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para o Estudo das Aves

Updated Information on the Breeding Status of Berlengas Archipelago Seabirds

Lisbon, December,

2016

Berlengas

Life

NATURA 2000

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Lisbon, December, 2016

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Missão

To work towards the study and the conservation of wild birds and their habitats by promoting sustainable development for the benefit of the future generations.

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Report of Action A1of Life Berlengas Project

Portuguese Society for the Study of Birds, 2016

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ÍNDICE

RESUMO

O arquipélago das Berlengas é um dos locais mais importantes de Portugal Continental para a nidificação de aves marinhas. Aqui reproduzem-se regularmente cinco espécies, incluindo a cagarra, o roque-de-castro, a galheta, a gaivota-de-patas-amarelas e a gaivota-d'asa-escura e o airo. Entre 2014 e 2016 foram implementados diversos esquemas de monitorização com o intuito de colmatar a falta de informação acerca do tamanho das populações, tendência populacional, produtividade e distribuição das áreas de nidificação das diferentes espécies de aves marinhas reprodutoras do arquipélago, no âmbito do projeto Life Berlengas. No presente relatório são apresentados novos dados das populações reprodutoras de cagarra, roque-de-castro, galheta e airo e compilada informação histórica sobre as mesmas espécies.

A população de cagarra foi estimada em 800 - 975 casais reprodutores para todo o arquipélago em 2015. Foram encontrados ninhos na Berlenga e nos principais ilhéus. Apesar da tendência ao longo dos últimos 10 anos indicar que o tamanho desta população se encontra estável, a tendência a curto prazo mostra evidências de uma redução considerável. De facto, apesar da população nidificante na ilha da Berlenga demonstrar um ligeiro aumento (principalmente devido à construção de cavidades artificiais para a nidificação), o mesmo não ocorre com a população do Farilhão Grande (a maior colónia reprodutora do arquipélago), onde foi estimada uma redução anual de cerca de 3,5% ao longo dos últimos 10 anos. Este decréscimo parece resultar quer da predação de ovos e juvenis, quer da pressão sobre novos indivíduos reprodutores, causadas pelas gaivotas-de-patas-amarelas.

Pela primeira vez foi confirmada a reprodução de roque-de-castro no Farilhão da Cova e no Farilhão do Nordeste. O tamanho da população reprodutora nos Farilhões foi estimado em 410 - 784 casais reprodutores, evidenciando a importância desta colónia no contexto Europeu. No entanto, o sucesso reprodutor estimado para os anos de 2014 e 2015 foi muito baixo, situação causada principalmente pela predação de adultos, ovos e juvenis pela gaivota-de-patas-amarelas. Além disso, a tendência populacional mostra um forte declínio no número de casais reprodutores do Farilhão Grande ao longo dos últimos 3 anos.

No arquipélago das Berlengas foram registados ninhos de galheta apenas na ilha da Berlenga e no Farilhão Grande. Este facto evidencia o desaparecimento de alguns locais de reprodução históricos, como é o caso dos ilhéus Maldito, Cerro da Velha e Estela Grande. A população reprodutora foi estimada em 75 casais em 2015. Todas as tendências populacionais mostram uma ligeira redução no número de casais reprodutores, sendo mais evidente para o período de 3 anos. Também o tamanho da postura e a produtividade têm diminuído ao longo dos últimos 20 anos. As razões apontadas para tal redução são a baixa disponibilidade alimentar, a mortalidade dos progenitores durante a estação reprodutiva (principalmente causada pela captura acidental em artes de pesca e predação) e a predação de ovos e/ou juvenis.

Entre 2014 e 2016 não foram observados airos a nidificar no arquipélago nem encontrados locais com evidências de reprodução. Uma vez que o último evento de reprodução foi registado em 2002, consideramos que o airo se encontra extinto como reprodutor no arquipélago das Berlengas, bem como em Portugal. São apontadas diversas razões para a redução abrupta desta população, entre as quais, o aumento da utilização de redes de pesca sintéticas, a redução de recursos alimentares, a competição direta e a perturbação dos locais de nidificação.

SUMMARY

Berlengas archipelago is one of the most important breeding sites on Portugal mainland coast. Six seabird species regularly breed on these islands: Cory's Shearwater, Band-rumped Storm-petrel, European Shag, Yellow-legged Gull, Lesser Black-backed Gull and Common Murre. To respond to the insufficient knowledge of seabird population size, trends, productivity and nesting sites distribution, several monitoring schemes were implemented under the scope of Life Berlengas Project in Berlengas archipelago from 2014 to 2016. Here we present new data on Cory's Shearwater, Band-rumped Storm-petrel, European Shag and Common Murre breeding populations and we collate historical data from these populations.

Cory's Shearwater population was estimated to 800 - 975 breeding pairs for the entire archipelago in 2015. Nests were found all over the main island and islets. Even though the 10-years trend shows a stable population, the short-trend evidences a considerable decrease. Although Berlenga Island population is facing a positive trend (mainly due to the artificial nest construction), the same is not happening on Farilhão Grande Islet (the biggest colony of the archipelago), where it was estimated an annual decrease of around 3.5% over the last 10 years. Such decrease may result from the Yellow-legged Gulls predation upon eggs or juveniles and high pressure over new breeding birds.

It was confirmed for the first time Band-rumped Storm-petrel population breeding on Farilhão da Cova and Farilhão do Nordeste islets. The population size in Farilhões group was estimated to 410 to 784 breeding pairs, showing the importance of this colony at an European level. The estimated breeding success for 2014 and 2015 was very low, mainly due to predation upon adult birds, eggs and juveniles by Yellow-legged Gulls. Also, the 3-years trend showed a noticeable decline on the breeding population at Farilhão Grande Islet.

In Berlengas archipelago, European Shag was only record nesting on Berlenga Island and Farilhão Grande Islet. Some historical nesting sites disappeared, mainly on Maldito, Cerro da Velha and Estela Grande islets. The breeding population size was estimated to 75 breeding pairs in 2015. All trends showed a smooth decrease in the numbers of European Shag, being higher on the 3-years trend. Also clutch size and productivity have decreased over the last twenty years. Reasons for such reduction may be explained by low food availability, progenitors' mortality during the breeding season (namely caused by bycatch or predation) or predation of eggs and/or juveniles.

No nesting Common Murres were observed, neither evidences of breeding sites. Since the last breeding event was documented in 2002, we may consider that Common Murre is extinct as breeder in Berlengas archipelago, as well as in Portugal. There are several reasons for the marked decline of Common Murre in Berlengas, among which are the increase in fishing activity using synthetic gillnets, as well as the reduction of food resources, direct competition with man for fishery resources and the disturbance of nesting sites.

1. INTRODUCTION

Berlengas archipelago is one of the most important breeding sites on Portugal mainland coast. Six seabird species regularly breed on these islands: Cory's Shearwater *Calonectris borealis*, Band-rumped Storm-petrel *Hydrobates castro*, European Shag *Phalacrocorax aristotelis,* Yellow-legged Gull *Larus michahellis,* Lesser Black-backed Gull *Larus fuscus* and Common Murre *Uria aalge*. For most of these species, there was a gap of knowledge in terms of baseline estimates. Over the last 10 years, only two dedicated census for Cory's shearwaters were conducted (Lecoq *et al.,* 2011). In the last 13 years, the Institute for Nature Conservation and Forests (ICNF) organized occasional non-systematic surveys for Yellow-legged gull, European Shag and Common Murre, but no detailed information is available about overall population sizes, distribution of nesting areas and population trends for Band-rumped Storm-petrel. This data is essential to understand the impact of habitat destruction, fisheries or alien predators on species survival.

Aiming to address the insufficient knowledge of seabird populations sizes and trends, several monitoring schemes were implemented under the scope of Life Berlengas from 2014 to 2016. We now present new data on Cory's Shearwater, Band-rumped Storm-petrel, European Shag and Common Murre breeding populations and collate historical data from these populations.

1.1 Cory's Shearwater

Cory's shearwater is a migratory seabird that nests in the Northeast Atlantic (Cramp & Simmons, 1977) and spends the winter in the South Atlantic (Dias *et al*., 2011). The global and European population is estimated at 250,000-253,000 pairs (BirdLife International, 2016). The species breeds on the Azores, Madeira (including Selvagens Islands), Berlengas and Canary archipelagos. Although the lack on accurate numbers of global population size and trends, Cory's Shearwater is listed as Least Concern (BirdLife International, 2016). The breeding population of the Atlantic coast of the Iberian Peninsula is somehow concentrated at Berlengas archipelago, where censuses have been carried out in the last decades (Teixeira, 1983a, Granadeiro, 1991, Lecoq *et al*., 2010, Lecoq *et al*., 2011) and is currently estimated at 980-1070 breeding pairs (Lecoq *et al*., 2011). Like what is happening across the wide area of its distribution, the population of Berlengas encounters several threats both on land and at sea, mainly predation of eggs and juveniles by introduced mammals, predation by gulls and bycatch on fishing gear. The species is classified as Vulnerable for the Portuguese Mainland area by the National Red Book (Cabral *et al.,* 2005).

