

Monitoring Report for the Conservation Actions: LIFE PanPuffinus! Project

LIFE 19 NAT/MT/000982

Action D1. Monitoring progress against performance indicators

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Action D1 fulfils the requirement of the LIFE programme to assess the project's conservation actions against performance indicators. LIFE PanPuffinus! had three main conservation actions, together tackling two of the main threats faced by *Puffinus mauretanicus* and *Puffinus yelkouan*, these being incidental seabird bycatch and predation by non-native predators.

Action C1. Creation and implementation of a seabird bycatch mitigation programme, focussed on testing available and new mitigation measures in all partner countries (Portugal, Spain, France, Malta and Greece) in various gears including nets, longlines and purse seine. The main outputs of Action C1 are the 'Seabird bycatch mitigation toolkit' and training in independent seabird bycatch reporting by fishers. The results from mitigation measure testing are reported here in the report for Action D1. Bycatch and any changes in bycatch or bycatch risk during mitigation measures are reported for the main conservation target species, *Puffinus mauretanicus* and *Puffinus yelkouan*, but also other seabird species.

Action C2 and Action C3 focussed on the conservation issue of non-native predators. *Action C2. Implementation of invasive non-native predator control/eradication*, was carried out in *Puffinus yelkouan* in Malta and Greece. Island eradication of rats was carried out on the Agreloussa islet complex, Greece, and seasonal rodent control was carried out at four colonies on the Maltese Islands. *Action C3. Increase the efficiency of invasive non-native predator control/eradication* was carried out in Spain, Malta and Greece, by which tools and measure to detect and prevent rodent incursions, while having the necessary equipment and trained personnel for rapid response, were developed. In addition to the 'Report on rat eradication/control operations & biosecurity plan implementation in Malta, Greece and Spain', the report for Action D1 presents further results on non-native predator detection and incursions, monitoring of rodenticide bait consumption during eradication and control campaigns until 2025 and most importantly the breeding success of *Puffinus mauretanicus* and *Puffinus yelkouan* at sites with biosecurity, eradication or control efforts.

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1. Bycatch Mitigation at Specific Fishing Gears

Bycatch, the incidental capture of non-target species in fishing gears, has been identified as the second most significant threat to globally threatened seabird species (Dias et al. 2019). In European waters alone, it is estimated that about 195,000 seabirds (ranging from around 130,000 to 380,000) are bycaught annually. This figure is likely an underestimation due to substantial, identified data gaps in the review (Ramírez et al. 2024).

Bycatch poses a significant threat to *Puffinus yelkouan* (Yelkouan Shearwater) and *Puffinus mauretanicus* (Balearic Shearwater) across their range, with documented mortality from nets and longlines in France, Greece, Italy, Spain, Malta, and Portugal (Bourgeois & Vidal 2008; Cortés et al. 2017; Lago et al. 2023, 2025), and from purse seines for *Puffinus mauretanicus* in Portuguese waters (Oliveira et al. 2015; SPEA et al. 2018; Lago et al. 2025). This bycatch, particularly during key breeding periods, can substantially reduce adult survival, with severe consequences for population viability. *Puffinus mauretanicus* is at risk of extinction within 60 years if current fisheries mortality continues (Genovart et al. 2016). While extinction risk is lower for the larger populations of *Puffinus yelkouan*, adult mortality was found to be similar to that of *Puffinus mauretanicus* (Oppel et al. 2011).

Understanding and addressing seabird bycatch is complex, as bycatch levels vary according to fishing practices, gear characteristics, species abundance, biological traits, and feeding behaviour. This complexity is further enhanced in European waters, where fishing fleets are highly variable in terms of vessel size, fishing effort, and operational practices, and characterised by polyvalent vessels which employ and interchange multiple gear types throughout the year (Ramírez et al. 2024).

Moreover, bycatch events are often sporadic and irregular, making them difficult to detect and quantify, highlighting the need for robust baseline data to inform effective mitigation strategies (Laneri et al. 2010). Increased efforts toward systematic data collection, combined with the implementation of proven mitigation measures, are essential for European coastal states to make substantial progress in reducing seabird bycatch (Ramírez et al. 2024). However, the effectiveness of mitigation measures may vary with the seabird assemblage present at fishing grounds and the specific gear in use (Cortés & González-Solís 2018), underscoring the importance of conducting targeted mitigation trials in different fisheries and regional contexts.

Several initiatives have sought to identify and test solutions to seabird bycatch in the region. These include the testing of visual deterrents, auditory devices, and discard management practices in southern Portugal under the LIFE Ilhas Barreira project (LIFE18/NAT/PT/000927) (Frade et al. 2025); visual deterrent trials in Berlengas, Portugal under the MedAves Pesca project (MAR-01.04.02-FEAMP-0023) (Almeida et al. 2023); ; in Spain testing of line weighting, olfactory deterrent, or fast

setting boxes in demersal longlines under Zepamed and Zepamar projects (EMMFF Programa Pleamar) and in France, where multi-taxa bycatch mitigation trials, including seabirds, are being implemented through the LIFE Marine Mobile Species project (LIFE22-NAT-FR-LIFE MMS) among other projects at the time of writing.

The level of bycatch mitigation implementation by fishers varies considerably, ranging from high uptake (e.g. set longlines in Spain and France) to low adoption (e.g. trammel nets in Portugal and Greece). However, irrespective of the extent to which fishers currently apply mitigation measures, there remains a common need to evaluate the effectiveness of existing measures and to test and develop new mitigation approaches (Lago et al. 2025).

The LIFE PanPuffinus! project adopted a multifaceted approach to address bycatch affecting *Puffinus yelkouan* and *Puffinus mauretanicus*. This included: (i) the collection of baseline information on the scale and frequency of seabird bycatch across fisheries in project sites and other key marine areas (Action A.1.1 and A.1.2, Lago et al. 2025); (ii) the identification of potential shearwater bycatch risk areas by overlapping fishing effort data with shearwater distribution data from breeding and non-breeding seasons (Action A.3, Dorémus et al. 2024); and (iii) the testing of available and new mitigation measures (Action C.1.1, current report).

During LIFE PanPuffinus! prioritisation was made to gears and fleets with high spatial overlap with *Puffinus yelkouan* and *Puffinus mauretanicus* (Dorémus et al. 2024) and with preliminary indications of seabird bycatch (Lago et al. 2025). Moreover, mitigation measures were also chosen based on demonstrations of success in other projects (Oliveira et al. 2021; Almeida et al. 2023; Frade et al. 2025, Poisson et al. 2025), as well as in exchange of knowledge between partners and fishers. This report does not cover an exhaustive analysis of all gears and fleets in the region, nor all possible mitigation measures (Lago et al. 2025). The main aim of this report is to assess the trialled mitigation measure effects in seabird bycatch and risk, identify impacts on fishing operations, while considering financial and practical feasibility of implementation by fishers in specific gears and project sites. The lack of inclusion of a given gear or fleet in this report, does not mean that the gear might not cause seabird bycatch; further work with fishers will be required and is thus suggested for future consideration.

1.1 Scale & Frequency of Seabird Bycatch

This section aims to present results from mitigation measure trials carried out in LIFE PanPuffinus! project, focusing on any changes in seabird bycatch or interactions of seabirds with fishing vessels. The number of seabird interactions with fishing operations can be used as a proxy for bycatch risk (Cortés et al. 2017). Further details on the implementation of measures and practical considerations are described in the Seabird bycatch mitigation toolkit produced under LIFE PanPuffinus! (Lago et al. 2026).

Data used for this analysis was collected using two methods, namely onboard observations and self-reporting logbooks¹.

Experienced onboard observers followed a protocol for data logging throughout the fishing trips. Data were recorded on paper forms or on a tablet device using a digital version of the forms build under CyberTracker © software by SPEA and transferred to the partnership. Every 30 minutes data on effort was recorded such as: observer position on the vessel; weather variables such as sea state, wind direction & strength, visibility and temperature; the activity of the vessel and the location coordinates. The fishing event was defined in time with a start and end time, and operation type (setting and hauling). All relevant fishing gear and effort data was recorded for the event including number of hooks and main line length, but also details such as mesh size, net colour, bottom depth and gear depth. The fishing event was recorded together with coordinates every time there was a change in fishing operation activity. All catches were recorded, both target catches and bycatch, by number and species (Oliveira et al. 2015). For seabird individuals, if possible, age, whether they were dead or alive and type of capture (e.g. entangled in net; caught on hook; entangled in the line; or collided with gear) were recorded.

Every 15 minutes onboard observers counted all birds in distance bands around the vessel (A = 0–20 m, B = 20–50 m, C = 50–100 m, D = 100–200 m, E = 200–300 m, F ≥ 300 m; Almeida et al. 2023). Each individual was registered to species or genus level and associated a behavioural code (direct flight, circular flight around the vessel or sitting on the water), following Camphuysen and Garthe (2004). During analysis, in general birds in circular flight around the vessel or sitting on the water were considered as interacting with the vessel, while those in direct flight were not (Calado et al. 2020). Specifically, during longline setting, the number of attempted attacks on baited hooks (Cortés et al. 2017), were counted in continuous 3-minute intervals and distance bands of 0–50 m

¹ The onboard observations protocol, forms and examples of self-reporting logbooks can be found here: <https://lifepanpuffinus.org/fisheries-resources/>

and 50-100m. These attempted attacks on baited hooks were termed as 'dives' in the protocol, but shearwaters do not necessarily submerge under the water.

Self-reporting logbooks were on the other hand filled in by fishers themselves, typically the vessel captain. The format was adapted from (Lago et al. 2023) and included the possibility for entry of different gear configurations by fishing trip. Each fishing trip was logged and fishers filled in the number of distinct fishing events (sets/hauls) and related information including for example the time of setting, soaking time, number of hooks, the type of bait, length of net and location of gear. Depending on the target fleet, some of the logbooks included the possibility to record an estimate of seabirds interacting with fishing operations per species. For each fishing event, corresponding fields were available for recording bycaught species, number and condition (alive/dead) and outcome (e.g. released safely or discarded). The printed booklets were bound, included a fixed number of fishing trip fields and meant for filling during fishing trips. Project staff were in regular contact with fishers and were available for any questions that could arise. As the logbook template described by Lago et al. (2023), logbooks included drawings for safe release of seabirds bycaught alive, seabird identification and a final questionnaire allowing fishers to give feedback on the data collection process, the effect of seabirds on operations and their perceptions of seabird bycatch.

Onboard observations and self-reporting logbooks carried out as part of the project action A1: *Reviewing the scale and characteristics of bycatch of target species*, were aimed to characterise the gears and nature of bycatch. Then, as part of action C1: *Creation and implementation of a seabird bycatch mitigation programme*, protocols and logbooks were adapted to include fields to record whether fishing trips/events were part of mitigation trials, the type of mitigation tested and whether the event was a control (mitigation measure not used) or experimental (mitigation measure used). As a final part to action C1, questionnaire surveys were carried out with fishers post-mitigation trials, either an in-person interview or a concluding part to self-reporting logbooks. The intention with these surveys were to understand any changes perception of fishers towards seabird bycatch, any costs incurred, their acceptance of mitigation measures tested and any feedback on the latter from their behalf.

An additional data collection method was the use of time depth recorders (TDR), which were attached in trammel nets operating at the Portuguese site (Aveiro-Nazaré SPA) and on longlines in Spanish, Maltese and Greek project sites in order to characterize their sinking profile. TDR analysis intended to identify the range of distances from the vessel that trammel nets and longlines were accessible for birds, while hauling or setting. Cefas G5 Long-Life 50bar TDR were attached to nets and longlines operated by different vessels, at different positions along the gears.

1.1.1 Trammel nets & Scarybird kite

Trammel net fishery was monitored in the Aveiro-Nazaré SPA, Portugal. The fishery targets demersal species, including *Trisopterus luscus*, *Diplodus vulgaris*, *Solea solea* and *Raja brachyura* (Oliveira et al. 2021), and is usually carried out by medium-sized vessels (15 - 18 m overall) operating relatively close to the coast. While nets are usually set at depths generally inaccessible to seabirds, incidental captures tend to occur during the setting and hauling operations. During these periods of the fishing operations, birds are attracted by discards and prey items in the nets. Interactions may lead to bycatch by entanglement and death by drowning. Therefore, the scarybird kite or bird scarer kite, which simulates the presence of a predator is a visual deterrent used to keep seabirds away from the fishing operation area (Almeida et al. 2023). SPEA observers collaborated with fishers to collect data through on-board observations and self-reporting logbooks in this fishery.

Seabird bycatch recorded in the fishery

Before mitigation trials started, 82 fishing trips on seven fishing vessels were observed by onboard observers, while 311 fishing trips on eight fishing vessels were logged by fishers. Data collection was carried out between 2021-10-19 and 2025-04-12. Seabird bycatch was observed for six species groups including *Puffinus mauretanicus* (Fig. 1).

Mitigation measure trials: Scarybird kite

For mitigation trials only nets with mesh size 100 and 110 mm were used, removing a confounding factor in bycatch rates (Annex 1, Fig. S2; S8). Since the scarybird kite is a visual measure, any events that took place entirely at night were also removed (Annex 1, Fig. S3). Mitigation trials were considered experimental if the scarybird kite was set up during fishing operations, while they were considered controls when it was not set up. Trials were either observed by onboard observers or logged by fishers, and took place on eight vessels in total. Trials during setting operations took place during 162 fishing trips, including 40 experimental trips and 122 control trips (Fig. 2). Mitigation trials were carried out between 2023-04-06 and 2025-09-02.

There was no effect of trials on seabird bycatch rates or probability (considering all species together and both onboard observations and self-reporting logbook data). On the subset of data from the self-reporting logbook data alone, bycatch rates were lower with the use of the scarybird kite (GLMM parameter estimate $\pm$ SE = -1.937 ± 0.916 , $p < 0.05$; Annex 1, Table S3).

Based on onboard observations and self-reporting logbooks, at species level, there was weak evidence that bycatch rates were lower with the use of the scarybird kite (experimental) for *Morus bassanus* (GLMM parameter estimate $\pm$ SE = -1.257 ± 0.647 , $p = 0.052$; Annex 1, Table S5), but

bycatch rates were higher for *Larus* spp. (GLMM parameter estimate $\pm$ SE = 1.942 ± 0.863 , $p < 0.05$; Table S6). However, bycatch can be sporadic and this might affect results.

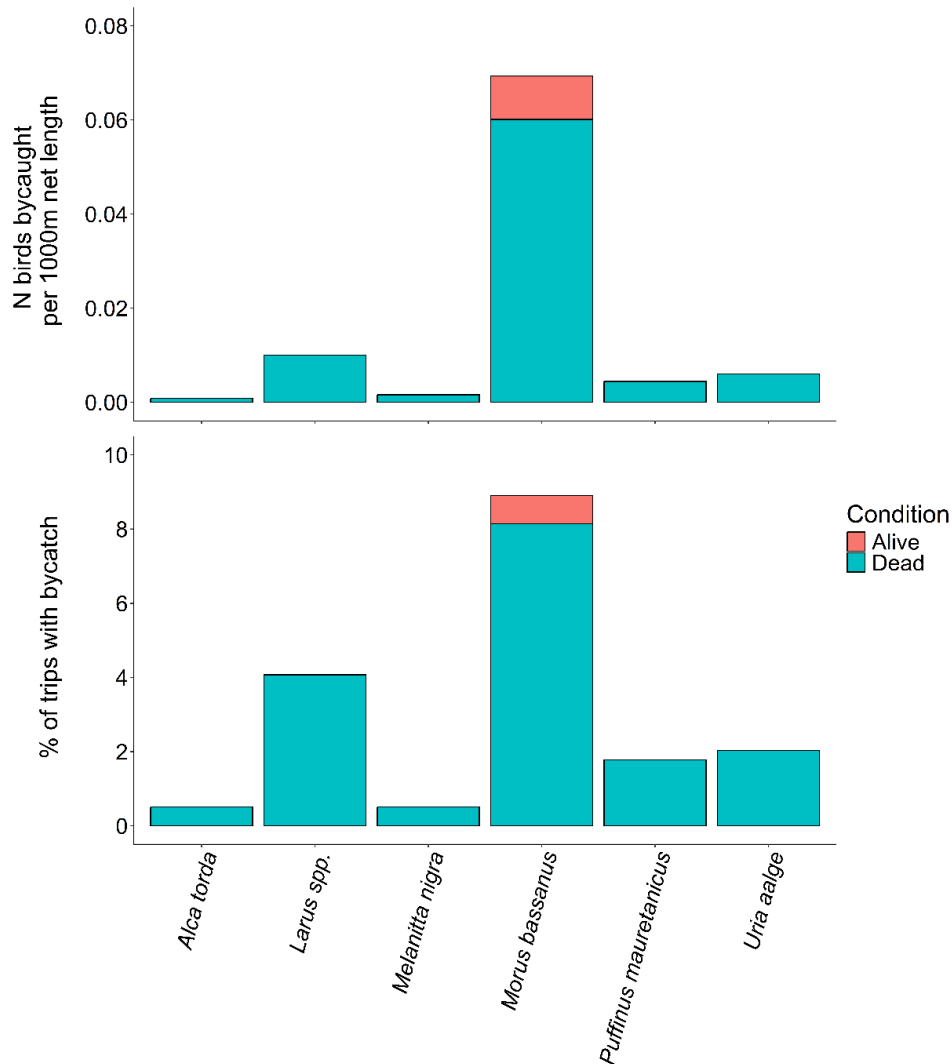


Figure 1: Number of bycaught seabirds per 1000m net length and percentage % of fishing trips with seabird bycatch per species, recorded bycaught by onboard observers and fishers using self-reporting logbooks, Aveiro-Nazaré SPA, Portugal. The condition of bycaught seabirds is shown in red for birds retrieved alive and green for those retrieved dead. No mitigation measure was used on these fishing trips (N = 393) on 15 fishing vessels.

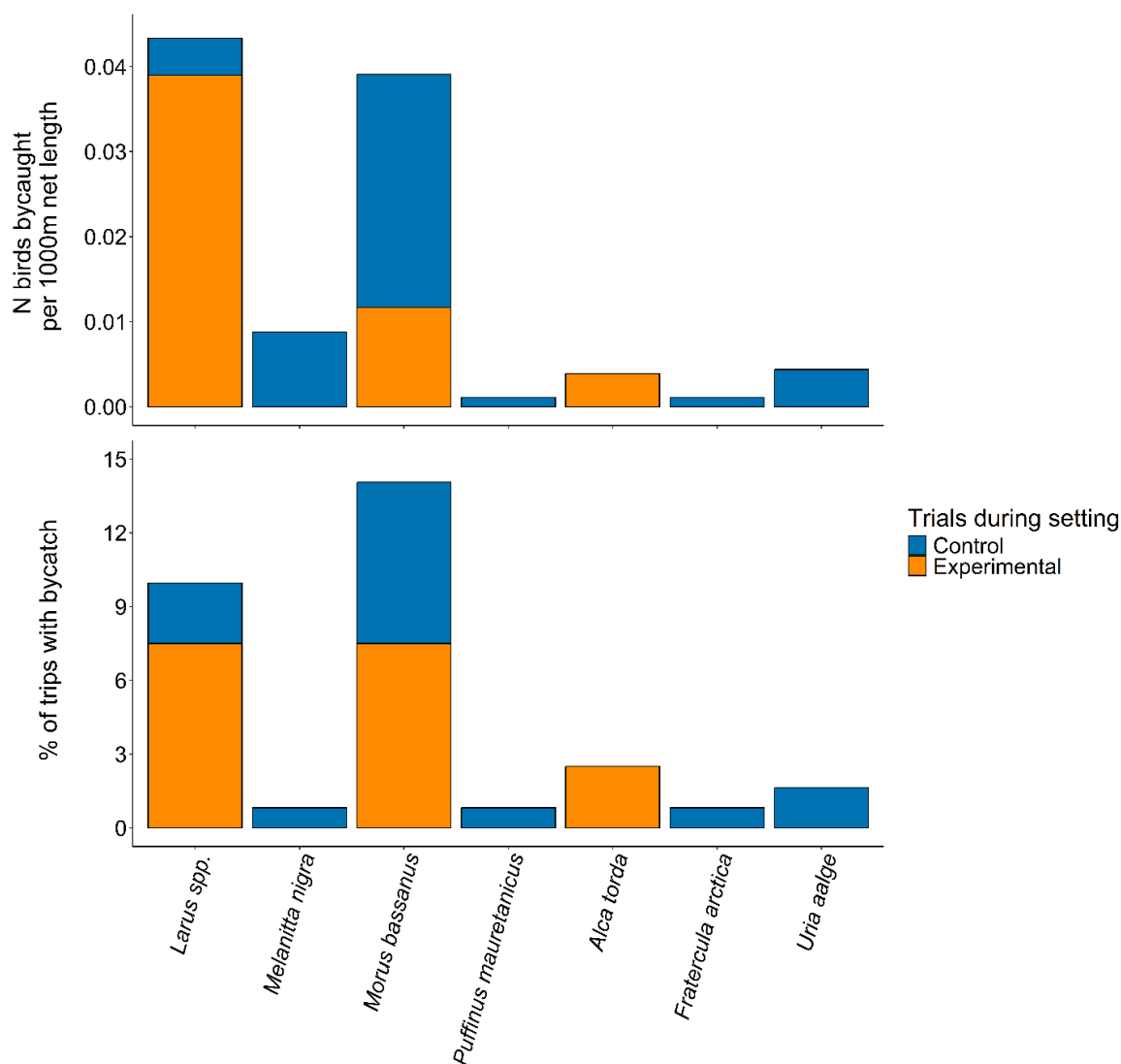


Figure 2: Number of bycaught seabirds per 1000m net length and percentage % of fishing trips with seabird bycatch per species and trial type, recorded bycaught by onboard observers and fishers using self-reporting logbooks, Aveiro-Nazaré SPA, Portugal. Bycatch is presented separately for trials of the scarybird kite during setting, where controls (no scarybird kite) are in blue (N=122), and experimental settings (with scarybird kite) are in orange (N=40).

