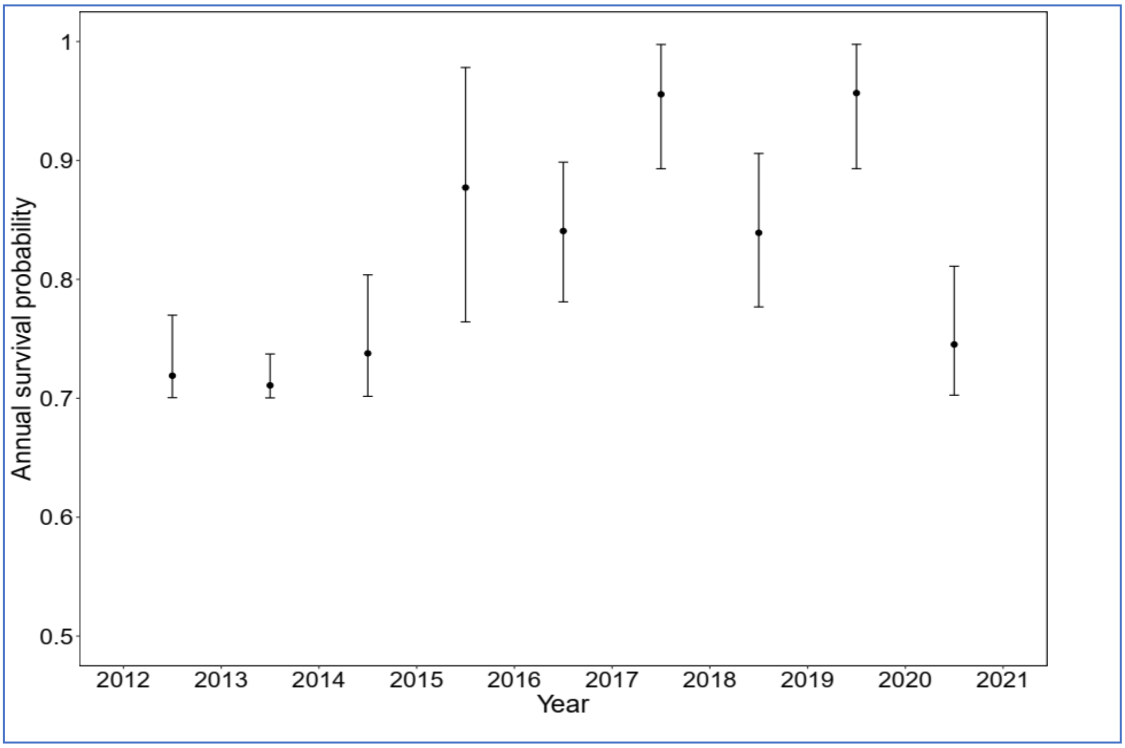

Fig. 19: Adult annual survival rates of *P. yelkouan* as assessed via modelling for the 2013 to 2021 breeding periods, based on CMR data from colonies in four Natura 2000 sites.

Annual survival rates of Scopoli's Shearwater *C. diomedea*

Due to limited and non-systematic ringing effort of the species in recent years it is currently not possible to adequately estimate the adult annual survival rate of the Maltese Scopoli's Shearwater population. Furthermore, the assessment period covering only a part of the 2021 breeding season was not long enough to allow for sufficient capture-mark-recapture effort at any of the breeding colonies. However, a good number of accessible nest sites (n=222) across most relevant colonies have been identified for monitoring during the 2021 breeding period, leading to a total number of 151 occupied nests.

In 2021, during the period covered by the tender at hand, at total of 198 individual adult Scopoli's Shearwaters were handled. Of these 118 individuals were ringed for the first time in 2021, while the remaining 80 individuals were recaptures. Moreover, repeated site visits lead to a total of 112 recapture events, meaning that some individuals were handled more than once during the season. 7 individuals ringed for the first time in 2021 were recaptured in the same season.

Active nests were more likely to be occupied by individuals ringed in previous years. On the other hand, birds which displayed prospecting behaviour were more likely not ringed (Table 11). Such behaviour includes being associated with apparently empty nests or sitting on the ground within the colony without apparent intent to move to a nest. This category is likely to contain failed breeders as well, which are known to still attend the colony. We do not exclude that we overestimate the proportion of prospectors by including active breeders that have already attended the nest and resting outside without apparent nest association. More frequent nest monitoring and CMR over several years, is required for a better separation of the proportion of prospectors attending colonies.

Broodpatch scores (the extent the featherless bare batch serving for efficient incubation and brooding); does not seem an effective way to separate prospectors and breeder due to considerable overlap.

The majority of Scopoli's shearwaters were handled on Filfla (MT0000016) (Table 12). A nest-based approach was carried out at the nests monitored on Filfla, but at this site Scopoli's shearwaters were additionally caught in mist nets during storm-petrel CMR sessions. At all other sites the approach of ringing Scopoli's shearwaters was nest-based, including birds close to or approaching nests.

Where possible, one or both partners of these nests under incubation have been captured and ringed or recaptured. If a similar approach is taken in future breeding seasons, this can cater for a nest-based CMR approach for the following assessment cycles and allow for adult survival estimates in the coming years.

Tab. 11: *C. diomedea, adult individuals assumed to be active breeders versus prospectors/failed breeders by status (new or recapture). Non-categorised birds were captured on the way into colonies by hand in cave entrances or by hand.*

Category	**New**	**Recapture**
Assumed breeders at active nests (ind.)	28	40
Assumed prospectors or failed breeders (ind.)	35	20
Non-categorised individuals	55	20

Tab. 12: *Number of Scopoli's shearwater adult individuals handled per N2K site.*

N2K site number	**Site name**	***C. diomdea*, ind. new**	***C. diomdea*, ind. recaptured**
MT0000009	Rdum tal-Madonna	0	2
MT0000016	Filfla	46	51
MT0000027	Ta'Cenc	2	0
MT0000029	Xlendi	12	0
MT0000030	Dwejra to Gharb	4	13
MT0000030	Fungus Rock	20	5
MT0000031	Ghar Lapsi	2	0
MT0000032	Fomm ir-Rih to Dingli	17	0
MT0000033	Wied Znuber to Benghisa	15	16

Annual survival rates of Mediterranean Storm-petrel *H. pelagicus melitensis*

The adult annual survival rate was assessed for the Filfla colony (MT0000016) based on CMR data and spatially explicit modelling including data of the breeding periods 2013, 2019 and 2021. Adult annual survival was calculated by the model at 0.879 (LCL: 0.867; UCL: 0.890). This adult annual survival rate of approximately 88% for the Filfla colony is believed to be high enough to maintain a viable population on the islet, at least in the short-term.

Data availability for the other Storm-petrel colonies is currently insufficient to determine adult annual survival for colonies in the additional Natura 2000 sites where the species breeds. However, values can be expected to be lower due to additional pressures such as the presence of alien mammalian predators (*R. rattus*) in the colonies.

Reproductive success/ nest survival rate for the 2021 breeding period

Reproductive success of Yelkouan Shearwaters *P. yelkouan*

A total of 81 nests (72 natural nests and 9 in nest boxes) out of 171 monitored nest sites (148 natural nests, 23 nest boxes) which had signs of breeding attempts or prospecting, were identified to be suitable for determining hatching success and reproductive performance in the 2021 breeding period. The selection followed the criteria that they could be monitored throughout the season (visibility of all stages) and that they were encountered under incubation upon the first visit. The discrepancy, therefore, between the total number of nests and those selected for determining reproductive performance, is due to several reasons including breeding failure taking place before the first visit, detection late in the season after the incubation period, or insufficient number of visits. On the other hand, at least 14 of the nests/nest boxes were only prospected and breeding attempts were not confirmed, while other nests are difficult to view to reliably confirm contents throughout the season.

The locations of these nests are spread over sub-colonies in five Natura 2000 sites. However, more than half of the nests (n=42) are situated in Rdum tal-Madonna (MT09), Malta’s largest colony for the species. Each nest was visited at least two times in case it failed during incubation and at least three times if it successfully hatched a chick. June 15, a date at which most chicks are at a size to be ringed and unlikely to be predated by rats, was used as a cut-off point to determine reproductive success. At this time, most chicks hadn’t yet started leaving the nest to wander around. The reasons for this cut-off date to be well before the actual fledging date is that chicks that move around are more likely to be hidden or make it difficult to assess to which nest they actually belong.

Overall hatching success across the sites was at 63.0%, while overall reproductive output was determined at 43.2% for the cut-off date June 15. Table 14 lists the number of nests, hatching success and preliminary reproductive success per site.

Tab. 13: *Number of Yelkouan shearwater nests and (total and in nest boxes) monitored per N2K site*

Natura 2000 site number	Name of site and subsite	total nests	of which in nest boxes
MT0000009	Rdum tal-Madonna RM01	22	18
	Rdum tal-Madonna RM02	3	
	Rdum tal-Madonna RM03	14	
	Rdum tal-Madonna RM04	23	
	Rdum tal-Madonna RM05	20	
MT0000017	Comino and Cominotto MT17	15	1
MT0000022	St Paul's Island MT22	10	2
MT0000024	Majjistral NHP	39	
	Cumnija	8	
MT0000027	MT30 Ta'Cenc and Ras in-Newwiela	4	2
MT0000030	MT19 Gharb	1	
MT0000031	Ghar Lapsi and Blue Grotto	9	
MT0000033	Ghar Hasan	3	

Not all chicks are believed to having survived from the cut-off date to the actual point of fledging. In fact two of the nests marked as successful as per having a live chick after 15th June, were found to contain dead (starved) chicks on even later visits. Furthermore, some visible nests are likely to have failed very early after egg laying, before the first nest-check and were not included in the analyses. Therefore, the actual reproductive output for the 2021 breeding season is certainly even below 43.2%. Despite predator control management implemented at all monitored nest sites, except for the three nests in Ghar Hasan, reproductive output is clearly too low to maintain a viable population. It is far below the targeted value of >75% as published in the latest International Single Species Action Plan for the Yelkouan Shearwater (Gaudard, 2018) and the Maltese national species action plan (Sahin et al. 2020). This is a reason of concern as the species is listed as Vulnerable by the IUCN.

Out of 46 monitored nests that were not successful 30 nests (36.6% of total) failed during incubation while 16 nests (19.5% of total) failed during the chick rearing period. Table 15 lists the stage and if known the reason for all failed nests. In various instances where the egg had disappeared from monitored nests during the incubation period, predation cannot be excluded as cause for the nest failure as rats are able to carry *P. yelkouan* eggs away from the nest into food storages. However, ultimate reasons for nest failure such as abandonment (but also increased predation risk due to reduced nest attendance by parents) are likely to reflect to some extent the conditions in the marine habitats utilized by the species during the reproductive season. It remains to be seen in the future whether the poor reproductive output encountered for the monitored nests during the 2021 breeding season will be a one-off or is indicative of a trend.

Tab. 14: *Number of nests monitored, hatched and preliminary reproductive success per N2K site for P. yelkouan during the 2021 breeding period.*

N2K number	Site name	no. nests monitored	no. hatched	% hatched	no. chicks June 15	% chicks June 15
MT0000009	Rdum tal Madonna,	42	24	57.1	20	47.6
MT0000017	Kemmuna & Kemunett	8	6	7.5	4	50.0
MT0000022	Selmunett	10	7	70.0	6	60.0
MT0000024	Majjistral NHP	18	11	61.1	5	27.8
MT0000033	Ghar Hasan	3	3	100	0	0.0
Grand total		**81**	**51**	**63.0**	**35**	**43.21**

In 2021, 55 pulli (in nest) and fledgling (outside nest, training wings in order to leave colony) Yelkouan shearwaters were ringed at colony sites (Table 16). The total number of 18 fledglings ringed is considerably lower than in previous years, despite comparable effort (Austad et al. 2020), confirming the low breeding success of the species in 2021.

Tab. 15: *Stage and cause of nest failure of failed P. yelkouan nests during the 2021 breeding period.*

Stage and cause of nest failure	Number of nests
Nest abandoned at egg stage	12
Egg found damaged (e.g. by trampling by pigeons; in fight with conspecifics)	2
Nest predated at egg stage	1
Egg disappeared during incubation, ultimate cause unknown	16
Nest predated at chick stage	4
Chick disappeared or found dead, ultimate cause unknown	10
Nest failed, stage and cause unknown	1
Total	**46**

Tab. 16: *Number of Yelkouan Shearwater nestlings (inside nest), and number of fledglings (outside nest, training wings) ringed per N2K site with accessible colony sites. Also shown is the number of visits to each site when pulli/fledglings were handled.*

Natura 2000 site number	Pulli	Fledgling	No. of visits
MT0000022	6	2	3
MT0000033	2	0	1
MT0000009	19	12	10
MT0000024	10	0	3
MT0000017	2	2	2
Total	**39**	**16**	**19**

In addition to the poor reproductive success of the species during the 2021 breeding season, a significant number of monitored chicks fledged significantly delayed as compared to previous breeding seasons. The delay in fledging can be deducted from the differences in the period of the year when light induced grounded fledglings are encountered. We compared the encounter dates (first, last and median) of grounded fledglings for the years 2018 to 2020 and compared them with the data of grounded fledglings encountered in the 2021 fledging period. An overview of the results is presented in Table 17. Median fledging date of *P. yelkouan* as derived from light-induced grounded birds was delayed by two weeks as compared with data from three previous years combined.