1.2 Band-rumped Storm-petrel

Band-rumped Storm-petrel has a global distribution extended by the Atlantic and Pacific oceans with a population size estimated to around 150,000 individuals (Brooke, 2004) and is listed as Least Concern (BirdLife International, 2016). The European breeding colonies are located in Spain (Canary archipelago) and Portugal (archipelagos of Azores, Madeira, including the Selvagens islands, and Berlengas). In Portugal Mainland the breeding of this species is restricted to Farilhões islets, Berlengas archipelago (Equipa Atlas, 2008) and it is currently classified as Vulnerable by the National Red Book (Cabral *et al.,* 2005).

Monteiro & Furness (1998) distinguished between "cold season" and "hot season" populations. In some places the species only nests during the cold months (between September and February), while in other colonies a population nests during the warm months (between April and September). The individuals of both populations occupy the same nests alternately, depending on their breeding season. The species shows a clear preference to reproduce in the cold season, so cold season

populations predominate in most of the places where only a single population is present (Magalhães, 2003), as is the case of the colony from Farilhões islets (Granadeiro *et al.,* 1998).

Farilhão Grande breeding colony was first described by Teixeira & Moore (1983), and the nesting population was estimated in 50 pairs. The colony was not visited by ornithologists until 1994, when Granadeiro *et al.,* (1998) estimated the population in 200-400 pairs. Subsequently, the colony was visited in 2002-03 (Magalhães, 2003). More recently, since 2011, SPEA has surveyed this colony annually, with the objective of monitor its reproduction, estimate productivity, assess the main threats and implement conservation measures (Oliveira *et al.,* 2013, 2015).

1.3 European Shag

European Shag can be found in the European side of the Atlantic Ocean and Mediterranean Sea as well as in the Black Sea and the northeast Africa (Cramp & Simmons, 1977), being listed as Least Concern (BirdLife International, 2016). Most of the European population is in Great Britain and Norway (Wanless & Harris, 1997) and it is estimated at 76,300-78,500 pairs (BirdLife International, 2016). European Shag nests discontinuously along the rocky coast of Portugal Mainland, occurring from Cape Carvoeiro to Cape S. Vicente (Equipa Atlas, 2008). Berlengas archipelago represents the main breeding site for this species, holding about 60 to 75% of the national population (Ramírez *et al.,* 2008). There are no records of its presence in the archipelagos of Azores and Madeira (Equipa Atlas, 2008). The species is listed as Vulnerable by the Portuguese Red Book (Cabral *et al.,* 2005)

1.4 Common Murre

The Common Murre is a species widely spread along the Atlantic Ocean and the Asian coast of the North Pacific Ocean, being the Iberian Peninsula (and the Berlengas archipelago in particular) the most southern point of its distribution (BirdLife International, 2016). The European population is estimated at 2,530,000-3,060,000 mature individuals and the species is listed as Least Concern (BirdLife International, 2016). Although several local populations are increasing, including in the UK (which holds nearly half the European population), a noticeable decline was observed in Iceland since 2005 (BirdLife International, 2016). Common Murre had 10 nesting sites dispersed across the Iberian Peninsula coast. The Berlengas archipelago is the only recent breeding site in Portugal (Lecoq, 2003), but over the last decades the population has diminished notably.

2. METHODS

2.1 Study Area

Field work took place in Berlengas archipelago, including Berlenga Island and surrounding little islets - Farilhões, Estelas and Cerro da Velha (fig. 1). The archipelago was designated as Natural Reserve in 1981 by the Portuguese Government, and later as a Special Protection Area and Special Area of Conservation under Birds and Habitat Directives of European law, respectively.

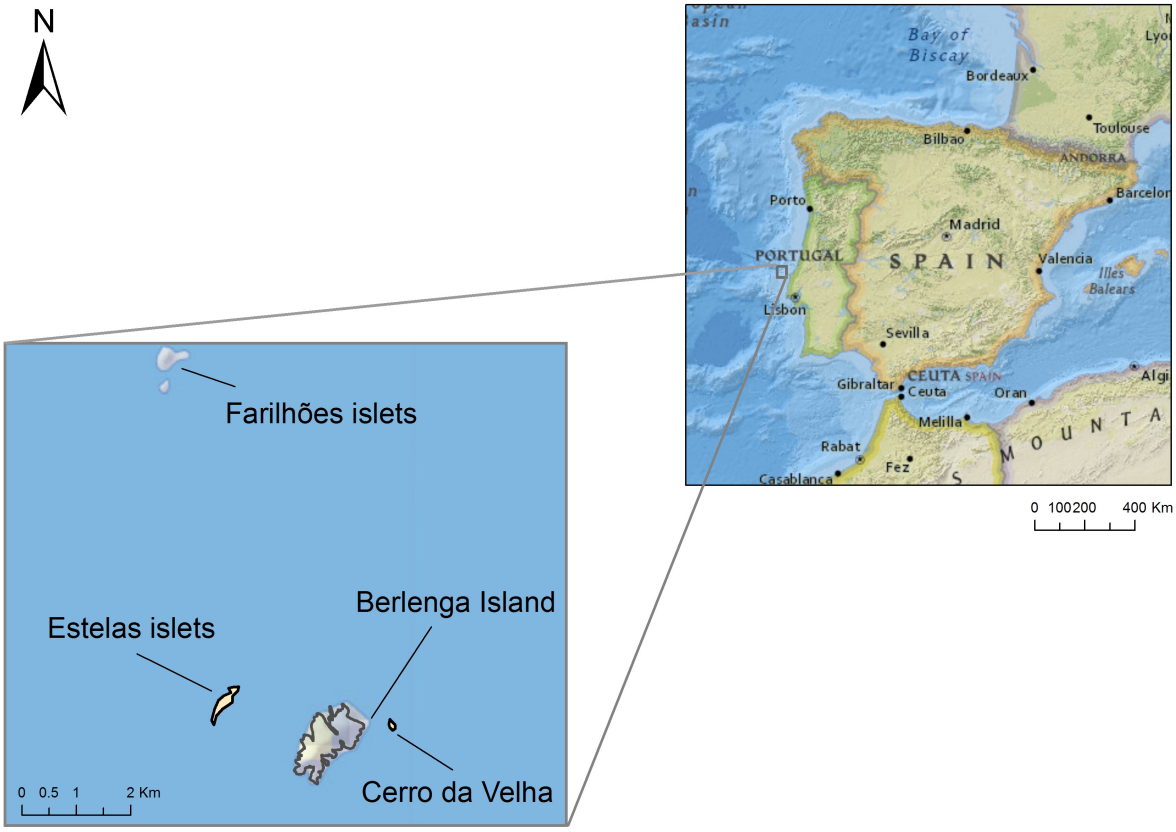

Figure 1_Geographic location of Berlengas archipelago and the different groups of islets and island.

2.2 Data collection and analysis

Overall data collection took place from June 2014 to June 2016. Data on breeding population size, colonies distribution , productivity and population tendencies was compiled for Cory's Shearwater, Band-rumped Storm-petrel, European Shag and Common Murre.

Productivity was estimated as follow:

$$P = \frac{j}{a}$$

- P = Productivity
- j = number of fledgling birds
- a = number of active nests (with at least one egg)

In case of Cory's Shearwater and Band-rumped Storm-petrel, productivity was estimated following the same formula being equivalent to the breeding success, once both species only lay one egg per breeding season.

Short, medium and long-term trends were estimated for each species depending on the availability of population size historical data. For each trend, the instantaneous growth rate, the annual multiplication rate and the annual growth rate were estimated (Munilla *et al*., 2007). The instantaneous growth (*r)* rate was calculated as:

$$r = \frac{lnNt - lnN0}{t}$$

- *r* = instantaneous growth rate of the population
- N0 = population size at outset
- N*t* = population size after the period *t* in years
- *t* = time in years

The annual multiplication rate (*y*) was estimated as:

$$y = e^{r}$$

The annual growth rate (%) was expressed as (*y*-1) x 100.

Further details on data collection methods and statistical analysis used for each species are present under each species subchapter.

2.3 Cory's Shearwater

From June 5 to 10, 2015, nest counts took place over the entire archipelago following the methodology proposed by Lecoq *et al.* (2010). Accessible areas of Berlenga Island and Cerro da Velha, Estela Grande, Farilhão do Nordeste and Rabo d'Asno islets were directly prospected and active nests counted (Lecoq, 2010). Farilhão Grande and Farilhão da Cova islets were prospected using climbing equipment. A nest was considered active when an adult incubating an egg was found inside or when strong breeding evidences were present, namely a broken and/or deserted egg. The number of pairs breeding in inaccessible areas was estimated (and presented separately) by assessing the proportion of available breeding habitat in these areas.

