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SHORT NOTE

Survey and population size estimate of Fiordland penguin (tawaki; *Eudyptes pachyrhynchus*) in Milford Sound / Piopiotahi, New Zealand

THOMAS MATTERN*
Department of Zoology, University of Otago, Dunedin
Global Penguin Society, Oceania Representative

ROBIN LONG
West Coast Penguin Trust, P.O. Box 63, Hokitika

The Fiordland penguin, or tawaki (*Eudyptes pachyrhynchus*), is one of three endemic crested penguin species in New Zealand (Garcia Borboroglu & Boersma 2013). Despite being the only eudyptid species to breed on the mainland, it remains one of the least studied penguin species world-wide; only a handful of studies have been published which mainly focussed on breeding biology (e.g. Warham 1974; St Clair 1992; McLean *et al.* 2000) or demography (e.g. McLean *et al.* 1997; Otley *et al.* 2017). The main reason for this dearth of research is likely because the species breeds in remote and difficult to access areas of South Westland, Fiordland, Stewart Island and its outlying islands; this also results in uncertainty about population size (Mattern 2013).

Current estimates of the tawaki population range between 5,500 and 7,000 mature individuals (BirdLife International 2016) and are largely based on terrestrial surveys conducted throughout the 1990's covering most of the species' known breeding range (McLean & Russ 1991; Russ *et al.* 1992; McLean *et al*. 1993; Studholm *et al*. 1994; McLean *et al*. 1997). The species is believed to have undergone significant declines in the last four decades (Taylor 2000), although Taylor's assessment is largely based on few observations from a single site (St. Clair 1998). A review of all available monitoring data indicated that the information is too sparse to draw general conclusions about the species' population trends (Mattern 2013). Moreover, recent population counts at some sites seem to indicate that the 1990's surveys either underestimated penguin numbers or that the population has in fact increased (Long *et al*. 2009; Long *et al*. 2011).

Milford Sound / Piopiotahi, Fiordland, is one of New Zealand's most prominent tourism destinations with boat cruises being the main visitor activity (Nicoll 2016); tawaki are a key

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*Correspondence: *t.mattern@eudyptes.net*

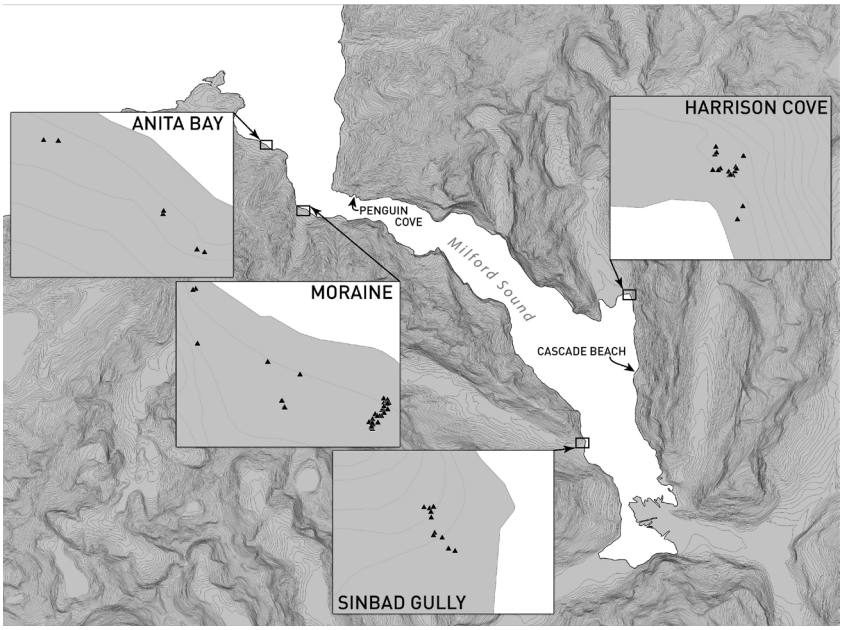

Fig. 1. Overview of Milford Sound showing tawaki breeding areas searched and approximate nest locations, as well as locations of two other likely breeding sites (Penguin Cove and Cascade Beach) not included in this survey.

attraction for most local tourist businesses. Yet few breeding penguins have been reported from Milford Sound. McLean & Russ (1991) found a total of five nests at Anita Bay in the outer reaches of the fiord. A nest count conducted by the Department of Conservation in 1994 which focussed on a colony in Harrison Cove, some 9 km from the open ocean, found 4 breeding pairs (Eason 1994). In comparison, a later study investigating the marine ecology of tawaki in 2015 (The Tawaki Project, http://www.tawaki-project.org) found 17 nests at Harrison Cove (Mattern & Ellenberg 2016). Anecdotal observations by skippers and nature guides of local tourism operators suggest that tawaki are abundant in the fiord during the breeding season (July-December).