Tab. 17: *Fledging dates of P. yelkouan as derived from light pollution induced grounding events of fledglings for the period 2018-2020 compared with 2021 (earliest, median, latest date).*

Year	Earliest grounding date	Median grounding date	Latest grounding date
2018-2020 (n=24)	22 June	5 July	15 July
2021 (n=11)	1 July	19 July	23 July

Apart from the delayed fledging, *P. yelkouan* fledglings left the nest in 2021 in poor body condition, as compared to previous years. We compared the average body mass of nestlings ready to fledge taken in 2019 and 2020 with the average body mass of nestlings at the same stage in 2021. The comparison of body mass around fledging is shown in Table 18. In 2021 *P. yelkouan* fledglings left the nest on average almost 50g lighter than in previous years.

***Tab. 18:** Comparison of body condition (bm) of nestlings at ready to fledge state between 2019/20 and 2021 breeding period (average, SD).*

Year	Average body mass of nestling ready to fledge	Standard deviation
2019,2020 (n=10)	397.7 g	43.8 g
2021 (n=10)	351.7 g	59.2 g

Nest survival rates/ hatching success of Scopoli's Shearwater *C. diomedea*

To start systematic data collection on the reproductive output of the Maltese breeding population of *C. diomedea*, a total of 222 accessible nests were identified and visited early during the incubation period. Monitored nest sites are widely distributed over various colonies in five Natura 2000 sites. Overall, 151 nests could be confirmed having an incubating bird at the first monitoring visit, leading to a relatively low occupancy rate of 68.2% of all identified nest sites. Out of the 151 nests it was possible to confirm for 84 nests upon the post-hatching visit whether or not they successfully hatched a chick. These nests were then utilized to determine the hatching success as a proxy of preliminary reproductive output with an early cut-off date. The total hatching success across all sub-colonies and sites was 70.2%. Table 19 lists the relevant data by (sub-)colony and site.

It is likely that some initially identified nests failed very early after egg laying, before the first nest-check and therefore couldn't be included in the analyses. Furthermore, it can be assumed that by far not all chicks that were encountered during the post-hatching monitoring visit will have survived until fledging. Therefore, the actual reproductive performance of *C. diomedea* for the 2021 breeding season is certainly significantly lower than 70%.

For future assessment cycles it is highly recommended to carry out at least one more visit later in the season (mid-September), to ring the chicks of all *C. diomedea* nests that survived until that stage and to achieve more realistic numbers of reproductive performance.

It is unclear whether the low estimated reproductive output of the 2021 breeding period is representative for the short or long-term situation in Malta. However, as a preliminary interpretation it can be stated that a reproductive output clearly below 70% is not sufficient to allow for a stable or increasing population. It remains to be seen with future assessments in the coming years, whether a low reproductive output in 2021 is just a one-off in a fluctuating scenario or if it is a trend that might be at least partially responsible for the registered short-term population decline of the species in Malta.

Scopoli's Shearwaters are known to sometimes take sabbaticals, most likely as part of decision making in years where it is unlikely for them to successfully raise a chick. Monitoring of the same nest sites in the coming years can reveal whether the relatively low occupancy rate of nests in the 2021 breeding season is a one-off and caused by a higher percentage of birds deciding to miss out on a season due to poor environmental or physiological conditions. Alternatively, it could be another indication of a negative population trend, as identified at least for the short-term in the latest assessment cycle.

Tab. 19: *Nest monitoring of C. diomedea during the first part of the 2021 breeding period with number of nests in total, under incubation and occupation and hatching rates per N2K*

N2K number	Site name	Nest count	Incubation check	Post-hatch check	Chick confirmed	% nests occupied	% hatching success
MT0000016	Filfla	21	16	10	10	76.2	100
MT0000027	Ta' Ċenċ	17	13	10	3	76.5	33.3
MT0000029	Xlendi	24	21	13	11	87.5	84.6
MT0000030	Dwejra	1	0	0	0	0.0	0.0
	Fungus Rock	29	19	16	9	65.5	56.3
	Gharb	36	22	6	3	61.1	50.0
	Total MT30	**66**	**41**	**22**	**12**	**62.1**	**54.5**
MT0000031	Ghar Lapsi	18	14	7	2	77.8	28.6
MT0000032	Fomm ir-Rih	4	3	2	2	75.0	100
	Migra	10	4	3	3	40.0	100
	Zuta	5	4	1	1	80.0	100
	Total MT32	**19**	**11**	**6**	**6**	**57.9**	**100**
MT0000033	Benghisa	12	6	5	4	50.0	80.0
	Hal Far	45	29	13	9	64.4	69.2
	Total MT33	**57**	**35**	**18**	**13**	**61.4**	**72.2**
Grand Total		**222**	**151**	**84**	**59**	**68.0**	**70.2**

Nest survival rates Mediterranean Storm-petrel *H. p. melitensis*

Despite careful assessments at two colonies that are suitable for monitoring of reproductive performance, only a relatively small number of nests of the Filfla colony and in the sea cave of Ta' Ċenċ are visible. These nest sites were utilized for a nest monitoring with two to four nest checks during the 2021 breeding period.

In the 2021 breeding season, 6 nests out of overall 18 monitored nest sites (9 natural nest sites, 9 nest boxes) could be utilized for nest monitoring on Filfla. 5 nests, including one inside a nest box, survived at least to the stage where they contained a downy chick (i.e. not older than four weeks) while the sixth monitored nest clearly failed (reason unknown). Due to the lack of visits later in the season, it is not clear how many of the chicks reached the age of fledging. The preliminary reproductive performance for the Filfla colony during the 2021 breeding period is 83%, however, the sample size appears too small and a visit later during the chick rearing period closer to fledging would be required.

Overall, the number of visible nests monitored during the 2021 breeding season appears too low to allow for a statistically robust assessment of breeding success. Furthermore, the fieldwork period as part of the tender was cut short, with the last visit to Filfla carried out on July 29. Therefore, the chicks had not yet reached an age close to fledging nor the appropriate size for being ringed. During various visits to the islets for the CMR, the number of wooden nest boxes has been gradually increased by 25, so that 34 artificial and easily accessible nest sites will be available from 2022 onward. This is believed to facilitate nest monitoring of the Mediterranean Storm-petrel on Filfla in future breeding seasons. The aim is to have at least 50 easily accessible nest sites available to monitor the reproductive performance of the species on Filfla in the longer term.

Out of 8 visible nests in the sea cave at Ta' Ċenċ (MT0000027) which had incubating adults during the first visit to the cave on June 15 none reached the age of fledging. This means that the reproductive performance of the Storm-petrel colony at the site for 2021 is 0%. Rats had invaded the sea cave at Ta' Ċenċ between the first and the last visit to the site. On a nest monitoring visit July 29, all monitored nests showed signs of predation at egg- or chick stage or abandonment or predation of the adults. Remains of more predated eggs, chicks and adults as well as dead and one dying downy chick, presumed to having been abandoned, were found in front of various nest entrances. Overall, at least 11 predated eggs, remains of 3 predated adults, remains of four predated downy chicks, 2 dead downy chicks, probably abandoned, and one dying chick outside a nest, probably abandoned were found.

Due to a lack of visible or accessible nest sites, no data of reproductive performance could be collected for the remaining two *H. pelagicus melitensis* colonies in the Maltese islands, namely Rdum tal-Madonna (MT0000009) and Għar Jaħra (MT0000030).

Main Anthropogenic pressures and threats

As part of the tender at hand, pressures and threats were assessed systematically where possible, e.g as bait consumed in stations in the P. yelkouan colonies with predator control or the light pollution in various sites via sky quality meters (SQM). However, in many cases and for various sites, threat monitoring could only be carried out opportunistically while carrying out work under specific criteria (e.g. illegal hunting of *C. diomedea* in the colony at night, signs of cat predation of *P. yelkouan*, both encountered while monitoring under D1C3). Unfortunately, data requests to relevant entities which could have further informed on pressures active in the colonies remained widely unanswered. In general, where data availability was poor or insufficient (e.g. for fishing at sea), pressures were indirectly assessed by making use of data from literature (e.g. work in the Mediterranean on bycatch) and low annual survival rates of adults.

Presence/absence, frequency, duration, and amplitude of pressures encountered at each site and for each species were assessed when ranking pressures from zero to high (see below). Additionally, susceptibility of the different species to each threat was considered. It has to be noted that within the short timeframe of the tender results on the assessment of pressures can only act as a preliminary indication. It is believed that a more systematic approach of the assessment of pressures and threats across the sites needs to be developed and implemented long-term.

Threats were ranked via assessing and extrapolating trends of pressures (e.g. the increase of light pollution due to the increase in development and the shift to LED emitting brighter and white light).

Due to a high degree of philopatry and site fidelity in all three pelagic seabird species nesting in Malta, it can be assumed that immigration from outside Malta that could compensate for a reduction in population size caused by anthropogenic pressures is negligible (e.g. no recoveries of any *P. yelkouan* or *C. diomedea* and only 5 of *H.p. melitensis* ringed abroad have been recorded potentially recruiting into the Maltese populations over the last 50 years). Thus, pressures and threats acting on demographic characteristics i.e., adult survival rates and reproductive performance will inevitably and ultimately also act on population size. Hence the assessment at hand does not deal separately with the anthropogenic pressures acting on D1C2 and D1C3, but rather look at both combined.

Monitoring of pressures by predatory invasive species

Pressures from predation of eggs and chicks by invasive rodents, *R. rattus*

Predation of eggs and chicks has been reported in the past as being high in most *P. yelkouan* colonies before implementation of predator control. Since 2017, predator control is carried out each reproductive season in 5 important *P. yelkouan* colonies with repeated deployment of wax cubes containing an anti-coagulant in defined bait stations. Bait consumption is closely monitored approximately bi-weekly as per N2K site, colony, and down to every single bait station, and thus bait consumption acts as a suitable site-specific proxy for the pressure exerted on breeding seabird species by predatory rodents. Under the current baiting regime, the bait stations are reducing this rat predation pressure on nests in major colonies of *P. yelkouan* in the Maltese islands. However, even under the current baiting scheme the development of resistances or avoidance of exposed rodent populations towards the bait could become a threat in the medium- and long-term (Lago et al., 2019).

Figures 20a-f (Annex 3) provide maps of integrated bait consumption per bait station, one area of each colony site with predator control during the 2021 *P. yelkouan* breeding season.

The pressure caused by predatory invasive rodents on all *P. yelkouan* colonies without baiting schemes (approximately 50%) as well as on most colonies of *C. diomedea* and all smaller colonies of *H. pelagicus* remains high, even at the small islet Fungus Rock (MT0000030). It is assessed as medium for sites were baiting schemes are currently in place, including Cominotto (MT0000017) and St Paul's Island (MT0000022). The offshore islet Filfla is currently the only Natura 2000 site in the entire Maltese islands where seabird colonies do not face any pressures by rat predation, however, an increasing risk of invasion remains one of the major threats for seabirds nesting on Filfla, specifically for the world's largest colony of *H. p. melitensis*.

Despite predator control, a nestling *P. yelkouan* was predated by rats at L-irdum tal-Madonna in 2021, the first case since 2007. In the small *P. yelkouan* colony in Ghar Hasan, all three accessible nests have been predated by rats in the 2021 breeding period. Nonetheless, with few accessible nests and sparse nest visits in many colonies without predator control, most predation events go undetected. Therefore, various other methods to detect rat pressure at each site such as rats seen in the colonies, rat signs other than predation (e.g., footprints and faeces), rats on camera trap imagery and bite marks on non-toxic wax blocks for biosecurity monitoring were utilized to get a more complete picture of the pressure rats exert on seabird colonies.

Fig. 21: Signs of rat presence in seabird colonies from right to left: bite marks on non-toxic wax-block, predated egg of *C. diomedea*, rat footprints next to footprints of *C. diomedea*.