An additional method to test scarybird kite efficacy, as an alternative to face the sporadic nature of bycatch, was to count the number of seabirds interacting with fishing operations in distance bands behind the vessel. There was weak to moderate evidence of reduced proportions observed interacting within 0-20m of the vessels during experimental events for both *Morus bassanus* (GLMM parameter estimate $\pm$ SE = -0.57 ± 0.282 , $p = 0.044$), and *Larus* spp. (GLMM parameter estimate $\pm$ SE = -0.399 ± 0.235 , $p = 0.089$), but no evidence of an effect for *Puffinus* spp. (GLMM parameter estimate $\pm$ SE = 0.430 ± 0.579 , $p = 0.457$; Annex 1, Fig. S12).

Trammel net sinking profile

TDR were deployed at the trammel nets of two different vessels. Two TDRs were deployed at each of the beginning and end of each net and a fifth one in the middle position. A total of 73 sinking events (37 haulings and 36 settings) were recorded from May to July 2023. Overall, data highlight the low speed which trammel nets were operated during hauling. The sinking profile was very dependent on the bottom depth, but only about 50 meters from the vessel the nets have begun to detach from the seabed (Fig. 3). Which means the hauling alter/increases the availability of the trammel nets to the birds only for the last 50m distance from the vessel.

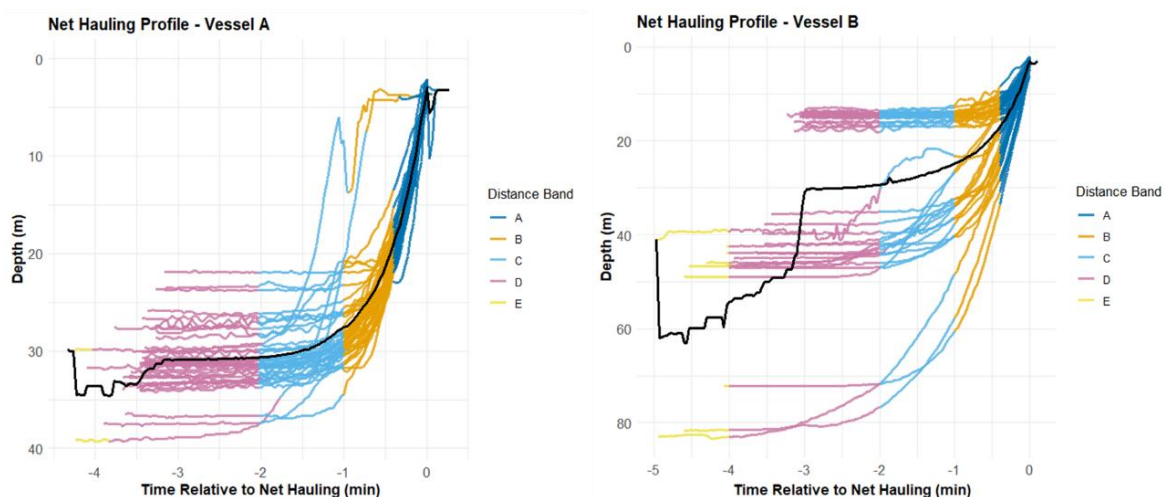


Figure 3: Net Sinking Profile for two different boats (boat A and B) operating trammel nets with a mesh size of 100mm in the Aveiro-Nazaré SPA, Portugal. Coloured lines represent different distance bands from the boats (Band A: 0-20m; Band B: 20-50m; Band C: 50-100m; Band D: 100-200m; Band E: 200-300m). Grey lines show individual setting events (23 for boat A; 14 for boat B). The black line shows the mean depth across all setting events per boat. Depth was recorded with 5 different TDR devices, positioned in different zones of the net panel: beginning, middle, and end.

Trammel nets are operated at a higher speed during setting, when compared to hauling, as observed by the sinking profile (Fig. 4). Also, when the vessel is already 300 m apart from the setting point, the net was yet in the first 20 m of the water column. Which may prevent the detection of any bycatch event by an onboard observer when the net is still available for seabirds. These findings are also very informative for future trials in mitigation measures. Any mitigation measure set at the vessel itself might have limited effect if bycatch occurs during setting, but this can vary with the seabird species and their diving behaviour.

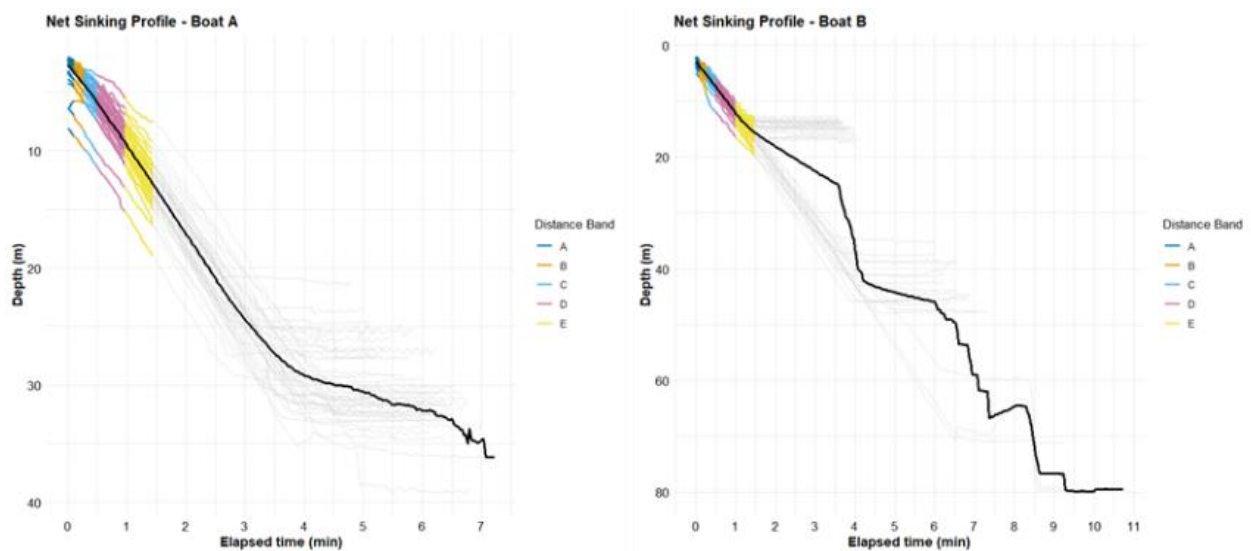


Figure 4: Net Sinking Profile for two different boats (boat A and B) operating trammel nets with a mesh size of 100 mm in the Aveiro-Nazaré SPA. Coloured lines represent different distance bands from the boats (Band A: 0-20m; Band B: 20-50m; Band C: 50-100m; Band D: 100-200m; Band E: 200-300m). Grey lines show individual setting events (22 for boat A; 14 for boat B). The black line shows the mean depth across all setting events per boat. Depth was recorded with 5 different TDR devices, positioned in different zones of the net panel: beginning, middle, and end.

1.1.2 Purse-seine & Scarybird kite

Purse-seine fishing was monitored in the Aveiro-Nazaré SPA, Portugal, on vessels between 21 m and 27 m length overall. The fishery typically targets small pelagic fish such as *Sardina pilchardus*, *Scomber colias*, *Trachurus pictarus* (Oliveira et al. 2021) and *Engraulis encrasicolus*.

Seabirds are attracted by prey items in the nets during the fishing operations. Seabirds may collide with or become entangled in the nets, leading to injury or drowning. Seabird bycatch might be particularly sporadic in this fishery, but when it occurs it often involves numerous individuals (Oliveira et al. 2015).

The scarybird kite or bird scarer kite, which simulates the presence of a predator was tested in its efficacy of keeping seabirds away from the fishing operation area during hauling. Fishing operations were monitored by SPEA onboard observers.

Seabird bycatch recorded in the fishery

42 fishing trips on seven fishing vessels were observed by onboard observers (76 fishing operation events). Data collection was carried out between 2021-07-07 and 2024-07-19. No seabird bycatch was observed during these trips so bycatch rates are estimated.

Mitigation measure trials: Scarybird kite

Mitigation trials were carried out between 2024-05-31 and 2025-07-28. Trials were observed by onboard observers and took place on 4 vessels. Only one individual *Larus michahellis/fuscus* was observed bycaught during trials. Therefore, scarybird kite efficacy was only tested using observations of seabirds interacting with the vessel. The observed purse-seine fishing activities occurred mostly at night (Fig. S16). So that counts by distance bands are not affected by species visibility during low light, only events with a daylight portion were retained for further analysis resulting in seven experimental events (scarybird kite was used) and 13 control events (scarybird kite was not used) on three fishing vessels between 2024-05-31 and 2025-06-05. During experimental events, lower proportions of *Larus* spp. and *Puffinus* spp. interacted with the vessel operations within 0-20m, but with low (*Larus* spp. GLMM parameter estimate $\pm$ SE: -0.860 ± 0.443 , p-value = 0.052) or no statistical support (*Puffinus* spp. GLMM parameter estimate $\pm$ SE: -0.562 ± 0.526 , p-value = 0.286; Fig S18, Tables S7; S8).

1.1.3 Trammel nets & Discard Management

For the same trammel net fishery described in Section 1.1.1 discard management was tested as alternative mitigation measure, which can be considered a good practice. The practice implies the retention of discards onboard the vessels in appropriate containers, releasing them only after the completion of the fishing operations. Therefore, the practice aims to reduce attraction of seabirds during phases such as hauling and setting that could lead to bycatch (Lago et al. 2025; Frade et al. 2025). The measure in trammel nets was recorded by SPEA onboard observers.

Seabird bycatch recorded in the fishery

For seabird bycatch in this trammel net fishery without mitigation measures refer to Fig. 1 and Annex 1, Fig. S1 – S7.

Mitigation measure trials: Discard management

Trials of discard management were observed by onboard observers and took place on three vessels. Trials took place during 50 fishing trips, including 59 experimental setting events (with discard management) and 18 control setting events (without discard management; Fig. 5). Since discard management is not a visual deterrent, any events carried out at night were not removed for tests on bycatch. Discard management trials were carried out between 2023-07-07 and 2025-05-01.

Onboard observers also counted seabirds around the vessel during discard management trials. While discard management is not a visual deterrent, night time events (Annex 1, Fig. S3) were removed for this analysis in case low light biases observations to those closer to the vessel.

There was no support for bycatch reduction with discard management. However, there was weak evidence of reduction of *Puffinus* spp. (including *P. mauretanicus* and *P. puffinus*) proportions interacting within 0-20 m of trammel net vessels during experimental operations (GLMM parameter estimate $\pm$ SE = -0.761 ± 0.404 , p-value = 0.059; Annex 1, Table S10; Fig. S25).

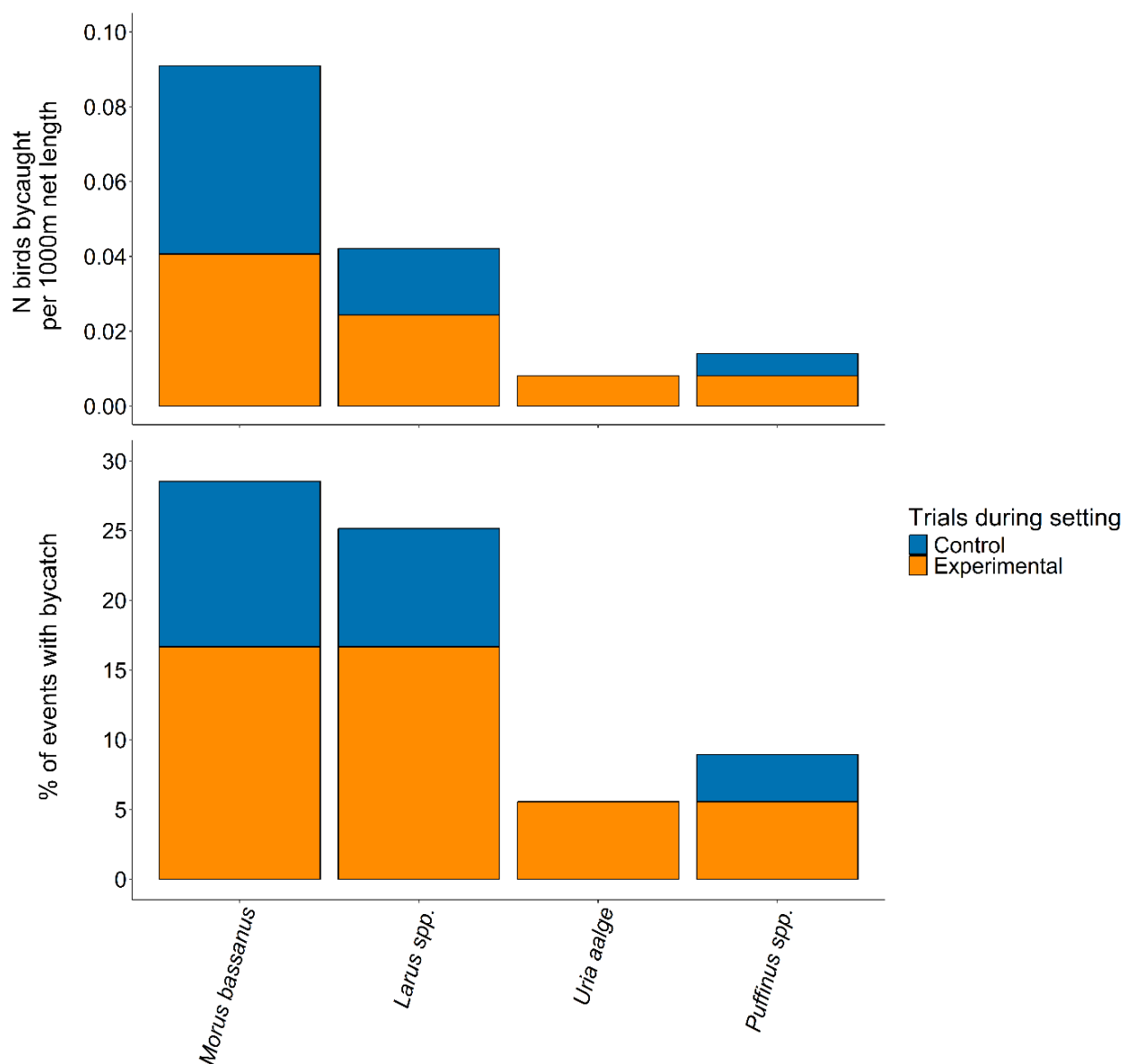


Figure 5: Number of bycaught seabirds per 1000m net length and percentage % of fishing events with seabird bycatch per species recorded bycaught by onboard observers, Aveiro-Nazaré SPA, Portugal. Bycatch is presented separately for trials of the discard management during setting, where controls (no discard management) are in blue (N=59), and experimental settings (discard management) are in orange (N=18).

1.1.4 Trammel nets & Contrast Panels

Fishing by trammel nets was also monitored in the Gulf of Kalloni SPA, Lesvos, Greece. The fishery primarily targets *Sepia officinalis*, and is typically conducted by small vessels (6 - 8 m length overall). Nets are generally set at shallow depths and bycatch occurs during soak time leading to mortality due to drowning. A seasonal overlap (February – April/May) occurs between this fishery and shoaling events of *Engraulis encrasicolus* that attract large numbers of foraging *Puffinus yelkouan*, thereby exacerbating the risk of bycatch (Lago et al. 2025). Therefore, high contrast panels were tested as a potential mitigation measure. Contrast panels were made out of alternating black and white ribbons attached at the top and bottom on 1 m belts, creating a 60x60 cm panel. The panels were then knotted on their four sides to the outer mesh of the trammel net. Contrast panels were integrated into the net every 6-7 m, and aimed to improve net visibility to diving shearwaters and thus reduce bycatch. HOS observers collaborated with fishers to collect data through on-board observations and self-reporting logbooks in this fishery.

Seabird bycatch recorded in the fishery

In addition to paired trials of contrast panels, 167 fishing events on 63 fishing trips were recorded by onboard observers (Fig. 6). However, bycatch events were sporadic, while usually involving multiple individuals. The bycatch rates in the larger sample of control events (N=468) are also a useful indication of bycatch rates in the fishery (Fig. 7).

Mitigation measure trials: Contrast panels

Contrast panels were integrated into nets (experimental), while control nets were otherwise identical but without the contrast panels. Fishers use various mesh sizes and net colours, but trials were evenly distributed amongst these net types (Figs. S30, S31). Trials were carried out on five vessels, observed by onboard observers, while in their absence, fishers filled self-reporting logbooks. Trials were carried out during two seasons, between 2024-02-14 to 2024-04-16 and 2025-02-12 to 2025-04-19, on 323 fishing trips. The main bycatch species logged by both methods was *Puffinus yelkouan* (N = 85; Fig. 7). 468 control fishing events and 464 experimental fishing events were retained for analysis (Annex 1). Bycatch rates were lower in experimental nets with contrast panels (GLMM parameter estimate $\pm$ SE = -0.728 ± 0.298 , $p = 0.015$; Fig. 4; Annex 1, Fig. S34; Table S13), and rates are also affected by mesh size (Annex 1, Fig. S35; Table S13). In the subset of data from self-reporting logbooks, a weak effect of net colour is also present (Annex 1, Table S12).

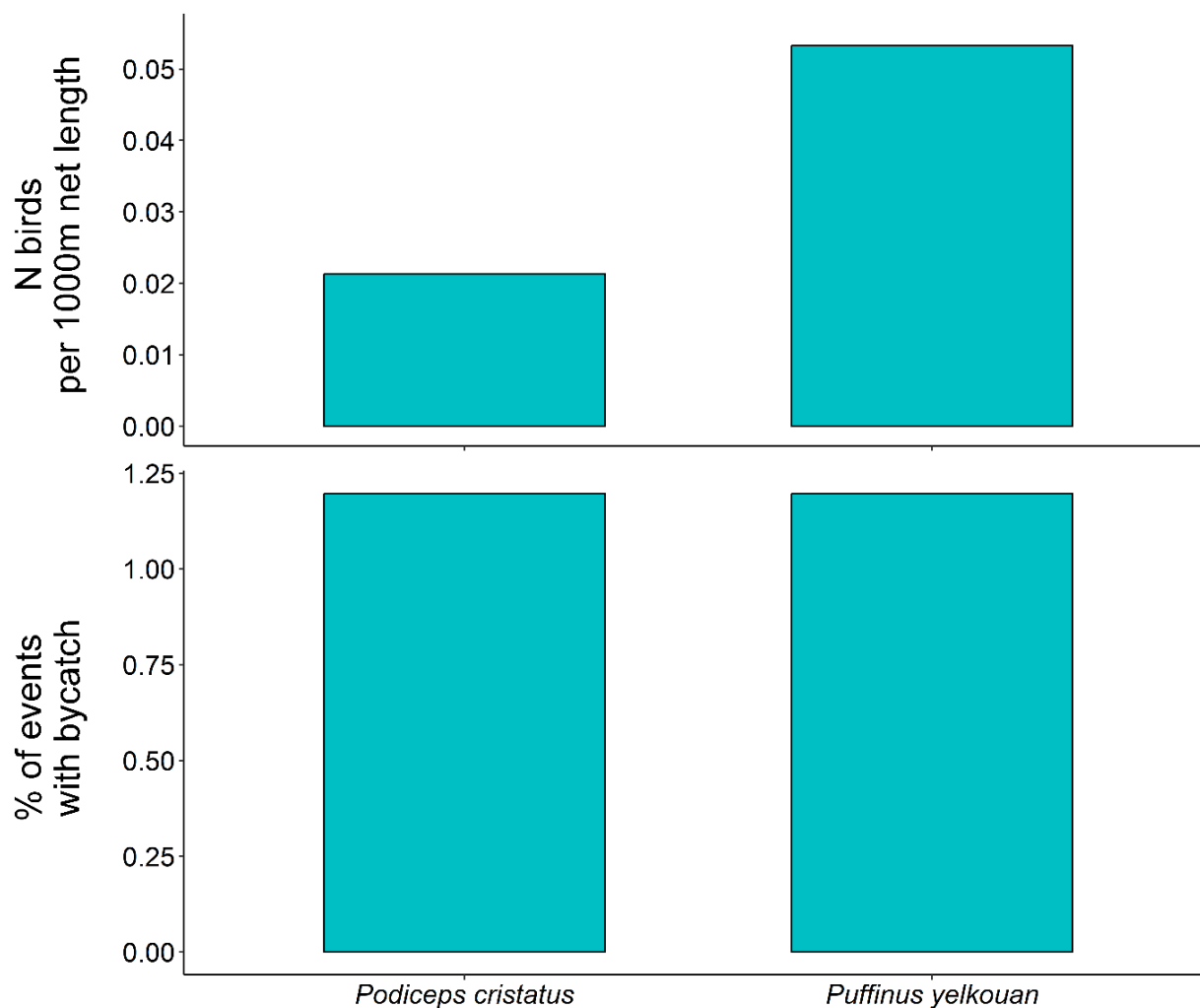


Figure 6: Number of bycaught seabirds per 1000m net length and percentage % of fishing events with seabird bycatch per species, recorded bycaught by onboard observers, Gulf of Kalloni, Greece. All bycaught birds were retrieved dead. No mitigation measure was used on these fishing events (N = 167).