While conducting field work for the Tawaki Project in spring 2015 and 2016, searches for tawaki nests were conducted opportunistically within Milford Sound, allowing us to complete more comprehensive searches than reported previously. Nest searches were carried out at 4 sites (Harrison Cove, Sinbad Gully, Moraine and Anita Bay; Fig. 1) within Milford Sound in late September and early October 2016. At Harrison Cove, field work for the Tawaki Project provided the opportunity over the course of 3 weeks in both 2015 and 2016 to thoroughly search and map the tawaki breeding colony located in the southwestern corner of the cove (also known as 'penguin corner'). The deployment of a GPS dive logger on a non-breeding tawaki in 2015 showed that the bird spent three days in the forest along the steep ridge at the eastern entrance of Sinbad Gully, suggesting a potential breeding area. The third site, locally referred to as 'Moraine', is a rocky beach just west of Anita Bay in the outer reaches of Milford Sound where tawaki are often seen ashore by cruise boats. We conducted a search at Anita Bay to allow comparison of our findings with previous survey efforts.

Searches were generally conducted by examining the shore for penguin entry points into the bush, identifiable by scat or scratch marks on the rocks. Following penguin trails from these entry points would eventually lead to breeding areas. Nests were located by the following methods: (1) visually if in the open or where scat marks radiated from underneath cover; (2) by smell (the nests often smell strongly of ammonia); or (3) by following the calls of chicks or adult penguins. Where possible nest status was identified as active, with eggs being incubated or chicks guarded, or failed if a nest bowl contained cold eggs or egg shells. However, particularly in areas where penguins breed under rocks or in rock crevices, nests were inaccessible, and so that status could only be deduced from chick calls. GPS positions of nests were recorded. If nests were out of sight, the position of the apparent access point to the nest was used. In some instances, these entrances would lead to a breeding cavern used by multiple pairs. The actual number of nests in these caves was estimated from the number of distinct chick voices that could be heard.

Table 1. Summary of Fiordland penguin / tawaki surveys at 4 sites in Milford Sound / Piopiotahi in September/October 2016. (Note: Estimated number of nests for Sinbad Gully, Moraine and Anita Bay have been determined by increasing the number of nests detected by 30%. Estimated numbers for Harrison Cove were not adjusted as we assume that all active nests were located. Estimates for Sinbad Gull are likely an underestimate due to very limited survey effort. Previous estimates for Harrison Cove and Anita Bay were derived from Eason (1994) and McLean & Russ (1991), respectively.)

Site	Habitat type	Nest types	Nests mapped	Estimated nest numbers	Previous estimates
Harrison Cove	Overgrown landslip	Rock caves, tree roots	17 (2015) 18 (2016)	17 18	4 (1994)
Sinbad Gully	Old growth forest	Tree root, wind falls	10	13	-
Moraine	Old growth forest, overgrown glacial moraine	Rock caves, underground warren	37	49	-
Anita Bay	Old growth forest	Rock caves, tree roots	6	9	5 (1990)
TOTAL			77	89	9

An initial 2-hour search at Harrison Cove (Fig. 1) conducted on 21 September 2015 by TM and a field assistant found 10 nests occupied by adults incubating eggs. The breeding area in Harrison Cove comprised an old rock fall largely overgrown by a lush forest of fuchsia (*Fuchsia excorticata*) and tree ferns (*Cyathea sp*.). Most tawaki in the area bred under large rocks from the old land slip, often in hard to access crevices and caves. Some birds established their nests under rock overhangs or under tree roots. During the subsequent field work at Harrison Cove (1-11 October 2015), another 7 nests with chicks were located opportunistically, bringing the total to 17 nests in that area (Table 1). A 2-hour search conducted on 23 September 2016 by TM and two field assistants found 13 active nests (eggs); an additional 5 nests with chicks were found between 28 September and 13 October (total number: 18 nests, Fig. 1, Table 1).

On the morning of 2 October 2016, a search was conducted by TM and RL at Sinbad Gully (Fig. 1), an area dominated by old growth beech forest with an understorey of ferns. The search had to be aborted after only 1.5 hours due to a change in the weather. While a search parallel to the beach produced little indication of tawaki presence, a total of 10 nests were found in the lower reaches of the northern ridge leading up to the Footstool and Mitre Peak (Fig. 1, Table 1). Eight of these nests each contained a single chick guarded by male penguins, while the remaining 2 nests had failed with either cold eggs or eggshells. Calls from other areas suggested that the tawaki breeding colony comprises further nests which could not be located in the time available.

