

New distribution records of collared petrel (*Pterodroma brevipes*) in Fiji and development of a rapid assessment monitoring method

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Abstract Nocturnal surveys for collared petrel (*Pterodroma brevipes*) indicate significant variation in the number of birds reported by site, time of year, and survey method. Collared petrels were recorded at 3 new islands within Fiji in 2011. These records indicate that locating collared petrels requires focussed survey effort, although they do not definitively confirm breeding on the islands, for which ground-based searches would be required. When visiting sites where there has been no recent evidence of collared petrel breeding, surveys should be undertaken between February and April (at the start of the breeding season), should use an active method of survey comprising both light for attraction and playback and/or with 'war whooping', and should be repeated at a number of sites before concluding that an island holds no breeding birds.

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Keywords collared petrel; breeding; Fiji; *Pterodroma*; survey methods

INTRODUCTION

The collared petrel (*Pterodroma brevipes*) global population is suspected to be fewer than 10,000 mature individuals with no sub-population supporting more than 1,000 individuals, and to be in decline owing to the impacts of invasive alien species. Consequently, it was up-listed to Vulnerable on the IUCN Red List in 2011 (Birdlife International 2012a). Its change in Red List status has coincided

with recent efforts to gather additional information on its status in Vanuatu (Tennyson *et al.* 2012) and prompted the surveys in Fiji that we report here.

In Fiji, the collared petrel was collected in some numbers in the second half of the 1800s (Bourne 1981), when breeding was confirmed on the islands of Viti Levu, Kadavu, Ovalau and Vanuabalavu (Table 1). It has probably since been extirpated from Fiji's largest island Viti Levu (and Vanua Levu where historic breeding is presumed but has never been confirmed) following the introduction of the small Asian mongoose (*Herpestes javanicus*; Watling

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2004). In modern times breeding has been confirmed from Gau, which has a population perhaps numbering in the low hundreds (Table 1). On Gau a concerted programme of nocturnal surveys and burrow-searching has been implemented to locate the Critically Endangered Fiji petrel (*Pseudobulweria macgillivrayi*). The presence of collared petrel on the island has provided fieldworkers with the opportunity to locate and monitor petrel burrows (O'Connor *et al.* 2010 and subsequent reports). The first collared petrel burrow was located in 2007, with further sites with burrows found in every year since (with the use of dogs trained specifically to locate petrel burrows). Collared petrels have been reported from Moala (K. Moce, *pers. comm.*) and Nakasaleka, east Kadavu, where a harvest of chicks, documented by Correia (1927-1929), was reported as continuing until recently (V. Masibalavu, *pers. comm.*). Elsewhere, the only recent active searches on land for collared petrels in Fiji have been unsuccessful nocturnal searches on Nabukelevu/Mt. Washington, west Kadavu and Ovalau (Masibalavu 2003; Masibalavu & Dutson 2004).

There is concern for the persistence of collared petrel (Birdlife International 2012a). Island extirpations have almost certainly occurred already (Watling 2004), although it is possible that breeding still occurs on several, perhaps many, hitherto unsurveyed islands (Watling 1986). This study presents observations from nocturnal surveys at a site with high numbers of birds at Waitabua, Gau from February to June 2010 and a site with low numbers on Nabukelevu, Kadavu from February to July 2012 and reports on snapshot surveys at a number of sites on other Fiji islands in April and May 2011. It is important, when prioritising conservation interventions for a species, to compare current distribution and abundance at sites with historical information.

METHODS

Spot-lighting and acoustic surveys

A passive survey method was used to assess the variation in numbers of collared petrels reported from Gau and Kadavu. Artificial lights are known to attract petrels (Crockett 1994; Rodriguez & Rodriguez 2009). Each night, a 8 W fluorescent tube light was erected at dusk (c.1830 h), attached to a 12V lead-cell battery. This floodlit an area around the survey point and was visible to petrels returning at night from the sea. In addition, a LED Lenser P7 200 lumen spotlight was used to attract any birds heard calling in flight, and to scan for passing birds. Each bird observed was recorded as a 'contact', and the number of all individual calls per hour was also logged. The number of cues per hour is the number of contacts + the number of calls. Night long surveys,

