

The Fiordland Crested Penguin (*Eudyptes pachyrhynchus*) survey, stage V: mainland coastline, Bruce Bay to Yates Point

BY IAN G. MCLEAN¹, MARTIN ABEL², CHRIS N. CHALLIES³, SIMON HEPPELTHWAITE³, JOHN LYALL² & RODNEY B. RUSS³

¹Department of Zoology, University of Canterbury, Private Bag 4800, Christchurch, New Zealand; ²Department of Conservation, Private Bag 701, Hokitika, New Zealand;

³Southern Heritage Expeditions, P.O. Box 20-219, Christchurch, New Zealand

ABSTRACT

We present results of the final stage of the Fiordland Crested Penguin (Tawaki) survey for the area north of Milford Sound. A total of 1,260 nests was counted: 389 south of the Hope River in August 1995, and 871 north of the Hope River between 1992-1994. A further 150 are estimated to occur on the Open Bay Is. The estimated breeding population for Tawaki, based primarily on counts of confirmed nests, now stands at 2,260 nests. A realistic estimate of the total number of nests is 2,500-3,000.

KEYWORDS: Fiordland Crested Penguin, distribution, survey, population estimate, Fiordland

INTRODUCTION

The Fiordland Crested Penguin or Tawaki (*Eudyptes pachyrhynchus*) survey is an attempt to provide the first complete count of the species. In previous years, we have surveyed most of the species range south of Milford Sound (McLean & Russ 1991, Russ *et al.* 1992, McLean *et al.* 1993, Studholme *et al.* 1994)².

Tawaki are the most temperate-living and rarest of the crested penguins. They are sometimes called the 'forest' penguin because they breed in dense rainforest, and the 'winter-breeding' penguin because breeding begins in July. Their distribution is restricted to southwest New Zealand and nearshore islands, where they breed in small, loosely structured colonies in a variety of habitats (see below). Once they have begun breeding at the age of 5-6 years (Warham 1974, I. G. McLean, unpubl. data) they appear to return consistently to the same colony each year (St Clair *et al.* in press).

In this report, we present the results of surveys conducted in 1995 on the mainland from John O'Groats River (just north of Milford Sound) to Gorge River by the University/Southern Heritage group, and between Sandrock Bluff and Hope River by the Department of Conservation (DoC) (Fig. 1). Mostly in August, 1992-1994, DoC used our techniques to survey the mainland coastline from Bruce Bay to the Hope River, and a summary of their results is provided here. Our previous surveys have been boat-based. However, the exposed coast of the 1995 survey area was inaccessible by boat and we broke the Southern Heritage/University party into three land-based groups that each surveyed different

¹ Current address: Department of Zoology, University of Western Australia, Nedlands, WA Australia 6009

² A complete set of the survey publications is available from the Department of Zoology, University of Canterbury.