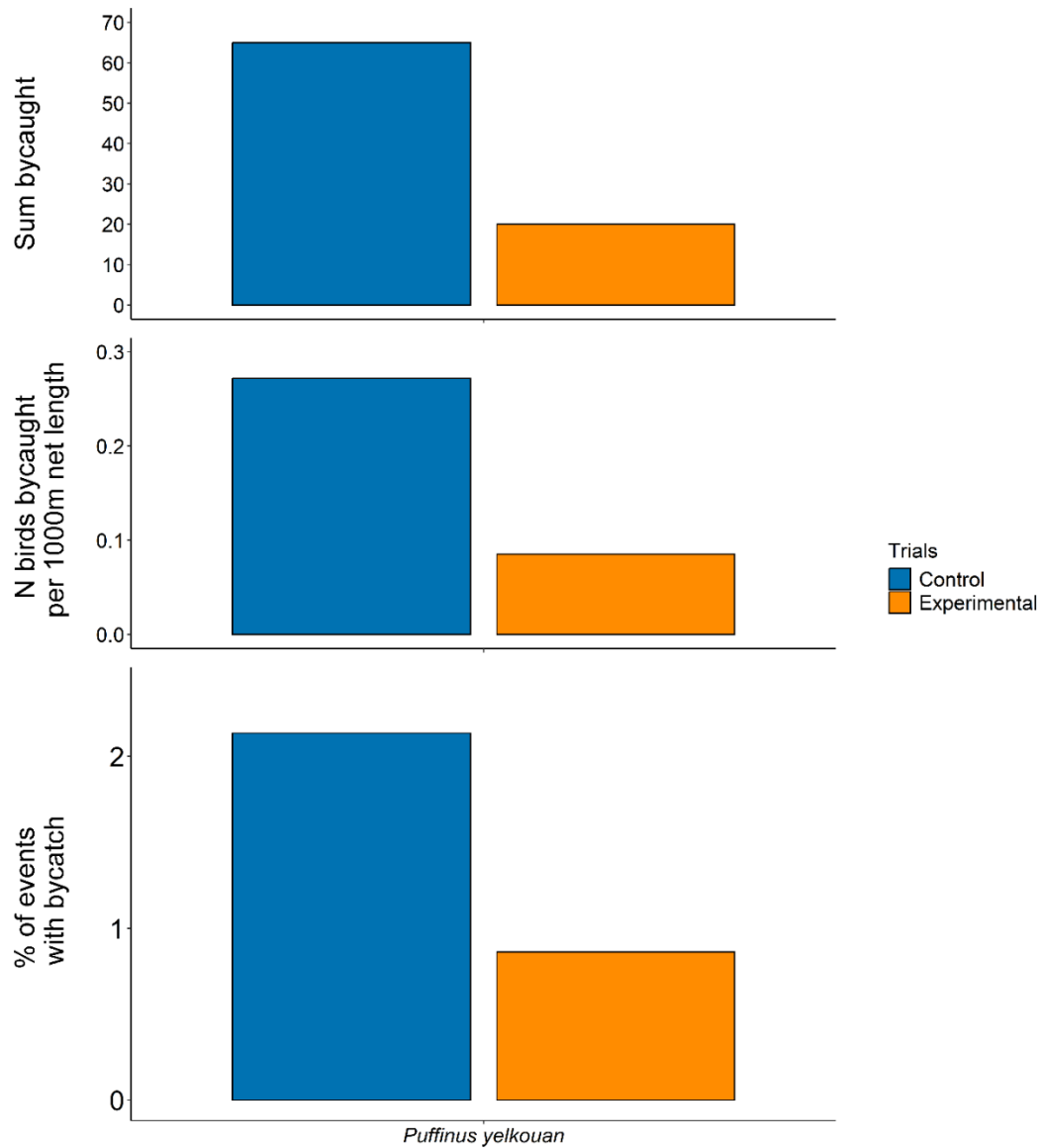


Figure 7: Number of *Puffinus yelkouan* individuals bycaught in total and per 1000m net length, and the percentage % of fishing events with bycatch, recorded by onboard observers and fishers in self-reporting logbooks, Gulf of Kalloni, Greece. Bycatch is presented separately for trials of the contrast panels, where controls (normal nets) are in blue (N = 468 fishing events), and experimental nets (with contrast panels) are in orange (N=464).

1.1.5 Longlines & various best practices/mitigation measures

Fishing with longlines was monitored in various project areas across the Mediterranean partner countries, namely in Spain, France, Malta and Greece. Set longlines (LLS) and pelagic drifting longlines (LLD) were monitored, including several variations in gear configurations within these broad categories. Gear configurations depend on target species, season and region, among other factors. Different gear categories were used, depending on the type of analysis and available data. Irrespective of longline type, seabird bycatch tends to occur during line setting when birds are attracted to baited hooks and either get caught on the hooks or entangled in the line, usually leading to drowning (Cortés et al. 2017; Lago et al. 2025). At this stage, seabirds can negatively affect fishing operations due to loss of bait and entanglement of the line (Lago et al. 2025). In some cases, seabirds can be released alive, mainly in small-scale fisheries that set longlines at slow speed, which allows fishers to decide to stop setting for a while, and retrieve some of the line to release the birds before continuing to set. Bycatch can also occur during hauling, when seabirds are attracted to any remaining bait on the hooks, and risk entanglement or getting caught on hooks (Lago et al. 2025; Poisson et al. 2025). While the chances of release by fishers are higher at this phase, seabirds might still have extensive and fatal injuries (Poisson et al. 2025). In longlines where the line with hooks stays close to the surface during soaking, interactions (Poisson et al. 2025) and bycatch could occur during soaking time as well.

During this project, data on various best practices and mitigation measures were collected. In fact, no single measure is likely to be sufficient to eliminate seabird bycatch on its own and a combination of measures should be explored (Lago et al. 2026). The following sections describe bycatch rates for different practices and mitigation measures.

Cefas G5 Long-Life 50bar TDRs were deployed on longline gear in Spain, Greece and Malta, either to compare the sinking rate of the line with hooks with different weight configurations or to measure the sinking rate for a particular gear. TDRs were also used to estimate the horizontal distance between the vessel and the location behind the vessel at which baited hooks attain a certain depth (2m, 5m, 10m), the so-called access window. The distance is dependent on the setting speed and the weight of the line, which in turn determines the distance astern that bird deterring devices need to be effective (Rouxel et al. 2022).

Seabird bycatch recorded in the fishery

In the project regions in Spain, Catalonia and Balearic Islands, data was collected using self-reporting logbooks on 1669 fishing trips on 22 fishing vessels (5.75 m - 13.79m overall). Data collection was carried out across the years 2020, 2021, 2022, 2023. Seabird bycatch was recorded for five species groups, *Puffinus* spp. including *P. mauretanicus* (Fig. 8), with a total of 386 seabirds

bycaught across all groups. Seabird bycatch varied between years (Fig. 9) and there was an observed reduction in bycatch rates during the years of the project (Annex 1, Table S19). Additionally, there are seasonal variations within years and by region (Annex 1, Fig. S46), with higher bycatch rates in Balearic Island from March to May and in Catalonia from May to June. The different gear configurations in set longlines have different bycatch rates (Fig. 10; Annex 1, Table S19; S20). In Annex 1, Section T06 the gear configurations are described in detail. On average, $690.47 \text{ hooks} \pm 403.34 \text{ SD hooks}$ were set per fishing day.

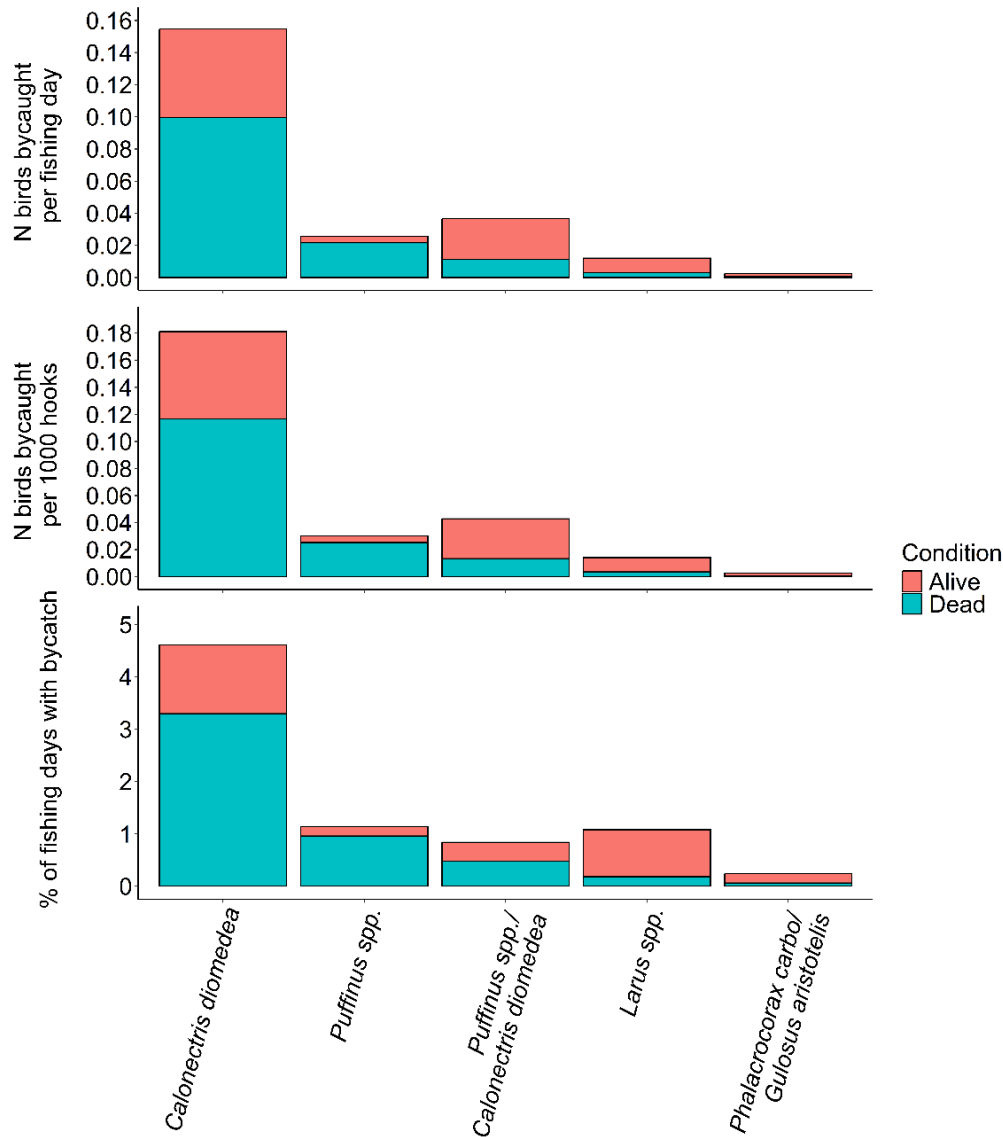


Figure 8: Number of bycaught seabirds per fishing day (trips <24 hours) and per 1000 hooks, and % of fishing days with seabird bycatch per species recorded bycaught by fishers using self-reporting logbooks, Catalonia and Balearic Islands, Spain (2020–2023). The condition of bycaught seabirds is shown in red for birds retrieved alive and green for those retrieved dead. Bycatch rates were recorded on 22 fishing vessels during 1669 fishing trips with set longlines including several gear configuration and practices.

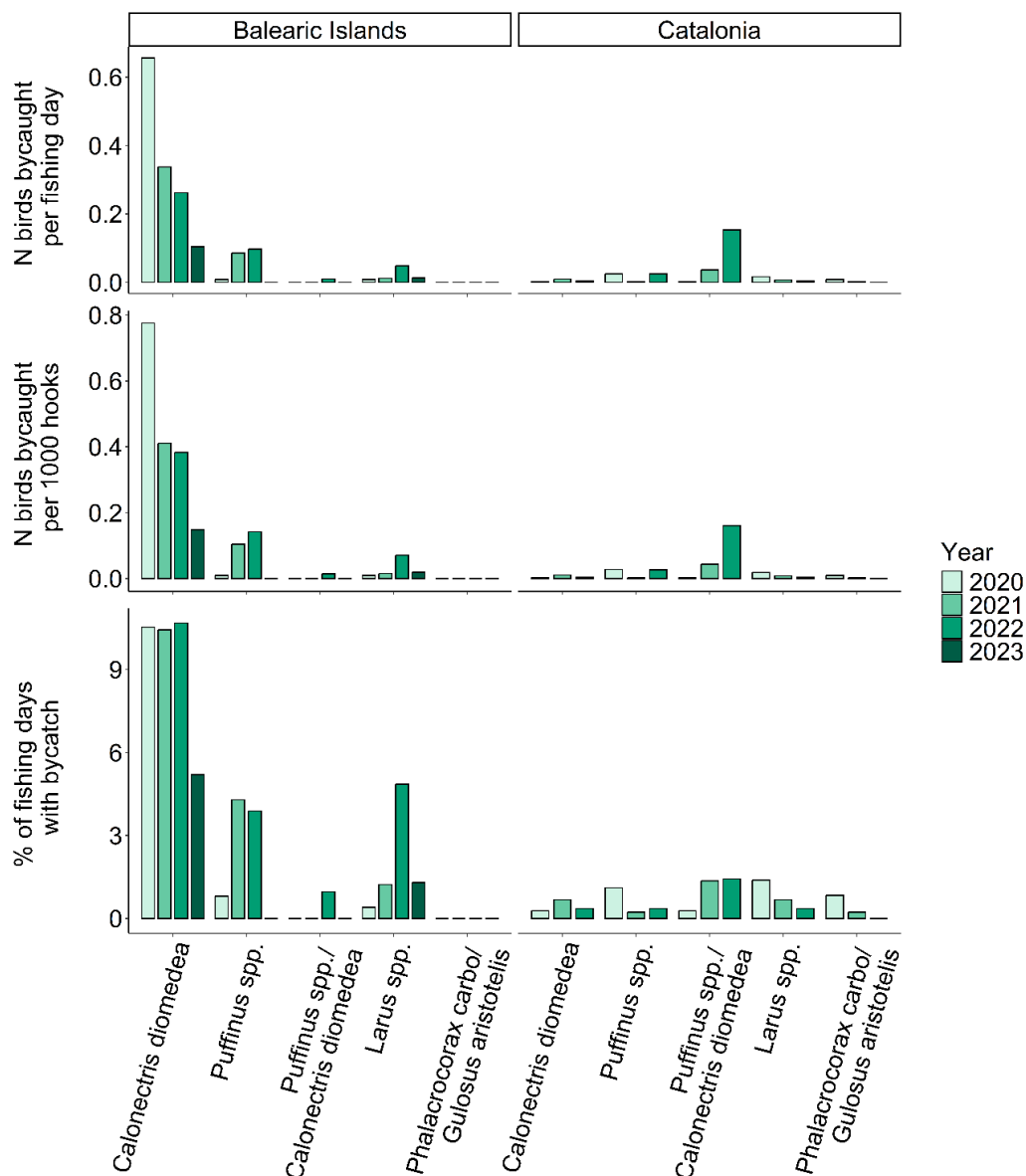


Figure 9: Number of bycaught seabirds per fishing day (trips <24 hours) and per 1000 hooks, and % fishing days with bycatch per year and species recorded bycaught by fishers using self-reporting logbooks, Catalonia and Balearic Islands, Spain (2020-2023). Bycatch rates were recorded on 22 longline fishing vessels during 1669 fishing trips all with set longlines including several gear configuration and practices.

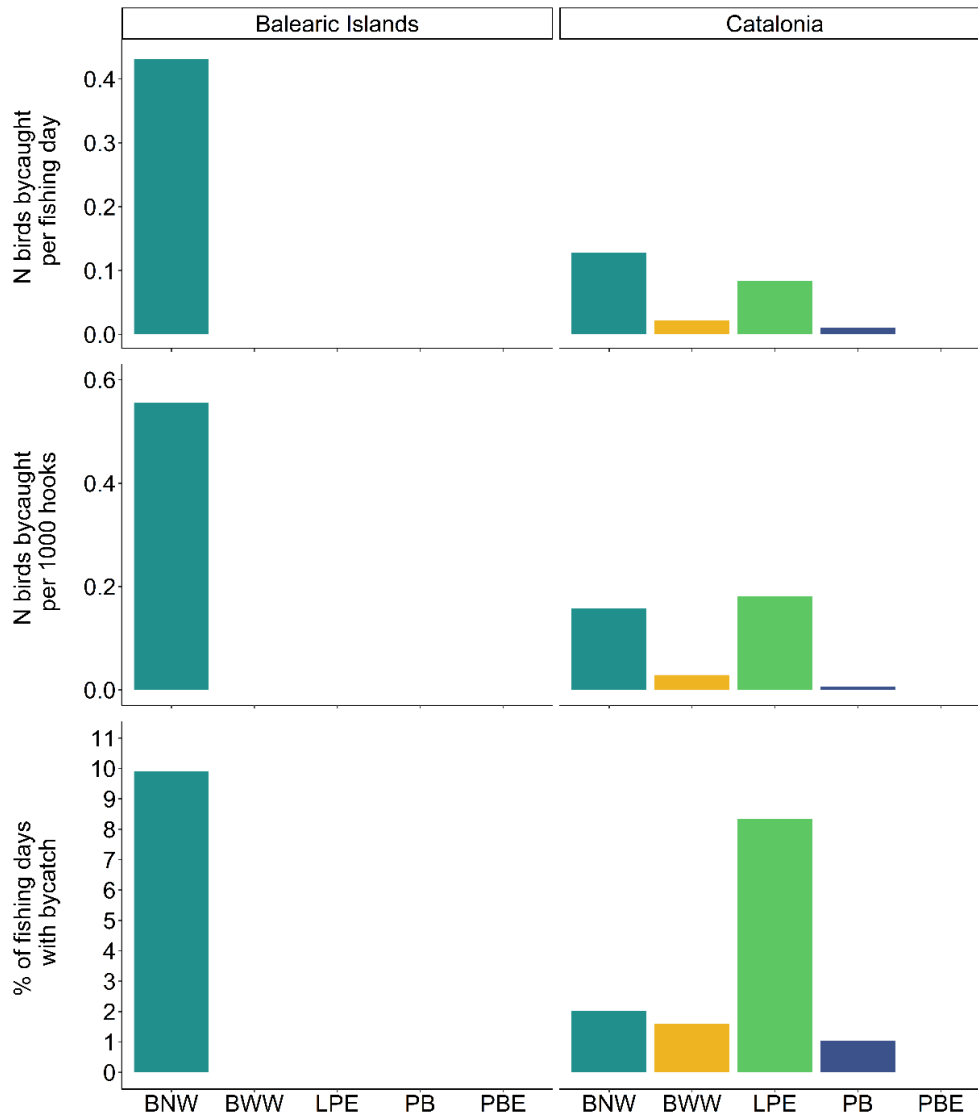


Figure 10: Number of bycaught seabirds per fishing day (trips <24 hours) and per 1000 hooks, and fishing days with bycatch per set longline configuration, as recorded by fishers using self-reporting logbooks, Catalonia and Balearic Islands, Spain (2020-2023; 1669 fishing trips on 22 fishing vessels). BNW: Botton longline without weights, BWW: Botton longline with weights, LPE: Set pelagic longline, PB: Floated demersal longline, PBE: Set semi-pelagic longline.

In the Maltese Islands, data was collected using onboard observations and self-reporting logbooks on 267 fishing days on 13 fishing vessels (6m - 12m overall). Data collection was carried out across the years 2023, 2024, 2025. Seabird bycatch was observed for two seabird species, including *Puffinus yelkouan* (Fig. 11). Longline types were grouped into two broad categories (LLD – drifting pelagic longlines and LLS – set longlines). LLS in the case of the MT dataset collected during the project are all set demersal longlines. On average, $997.10 \text{ hooks} \pm 261.09 \text{ SD}$ hooks were set per fishing day with LLD and $1872.61 \text{ hooks} \pm 997.09 \text{ SD}$ were set per fishing day with LLS.

In Greece, namely Paros, Syros and Rafina ports in the Aegean Sea region, data on longline operations were collected by HOS and NECCA through onboard observations during 43 fishing trips on 7 longline vessels (8m – 14m overall) in 2024 and 2025. All longline operations observed were set longlines (LLS), specifically bottom longlines. Seabird bycatch was observed for two seabird species (Fig. 12); the majority were released alive in part due to slow setting speed and efforts by fishers to pause setting to be able to release birds. Although these bycaught birds were released, their post-release survival is not known. In similarity to results from Malta and Spain, the highest bycatch rates on longlines are found for *Calonectris diomedea*. Further onboard observations, and also data collection by self-reporting logbooks, are needed in the fishery to better understand the species affected and their bycatch rates.

In France, in the project areas in the Provence-Alpes-Côte d'Azur (PACA) region, data was collected using onboard observations and self-reporting logbooks on 264 fishing trips on 18 fishing vessels using both drifting and set longlines. Seabird bycatch was not detected during the study, probably due to the low frequency of seabird bycatch on longlines in the region (Lago et al. 2025; Poisson et al. 2025).