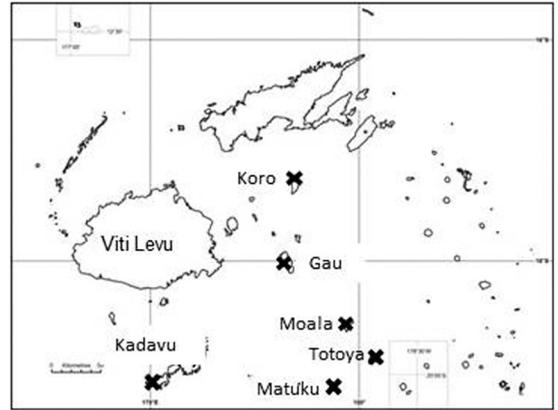


Fig. 1. Islands surveyed for collared petrel between 2010 and 2012.

around the new moon period, were undertaken between February and June at Waitabua, Gau in 2010 and Nabukelevu, Kadavu in 2012.

To maximise the chances of an encounter during the short survey periods available on outer islands, 2 further methods of attraction were used. Petrels can be attracted to the playback of conspecific calls (*e.g.*, Podolsky & Kress 1992; Luzardo *et al.* 2008) or even 'war-whoops' (Tennyson & Taylor 1990). From 1900 h vocalisations of collared petrel, Tahiti petrel (*Pseudobulweria rostrata*) and white-throated (Polynesian) storm-petrel (*Nesofregatta fuliginosa*) were broadcast from a Radioshack mini amplifier-speaker for periods of 3 minutes every 30 minutes. These were interspersed with 'war-whooping' by observers every 10 minutes for 1 minute. Spot-lighting, playback and calling continued until at least midnight to cover the hours considered to have the highest encounter rates, as identified during surveys at Waitabua, Gau in 2010 (see results and O'Connor *et al.* 2010). This method is termed the 'active' method.

Site identification for outer island rapid assessments

To identify where surveys should focus we first assessed historical and anecdotal records (Table 1). On this basis, Nabukelevu/Mt. Washington and Nakaseleka on Kadavu, Koro, Ovalau, Moala and Vanuabalavu were selected as sites where breeding was suspected, or confirmed, historically for collared petrel.

We then ranked the 20 largest islands in Fiji by land area, and used an *ad hoc* assessment to identify other potentially suitable breeding islands based upon: (i) the status of mongoose, (ii) island elevation, and (iii) habitat quality appraised by looking at Google Earth. This enabled us to identify mongoose-free, 'high' islands with considerable remnant forest

Table 1. Historic and contemporary records of collared petrel in Fiji.

Island	Site	Year	Note	Source
Kadavu	Nabukelevu/ Mt Washington	1876	Recorded in July near the summit; noted that collared petrels visiting their nests "encircled the mountain peak"	Kleinschmidt in Jenkins (1986)
Kadavu	Nakasaleka	1925	Many 'hundreds' harvested and 20 specimens taken from burrows	Correia (1927-1929)
Kadavu	Nakasaleka	2004	Burrows visited in February but no evidence of breeding; continuing harvesting reported	V. Masibalavu, <i>pers. comm.</i>
Koro		?	Photograph of bird on land	D. Watling, <i>pers. comm.</i>
Ovalau		1882	Reported breeding on Ovalau	Ramsay (1882)
Moala		1983- present	Unverified but well established cultural knowledge	K. Moce, <i>pers. comm.</i> ; Watling (2004)
Gau		1986	165 individuals attracted to lights during 4 nights of spot-lighting and playback in April-May; 20+ burrows identified	Watling (1986)
Gau		2010	An ongoing survey programme on Gau has recorded tens or possibly hundreds of collared petrels between 2007 and 2010	O'Connor <i>et al.</i> (2010)
Gau		2009-2011	The only known collared petrel burrow in Fiji monitored (fledged successfully)	O'Connor <i>et al.</i> (2010); Fraser (2011)
Gau		2014	92 'burrows' located by search dogs; 30 confirmed breeding with additional 13 active in 4 loose colonies	P. Qalo, <i>pers. comm.</i>
Vanuabalavu	Lomaloma	1870s	Collected by E.L. Layard	M.J. Largen, <i>pers. comm.</i> to Jenkins (1986)
Viti Levu	Korobasabasaqa Range	1865	Captain H.M. Jones VC recorded breeding collared petrels in the Korobasabasaqa Range in southern Viti Levu	Graeffe (1869)
Viti Levu	Wainimala River	1876	Birds collected at burrows and extensive harvesting recorded in July	Roth & Hooper (1985)
Viti Levu		1878	Two individuals collected on Viti Levu in May	Kleinschmidt in Jenkins (1986)
Viti Levu	Rewa River	1878	A juvenile collected from the upper Rewa River in March	Bourne (1981)

