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Conservation of the Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* at Benidorm Island (Spain)

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Summary: The effectiveness of the management actions developed at Benidorm Island (western Mediterranean) for the conservation of the Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* are revised. Plastic nest-boxes were installed inside two caves where Storm-petrels bred in 1996 and individuals of Yellow-legged Gulls (a predator of Storm-petrels) have been selectively culled in 2004, 2005, 2006, 2010 and 2011. Conservation actions implemented at Benidorm Island have been highly effective at increasing Storm-petrel breeding success, survival and breeding numbers.

Key Words: Mediterranean Storm-petrel, *Hydrobates pelagicus melitensis*, conservation action, nest-box, breeding success, survival.

Introduction

The European Storm-petrel *Hydrobates pelagicus* is one of the smallest long-lived procellariiform seabirds (average body mass 28g, Warham 1990). There is no particular concern for the status of the species worldwide, but the Mediterranean subspecies *H. p. melitensis* is considered vulnerable. Populations of this subspecies are confined to sites free of invasive rats (De Leon *et al.* 2006), which remain scarce among Mediterranean islands (Ruffino *et al.* 2009). Storm-petrels lay a single egg in natural borrows, under boulders or in crevices. Incubation last about 40 days and chick rearing takes about 63-70 days (Warham 1990, Mínguez 1996 and 1998). They are pelagic and return to land at night only to breed or to prospect potential breeding colonies (Warham 1990). Their behaviour and nesting habitat make its populations very difficult to monitor (Mitchell & Newton 2000, Sanz-Aguilar *et al.* 2010) and insights in their population dynamics are usually achieved through the analysis of life-histories of individually marked birds (Tavecchia *et al.* 2008, Sanz-Aguilar *et al.* 2008, 2009a-b and 2010). Major threats of Mediterranean Storm-petrels in their current breeding colonies are predation by sintopic bird species as gulls or raptors (Oro *et al.* 2005, Sanz-Aguilar *et al.* 2009a) and habitat deterioration (Cadiou *et al.* 2010). Monitoring of Mediterranean Storm-petrels, habitat management (installation of artificial nest boxes) and

selective culling of predatory Yellow-legged Gulls *Larus michahellis* have been carried out in recent years at Benidorm Island, a 6.5ha Special Protection Area off the Mediterranean coast of Spain (38º 30'N, 0º 08'E) (De León & Minguez 2003, Sanz-Aguilar *et al*. 2009a). Here we review the actual knowledge on the effectiveness of the management actions performed, in terms of predatory pressure, Storm-petrel survival, breeding success and evolution of breeding numbers.

Methods

Study area. At Benidorm Island, Mediterranean Storm-petrels breed under boulders and in crevices on cliffs but concentrate in two caves where they nest at high densities: Cave 1 contains over 200 breeding pairs, whereas Cave 2 is home to approximately 100 breeding pairs (Mínguez 1994). Previous studies have provided evidence that young individuals are highly philopatric and return to the cave they were born in; and that there are high levels of nesting-site fidelity in breeders; individuals start breeding at three years of age and reproduce annually, being rarely sabbaticals (Sanz-Aguilar *et al*. 2008 & 2009b). An average of 535 pairs of Yellow-legged Gulls (median = 515, range = 300-750) have bred annually at Benidorm during the study, with a mean population growth rate of 6% during 1993-2007 (95%CI = 1.04-1.09) (Sanz-Aguilar *et al*. 2009a). Gulls nest mostly on open ground but a few pairs breed in close proximity to the two major petrel colonies.

Storm-petrel monitoring. Breeding birds (n=1252) and chicks (n=1527) have been captured and recaptured (>4000 recaptures) at their nest sites since 1993 to 2011 and marked with stainless steel rings with a unique alphanumeric code. Each year, breeding birds were caught only once, during the incubation period. These individual data have been used to estimate survival and recruitment probabilities by means of capture-recapture models (Tavecchia *et al*. 2008, Oro *et al*. 2005, Sanz-Aguilar *et al*. 2008, 2009a,b and 2010, Libois *et al.* 2012). During the 19 years of the study, 435 different natural nests have been recorded, i.e. nests where reproduction (= egg laying) occurred at least in one breeding season. Each nest (both natural nests and nest boxes, see below) is inspected at least four times during the whole breeding period annually, to record occupancy, laying dates, hatching success, fledging success and breeding success. Chicks are considered to have fledged if they are at least 35 days when visited for the last time. Since 2008, the monitoring effort was reduced by removing 193 nests from the monitored sample. Data on Storm-petrel breeding success at Benidorm colonies has been analyzed using Generalized Linear Models (GLM, GLMM) (Tavecchia *et al*. 2008, Sanz-Aguilar *et al*. 2008 and 2009a,b, Libois *et al.* 2012).

