Metal fence removal improved survival of a nocturnal seabird on Isla Natividad, Mexico

Yuri V. Albores-Barajas [1], Cecilia Soldatini [1]*, Alejandro Ramos-Rodriguez[1] & Giacomo Dell'Omo[2]

[1] *Unidad La Paz, Centro de Investigación Científica y de Educación Superior de Ensenada, Miraflores 334, La Paz, Baja California Sur, 23050, Mexico*

[2] *Ornis italica, Piazza Crati 15, 00199, Rome, Italy*

SUMMARY

The black-vented shearwater *Puffinus opisthomelas* is endemic to Mexico and is currently listed as Near Threatened by the IUCN Red List. Ninety-five percent of the world population of the species breeds on a single island in Mexico, Isla Natividad. In 2014 a metal fence was placed on the perimeter of the island landfill site to prevent wind-blown garbage dispersal. The fence was close to the black-vented shearwater colony and we found 116 shearwater carcasses during our first survey in the area. Using thermal cameras, we assessed the harm caused by the fence to the bird population as between six and seven birds/night. After discussion with local stakeholders the fence was removed in April 2016. Since then no more carcasses of black-vented shearwaters were found in the area. These results demonstrate that such structures can have dramatic effects on the survival of nocturnal seabirds and should be avoided, particularly in the vicinity of colonies. This was an example of positive collaboration with the local community and the application of research results to reserve management.

BACKGROUND

Many major threats to seabird populations are of human origin. Seabirds are particularly vulnerable to introduced predators (Towns *et al*. 2011), human disturbance (Burger & Gochfeld 1991, Beale & Monaghan 2004, Albores-Barajas *et al*. 2011), fisheries or other human activities (Sullivan *et al*. 2006, Wilcox *et al*. 2015, Fromant *et al*. 2016, Genovart *et al*. 2016) and man-made structures (Podolsky *et al*. 1998, Furness *et al*. 2012, Busch & Garthe 2016). All these factors can directly or indirectly increase adult mortality with a cascade effect at population level (Frederiksen *et al*. 2008). For seabirds, the effect can be even greater due to life-history traits such as low annual productivity, long reproductive cycles, delayed reproductive maturity and low adult mortality (Warham 1990).

The black-vented shearwater *Puffinus opisthomelas*, is a species endemic to Mexico. It is a burrow-nesting seabird which lays a single egg and exhibits the nocturnal behavior typical of nesting shearwaters. The bird is 30–38 cm in size, with a 76–89 cm wingspan (Keitt *et al*. 2000). Once considered a subspecies of the Manx shearwater *Puffinus puffinus* it is now recognized as a nominal species although the lineage polytomy is still unresolved (Austin *et al*. 2004). Colonies are distributed both on the Pacific and on the Gulf of California, but 95% of the world population breeds on Isla Natividad in Mexico, which is part of the El Vizcaino Biosphere Reserve. In the past, this population has suffered severe pressure from human activities and from introduced species, particularly feral cats (Keitt *et al*. 2002) As a consequence, the species is catalogued as Near Threatened by the IUCN Red List due to the restricted number of breeding sites, population declines caused by predation, and the uncertain impact of the fishing industry. Before cat eradication was carried out in 2000, the population on Natividad was estimated at 76,750 ± 18,411 (s.d.) pairs (Keitt *et al*. 2003). In the presence of cats, mortality was estimated at 1,000 individuals per month but after the cat eradication mortality fell to below 100 individuals/month in 2001 (Keitt *et al*. 2002).

* To whom correspondence should be addressed: csoldatini@cicese.mx

Since cats were removed in 2000, human pressure has decreased and as a consequence there were no known major threats to the birds on the island. In 2016 we visited Natividad Island and learned about the presence of a metal fence surrounding the landfill area on the north-eastern tip of the island. The fence was erected in 2014 and inhabitants noticed the frequent presence of dead black-vented shearwaters in the area. As a result of the concerns of local inhabitants and the biosphere reserve's personnel we monitored the effects of the fence on the nearby colony.

Our hypothesis was that the fence could represent a dangerous barrier for the birds flying in the darkness and could affect the portion of the colony immediately next to the landfill site. Therefore, we monitored nocturnal activity along the fence, to count the collisions and estimate the impacts on the shearwater colony in relation to the density of nests in the area.