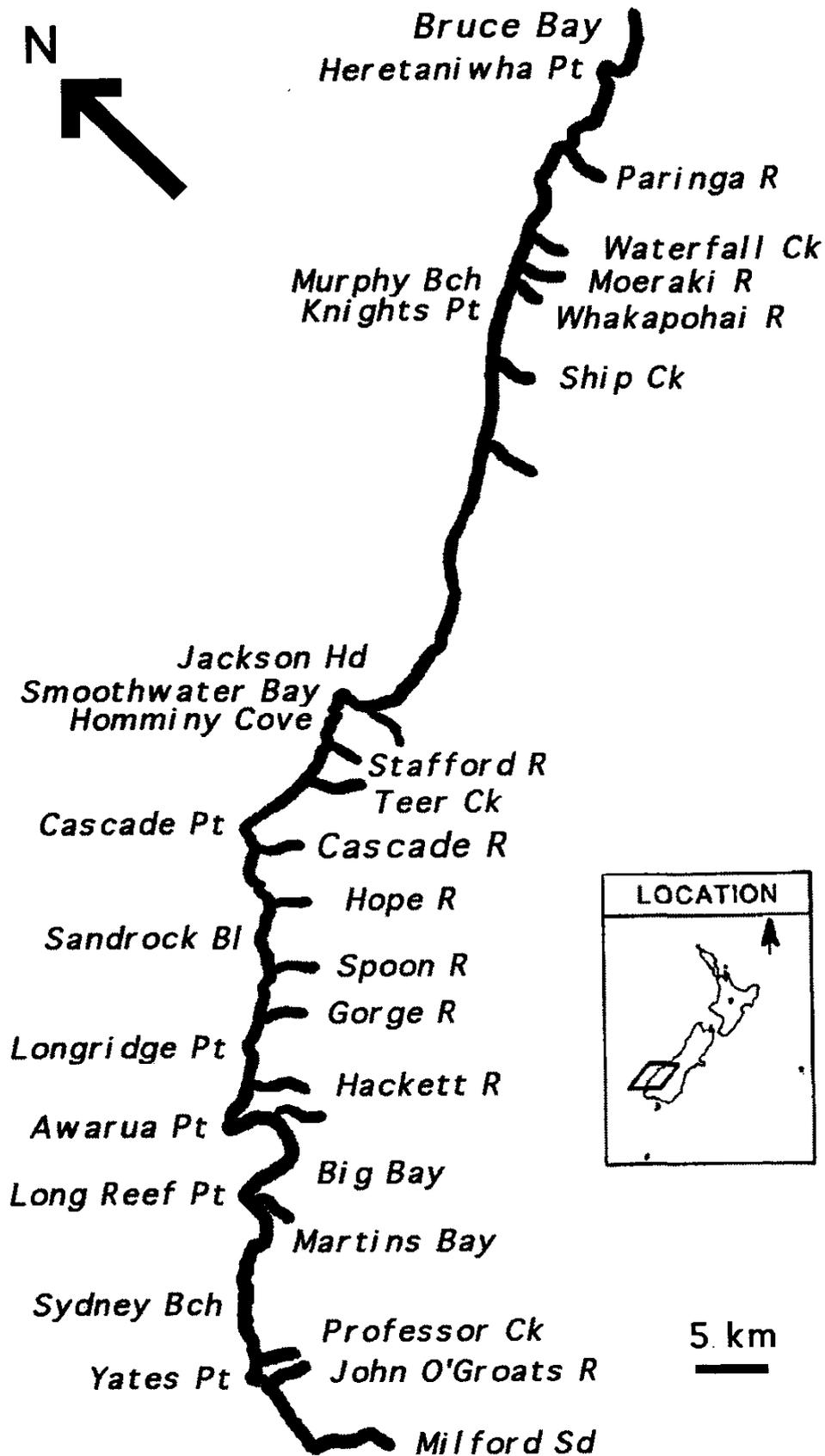


FIGURE 1 - The coastline surveyed for the presence of Tawaki in 1995, showing names given in the text. Milford Sound is immediately south of the southern edge of the map. Penguin and Crayfish Rocks are on the south and north sides of Big Bay respectively.

parts of the coastline. Our aim in 1995 was to complete the species-wide survey. To a large extent that objective has now been achieved. There are still several short sections of coast that either need further attention or have not been visited. These are noted below.

METHODS

Survey methodology was outlined in detail in McLean *et al.* (1993) and will only be summarised here, except for details specific to the mainland surveys (most earlier surveys were on islands).

Groups of 2-4 people worked their way along the coast searching and listening for signs of penguins. On sandy beaches we searched for tracks in the sand above the tide line. On all beaches we watched for drainage channels, creeks, or trails leading into the forest. Areas of kiekie (*Freycinetia banksii*) were targeted, especially when adjacent to the beach. Unfortunately, kiekie is frequently impenetrable and we could only check kiekie zones from the outside even when we knew Tawaki were nesting within. Tawaki generally choose wet areas for nesting, hence our emphasis on small creeks. A 'check' of a drainage channel or trail involved following it for 20-50 m. Although Tawaki may nest up to 200 m inland, signs of the colony (tracks, birds, scratches on rocks, faeces) can usually be found within a short distance of the forest margin and the nearest nests are almost always within 50 m.

When penguins were located, they were approached cautiously and a count made of nests and birds. Two birds standing together were treated as a pair. A 'nest' was counted if i) a single bird was prone on a nest site, ii) a single bird was upright but clearly attached to a site (an egg can usually be seen if an incubating bird is upright), iii) eggs were seen in a nest whether or not a bird was present, or iv) a pair was present. On the rare occasions when a pair did not appear to be associated with an obvious nest site, a nest was still counted on the assumption that such birds represented a breeding unit that had not yet settled on a nest site. A nest was not counted for single birds on empty nests (we assumed that a single bird sitting tight had eggs).