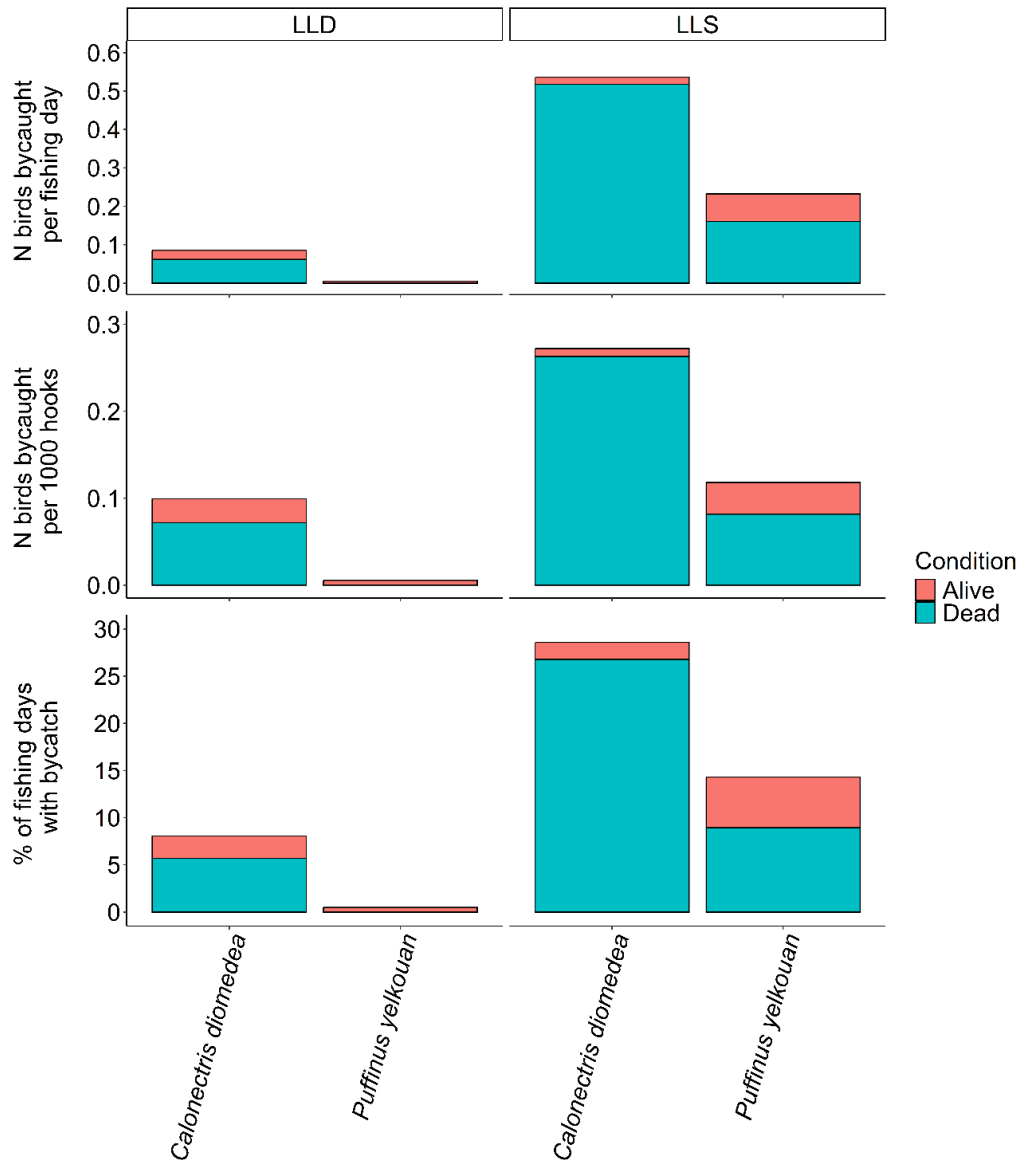


Figure 11: Number of bycaught seabirds per fishing day and per 1000 hooks, and % of fishing days with seabird bycatch per species, recorded by fishers using self-reporting logbooks and by on-board observers, Malta. The condition of bycaught seabirds is shown in red for birds retrieved alive and green for those retrieved dead. Bycatch rates were recorded on 13 longline fishing vessels during 267 fishing days (Set longlines LLS – 56; Drifting Pelagic longlines LLD – 211).

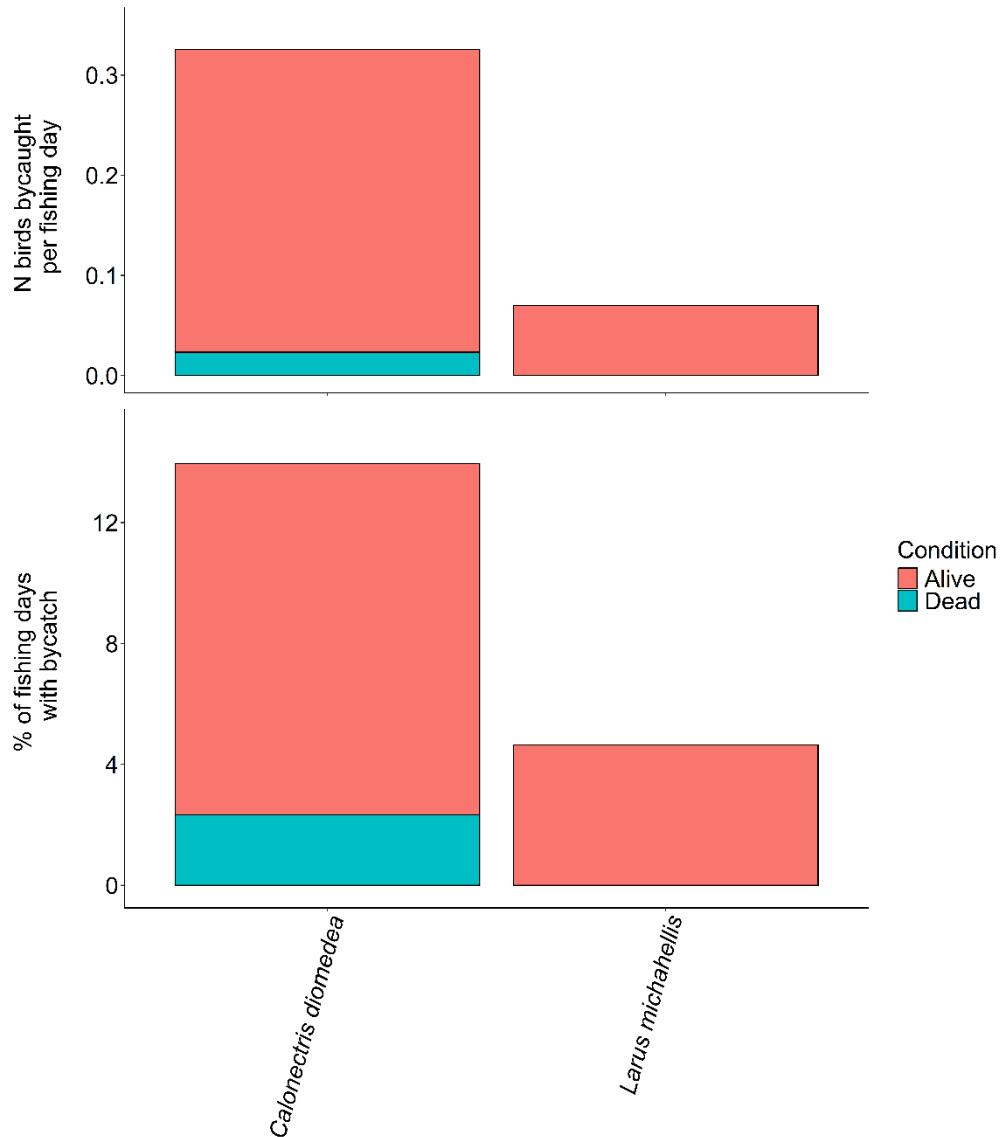


Figure 12: Number of bycaught seabirds per fishing day and % of fishing days with seabird bycatch per species recorded by onboard observers on vessels operating bottom longlines, Greece. The condition of bycaught seabirds is shown in red for birds retrieved alive and green for those retrieved dead. Bycatch rates were recorded on seven longline fishing vessels during 43 fishing days, including mitigation measure trials of the scarybird kite.

Mitigation measure trials: Scarybird kite

The scarybird kite has been tested on small-and-medium scale fisheries (6 – 20 m overall) as a visual deterrent to keep seabirds away from the line setting area. In France, the scarybird kite was also tested as a deterrent during hauling operations.

In France, this mitigation measure has been tested during 38 fishing events in four vessels monitored by onboard observers in 2024-2025, during both setting and hauling. Seabird bycatch was not recorded during neither control neither experimental fishing events. Therefore, the analysis focused on the interaction between seabirds and longlines fisheries as a proxy of a potential deterrent effect. Large flocks of *Puffinus yelkouan* have been observed interacting with vessels, but only during a few observations (Annex 1, Fig. S37; S38). On the other hand, a weak deterrent effect on *Calonectris diomedea* (GLMM parameter estimate $\pm$ SE = -0.735 ± 0.43 , $p = 0.087$) was found (Annex 1, Fig. S39), but no effect for *Larus michahellis* (GLMM parameter estimate $\pm$ SE = 0.572 ± 0.644 , $p = 0.374$). The interaction by seabirds was higher during setting operations (Annex 1, Table S14). Analyses also indicate variance by vessel, which needs further data and analysis to conclude on the reasons. Self-reported logbook data could not be used for analysis of trials, because of the lack of seabird bycatch and detailed information on seabird interactions with the vessels.

In Malta, the scarybird kite efficacy in deterring seabirds was tested using 210 fishing events logged with self-reporting logbooks on 10 vessels operating both demersal and drifting pelagic longlines. Mitigation measure testing took place in spring-summer of 2023, 2024 and 2025. Trials included events during which fishers used other mitigation measures (towed ball; a deterrent measure consisting of one or more buoys towed astern of the vessel, refer to the next section for more information) and combination of measures (towed ball and scarybird kite). Events where mitigation measure was not logged were excluded. Both *Calonectris diomedea* and *Puffinus yelkouan* were bycaught (Fig 11, Fig S40), but to have sufficient sample size the two shearwater species were analysed together. When considering both types of longlines, the scarybird kite had a weak effect on shearwater bycatch reduction (GLMM parameter estimate $\pm$ SE = -0.958 ± 0.533 , $p = 0.083$; Annex 1, Table S16; Fig. S42). The effect was slightly stronger for drifting pelagic longlines (GLMM parameter estimate $\pm$ SE = -2.325 ± 1.152 , $p = 0.044$; Annex 1, Table S17; Fig. S43). There was not sufficient data to test on set demersal longline events on their own, nor to conclude on efficacy of the combination of scarybird kite and towed ball. Refer to the next section for results on the towed ball during the same trials.

In Greece, trials of the scarybird kite were carried out in spring-summer of 2024 and 2025, on seven vessels operating bottom longlines. 61 fishing events were monitored by onboard observers, of which 26 were experimental and 35 were controls. Bycatch events (Fig. 12) were not sufficient to test the mitigation measure efficacy in bycatch reduction. Instead, the number of baited hook attack

attempts by seabirds during setting were used as a proxy for bycatch risk. The scarybird kite reduced the probability of attack attempts on baited hooks during setting (GLMM parameter estimate $\pm$ SE = -1.855 ± 0.872 , $p = 0.033$; Annex 1, Table S18; Fig. S44).

In Spain, the scarybird kite was tested in Catalonia region on 8 fishing events in one vessel, of which 3 were experimental and 5 were controls. The trials were exploratory with the intention to test the operativity of the measure and acceptance by the fishers (1.1.2; Rayment et al. 2026). The sample size was low, and trials were done out of the season with higher seabird attendance. Therefore, the trials could not be analysed further in terms of reduction to seabird bycatch or seabird interactions.

Mitigation measure trials: Towed buoy

The towed buoy consists of one or several buoys attached by a rope, either to a vessel structure or a pole in the stern, and deployed during setting to reduce interactions with seabirds leading to loss of bait and gear entanglement. This measure was already used by some fishers in France, Greece, Malta and Spain.

In Malta, this measure was tested on the 10 vessels on which the scarybird kite was trialed and logged by self-reporting logbooks, several fishing events were carried out with the towed ball or a combination of the towed ball and scarybird kite (Annex 1, Fig. S41). In the case of these fishers, the towed ball consists of a single towed buoy on a line tied to the stern or cabin roof of the vessel. Overall, considering both set demersal and drifting pelagic longlines, the towed ball reduced shearwater bycatch (GLMM parameter estimate $\pm$ SE = -1.641 ± 0.736 , $p = 0.026$; Annex 1, Table S16; Fig. S42), compared to control settings. The effect, albeit with weaker statistical support, was also present when only considering surface longlines (GLMM parameter estimate $\pm$ SE = -2.001 ± 1.169 , $p = 0.087$; Annex 1, Table S17; Fig. S43). Refer to the previous section for a description of the results obtained with the scarybird kite. Further data collection is required to establish whether improvements to the very basic towed buoy configuration used or a combination of measures could be more effective at reducing seabird bycatch. Bird scaring lines might be a valuable combination of towed buoys and visual deterrents (Lago et al. 2026) that should be explored further in the fishery.

In Spain, this measure was monitored with self-reporting logbooks during 120 fishing trips by three vessels that use it during their normal fishing operations. Fishers usually use one towed buoy but some may use up to three buoys tied together and separated by around 10 m. Fishers used the towed buoys only during the fishing days or season with higher probability of seabird interaction and it was difficult to convince them to do paired trials consisting in control and experimental settings under these conditions. Therefore, even if the sample size of number of experimental settings was high, there were not enough paired trials comparing control and experimental events to analyse the data.

Both trials in Malta and Spain found the difficulty to have baseline data or comparable data of control and experimental due to the use of different longline configurations and other variables such as bait species, the use in combination with other mitigation measures, and the reluctance to do paired trials with controls in similar conditions of the experimental settings. Further trials are needed to determine whether this measure is effective at specifically reducing *Puffinus* spp. bycatch in Malta and Spain. Paired trials should be planned to compare experimental settings with control settings where other variables (gear configuration, bait species, seabird presence) are the most homogeneous as possible.

Surface longline sinking profile

In Malta, TDRs deployed on drifting pelagic longlines targeting *Xiphias gladius* and *Thunnus thynnus* were used to estimate the access window during longline setting. Results were obtained from 101 TDR settings from four fishing vessels on 16 fishing trips, during April to July 2024 and 2025. Per setting event 3 to 9 TDRs were deployed along different positions of the line, either along the branch line or on the hook instead of a bait item (Fig. 13). The setting speed was noted by fishers for each setting and ranged between 4 and 7 knots. Each line consisted of 200-250 hooks, while each setting consisted of multiple lines tied together making up 520 to 1250 hooks in total.

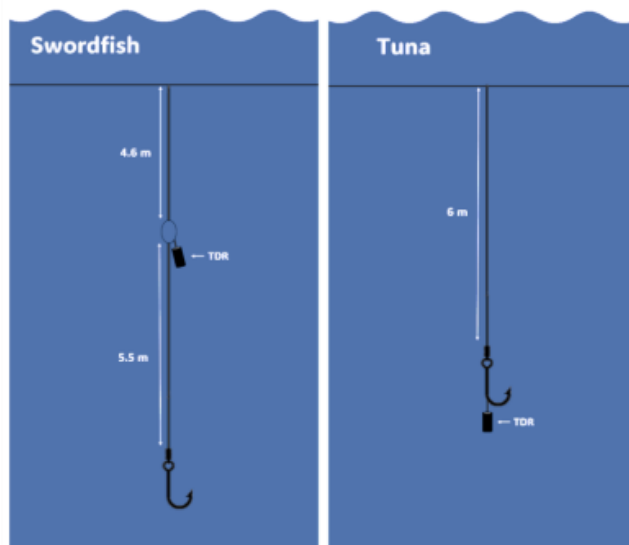


Figure 13: Time Depth Recorder (TDR) attachment position on different drifting pelagic longline gear configurations in Malta, dependent on target species: Swordfish (*Xiphias gladius*) or Tuna (*Thunnus thynnus*). Illustration by Ana Raposo.

There was large variation in the sinking rate, but generally sinking rates were slower for the beginning and the middle of the line compared to the end of the line, which was set last and had a pulling effect from the set line (Fig. 14). The result advocates for the use of mitigation measures

from the start of setting, when bycatch risk is highest, rather than an adaptive approach taken if seabird interactions increase during setting.

There were also large variations in the access window (distance astern from the vessel to the line attaining a specific depth; Fig. 15). These should be regarded as preliminary results, and future studies should ensure continuous logging of setting (vessel) speed for more accurate estimates. However, based on the current results, to reduce bycatch risk within the first 5m depth, where hooks are most accessible to shearwaters, one would need towed buoys tied with a rope at least 50m long, or bird scaring lines that cover the same distance. More data is required on what distance from the vessel the scarybird kite is effective at deterring seabirds. However, the results by Almeida et al. (2023), indicate highest efficacy at 0-20m from the vessel, which would not cover the entire access window measured here for surface longlines.

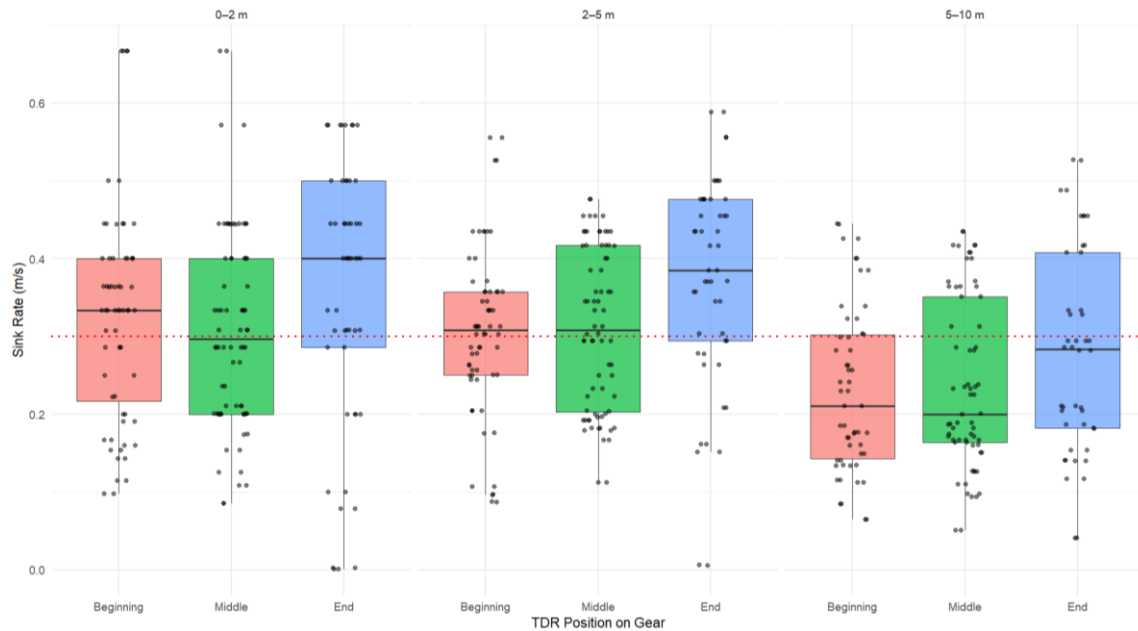


Figure 14: Sinking rate of surface pelagic longlines measured by Time Depth Recorders (TDRs) on four fishing vessels in Malta. Sinking rate is presented by position of TDRs along the longline.

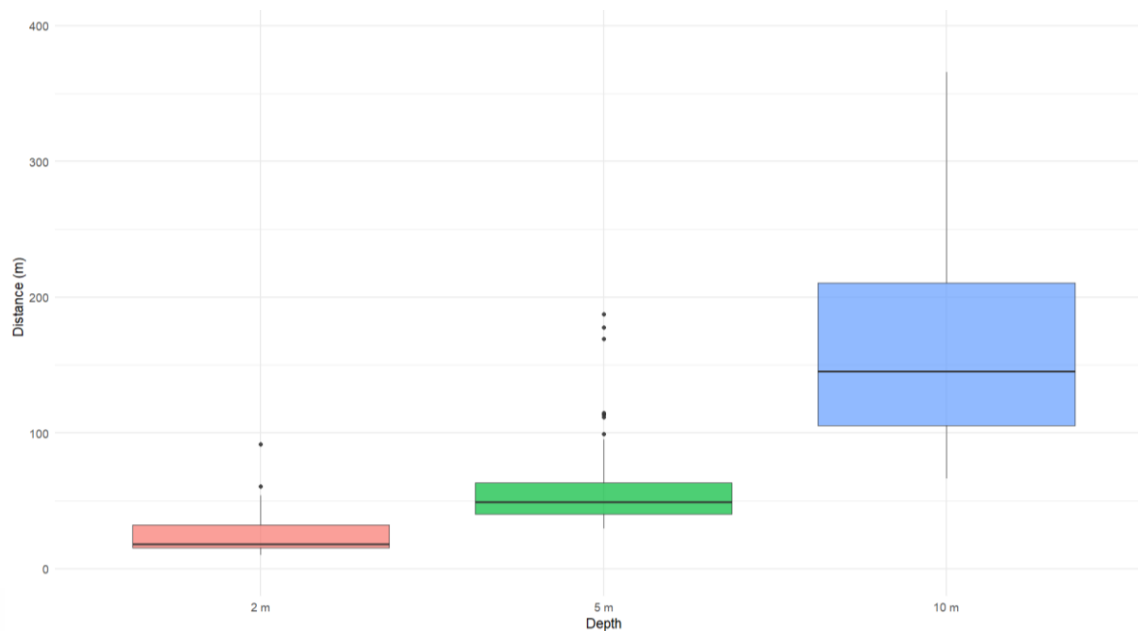


Figure 15: Distance astern of the vessel setting longlines and the gear attaining depths of 2m, 5m and 10m respectively, as measured using Time Depth Recorders (TDRs) on four fishing vessels in Malta.

Mitigation measure trials: Line weighting

Trials were done in Spain in demersal longlines to test the efficacy of line weighting to reduce seabird bycatch. Tests were done in one vessel from Balearic Islands using a gear configuration of bottom longlines in its smaller version called “palangrillo” typical in the Spanish Mediterranean small-scale fleet. The hook used was 4/0 (approx. 50 mm total length and 17 mm gape) baited with Round sardinella *Sardinella aurita* and in few sets with cephalopods. The target species are demersal fishes, mainly Red porgy *Pagrus pagrus* and Red scorpionfish *Scorpaena scrofa*. The fisher usually sets around 700 hooks per day.

In 2021, 2022, and 2023 a total of 31 trips and 62 settings (31 control and 31 experimental) were monitored with self-reporting logbooks. The control gear configuration was a bottom longline without weights at regular intervals along the line, only using sometimes a weight of 2 to 5 kg to change line direction or to avoid sea bottom features, usually in intervals of more than 100 hooks. This configuration was considered as a bottom longline without line weighting (BNW). The experimental gear was the same bottom longline but adding weights of 2-2,5 kg at regular intervals of 25, 35, or 40 hooks depending on the individuals setting, but mainly every 25 hooks considered as bottom longline with weights (BWW). The tests were paired trials setting in the same day and the same location one line control and one line experimental with a similar number of hooks each, varying depending on the day between 200 and 350 hooks each line.

