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Short communication

Nest boxes: A successful management tool for the conservation of an endangered seabird

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ABSTRACT

Nowadays seabirds are among the most threatened animal taxa. Due to introduction by humans of mammalian predators on large islands, Mediterranean Storm Petrels are now confined to islets and considered locally vulnerable, especially threatened by predatory overabundant gulls. In this study, we evaluate the effectiveness of nest boxes installation as a management measure for their conservation at Benidorm Island (Spain). We compare demographic parameters of individuals breeding in natural nests and nest boxes using capture–recapture and generalized linear mixed models. Our results show higher survival rates and breeding success probabilities for birds breeding in artificial nests than in natural sites, probably as a consequence of protection against gulls. Following the installation and successful occupation of nest boxes, breeding numbers of Storm Petrels greatly increased. Although conservation measures have proved highly effective we recommend the maintenance of the monitoring and evidence-based management of the Storm Petrel breeding population.

1. Introduction

Coastal, island and marine ecosystems have been largely modified during the last centuries by habitat destruction, introduction of alien species, pollution, over-exploitation and climate change, jeopardizing the conservation of their biodiversity (Millennium Ecosystem Assessment, 2005). Nowadays, the loss of species is of major concern and the implementation of effective management actions designed to restore habitats and enhance the conservation status of endangered species is urgently needed (Pullin et al., 2004).

Procellariiform (albatrosses, shearwaters and petrels) populations have experienced substantial declines, being one of the most threatened animal taxa (Bird Life International, 2000; Butchart et al., 2004). The introduction of alien mammalian species on islands (Martin et al., 2000); the incidental mortality in fisheries, especially in longlining (Lewison et al., 2004); and the loss or deterioration of breeding habitat (Cadiou et al., 2010) are their most important threats. Conservation actions developed to recover Procellariiform populations are usually carried out on breeding grounds and include the eradication of predators and the improvement of nesting habitat (Carlile et al., 2003; Sanz-Aguilar et al., 2009a). In fact, conservation actions on breeding grounds are easier to implement and less expensive than at sea (Wilcox and Donland, 2007); and can be highly effective for small species that are not at risk of bycatch (Baker et al., 2002; Sanz-Aguilar et al., 2009a).

The Mediterranean Storm Petrel (*Hydrobates pelagicus melitensis*) is one of the smallest Procellariiform species (Warham, 1990). Major threats of Storm Petrels in their current breeding colonies are predation of adults by syntopic bird species as gulls (Sanz-Aguilar et al., 2009a) and habitat deterioration (Cadiou et al., 2010). Their current populations are confined to rat-free sites, which remain scarce among Mediterranean islands (Ruffino et al., 2009). In order to increase the availability of suitable breeding sites, nest boxes have been installed in several Storm Petrel colonies (De León and Mínguez, 2003; Bolton et al., 2004; own data).

The provision of nest boxes is a common management tool for the monitoring and conservation of different bird species, including seabirds, waterfowls, passerines, parrots or raptors (Bolton et al., 2004; Corrigan et al., 2011). Several studies have shown a positive growth of population density following the increase of available nesting habitat provided by nest boxes (Corrigan et al., 2011). The growth of a population can be a consequence of an increase of individual productivity, recruitment or survival (Caswell, 2001). Breeding success of birds using nest boxes has been shown to be higher than that of those breeding in natural sites, mainly due to protection from predators (Møller, 1989), reduction in egg damage and inter- or intraspecific interferences (Bolton et al.,

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2004). Nest boxes also improved recruitment (Lalas et al., 1999) but their impact on survival remains unknown. Nest boxes can improve survival by protecting individuals from predators (De León and Mínguez, 2003). However, nest boxes can also have undesirable and unexpected effects acting as 'ecological traps' (Mänd et al., 2005; Klein et al., 2007): allowing supra-optimal breeding density or even increasing attractiveness of predators (Sanz et al., 2003; Mänd et al., 2005).

The aim of this study was to evaluate the long-term effectiveness of provisioning nest boxes for the conservation of Mediterranean Storm Petrel at Benidorm Island (Spain). To do so, we estimated and compared the demographic parameters (breeding success and local survival) of birds breeding in natural sites and nest boxes, and analyze their local population trends.