Tawaki lay two eggs, about 4 days apart (Warham 1974). Only the larger, second-laid egg hatches in up to 50% of nests because the other is lost during incubation (St Clair 1992). Newly-laid eggs become dirty and stained during the first week. Thus a clean egg indicates a nest in which incubation has just begun, and 1-egg nests indicate that enough time has passed for egg-loss to occur (probably at least a week if the remaining egg is dirty). Information on number and discolouring of eggs can therefore be used to make broad estimates of when incubation began and is provided in the colony descriptions below. Details on number and discolouring of eggs is presented separately as we frequently saw eggs without determining clutch size. Also, sightings of eggs were routinely fleeting and in poor light and discolouration was not always recorded even if the clutch size was determined. Thus the reports: '17 nests', '2x2 eggs, 2x1 egg'; '3 nests with 1 clean egg'; mean respectively: 'of 17 nests there were 2 nests containing 2 eggs and 2 nests containing 1 egg' and 'there were 3 nests that contained a clean egg'. The nests referred to in each phrase might or might not overlap because clutch size might not have been determined for any of the three nests containing a clean egg and discolouration might not have been recorded for any of the 3 nests in which clutch size was known.

We are confident that most larger colonies (i.e. 10+ nests) in the survey area were located. However, our ability to obtain precise counts of nests varied with habitat. Most difficult were colonies under kiekie, and scattered nests under coastal scrub. The former were frequently either completely inaccessible or our presence was too disturbing for the birds; counts were only possible by sitting near the edge of the colony and listening. The latter were likely to go undetected because there was little sign of their existence and isolated birds rarely vocalise. We obtained good counts for colonies under tall forest, among rocks along coastal margins, and in caves or dugouts/burrow systems.

Minimising disturbance to penguins was given a higher priority than obtaining accurate counts. In some cases we remained on the edge of penguin colonies and obtained counts by watching and listening. Locations at which counts were either rushed, or could not be made precisely, are noted in the results. We assumed that nests for which we obtained information about contents were a random sample.

RESULTS

Nest Site Characteristics

Over the six years of the survey, we have seen examples of most or all of the locations in which Tawaki nest, and provide a summary of the colony and nest site characteristics here. Tawaki nest in a wide variety of conditions and habitats. Several generalisations are possible, although we emphasise that exceptions to all these generalisations can be found:

i) Colonies are small, ranging from 1 to 25 nests. In areas where more than 25 nests can be found, they tend to be either loosely aggregated into smaller colonies, or scattered along the coastline with no obvious colony structure. Except in caves, it is rare for more than 3 nests to be within 1 m of each other.

ii) Nesting areas are wet and cool. Colonies on steep slopes are usually in a drainage gully and/or face towards the south. Dry caves, well-drained sites, north-facing slopes, ridge-tops, etc, are infrequently used by Tawaki for nesting. Despite the preference for wet sites in general, individual nests are rarely in sites prone to flooding although they can become quite muddy.

iii) Nesting areas and individual nests are well shaded. Most Tawaki nests that might be regarded as in the 'open' (i.e. without the shelter provided by a cave, dugout or burrow) are under dense vegetation, frequently with a very low canopy (kiekie is typically extremely dense from the ground to about 3 m). Nests along the coast (i.e. not within adjacent forest) are typically among large rocks, in small caves, or under scrub vegetation such as flax (*Phormium* spp).

iv) Colonies and access routes can be on terrain varying from flat to quite steep. However, Tawaki do not seem to be as adept as Little Penguins (*Eudyptula minor*) at negotiating steep slopes.

v) Open or exposed nests usually have some form of protection on one side, such as a rock wall, a flax bush, or a log.

vi) Most colonies appear to have landings on rocky points or beaches. However, Tawaki will also land on boulder and sand beaches and they may have no preference for landing terrain, as rocky beaches predominate in Fiordland and South Westland.

TABLE 1 - Dates of survey and counts of Tawaki between Bruce Bay and the Hope River, for surveys conducted by DoC personnel, 1992-1994. Sites are listed from north to south.

Date	Location	Nests	Adults
12, 28 Aug 1992	Heretaniwha Pt	54	85
17-19, 30 Aug-1 Sep 1993	Paringa R-Waterfall Ck	133	166
17, 18 Aug 1993	Moeraki R-Whakapohai R	21	29
13, 16 Aug 1993	Whakapohai R-Murphy Bch	24	33
31 Aug, 2, 27 Sep 1993	Knights Pt-Ship Ck	11	11
15, 23, 24 Sep 1993	Jackson Head	316	323
13-15 Sep 1994	Smoothwater Bay-Homminy Cove	0	0
13-15 Sept 1994	Stafford River-Teer Ck	32	32
16-20 Aug 1994	Teer Ck-Cascade Pt	260	680
5-9 Sep 1994	Cascade R-Hope R	20	26

Bruce Bay to Hope River

A summary only of this information is provided here (Table 1). For more detail, the reader should contact the DoC West Coast Conservancy. Main areas of concentration were between the Paringa River and Waterfall Creek, on Jackson Head, and between Teer Creek and Cascade Point. Totals of 871 nests and 1,385 Tawaki were found.