Predation pressure by domestic or feral cats *Felis catus domestica*

Cats, both feral and domestic, predate on all life stages of seabirds. By taking also adult breeders and prospecting seabirds, cats can have a stronger impact on a population level. Cats and signs of cats such as footprints, camera trap imagery, prey remains, or faeces have been observed in 4 Natura 2000 sites within seabird colonies during the assessment periods, namely Rdum tal-Madonna (MT0000009), Majjistral NHP (MT0000024), Ras in-Newwiela (MT0000027) and Benghisa (MT0000033). Remains of one ringed adult breeding *P. yelkouan* found in a cave in Ras in-Newwiela and of one predated *P. yelkouan* chick in Rdum id-Delli in Majjistral NHP clearly point towards predation by cats (also confirmed by trail camera images). It is believed that the actual toll feral and domestic cats take on *P. yelkouan* and on *C. diomedea* is in reality much higher with a positive trend as the population of domestic and feral cats close to seabird colonies increases due to a growing human population, cat feeding stations, urban sprawl and development projects close to colonies. Thus, at least a medium pressure is currently exerted by feral and/or domestic cats on seabird colonies on Malta and Gozo while this threat for the same areas is evaluated as high if no strong monitoring scheme followed by adequate conservation actions is implemented.

Fig. 22: Remains of a ringed adult Yelkouan Shearwater predated by a cat at its nest site inside a sea cave at Ras in-Newwiela in May 2021.

Monitoring of light pollution

Light pollution was measured via sky quality meters (SQM) at seabird colonies in five Natura 2000 sites, three of them mainly targeting areas and time periods relevant for *P. yelkouan* and two for *C. diomedea*. Table 11 lists the exact location and deployment period of SQMs for each site.

Tab. 11: List of Natura 2000 sites with SQM deployed during the 2021 breeding period, main target species, deployment and retrieval dates, coordinates.

N2K site	**Location name**	**Target species**	**Code**	**Deployed**	**Retrieved**	**Latitude**	**Longitude**
MT0000009	Rdum tal-Madonna	*P. yelkouan*	MT09	2/4/2021	12/6/2021	35.994122	14.371269
MT0000017	Cominotto	*P. yelkouan*	MT17	17/05/2021	9/7/2021	36.013041	14.321426
MT0000024	Majjistral NHP	*P. yelkouan*	MT24	24/03/2021	11/6/2021	35.954726	14.339868
MT0000027	Ras in-Newwiela	*C. diomedea*	MT30	23/06/2021	5/8/2021	36.011528	14.261965
MT0000033	Halfar	*C. diomedea*	MT27	20/05/2021	27/07/2021	35.809828	14.505697

Temporary light pollution affecting the Majjistral NHP (MT0000024) and Rdum tal Madonna (MT0000009) colonies of *P. yelkouan* is mainly caused by bunkering vessels in the designated bunkering areas in front of the colonies. Colony attendance of adult Yelkouan Shearwaters has been shown to be negatively correlated with light pollution caused by bunkering events (Austad et al. in prep.), disrupting natural behaviour and leading to disturbance and potentially abandonment. In the areas, bunkering occurs mainly under conditions of strong easterly winds and swell for the Majjistral colony and strong westerly winds and swell for the Rdum tal-Madonna colony, respectively. Various bunkering events have been picked up by the SQMs at both sites during the 2021 breeding period (Figure 24).

Extended temporary light pollution is also caused by leisure crafts, tourist boats, and fishing vessels anchoring or fishing in front of seabird colonies at night. An example of a large leisure craft (MV H6.0) on anchor at Dwejra in the night of 04-08-2021, in breach of regulations by exhibiting excessive lights and illuminating the *C. diomedea* colony on Fungus Rock is given in Figure 23.

Fig. 23: A large leisure craft at anchor, exhibiting excessive lights at night, illuminating the *C. diomedea* colony on Fungus Rock during the 2021 breeding season, disrupting the birds' natural behaviour.

Ferries, including the recently introduced fast-ferry services between Valletta and Mgarr, boat-parties, and other vessels passing in front of the colonies at night are an additional source of light pollution, however their impact might be smaller as they light up the cliff face for shorter periods per event (see e.g. SQM for MT0000017), thus giving birds potentially the opportunity to exhibit natural behaviour in dark periods between the events.

Figure 24 presents the data of SQM of all five sites that have been monitored during the 2021 breeding season as values of relative darkness during the night (y-axes) versus date (x-axes). Lower y-values (black dots), indicate a brighter night-sky. Larger, standalone versions of the graphs are provided in Annex 2. The graphs clearly show periodic changes in illumination caused by the moon phases. Events with strong light pollution can be detected as lower darkness values (low peaks) on single nights that can reach and even exceed levels encountered during full moon.

Permanent light pollution poses a high pressure and threat to colonial seabirds in Malta and has led to abandonment of shearwater colonies or parts of them in the past (Borg pers. comm.). Due to an increase in urban sprawl, industrial, domestic and tourist sector related development as well as increased road infrastructure and insensible lighting schemes, permanent light pollution still shows a strong increase across the Maltese islands (Brincat & Pace, 2018). However, there is currently no system in place which is monitoring the increase of permanent light pollution across sensitive sites systematically over time.

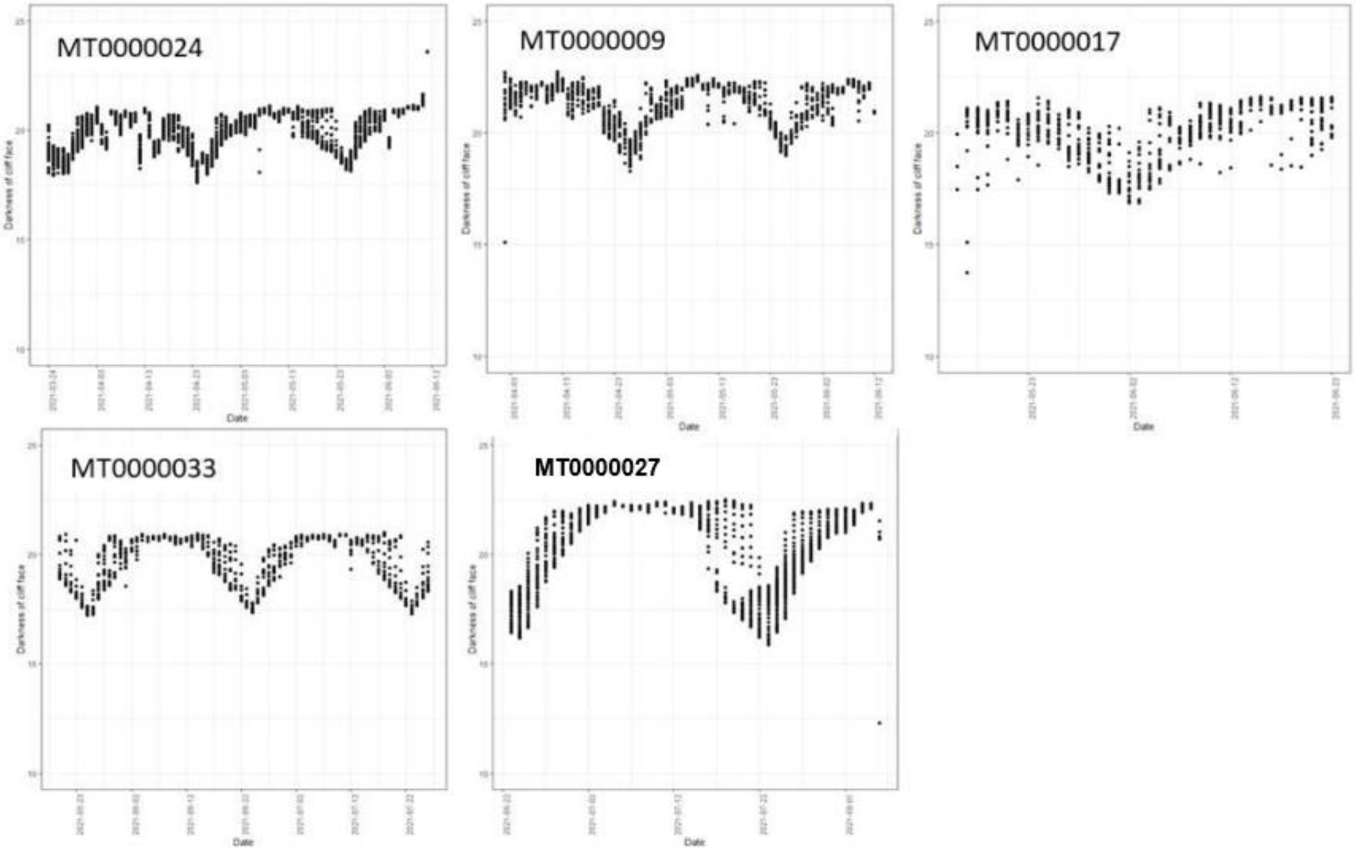

Fig. 24: Measure of SQM from 5 Natura 2000 sites inside or next to seabird colonies, deployed during the 2021 breeding period. Larger, standalone versions of the graphs are provided in Annex 2.

Fig. 25: Industrial buildings in direct vicinity to Natura 2000 sites and sensitive *C. diomedea* nesting areas at Hal Far (left, old) and Ghar Hasan (right, in recent years), exhibiting excessive lights towards the colonies at night. Pictures were taken during the 2021 breeding period.

Apart from the direct impact of light pollution on colony sites, seabird fledglings are attracted by artificial lights when leaving their nest site for the first time on their maiden flight and get grounded on land and die if not taken care of. Monitoring light induced groundings of seabird nestlings over the years has revealed a high and increasing trend of this pressure (especially after 2013) and highlighted various hotspots where grounding occurs more frequently (Crymble et al., 2020). As light pollution in the Maltese Islands is still on the increase, the threat for fledglings of all three species but especially the two shearwater species to get grounded by artificial light can be defined as high.

In the period July 1 to July 23, 11 grounded *P. yelkouan* fledglings were retrieved. This number appears high considering the overall poor breeding performance in 2021 and indicates that light induced grounding is still on the increase. However, with the early termination of fieldwork due to the timeline of the tender, no statistics of groundings are available for *C. diomedea* and *H. pelagicus melitensis* for the 2021 breeding season.

Monitoring of impact of fishing activities

There is strong indication that the pressures of fisheries on *C. diomedea* and *P. yelkouan* are high. However, as the tender at hand did not include any monitoring of this impact nor other impacts out at sea, the few data collected during the 2021 breeding period are anecdotal.

During a nest-check of the *P. yelkouan* colony at Ghar Hasan (MT0000033) on June 19, the chick of one of the nests was encountered in poor condition with a 2.5m long, strong monofilament line coming out of its beak (Figure 26). It succumbed to its injuries later and was predated by a rat, however, the line was recovered with a fishing hook at the end. It is likely that the parent had been by-caught when trying to eat the bait and the fisher had either cut the line or the line snapped. The bird must then have managed to fly with the line and the hook in its crop back to the nest and regurgitate the fish, hook and line feeding them to its chick.

Fig. 26: *P. yelkouan* chick with a 2.5m long fishing line coming out of its beak, Ghar Hasan, 2021 breeding season. The bird was weak and succumbed to internal injuries caused by the fishing hook it had swallowed.

One dead adult *P. yelkouan* that had swallowed a hook and line was found beached on Cominotto, while 22 *C. diomedea* were encountered by members of the public caught on hooks on a surface longline. 18 birds were still alive and could be released while 4 individuals died. These incidents were not encountered during monitoring work for this tender but point towards a potentially high bycatch risk for Maltese shearwaters, which requires further attention.

Other activities encountered regularly in various Natura 2000 sites include cliff-top fishing with sound and light disturbance at night, littering and open fires as well as lines left in place with a high risk of birds getting entangled, as has been reported in the past.

Various fishing activities were also recorded at night very close to the colonies, such as setting and hauling gillnets less than 300m off Filfla, net- and long-line setting in front of the colonies at Majjistral, Rdum tal-Madonna and various other sites. A large purse seiner with associated small boat was encountered fishing with two very bright lights on several occasions for entire nights presumably for Mackerel directly in front of the *P. yelkouan* colony of Blue Grotto and Wied Babu during the species' chick-rearing and fledging period.

All these incidences indicate that by-catch risk and disturbance by fishing activities could be high, and this potential pressure and threat certainly needs further assessment.

Seabirds are central place foragers during the breeding period, thus relying on resources in the vicinity of their colonies for energetic reasons. Depletion of fish-stock specifically forage fish in these areas means that food provisioning to their nestling and even self-maintenance might become compromised. Poor body condition of *P. yelkouan* fledglings and delayed fledging dates of the species in the 2021 breeding period both point towards an insufficient nutritional status, which in turn might mean a lack of food in reasonable distance to the colonies. It is not unlikely that this is linked to overfishing as a potentially high pressure and threat and requires further assessment in the future.