2. Methods

2.1. Species and study area

The Mediterranean Storm Petrel is a small (28 g) and long-lived vulnerable pelagic seabird (Mínguez, 2004). They are single egg layers with an extended breeding period (Mínguez, 1994). At their breeding colonies, Storm Petrels return to land only during the hours of darkness (Warham, 1990).

The study was conducted from 1993 to 2010 at Benidorm Island (6.5 ha; 38°30′N, 0°08′E), a Special Protection Area for the conservation of the Storm Petrel in the Mediterranean coast of Spain. At Benidorm Island petrels concentrate at high densities in two caves, cave 1 and cave 2, where more than 200 and 100 pairs respectively breed under boulders and in crevices (Mínguez, 1994). Here, their main threat is predation by specialized individuals of Yellow-legged Gulls, *Larus michahellis* (Sanz-Aguilar et al., 2009a). Since 2004, individual breeding gulls identified as predators are selectively culled (Sanz-Aguilar et al., 2009a).

Since 1993 in cave 1 and 1994 in cave 2 breeding adults have been captured in their nests and marked with stainless steel bands. Breeding birds are captured only once each breeding season (Sanz-Aguilar et al., 2008). Additionally, from 1993 to 2007 every nest found at the colonies was monitored by weekly to 15 days visits during the whole breeding period (April to September) to study nest occupancy and breeding success. From 2008 to nowadays nest monitoring effort has been reduced by excluding some nests from the monitoring, namely those in which adults have never been captured. Nests were considered as occupied if an adult bird was found incubating in at least one of the visits. Chicks were considered to fledge if they were at least 35 days old when observed last time. Breeding success was estimated as the proportion of chicks fledged in relation to the number of eggs laid (Sanz-Aguilar et al., 2008).

In November 1996, 87 nest boxes were installed, 45 in cave 1 and 42 in cave 2 (see details on nest boxes design in Appendix A). Only those nest boxes placed in cave 2 have shown high occupancy levels during the study period (Fig. 1) (De León and Mínguez, 2003).

2.2. Estimation of demographic parameters

Given the low occupancy rates of nest boxes at cave 1 (maximum of 6 occupied since 2008), we only considered data on cave 2 to estimate the potential differences in recapture, survival, dispersal to a new nest type and reproductive rates between individuals nesting in natural nests and nest boxes.

Survival, recapture and transition (i.e. change of nest type) probabilities were estimated simultaneously by means of multistate capture–recapture models (Lebreton et al., 2009) using data from 388 breeding adults marked between 1994 and 2010 at cave 2. Capture–recapture analysis began by the assessment of the goodness-of-fit (GOF) of a general model to the data (Pradel et al., 2003). Multistate GOF tests were performed using program U-CARE 2.3.2 (Choquet et al., 2009b). We found both a transient effect (3G.SR test: $\chi^2 = 42.2$, d.f. = 23, $p = 0.009$) and a trap-dependence effect (M.ITEC test: $\chi^2 = 29.04$, d.f. = 8, $p = 0.000$) (see Section 3). Consequently, we built models including a "transient effect" (models with two relative age-classes for survival parameters: one for newly marked individuals and another for confirmed resident birds, see details in Pradel et al., 1997) and a "trap-dependence effect" (we considered specific recapture parameters for individuals previously captured at $t-1$ and birds non-captured on the previous capture occasion as detailed in Pradel and Sanz-Aguilar, 2012). The overall goodness-of-fit test for the model incorporating the transient and the trap-dependence effects was not statistically significant ($\chi^2 = 25.04$, d.f. = 31, $p = 0.766$). We tested the effects of time and nest type on survival, recapture and transition between nest type probabilities. Models were built and fit to the data using program E-SURGE 1.6.3 (Choquet et al., 2009a). Model selection was based on Akaike's Information Criterion adjusted for the effective sample size (AICc, Burnham and Anderson, 2002). In addition, for each model j, we calculated the Akaike weight, w_j, as an index of its relative plausibility (Burnham and Anderson, 2002). Estimates were obtained by model averaging in which each model contributed to the final estimate according to its w_j (Burnham and Anderson, 2002).