The presence of seabirds interacting with the vessel in the surroundings was recorded. Shearwaters are usually more active around vessels in the Balearic Islands from March to May. In fact, out of the trials, seabirds attended the vessel on 18 events (Annex 1, Fig. S49), of which 9 were experimental sets with line weighting and 9 were control sets with normal weight configuration. During these events only fish bait was used. In the presence of seabirds attending the vessel, line weighting reduced the number of bycaught seabirds (paired-sample Wilcoxon test: $p = 0.049$; Annex 1, Fig. S49).

Demersal longline sinking profile

In the context of these trials in Spain, TDR were deployed on bottom longlines of one vessel. A total of 9 paired trials (9 control and 9 experimental settings) were recorded from May to July 2022. Overall, data highlights the lower sinking rate of bottom longlines without line weighting (Fig. 16) and the long access window during setting compared to the lines with added weights (Fig. 17). The sinking profile was very dependent on the conditions of each setting (Soliño et al. 2023).

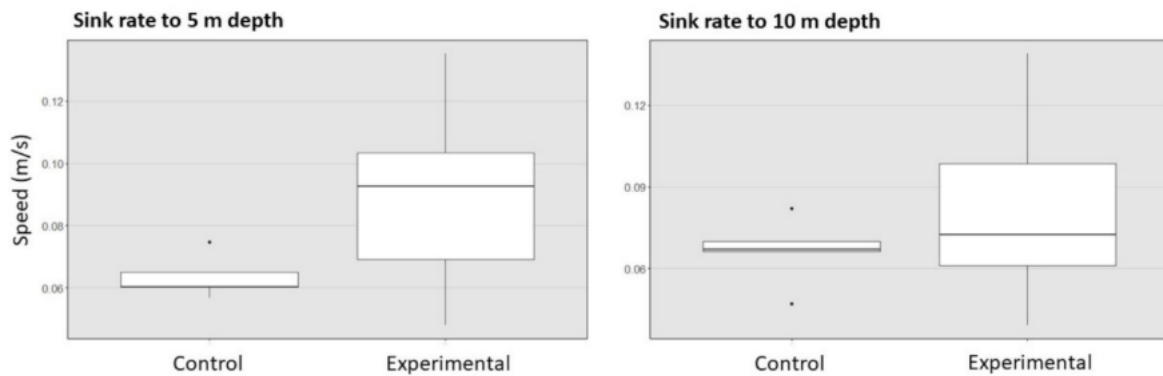


Figure 16: Sinking rate at 5 and 10 m of bottom longline, measured by Time Depth Recorders (TDRs) on one fishing vessel in Spain. Control: bottom longline without weights BNW Experimental: bottom longline with weights BWV. From: Soliño et al. 2023.

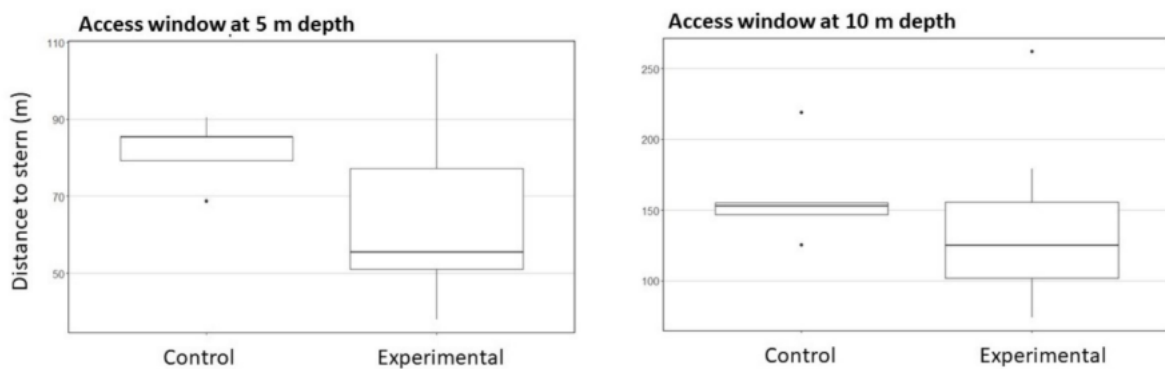


Figure 17: Access windows at 5 and 10 m depth for bottom longlines measured by Time Depth Recorders (TDRs) on one fishing vessel in Spain. Control: bottom longline without weights BNW Experimental: bottom longline with weights BWV. From: Soliño et al. 2023.

Mitigation measure trials: Bait type

In Spain the effect of bait type on seabird bycatch in set longlines (LLS), most of them demersal longlines, was tested analysing the extensive self-reporting logbook dataset from Catalonia and Balearic Islands, Data collection was carried out in the years 2020 to 2023 on 22 vessels (5.75 m - 13.79m overall), using different gear configurations (Annex 1, Fig. S45). For analysis of how

different bait types affect bycatch, analysis was restricted to February to June which are the months with highest interactions and bycatch rates (Annex 1, Fig. S46), leaving 934 fishing trips for further analysis. Bycatch rates per trip varied by gear configuration and bait type (Annex 1, Table S19; Fig. S47). While further data collection and analysis is required to determine whether some bait combinations and bait and gear combinations are less susceptible to bycatch, overall fish bait resulted in higher bycatch rates than cephalopod bait (Tukey post-hoc estimate $\pm$ SE = 1.450 $\pm$ 0.470, p = 0.045). The most common fish bait was Round sardinella *Sardinella aurita* and European pilchard *Sardina pilchardus*.

Mitigation measure trials: Time of Setting

A best practice that is often carried out by longline fishers is night setting to avoid the presence of seabirds and reduce bycatch risk. However, if night setting extends into sunrise or starts at sunset, fishing operations might overlap with peak foraging times of shearwaters, including *Puffinus yelkouan* (Austad et al. 2024). To test the effect of setting time on seabird bycatch rates, 1037 settings during 818 trips logged by self-reporting logbooks on 21 fishing vessels from Catalonia and the Balearic Islands, Spain, were used. Only fishing events with registered start and end of setting were retained. Each setting was allocated one of four periods (Day, Sunset, Night or Sunrise). Day was defined the interval between one hour after sunrise and one hour before sunset, while night was defined as the interval between one hour after sunset and one hour before sunrise. Sunrise and sunset were defined as one hour $\pm$ sunrise and sunset respectively. If a setting overlapped the sunrise or sunset periods, it was allocated to the respective sunrise or sunset period. If a setting took place within the day or night entirely it was allocated to the day or night respectively.

While seabird bycatch was not completely absent from night settings, bycatch rates at night were lower than all other time periods (Annex 1, Fig. S48; Tables S20-S22), providing strong evidence to support this practice. However, further measures such as line weighting and change of bait type, which are not visual deterrents might be required in addition to night setting to reduce bycatch further. Further analysis should look at lunar effects. Moreover, the results demonstrate that setting at sunrise should be avoided.

1.2 Financial assessment of mitigation measures and fisher acceptance

The mitigation measures tested in LIFE PanPuffinus! and used by fishers during the data collection period, were not only assessed for their seabird risk reduction, but also for their costs, ease of implementation and acceptance by fishers. The LIFE PanPuffinus! Action C1 Seabird bycatch mitigation toolkit (Lago et al. 2026) summarises the main advantages, level of investment needed, and possible issues with troubleshooting advice for each measure included, while the Action D2 report Final Assessment of Economic and Social Impacts (Rayment et al. 2026) provides material cost estimates per vessel. Equipment costs for recommended mitigation measures range from 20 and 375 € per vessel, with an average of 200 €. Considering replacements, costs are estimated to be around 67 € per year (Rayment et al. 2026).

Post-trial interview surveys with fishers were analysed and reported in Final Assessment of Economic and Social Impacts (Rayment et al. 2026). 31 such interviews were carried out, 68% of which were with fishers that had trialled the scarybird kite in different gears.

The majority of fishers did not report changes to target catches due to the use of mitigation measures and none reported changes to catch species composition (Rayment et al. 2026). The reported change to catches was positive, due to less bait loss to seabirds during setting.

Interviews with fishers indicate that setting up mitigation measures was easy and did not take up much time (Rayment et al. 2026). Moreover, the majority of fishers that participated in trials, were overall positive to the measures tested and would be willing to continue to use the measures in day-to-day operations since they regarded reduction in seabird bycatch as having direct economic and time-saving benefits (Rayment et al. 2026). Fisher acceptance of mitigation measures could be dependent on financial support to purchase and maintain the necessary equipment (Rayment et al. 2026), while acceptance by fishers participating in trials might not reflect the attitude of fishers at the wider fleet scale. Further testing is required with a larger sample of vessels to understand habituation processes by seabirds to visual deterrents such as the scarybird kite, a concern that was observed and expressed by the fishers (Rayment et al. 2026).

While the post-trial surveys indicate fisher acceptance towards mitigation measures tested, they also indicate reluctance to changes in practices such as line weighting, discard management and changes in bait type (Rayment et al. 2026). On the other hand, some fishers have on their own initiative changed bait type to fake lures and set up the towed buoy, which some find more effective than the scarybird kite (Rayment et al. 2026). Level of mitigation measure implementation and practices adapted to by fishers to avoid seabird interactions was already quite high in some fleets while absent in others (Lago et al. 2025).

The contrast panels tested in trammel nets in Gulf of Kalloni, Greece, might not adhere to the above findings on ease of implementation and were the most expensive of the mitigation measures assessed (Rayment et al. 2026). In addition, modifying trammel nets to include contrast panels was time consuming and required considerable time input from HOS observers as well as fishers. Unfortunately, nets with contrast panels also wore faster than unmodified nets, especially the outer net mesh, leading to high maintenance costs that have not been quantified. The mitigation measure has not been included in the Seabird mitigation measure toolkit (Lago et al. 2026) because the long-term application of the measure seems unfeasible and unsustainable. Further testing of the variations to the measure and other best practices, such as using traps during February to April or limiting operations to night-time, is required in the Gulf of Kalloni and thus proposed for future consideration.

1.3 Success of the independent monitoring programme

The project used of self-reporting logbooks and onboard observations to assess seabird interactions, seabird bycatch and efficacy of mitigation measures across multiple fleets. Engagement and collaboration with fishers were key to this approach. Table 1 reports the number of fishing vessels participating in data collection by self-reporting logbooks (SRL) and onboard observations (OBO) by gear category and partner country. The two data collection types are presented separately because they pose different levels of commitment and engagement by fishers. However, some fishers participated in both data collection types, in addition to using multiple gears, and these overlaps mean that the number of vessels in Table 1 should not be summed. Moreover, the subset of vessels participating in mitigation measure trials are also presented as are the number of reported individual seabirds bycaught.

As part of Action C1, national authorities were engaged to improve fields for seabird interaction and bycatch monitoring within national reporting and electronic logbooks. Future assessment of the success of the monitoring programme should assess the number of fishers who complete electronic logbooks with information on seabird bycatch as part of national monitoring. At the time of completion of the current report this data was not available.

Table 1: Summary of fisher participation during LIFE PanPuffinus!, 2020-2025 using self-reporting logbooks (SRL) and onboard observers on fishing vessels (OBO) by partner country and gear category (PS – Purse Seine; OTB – Bottom otter trawls; OTM – Midwater otter trawls; GNS – Set gillnets; GTN – Combined gillnets-trammel nets; GTR – Trammel nets; FPO – Pots and traps; FIX – Traps unspecified; LHP – Handlines and pole-lines; LL – Longlines unspecified; LLD – Drifting longlines; LLS – Set longlines).

Country	Gear Category	Data collection Type	N Vessels Total	N Vessels Mitigation Measure Trials	N Fishing trips/days	N Seabirds Bycaught
Portugal	GNS	SRL	1	0	30	30
Portugal	GTR	SRL	8	4	438	227
Portugal	PS	SRL	4	2	73	0
Portugal	FPO	OBO	5	0	51	0
Portugal	PS	OBO	7	4	85	1
Portugal	GNS	OBO	5	2	27	1

Country	Gear Category	Data collection Type	N Vessels Total	N Vessels Mitigation Measure Trials	N Fishing trips/days	N Seabirds Bycaught
Portugal	GTR	OBO	7	5	154	102
Portugal	FIX	OBO	1	0	5	0
Spain	LLS	SRL	22	4	1669	386
Spain	LLS	OBO	1	1	8	0
France	FPO	OBO	1	0	1	0
France	GNS	OBO	2	0	3	0
France	GTR	OBO	8	0	13	0
France	LHP	OBO	2	0	2	0
France	LL	OBO	2	1	4	0
France	LLD	OBO	8	3	23	0
France	LLS	OBO	7	2	13	0
France	LTL	OBO	2	0	2	0
France	OTB	OBO	1	0	1	0
France	GNS	SRL	2	0	15	0
France	GTN	SRL	1	0	2	0
France	GTR	SRL	3	0	95	0
France	LHP	SRL	1	0	8	0
France	LLD	SRL	3	2	86	0
France	LLS	SRL	3	2	138	0
France	OTB	SRL	1	0	15	0
Greece	GTR	SRL	5	5	237	72

Country	Gear Category	Data collection Type	N Vessels Total	N Vessels Mitigation Measure Trials	N Fishing trips/days	N Seabirds Bycaught
Greece	GNS	OBO	2	0	4	0
Greece	LLS	OBO	7	6	43	17
Greece	GTN	OBO	2	0	4	0
Greece	GTR	OBO	5	5	104	24
Malta	LLD	SRL	8	7	209	19
Malta	LLS	SRL	5	2	51	41
Malta	LLS	OBO	1	1	7	4
Malta	OTM	OBO	1	0	1	0
Malta	LLD	OBO	3	2	5	0

2. Control & Eradication of Non-native Predators

Invasive alien species are the threat with highest overall impact on seabirds and affecting most species worldwide (Dias et al. 2019). While invasive plants and herbivores can degrade and alter habitat suitability, the largest negative impact is made by non-native predators by direct predation on adult seabirds and their eggs and nestlings (Spatz et al. 2022). Amongst these, Rats *Rattus* spp. and cats *Felis catus* are the non-native species, particularly to islands, with highest documented impact (Dias et al. 2019). Pigs *Sus* spp. introduced to islands have both predation and habitat damaging effects due to having an omnivorous diet, while trampling and digging up burrows (Spatz et al. 2022). Shearwaters and related species are particularly vulnerable to predation because of various life-history strategies including long nesting seasons, a maximum of one offspring per year, slow maturity to reach breeding age and a strong tendency to return to the natal colony, while having few if any mechanisms to repel mammal predators (Spatz et al. 2022). Non-native predators can cause complete extirpation of seabird colonies, or contribute to decline through repeated annual reduction in breeding success (Rodríguez et al. 2019).

Fortunately, conservation efforts have been made to eradicate non-native species from islands with positive outcomes including re-colonisation and recovery by seabird populations (Jones et al. 2016). Several of these eradications have taken place in the Mediterranean region (Capizzi et al. 2020) and more recently reviewed as part of the LIFE PanPuffinus! project including control efforts (Greetham et al. 2022). While eradication aims to permanently remove an entire population of a non-predator species from an island, this is not always feasible. For example, rat eradication on the island of Kemmuna, part of the Maltese archipelago, was not deemed feasible as part of a dedicated feasibility study, due to the large risk of rat re-incursion by swimming from surrounding islands and by the large number of vessels visiting the island on a daily basis (Varnham et al. 2017). Instead, seasonally controlling rodents in specific areas of high conservation concern can have similar conservation benefits (Lago et al. 2019).

The aims of LIFE PanPuffinus! on non-native predators, was to improve the efficiency of rodent control actions at Maltese *Puffinus yelkouan* colonies, eradicate rodents from further islands in Greece and improve methods and frequency of biosecurity visits in the Mediterranean region. In fact, one main finding by Greetham et al. (2022), was that funding and resources often did not allow for frequent enough biosecurity surveillance visits to islands that had been previously eradicated. During the project lifetime, illegal introduction of feral pigs to Gyaros island, Greece, hampered the plans of rodent control at the shearwater colony there, while the immense negative impact on the island and the *Puffinus yelkouan* colony were documented (Visalli et al. 2025). Ultimately, the

success of conservation actions on non-native predators were measured through stable or increased breeding success of the target shearwater species. During all baiting and monitoring visits, personnel remained vigilant for any non-target species potentially affected by control and eradication methods.

2.1 Monitoring for the presence/absence of the target invasive species

2.1.1 Eradication Sites

Eradication operations in Greece took place in the Project site “Northern Dodecanese islands and islets” and specifically the Agreloussa islet complex comprising of four islets (Agreloussa, Stroggylo, Marathi and Spolato) (Christidi et al. 2022a, b; Christidi & Portolou 2022; Visalli et al. 2025). Of these islets, Agreloussa is the largest uninhabited islet, hosting a significant *Puffinus yelkouan* colony (810 - 1170 pairs), while Stroggylo and Spolato are uninhabited islets with livestock. Lastly Marathi islet is the only inhabited islet in Agreloussa complex.

The *baiting phase* of the eradication commenced during winter 2022 with the laying of 248 bait stations in a 100x100m grid. Eradication visits took place every 2-5 days during December 2022, then during January and February 2023, visits were performed every 2 weeks. The *monitoring phase* commenced in April 2023 until 12/2025. In Agreloussa islet overall, 21 visits were performed, of which 9 eradication visits (Fig. 18; Fig. 19) and 12 monitoring visits. At each monitoring visit, remaining bait was evaluated and noted, while any consumption by invertebrates or weathering was also recorded. During each visit, all remaining bait was collected and removed from the islet for safe disposal and then bait stations refilled with bait. Bait consumption on Agreloussa islet reached zero within 3 months (2/2023; Fig. 18; Fig. 19) and since then no rats signs were recorded (bites, faeces, nest material, footprints, or other indicators).

During the monitoring phase camera traps were selectively deployed in Agreloussa colony in order to monitor rodent activity post-eradication in 2023, 2024 and 2025. Camera traps were placed in areas with high nest density and where *Puffinus yelkouan* predation had been noted from unknown avian predators. No images of rats were recorded on camera traps in any of these deployments. On the other hand, Goodnature E2 traps were not placed on Agreloussa. Goodnature E2 traps are humane, fast-acting devices that kill rodents mechanically without the use of rodenticides and feature an automatic reset system that allows multiple kills. Their weather-resistant design and low maintenance requirements can make them particularly suitable for hard-to-access field sites. However, prior experience in Greece, namely on Gyaros and Marathi islets, no hits were recorded on the traps and no interest was shown by rats. Through camera trap videos and photos, it was observed that rats frequented the vicinity of the Goodnature E2 traps in Marathi, however within 3 months of trials, the traps themselves were never visited by rats (zero hits) even though their location and lure was changed. Similarly, it was decided not to use chocolate-flavoured wax blocks on Agreloussa as these were trialled in two islets during 2021-2023 and seemed to lose their shape due to heat and invertebrate consumption.

Agreloussa, Stroggylo and Spolato islets have been added on the online LIFE PanPuffinus! Invasive species management database².



Figure 18: Average consumption of bait in Agreloussa islet at Visit #1 (4-7/12/2022).

² LIFE PanPuffinus! Invasive species management database:

https://www.google.com/maps/d/u/0/edit?mid=1rB-ZjXd_YH_XlhrbWT3X884g11aYjMg&usp=sharing



Figure 19: Average consumption of bait in Agreloussa islet at Visit #9 (22-23/2/2023).

2.1.2 Control Sites

Rodenticide baiting was carried out in four *Puffinus yelkouan* colonies in the Maltese Islands during the shearwater nesting period, including seasons from 2020 to 2025 (Visalli et al. 2025). All four sites – Rdum tal-Madonna, Kemmuna and Kemmunett, Selmunett Island, and Majjistral Natural History Park (NHP) – are either located on, or too close to, inhabited large islands on which permanent rodent eradication is not feasible. Rodents re-appear at these sites both between and within the breeding seasons, even on the islets of Selmunett and Kemmuna/Kemmunett, where incursions occur from adjacent areas and with all islets being well within rat swimming distance (Visalli et al. 2025). Bait stations were placed in grids adapted to the site and targeting only areas surrounding the colonies (Annex 2).

Given that complete eradication is not achievable at any of the locations, seasonal rodent control using rodenticide baiting (Protect wax blocks - 0.005% bromadiolone) was adopted in 2018 as a conservation measure for *Puffinus yelkouan* under LIFE Arcipelagu Garnija (LIFE14 NAT/MT/991), successfully achieving seasonal control of rodent populations at the colonies (Sahin et al. 2020). As part of the AfterLIFE of that same project, rodent control continued to be carried out in 2021 and 2022 seasons. In 2023 the operational plans for rodent control on each site were revised and updated as part of LIFE PanPuffinus! (Greetham et al. 2023a, b, c, d), reaffirming seasonal control as the most effective management approach for protecting valuable *Puffinus yelkouan* colonies in long term. In addition to rodenticide baiting, monitoring tools were used in parallel to detect and estimate rodent abundance. These tools followed the monitoring toolkit developed under LIFE PanPuffinus! (Boucher et al. 2022).

To monitor control sites, motion-sensor camera traps were deployed throughout the *Puffinus yelkouan* breeding season to assess rodent presence in the main colony areas. They were deployed in key sites where rodents were expected to visit in the colony such as entrances to *Puffinus yelkouan* breeding caves. Camera traps were used both to confirm any rat presence within the colonies and to provide a proxy measure of rodent abundance. The number of images capturing rodents at each camera trap was counted, monitored at intervals ranging from one to three weeks (similar to the visit frequency to replace rodenticide bait), allowing for an assessment of temporal variation in rodent activity. This measure of rodent presence was then compared with bait consumption within the colonies to evaluate potential correlations. In most cases, rodent activity recorded by camera traps matched bait consumption, where activity typically peaked at the beginning of rodenticide deployment at control sites, declined as baiting efforts continued, and increased again later in the breeding season.