cover (Table 2). These loose selection criteria were chosen based upon characteristics of the islands where the species has been confirmed breeding in the past, from accounts of breeding colonies (see Jenkins 1986; Watling 1986), and because the mongoose is assumed to have driven extirpation from historic sites. Using these criteria we identified Rotuma, Qamea, Totoya, Kabara and Matuku as suitable islands to survey (Table 2; Fig. 1). The time, funding and opportunities available allowed us to undertake rapid assessment surveys in 2011 on Nabukelevu, Kadavu, Koro, Moala, Totoya and Matuku.

Passive surveys on Gau, in 2010 provided information on the time of year and time of night of peak periods of activity. In 2011, short visits were made to Koro, Matuku, Totoya, Moala and Nabukelevu, Kadavu, where the active survey method was used to maximise the likelihood of recording a collared petrel. In 2012, passive surveys were undertaken between February and June at Nabukelevu, Kadavu, which enabled petrel cues at this site to be directly comparable with the sites on Gau, and also provided a comparison between the

findings of the passive and active survey methods at one site in successive years.

RESULTS

Seasonal collared petrel surveys

Information on the number of cues (total calls + total sightings), using the passive survey method, were compared monthly through the season at both Waitabua, Gau and Nabukelevu, Kadavu (Fig. 2).

The number of cues (registrations per hour) for Gau (the high numbers site) was 2 orders of magnitude greater than for Kadavu (the low numbers site). For both sites the number of cues was 2 to 3 times higher in March than in the next highest month (April in Gau, February in Kadavu). For both sites the proportion of cues due to calling birds was high early in the season, with the proportion of sightings increasing as the season progresses, particularly on the low density site.

To eliminate bias caused by variable cue frequencies of individual birds we considered the variation in the presence of birds by hour through the season (Fig. 3). Birds were recorded in over 90%

Table 2. Priority islands to survey in Fiji for collared petrel.

Rank	Island name	Area (km ²)	Elevation (m)	Human population	Historic status	Current status	Notes
1	Viti Levu	10758	1303	662,000	Confirmed	Extirpated?	Mongoose present
2	Vanua Levu	5794	1004	120,500	Suspected	Extirpated?	Mongoose present
3	Taveuni	480	1215	15,500		Unknown	
4	Kadavu	454	795	10,150	Confirmed	Confirmed	Ongoing surveys
5	Gau	142	709	10,500		Confirmed	Ongoing surveys
6	Ovalau	109	585	9,100	Confirmed	Unknown	Surveys in 2004, mongoose recently reported as established
7	Koro	107	542	4500		Suspected	
8	Moala	63	460	3000		Suspected	
9	Lakeba	56	210	2100		Unknown	Heavily deforested
10	Vanuabalavu	54	264	1200	Confirmed	Unknown	
11	Rotuma	46	241	2000		Unknown	
12	Beqa	38	402	1500		Unknown	Unlikely, mongoose present
13	Qamea	37	278	2213		Unknown	
14	Naviti	36	342	1549		Unknown	Heavily deforested
15	Cicia	35	170	937		Unknown	Heavily deforested
16	Yasawa	34	157	1120		Unknown	Heavily deforested
17	Totoya	34	339	937		Unknown	
18	Kabara	33	132	937		Unknown	
19	Vatulele	32	40	937		Unknown	Low island
20	Matuku	32	371	2918		Unknown	

of hours surveyed on Gau except during June at the end of the breeding season, but only a maximum of 40% of hours on Kadavu even early in the season. The proportion of hours in which birds were recorded increased from April to June on Kadavu – although Fig. 1 indicates that the number of calling birds declined as the season progressed.

Hourly variation in the number of petrel cues contrasted between the high numbers, Gau, and the low numbers, Kadavu, site (Fig. 4). At Gau, sightings were concentrated in the hours immediately following dusk – with a marked reduction in numbers after midnight. By contrast, on Kadavu, the number of cues tended to be higher in the early hours before dawn.