The productivity/breeding success was monitored for the 2 main colonies of Berlenga Island, Melreu and Furado in 2015. Three surveys were conducted in order to record the different stages of the Cory's Shearwater breeding season. The first one was done from June 5 to 10 (coincident with laying period), the Sêcond from July 24 to August 10 (coincident with hatching period) and the third from October 20 to November 3 (coincident with fledgling period).

2.4 Band-rumped Storm-petrel

a. Captures with mist-nets on Farilhão Grande Islet

Two sessions to capture Band-rumped Storm-petrels were carried out using mist-nets on Farilhão Grande Islet (fig. 2). The first occurred between October 25 and 29, 2014 (4 nights), and the Sêcond between November 17 and 20, 2015 (3 nights). During both sessions five mist-nets of 15 meters long, with 4 pockets (20x20mm mesh), were set up in the locations indicated in figure 2. The arrangement of the nets followed the recommendations proposed by Bolton et al. (*in press*), which state that the nets should be about 60m apart, covering the entire nesting area, in this case corresponding to the whole island. The number of nights of capture was chosen to ensure that all individuals in the population are equally likely to be captured, assuming that the cycle of bird visitation to the colony is similar to the population of the islet of Praia, Azores (Bolton *et al., in press*).

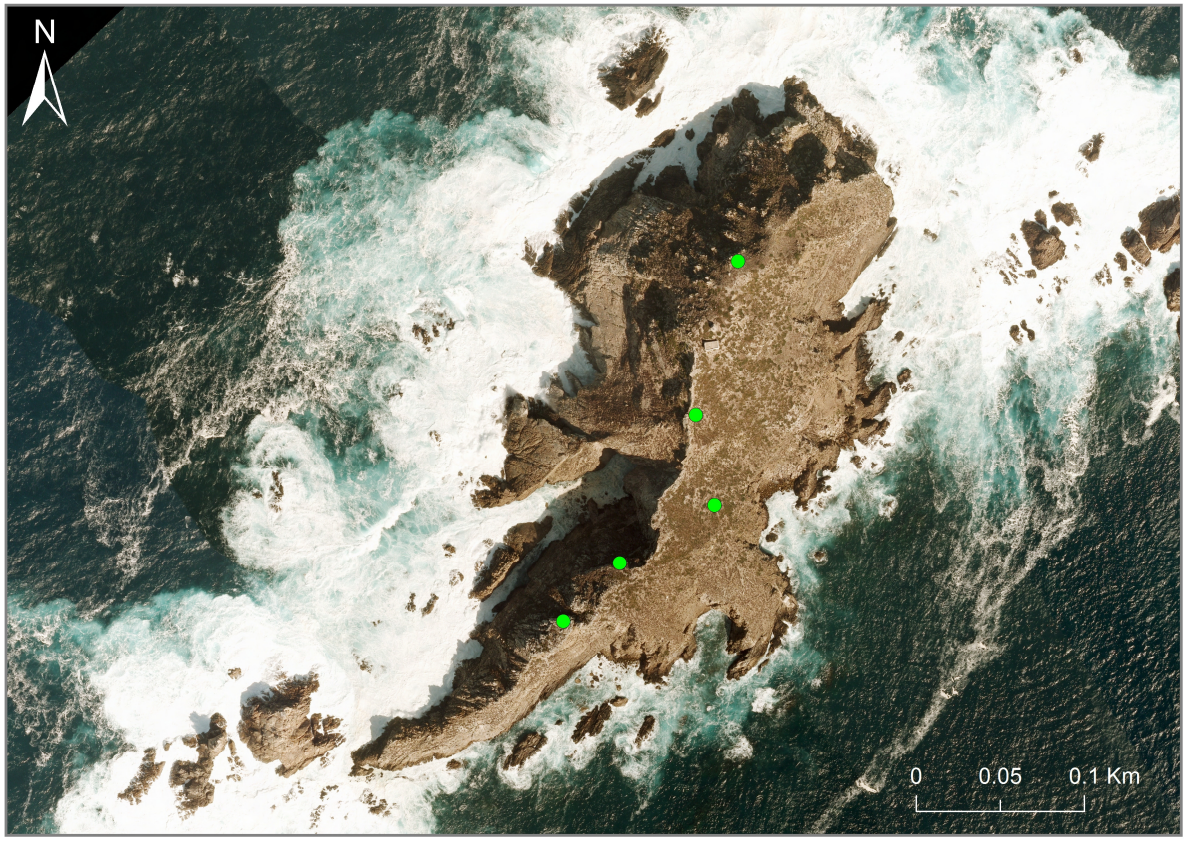

Figure 2_Location of the mist-nets set on Farilhão Grande Islet to capture Band-rumped Storm-petrel. The circles in green indicate the location of the nets during October 25-29, 2014, and November 17-20, 2015.

Nets were opened daily 30 minutes after sunset and visited at 1-hour intervals in order to minimize the time spent by the animals captured in the nets and subsequent stress. Birds were marked with a metal numbered ring and the length of the wing, tarsus, beak and depth of the bifurcation (= difference in length between the central and borderline tail fathers) were measured, the presence of incubation plate, other characteristics (e.g., morphological deformations) and hour of capture were also recorded. All data were compiled in a MS Excel spreadsheet and later sent to the Portuguese Ring Center (CEMPA).

b. Ground search for count nesting birds on the other islets

On October 25, 2014, Farilhão do Nordeste and Farilhão da Cova islets were prospected to find nesting sites for Band-rumped Storm-petrel. The sloping cliffs of the Farilhão da Cova were prospected using climbing equipment. For each nest, the breeding status (number of adults and presence of egg or juvenile) was recorded. Whenever possible, the adult and juvenile were marked with a metal ring. In Farilhão do Nordeste Islet, surveys were conducted by a group of 2 technicians, who searched for storm-petrel nests. The prospection lasted about 3 hours and was held in the morning. Farilhão da Cova is characterized by its steep slope, with great cliffs. The ground search of Farilhão da Cova was restricted to about 20% of the surface, corresponding to a partial coverage of the northeast and east slopes. The area was covered by 2 technicians with support of climbing equipment for about 5 hours, which were joined by 2 other technicians in the last 2 hours.
During the first fortnight of August 2014, it was listened 1 to 2 Band-rumped Storm-petrels calling in flight around “Bairro dos Pescadores” and Melreu areas. The need to confirm the possible reproduction of the species, led to a technician to prospect the Inês Islet on 5 September. Although no evidence of nesting was observed visually, one of the islet's few cavities contained the characteristic

odor of storm-petrels. Unfortunately the weather did not allow disembarking in the islet later again. However, it is open to possible reproduction of the species at this location.

c. Data analysis

Capture-recapture data collected on Farilhão Grande Islet was analyzed in order to estimate the breeding population size of Band-rumped storm-petrel. The population size was estimated using the function "openp" of Rcapture (Rivest and Baillargeon, 2014) that fits both the Cormack-Jolly-Seber and the Joly-Seber model for open populations following the log-linear approach of Cormack (1985,1989). Besides the survival rates φ1 to φI−1, these functions estimate the capture probabilities p∗1 to p∗I , the population sizes N1 to NI , the number of new units entering the population B1 to BI−1 and the total number or units who ever inhabited the survey area *Ntot*. The argument "m" of the function "openp" was given by the value "ep" because it sets the capture probabilities equal to a common value (ep = equal probabilities) securing the parameters p∗1, p∗I , the survival rate φI−1 between periods I − 1 and I, N1 and NI to be estimated. The function openp insures that the estimated survival probabilities belong to [0, 1] and that the births Bi are positive by imposing constraints to the loglinear parameters. Setting the argument "neg" of this function to FALSE removes these constraints. For full explanations on the function "openp" and Rcapture estimates see Baillargeon and Rivest (2007).
We collated data from 2014 and 2015 captures to the previous sessions data from 2011, 2012 (Oliveira *et al.,* 2013) and 2013 (Oliveira *et al.,* 2015) in order to have a more complete capture history. A reduced matrix of capture history was produced by merging capture occasions from the same year, resulting in one single capture event per year. Estimates were presented with standard errors. All analysis were developed with RStudio software (RStudio Team, 2015) under R environment (R Core Team, 2016).

2.5 European Shag

Monthly counts were carried out from January to June 2015 in order to access the European Shag breeding population size in Berlengas archipelago. Later, monthly counts were done from April to June 2016, only in Berlenga Island. Occasional surveys were conducted by rangers, during their regular boat patrol actions on the Natural Reserve marine area, and new nest locations were added to the original database. Nests are usually located on cliffs and caves, so the counts from land were done at distance, using binoculars and spottingscope, others were searched by boat using binoculars. Number of adults present on each nest was recorded, as well the location of the nest and the number of eggs/chicks. Productivity and trends were estimated as stated above.

2.6 Common Murre

Common Murres surveys were conducted simultaneously with Shag surveys. Special attention was paid to historical reference sites, where the species has bred.