ACTION

Study site: The study area is on Isla Natividad (27°51'25.6"N, 115°10'14.2"W), on the Pacific side of Baja California Sur, Mexico (Figure 1a). Black-vented shearwaters were present on the island from December, prospecting for nests and reinforcing pair bonds, before laying eggs from February to March and chick rearing until July (Keitt *et al*. 2000, Keitt *et al*. 2003).

Before fence removal - quantifying fence impact*:* On our first visit to the area (11 February 2016), we mapped the colony area close to the landfill (Figure 1b), and measured the three portions of the metal fence. The fence was 2.5 m high and was supported by 3 m high metal poles placed every 3 m. For convenience we named the three portions of the fence according to their position in reference to the landfill: "South" 162 m long, "Northeast" 120 m long and "East" 108 m long (Figure 1c). We initially collected and removed all carcasses found within a maximum distance of 20 m from the fence, recording their positions.

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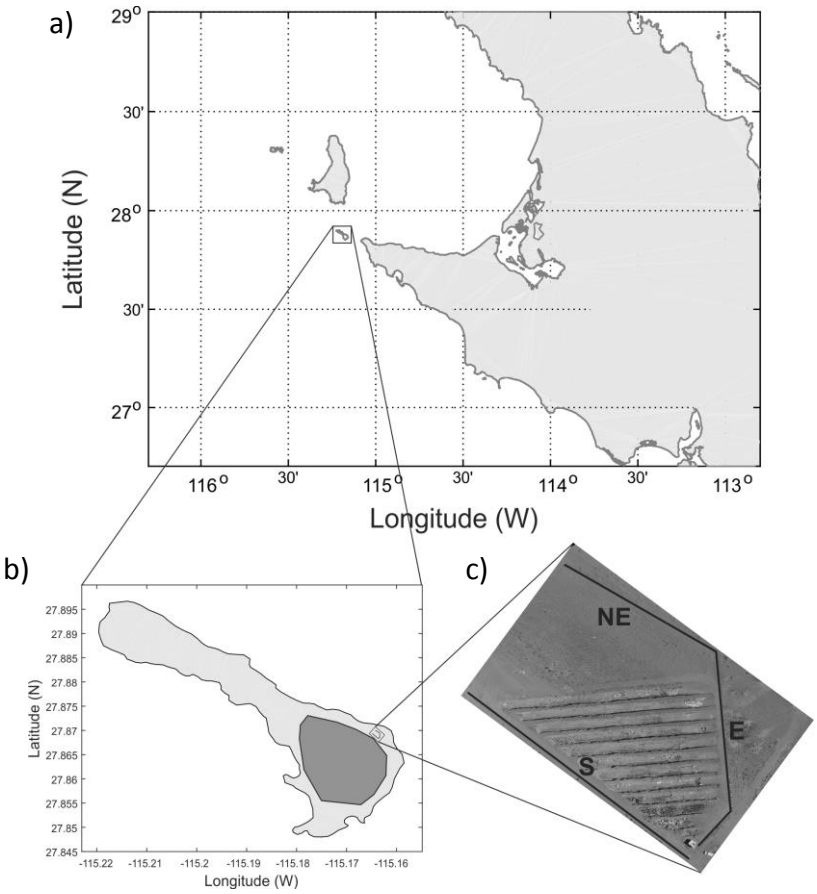

Figure 1. Map of Isla Natividad with details of the colony, landfill and metal fence positions. The black-vented shearwater colony is present in the southern part of the island (dark grey area in Figure 1b). The landfill is in the east part of the island and surrounded on three sides by metal fence (S for South, NE for Northeast, and N for North portions in Figure 1c).

The colony extends to the southeast of the South fence of the landfill, the other two sides of the fence are closer to the shore and more distant from the colony. We counted nests on the southern side of the South fence, by five people walking along five parallel straight transects, spaced 20 m apart. Each observer recorded the burrows within 10 m on either side of their transect. The total area covered was 16,200 m^2 (162 x 100 m). We did not systematically count nests on the east and north sides of the landfill because there were very few (fewer than 20 in total).

We estimated occupancy in the area during a later survey, as during winter and spring the dominant weather conditions were influenced by El Niño, which led to a delay in the breeding season. As a consequence, we conducted the occupancy survey in April, during peak laying activity (Keitt *et al*. 2003). We placed upright toothpicks in the entrance of 309 burrows, and revisited the nests the following day to count the proportion of burrows where the toothpicks were knocked over during the night. These were then assumed to be occupied by shearwaters.