Monitoring of illegal hunting

During the monitoring period, two incidences of illegal killing were recorded. One involved two people shooting at and killing Scopoli's Shearwaters circling over land on their way into the colony east of Ghar Hasan (MT0000033) in the night of July 27. The suspects fled the scene before the police arrived. The other is indication of poaching at Gharb (MT0000030), where fresh cartridges and other signs of hunting were encountered in the sea cliffs, just on top of Ghar Jahra where all three seabird species breed, on June 7. It is likely that the poacher at Gharb was also targeting *C. diomedea*. Overall, higher surveillance effort would be required to assess, monitor, and stop illegal hunting of Maltese seabirds from land and out at sea. Even if the observed frequency of such incidences is low, they can have large detrimental impacts as they can involve many individuals at a time due to the gregarious behaviour of the species and add to the mortality of adults in the population.

Monitoring general pressures by Natura 2000 site visitors

Disturbance in the direct vicinity of seabird colonies is mainly caused by insensible behaviour of site users of Natura 2000 sites such as wild camping and campfires, anchoring with pleasure crafts in front of colonies, speeding, loud music, and loud boat engines, visiting sea-caves, boulder screes, and islets, sometimes also with dogs that are not on the leash. Overall, this is creating a medium strong pressure on nesting seabirds in the Maltese islands, however, in case visitors' management, surveillance and enforcement is not improved, this imposes a high threat as visitor numbers are on the increase as is the overall human population in Malta.

Monitoring threats caused by feral pigeons *Columba livia domestica*

In recent years the population of feral pigeons *C. livia domestica* in the sea-cliffs of most Natura 2000 sites, originating mainly from abandoned or lost racing pigeons and their offspring, has been continuously increasing. Feral Pigeons seem to show a niche overlap in nest sites with *P. yelkouan* and in several cases and at least two N2K sites (MT0000009, MT0000022) pigeon nests at various stages were encountered in nest sites that had been occupied by *P. yelkouan* earlier in the season. Furthermore, pigeons carry a large variety of pathogens and parasites that might impact seabirds nesting in direct proximity. Though the pressure is currently not considered high, the threat can be considered at least as medium high as the feral pigeon populations are rapidly increasing. There is currently increasing interest in the topic also outside Malta, as indicated in a recently uploaded pre-print by (Rodríguez et al., 2021). Further monitoring of pigeon populations in seabird colonies is recommended.

Indirect pressures and threats reinforcing main pressures

Littering and improper waste management

Mixed waste that is not disposed adequately, waste bins that are not ratproof and waste in overflowing bins, regularly left overnight, mean that an overabundance of food is created next to seabird colonies leading to a high density of rats (and feral cats). High population pressure then leads rats to emigrate and move into sea cliffs in the vicinity, where they predate on seabird eggs and chicks. Overflowing waste bins, left overnight were encountered at Rdum tal-Madonna next *to P. yelkouan* colonies during 80-90% of visits to the site.

Fig. 27: Example of overflowing waste bins at Rdum tal-Madonna (MT0000009).

Development in or close to N2K sites

Increased development and infrastructure such as roads, parking spaces, camping areas, hunting hides and other buildings next to seabird colonies in Natura 2000 sites without creating buffer areas, lead to an increase in most above listed pressures and threats such as higher rat and cat predation, cliff top fishing, disturbance and noise and light pollution.

Lack of or insufficient enforcement

Insufficient enforcement of rules and regulations such as Natura 2000 site regulations and legal notices to mariners increase the magnitude of the above-mentioned pressures and threats.

Tab. 12: *Detailed list of main of pressures by N2K site and estimated magnitude*

		Pressures										
N2K site code	**Species concerned**	**rats**	**cats**	**LP fixed**	**LP temp.**	**fishing land**	**fishing sea**	**illegal killing**	**boat disturb**	**land disturb**	**littering**	**feral pigeon**
MT0000009	*P. yel, C. dio, H. pel*	H	M	M	M	L	M	L	H	H	H	M
MT0000016	*C. dio, H. pel*	0	0	L	M	0	M	L	M	L	L	0
MT0000017	*P. yel, C. dio*	H	0	L	M	L	M	L	H	M	M	M
MT0000022	*P. yel*	H	0	M	L	L	M	L	H	L	M	M
MT0000024	*P. yel*	H	H	L	H	M	M	L	H	L	M	M
MT0000027	*P. yel, C. dio, H. pel*	H	H	L	L	L	M	M	L	M	M	L
MT0000028	*P. yel, C. dio*	H	L	L	L	M	M	M	L	M	H	L
MT0000029	*P. yel, C. dio*	H	L	M	L	M	M	M	L	M	L	L
MT0000030	*P. yel, C. dio, H. pel*	H	L	L	L	L	M	M	M	M	M	L
MT0000031	*P. yel, C. dio*	H	L	H	M	M	M	M	M	M	M	L
MT0000032	*P. yel, C. dio*	H	L	L	L	M	M	M	L	L	L	L
MT0000033	*P. yel, C. dio*	H	M	H	L	H	M	H	L	H	H	M
MT0000037	*P. yel, C. dio*	H	L	L	L	M	M	M	L	L	L	L
G1-Isopu	*P. yel*	H	M	L	L	0	M	L	L	L	L	M

Pressures: H = high; M = medium; L = low; 0 = none

To quantify each threat, the increase in direct and indirect pressures in recent years was extrapolated for most specific pressures (except illegal killing) at most sites. In the current scenario, with a strong increase in overall population pressure, site users in Natura 2000 areas, urban sprawl and associated light pollution, leisure crafts in direct vicinity to colonies, sea cave tourism and camping and littering, among others, it is almost certain that the pressures on Maltese seabird population will have increased towards the end of the current assessment cycle.

Tab. 13: *Detailed list of main threats by N2K site and projected magnitude*

		Threats										
N2K site code	**Species concerned**	**rats**	**cats**	**LP fixed**	**LP temp.**	**fishing land**	**fishing sea**	**illegal killing**	**boat disturb**	**land disturb**	**littering**	**feral pigeon**
MT0000009	*P. yel, C. dio, H. pel*	H	M	M	H	L	M	L	H	H	H	M
MT0000016	*C. dio, H. pel*	H	0	M	M	0	M	L	M	L	L	0
MT0000017	*P. yel, C. dio*	H	L	M	M	L	M	L	H	H	M	M
MT0000022	*P. yel*	H	L	M	M	M	M	L	H	M	M	M
MT0000024	*P. yel*	H	H	M	H	M	M	L	H	M	M	M
MT0000027	*P. yel, C. dio, H. pel*	H	H	M	M	M	M	M	M	M	M	M
MT0000028	*P. yel, C. dio*	H	M	M	M	M	M	M	M	M	H	M
MT0000029	*P. yel, C. dio*	H	M	M	M	M	M	M	M	M	M	M
MT0000030	*P. yel, C. dio, H. pel*	H	M	M	M	M	M	M	M	M	M	M
MT0000031	*P. yel, C. dio*	H	M	H	M	M	M	M	M	M	M	M
MT0000032	*P. yel, C. dio*	H	M	M	M	M	M	M	M	M	M	M
MT0000033	*P. yel, C. dio*	H	M	M	M	H	M	H	M	H	H	M
MT0000037	*P. yel, C. dio*	H	M	M	L	M	M	M	M	M	M	M
G1-Isopu	*P. yel*	H	M	M	L	0	M	L	L	M	L	M

Table 14 to 16 list the main pressures and threats for each of the three seabird species breeding in Malta, following EU Birds Directive Article 12 reporting requirements. This includes a ranking where only medium and high pressures and threats are listed as well as a coded location where each pressure or threat is active.

Tab. 14: *List of main pressures and threats for P. yelkouan, following BD Art. 12 reporting requirements including ranking, location, scope, and timing.*

Puffinus yelkouan								
Characterisation of Pressures and Threats		**Pressure**			**threat**			**timing**
Code	**Explanation**	**ranking**	**location**	**Scope**	**ranking**	**location**	**scope**	
E02	ship traffic, including bunkering	M	4	maj	M	4	maj	O/F
E08	noise and light pollution by vessels	M	4	maj	M	4	maj	O/F
F24	light & noise residential/ recreational sources	M	4	maj	H	4	maj	O/F

F25	light & noise industrial/ commercial sources	M	4	maj	H	4	maj	O/F
G01	impact of fisheries other than bycatch	H	1	whole	H	1	maj	O/F
G10	illegal killing	M	4	min	M	4	min	O/F
G12	bycatch	H	1	whole	H	1	maj	O/F
I04	Invasive and problematic species (rats, cats)	H	4	maj	H	4	maj	O/F

ranking: M = medium; H = high
location: 4 = inside the Member State; 3 = elsewhere in the EU; 2 = outside the EU; 1 = both inside and outside the EU; x = unknown
timing: P = in the past, O = ongoing, O/F = ongoing and likely to be in the future, F only in the future
scope: The proportion of the population affected (whole >90%, maj = majority 50-90%, min = minority <50%)

Tab. 15: *List of main pressures and threats for C. diomedea, following BD Art. 12 reporting requirements including ranking, location, scope and timing.*

Calonectris diomedea								
Characterisation of Pressures and Threats		**pressure**			**threat**			**timing**
Code	**Explanation**	**ranking**	**location**	**scope**	**ranking**	**location**	**scope**	
F24	Light & noise residential/ recreational sources	M	4	maj	H	4	maj	O/F
F25	Light & noise industrial/ commercial sources	M	4	maj	H	4	maj	O/F
G01	Impact of fisheries other than bycatch	H	1	whole	H	1	maj	O/F
G10	Illegal killing	M	4	maj	M	4	maj	O/F
G12	Bycatch	H	1	whole	H	1	maj	O/F
I04	Invasive and problematic species (rats, cats)	H	4	maj	H	4	maj	O/F

ranking: M = medium; H = high
location: 4 = inside the Member State; 3 = elsewhere in the EU; 2 = outside the EU; 1 = both inside and outside the EU; x = unknown
timing: P = in the past, O = ongoing, O/F = ongoing and likely to be in the future, F= only in the future
scope: The proportion of the population affected (whole >90%, maj = majority 50-90%, min = minority <50%)

Tab. 16: *List of main pressures and threats for H. pelagicus melitensis, following BD Art. 12 reporting requirements including ranking, location, scope and timing.*

Hydrobates pelagicus melitensis								
Characterisation of Pressures and Threats		**pressure**			**threat**			**timing**
Code	**Explanation**	**ranking**	**location**	**scope**	**ranking**	**location**	**scope**	
F24	Light & noise residential/ recreational sources	L	4	min	M	4	maj	O/F
F25	Light & noise industrial/ commercial sources	L	4	min	M	4	maj	O/F
I04	Invasive and problematic species (rats, gulls)	L	4	whole	H	4	maj	O/F
L01	Erosion of Filfla	L	4	whole	M	4	whole	O/F

ranking: M = medium; H = high
location: 4 = inside the Member State; 3 = elsewhere in the EU; 2 = outside the EU; 1 = both inside and outside the EU; x = unknown
timing: P = in the past, O = ongoing, O/F = ongoing and likely to be in the future, F = only in the future
scope: The proportion of the population affected (whole >90%, maj = majority 50-90%, min = minority <50%)

Distributional range, range size and trends of Maltese seabirds

For the assessment of the distributional range and range size, all surveyed colony locations were mapped. High resolution distribution maps differentiated by range certainty categories for each species and including SPA areas are provided in WGS84 (Figures 28a-30a).

The breeding distribution of each species was also mapped on the 1km² reference grid for Malta in ETRS89, provided by the European Environment Agency, EEA (https://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2) (Figures 28b-30b).

Two main certainty categories in categorizing distribution range were used following the methodology and definitions as per the latest MSFD assessment (Environment and Resources Authority, 2020):

"1" –Complete possible range based on adult birds calling in flight and suitable habitat. This category represents the total breeding range for the species. It has a medium confidence level in comparison to category 2.

"2" –Known nests or adults seen entering with thermal imaging camera or heard calling from inside nests. This category represents the distributional range where breeding was confirmed, and therefore has the highest confidence level.

Distributional range of *Puffinus yelkouan* for the 2021 breeding period

Due to the start of the tender's fieldwork period late into the season, not all suitable nesting habitat for *P. yelkouan* could be visited during the 2021 breeding season at a period which is suitable for mapping. Thus, the range and size assessment had to partially rely on data collected during previous years (2016-2019). Therefore, temporarily a third certainty category for range distribution was introduced (“3”), for areas that had been positively assessed recently but lacked an assessment in the current year of survey. However, within the sites that could be assessed during the 2021 period, no changes in distributional range could be detected as compared to previous years. Figure 28 maps the entire *P. yelkouan* breeding distribution in the Maltese islands differentiated by certainty categories.

The breeding distribution area

The breeding distribution area size for *P. yelkouan* was assessed as the number of occupied grid cells (EEA 1km²), including all three certainty categories. The total breeding distribution area size for *P. yelkouan* amounts to 64 occupied 1km² grid cells, of which 33 are located on Malta, 25 on Gozo, 5 on Comino, and 1 on St Paul’s Island.