Figure 1. Artificial nest-boxes for Mediterranean Storm-petrels placed in Cave 2, at Benidorm Island.

Nest boxes. In November 1996, 86 artificial nest boxes were installed in the Storm-petrel colonies (45 in Cave 1 and 42 in Cave 2) to increase the availability of suitable breeding sites (Figure 1, De León & Minguez 2003). The design of the artificial nest-boxes is straightforward, inexpensive

and endurable. It consists of a rectangular nesting chamber (25 x12 cm) accessed via a short tunnel (*c.*10cm). Nest-boxes were manufactured from plastic PVC containers. Each box was perforated to allow drainage as well as transpiration and body heat dissipation from its potential occupants. The entrance tunnel prevents predation of adults, eggs or chicks by gulls. Sand from the surroundings of the colonies was inserted into the boxes to provide an adequate substratum. In 2004, 22 nest boxes were removed from Cave 1 and moved to a neighboring island.

Year	Colony: Cave 1	Colony: Cave 2
2004	4	4
2005	2	1
2006	10	2
2010	3	0
2011	1	0

Table 1. Number of Yellow-legged Gulls removed from the vicinity of Mediterranean Storm-petrel colonies at Benidorm Island from 2004 to 2011.

Evaluation of predatory pressure and culling of specialist gulls. Mediterranean Storm-petrel predation by Yellow-legged Gull is assessed by the inspection of indigestible food items in pellets collected near gull nests around the Mediterranean Storm-petrel colonies, Cave 1 and Cave 2, since 2002 (see details in Oro *et al.* 2005). The minimum number of Mediterranean Storm-petrels killed by gulls is estimated as half the number of pellets containing petrel remains found, because gulls produce two pellets for every Storm-petrel eaten (Oro *et al.* 2005). 'Specialist' gulls are identified as those individuals in which territory (three meters around gull nests) more than one pellet with Storm-petrel remains is found (Oro *et al.* 2005). From 2004 to 2005 a total of 8 gulls breeding in territories identified as belonging to 'specialist' pairs were captured by means of nest traps placed on the nests (Table 1). All individuals were killed by an authorized wildlife agent through the injection of an excess sedative in jugular vein. In 2006, 2010 and 2011, 16 additional individuals were trapped on nests located close to the breeding colonies as a precautionary measure.

Results

Nest boxes: occupancy, breeding success and survival. Occupancy rate of nest boxes placed in Cave 1 has been very low. In Cave 2, occupancy rate increased gradually until 2005 and remained relatively stable until the end of the study period (Figure 2). A recent study has shown that mean breeding success and survival of birds breeding in natural nests at Cave 2 (0.53 and 0.82, respectively) was lower than in artificial nest boxes (0.78 and 0.89, respectively; Libois *et al.* 2012).

Culling of specialist gulls: predatory pressure, breeding success and survival. The number of pellets containing petrel remains found after the removal of specialist gulls in 2004-2005 was lower than in previous years at both colonies (Figure 3). In 2006 a group of juvenile gulls spent the night and preyed upon Mediterranean Storm-petrels in both colonies (direct observation, Figure 3). Some gull territories in Cave 1 from which adults were removed were reoccupied by other gulls during 2007 when culling was stopped. There was an apparent increase in predation rates following the reoccupation of gull territories during 2008-2009, but after removal of 4 gulls in 2010-2011 the number of preyed Storm-petrels decreased again (Figure 3). In Cave 2, with the exception of 2006, the predatory pressure has been relatively low (Figure 3). The selective removal of a few gulls in Cave 1 led to a reduction of *ca.* 65% in the number of Mediterranean