Breeding success was modeled as a binary variable (1 = successful, 0 = unsuccessful) using generalized linear mixed models with a logit-link function and binomial error distribution (McCulloch and Searle, 2001). We tested the effects of time and nest type on breeding success. Analyses were conducted with the R software (http://www.R-project.org/) using the "lmer" function (package "lme4") in which "year" (14 levels) and "nest type" (2 levels) were considered as fixed terms and the nest identity treated as a random term. Model selection was based on AIC.

3. Results

3.1. Survival, recapture and change of nest type probabilities

A general model, including the effects of time and nest type on survival and recapture and the effect of nest type on transition probabilities was the starting point for the analyses (Model 1, Table B1 – Appendix B). We began model selection by testing the effects of time and nest type on recapture probabilities (Models 1–4, Table B1 – Appendix B). The best model in terms of AICc included both effects (Model 1, Table B1 – Appendix B). Then we tested the effects of time and nest type on survival of newly marked and confirmed resident birds simultaneously (Models 1, 5–7, Table B1 – Appendix B). A model including the effect of nest type on survival (Model 5, Table B1 – Appendix B) had the lowest AICc. Finally, we tested if change of nest type probability was dependent (Model 5, Table B1 – Appendix B) or independent on nest type of departure, i.e. constant (Model 8, Table B1 – Appendix B). This last model (Model 8, Table B1 – Appendix B) was the best in terms of AICc, and assumed a nest type effect on survival, a time and nest type effects on recapture probability, and a constant transition probability between natural and artificial nests. However, this model was tied in terms of AIC with Model 5 (Table B1 – Appendix B). Therefore, we resorted to model averaging of Models 5 and 8 resulting in survival estimates of 0.82 (95% CI = 0.78–0.86) and 0.89 (95% CI = 0.86–0.92) for resident birds breeding in natural and in nest boxes, respectively. Newly marked birds breeding at natural sites and nest boxes showed a local survival of 0.66 (95% CI = 0.59–0.72) and 0.78 (95% CI = 0.71–0.83), respectively. Transition

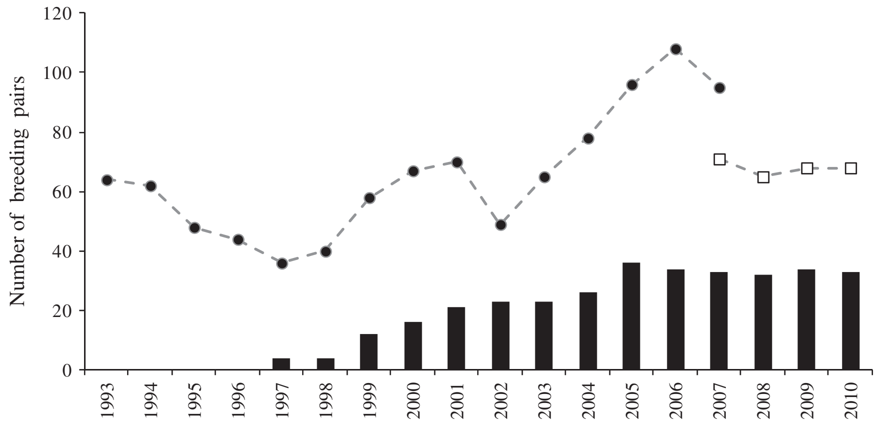

Fig. 1. Annual number of nests occupied by breeding Storm Petrels observed in cave 2 of Benidorm Island from 1993 to 2010 (dots and squares). The two values for 2007 indicate the breeding pairs observed under the full (black dots) and the reduced (white squares) monitoring protocol established since 2008. Black bars indicate the number of artificial nest boxes occupied (the number of nest boxes available was 42 and were installed before the breeding season of 1997).

probability from natural nests to nest boxes was 0.006 (95% CI = 0.003–0.02), and from nest boxes to natural nests 0.004 (95% CI = 0.0004–0.018). Mean recapture probabilities at natural nests were 0.74 (95% CI = 0.69–0.79) and 0.36 (95% CI = 0.25–0.47) for individuals captured and not captured in the previous occasion respectively (Model 9, Table B1 – Appendix B). Recapture probabilities of individuals breeding in nest boxes were higher: 0.96 (95% CI = 0.76–0.99) and 0.90 (95% CI = 0.86–0.93) for the two trap-dependence types of individuals (Model 9, Table B1 – Appendix B).