3. RESULTS AND DISCUSSION

3.1 Cory's Shearwater

a. Analysis of the breeding population size

In 2015, 681 active nests were counted in all archipelago. The main island and 7 other islets were prospected. Estelão, Manuel Jorge and Farilhão dos Olhos islets could not be visited due to adverse sea conditions. We estimated a total of 800-975 breeding pairs for the entire archipelago (table 1). On Berlenga Island, more than 90% of the island was prospected. Five small caves located in inaccessible areas were not prospected, 2 on the cliff that faces São João Baptista Fortress, 1 in Carreiro do Mosteiro and 2 others in Zé da Carolina. Also, some birds nest in European rabbit *Oryctolagus cuniculus* holes where breeding is virtually impossible to confirm. Some of those nests were later confirmed as occupied, during the chick rearing period, when chicks come to the nest entrance. Three nests were confirmed on Inês Islet and 3 others were not confirmed, because were located on a small crevice. Cerro da Velha was all prospected. Although Estela Grande, Farilhão do Nordeste and Farilhão dos Olhos islets had a good survey effort, some nests potentially located in inaccessible vertical cliffs might have been missed. Estelão, Manuel Jorge and Farilhão dos Olhos were not prospected and numbers were estimated based on data from islets with similar habitat. Approximately 90% of Farilhão Grande area was inspected. Only a small rocky beach located on the Northeast side and a small portion of wall located on the East cliff were not prospected. Only about 30% of Farilhão da Cova Islet was prospected. This is the islet with most difficult access of all accessible islets. The very steep cliffs limited the progression on the terrain in most of the area. Though those places probably hold small numbers of pairs due to the lack of suitable nesting habitat.
Overall numbers were very similar to those reported by Lecoq *et al.*, (2011) during the last census, when 980-1070 breeding pairs were estimated for the entire archipelago. However, attention must be paid to some of the breeding colonies, mainly the one located on Farilhão Grande Islet (see below for further analysis), where the highest reduction was noticed.

Table 1_Number of breeding pairs counted and estimated in 2015 for the different colonies of Berlengas archipelago.

Island/Islet	Counted	Estimated
Berlenga	245	280 - 300
Inês Islet	3	3 - 6
Cerro da Velha	15	15 - 20
Estela Grande	16	16 - 20
Estelão		5 - 10
Manuel Jorge		5 - 10
Farilhão Grande	325	350 - 425
Farilhão da Cova	56	100 - 150
Farilhão do Nordeste	15	15 - 18
Farilhão dos Olhos		5 - 10
Rabo d'Asno	6	6
TOTAL	681	800 - 975

b. Distribution of the sub-colonies located on Berlenga Island

Nests were found throughout all Berlenga Island and were grouped together to facilitate the visualization (fig. 3). The main sub-colonies were in Melreu, Capitão and Furado Sêco, holding near 69% of the entire population of the island (table 2). Our results show an increment in the number of breeding pairs when compared with the 237 pairs counted in 2010 (Lecoq *et al.,* 2011), although the estimate for the entire archipelago was similar. Also during 2010, near 58% of Berlenga population was breeding in the 3 main sub-colonies (Lecoq *et al.,* 2011). The shown increment may be due to the new artificial nesting boxes installed in those sub-colonies, over the last years. During 2011, 50 new

artificial boxes were built and other 34 were recovered (Lecoq & Oliveira, 2011). In 2015, under the scope of Life Berlengas 34 new artificial boxes were set down and other 6 suffered minor maintenance work, though by this time the biggest effort took place in Furado Sêco sub-colony (table 3). The new artificial nests showed a 41% occupancy rate in 2015. Actually, this year, more than 80% of pairs from Melreu and Furado were breeding in artificial nests.

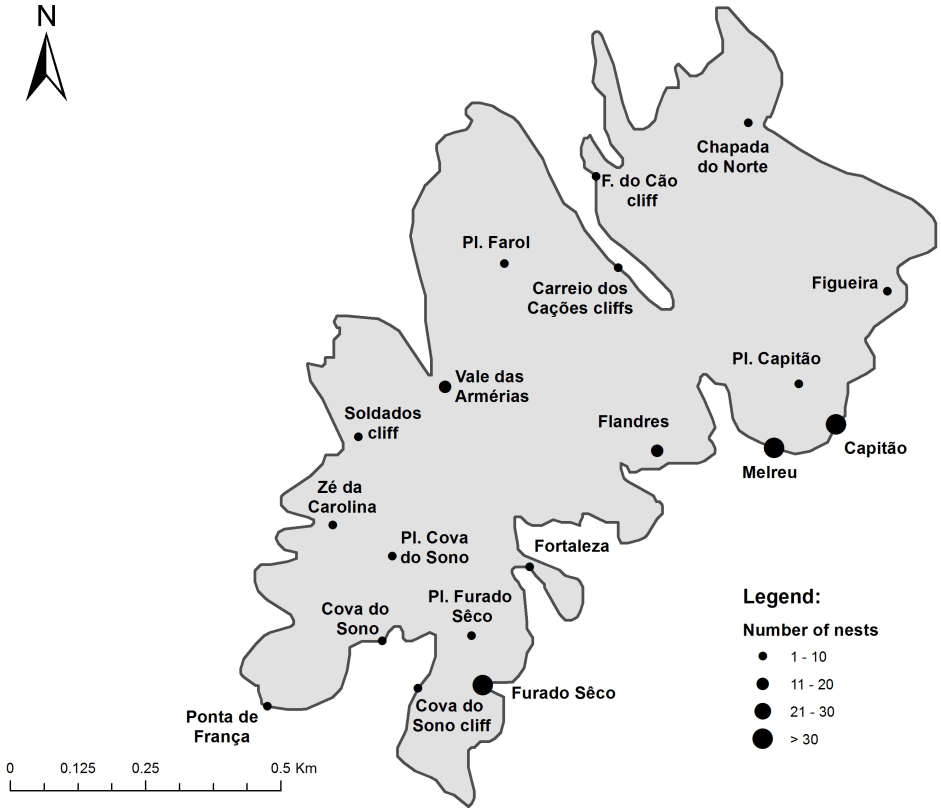

Figure 3_Distribution of Cory's shearwater breeding sub-colonies on Berlenga Island in 2015. Nests were found throughout the island and were grouped together to facilitate the visualization.

Table 2_ Number of active nests counted in 2015 in the different sub-colonies of Berlenga Island.

Breeding sub-colony	Number of active nests
Melreu	103
Capitão	36
Furado Sêco	31
Flandres	13
Cova do Sono	6
Vale das Armérias	16
Figueira	6
Zé da Carolina	5
Outros	29
Total	245

Table 3_Number of new nests built and recovered during both 2011 and 2015 campaigns in 4 sub-colonies. The number of new nests built under both campaigns that were occupied (where at least one egg was laid) is also presented together with the respective breeding success.

Breeding sub-colony	Artificial nests				
	2011		2015		New artificial nests occupied (breeding success)
	New	Recovered	New	Recovered	
Melreu	42	24	4	2	18 (1)
Capitão	8	8	0	4	--
Furado Sêco	0	2	21	0	14 (0.69)
Flandres	0	0	9	0	3 (0)
Total	50	34	34	6	35 (0.76)

c. Breeding success

In 2015 at Melreu sub-colony, from the 73 monitored nests, 57 hatched a chick from which 55 fledged successfully. At Furado, from the 31 monitored nests, 26 hatched a chick from which 25 fledged successfully. The estimated breeding success for Melreu and Furado (n=31) was 0.72 and 0.81, respectively. The main stage for the unsuccessful breeding was during the incubation, mainly at Melreu where 2 eggs were found cracked, other 2 disappeared and the remaining were deserted resulting on 25% of lost eggs. While at Furado 16.13% eggs were lost, 2 eggs were deserted and 3 disappeared. All the 3 chicks found dead presented evidences of predation. The corpses were found partial consumed with signs on the head and neck assumed as Black rat *Rattus rattus* bites, once it is the only possible ground predator present on Berlenga Island able to produce such effect. Overall, the breeding success was similar to the one estimated in 2010 (Lecoq, 2010; tab. 4) but smaller than in 2006 (Alonso *et al.,* 2009). However, this last study only took into account a small sample from Melreu colony. For 1987 the breeding success was very low, probably due to the intense handling of birds during the incubation period, since very few dead chicks were observed after hatching (Granadeiro, 1991).

Table 4_Cory's Shearwater breeding success estimated to Berlenga Island population from 1987 until 2015. Granadeiro (1981) estimated the breeding success based on nests from the entire island, while Alonso *et al.* (2009) presented their estimates based on Melreu sub-colony and Lecoq (2010) based his estimates on nest monitoring from Melreu, Furado and Capitão sub-colonies.