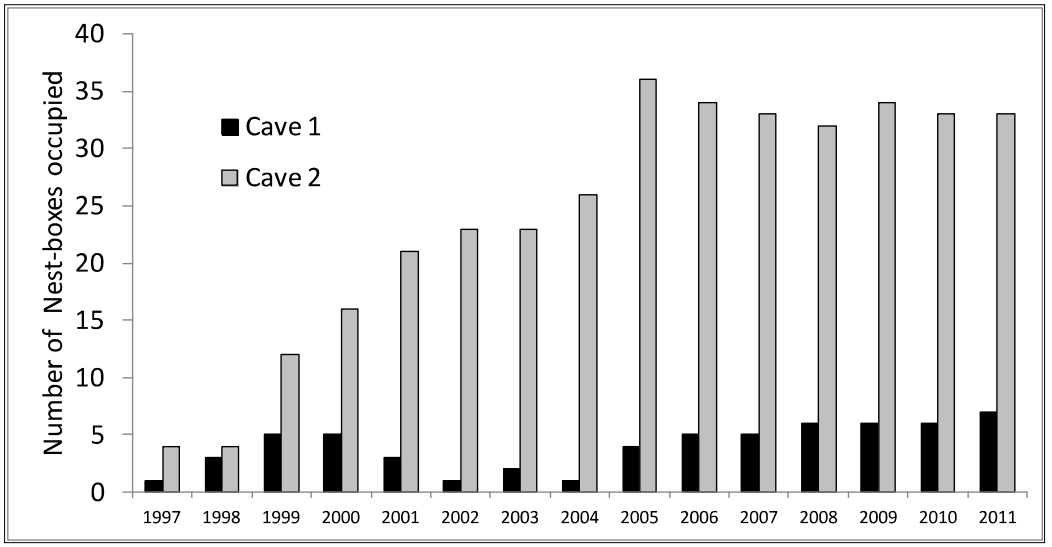

Figure 2. Annual number of artificial nest boxes occupied by breeding Mediterranean Storm-petrels in Caves 1 and 2, at Benidorm Island.

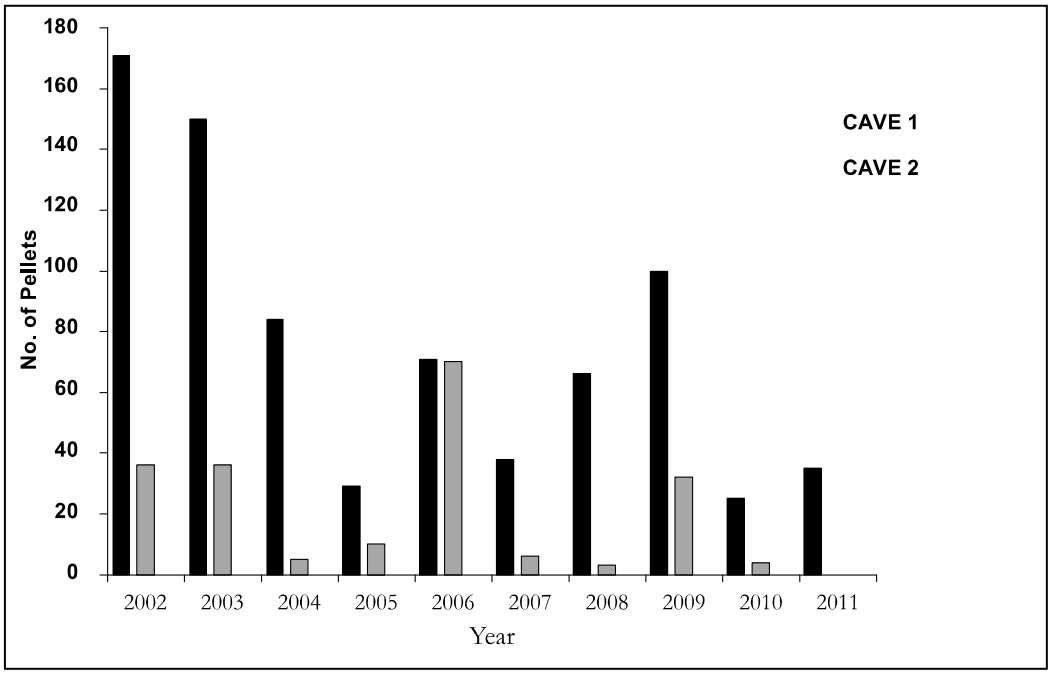

Figure 3. Annual number of Yellow-legged Gull pellets containing remains of Mediterranean Storm-petrels collected in Caves 1 and 2, at Benidorm Island.