3.2. Breeding success probabilities

Model selection began with the most complex model, which included the effects of nest type, time and their statistical interaction (Model 1, Table B2 – Appendix B). Although no simpler model (Models 2–5, Table B2 – Appendix B) improved over Model 1 in terms of AIC, we note that the model including only the effect of nest type (Model 3, Table B2 – Appendix B) was better than the model including only a temporal variation (Model 4, Table B2 – Appendix B). Mean breeding success in natural nests was significantly lower than in nest boxes, 0.53 (SE = 0.07) and 0.72 (SE = 0.08) respectively (Model 3, Table B2 – Appendix B).

3.3. Artificial nest-boxes occupancy and population growth

Nest boxes occupancy increased between 1997 and 2005, reaching a maximum of occupancy in 2005 (36 nest boxes occupied, Fig. 1). Between 2005 and 2010, the number of nest boxes occupied in cave 2 was relatively stable (Fig. 1).

At the beginning of the study, in 1993, 64 breeding pairs were detected at cave 2 (Fig. 1). This number decreased to 36 pairs in 1997 (Fig. 1). Since 1997 (when nest boxes were available for the first time), the number of occupied nests increased up to 108 nests in 2006 (observed population growth rate $\lambda = 1.100$; 95% CI = 1.061–1.141, Fig. 1). During the last years (2007–2010) the number of observed breeding pairs was fairly stable (Fig. 1). Colony growth rate has been positive from the installation of the nest boxes except in 2002 and 2007 (Fig. 1). The estimates of population growth rate based on demographic parameters of birds breeding at natural nests and nest boxes were $\lambda = 0.895$; 95% CI = 0.797–0.992 and $\lambda = 0.982$; 95% CI = 0.927–1.037, respectively (Appendix C).

4. Discussion

Like most seabirds, Storm Petrels spend more than 90% of their life at sea (Warham, 1990). Storm Petrels are one of the smallest seabird species, and one of the few species that is not at risk of bycatch (Baker et al., 2002). Consequently, management actions developed at their breeding colonies, like predator removal or habitat amelioration, have been proved to be highly effective (Carlile et al., 2003; Bried et al., 2009; Sanz-Aguilar et al., 2009a). At Benidorm Island, the main threat for the Storm Petrel is the Yellow-legged Gull (Sanz-Aguilar et al., 2009a). Originally, nest boxes were installed to improve habitat availability and increase breeding success and breeding numbers (De León and Mínguez, 2003). However, our results reveal that nest boxes can additionally improve adult survival.

In accordance with our results, breeding success of individuals breeding in artificial nests has been found to be higher than in natural sites in several seabird species (e.g. Byrd et al., 1983; Wilson, 1986; Priddel and Carlile, 1995; Bolton et al., 2004; Bried et al., 2009; Sherley et al., 2012; but see Thayer et al., 2000). Storm Petrel breeding success can be affected by factors such as intraspecific disturbance (e.g. egg damage by adults trampling, see Warham, 1990), habitat features (e.g. egg damage caused by small stones that stand out from the walls of the cave and occasionally fall, Bolton et al., 2004), predation (Sanz-Aguilar et al., 2009a) and/or individual characteristics (e.g. age and breeding experience, Sanz-Aguilar et al., 2008, 2009b). During the study period we have detected very few movements from natural nests to nest boxes. Consequently, we think that the majority of birds that settled in the artificial sites were probably prospector individuals breeding for the first time (De León and Mínguez, 2003). As breeding success increases with age and experience (Sanz-Aguilar et al., 2008, 2009b) and birds breeding in natural nests were presumably older and more experienced, the higher breeding success of individuals breeding in nest boxes may respond to the nesting habitat features (De León and Mínguez, 2003; Bolton et al., 2004).