Trends in breeding distribution of *P. yelkouan*

Short-term (last 12 years): The apparent positive short-term trend in the distribution of *P. yelkouan* in the Maltese islands can be entirely attributed to the increase in monitoring and assessment effort and thus improved knowledge of the species’ distribution, e.g. the discovery in 2013 that the species is still nesting on St Paul’s Island. We therefore abstain from giving a magnitude of this apparent trend.

Long-term (since 1-980): The heterogeneity in data quality regarding the distribution range of *P. yelkouan* in Malta before 2013 does currently not allow for a long-term trend assessment.

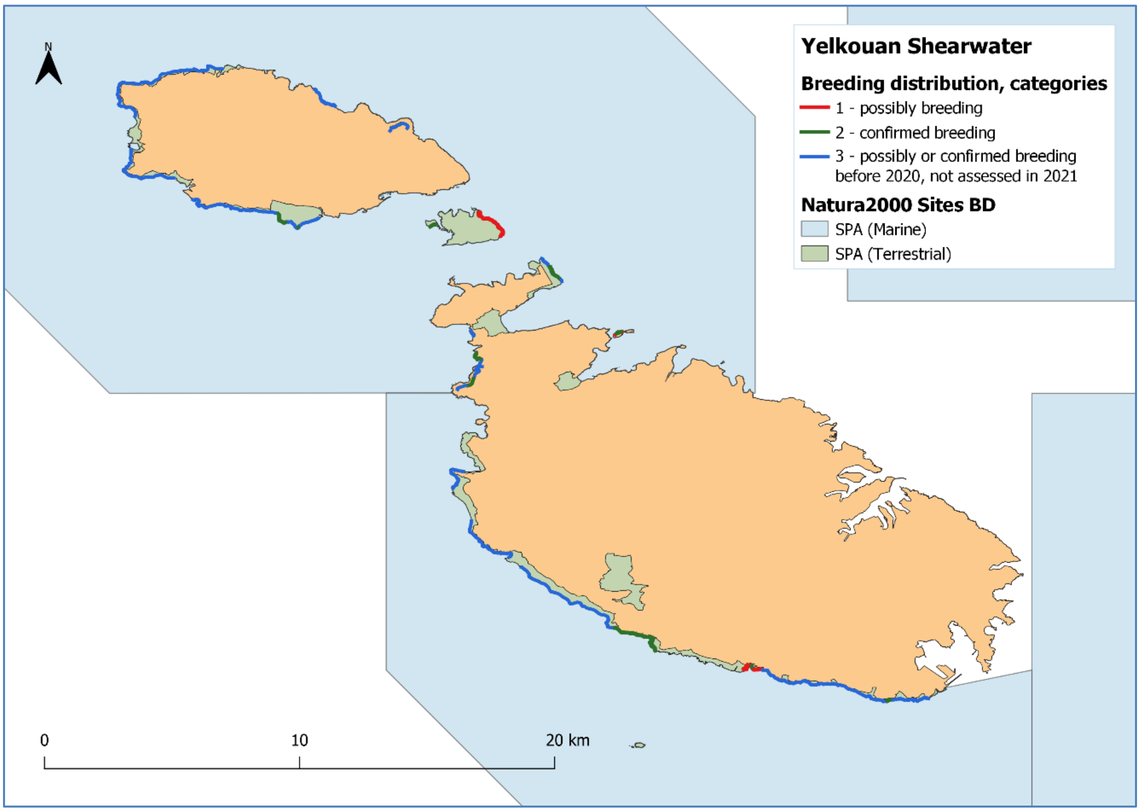

Fig. 28a: Mapped breeding distribution of *P. yelkouan* in the Maltese Islands including range certainties, Natura2000 Sites (WGS84; coastline 2018, provided by the Mapping Unit, Planning Authority).

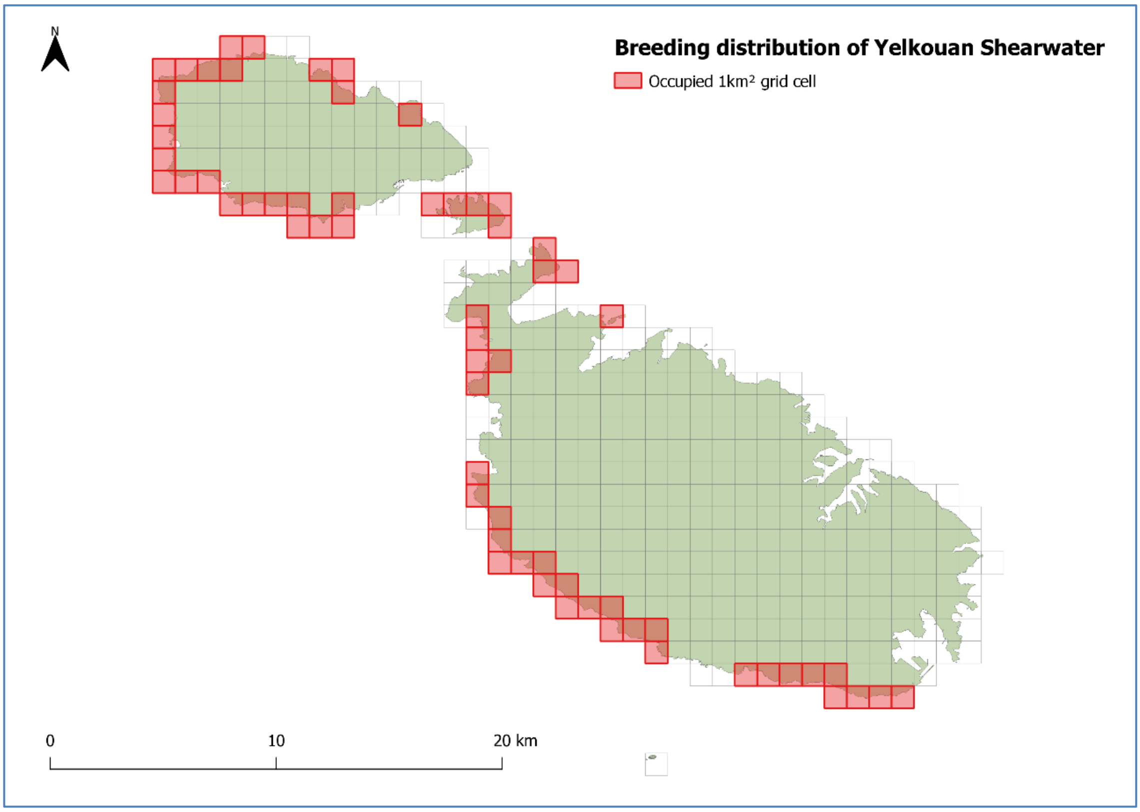

Fig. 28b: Range size of *P. yelkouan* (Species Code: A464) breeding distribution in the Maltese Islands as occupied 1km² grid cells (ETRS89; coastline 2018, Mapping Unit, Planning Authority; grid provided by EEA).

Distributional range of *Calonectris diomedea* for the 2021 breeding period

All suitable nesting habitat for *C. diomedea* was visited during the 2021 breeding and assessed with a variety of methods (see chapter on population abundance), however not all sites could be covered with the same effort. Thus, the range and size assessment had to partially rely on data collected for the previous assessment. No changes in distributional range were detected as compared to previous the latest MSFD assessment. Figure 29 maps the entire *C. diomedea* breeding distribution in the Maltese islands, differentiated by certainty categories.

The breeding distribution area

The breeding distribution area size for *C. diomedea* was assessed as the number of occupied grid cells (EEA 1km²), including both certainty categories. The total breeding distribution area size for the species amounts to 57 occupied 1km² grid cells, of which 30 are located on Malta, 24 on Gozo, 2 on Comino, and 1 on Filfla.

Trends in breeding distribution of *C. diomedea*

Short-term (last 12 years): The apparent positive short-term trend in the distribution of *C. diomedea* in the Maltese islands can be entirely attributed to the improved knowledge, specifically the discovery of nesting areas in the north of Gozo, east of St Dimitri Point after 2010. We therefore abstain from giving a magnitude of this apparent trend.

Long-term (since 1980): The heterogeneity in data quality regarding the distribution range of *C. diomedea* in Malta since 1980 does not allow for an adequate long-term trend assessment. It appears however though, that due to development (urban sprawl) increasing light pollution and disturbance towards cliff edges above colonies, e.g. at Hal Far and in general increased human pressure next to breeding sites has led to a reduction in suitable nesting range in the boundaries of colonies and an abandonment of nest sites specifically close to the cliff tops (Borg pers. comm.).

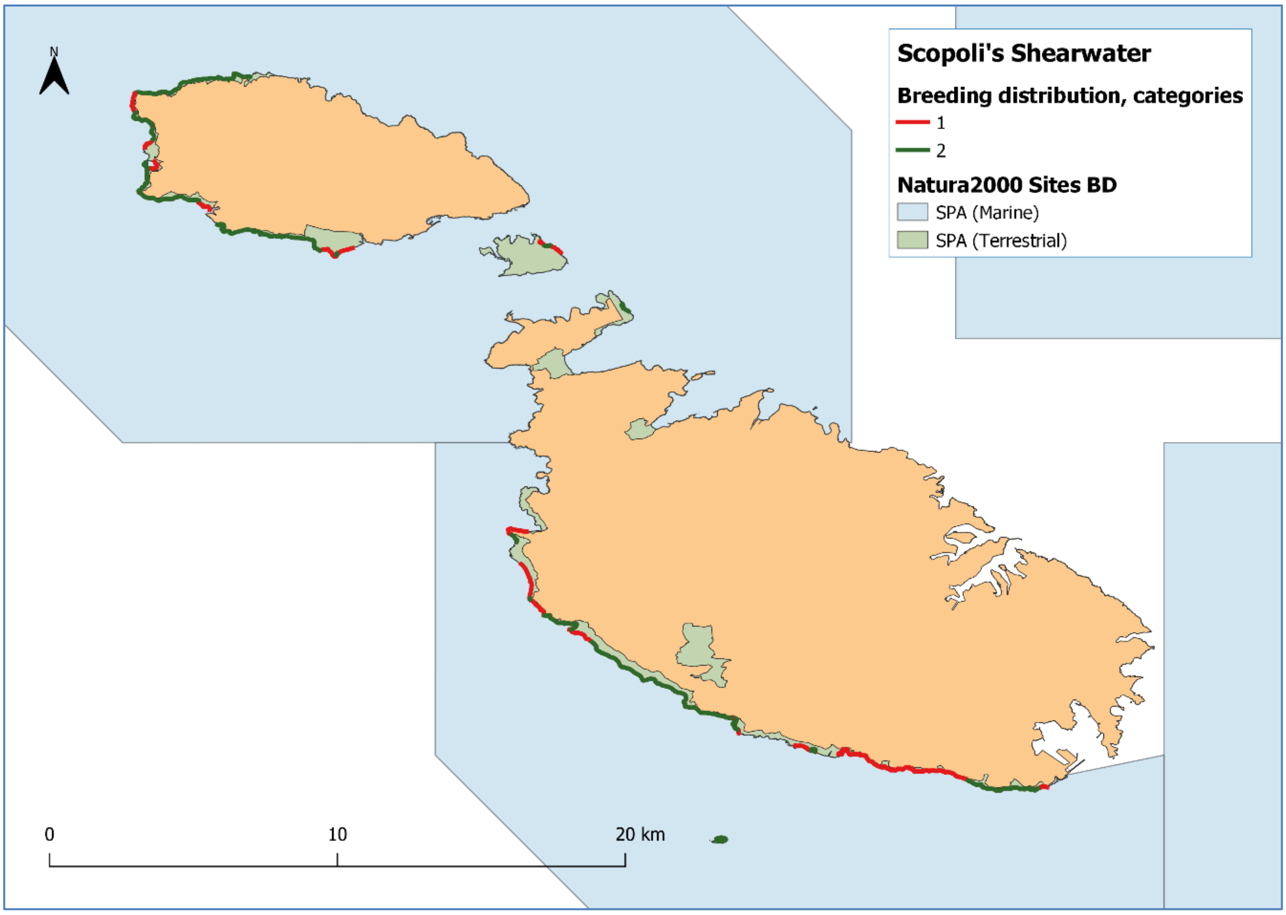

Fig. 29a: Mapped breeding distribution of *C. diomedea* in the Maltese Islands including range certainties, Natura 2000 sites (WGS84; coastline 2018, provided by the Mapping Unit, Planning Authority).