In Kemmunett, during the 2024 season, three camera traps were deployed in cliff-side caves covering the extent of the nesting area of the Yelkouan Shearwater. Bait consumption through the

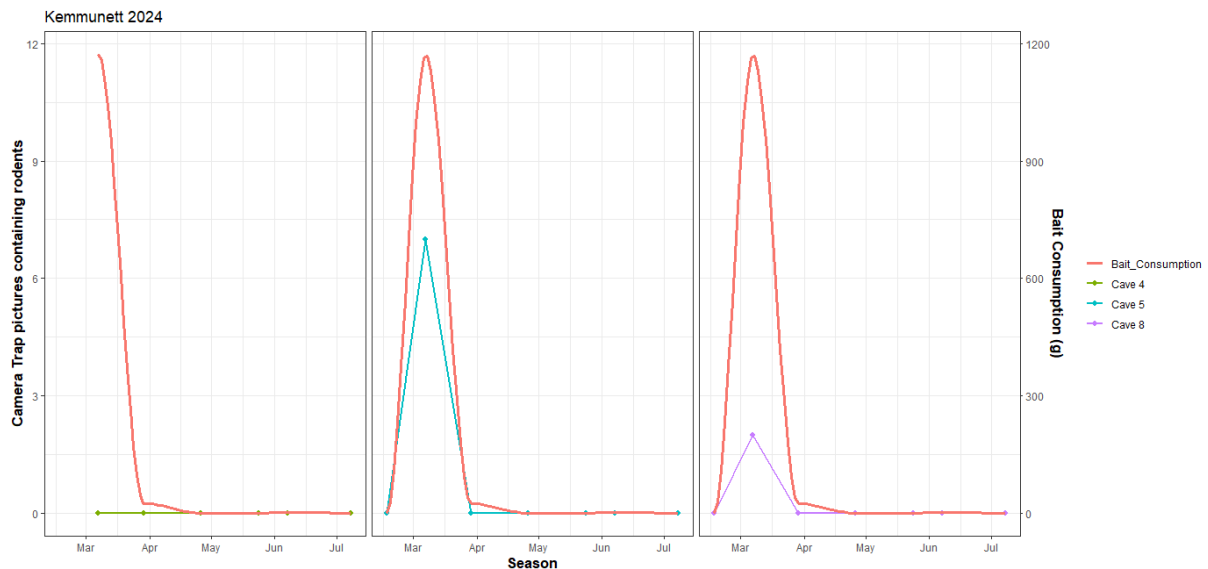


Figure 20: The graph shows the total rodenticide anticoagulant bait consumption over the season (March to ~July) plotted against the total amount of images with rodent presence at Kemmunett. The solid red line represents the estimated bait consumption by *Rattus* sp., while the coloured line represents the images at different sub-areas in the colony.

season was very low and after the first month it remained at zero, showcasing how the biosecurity measures in this site were effective. Likewise, camera trap images on all areas displayed the same trend, where the few images with rodents present were found at the peak of bait consumption and then remained at 0 throughout the season (Fig. 20).

On a similar note, at Rdum Tal-Madonna (RM01 subsite), during the 2025 season, bait consumption and camera trap images displayed comparable trends, with peak of bait consumption situated in the first month and then remaining low throughout the season (Fig. 21). A small incursion took place at the end of the season, detected both by the consumption and the camera trap thanks to regular bait replacement and checks (Fig. 21).

At Selmunett during the 2025 season, bait consumption varied markedly among subsites where camera traps were deployed. These differences appear to be influenced by site topography and rodent species composition on the island. Bait consumption was particularly low in the northern cliff-side area of Selmunett (Next Boxes Ledge; Fig. 22). At the western part of Selmunett (subsite “Plateau – Opposite E2”; Fig. 22) both metrics showed the consistent seasonal pattern, with a

primary peak in rodent activity in early March and a secondary, shorter peak between May and June. The eastern part of the island (subsite "Small Island"; Fig. 22) recorded the highest bait consumption during the 2025 season. Notably, the second seasonal peak was substantially higher and more prolonged than that observed in the western subsite. This pattern is attributed to the additional presence of house mice (*Mus musculus*), which were more abundant in the eastern subsite in 2025 (Fig. 23).

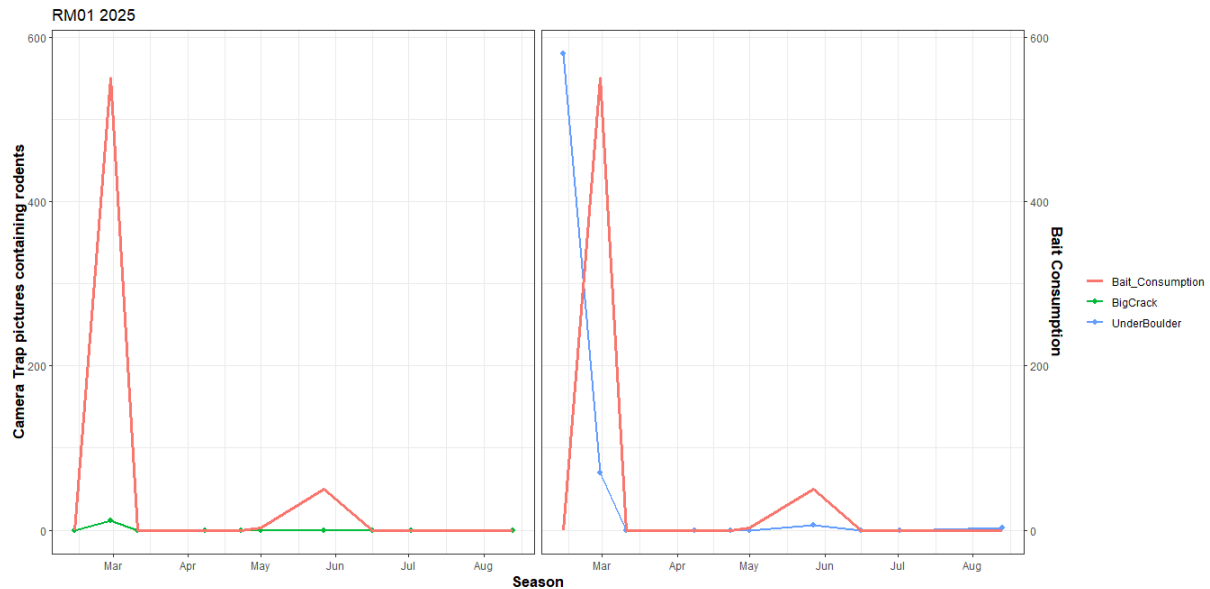


Figure 21: The graph shows the total rodenticide anticoagulant bait consumption over the season (March to ~August) plotted against the total amount of images with rodent presence at Rdum Tal-Madonna. The solid red line represents the estimated bait consumption by *Rattus* sp., while the coloured line represents the images at different sub-areas in the colony.

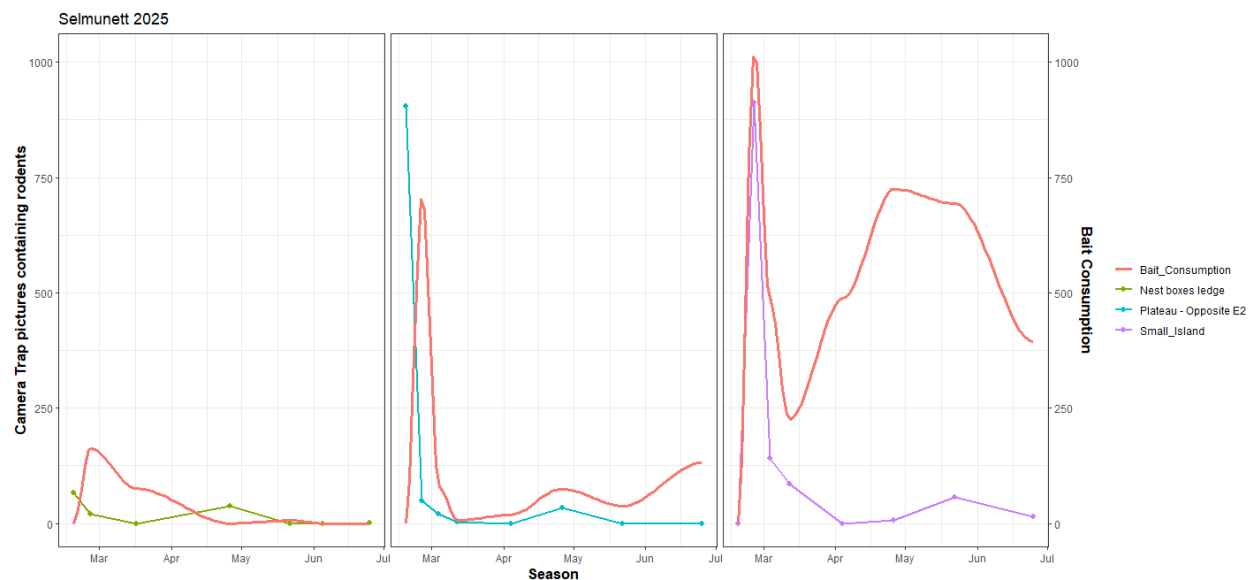


Figure 22: The graph shows the total rodenticide anticoagulant bait consumption over the season (March to ~July) plotted against the total amount of images with rodent presence at Selmunett. The solid red line represents the estimated bait consumption by rodents, while the coloured lines represent the images at different sub-areas in the colony.

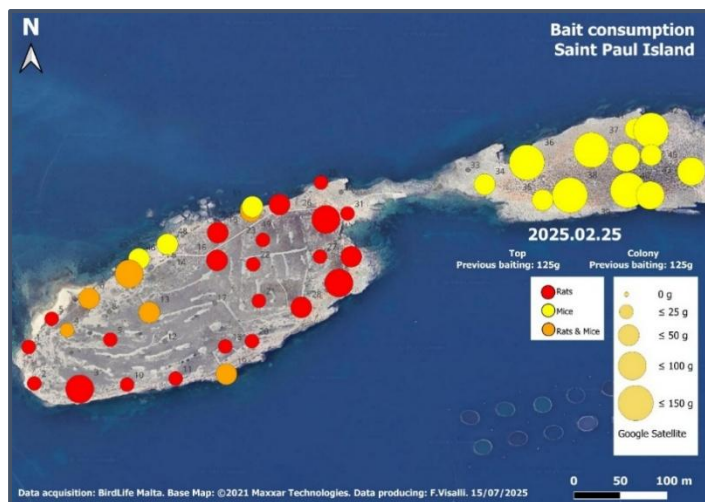


Figure 23: Example of distribution map of different species of rodent (*Rattus* sp. and *Mus musculus*) based on bait consumption (recognized by bite marks on rodenticide blocks) recorded for Selmunett (MT22) in 2025. Eastern area of the island showcases a unique consumption by house mice, in comparison to the western area. Orange circles represent consumption demarked by both species. Size of the circles represent estimated amount of bait consumed.

All subsites at Majjistral colony during the 2024 season exhibited overall low bait consumption, with variations linked to specific incursions occurring during the breeding season (Fig. 24). Although bait consumption typically peaks during the first and last months of the breeding season, a notable incursion was recorded between June and July. The four camera traps deployed within the colony are distributed along a north-south gradient, providing spatial coverage of the site. This arrangement enables the identification of where and when incursions occur, as well as the assessment of potential rodent movement across the colony. During the June–July incursion, only subsites Cave 1 and Cave 3 recorded camera trap images showing the presence of rats. These findings suggest that the incursion was localized and did not result in the spread of rodents throughout the colony after bait consumption. Overall, the monitoring system proved effective in identifying the origin and extent of the incursion, demonstrating the success of the baiting grid implemented at the site.

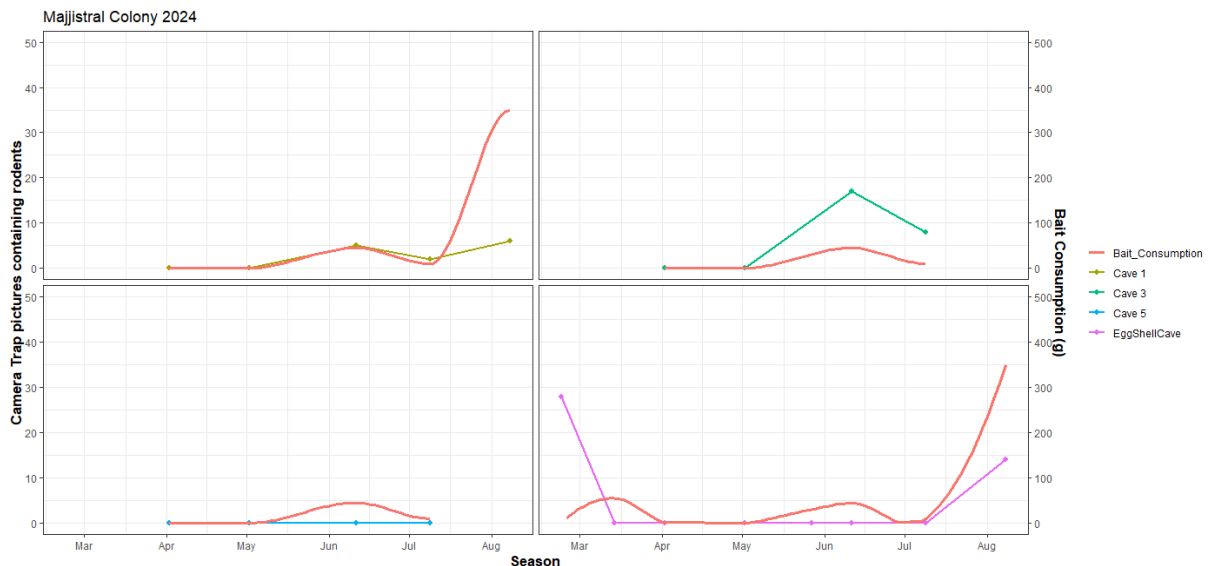


Figure 24: The graph shows the total rodenticide anticoagulant bait consumption over the season (March to ~July) plotted against the total amount of images with rodent presence at Majjistral colony (MT24). The solid red line represents the estimated bait consumption by rodents, while the coloured lines represent the images at different sub-areas in the colony.

To further monitor rodent activity at control sites, Goodnature E2 traps were deployed in locations comparable to those of the camera traps, primarily within the shearwater colony areas. These traps served both to assess rodent presence and to provide an additional control measure in the event of rodent incursions. In contrast to trials on Greek islands, they have been found to be fairly effective as a secondary control measure at Maltese sites. The main limitation is that they cannot be placed in extensive grids in the same way as bait stations.

Traps were mounted vertically or placed inside wooden boxes to enhance rodent attraction and minimise non-target risks; in sheltered locations, some traps remained deployed year-round. Visits to check traps coincided with checks of camera traps and bait stations. During maintenance visits, lure and CO₂ canister condition were checked and replenished as required. An impact counter were fitted on the traps. Readings were recorded and reset at each visit, recognising that counters may occasionally be triggered by non-identifiable impacts on the exterior of the trap. Consequently, rodent mortality was estimated using both carcass counts near traps, representing minimum kill estimates, and counter data, representing maximum kill estimates (Fig. 25). However, rodent presence was only

quantified based on the minimum number of rodents killed per trap, standardized by the number of traps deployed at each colony, considering the possibility of carcasses not being found due to events of scavenging, or by natural deterioration due to weather conditions. Annual variation in rodent kills per trap was recorded for each year of deployment (2018–2025) and subsequently aggregated by month for each colony (Fig. 26).

Overall, rodent kill patterns closely mirrored trends observed in bait uptake and camera trap detections, with activity peaking during the early months of the breeding season, declining as the season progressed in conjunction with bait deployment, and increasing again later in the season as new incursions took place, although patterns differ between sites. The minimum kill estimates (confirmed rodents killed by a trap) per trap deployed in each locations was plotted against the total bait consumption recorded in each site, averaged across 2018 to 2025 (Fig. 26). Apart from offering a secondary control method to rodenticide at colony ledges (Visalli et al. 2025), protecting against rodents that make it to shearwater breeding caves, Goodnature E2 traps control incurring rodents in the off-season when rodenticide is not deployed. The latter could help to reduce rodent populations from establishing at colonies.

No non-target species were found affected by the presence of either rodenticide bait stations or Goodnature E2 traps. No vertebrates, including mammals, birds, or reptiles, were observed to be harmed by the bait or traps during monitoring at the target sites. This indicates that both methods were highly species-specific, effectively targeting rodents while minimising potential impacts on non-target wildlife.

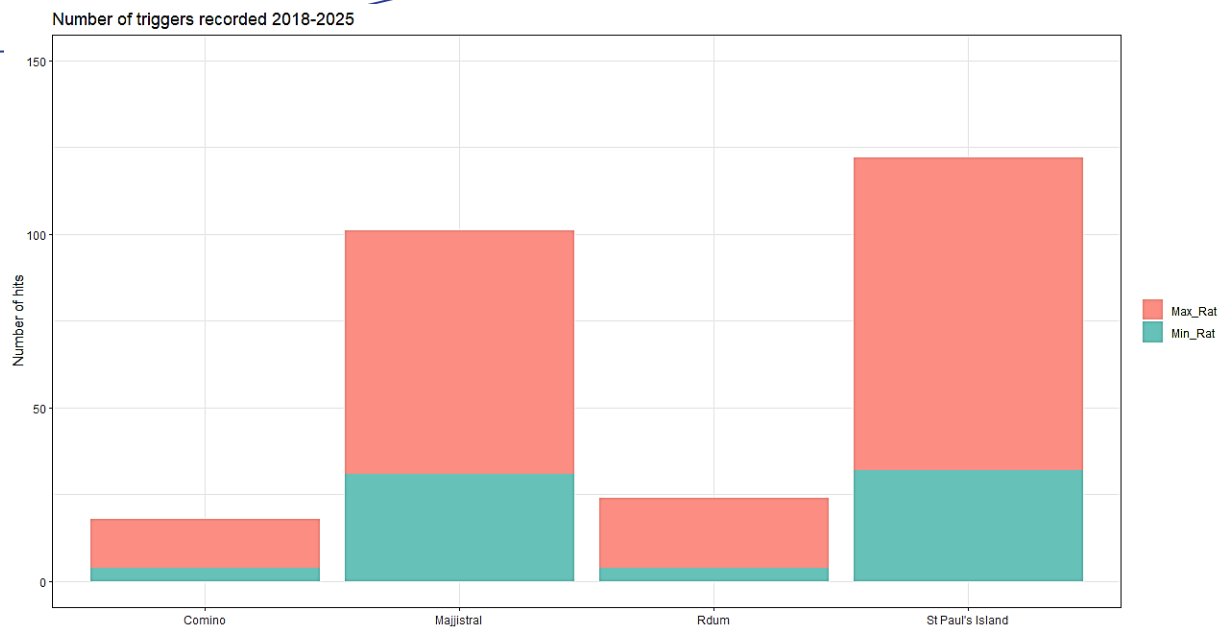


Figure 25: Number of rodents killed by Goodnature E2 traps at Puffinus yelkouan colonies in the Maltese Islands, between 2018 and 2025. Minimum numbers (green) are based on rodent carcasses found below traps, while maximum numbers (red) are based on impact counts.

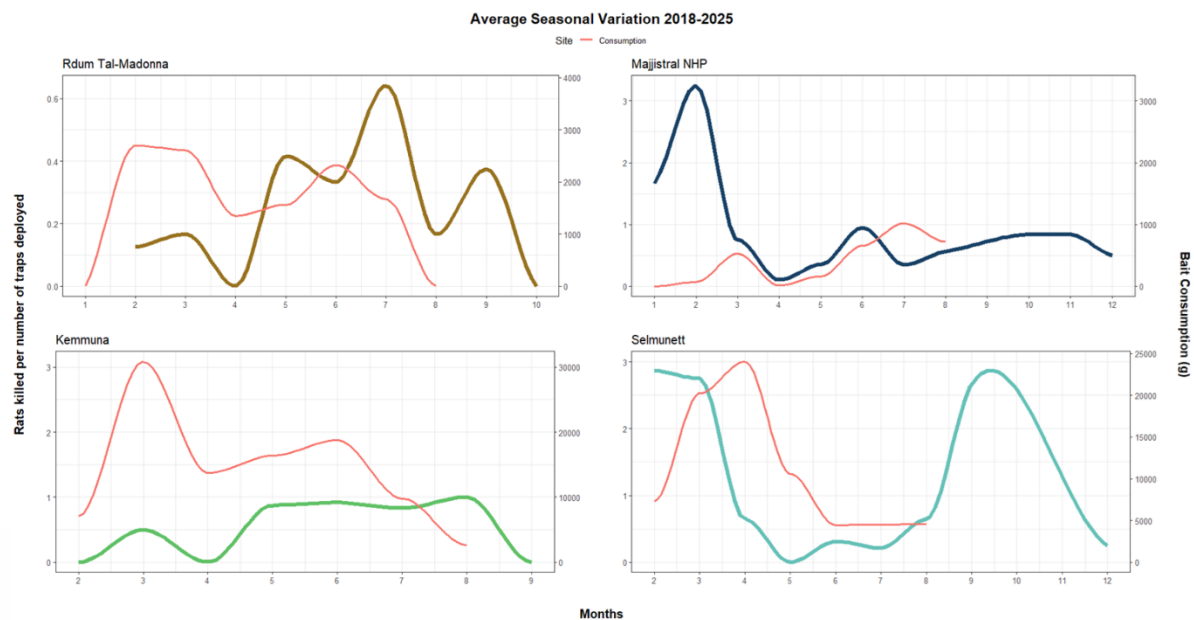


Figure 26: Number of rodents killed per Goodnature E2 traps at four different Puffinus yelkouan colonies in the Maltese Islands, averaged between 2018 to 2025 seasons, plotted against average bait consumption within the same locations. Red line represents bait consumption (in grams) throughout the season of rodenticide baiting (February-August).