Survival rates of Storm Petrels breeding at Benidorm Island are mainly affected by predatory pressure of gulls (Sanz-Aguilar et al., 2009a) but also individual factors such as age and breeding experience influence survival (Sanz-Aguilar et al., 2008, 2009b). Again, if predation levels were similar in the two nest types, survival of birds breeding in natural nests should be higher because they are probably older and more experienced than individuals breeding in nest boxes. However, we observed the contrary, suggesting that birds breeding in nest boxes are better protected from gull predation. In fact, survival of birds breeding in nest-boxes was very similar to those found in other colonies (0.86–0.90) where predation is lower (Scott, 1970; Insley et al., 2002; Sanz-Aguilar et al., 2009b). This suggests that monitoring of marked individuals might be a useful guide to whether provision of nest boxes might be beneficial in terms of improving adult survival. Although probabilities of transition between nest types were extremely low, our results suggest a positive selection of nest boxes by individuals changing their previous nest. Recapture probability of Storm Petrels breeding in artificial nest-boxes was higher than that of individuals breeding in natural nests because artificial nests are easier to monitor (pers. obs.).

The occupancy rate of artificial nest boxes varied between colonies, probably due to differences in the availability of natural nests (De León and Mínguez, 2003). In contrast to cave 1 (a large cave with high amounts of boulders), cave 2 has few protected natural cavities available for breeding (pers. obs.). This fact may render birds breeding in cave 2 particularly vulnerable to predators and could explain the high success of nest boxes. Breeding numbers in this colony had a worrying tendency to decrease prior to the installation of nest boxes, in accordance with the estimated negative population growth rate for natural nests. The estimate of population growth rate for nest boxes parameters was around 1, i.e. a stable population. However, both estimates of population growth rate are lower than the observed positive growth rate of the colony since 1997. This could be explained by an underestimation of prebreeder survival, a parameter extremely difficult to estimate (Sanz-Aguilar et al., 2009b) or by a recruitment of birds born in other colonies. The high levels of nest box occupation and the substantial increase of breeding pairs observed since 1997 suggest that habitat availability was a limiting factor for Storm Petrels there. In addition, the culling program of adult predatory gulls implemented since 2004 (Sanz-Aguilar et al., 2009a) could also have favored the substantial increase in Storm Petrel population numbers occurred during 2005–2006. The drops in the observed number of breeding pairs in cave 2 observed since 1997 were probably related to stochastic predatory events by juvenile gulls that are not selectively culled (Sanz-Aguilar et al., 2009a).

In conclusion, we have demonstrated that recapture, breeding success, adult survival and population numbers of a vulnerable seabird species can be locally enhanced by providing artificial nest boxes, which can be viewed as a conservation success. Nest boxes can be highly beneficial for the conservation of this species, especially in those colonies where nest are not protected from predators. However, we would like to point out the importance of caution when extrapolating estimates on demographic parameters obtained by nest box monitoring studies to a whole population (Møller, 1989). In addition, given the high density of petrels reached at the small cave 2 after the installation of nest boxes, we consider that the monitoring of this population must continue in order to detect future potential problems linked to denso-dependence processes (e.g. predator attraction, food limitation or diseases, Møller, 1989; Mänd et al., 2005). This study is an example of evaluation of conservation measures, which ideally should be part of any conservation plan, in order to produce information on which conservation managers can base their decisions, and implement effective conservation plans, maximizing the financial, human and logistical resources (Pullin et al., 2004).

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Appendices A–C. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2012.05.020.

References

Baker, G.B., Gales, R., Hamilton, S., Wilkinson, V., 2002. Albatrosses and petrels in Australia: a review of their conservation and management. Emu 102, 71–97.

Bird Life International, 2000. IUCN Red List of Threatened Species. IUCN Gland, Switzerland and Cambridge, UK.

Bolton, M., Medeiros, R., Hothersall, B., Campos, A., 2004. The use of artificial breeding chambers as a conservation measure for cavity-nesting Procellariiform seabirds: a case study of the Madeiran Storm Petrel (*Oceanodroma castro*). Biol. Conserv. 116, 73–80.