The decline in the proportion of hours in which cues are reported through the night is apparent on Gau but not on Kadavu (Fig. 5).

Outer island collared petrel surveys

Surveys on outer islands comprised one or a few survey days, from one or more locations on the island and were not restricted to the new moon

period. The numbers of birds recorded have been compared with a comparable time of year (February to April) from the 2 seasonal surveys (Figs. 6 & 7).

Collared petrels were recorded from all the islands surveyed. Of the sites surveyed, using the active method, the highest number of cues and birds were recorded in a higher proportion of hours on Kadavu than the other islands surveyed.

The contrast between number of cues reported (12.9 versus 0.7 cues/hour), and the proportion of hours in which birds were recorded (0.72 versus 0.34) on Kadavu in 2011 and 2012 may reflect the difference in ‘detectability’ of collared petrels when using the passive compared with the active method of survey.

None of the sites were comparable, either in terms of the number of cues/hour or the proportion of hours in which a bird was recorded, with the numbers recorded at Waitabua on Gau. This includes the 2 other sites on Gau. It is evident that the location of the monitoring site can significantly influence the number of birds detected.

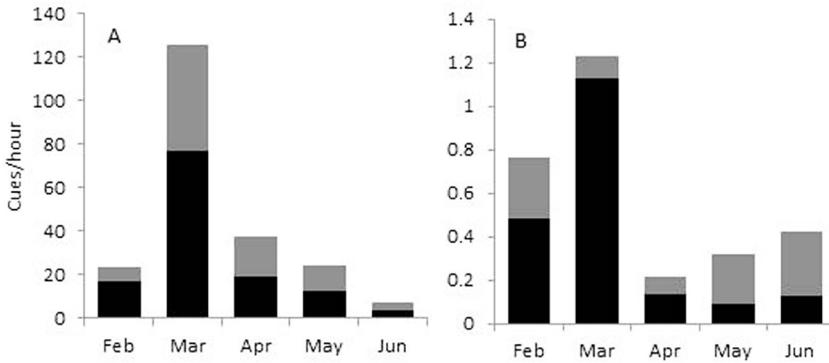


Fig. 2. The mean number of calls (black), and the mean number of sightings (grey), per hour between February and June at (A) Waitabua, Gau in 2010 and (B) Nabukelevu, Kadavu in 2012.

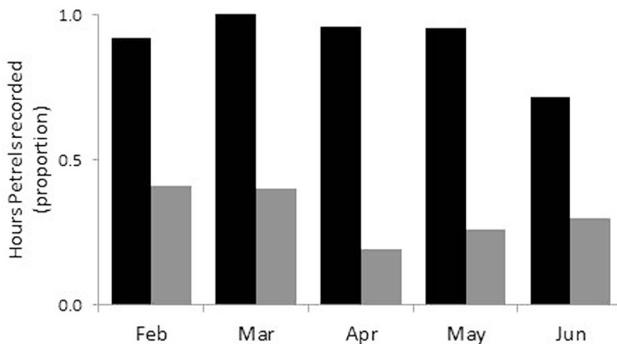


Fig. 3. The proportion of hours in each month that collared petrels were recorded as present on Waitabua, Gau in 2010 (dark) and Nabukelevu, Kadavu (light).

DISCUSSION

There is considerable evidence that collared petrel numbers have declined significantly in Fiji over the past 150 years (Jenkins 1986; Watling, 1986). It is therefore encouraging that this survey detected collared petrels on all 4 of the small islands visited. These represent the first records of collared petrels from Totoya and Matuku, and confirms earlier reports from Koro and Moala. Encounter rates at these outer islands were lower than that recorded on Kadavu although the timing of the Kadavu survey (April 2011 during the new moon period, corresponding with April/May 2011 at various stages of the lunar cycle for other islands), rather than an increased number of birds present at the site, may partially explain this difference. The records we report suggest that collared petrels may well continue to breed on the 4 islands visited. However, only detection of active nest burrows is definitive proof of breeding. Encounters with non-breeding petrel species on islands appear to be rare. Most, but not all, historic surveys that encountered fly-over collared petrels succeeded in locating burrows at the same locality (Jenkins 1986). For example, calling birds flying over land does not always equate with breeding sites—Cook's petrels (*Pterodroma cookii*) flying over Northland and Auckland can be heard calling on their return from feeding in the Tasman Sea, although their

nesting sites are on the islands of the Hauraki Gulf (Taylor & Rayner 2013).