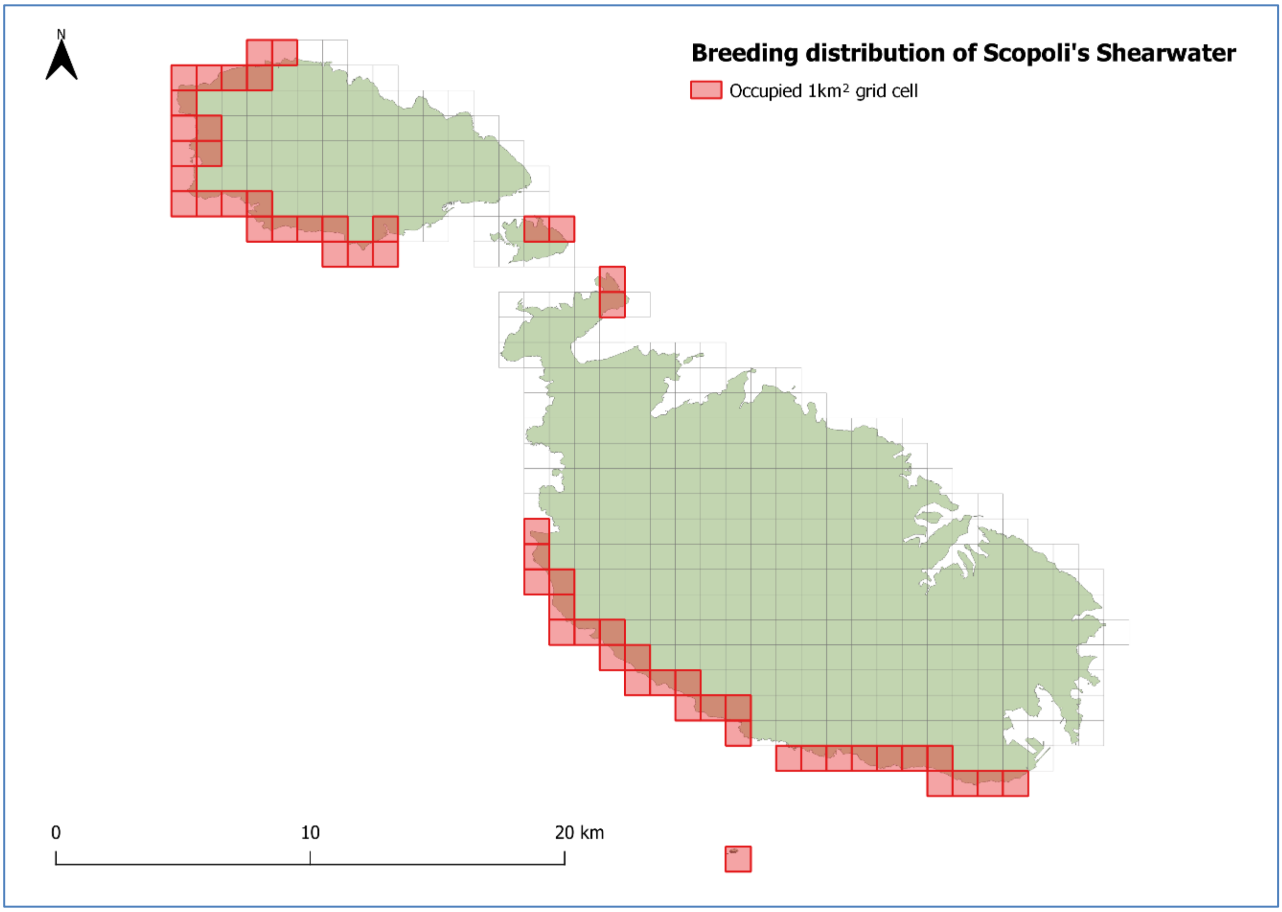

Fig. 29b: Range size of *C. diomedea* (Species Code: A850) breeding distribution in the Maltese Islands as occupied 1km² grid cells (ETRS89; coastline 2018, Mapping Unit, Planning Authority; grid provided by EEA).

Distributional range of *H. pelagicus melitensis* for the 2021 breeding period

All suitable nesting habitat for *H. p. melitensis* was visited during the 2021 breeding season, however, due to the secretive nature of the species it cannot be excluded that additional small colonies are still to be discovered. Despite a positive population trend for the species on Filfla, no changes in distributional range were detected as compared to the previous MSFD assessment. Figure 30 maps the entire *H. p. melitensis* breeding distribution in the Maltese islands.

The breeding distribution area

The breeding distribution area size for *H. pelagicus melitensis* was assessed as the number of occupied grid cells (EEA 1km²). The total breeding distribution area size for the species amounts to 7 occupied 1km² grid cells, of which 5 are located on Gozo, 1 on Malta, and 1 on Filfla.

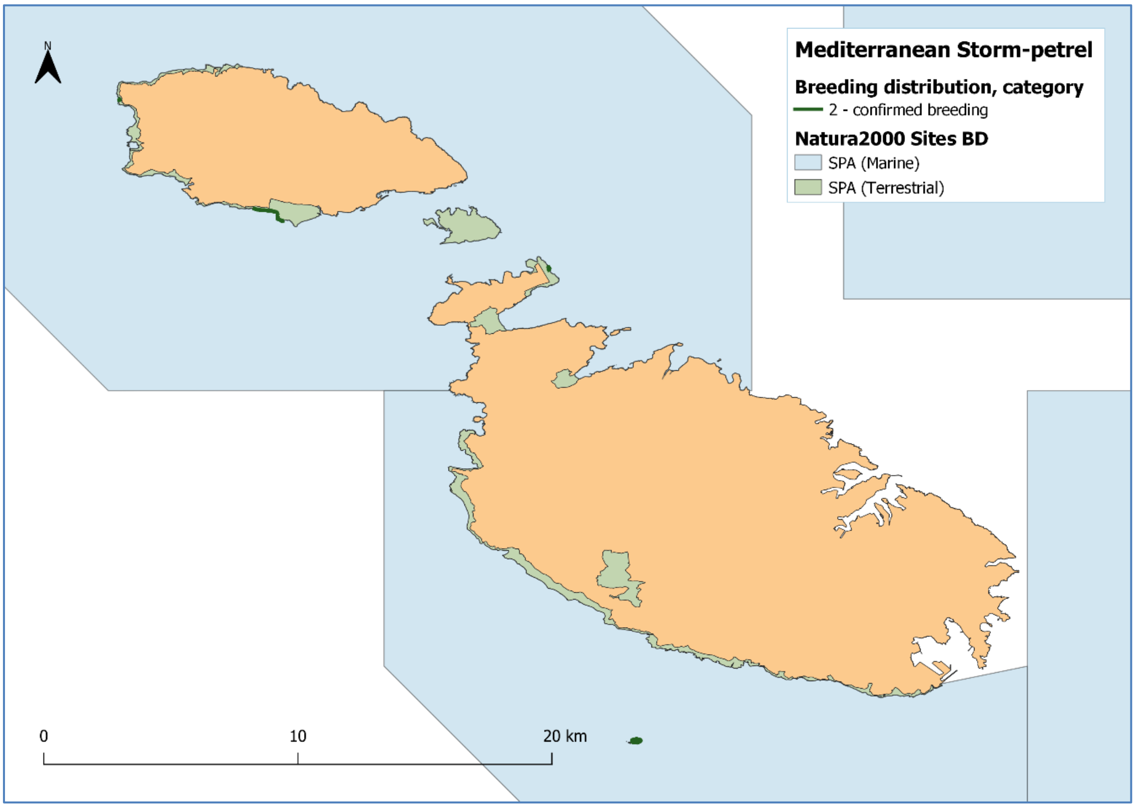

Fig. 30a: Mapped breeding distribution of *H. pelagicus melitensis* in the Maltese Islands, including range certainty, Natura 2000 Sites (WGS84; coastline 2018, Mapping Unit, Planning Authority).

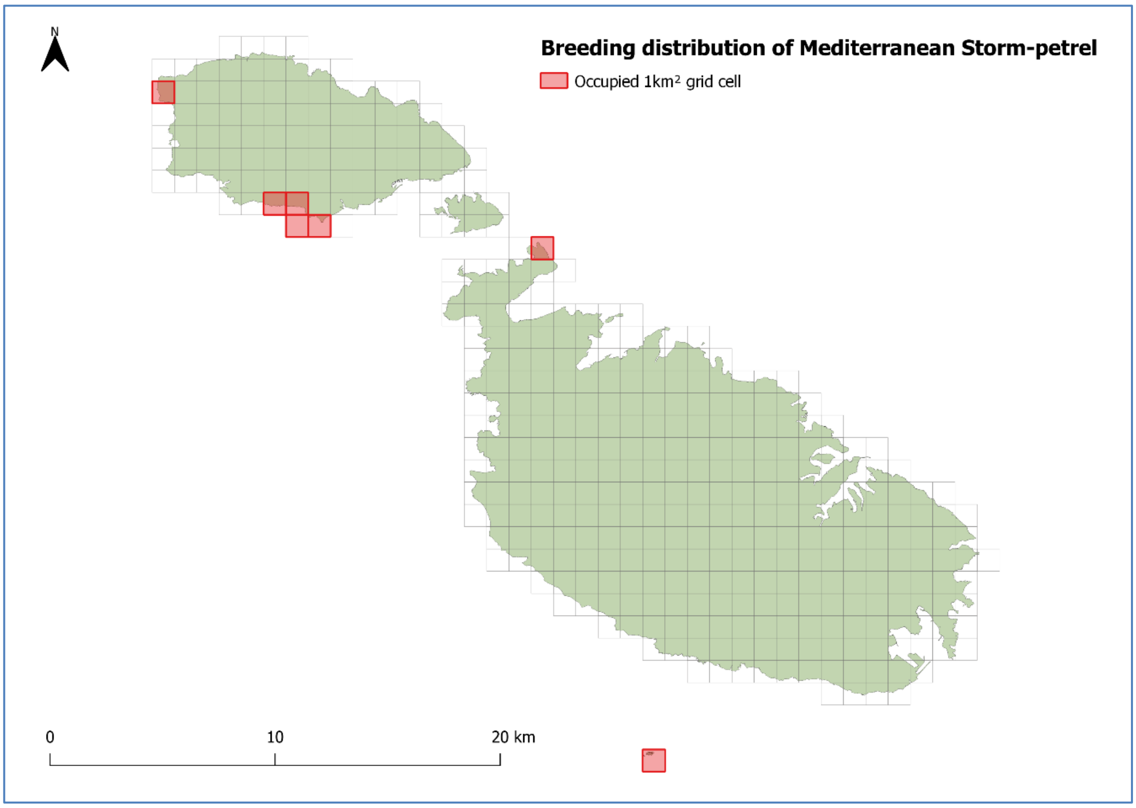

Fig. 30b: Range size of *H. pelagicus melitensis* (Species Code: A014) breeding distribution in Malta as occupied 1km² grid cells (ETRS89; coastline 2018, Mapping Unit, Planning Authority; grid provided by EEA).

Assessment and conclusions of distribution pattern

It was briefly assessed whether the species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic, and climatic conditions:

There is no doubt that the current distributional range in the Maltese islands for all three species inside and outside Natura 2000 sites is far from the pattern that would be in line with prevailing physiographic, geographic, and climatic conditions. The distribution pattern that is currently found has been shaped directly or indirectly by human pressures. This means that the breeding distribution range has been strongly reduced by factors such as habitat modification, harvesting of all life cycle stages (eggs, chicks, adults) for human consumption and use as bait in historic times, disturbance, light pollution, urbanisation and especially the introduction and population maintenance of problematic predatory species such as rats as well as feral and domestic cats and dogs. In some areas outside the Maltese islands where these pressures are lower or absent all three species breed also on top of the cliffs, in rubble walls, in dug burrows in areas covered by vegetation, and in cliffs or sloping bolder screes much further inland. The fact that in historic times *P. yelkouan* used to nest on the top of Selmunett and in the south-facing areas opposite of St Paul's Bay (Stenhouse's correspondence in (Sultana et al., 2011)), which are now heavily impacted by light pollution, is just one example for a reduction in distributional range.

The reason that the breeding range of *H. pelagicus melitensis* is currently almost exclusively restricted to Filfla can be attributed to the fact that in the vast majority of otherwise suitable nesting habitat the pressure caused by small mammalian predators, introduced, and maintained by humans is too high for the species to maintain viable populations.

Habitat quality and quantity

For the current populations of any of the three Maltese seabird species, the physical breeding habitat quantity appears to be not the limiting factor to support relevant life history stages that are associated to the Natura 2000 sites on land.

The entire known Maltese breeding populations of *C. diomedea* and *H. p. melitensis* and a large proportion of the Maltese breeding population of *P. yelkouan* (>96%) are nesting inside the Natura 2000 network, most of them in SPA. In most accessible communal nest caves for both *P. yelkouan* and *C. diomedea* not all nest locations are occupied in any given year, including 2021. At least for *P. yelkouan* it is known that the adult annual survival rate and the reproductive success are currently too low for the population to recover in the long-term. In case habitat quantity was of concern, we would expect to observe more density related pressures such as stress from seabirds nesting close to each other, more frequent fights for nest sites and a large proportion of first-attempt breeders not able to find a suitable nest site. Additionally, the Storm-petrel population on Filfla would be expected to reach capacity on the islet and expand and recruit into suitable nest-sites of other Maltese islands. However, despite some indication of prospecting at various new sites, colonisations of such sites fail because of constraints in nesting habitat quality, in this case the presence of problematic native species such as rats.