We visited the area in the early morning before dawn (05:00-06:44 h) on 13 February 2016 to observe birds' movements. Before carrying out observations we removed the carcasses from the previous day (12 February). To detect and record the events of collision with the fence we used a thermal camera (FLIR Vue, 13 mm lens, 640x512 resolution). The resolution of the thermal camera allowed us to detect small mice at a distance of 50 m. With this thermal camera we could observe the entire length of the South fence and the individuals flying over it or colliding with it. We inspected each bird after impact with the fence, with the assistance of a veterinarian, then left them in the original position and observed subsequent events, such as recovery, death or attacks from ravens.

After fence removal - verifying measure effectiveness*:* The fence was removed by personnel of the Cooperativa Buzos y Pescadores at the beginning of our second survey on the island on 20 April 2016. We visited the landfill area eight times at dawn between the end of April and the first half of May 2016, after the fence removal, to observe birds' movements and count carcasses.

Table 1. Number of black-vented shearwater carcasses (other species in brackets) counted in surveys of each fence portion (S - south, NE - northeast, N – north, Figure 1c), before and after the removal of a metal fence.

	Survey date	S (162 m)	NE (120 m)	E (108 m)	Buffer zone
Before	11 Feb	100 (4)	8	8	3
	12 Feb	2	2	2	0
	13 Feb	7	0	0	0
After	21 Apr	0	0	0	0
	22 Apr	0	0	0	0
	24 Apr	0	0	0	0
	26 Apr	0	0	0	0
	28 Apr	0	0	0	0
	29 Apr	0	0	0	0
	30 Apr	0	0	0	0
	01 May	0	0	0	0

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Figure 2. Carcasses collected during our first survey at the landfill on 11 February 2016.

CONSEQUENCES

In our first visit to the landfill area (11 February 2016) we collected carcasses or parts of carcasses which could be attributed to 116 shearwaters (Figure 2, Table 1). There might have been some underestimation, as we tried to pair wings to make individuals, but in some cases could not match the parts dispersed by scavengers. In detail, we collected 100, eight and eight carcasses along the South, East and Northeast fences respectively. In addition to shearwater carcasses we found parts of one peregrine falcon *Falco peregrinus*, one western gull *Larus occidentalis*, one Cassin's auklet *Ptychoramphus aleuticus*, and one wader (unidentified species). We removed all carcasses from the area. We observed the presence of 16 common ravens *Corvus corax* in the area. They usually roost on rocks uphill of the landfill. Their use of the roost as an observation point on the landfill was evidenced by the presence of abundant faeces close to highest rocks. They were probably attracted to the area in the early morning by the presence of wounded or dead birds in addition to the landfill.

On the South fence transect 417 burrows were counted, equivalent to a density of 0.03 nests/m^2. This figure is representative of the whole colony, defined as 0.03 nests/m^2 by Keitt *et al*. (2000, 2003). The average burrow occupancy in the area during the laying period was 80%, estimated by tooth pick observation (Albores *et al*. in prep.).

There was no moon during the survey of bird movements on 13 February and individuals waited until the last opportunity before dawn to leave the colony in complete darkness. Using a thermal camera we observed the peak of birds leaving the colony 30 minutes before sunrise, although we observed birds flying during the whole survey. The direction of flight was from the colony to the sea, perpendicular to the fence, and most birds flew above the fence. We also observed birds arriving at faster speed from the uphill portion of the colony (at least 100 m to south of the fence) in comparison with birds from closer nests. We recorded a total of 16 impacts along the entire fence-line. Slower flying birds probably took off from nests closer to the fence, and these recovered rapidly after collision. Individuals flying at higher speed appeared to come from more distant nests, and these individuals often sustained serious injuries. At dawn, when seabird movements towards the ocean stopped, we recorded seven impact victims. Two birds died immediately as a consequence of the impact and five reported serious injuries incapacitating flight (fractured wing, eye loss, hip injured and loss of consciousness); in all these cases recovery was not possible because birds were predated by ravens at first daylight. In the same area we recorded two birds predated the day before our survey (12 February 2016), and we also collected four carcasses in the areas of the Northeast and East fences (two and two respectively) from the previous day. In total we recorded six carcasses of birds that hit the fence on 12 February, and seven dead/dying individuals on 13 February (Table 1). This figure may be higher, as ravens may move carcasses away from the area.

