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SHORT NOTE

Confirmation of the extinction of South Georgian diving petrels (*Pelecanoides georgicus*) on Enderby Island

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Similar to most burrowing Procellariiformes in New Zealand, diving petrels (*Pelecanoides spp.*) do not appear to coexist with introduced mammals (Taylor 2000; Holdaway *et al*. 2003). All four extant diving petrel taxa (northern diving Petrel [*P. urinatrix urinatrix*], southern diving petrel [*P. u. chathamensis*], Subantarctic diving petrel [*P. u. exsul*; hereafter SubDP] and South Georgian diving petrel [*P. georgicus*; hereafter SGDP]) have experienced substantial population declines, predominantly due to predation from introduced mammals (Marchant & Higgins 1990, Taylor 2000). The SGDP, which has a circumpolar distribution, has experienced particularly steep declines in New Zealand, where it is a foredune-breeding specialist (Fischer *et al*. in press). SGDP colonies are considered extinct on the Otago Peninsula (Sandfly Bay), Stewart Island (Mason Bay), the Auckland Islands (Enderby and Dundas Island) and the Chatham Islands (Marchant & Higgins 1990; Worthy 1998; Taylor 2000; Holdaway *et al*. 2003; Wood & Briden 2008). The only known SGDP colony in New Zealand now remains in the foredunes of the Sealers Bay on Codfish Island (Whenua Hou), with an estimated population size of 150 individuals (Wood & Briden 2008; Taylor 2013; Fischer *et al*. 2017, in press). In recognition of its precarious population size, the New Zealand conservation status of the SGDP is

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considered Nationally Critical (Robertson *et al*. 2013).

Some uncertainty, however, remains as to the status of the SGDP on Enderby Island (Taylor 2000). Introduced mammals (mice [*Mus musculus*], rabbits [*Oryctolagus cuniculus*], and cattle [*Bos taurus*]) were eradicated from Enderby Island in 1993 (Torr 2002). Furthermore, while Procellariiformes are extremely philopatric (Warham 1996), they have been shown to rapidly (re)colonize areas after eradication of introduced mammals (Ismar *et al*. 2014). There had been no recent dedicated surveys for SGDPs on Enderby Island, and the potential persistence / reestablishment of the species would be of great conservation importance. Outlined in this short note are the results of a survey we undertook to reassess the status of the SGDP at Enderby Island.

We searched for Procellariiforme burrows in the dunes of Sandy Bay (-50.500°, 166.285°), Enderby Island, and subsequently identified their occupants using protocols developed for SGDPs on Codfish Island (Fischer 2016). We conducted surveys each day and night between 12 and 22 December 2016 when diving petrels should be nesting (Payne & Prince 1979; Marchant & Higgins 1990; Fischer *et al.* 2017, in press). Survey efforts were limited to the dunes of Sandy Bay (200 m x 900 m), because SGDPs in New Zealand are considered dependent on this habitat (Fischer *et al.* in press). Surveys were completed during daylight hours by two observers working 10 m apart until the entire dunes of Sandy Bay were covered. We marked burrows with temporary markers and reflectors and recorded their GPS locations. Stick palisades were placed in burrow entrances to assess activity patterns (Johnston *et al*. 2003; Fischer *et al*. 2017, in press). We checked these palisades daily ($n = 9$), and to account for false positives, we only considered burrows with three or more records as active (Fischer *et al*. 2017, in press).

Detected burrows were revisited at night (2300 h to 0200 h; Fischer *et al.* 2017) and a variety of techniques were used to identify the occupants. We used playback calls of various Procellariiformes that are presumed to breed at Enderby Island (Payne & Prince 1979; Taylor 2000; Heather & Robertson 2015): SGDP (calls sourced from Codfish Island), SubDP, white-headed petrel (*Pterodroma lessonii*), grey-backed storm petrel (*Garrodia nereis*), white-faced storm petrel (*Pelagodroma marina*), black-bellied storm petrel (*Fregetta tropica*), Antarctic prion (*Pachyptila desolata*), and fulmar prion (*Pachyptila crassirostris*). In addition, we used burrow traps specifically designed for diving petrels (length = 30 cm, diameter = 8 cm; Fischer *et al.* in press). We deployed a maximum of 10 burrow traps per night and trapped for a cumulative total of 86 trap hours spread over seven nights. Once one of the occupants of a detected burrow was identified no further trapping efforts were made at that burrow. For burrows that were not suitable for trapping, supportive evidence (e.g., feathers in burrows, or burrow entrance size) was used to infer identification. Finally, we also spotlighted for Procellariiformes with a handheld torch (500 lm) between 2300 h and 0200 h on seven nights to identify species away from detected burrows (Crockett 1994; Ismar *et al.* 2015). We only attempted to ground diving petrels (for identification), while we let other burrowing petrel species pass overhead. Once captured, we used bill shape, placement of paraseptal process, tail shape, outer primary coloration and extent of collar to identify diving petrels to species and subspecies level (Murphy & Harper 1921; Payne & Prince 1979; Fischer 2016). We also recorded the state of brood patches to infer breeding status (Rayner *et al.* 2013).