Year	n	Breeding success	Source
1987	59	0.37	Granadeiro, 1991
2006	34	0.88	Alonso *et al.,* 2009
2010	134	0.71	Lecoq, 2010
2015	107	0.75	this study

d. Population trends

The annual growth rate on the five-years period shows a considerable decrease whereas on the 10 years-trend the population seems to be stable (tab. 5). Although the Berlenga Island population is facing a positive trend, some evidences suggest that the same is not happening in the biggest sub-colony of the archipelago, located in Farilhão Grande Islet. In 2005, 500-550 breeding pairs were estimated for Farilhão Grande (Lecoq *et al.,* 2010). The same estimate was presented in 2011, but only 261 nests were counted (Lecoq *et al.,* 2011). In 2015, 325 nests were found resulting in an estimate of 350-425 breeding pairs. Considering the estimated population size, Farilhão Grande is facing an annual decrease of around 3.5% for the last 10 years, but around 1.5% in case we only use counted pairs for the same period. Farilhão Grande holds a Yellow-legged Gull *Larus michahellis* breeding population of 170-180 breeding pairs (Oliveira *et al.,* 2013). Although no cases of predation by gulls on adults were recorded, eggs and chicks are often taken by gulls (Lecoq *et al.,* 2010)

specially on very exposed nests (e.g. under thin vegetation or with no cover at all). Previous works reported signs of predation by gulls on 16 to 34% of all counted nest (Lecoq *et al.*, 2010, 2011). Although Cory's shearwaters tend to use the same nest for the entire life, new breeders are known to change nest in case of breeding failure. However, there are no reported cases of birds that moved away to other breeding colony after failure occurred. Breeding success on Farilhão Grande must be properly monitored in the future, and action must be taken in case the Cory's Shearwater population decrease continues.
With regard to long-term trend (here presented as a 28 years' trend), the population shows a considerable increase mainly due to the low numbers record during the 1980's on Farilhão Grande (table 6) and the increasing of nesting cavities on Berlenga Island through the installation of artificial boxes.

Table 5_Cory's Shearwater trends within five, ten and 28 years on Berlenga island. The low limit of each annual estimate was used to calculate the instantaneous rate, annual multiplication rate and annual growth rate.

Trend (years)	*Years*	*Instantaneous growth rate (r)*	*Annual multiplication rate (y)*	*Annual growth rate (%)*
5	2010-2015	-0.041	0.960	-3.98
10	2005-2015	0.000	1.000	0.00
28	1987-2015	0.03	1.055	5.47

Table 6_Censuses and estimates of Cory's Shearwaters breeding in Berlengas archipelago. Estimates in 2005 for Farilhões islets only include Farilhão Grande.

Year	Berlenga Island	Farilhões islets	All archipelago	Method	Source
1978	50	-	-	Nest counts (breeding birds); estimate	Araújo & Luís, 1982
1981			100-200	Nest counts (breeding birds); estimate	Teixeira, 1984
1985	80-100	80-90		Estimate (based on a few nests counted)	Nuñez & Concepción, 1986
1987	100-120	80-100		Nest counts (breeding birds) and counts at sea; estimate	Granadeiro, 1991
2005	300	500-550		Nest counts (breeding birds); estimate	Lecoq *et al.*, 2010
2010	310	625-710	980-1070	Nest counts (breeding birds); estimate	Lecoq *et al.,* 2011
2015	280-300	476-609	800-975	Nest counts (breeding birds); estimate	This study

3.2 Band-rumped Storm-petrel

a. Distribution of the breeding colonies

The Band-rumped Storm-petrel population that breeds on Farilhão Grande Islet is being followed over the last years, once it was the only islet from Berlengas archipelago where the species was confirmed to breed (Teixeira, 1983, Granadeiro *et al.,* 1998, Oliveira *et al.,* 2015). For the first time, breeding was confirmed on Farilhão da Cova and Farilhão do Nordeste islets. In total, 4 nests were observed, one of which (ID = 050) was empty and only had the characteristic odor of this species (table 7). Of the remaining nests, two were located on the south slope and one on the north slope (fig. 4). This islet has few cavities or fissures in the main blocks of stones available to be occupied by Band-rumped Storm-petrels, so there should not be many more couples than those found during this day.

Table 7_ Description of the nests found on Farilhão do Nordeste and Farilhão da Cova islets in October 25, 2014.

Islet	Nest ID	Number of adults	Breeding patch	Presence of egg
Farilhão do Nordeste	048	2	√	?
	049	1	?	√
	050	0		
	051	1	√	
Farilhão da Cova	052a	0		√
	052b	1	?	?
	053	1	?	√
	004	0		

The difficulties of accessibility to some areas of Farilhão da Cova together with the existence of places of almost impossible access and the reduced time spent on searching reflected the reduced number of nests found (fig. 4). In total, 4 nests were found, 2 of which with an adult inside (table 7).

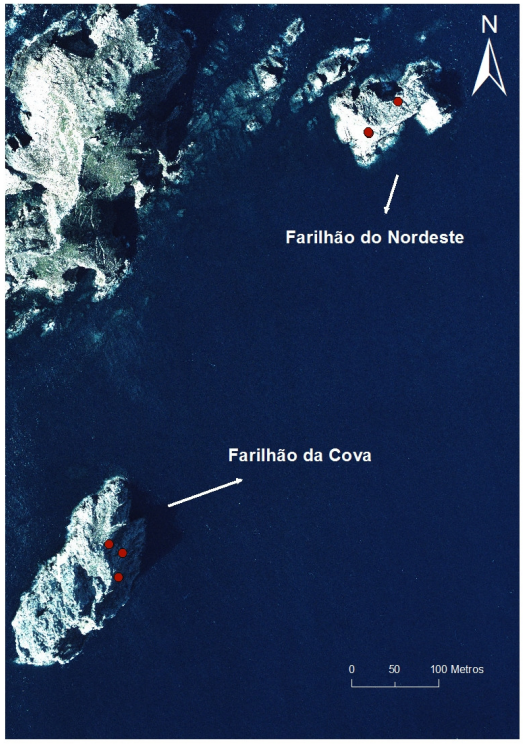

Figure 4_Location of the nests found on Farilhão do Nordeste and Farilhão da Cova islets in October 25, 2014.

b. Analysis of the breeding population size

Between October 25th and 29th 2014, 276 birds were caught: 127 catches on the first night, 75 on the second, 34 on the third and 40 on the last. In total, 25 recaptures were performed. During the session of November 17 to 20, 2015, 88 catches were made on the first night, 70 on the second and 37 on the

third. Overall, 177 different individuals were captured and 18 were recaptured. More birds showing no incubation patch were captured in 2014 than in 2015. Of the 251 individuals captured in 2014 and the 177 captured in 2015, only in 11 and 1, respectively, was not detected a breeding patch, corresponding to about 4.38% and 0.56% of the catches. Also, some birds showing a breeding patch may not be effectively incubating an egg. We used the percentage of breeders estimated by Robert *et al.,* (2012) for Praia Islet (Azores) as 83.5% to transform the estimate of birds present during the CMR exercise into an estimate of the size of the breeding population, resulting in 463 breeding pairs (IC95% = 318 - 609).During 2015, captures occurred later in the breeding season and most birds should already show the breeding patch while during October 2014 some birds could not start yet their breeding patch formation. Other theory can be related with the fact that in October (during the beginning of breeding season) more new prospectors may be around the breeding colony to find the first mate while later in November, when most of the eggs are already being incubated, only successful breeding birds attend the breeding grounds. Also, it should be borne in mind that one of the assumptions of catch-mark-recapture methods is that all individuals in the population have the same probability of being caught. The nest visitation cycle, which is assumed to be similar to the population breeding on Praia Islet, Azores, where it was estimated that individuals alternate 4.89 $\pm$ 0.18 days to incubate (on land) with 5.21 $\pm$ 0.18 at sea (Bolton *et al*., *in press*). However, sampling during 4 nights should allow to obtain more accurate estimates, since the number of nights is closer to the nest visitation cycle. For a more robust estimate, which would allow to assume that all individuals of the population are equally likely to be captured, a minimum of 6 nights of sampling will be required.

We ran 4 different models and results are presented in table 8. Models were built considering several capture occasions per year *vs* a single capture occasion per each year and capture probabilities (m) varying between periods *vs* equal capture probabilities. The model which fitted better our data on basis of lesser Akaike Information Criterion (AIC) was the one with each year as single occasion and considering equal capture probabilities (Occ = "single", m = "ep"). Also, the result of the trap effect analysis for the model with a single capture occasion per year and capture probabilities varying between periods points, the model assuming homogeneous trap effect was the one that fitted better our data (table 9). Following the best model results, the population estimate for 2015 is 1110 $\pm$ 229 (N $\pm$ *standard error*).

Table 8_Results of the 4 different models used to estimate the population size of Band-rumped Storm-petrel breeding on Farilhão Islet. Models were built considering several capture occasions per year (Occ = "multiple") *vs* a single capture occasion per each year (Occ = "single") and capture probabilities varying between periods (m = "up") *vs* equal capture probabilities (m = "ep"). Deviance, degrees of freedom (Df) and AIC values are presented for each model. * indicates the best model selected on basis of lesser AIC value.