Rodent activity was also monitored throughout the sites with non-toxic chocolate-flavoured wax blocks (Boucher et al. 2022), deployed in strategic areas in the colonies. The use of non-toxic wax blocks assisted in identifying presence and species of rodents, including any individuals that may have been aversive to the rodenticides applied. Kemmunett and Selmunett had the largest deployment of wax blocks, most of them deployed as well within bait stations, covering large extents of the sites. Number of wax blocks deployed during 2021-2022 were accounted by site number for Kemmuna and Kemmunett. For Rdum tal-Madonna, during 2021-2022, wax blocks were deployed only in strategic areas of the colony, whereas during 2023-2025, wax blocks were also deployed in bait stations (Table 2).

Table 2: Number of non-toxic flavoured was-blocks deployed to assist in rodent monitoring at Puffinus yelkouan colonies, Malta

Site Number	Site Name	Wax Blocks deployed from 2021-2022	Wax Blocks deployed from 2023-2025	Total
MT09	Rdum Tal-Madonna	29	21	81
	Rdum Tal-Madonna*		31	
MT17	Kemmuna	27	15	124
	Kemmunett		82	
MT22	Selmunett	41	157	198
MT24	Majjistral NHP	23	17	40

*wax blocks deployed inside bait stations

2.2 Monitoring of the impact of the removal of target invasive species on native species

The main method of monitoring the impact of alien predator removal on shearwater species at the colonies was assessed by measuring breeding success at various colonies and nest sample sizes. In general, a minimum of two visits were made; one during incubation and one in late chick-rearing. Usually, at least one intermediary visit was also made in the early chick-rearing. Only nests with an attending adult during the incubation period were counted (nests which fail prior to first visit are not counted in breeding success estimation). Not all nests could be checked at fledging age; but chicks were at least around 4 weeks old when assigned as successful. In this case, any chicks which might have died after the last check, before fledging, went undocumented. In other cases when visits were made at expected fledgling and any nest was found empty but with flatted down lining the burrow, then it was assigned as successful.

On the Maltese Islands, breeding success monitoring at all the four LIFE PanPuffinus! colony sites had started during LIFE Arcipelagu Garnija. Hence, breeding success of *Puffinus yelkouan* on Malta is presented for 2018-2025 (Table 3).

Table 3: Breeding success of *Puffinus yelkouan* at four colonies with predator management on the Maltese Islands for the years 2018-2025. Breeding success is estimated for nests occupied by incubating adult shearwaters (Active nests).

Colony	Year	# Active Nests	# Hatching successful	% Hatched	# successful	% breeding success
Kemmuna & Kemmunett	2018	9	8	88.89	8	88.89
	2019	3	2	66.67	2	66.67
	2020	12	9	75.00	9	75.00
	2021	8	5	62.50	4	50.00
	2022	8	3	37.50	3	37.50
	2023	8	5	62.50	5	62.50
	2024	12	10	83.33	9	75.00
	2025	12	10	83.33	10	83.33
Majjistral &	2018	48	31	64.58	26	54.17

Ċumnija	2019	47	24	51.06	22	46.81
	2020	45	30	66.67	27	60.00
	2021	21	14	66.67	8	38.10
	2022	37	25	67.57	24	64.86
	2023	30	22	73.33	21	70.00
	2024	40	18	45.00	15	37.50
	2025	38	22	57.89	21	55.26
Rdum tal-Madonna	2018	45	35	77.78	35	77.78
	2019	43	31	72.09	30	69.77
	2020	44	34	77.27	34	77.27
	2021	41	22	53.66	21	51.22
	2022	37	25	67.57	25	67.57
	2023	44	37	84.09	35	79.55
	2024	48	32	66.67	26	54.17
	2025	55	37	67.27	34	61.82
Selmunett	2018	7	5	71.43	5	71.43
	2019	8	4	50.00	4	50.00
	2020	8	4	50.00	4	50.00
	2021	10	7	70.00	5	50.00
	2022	9	7	77.78	7	77.78
	2023	7	6	85.71	6	85.71
	2024	7	6	85.71	4	57.14
	2025	6	5	83.33	4	66.67

On Greek islands, the monitoring method was as described above with the following additional notes. During early years (<2020) nests that were inactive during the first visit were not revisited in subsequent visits. Since 2021, all nests were monitored during all visits even if not active during the first visit. Those nests where an incubating adult, an egg or chick were recorded were considered “Active”. Not all nests could be checked at fledging age (weather not permitting visits to the island sites) but chicks were at least around 4 weeks old when assigned as successful.

Agreloussa colony is estimated to host 810-1,170 breeding pairs of *Puffinus yelkouan*. Since the eradication phase was completed in the end of February 2023, rats were still present but at lower population density at the start of that year's breeding season. Hatching success (taking chicks of all ages into account) in 2024-2025 has increased by ~80% since 2022 thanks to rat eradication (Table 4). For comparison, hatching and breeding success at a rat free islet, Alatzonisi colony, Greece, is provided for similar years (Table 5).

Table 4: Breeding success of *Puffinus yelkouan* at Agreloussa colony, Greece 2022-2025. Rat eradication was completed in February 2023.

Year	# nests monitored	# active nests	% active nests	# Hatching successful	% Hatched	# successful	% breeding success
2022	45	42	93.3	18	42.9	NA	NA
2023	56	50	89.3	32	64.0	3	6.0
2024	64	62	96.9	50	80.6	41	66.1
2025	64	64	100.0	50	78.1	48	75.0

Table 5: Breeding success of *Puffinus yelkouan* at Alatzonisi colony, Greece 2023-2025. The islet is rat free.

Year	# nests monitored	# active nests	% active nests	# Hatching successful	% Hatched	# successful	% breeding success
2023	23	17	73.9	11	64.7	3	17.6
2024	36	33	91.7	21	63.6	19	57.6
2025	45	39	86.7	20	51.3	20	51.3

3. Implementation of Biosecurity Plans

3.1 Number of incursions to rat free/eradicated islands

Greece

In Greece, 103 biosecurity visits were carried out between 2021 and 2025, to 10 islets (Table 6) using tools in the monitoring toolkit (Boucher et al. 2022), namely non-toxic flavoured wax blocks, snap traps and trail cameras. No rodents were detected with these tools. Thanks to the visits rodent free status was confirmed, but biosecurity visits should continue annually.

Table 6: Number of Biosecurity Assessment Visits (BAVs) by site and year to rat free or eradicated islets in Greece. Visits to Agreloussa, Stroggylo and Spalathonisi prior to eradication are indicated with an asterix.

Project Site	Region	Number of BAVs				
		2021	2022	2023	2024	2025
Agreloussa	Arkioi	3*	3*	9	7	5
Stroggylo	Arkioi		1*	12	9	4
Spalathonisi	Arkioi		1*	5	5	4
Arethousa	Lipsi		1			
Omvriokastro	Paros		2	1	1	1
Tourlites	Paros		1	1	1	1
Rineia	Skyros	1	4	2	1	2
Podies	Skyros	1				
Prasouda	Skyros	1	3	3	3	3
Makares	Donousa			1		

Spain

In Spain, 74 biosecurity assessment visits were carried out between 2021 and 2025, to three islands (Table 7) using tools described in the monitoring toolkit, namely non-toxic flavoured wax blocks and camera traps (Boucher et al. 2022). In Sa Conillera and s'Espartar no rats were detected. There are some indications that mice could be present in Sa Conillera because of some inconclusive signs on wax-blocks, but this was not confirmed by other tools as camera traps. In Es Bosc an incursion of at least one rat was detected at the end of September 2022 thanks to the biosecurity assessment

visits. Theet bite marks were found in wax blocks and confirmed with a picture of a rat in a camera trap. Thanks to the BAV and the response to the incursion detected the three islets keep the rodent free status at the end of 2025, but the biosecurity visits should continue annually.

Table 7: Number of Biosecurity Assessment Visits by site and year in Spain.

Project Site	Number of BAV				
	2021	2022	2023	2024	2025
Sa Conillera	2	9	7	6	5
Es Bosc	2	9	6	6	5
s'Espartar	2	6	2	3	4

3.2 Reduced bait update at seasonal predator control sites

In shearwater colonies with predator control on Malta, bait stations were monitored at intervals ranging from one to three weeks, depending on rodenticide anticoagulant consumption at each site. Higher consumption prompted more frequent checks, whereas lower consumption resulted in reduced monitoring frequency. However, the effectiveness of this adaptive schedule depended on site accessibility, which was influenced by weather conditions.

At each site, the quantity of bait deployed was adjusted to reflect monitored rodent consumption, as to ensure that bait stations were never left empty, therefore encouraging repeated visits by rodents previously attracted to the bait (Visalli et al. 2025). Since rodents are generally cautious when encountering new food sources, delayed-response anticoagulant rodenticides prove to be effective as they disrupt the association between food intake and subsequent illness in rodents. Nevertheless, maintaining continuous bait availability is essential, as empty bait stations would compromise population control efforts.

The plots illustrate temporal trends in total bait consumption and deployment across multiple sites where BirdLife Malta has implemented rat control measures since 2018. Solid lines represent estimated bait consumption, extrapolated from percentage of bait blocks eaten by rodents compared to the blocks present from the previous deployment visit (consumption formula extracted from Visalli et al. 2025), while dashed lines indicate bait deployment. In some plots, the grey line denotes bait deployment on the plateaus above colonies, whereas the black line represents deployment at the colony site (Fig. 27- Fig. 30). Estimated bait consumption is also plotted per bait station (Annex 2).

On Selmunett Island, substantial rodenticide consumption by rats and mice was recorded in 2020-2022 without a corresponding reduction in the rodent population (Fig. 27). Given concerns about the potential development of genetic resistance, the rodenticide used at this site was changed from Protect (0.005% bromadiolone) to Nocurat wax blocks (0.005% difenacoum; 0.001% denatonium benzoate). Although this compound is less toxic to *Rattus rattus* (Borah & Bhattacharyya, 2015), it exhibits lower resistance factors—meaning that the dose required to achieve the same effect in resistant strains is closer to that needed for susceptible strains (Baxter et al. 2022). Thanks to these improved practises, successful seasonal eradication of rats was achieved for the 2023, 2024 and 2025 seasons.

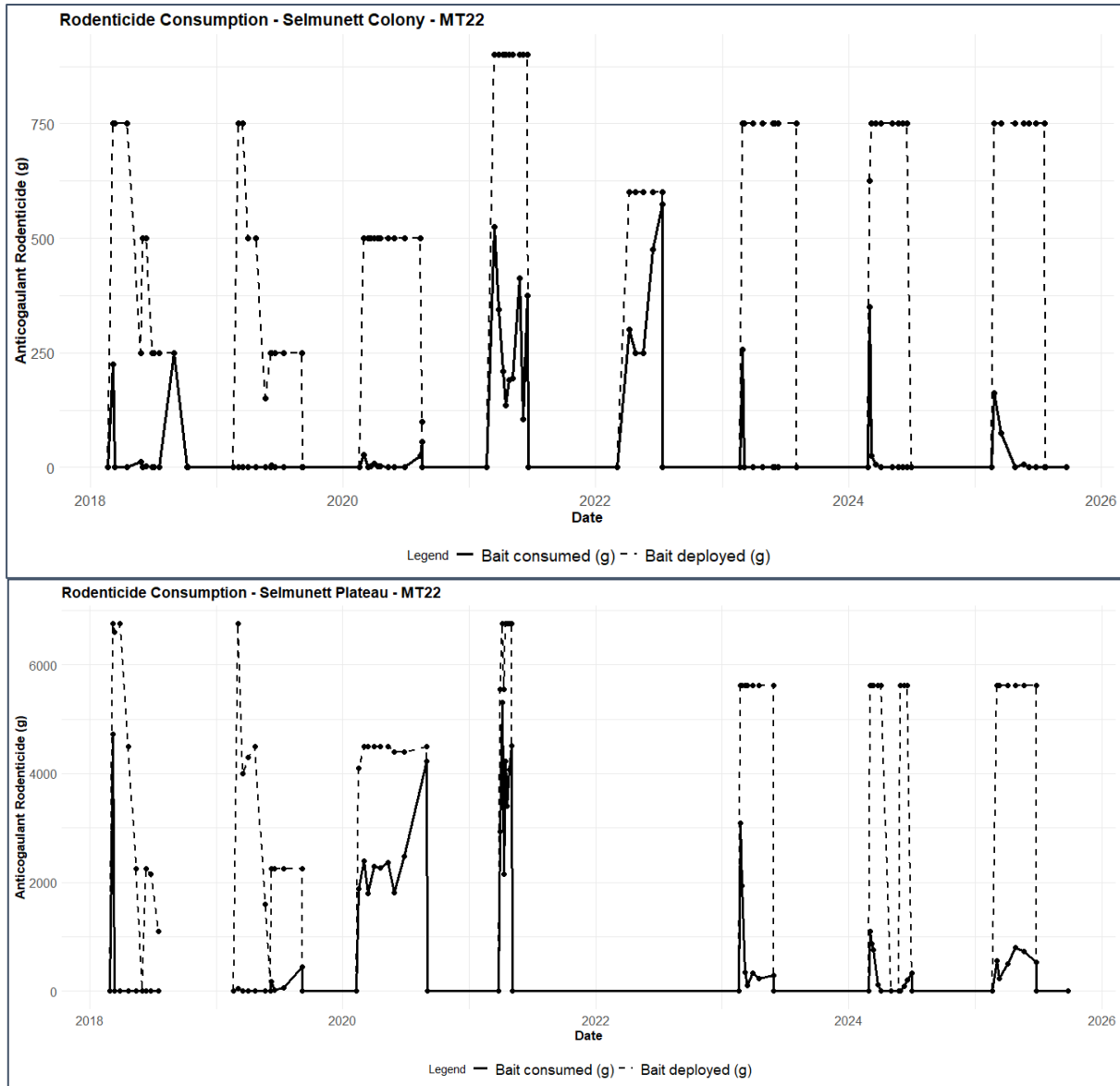


Figure 27: The plots show the total rodenticide anticoagulant bait consumption pattern and bait deployment over time (February to ~July) at project site Selmunett (divided by baiting areas of Plateau and Colony) from 2018 (starting left) to 2025 (ending right). The solid line represents the estimated bait consumption by rodents, while the dashed line represents the amount of bait deployed.

At Kemmunett (MT17), rodenticide consumption followed a similar pattern across the years (Fig. 28). Overall, consumption remained low throughout the seasons, with a brief peak during the initial months, followed by a steady decline to near-zero levels. This minimal consumption persisted until the end of each season. In contrast, Kemmuna (MT17) was one of the project sites exhibiting consistently higher levels of consumption. Multiple peaks were recorded throughout the seasons, with little variation observed between years.

At Rdum tal-Madonna (MT09), the RM01 and East Cliffs project sites showed a slight decline in rodenticide consumption over the years (Fig. 29). At both sites, consumption levels decreased after 2022 compared to earlier baiting periods. In addition to existing biosecurity measures, improved waste management during the project - such as the removal of waste bins and enhanced waste collection from 2023 onward - may have contributed to the observed reduction in rodent activity. Nevertheless, consumption remained irregular across years, reinforcing the need for continuous biosecurity measures to effectively control rodent populations within shearwater colonies.

Overall rodenticide consumption data did not show a marked decline over the years, indicating relatively similar rodent activity between seasons. Most colony sites exhibited a similar pattern of activity, with peak consumption occurring shortly after rodenticide placement, followed by a mid-season decrease, and a resurgence toward the end of the season. While this general trend was consistent, some colonies showed different peak timings and, in certain cases, irregular rodent activity between years. Regular checks and bait replenishment ensured that bait stations were not left empty after complete consumption, thereby encouraging repeated visits by rodents already attracted to the bait. The results suggest that rodent incursions are often unpredictable and that rat populations can recover rapidly from surrounding areas, demanding monitoring and control throughout each season.

Rodent bait consumption fluctuates from year to year, but the overall timing of peak consumption is similar. The monitored rodent bait consumption during eight rodent control seasons gives a solid foundation to continue to adapt and improve the baiting practices. Effective rodent control using rodenticides is enhanced and complemented using automatic mechanical Goodnature E2 traps on specific nesting ledges (Visalli et al. 2025) both during and between seasons (section 2.1.2). Future work following LIFE PanPuffinus! should consider removing rodenticide bait earlier at colonies such as Kemmunett and baiting in two shorter periods to account for the first and second peaks in rodent presence. The results from the project show the importance of close monitoring of bait consumption, use of multiple methods to monitor rodent presence and targeting such control measures to specific areas around colonies where a conservation impact is measured (section 3.3). Finally, predator

management needs to take place with good waste management in surrounding areas to avoid supplementing rodent populations with excess food sources.

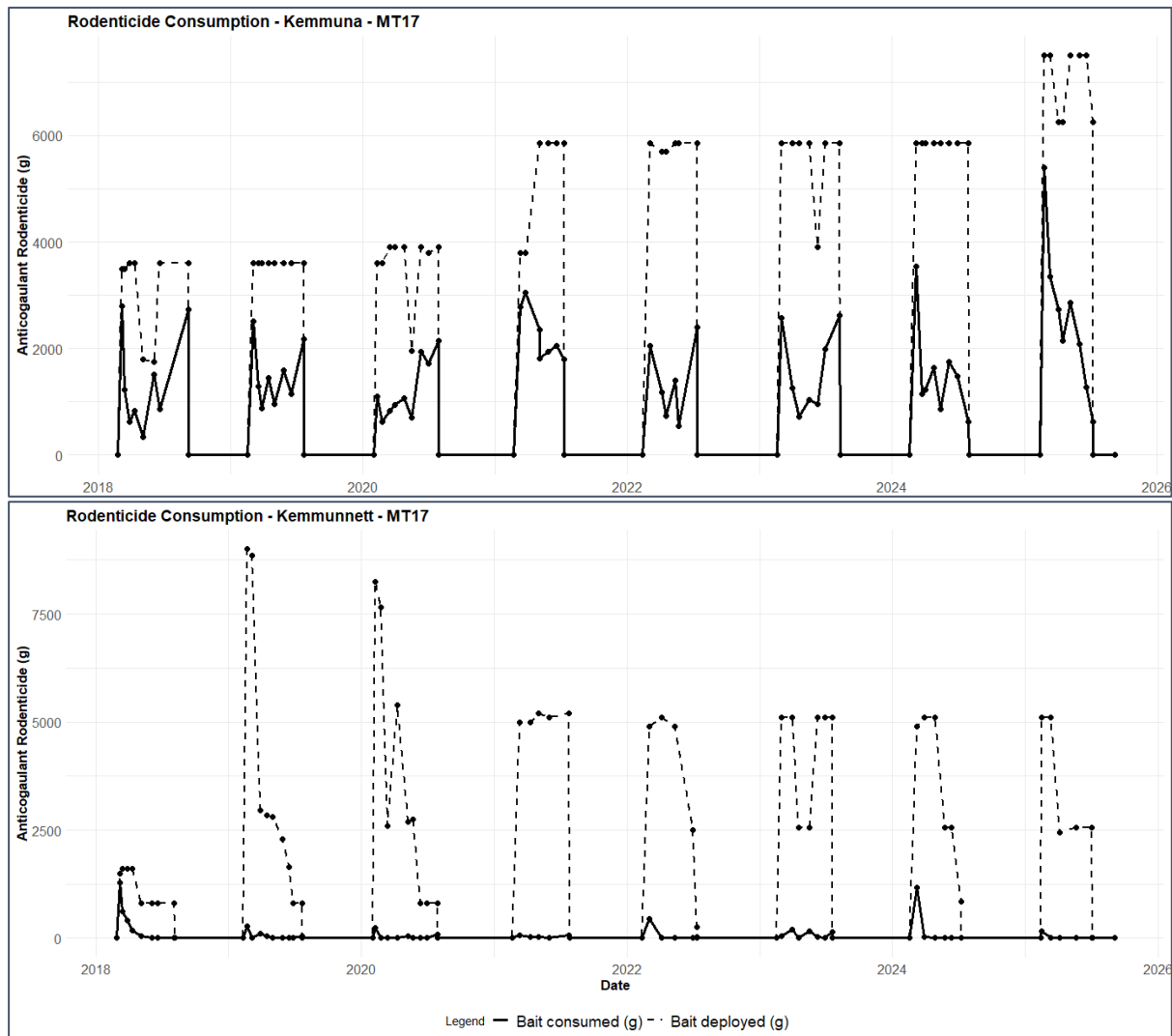


Figure 28: The plots show the total rodenticide anticoagulant bait consumption pattern and bait deployment over time (February to ~July) at project sites Kemmuna and Kemmunnett from 2018 (starting left) to 2025 (ending right). The solid line represents the estimated bait consumption by rodents, while the dashed line represents the amount of bait deployed.