Bried, J., Magalhães, M.C., Bolton, M., Neves, V.C., Bell, E., Pereira, J.C., Aguiar, L., Monteiro, L.R., Santos, R.S., 2009. Seabird habitat restoration on Praia Islet, Azores archipelago. Ecol. Restor. 27, 27–36.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference a Practical Information–Theoretic Approach, second ed. Springer, New York.

Butchart, S.H.M., Stattersfield, A.J.L., Bennun, A., Shutes, S.M., Akcakaya, H.R., Baillie, J.E.M., Stuart, S.N., Hilton-Taylor, C., Mace, G.M., 2004. Measuring global trends in the status of biodiversity: red list indices for birds. PLoS Biol. 2, 2294–2304.

Byrd, G.V., Moriarty, D.I., Brady, B.G., 1983. Breeding biology of the wedge-tailed shearwaters at Kilauea Point, Hawaii. Condor 85, 292–296.

Cadiou, B., Bioret, F., Chenesseau, D., 2010. Response of breeding European Storm Petrels *Hydrobates pelagicus* to habitat change. J. Ornithol. 151, 317–327.

Carlile, N., Priddel, D., Zino, F., Natividad, C., Wingate, D.B., 2003. A review of four successful recovery programmes for threatened sub-tropical petrels. Mar. Ornithol. 31, 185–192.

Caswell, H., 2001. Matrix Population Models. Sinauer Associates, Sunderland.

Choquet, R., Lebreton, J.D., Gimenez, O., Reboulet, A.M., Pradel, R., 2009a. U-care: utilities for performing goodness of fit tests and manipulating capture–recapture data. Ecography 32, 1071–1074.

Choquet, R., Rouan, L., Pradel, R., 2009b. Program E-Surge: a software application for fitting multievents models. In: Cooch, E., Conroy, M., Thomson, D. (Eds.), Modeling Demographic Processes in Marked Populations. Springer, Berlin, pp. 845–865.

Corrigan, R.M., Scrimgeour, G.J., Paszkowski, C., 2011. Nest boxes facilitate local-scale conservation of common goldeneye (*Bucephala clangula*) and bufflehead (*Bucephala albeola*) in Alberta, Canada. Avian Conserv. Ecol. 6, 1.

De León, A., Mínguez, E., 2003. Occupancy rates and nesting success of European Storm Petrels breeding inside artificial nest-boxes. Sci. Mar. 67, 109–112.

Insley, H., Hounsome, M., Mayhew, P., Chisholm, K., 2002. A preliminary comparison of population estimation by tape response and mark/recapture methods for Storm Petrels *Hydrobates pelagicus* in two contrasting Scottish colonies. Ring. Migr. 21, 75–79.

Klein, Á., Nagy, T., Csörgő, T., Mátics, R., 2007. Exterior nest boxes may negatively affect Barn Owl *Tyto alba* survival: an ecological trap. Bird Conserv. Int. 17, 273–281.

Lalas, C., Jones, P.R., Jones, J., 1999. The design and use of a nest box for Yellow-eyed Penguins *Megadyptes antipodes* – a response to a conservation need. Mar. Ornithol. 27, 199–204.

Lebreton, J.D., Nichols, J.D., Barker, R.J., Pradel, R., Spendelow, J.A., 2009. Modeling individual animal histories with multistate capture–recapture models. Adv. Ecol. Res. 41, 87–173.

Lewison, R.L., Crowder, L.B., Read, A.J., Freeman, S.A., 2004. Understanding impacts of fisheries bycatch on marine mega fauna. Trends Ecol. Evol. 19, 598–604.

Mänd, R., Tilgar, V., Lõhmus, A., Leivits, A., 2005. Providing nest boxes for hole-nesting birds—does habitat matter? Biodivers. Conserv. 14, 1823–1840.

Martin, J.L., Thibault, J.C., Bretagnolle, V., 2000. Black rats, island characteristics, and colonial nesting birds in the Mediterranean: consequences of an ancient introduction. Conserv. Biol. 14, 1452–1466.