Therefore, it is presumably mainly the overall habitat quality not being high enough to provide suitable conditions for Scopoli's Shearwaters (declining) and Yelkouan Shearwaters (VU) as well as for Storm-petrels in sites other than Filfla to thrive and to exhibit population growth and expansion in breeding range.

Alternatively, the habitat quality outside the breeding period or in the main foraging grounds are at least partially responsible for the low adult annual survival rate and for the poor reproductive performance respectively. Due to their high mobility and flexibility to exploit food resources out at sea, it is equally unlikely that the at-sea habitat quantity is an issue for Maltese seabirds, but rather the habitat quality e.g. with provision of profitable feeding grounds. The foraging and rafting areas offshore however are not part of the tender at hand.

The pressures listed as medium and high in the tables of the relevant chapter are all directly or indirectly impacting the quality of the Natura 2000 habitats. Therefore, working on removing or reducing these pressures can certainly improve the habitat quality in the nesting areas of all three seabird species. Most relevant for the improvement of habitat quality at colony sites are listed here briefly:

1. The removal/ management and biosecurity measures of problematic invasive predatory species, such as cats and rats from the majority of Natura 2000 sites. This includes the improvement of mixed and organic waste management close to seabird colonies to keep rat populations low in the first place.
2. A significant reduction of temporary and permanent light pollution inside and in the vicinity of relevant Natura 2000 sites and at grounding hotspots outside the protected areas, at least during the fledging periods of all three seabird species.
3. The effective reduction of man-made disturbance and the improvement of visitors' management with the creation of buffer areas around seabird nesting sites, including the seaward extensions regarding boating, fishing, and other detrimental recreational and commercial activities in the vicinity of seabird colonies.

International Species Action Plans and Management plans for Natura 2000 sites

BD - Progress made in international Species Action Plans (SAPs)

An International Single Species Action Plan has been developed for P. yelkouan as part of the preparatory LIFE EuroSAP (LIFE14 PRE/UK/000002) led by BirdLife International (Gaudard, 2018). It was finalized in 2018 with the aim of improving the conservation status of the species across its range in a ten-years period. Here we assess which parts of it have been implemented and which results have been achieved for the Maltese *P. yelkouan* population so far.

According to the SAP, the general goal of the action plan is to prevent the Yelkouan Shearwater breeding population from further declining and accomplish a significant and measurable improvement in the species status by achieving the following objectives:

- To protect the population of Yelkouan Shearwater in its main breeding colonies. To achieve this goal, it is important to identify the main breeding colonies, rafting and feeding areas adjacent to the colonies as marine Important Bird Areas (IBAs) and to declare them as protected areas. – *This has been widely achieved in Malta before 2018.*
- To mitigate major threats at sea and on land responsible for the population declines. – *This has been partially achieved on land with predator control being carried out in 5 areas, four*

of which are N2K areas accounting for approximately 50% of the Maltese breeding population. However, threats at sea are believed to be still inadequately mitigated.

- To conduct research in areas where there is a significant knowledge gap about the breeding status and the distribution of the species at all stages. Actions should aim at reducing adult mortality, increasing breeding success through a better understanding of the impact of the threats, assessing adult survival and breeding success in all the colonies, promoting mitigation measures in policy and raising public awareness about the species and sea birds in general. – *ongoing, currently with LIFE PanPuffinus! (LIFE19 NAT/MT/000982) led by BirdLife Malta.*

Goal of the SAP is to restore the species to a Least Concern status (global IUCN Red List) with the following objectives:

1. To increase adult survival up to ≥92% and breeding success up to ≥75% (Louzao et al., 2006) – *currently not achieved in Malta.*
2. To improve breeding habitat quality within 10 years and foraging habitat quality in the long term – *currently partially achieved for some of the breeding habitats in the N2K sites on land; currently not achieved for the foraging habitat quality at sea.*
3. Acquire more information on the species' distribution and numbers in order to be more confident about its status – *ongoing (see report at hand).*

Expected results at the end of the SAP period (2027):

Result 1.1. Average adult survival rate is close or over 92% - *currently not achieved.*

Result 1.2. Average breeding success rate is close or over 75% - *currently not achieved.*

Result 2.1. Conservation of breeding habitat is ensured – *widely achieved theoretically as >90% of the species' population nests in N2K, implementation on ground so far insufficient and pressures on breeding habitats increasing.*

Result 2.2. Conservation of marine habitat (foraging and congregating areas) is ensured – *coastal and offshore mSPA for species designated but management plans not yet finalized nor implemented.*

Result 3.0. Knowledge gaps are filled – *ongoing.*

Apart from the International Single Species Action Plan, a **National Single Species Action Plan** was developed for *P. yelkouan* as action E5 of LIFE Arċipelagu Garnija (LIFE14 NAT/MT/991) led by BirdLife Malta (Sahin et al., 2020).

Management plans for Natura 2000 sites

Management plans are available for all Natura 2000 sites on land in which the three seabird species nest and all of them list the relevant colonies of the species and conservation action. Relevant information has been submitted to ERA by BirdLife Malta regarding Natura 2000 sites which are currently declared SAC and for which the seabird colonies would trigger SPA status, namely Majjistral NHP (MT0000024) and Selmunett (MT0000022) and their final recognition as SPA is currently pending. Management activities such as predator control in the vicinity to colonies have been implemented in a number the SPAs, with further implementation required in others.

Legal notices to mariners have been published, implemented and enforced by TM for the sea areas in the vicinity of some colonies (e.g. speed limit in Selmunett channel) but further improvement in the implementation process may be required.

Further MT has designated eight marine SPAs, based on research carried out under the LIFE+ Malta Seabird Project (LIFE10 NAT/MT/090) for the three seabird species within the Maltese FMZ (25m). Following conservation orders and measures have been drafted and were recently issued for public consultation in line with the requirements of the EU Nature Directives.

Conservation measures

Request to relevant authorities to share data on conservation measures

Even with the high effort of monitoring the various seabird colonies in all Natura 2000 sites during the 2021 breeding period, it was not possible for the fieldwork team to gather significant knowledge and statistics on conservation measures taken to curb problematic site user behaviour such as breaches of local Nature legislation, breaches of legal notices to mariners and alike. Therefore, we requested additional intelligence and statistics from the authorities and park administrations regarding the surveillance, implementation and enforcement of Natura 2000 site legislation, enforcement of legal notices to mariners, statistics on site visitor behaviour, site warden hours in the field, statistics on breaches and fines issued, but also statistics on bunkering activities among others.

In July, official requests with an endorsement letter provided by ERA were sent to TM, AFM, the police, AM and Majjistral Park Management. Unfortunately, no data were provided by any of the entities by the time when the report at hand was finalized. Therefore, the assessment of some of the conservation activities carried out by the above-mentioned entities inside Natura 2000 sites and/or adjacent areas might be incomplete.

Raising of awareness and appreciation with the aim of improving behaviour of the public

Countless activities have been carried out by BirdLife Malta to raise the profile and general awareness of the seabird species in Malta such as shearwater boat trips for the public to rafting areas at sunset in front of Ta’ Cenc (MT0000027), site clean-ups e.g. at Rdum tal-Madonna (MT0000009), evening walks to listen to shearwater calls at Majjistral (MT0000024) attending relevant TV, radio programs and Science in the City, video clips regarding the problem of light pollution for shearwater fledglings to become grounded, public talks about seabird conservation at UM and elsewhere, leaflets to boat operators and tourists among others. Such activities are ongoing, currently widely under the umbrella of the current Project of LIFE PanPuffinus! (LIFE19 NAT/MT/000982). For all past EU-LIFE projects on seabirds in Malta, statistics on public awareness revealed by surveys pre- and post-implementation of each project are available at BirdLife Malta.

Implementation of predator control

Since 2007, control of predatory rodents (mainly *R. rattus*) by means of toxic bait (anti-coagulant) presented in defined bait stations has been carried out at Rdum tal Madonna (MT0000009) and in 4 additional sites, 3 of them N2K, since 2017. The activities are mainly targeting colonies of *P. yelkouan* (Majjistral NHP – MT0000024, Selmunett - MT0000022, Comino and Cominotto - MT0000017, and at Isopu military base) together accounting for approximately 50% of the Maltese *P. yelkouan* population. Predator control has significantly increased reproductive performance at most sites and for most years. It is carried out each reproductive season of *P. yelkouan*, however no such predator control is currently implemented for larger *C. diomedea* colonies nor for the small *H. pelagicus* colonies on Gozo. Biosecurity monitoring with non-toxic wax-blocks is carried out in most sites, including Fungus Rock and Filfla, but so far, no additional actions have been taken where rat invasion or reinvasion occurred (e.g Fungus Rock). No control of other problematic native species, specifically of feral or domestic cats have been implemented in any Natura 2000 site.

Implementation of mitigation measures against accidental bycatch

Tackling the issues related to incidental by-catch of seabirds in the Malta is at an early stage with LIFE PanPuffinus! (LIFE19 NAT/MT/000982) currently carrying out research on the topic including on-board surveys and questionnaires to fishers. It is foreseen that concrete conservation actions will be implemented towards the second half of the project's timeline.

Site-management, site-user guidance and enforcement at land

Majjistral NHP (as part of MT0000024) is currently either the only or one of very few Natura 2000 sites in the Maltese Islands with a functional ranger system in place, employed and managed by the park's administration, however the rangers are mainly on foot and have a large area and large list of tasks to cover.

Littering and insufficient waste management, fly-tipping, wild camping and open fires, cliff-top fishing with lights as well as leaving lines in place creating the risk of entanglement remain rampant in the majority of relevant Natura 2000 sites and illegal killing of shearwaters at night remains a pressure in some of them, all of which highlights the need for effective management in these areas, including surveillance, nature warden presence, education and enforcement.

Site-management, site-user guidance, and enforcement at sea

During the implementation phase of LIFE Arċipelagu Garnija (LIFE14 NAT/MT/991) BirdLife Malta published a code of conduct for commercial boat operators with the aim of improving behaviour of this group of stakeholders towards sensitive seabirds in rafts and close to the colonies in sea cliffs.

https://birdlifemalta.org/wp-content/uploads/2020/09/LIFE-Arcipelagu-Garnija_Code-of-conduct-for-commercial-boat-operators.pdf

Currently, no statistic is available regarding the effect of this conservation action. Transport Malta is the main entity at sea enforcing legal notices to mariners including those related to Natura 2000 sites and sensitive breeding sites of seabirds. TM staff with RIBs were seen on various occasions approaching vessels in breach of LNM and also responded to a call when a group of jet-ski users approached Filfla. However, it appears that their presence is focusing more on the areas along the northern coast of Malta (MT0000022, MT0000009) as well as Blue Lagoon and Santa Maria Bay (MT0000017) and less on areas along the southwest coast and around Gozo. Furthermore, the RIBs have been mainly spotted during the day and it is not clear how much surveillance and enforcement is carried out at night-time when the colonies are more sensitive to disturbance by light and noise pollution.

Implementation of mitigation measures against light pollution

For many years now, BirdLife Malta has campaigned to safe seabird fledglings that become disoriented and grounded due to artificial light and has mapped the hotspots where these events are more likely. Over the years, hundreds of grounded fledglings have been taken care of, ringed and released back at sea, including 11 grounded *P. yelkouan* fledglings during the 2021 breeding period. As part of LIFE Arċipelagu Garnija (LIFE14 NAT/MT/991), three publications were released with the aim to tackle different aspects on the way to reduce light pollution, also working closely together on the issue with the national Light Pollution Awareness Group (Brincat & Pace, 2018; Crymble, 2019; Crymble & Austad, 2018).

Lighting in some places has improved as part of conservation actions carried out by LIFE Arċipelagu Garnija (LIFE14 NAT/MT/991), for example at Cirkewwa ferry terminal (opposite Cominotto colony, MT0000017) and Isopu military base. However, the situation has deteriorated in other places, e.g. Ghar Hasan, Half Far (MT0000033) and at Buggiba, Qawra and St. Paul's Bay (opposite MT0000009, MT0000022). Overall, there is strong indication that light pollution in the Maltese islands is still increasing strongly and rapidly and that seabirds both, in their colonies and when fledging, continue to be increasingly affected by it.