Hope River to Gorge River

Six colonies were located by DoC staff between the Hope River and Sandrock Bluff on 29 - 31 August 1995. Numbers of nests were (north to south): 8, 12, 14, 11, 13, 15. Totals were 73 nests and 105 birds.

A Southern Heritage/University party walked the coastline between Gorge River and Sandrock Bluff with one dead bird being the only sign of Tawaki. However, the search was not intensive as this section had been assigned to DoC (who were prevented from doing it by weather). The beach from Gorge River to Spoon River was sand, and no Tawaki tracks were seen. From Spoon River to Sandrock Bluff was boulders. Drainage gullies and small creeks were not checked.

Big Bay to Gorge River

This section was surveyed south to north from 20-24 August 1995 by I. McLean, P. Bell, V. Smytheman and N. Williams. Our sightings corresponded with the experiences of Robert Long, a resident at Gorge River for about 12 years, who reported that Tawaki are routinely seen on the beach for 1.5 km south of the small airstrip on the south side of the river after which they are rarely seen until Awarua Point. Long reported a large (typically 10-20 nests) colony on Awarua Point that is under forest, probably directly inland from Crayfish Rock on the south side of the Point. Locals at Big Bay indicated that we would see Tawaki at Crayfish Rock. We found sign but did not locate the colony despite camping at Crayfish Rock overnight.

Awarua Point, 20-21 August. The search was intensive on the south side, but weather conditions were poor. The coastal terrain above the rocky beach west of Crayfish Rock on the outer point consisted of an extensive swamp, unsuitable for Tawaki. About 0.5 km along the northern side of the point the coastal terrain became steeper and one Tawaki was heard calling from kiekie on a slope about 20 m from the beach. This colony appeared to be small as there were no obvious tracks into it. However, the kiekie was impenetrable and no count was obtained. One Tawaki was seen on the beach 1 km further north. The coastal vegetation between Awarua Point and the Hackett River was steep and dense, and our search was restricted to checking creeks and listening.

Hackett River - Gorge River, 21-23 August. No Tawaki or sign on the mostly sandy beach between the Hackett River (camp 21 August) and Longridge Point (camp 22 August). The beach flats were dominated by flax with little kiekie and there were many drainage channels, all of which were checked. No penguin tracks were found on the sand, nor were any birds seen on the beach. We are confident that the absence of Tawaki along this stretch of coast is a true result, although occasional nests among the flax would have been missed. The first penguins were found as we approached the Gorge River, as described below.

Gorge River, south side, 23-24 August: Small creek 200 m south of airstrip. Colony on slope 50-200 m inland. 17 nests, 24 birds. 2x2 eggs. 2 nests with 1 clean egg, 1 with 2 dirty eggs. Therefore, most laying within the previous week. One broken egg we attributed to Weka (*Gallirallus australis*), although Robert Long had not seen Weka in the area. One Tawaki heard calling in flax adjacent to the beach 20 m south of airstrip. The flax was searched but no nests or birds were found.

One km south of the airstrip is a small point. Immediately south was a small creek with a colony under forest. 25 nests, 43 birds. 2x2 eggs, 1x1 egg (dirty), 3x0 eggs. 5 nests with 1 clean egg. Most laying completed within the last week.

Between the two large colonies above were 2 large boulders with a small creek. 1 nest and 1 bird at the creek entrance.

Two birds on the beach 300m south of the southern colony above.

Martins Bay, 20-26 August

A team consisting of C. Challies, D. & R. Calvert and G. Williams was based at the Martins Bay hut and searched north to Penguin Rock, Big Bay (5 km north of Long Reef Point), and south to 1 km beyond the south point of Martins Bay. Martins Bay is a wide sweeping sandy beach ending as a spit at the northern end just inside Long Reef Point. At the southern end the beach merges into a rocky point, with steep sides covered in dense forest.

Long Reef Point: counted on 20, 23-25 August. Nests in caves, around and under huge boulders, and under dense kiekie. All searching was between the coastal walking track (50-100 m inland) and the sea, except for small areas north and east of the old hut site (located 200 m south of the point) where penguins nest in caves and amongst logs. Searches and counts on the point were intensive and detailed. Along the north coast

TABLE 2 - Counts of Tawaki on the south side of Yates Point in different years.