We detected 18 Procellariiforme burrows at Sandy Bay, of which 12 were actively used (Fig. 1). Ten burrows were occupied by SubDPs and 1 by white-headed petrels. The occupants of 1 burrow remained unidentified. SGDPs were not confirmed in any of the burrows detected. The occupants of 9 SubDP burrows were identified through capture with burrow traps, while the occupants of the remaining SubDP burrow were identified using playback. The occupants of the white-headed petrel burrow were identified through supporting evidence (25 x 25 cm burrow entrance and large (length = 10 cm), pure white feathers present in the burrow). Stick palisades showed that most (mean = 71.7%; *se* = 6.2%) SubDP burrows were active every monitoring night. The white-headed petrel burrow showed activity on 66.7% of monitoring nights. In addition, a variety of Procellariiformes were spotlighted flying overhead: white-headed petrel (mean = 3.20; *se* = 0.57 individuals/h), unidentified diving petrels (mean = 1.09; *se* = 0.43), grey-backed storm petrel (mean = 0.96; *se* = 0.41) and black-bellied storm petrel (mean = 0.22; *se* = 0.13). Only one bird was caught, which was subsequently identified as a SubDP. This individual and all SubDPs captured with burrow traps ($n = 12$) showed a fully developed, bare brood patch.

Our results indicate that SubDPs breed, at low densities, in the Sandy Bay dunes. Both stick palisade records at burrows, showing activity on most monitoring nights, and well developed brood patches, suggest that the SubDPs were tending either eggs or young chicks in mid-December (Marchant & Higgins 1990), mirroring the SubDP breeding cycle reported from South Georgia (Payne & Prince 1979). Claims of southern diving petrels co-occurring with SubDPs at Enderby Island have also been made (Murphy & Harper 1921). We did not detect any southern diving petrels in the dunes

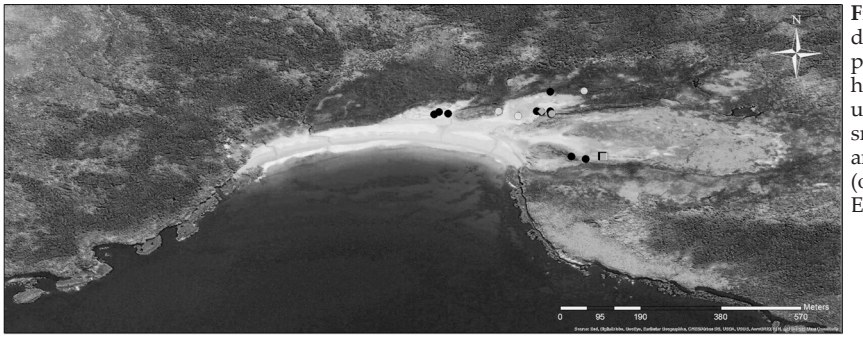

Fig. 1. Distribution of detected Subantarctic diving petrel (filled circle), white-headed petrel (filled square), unidentified (open diamond), small inactive (open circle) and large inactive burrows (open square) at Sandy Bay, Enderby Island.

of Sandy Bay, but we cannot exclude the possibility that this subspecies coexists with SubDPs on Enderby Island outside the dunes.

We did not detect any SGDPs in the dunes of Sandy Bay with any monitoring techniques, confirming previous observations suggesting that the species is indeed extinct on Enderby Island. The SGDP was probably extirpated from Enderby Island by the activities of introduced mammalian species. For example, rabbits and cattle probably changed dune vegetation, reduced the dune dynamics (Torr 2002) on which the SGDPs depended (Fischer *et al*. in press), and trampled SGDP burrows (Taylor 2000). Furthermore, mice have been shown to reduce the breeding success of various larger Procellariiformes (Cuthbert *et al*. 2013). The presence of SubDPs in the dunes of Sandy Bay, contrasting with the absence of SGDPs, can be explained by the wider range of SubDP breeding habitats (Payne & Prince 1979) allowing this species to be more resilient. SGDP are likely to be extinct on Dundas Island as well, where the species was probably extirpated by New Zealand sealions (*Phocarctos hookeri*) trampling their burrows (Taylor 2000). While no recent surveys targeting SGDPs have been conducted on Dundas Island, sealions are still very prevalent (Robertson & Chilvers 2011). The foredunes of Codfish Island thus indeed appear to harbour the last remaining colony of the SGDP in New Zealand, underlining the importance of this colony.

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