Storm-petrels killed, and to a relative increase in their survival and breeding success probabilities, 16% and 23% respectively (Sanz-Aguilar *et al.* 2009a).

Evolution of observed breeding numbers. The number of observed breeding pairs decreased in both colonies during the first years of monitoring (Figures 4-5). In Cave 1, the number of breeding pairs began to increase following the culling of specialist gulls (Figure 4) but without reaching the 1993 level. In Cave 2, breeding numbers greatly increased after the installation of artificial nest-boxes and the culling of specialist gulls (Figure 4). During the last years, when monitoring effort has been reduced, breeding numbers remain relatively stable at both colonies (Figures 4-5).

Discussion

Conservation actions developed to recover Procellariiform populations are usually carried out on breeding grounds and include the eradication of predators (especially alien carnivores and rats) and the improvement of nesting habitat (De León & Mínguez 2003, Bried *et al.* 2009, Sanz-Aguilar *et al.* 2009a). The fact is that conservation actions are easier to implement on breeding grounds and less expensive than at sea (Wilcox & Donlands 2007), and can be highly effective for small species that are not at risk from fisheries bycatch (Baker *et al.* 2002, Igual *et al.* 2009, Sanz-Aguilar *et al.* 2009a). Accordingly, conservation actions implemented at Benidorm island have been highly effective at increasing Mediterranean Storm-petrel breeding success, survival and breeding numbers when the populations were declining.

Nest-boxes used at Benidorm are inexpensive and very endurable. Breeding success of Mediterranean Storm-petrels breeding in nest-boxes is higher than in natural nests, probably as a consequence of thermal conditions inside boxes, a reduction in egg damage caused by small stones on the nest floor puncturing the egg shell, and a reduction of intra- and inter-specific interferences (egg breakage due to trampling by the adults, adult-chick attacks, infanticides, gull predation, etc.; Warham 1990, De León *et al.* 2003, Bolton *et al.* 2004). In Cave 2, where most nest-boxes were occupied, high proportions of natural nests were exposed and vulnerable to predators. Probably, the lack of adequate breeding cavities in this cave limited breeding numbers before the installation of nest-boxes and was the determinant of the high proportions of nest-boxes occupation (De León *et al.* 2003). On the contrary, in Cave 1, there were high numbers of empty natural cavities suitable for nesting and occupancy rates of nest-boxes were low. As artificial nest-boxes protect breeding individuals from gull predation during incubation, survival of birds breeding in nest-boxes was higher than that of individuals breeding in natural nests. Monitoring of birds breeding in nest boxes is easier; however the extrapolation of parameters (survival and breeding success) estimated by the monitoring of nest boxes to the whole breeding population may be biased.

The selective removal of low numbers of gulls led to substantial reductions in the number of Mediterranean Storm-petrels killed, and to an increase in the survival and breeding success probabilities of individuals breeding in Cave 1. We have evidenced that only a few specialized predators (Oro *et al.* 2005) were responsible for the bulk of the impact on the Storm-petrel population and that the removal of those specialized individuals is an effective and efficient way to improve demographic parameters of Mediterranean Storm-petrels and recover their breeding