Fitted model	Deviance	Df	AIC	Population estimate ($\pm$ *standard error)*
Occ = "single", m = "ep"	32.43	23	129.71*	1109.98 $\pm$ 173.82
Occ = "single", m = "up"	31.74	21	133.02	2047.50 $\pm$ 309.77
Occ = "multiple", m = "up"	197.34	4071	476.32	1146.28 $\pm$ 830.13
Occ = "multiple", m = "ep"	229.00	4082	485.98	784.99 $\pm$ 814.55

Table 9_Trap effect analysis for the model with a single capture occasion per year and capture probabilities varying between periods. Deviance, degrees of freedom (Df) and AIC values are presented for each model. * indicates the best model selected on basis of lesser AIC value.

Fitted model	Deviance	Df	AIC
Homogeneous trap effect	30.93	20	134.21*
Heterogeneous trap effect	30.91	19	136.09

Four nests were counted during the prospection of Farilhão do Nordeste Islet which allow us to estimate the population size between 3 - 4 breeding pairs (table 10Despite the small number of recorded nests, Farilhão da Cova presents a great availability of nesting habitat for the species, being likely that the number of couples here is much higher than the one found. Taking into account the similarity with Farilhão Grande habitat, it is assumed a similar density of nests on both islets, resulting in an estimate of 89 - 171 breeding pairs. However, it is necessary to increase the search effort over the next few years and develop some capture sessions with mist nets and / or methods based on night vocal activity (e.g. listening points to record call activity or using automatic audio recording devices).

Table 10_Size of Band-rumped Storm-petrel populations breeding on Farilhões islets in 2014 and 2015.

Islet	Area (ha)	Number of breeding pairs
Farilhão Grande	8.2	318 - 609
Farilhão do Nordeste	2.4	3 - 4
Farilhão da Cova	2.3	89 - 171
Total		410 - 784

The population size of Band-rumped Storm-petrel breeding on Farilhões islets was then estimated to 410 - 784 breeding pairs. The result achieved in this work emphasizes the importance of Farilhões group for this species at an European level, as mentioned in previous works, when breeding was only known for Farilhão Grande (e.g. Granadeiro *et al*., 1998). We cannot discard the possibility of nesting in other islets of the archipelago, such as Inês and Cerro da Velha islets, but still without confirmation.

c. Breeding success

Breeding success was analyzed only for Farilhão Grande colony. In 2014, from the 9 monitored nests, we registered successful hatching in 6 of them (1 chick per nest, having all chicks fledged successfully). In 2015, from the 13 monitored nests, 8 nests had successful hatching (chicks from 7 nests fledged successfully). The estimated breeding success results, in 2014 and 2015, were 0.67 (n = 9) and 0.54 (n = 13), respectively.

The main reason for the unsuccessful breeding was probably the ineffective incubation, specially in 2014 where 1 egg was found cracked, 1 deserted and 1 disappeared, resulting on 33.33% of eggs lost. In 2015, 38.46% of the eggs were lost, 1 egg was deserted and 4 disappeared. Also during the last year, one chick was recorded on automatic cameras being predated by an adult Yellow-legged Gull. For the total of 10 nests monitored during 2015, 7 nests were recorded being frequently visited by Yellow-legged Gulls (mainly adult), actively searching around and on the nest entrance. The only other predator recorded on cameras was a Peregrine Falcon *Falco peregrinus.* In 2014, from 6 cameras set recording the nest entrance, 5 recorded Yellow-legged Gulls actively searching around and on the nest entrance. Overall the breeding success in Farilhão Grande was low when compared with Praia Islet population (Azores) during the recent years (2012 - 0.81; 2010 - 0.77; Bried & Neves 2015). Both islets show evidences of strong pressure by Yellow-legged Gull, but gulls are much more abundant on Farilhão Grande. Gulls using Farilhão Grande Islet, the surrounding islets and the marine area between them were counted from October 2013 to January 2014. Total numbers ranged from 91 (in November) to 611 gulls (in October), mainly feeding and resting at sea but also a good proportion resting in land (table 11). Information on Yellow-legged Gull numbers using Farilhões islets during winter is scarce. Granadeiro *et al.* (1998) reported a near absence of the species during the winter, with significant growth during the months of January and February, just before the beginning of the breeding season. During the early winter of 2012, 8 gulls were counted resting on Farilhão Grande and 441 on the remaining islets of the group and resting at sea (Oliveira *et al.,* 2013). The sea around Farilhões group seems to be a place of special interest for gulls, especially when great concentrations of crabs *Polybius henslowii* occurs, due to be its main natural prey (Almeida, 2013). This significant increase in the number of gulls wintering on Farilhões islets, during the last decades, may represent a critical threat to the Band-rumped Storm-petrel population and therefore monitoring is required.

Table 11_ Average number (N) of Yellow-legged Gulls observed on Farilhões islets and surrounding waters. Standard deviance (SD) obtained from the different counts (n) is also presented.

Area	N (*n*)	SD
Farilhão Grande	107.25(4)	11.03
Farilhão do Nordeste	14 (1)	-
Farilhão da Cova	6 (1)	-
At sea	580(1)	-

The main portion of monitored nests of Praia Islet are in artificial chambers that guarantee good protection for adults, eggs and chicks (Bried & Neves, 2015) while on Farilhão only few pairs have already successfully occupied the recently build artificial chambers. Although other studies highlight the effective protection secured by Hotentot Fig *Carpobrotus edulis* against gulls (Granadeiro *et al.,* 1998), the images recorded by automatic cameras, together with the evaluation of nest vegetal cover by the end of each storm-petrel breeding season, along the last years, suggested an insufficient protection capacity secured by Hotentot Fig.

d. Population trends

In order to compare our results with previous works (see table 12), we excluded captures from nets set out at the east cliff of Farilhão Grande Islet and run the trend analysis again (table 13). This approach reduced our sampling effort to 45m of mist-net length. The annual growth rate on the three-years period shows an extremely high decrease on numbers of breeding pairs, whereas on the 13 years period results show a great population increase. Such variation is most likely related with differences on sampling effort and analytical approach between our work and the one developed in 2002 (Magalhães, 2003). Actually, if we run 2015 estimate following the Lincoln-Petersen estimator used by Magalhães (2003), the value decreases to 259 breeding pairs, resulting on an annual growth rate of 5.76%. However, one assumption of the Lincoln-Petersen estimator is that all individuals in the population must have the same probability of being caught, which is not the case of any of these samples.

Table 12_Population size estimates (breeding pairs) for the Band-rumped Storm-petrel population breeding on Farilhão Grande Islet from 1983 to 2015. Besides the analytical method used to calculate the population size estimates, also the numbers of mist-nets used (total net length in meters) are presented.

Year	Source	Method	Breeding pairs	Nets (length)
1983	Teixeira, 1983	Estimate	50	*n.a.*
1994-95	Granadeiro *et al.,* 1998	Estimate	200-400	5 (72m)
2002	Magalhães, 2003	Lincoln-Petersen	~125	4 (60m)
2012	Oliveira *et al*., 2013	Cormack-Jolly-Seber	482	8 (120m)
2015	Present study	Cormack-Jolly-Seber	463	3 (45m)

n.a. not applicable since no mist-nets were used (empirical estimate)

Table 13_Band-rumped Storm-petrel trends within three, thirteen and 21 years for Farilhão Grande breeding population. Estimates for 2015 were recalculated to allow comparing with previous year estimates.

Trend (years)	*Years*	*Instantaneous growth rate (r)*	*Annual multiplication rate (γ)*	*Annual growth rate (%)*
3	2012-2015	-0.113	0.893	-10.72
13	2002-2015	0.092	1.096	9.58
21	1994-2015	0.006	1.006	0.64

Despite little is known about the analytical methods under the population size estimate for 1994-1995 period, the long-term trend seems to show a stable population over the last decades. By 1994 small numbers of gulls were using Farilhões islets during winter time (Granadeiro *et al.,* 1998). The recent increase in number of gulls may point for an increasing predation upon Band-rumped Storm-petrels, which may explain the negative impacts showed by the 3 years trend. The monitoring of gulls predation upon storm-petrels must be carried on using automatic cameras set on nest entrances. Also, the occupancy of the last artificial nests built on Farilhão Grande must be monitored, as well as the effectiveness against gulls predation and breeding success. And on top of this, gulls population overall increment must be tackled on the source, and efforts to reduce food availability on anthropogenic sources (e.g. urban residuals and fishery discards) must be proceeded. Finally, further mist-netting sessions for storm-petrel population size estimates should include a minimum of 4 nights (ideally 6) and should cover the same areas sampled during 2014-2015, to ensure a systematic long-term monitoring scheme.