Moraine (Fig. 1) was visited on 3 October 2016 and searched for 4 hours by TM and RL. The site is dominated by an old glacial moraine. The forest floor is a jumble of large rocks under which exist a network of tunnels and cave systems utilized by the penguins. The moraine itself is overgrown by old-growth forest (mainly beech and rimu) with a fern understorey (see https://vimeo.com/187603140). Solitary breeding pairs were located at the western edges of the rocky shore (Fig.1, Table 1). However, the majority of tawaki utilized the central region with a well-defined entry into the bush behind a rock that local skippers call 'peanut rock' owing to its shape and colouring. A total of 37 nests were located, most of which proved to be inaccessible as they were situated deep underground. Sounds of footsteps on muddy ground, penguin trumpeting and chick calls, often muffled or emanating from small holes in the ground, suggest an extensive network of tunnels and caves deep beneath the forest floor. Hence, the actual number of nests is potentially greater than our counts suggest.

On 6 October 2016, the entire length of Anita Bay was searched over a period of 4 hours by a team of 4. Six nests were located towards the eastern end of the bay, only 2 of which were still active (Fig. 1, Table 1). However, 1 area with old penguin nests was found along a creek emerging in the eastern third of the bay. The area appeared to have been subject to substantial flooding in the past as indicated by the deposition of silt and debris on a forest dominated by tree ferns. Some potential tawaki nests were found under tree trunks, but no signs of recent usage were found. It seems likely that the flooding rendered the area unsuitable to penguins for breeding.

Based on the results of our surveys, it appears that the breeding population of tawaki in Milford Sound is substantially greater than previous records suggest. The 77 nests we mapped at 4 different sites are likely an underrepresentation of the true number of tawaki breeding in Milford Sound.

There are at least 2 more sites where tour operators frequently observe penguins – Penguin Cove and Cascade Beach (Fig. 1) – suggesting further pockets of breeding tawaki. Moreover, except for Harrison Cove where the majority of nests were probably located due to our prolonged research activity at that site, it is reasonable to assume that nests were missed at other sites either due to time constraints or inaccessible habitat. Hence, the number of nests counted by us likely still represents an underestimate of the true number of breeding pairs.

Using the difference between the number of nests found during the initial searches at Harrison Cove and total number of nests subsequently found during 2-3 weeks of field work at that site in 2015 (10 vs 17 nests) and 2016 (13 vs 18 nests), it can be assumed that about one third of the breeding population was missed during the one-off searches at the other sites; this corresponds to the initial detection rates reported in Ellenberg *et al*. (2015). Adjusting the nest counts accordingly would result in an estimation of 89 breeding pairs (Table 1). Using the median nest numbers resulting from this estimation – 15 nests per site – as a rough estimate for the two other unsurveyed sites, there may have been 119 nests active in Milford Sound at the time of our searches. Finally, considering that between 10% and 30% of tawaki nests fail early in the breeding season (Warham 1974), and thus remain undetected, we conclude that the total breeding population of Milford Sound is likely to be between 130 and 150 pairs.

The previous records of a total of 9 breeding pairs in Milford Sound (McLean & Russ 1991; Eason 1994) underestimate the number of penguins by more than an order of a magnitude. The 5 nests reported by McLean & Russ (1991) for Anita Bay are comparable to the 6 nests we found (Table 1). However, 4 nests found in 1994 at Harrison Cove reported by Eason (1994) was considerably lower than the 17 recorded in this current survey. Search effort of the 1994 survey (4 nests found) may have been comparable to the initial searches we conducted (10 and 13 nests found in 2015 and 2016, respectively), perhaps indicating that penguin numbers at Harrison Cove may have doubled in the past 2 decades. This, in turn, could indicate an overall rise in penguin numbers in Milford Sound which corresponds to an increasing abundance of penguins as perceived by some seasoned cruise ship skippers and researchers (Kerry-Jayne Wilson, *pers. comm*.). Such a trend would be surprising given that tawaki are believed to be undergoing substantial declines throughout their range (BirdLife International 2016).

However, there is mounting evidence that the species may in fact be faring better than assumed. A recent survey of tawaki between Big Bay and Cascade River in south Westland (RL, *unpubl. data*) found significantly greater numbers of breeding pairs (877 pairs) along that stretch of coast compared to numbers previously reported (150 pairs; McLean *et al*. 1997). Observations made by TM provide a minimum estimate of 50 breeding pairs along the northwest coast of Stewart Island (Halfmoon Bay to Rollers Beach, http://bit.ly/2mKVdFt), an area that was practically devoid of tawaki in the 1970s (Kerry-Jayne Wilson, *pers. comm*.) as well as during surveys in the 1990's (Studholm *et al*. 1994). More recently, breeding attempts by tawaki have been reported on the Otago coast (Young *et al*. 2015), suggesting a potential range expansion of the species.

In this light, reassessment of tawaki numbers across their entire breeding range is warranted to assess the validity of previous records and gain additional information that may help form an understanding of the species' overall population trends.

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