From our observations we may consider a representative increase in mortality due to the fence of between six and seven birds per night. Cautiously extrapolating this result on a monthly basis (30 days) we can estimate a potential average mortality due to the presence of the fence of 195 ± 15.25 (s.d.) individuals per month during the breeding season.

During our surveys after the fence removal we did not observe any carcasses of seabirds in the area (Table 1). At present there are no major threats posed by human presence for this species on the island. Thus shearwater mortality should thus be close to natural values estimated by Keitt and Tershy (2003) of 90-100 individuals per month.

DISCUSSION

The erection of the fence introduced a severe impact on the black-vented shearwater, causing a threefold increase in the mortality of the affected portion of the colony. Natural mortality was estimated at around 90-100 individuals per month (Keitt *et al*. 2002, Keitt & Tershy 2003). To this estimate we should add an estimated 195 ± 15.25 individuals per month in the landfill area as a result of the mortality introduced by the presence of the fence (assuming a constant mortality rate equal to that observed on one morning). Monthly predation rate by cats before 2000 was estimated at around 40.5 individuals per cat (Keitt *et al*. 2002, Keitt & Tershy 2003); as a consequence we may infer the impact of the fence was similar to that caused by the presence of five cats on the island. However, this figure could be higher still, as ravens may have moved away other carcasses.

Contrary to our hypothesis that the entire portion of the colony to the south of the landfill would be affected by the fence, we found that individuals from further uphill were more affected. This was because birds flying from higher and further nests arrived at a higher speed and impacted the fence more violently, with consequent serious injuries. Birds nesting closer to the landfill were flying more slowly just after take-off, and did not get injured when impacting; these birds were probably aware of the danger (likely having impacted previously). Such observations indicate that the presence of the fence was even more dangerous than initially supposed, as the portion of the colony close to the landfill is only a small part of the large black-vented shearwater colony present on the island, and the fence poses a serious danger to a significant part of it. For this reason we rapidly suggested to the local authorities and the reserve managers that the removal of the fence was a high priority, and they understood our concern and followed our advice.

The fence removal resulted in a drop of local mortality for the species, with a positive effect on the colony as a whole. Nonetheless predation pressure from ravens and gulls remains a problem that needs further assessment with special reference to ravens; the species arrived on the island following humans and is strongly dependent on humans for fresh water, as there is no natural source on the island.

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The purpose of the fence was to prevent garbage from being blown southwards, due to prevailing northerly winds, in the direction of the colony. We observed that light garbage (plastic bags and similar items) was not stopped by the fence and was present in the colony. The fence also resulted in a severe impact on the birds. Collisions of birds with man-made structures such as buildings and windows, power lines, communication towers, and wind turbines have been reported in many cases (Podolsky *et al*. 1998, Desholm & Kahlert 2005, Erickson *et al*. 2005, Veltri & Klem 2005, Klem 2009, Klem *et al*. 2009, Furness *et al*. 2012). Our observations of a threatened seabird population add one more case to the list, and confirm the importance of taking possible bird collisions into account when planning the construction of new structures. In our case the fence was built to protect the colony from contamination by garbage, and collision risk was not considered, probably because the birds fly at night and their pattern of activity was not known by those planning the fence construction. Fortunately, once the risk associated with the fence was communicated, the authorities reacted rapidly and efficiently to remove the fence with an immediate positive effect on the population, reducing fatalities.

We stress the importance of an Environmental Impact Assessment as required by Mexican law and, in this case, the importance of planning a "zero waste" policy on small islands with high conservation value. This should also consider the human population on the island: there were 30 families on Isla Navidad in 2016. In particular, in cases with fishing and other settlements on small islands, a proactive approach toward recycling and waste reduction should be encouraged (as recommended by the Convention on Biological Diversity on Island Biodiversity Work Programme COP 8 Decision VIII/1); construction of landfill sites should be a last resort. It is impossible to exactly assess the impact of the fence during the last two years on shearwaters of Natividad Island, but we can now use this example to emphasize the importance of the precautionary approach towards any kind of human structure in proximity of seabird colonies.

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