McCulloch, C.E., Searle, S.R., 2001. Generalized, Linear, and Mixed Models. Wiley, New York.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Mínguez, E., 1994. Censo, cronología de puesta y éxito reproductor del paíño común (*Hydrobates pelagicus*) en la Isla de Benidorm (Alicante E de España). Ardeola 41, 3–11.

Mínguez, E., 2004. Paíño Europeo, *Hydrobates pelagicus*. In: Madroño, A., González, C., Atienza, J.C., (Eds.), Libro Rojo de las Aves de España. Dirección General para la Biodiversidad–SEO/BirdLife, Spain, pp. 55–57.

Møller, A.P., 1989. Parasites, predators and nest boxes: facts and artefacts in nest box studies of birds? Oikos 56, 421–423.

Pradel, R., Sanz-Aguilar, A., 2012. Modeling trap-awareness and related phenomena in capture–recapture studies. PLoS One 7 (3), e32666. http://dx.doi.org/10.1371/journal.pone.0032666.

Pradel, R., Hines, J.E., Lebreton, J.D., Nichols, J.D., 1997. Capture–recapture survival models taking account of transients. Biometrics 53, 60–72.

Pradel, R., Wintrebert, C.M.A., Gimenez, O., 2003. A proposal for a goodness-of-fit test to the Arnason–Schwarz multisite capture–recapture model. Biometrics 59, 43–53.

Priddel, D., Carlile, N., 1995. An artificial nest box for burrow-nesting seabirds. Emu 95, 290–294.

Pullin, A.S., Knight, T.M., Stone, D.A., Charman, K., 2004. Do conservation managers use scientific evidence to support their decision-making? Biol. Conserv. 119, 245–252.

Ruffino, L., Bourgeois, K., Vidal, E., Duhem, C., Paracuellos, M., Escribano, F., Sposimo, P., Baccetti, N., Pascal, M., Oro, D., 2009. Invasive rats and seabirds after 2000 years of an unwanted coexistence on Mediterranean islands. Biol. Invasions 11, 1631–1651.

Sanz, V., Rodríguez-Ferraro, A., Albornoz, M., Bertsch, C., 2003. Use of artificial nests by the Yellow-shouldered Parrot (*Amazona barbadensis*). Ornitol. Neotrop. 14, 345–351.

Sanz-Aguilar, A., Tavecchia, G., Pradel, R., Mínguez, E., Oro, D., 2008. The cost of reproduction and experience-dependent vital rates in a small petrel. Ecology 89, 3195–3203.

Sanz-Aguilar, A., Martínez-Abraín, A., Tavecchia, G., Mínguez, E., Oro, D., 2009a. Evidence-based culling of a facultative predator: efficacy and efficiency components. Biol. Conserv. 142, 424–431.

Sanz-Aguilar, A., Massa, B., Lo Valvo, F., Oro, D., Mínguez, E., Tavecchia, G., 2009b. Contrasting age-specific recruitment and survival at different spatial scales: a case study with the European Storm Petrel. Ecography 32, 637–646.

Scott, D.A., 1970. The Breeding Biology of the Storm Petrel. Ph.D. Thesis. University of Oxford, UK.

Sherley, R.B., Barham, B.J., Barham, P.J., Leshoro, T.M., Underhill, L.G., 2012. Artificial nests enhance the breeding productivity of African Penguins (*Spheniscus demersus*) on Robben Island, South Africa. Emu. http://dx.doi.org/10.1071/MU11055.

Thayer, J.A., Hester, M.M., Sydeman, W.J., 2000. Conservation biology of rhinoceros auklets, Cerorhinca monocerata, on Año Nuevo Island, California, 1993–1999. Endanger. Species Update 17, 63–67.

Warham, J., 1990. The Petrels Their Ecology and Breeding Systems. Academic Press, London.

Wilcox, C., Donland, J., 2007. Compensatory mitigation as a solution to fisheries bycatch-biodiversity conservation conflicts. Front. Ecol. Environ. 5, 325–331.

Wilson, U.W., 1986. Artificial rhinoceros auklet burrows: a useful tool for management and research. J. Field Ornithol. 57, 295–299.