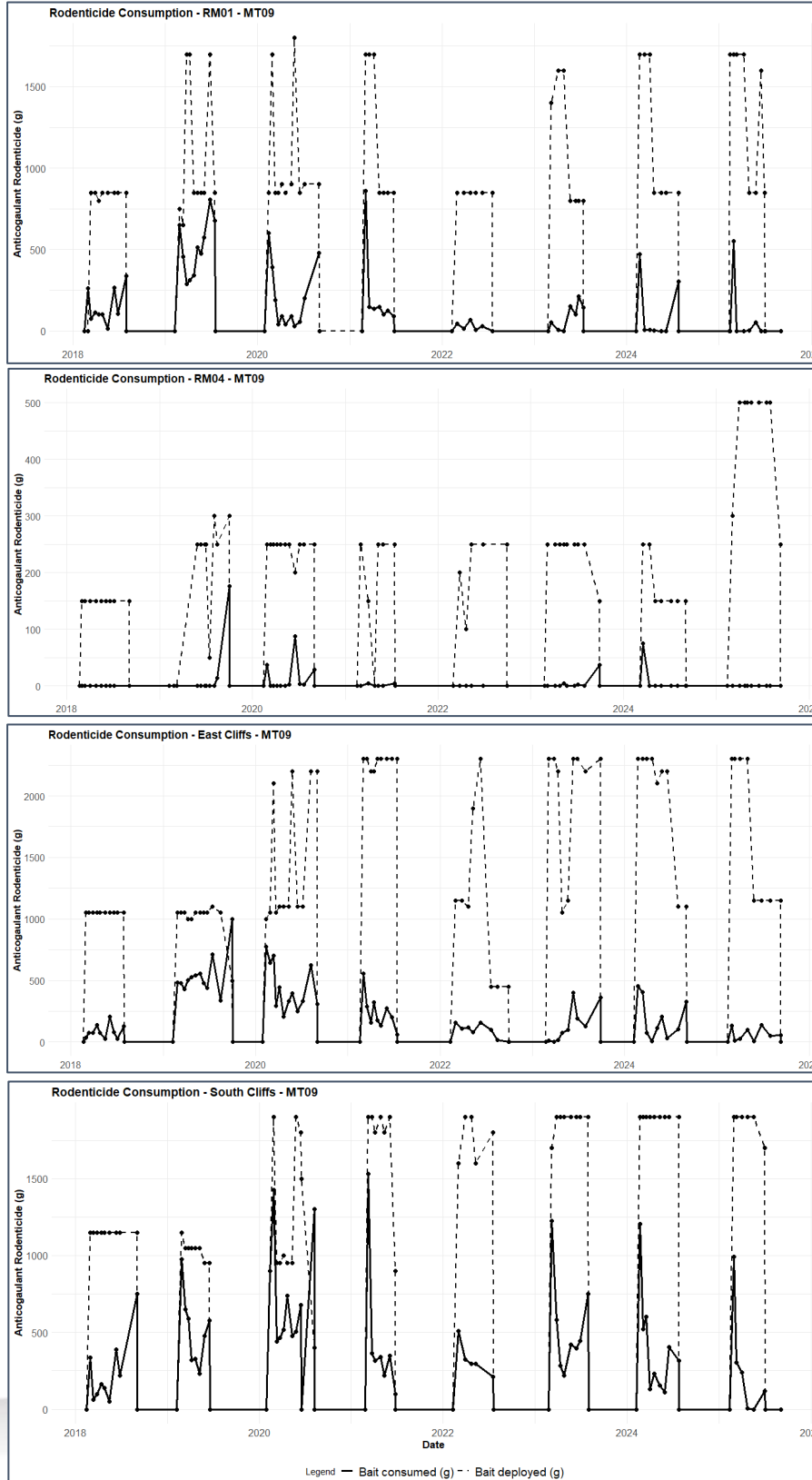


Figure 29: The plots show the total rodenticide anticoagulant bait consumption pattern and bait deployment over time (February to ~July) at project site Rdm Tal-Madonna (divided by baiting areas of RM01, RM04, East Cliffs and South Cliffs) from 2018 (starting left) to 2025 (ending right). The solid line represents the estimated bait consumption by rodents, while the dashed line represents the amount of bait deployed.

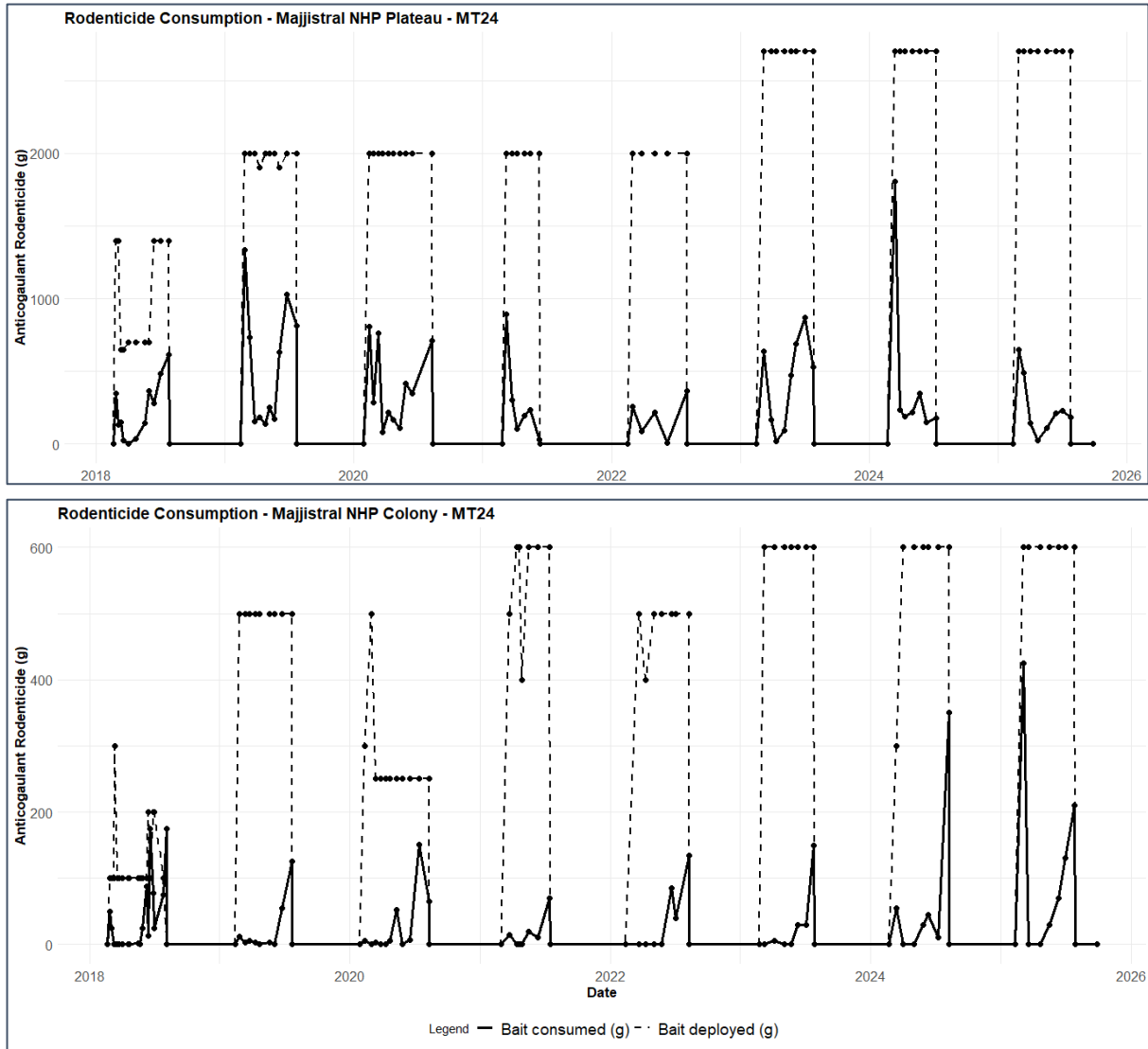


Figure 30: The plots show the total rodenticide anticoagulant bait consumption pattern and bait deployment over time (February to ~July) at project site within Majjistral NHP (divided by baiting areas of Plateau and Colony) from 2018 (starting left) to 2025 (ending right). The solid line represents the estimated bait consumption by rodents, while the dashed line represents the amount of bait deployed.

3.3 Stable/Increased breeding success of *Puffinus* species

Malta

Successful predator management by rodent control on Malta, is reflected by the stable breeding success over the duration of the project, with variations between years and colonies (Fig 31). Several factors other than rat predation can be the cause of this, including nutritional stress in nestlings and differences in adult shearwater foraging areas (Austad et al. 2025). Average across 2018-2025 at four colonies with seasonal rodent control (rodenticide baiting) and monitored annually is 65.3% (mean of 99 nests monitored per year).

Greece

Eradication of rodents from Agreloussa had a successful conservation outcome on *Puffinus yelkouan* shearwater hatching success with around 80 % increase compared to pre-eradication. Breeding success post eradication is comparable or even surpasses a rat free islet colony (Table 3; Table 4).

Spain

In the Spanish project sites, the breeding success of *Puffinus mauretanicus* was monitored in the three islets where the biosecurity plans were implemented. The data for each islet for the project period and before is presented in Figures 32, 33 and 34. There are not breeding success data for 2020 due to the COVID-19 pandemic and 2023 due to logistic problems to access the islets that meaning it was not possible to visit the colonies in the periods needed for monitoring the breeding success.

Breeding success was maintained within the normal range of the species recorded before the project in these and in other colonies of the species. Two islands were rat free during the whole project period. A rat incursion during the non-breeding period of *Puffinus mauretanicus* was discovered in the third island but an effective incursion response was carried out. Therefore, the breeding success fluctuation between years and colonies along the years of the project are not influenced by the presence of rats.

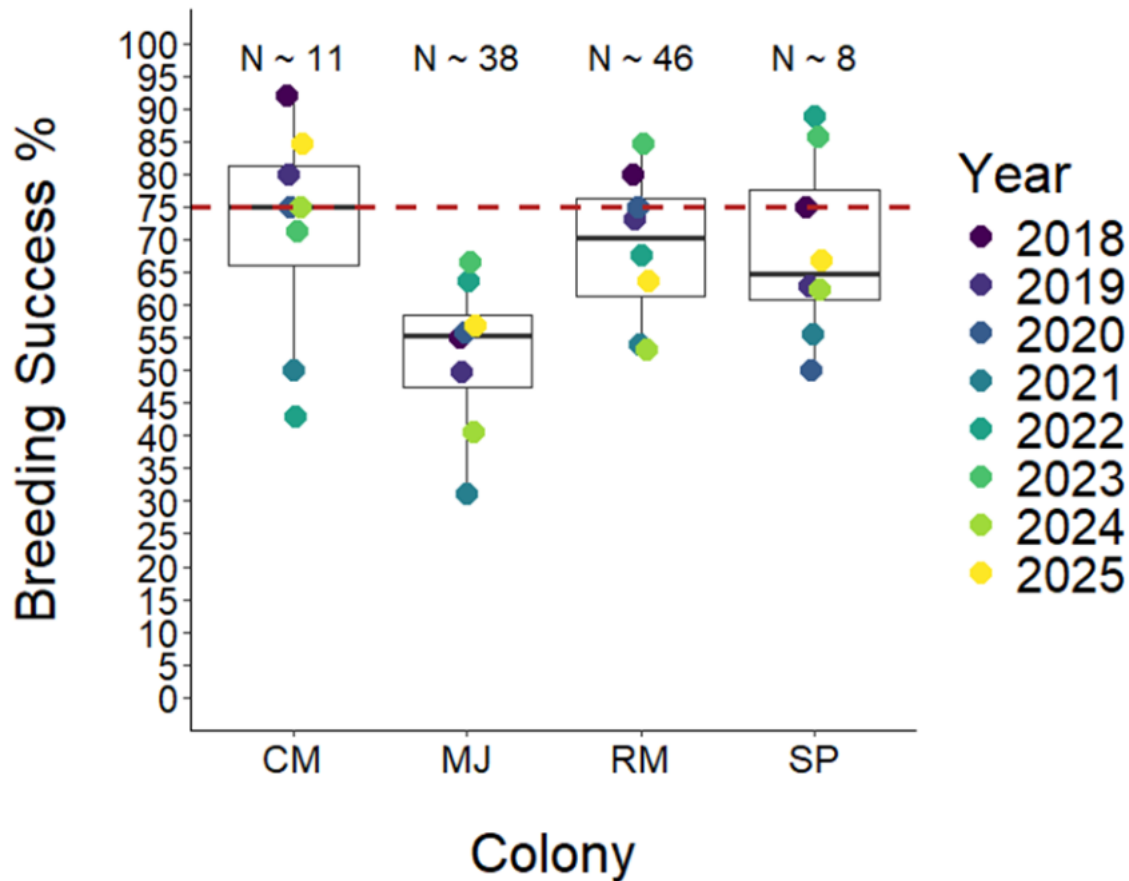


Figure 31: Breeding Success (%) of Yelkouan shearwater nests at four colonies in Malta, all with rodent control. The central mid-line in each boxplot corresponds to the median, the lower and upper horizontal lines to the first and third quartiles and the vertical whiskers extend to the values at 1.5 of the inter-quartile range. Each point represents the breeding success % per year. Average number of nests monitored per colony is annotated above the respective boxplots. The horizontal dashed line represents the 75% target in the species action plan (Gaudard et al. 2018).

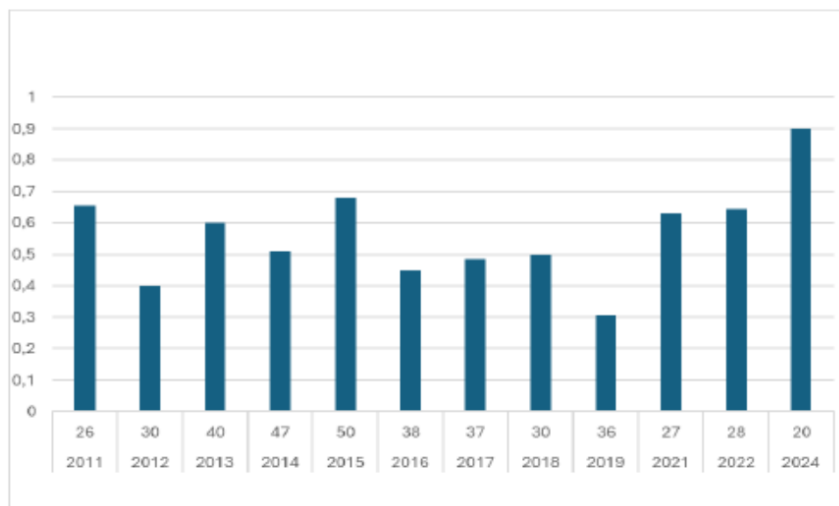


Figure 32: Breeding success and number of nests monitored of Puffinus mauretanicus between 2011 and 2024 in Sa Conillera islet (extracted from García et al 2025).

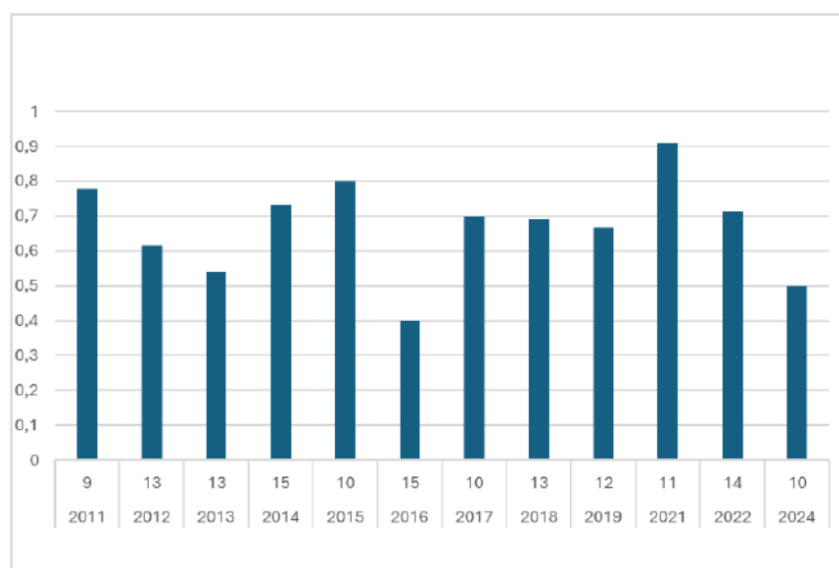


Figure 33: Breeding success and number of nests monitored of Puffinus mauretanicus between 2011 and 2024 in Es Bosc islet (extracted from García et al 2025).

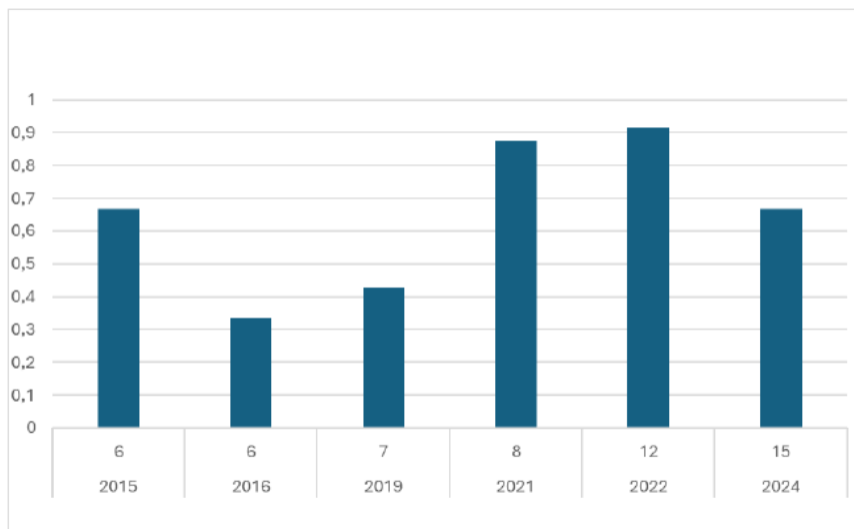


Figure 34: Breeding success and number of nests monitored of *Puffinus mauretanicus* between 2015 and 2024 in s'Espartar (extracted from García et al 2025).

4. Conclusion

LIFE PanPuffinus! tackled two of the main threats to seabirds which affect *Puffinus mauretanicus* and *Puffinus yelkouan*, in the Mediterranean and Atlantic region of Portugal.

Through collaboration with fishers, seabird interactions with various fleets and gears were explored. These interactions lead to socio-economic issues for fishers in addition to relatively high seabird bycatch rates, as documented in previous studies and through LIFE PanPuffinus! data collection efforts. High seabird bycatch rates were documented in longlines in Spain, Malta and Greece, including both *Puffinus mauretanicus* and *Puffinus yelkouan*, while trammel nets in Portugal affect *Puffinus mauretanicus* amongst other seabirds and trammel nets in Greece were found to impact *Puffinus yelkouan*. Undoubtedly, collaboration with fishers, including those who participated in LIFE PanPuffinus!, needs to continue, building on and expanding the trust with the fishing community, for collecting further data on seabird bycatch and mitigation measure testing.

The mitigation measure trials carried out under LIFE PanPuffinus! showed that there are possible and promising solutions. The scarybird kite is a widely applicable mitigation measure with overall acceptance by fishers, and reduced seabird interactions on trammel, purse-seine and longline vessels. Further data collection should focus on the distance astern at which it is effective and improved information on species level effects. The same can be said of the towed buoy and bird scaring lines in longline fisheries. Discard management in trammel nets, line weighting, bait type used and night-setting in longlines are practices that were found to reduce seabird interactions and/or bycatch. Other measures, namely the contrast panels, showed positive effects on bycatch reduction but were not economically or practically viable.

Measures might need further evaluation to ensure they can be effectively adapted to the specific fisheries at a national level. The dataset for some mitigation trials was small. Additional data should therefore be collected to increase the sample size, improve its representativeness, and strengthen its statistical robustness. Through the results obtained, no single measure stood out as an ultimate solution to seabird bycatch reduction, instead, multiple measures and practices are required in conjunction. The Seabird bycatch mitigation toolkit (Lago et al. 2026), which was tailored for use by fishers, lays the basis for this work.

Additionally, mitigation measures and best practices need to be strongly embedded in policy frameworks, to ensure that seabird bycatch reduction actions are effectively implemented by fishers, and where necessary become mandatory rather than merely voluntary measures. National

strategies, in collaboration with fishers, should target continued testing, and modification of measures that showed positive results during trials conducted under LIFE PanPuffinus!. National policy recommendations for seabird bycatch mitigation are presented further in the output of sub-action E2.1. LIFE PanPuffinus! laid out two important and successful data collection methods used across the partner countries, namely self-reporting logbooks and onboard observations, which should be continued both for documenting seabird bycatch and trialling mitigation measures. Ultimately, seabird bycatch reduction should be measured at a fleet scale, which can be achieved by the widespread implementation of best practices and by including the recording of seabird interactions in fishers' national logbook reporting obligations.

During LIFE PanPuffinus! the efficiency of rodent control and its monitoring at *Puffinus yelkouan* colonies in the Maltese Islands was optimised further, building on past work (Lago et al. 2019). Several seasons of rodent activity were measured through multiple methods, providing a good foundation for further adaptation of management actions needed. Based on findings presented here and in Visalli et al. (2025), it is recommended that conservation and targeted rodent control at Rdum tal-Madonna, Majjistral NHP, Kemmunett, Selmunett and Kemmuna east cliffs are continued in the years to come. While direct correlations were not possible, improved waste management at Rdum tal-Madonna were simultaneous with reduced bait consumption at the colony. Other sites such as Kemmuna, still require further improvements in waste management. Both rodent control and waste management need regular maintenance and upkeep on a seasonal basis.

The project refined monitoring methods for rodents in the Mediterranean region (Boucher et al. 2022; Visalli et al. 2025; current report section 2.1.2). These tools should be widely implemented in biosecurity visits to rat free islands in the region. Such visits should, at a minimum, take place on an annual basis. The value and importance of such visits was exemplified by the incursion detected at Es Bosc, Spain (section 3.1).

The ground-based eradication of rats from Agreloussa, Greece, showed immediate positive effects on the breeding success of *Puffinus yelkouan* on the island. Such efforts should be carried out on other islands, where feasible, and followed up with repeated biosecurity surveillance (Greetham et al. 2022). In addition to the threat by rats, the project showcased the devastating impact of feral pigs on the *Puffinus yelkouan* colony on Gyaros, which calls for immediate island-wide eradication of this non-native species. Finally, while eradicating and controlling non-native predators have been shown to have positive effects on the breeding success of *Puffinus* shearwaters in the project region, it is also clear that other effects cause fluctuations in breeding success (section 3.3). These are likely

linked to marine food resource availability (Austad et al. 2025) and require additional attention and conservation action targeting marine restoration.

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