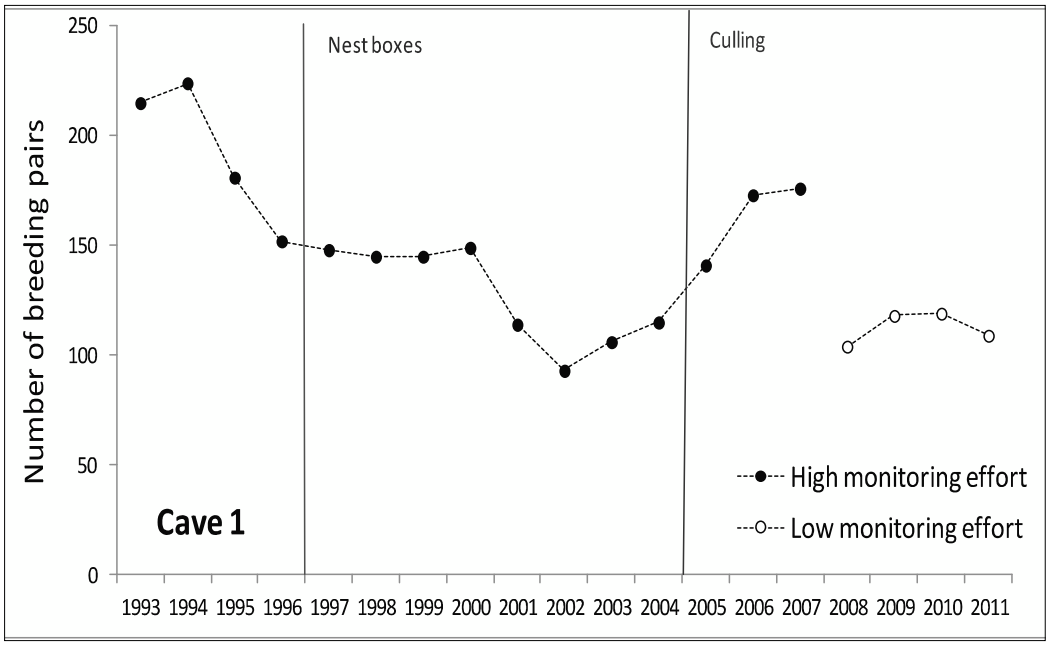

Figure 4. Number of breeding pairs of Mediterranean Storm-petrels observed annually in Cave 1 at Benidorm Island.

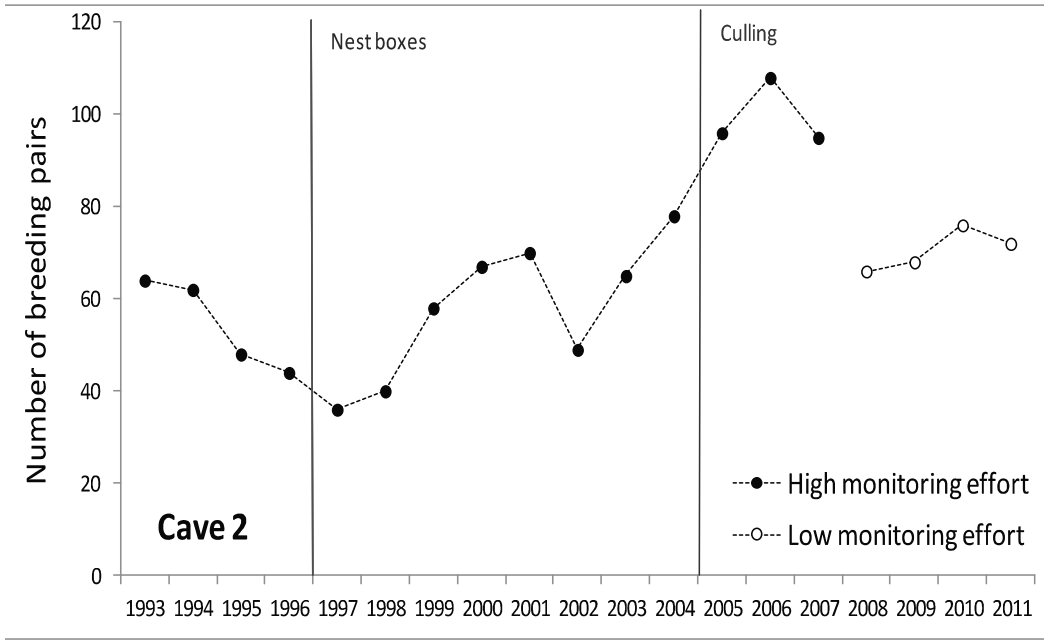

Figure 5. Number of breeding pairs of Mediterranean Storm-petrels observed annually in Cave 2 at Benidorm Island.

numbers. At Benidorm Island the high spatial concentration of breeding Mediterranean Storm-petrels in two caves facilitated the identification of specialized predators. Nevertheless, stochastic predation by juvenile gulls remains a problem to be solved.

In conclusion, management actions based on previous evidences developed at Benidorm island are easy to implement, inexpensive and highly effective for guaranteeing the conservation of Storm-petrels. We recommend that both the management actions (annual removal of predators and maintenance of nest boxes) and the evaluation of their efficacy should continue in the future.

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