3.3 European Shag

a. Distribution of the breeding colonies

European Shag nests were found distributed over 14 sub-colonies located on Berlenga Island and Farilhão Grande Islet (fig. 5). Although all other islets were prospected, only the ones where nests were found in the current or previous surveys were included in table 14. No significant differences were present when comparing our data with 2012 census ($t(43)=0.95$, $p=0.35$; Lecoq *et al.,* 2012). However, historical breeding areas have disappeared over the last 20 years (see Lecoq *et al.,* 2012), namely the ones located on Maldito, Estela Grande and Cerro da Velha islets.

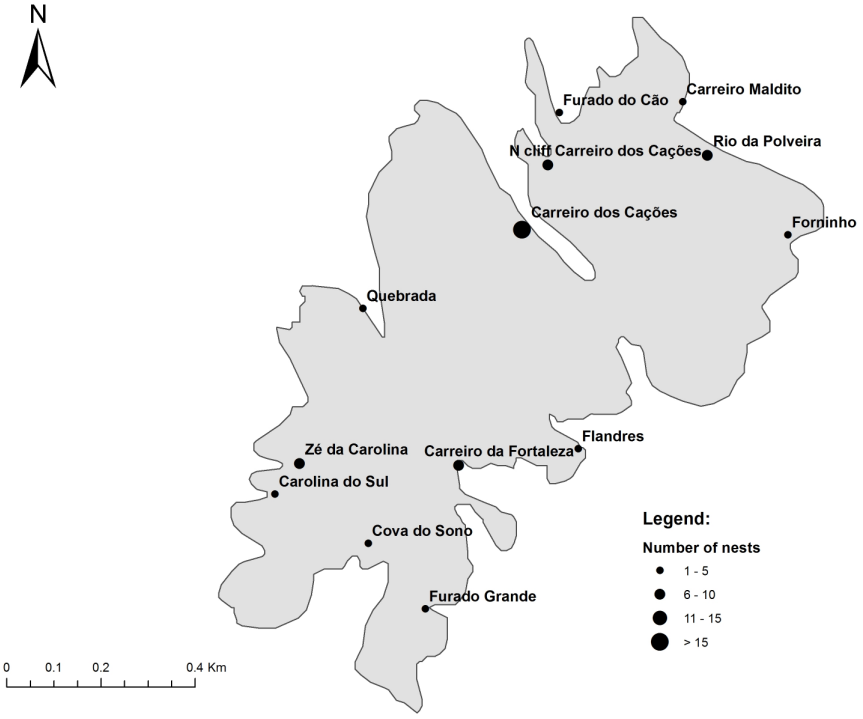

Figure 5_Distribution of European Shag breeding sub-colonies on Berlenga Island in 2015. Nests were found throughout the island and were grouped together to facilitate the visualization.

Table 14_Number of active nests counted in 2015 and 2016 in the different sub-colonies of Berlengas archipelago. Only the sub-colonies where nests were found in the current and previous surveys were included.

Island or islet	Breeding sub-colony	2015	2016
Berlenga Island			
	Forninho	5	3
	Rio da Poveira	10	
	Carreiro Maldito	3	6
	Furado do Cão	3	1
	Ponta N do Carreiro dos Cações	6	6
	Carreiro dos Cações	17	15
	Carreiro do Carolina do Sul	2	5
	Carreiro do Zé da Carolina	10	9
	Cova do Sono	4	
	Furado Grande (acima entrada Leste)	2	
	Flandres	3	4
	Quebrada	1	
	Carreiro da Fortaleza	6	3
Cerro da Velha		0	
Estela Grande		0	
Farilhão Grande		3	
Total Berlenga Island		72	52
Total archipelago		75	

b. Analysis of the breeding population size

In 2015, 75 different active nests of Shag were counted in Berlengas archipelago during the intensive observation effort. Nests were mainly located in Berlenga Island, but 3 were located on Farilhão Grande Islet (table 14). During 2016, the partial counting target only 10 sub-colonies located on Berlenga Island with a total of 52 nests counted. Numbers of nests found in the 2016 were not significantly different from the numbers counted during 2015 ($t(9)=0.45$, $p=0.66$). The first population estimate dates to 1939, when Lockley visited the archipelago during the month of June (Lockley 1952) and estimated the population in 70 breeding pairs. After the classification of Berlengas archipelago as Natural Reserve, with the consequent protection of seabird colonies, the population seems to have increased and stabilized around the 90 breeding pairs (Neto, 1997; Lecoq, 2003; Lecoq *et al*., 2012). Here we present an estimate to the Berlengas' Shag population of 75 breeding pairs. Other 13 platforms were detected as likely nesting sites. Here we show the importance of Berlengas archipelago to the population of European Shag that breeds in Portugal, following the statements presented by other authors (e.g. Teixeira, 1984, Neto, 1997 and Lecoq *et al.,* 2012). Although representing less than 1% of the global population (BirdLife 2016) and only ~2% of the Iberian Population (Juana and Garcia 2015) Berlengas is among the top 5 Iberian breeding colonies in terms of population size, highlighting the importance of its conservation and monitoring.

c. Productivity

The reproduction of European Shag is very asynchronous with the construction of the nest and the dates of laying and hatching occurring from January until May, therefore number of monitored nests was increasing along the breeding season. The first egg was placed between 1 and 7 March and the

last was laid between 24 and 30 April. Regarding the dates of hatching, the first occurred between April 1 and 7 and the last between May 24 and 31 (n = 40, number of monitored nests). In 2015, the mean clutch size was 2.14 eggs/nest (n = 58) and near 38.7% of the eggs failed to hatch or were deserted. Failure after hatch was found to be also low, from the 82 observed chicks (n = 62) only 2 were found dead and other 2 disappeared. In 2016, the mean clutch size was 2.23 eggs/nest (n = 46) and nearly 32% of the eggs failed to hatch or were deserted. Failure after hatching was found much lower with only 4 chicks found dead (n = 27). Shag productivity in 2015 was estimated at 1.32 chicks/nest (n = 58) and in 2016 was 1.31 chicks/nest (n = 50), while the breeding success was estimated at 0.88 and 0.67 in 2015 and 2016, respectively (see Silva, 2015 and Bellier, 2016 for further details). Despite the difference on sample sizes, overall numbers are similar. Both clutch size and productivity were found lower for 2015 and 2016 years then previous years (table 15). Comparing with other colonies, our values are smaller than productivities found on British and Norwegian colonies, where means were estimated on about 1.55 chicks/nest (JNCC, 2016) and 1.8 chicks/nest (Barret *et al.,* 1986), respectively. Reasons for such low productivity on Berlenga Island may be explained by low food availability, progenitors' mortality during the breeding season (namely caused by bycatch or predation) or predation of eggs and/or juveniles.

Year	Clutch size (*n*)	Productivity (*n*)	Source
1982	2.9 (10)	1.1 (47)	Luís, 1982
1991	--	1.36 (14)	Morais, 1991
1995	2.57 (23)	1.33 (58)	Neto, 1997
2015	2.14 (58)	1.32 (58)	This study
2016	2.23 (46)	1.31 (50)	This study

Table 15_Shag clutch size and productivity estimated for the Berlenga Island population between 1982 and 2016. Sample size numbers are present within brackets for each year.

d. Population trends

Despite the oscillation in size numbers of European Shag breeding population from Berlengas archipelago over the last 40 years (fig. 6), the annual growth rate for the 3-years, 13-years and 20-years periods shows a decrease on numbers of breeding pairs (table 16). Counts were selected based on the years in which complete census took place. After the apparently increase on breeding pairs following the designation of Berlengas archipelago as Natural Reserve, when a maximum count was recorded by Neto (1997) as 90 breeding pairs, this population seems to face a slight decrease. The main causes behind the recent decrease in the entire Iberian Peninsula are the bycatch in fishing nets (Velando & Freire, 2002, see also Oliveira *et al*., 2015) and the oil spill of the tanker "Prestige" (Martinez-Abrai *et al*., 2006). Although the use of fishing nets is forbidden within Berlengas Natural Reserve limits, great numbers of these gears are daily set on the surrounding areas which probably are also Shags' foraging areas. Efforts to track breeding adults from Berlenga Island are being made and we expect to very soon obtain useful information on the overlap between fisheries and Shag feeding areas. Also, data on diet of breeding birds must be collected as well as data on fisheries landings and discards to evaluate the overlap/competition among them and assess the impacts of the fishing sector on Shag potential preys (JNCC, 2016).

Table 16_European Shag trends within three, thirteen and twenty years for Berlengas archipelago breeding population. Historical data was compiled from Neto (1997), Lecoq (2003) and Lecoq *et al*.(2012).