Tab. 17: *List of main conservation actions as per N2K site according to BD Art. 12 codes.*

		Main conservation measures			
		CI01 **Reduce impact of**		**CF03 Reduce impact of**	**CF09 Reduce impact of**
N2K site code	**Species concerned**	**Rats**	**Cats**	**Leisure activities**	**Light & noise**
MT0000009	*P. yel, C. dio, H. pel*	Y	N	P	P
MT0000016	*C. dio, H. pel*	NA	NA	Y	P
MT0000017	*P. yel, C. dio*	Y	N	P	p
MT0000022	*P. yel*	Y	N	P	P
MT0000024	*P. yel*	Y	N	Y	P
MT0000027	*P. yel, C. dio, H. pel*	N	N	N	N
MT0000028	*P. yel, C. dio*	N	N	N	N
MT0000029	*P. yel, C. dio*	N	N	N	N
MT0000030	*P. yel, C. dio, H. pel*	N	N	N	P
MT0000031	*P. yel, C. dio*	N	N	N	N
MT0000032	*P. yel, C. dio*	N	N	N	N
MT0000033	*P. yel, C. dio*	N	N	N	N
MT0000037	*P. yel, C. dio*	N	N	N	NA
G1-Isopu	*P. yel*	Y	N	NA	Y
Total scope	*P. yelkouan*	a)	NA	a)	a)
Total scope	*C. diomedea*	a)	NA	a)	a)
Total scope	*H. pelagicus*	a)	NA	a)	a)

Implementation: Y = yes; N = no; P = partially, insufficient, NA = not applicable
Scope: measures impact a) <50%; b) = 50-90%; c) >90% of the Maltese population

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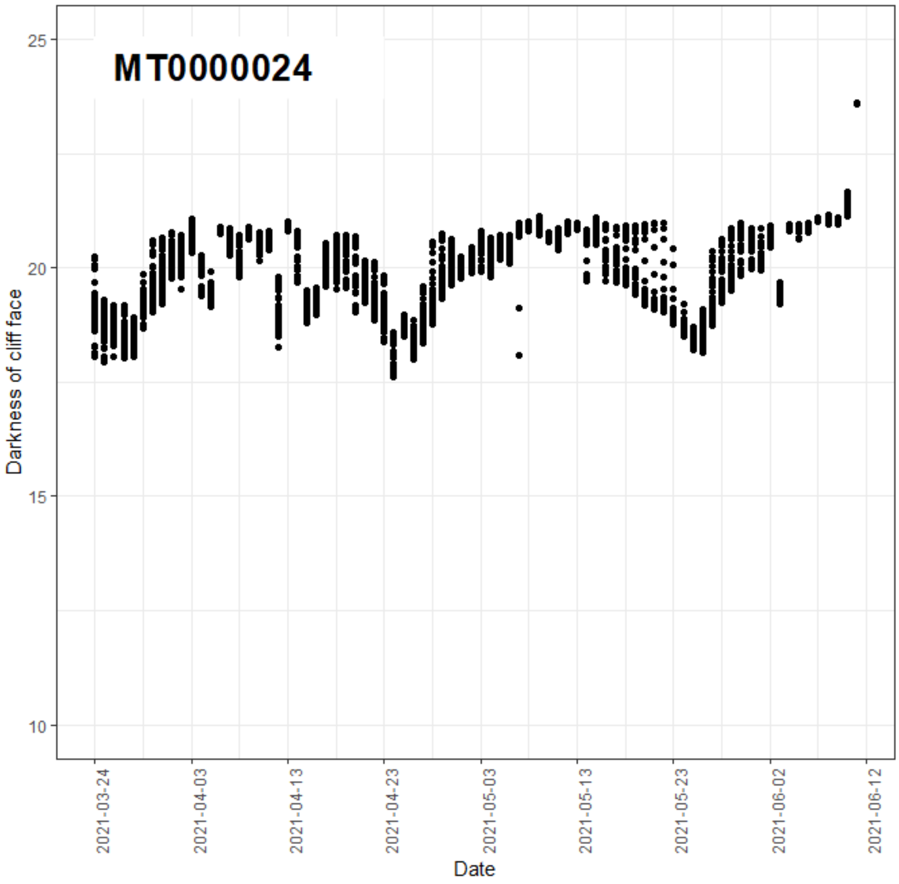
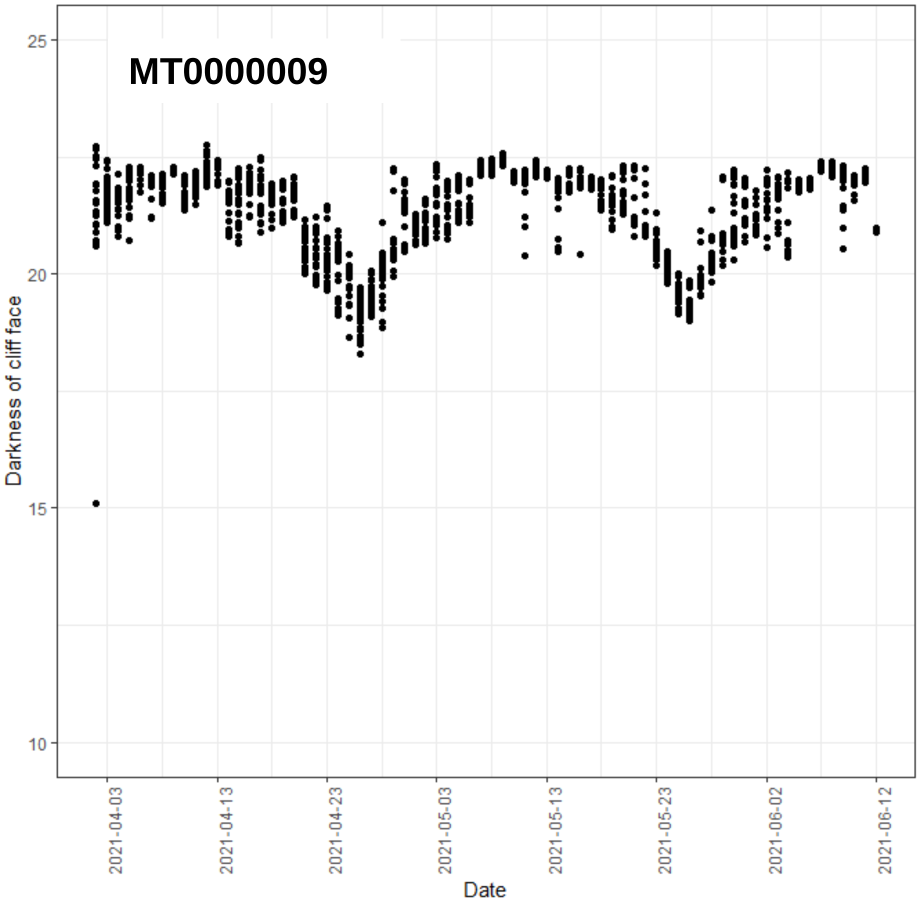
Annex 1: Photomapping examples

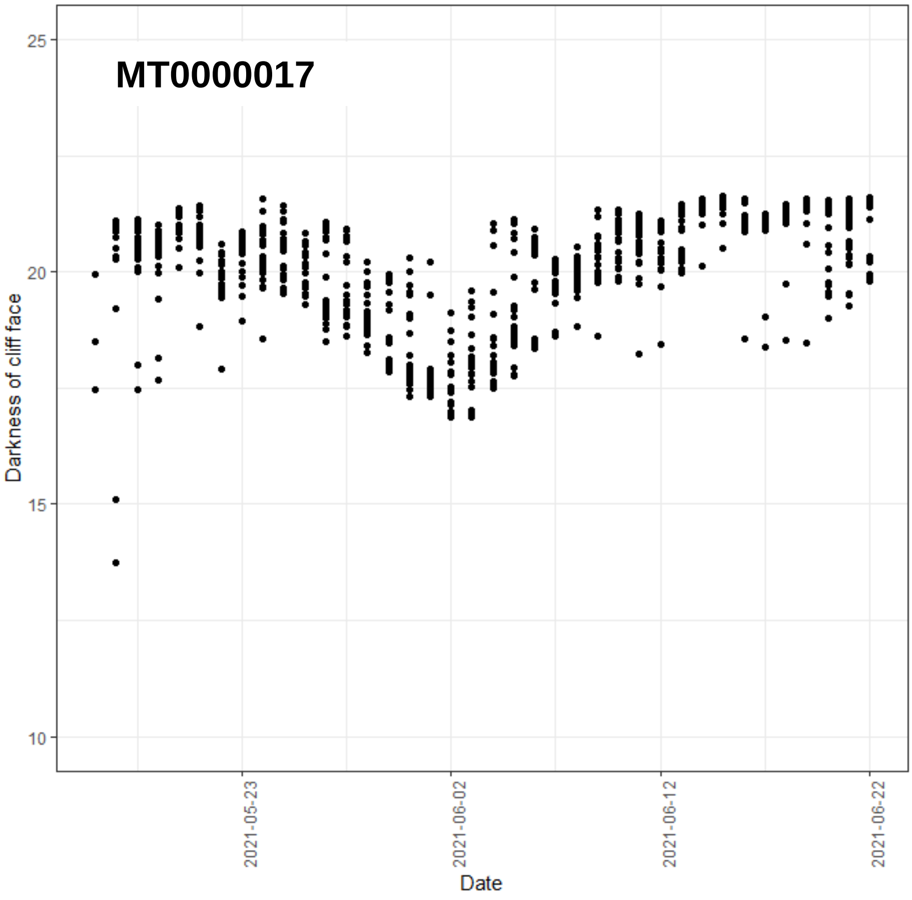
Figures in annex 1 have been removed in view of sensitivity. Please contact the Environment and Resources Authority for further clarification

Annex 2: SQM measurement graphs for five sites as obtained in 2021.

Enlarged versions of graphs presented in Figure 24



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Darkness of cliff face
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20
15
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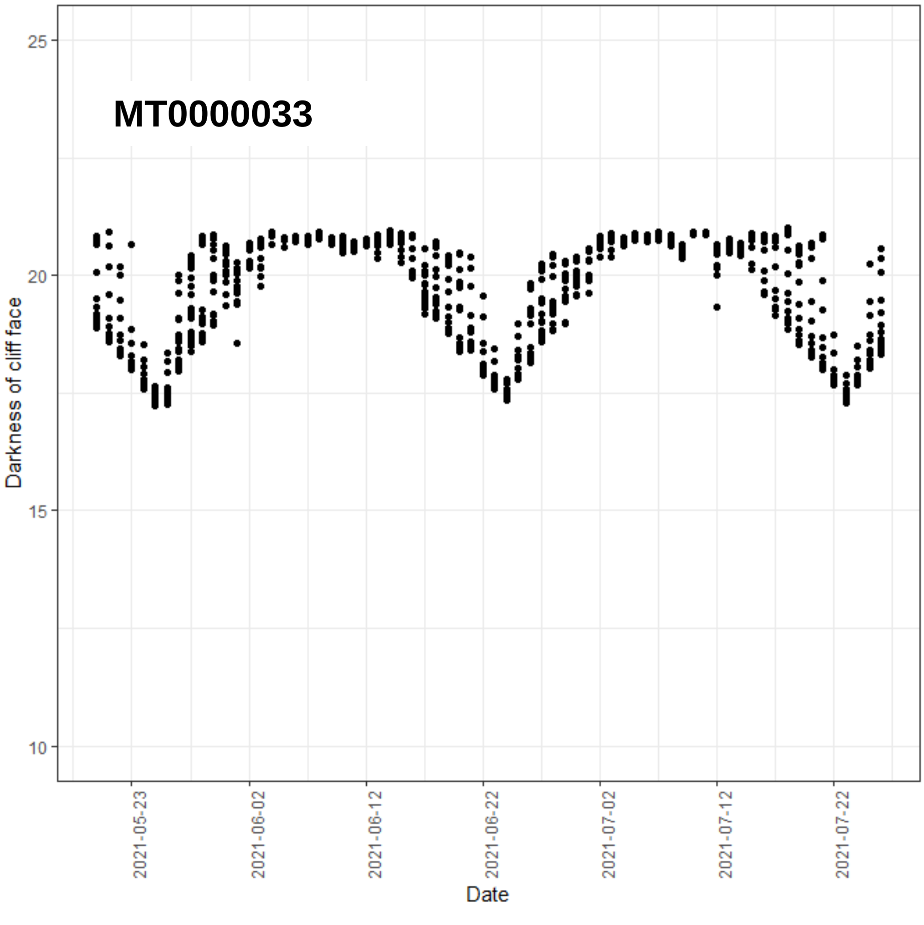
2021-05-23
2021-06-02
2021-06-12
2021-06-22
Date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2021-05-23
2021-06-02
2021-06-12
2021-06-22
2021-07-02
2021-07-12
2021-07-22
Date

Annex 3: Bait Consumption maps

Figures in annex 3 have been removed in view of sensitivity. Please contact the Environment and Resources Authority for further clarification