The last report of a nesting collared petrel on Mount Nabukelevu was from 2010 when a dog found and excavated a juvenile near Lomati village (J. Drau, *pers. comm.*). There is currently no local knowledge regarding nesting at this site. The account from Kleinschmidt in the 19th Century (1879: in Jenkins 1986) noted collared petrels 'visiting their nests, encircling the mountain peak as though wishing to express their astonishment at our fires'.

The 30 fold increase in the number of collared petrel cues recorded from active surveys on Kadavu in 2011 compared with passive surveys in 2012 shows, conclusively, that direct comparisons between counts using the different methods is inappropriate. Tennyson and Taylor (1990) note that birds deviate toward the location of active calls and that birds reply repeatedly to war whoops. It is therefore apparent that during passive surveys, many birds fly past undetected without calling, and do not get located in the light. Consequently, the detectability of any individual bird at a high density site is likely to be substantially increased, and the 100 fold difference in the number of petrel cues on Gau compared with Kadavu in 2012 does not reflect the true difference in breeding density between the sites. This density dependent variation in detectability creates particular difficulties when

Fig. 4. Variation in the number of calls and sightings of collared petrels through the night at (A) Waitabua, Gau and (B) Nabukelevu, Kadavu. The hour given is the time at the start of the 1 hour survey.

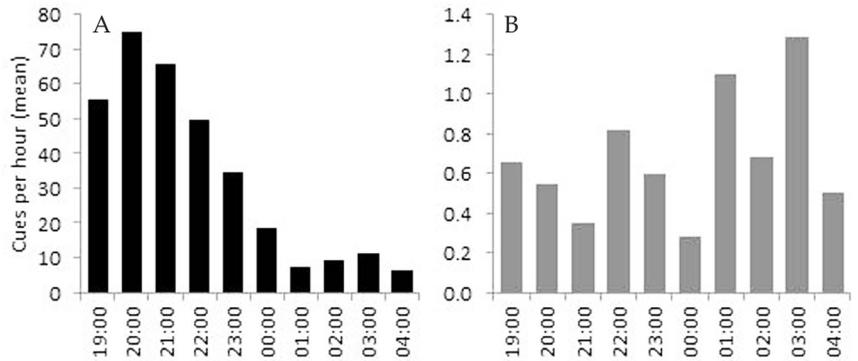
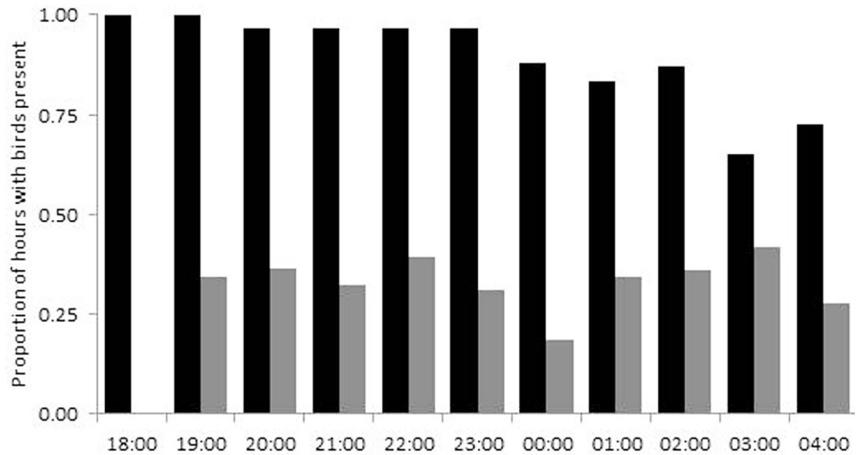


Fig. 5. The likelihood of recording a collared petrel at different times through the night for Waitabua, Gau (dark) and Nabukelevu, Kadavu (light).



attempting to use this method as a means of monitoring of breeding populations.