Trend (years)	*Years*	*Instantaneous growth rate (r)*	*Annual multiplication rate (γ)*	*Annual growth rate (%)*
3	2012-2015	-0.030	0.971	-2.93
13	2002-2015	-0.004	0.996	-0.40
20	1995-2015	-0.009	0.991	-0.91

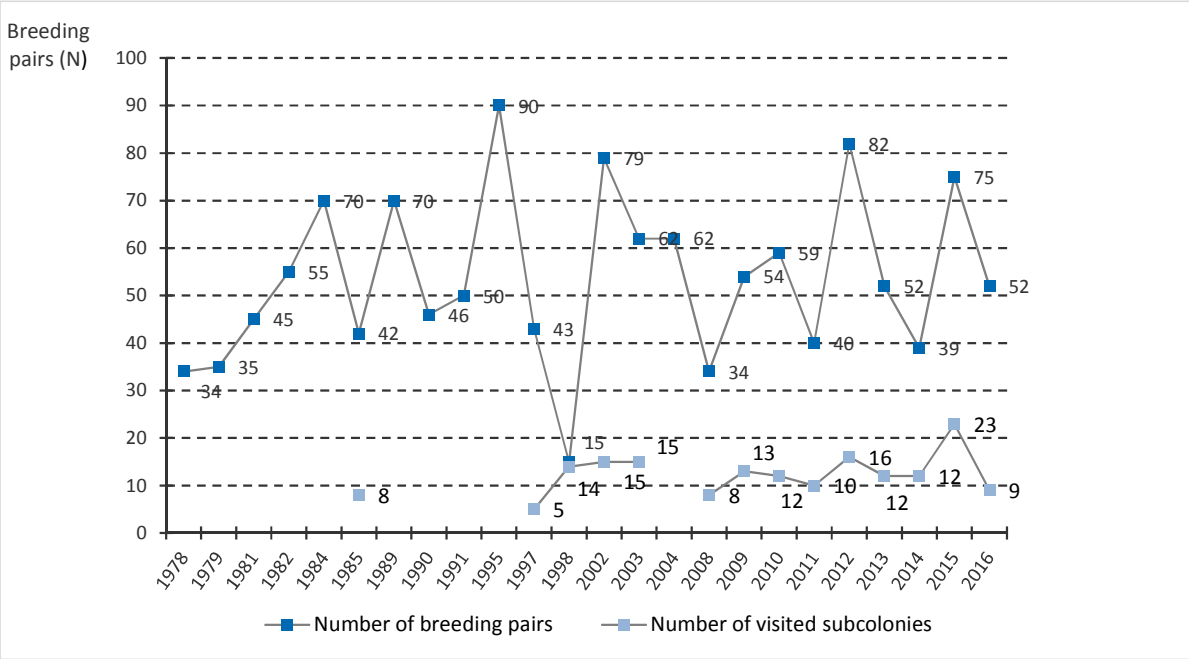

Figure 6_Population size (number of breeding pairs) of European Shags breeding in Berlengas archipelago from 1978 to 2016 (Teixeira 1984, Neto 1997, Morais *et al*., 2003, Lecoq 2003, Morais *et al*., 2009, 2010, 2011, 2013, 2014, Lecoq *et al*., 2012)**.** Once sampling effort was not constant over the time, number of visited sub-colonies is also presented. On 1984 the total of counted nests was 96 (70 confirmed, 18 recorded as probable, 8 as possible; Teixeira, 1984).

3.4 Common Murre

a. Distribution of the breeding colonies

No breeding individuals were detected, neither evidences of breeding sites. During June 2016, a possible Common Murre was observed flying in the "Carreiro dos Cações". Following the previous works (Rufino, 1989; Lecoq, 2003; Munilla *et al.,* 2007; Equipa Atlas, 2008; Catry *et al*., 2010; Meirinho *et al*., 2014) we may consider Common Murre is extinct as breeder in Berlengas archipelago as well as in Portugal.

b. Population trends

During the last 40 years, Common Murre faced a sharp decline resulting on its extinction as breeder in Berlengas grounds (fig. 6). Given that the last breeding event was observed in 2002 (Lecoq 2003), trends for the last 5 to 10-years period resulted in an annual growth rate of 0%, while the 35-years trend showed a decrease of 14% birds per year (table 17).
There are several reasons for the marked decline of Common Murre in Berlengas, namely the increase in fishing activity using gillnets, as well as the reduction of food resources, direct competition with man for fishery resources and the disturbance of nesting sites (Catry *et al*., 2010). Munilla *et al*. (2007) identifies the mortality of adult birds caused by synthetic fishing nets as the main cause of the decrease of Iberian Peninsula population, and refutes the hypotheses of global climate change or disturbance of the colonies.

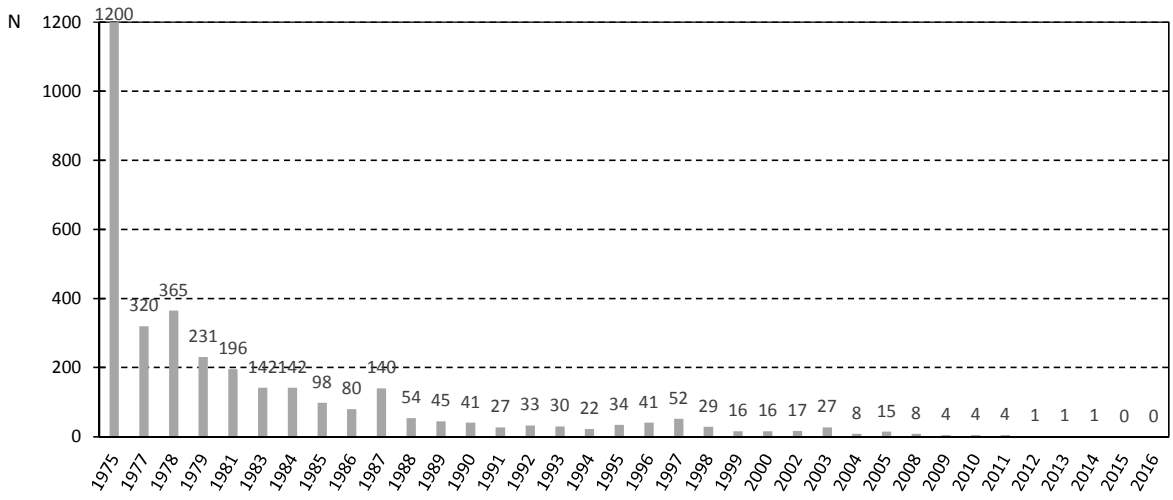

Figure 6_Population size (number of individuals) of Common Murre breeding in Berlengas archipelago from 1975 to 2016 (Lecoq, 2003; Morais *et al.,* 2014)**.**

Table 17_Common Murre trends within five, ten and 35 years for Berlengas archipelago breeding population. Historical data was compiled from Lecoq (2002) and Morais *et al*. (2014).

Trend (years)	***Years***	***Instantaneous growth rate (r)***	***Annual multiplication rate (γ)***	***Annual growth rate (%)***
5	2011-2016	0	0	0.00
10	2006-2016	0	0	0.00
35	1981-2016	-0.15	0.86	-14.00

4. FINAL CONSIDERATIONS

- The population size of the 4 species that breed in Berlengas archipelago resulted in 800 - 975 breeding pairs of Cory's Shearwaters, 410 - 784 pairs of Band-rumped Storm-petrels and 75 pairs of European Shags.
- We may consider that Common Murre is extinct as breeder in Berlengas archipelago, as well as in Portugal. There are several reasons for the marked decline of Common Murre in Berlengas, among which are the increase in fishing activity using synthetic gillnets, as well as the reduction of food resources, direct competition with man for fishery resources and the disturbance of nesting sites.
- It was confirmed for the first time Band-rumped Storm-petrel population breeding on Farilhão da Cova and Farilhão do Nordeste islets. However, it is necessary to increase the search effort over the next few years and develop some capture sessions with mist nets and / or methods based on night vocal activity (e.g. listening points to record call activity or using automatic audio recording devices) in Farilhão da Cova and Cerro da Velha islets.
- Despite on Berlenga Island, the trends of Cory's Shearwater and European Shag showed a stable or positive trend, the same is not happen along the islets of the archipelago. Cory's Shearwater and Band-rumped Storm-petrel showed a negative trend on Farilhão Grande. Also European Shags were not seen breeding on Estelas group for more than 20 years. The causes that have lead to such decreasing in terms of spatial distribution and population size are not very clear. During the next 2 years, the project team intend to evaluate the impact of the main causes of threat for the populations that breed in Farilhão Grande, even on land (e.g. predation by gulls) or at sea (e.g. bycatch). Also, it is urgent to understand the causes of such low productivity in European Shag population, mainly through diet analysis, assessment of competition with fisheries and bycatch estimate.
- The occupancy of the artificial nests built on Farilhão Grande for Band-rumped Storm-petrels must be monitored over the next years, as well as the effectiveness against gulls predation and breeding success.
- The main factors that have lead to the increment of the Yellow-legged Gull population that use the archipelago islets, all over the year, must be tackled on the source, and efforts to reduce food availability on anthropogenic sources (e.g. urban residuals and fishery discards) must be proceeded.

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