The recent elevation of collared petrel to 'Vulnerable' status on the IUCN Red List was based on the paucity of recent records from any islands (Birdlife International 2012a). The BirdLife IBA survey of Nabukelevu, on Kadavu, was undertaken in August 2004, and similar trips to Ovalau, formerly a breeding site, were undertaken in July 2004 – outside the main period for surveying collared petrel. BirdLife IBA surveys to Gau were undertaken in February 2005, although the survey method was focussed on forest species, and little time was spent listening for seabirds at night. The analysis reported here indicates that unless specialist survey methods are used, there is a high chance that breeding petrels will be missed, even if they are present. Given this, it is premature to assume that other former breeding sites are now not occupied – and that even former breeding sites on Viti Levu warrant a survey, using the active method advocated above, to check for continued presence. It is, however, clear that the numbers of birds using sites are markedly reduced as reports from the 19th

century, of birds flying past during daylight hours while surveyors walked through the bush of Viti Levu, are not now repeated.

Numbers of collared petrel recorded at the 3 sites on Gau vary substantially. It is tempting to suggest that the well-studied site with the highest number of cues and the highest proportion of hours with petrel reports is closest to the main breeding site for the species on the island. However, this appears not to be the case. Extensive searches to date have found no nesting burrows near Waitabua; the nearest nest is more than 1 km away. Instead, variation in detection rates must relate to island topography and flight paths. More detailed information on the various physical features of each of the sites may enable future surveys at other sites to be more precisely located for optimal recording of flyover birds.

A high proportion of the cues used to record the presence of collared petrels at the various sites have been based on the calls of birds flying over. One possibility to increase the collection of data at a range of sites, might be to use automatic sound-recording devices that are set up to record

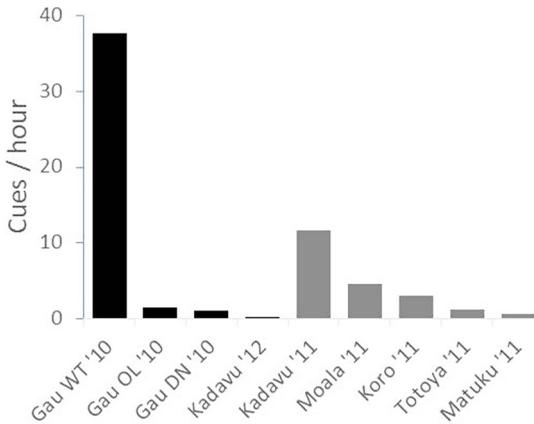


Fig. 6. The number of cues (calls plus sightings) per hour of collared petrels on islands surveyed in 2010 and 2011, in comparison with cues for the appropriate time of year for Waitabua WT, Gau in 2010 and Nabukelevu, Kadavu in 2012. Data also included from surveys for other observation sites on Gau, at Onealailai OL, and Delainakoro DN are also presented. Sites surveyed using the passive method are in dark shade, those using the active method are in light shade.

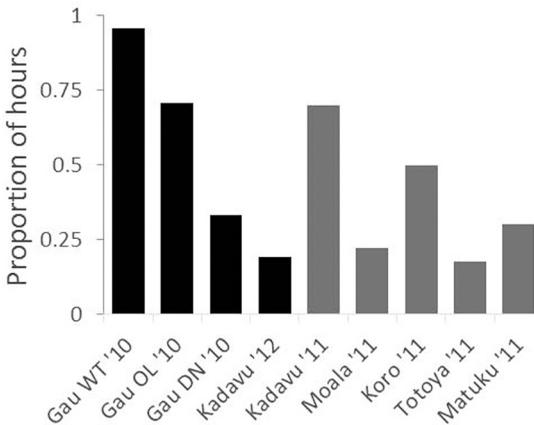


Fig. 7. The proportion of hours during which at least one collared petrel was recorded at the site. The sites are in the same order as presented in Fig. 6.

for multiple nights at likely sites. This approach has recently been used in New Zealand to search for New Zealand storm-petrel breeding sites (Chris Gaskin, *pers. comm.*) and in Alaska to monitor the response of seabirds to the removal of invasive predators (Buxton & Jones 2012). An automatic recording system, combined with a device that transmits collared petrel calls at regular intervals, may provide the most effective means of obtaining further information on the occurrence of the species on many Fiji islands and at potential sites elsewhere within the collared petrel breeding range.

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