Date	Nests	Birds	Personnel
17 Sept 1986	259	329	K. Morrison, A. Wright
22 Aug 1994	124	205	K. Morrison, R. McGarry
11-12 Aug 1995	266	560	D. Eason
20-21 Aug 1995	155	267	Heppelthwaite <i>et al.</i>

towards Big Bay, intensive searching was impossible because of dense kiekie although Tawaki were heard up to about 500 m from the point.

On the point itself: 41 nests, 48 birds. At the base of the reef, south side of the point: 18 nests, 22 birds. Along the north coast: 9 nests, 10 birds, more present.

There was a wide range of nesting stages. 2 nests contained no eggs, 2 nests had 1 egg but were not yet being incubated, 5 nests had 2 eggs with 1 clean egg, 2 nests had only 1 dirty egg (indicating egg-loss had occurred), 20 nests contained 2 dirty eggs, 1 nest hatched on 23-24 August. Clearly, there was one unusually early nest in this area, whereas most birds were probably in early-mid incubation and a few were still laying.

South Martins Bay, 22 August. Searches were conducted to about 1 km south of the rocky point. Tawaki were found at two sites, one adjacent to the old boat landing half way between the sandy beach and the point; the other 100m east of the point. The first was a compact group of nests about 50 m inland among logs under open forest. The second was a small group by a clearing, 30 m inland. 16 nests, 22 birds. 5x2 dirty eggs, 1x1 dirty egg, 1x1 clean egg. Breeding stage similar to Long Reef Point.

Coast, north of Long Reef Point, 26 August. From about 500 m past Long Reef Point, no sign of Tawaki was found until Penguin Rock, 5 km from the point, and 3 km from the sandy beach of Big Bay. Nests were in two small colonies on either side of the outcrop that forms Penguin Rock, in rock fissures or under large boulders. 11 nests, 15 birds. 5x2 dirty eggs.

Yates Point to Sydney Beach, 20-25 August

A team consisting of S. Heppelthwaite, D. Morrison, P. Riley and D. Wilson attempted to survey from John O'Groats River to Martins Bay, but were blocked by weather and tide at Sydney Beach.

There is a large concentration of Tawaki on Yates Point, consisting of nests and small colonies scattered through thick kiekie, coastal scrub, flax and boulders along the coastal margin, mostly on the south side of the point for about 1.5 km. D. Eason (pers. comm.) noted that the large number of seals made nesting in the flax hazardous, and Heppelthwaite *et al.* found the flax-covered flats to be too swampy for nesting penguins. Counts on Yates Point have been made by several parties in recent years (Table 2). The results differ substantially, due presumably to factors such as the difficult terrain, variation in the number and experience of personnel, the time spent searching by each party,

and the area covered. Morrison's data (Table 2) suggest that there has been a decline at Yates Point. The three later counts taken together neither support nor refute that conclusion.

John O'Groats - Yates Point, 20-21 August. No Tawaki were found from John O'Groats River to 1.5 km south of Yates Point, after which penguins were encountered in scattered small colonies to 200 m along the north side of the point, mostly within 20 m of the beach. To make the counts in Table 1 comparable, 19 nests and 33 birds found on the north side of the point were not included in the total for Heppelthwaite *et al.* Thus their complete total for Yates Point was 174 nests and 300 birds. Some clean eggs were seen, indicating that some birds had laid only recently.

At a creek 800 m north of Yates Point, 1 bird seen, 1 heard. 1.5 km from Yates Point is a small creek: 2 nests, 4 birds in forest behind the kiekie. Overnight camp at Professor Creek.

Professor Creek - Sydney Beach, 22 - 23 August. Beaches consisted of rounded boulders against truncated alluvial fans between steep forested spurs. 1 nest and 1 bird were found near a small creek half way between Professor Creek and Madagascar Beach (which is immediately south of Sydney Beach; Fig. 1). The survey was intensive from Professor Creek to Madagascar Beach.

DISCUSSION

The number of of Tawaki nests for the entire region from Milford Sound south is about 850 nests (Studholme *et al.* 1994). This total includes an estimate of 100 nests for Stewart and the Southern Titi Is, and some adjustment for undercounting on Breaksea and the Shelter Is. To that total needs to be added the 871 nests recorded by DoC north of the Hope River, 389 reported here (or 481 if Eason's 1995 count on Yates Point is used), and an estimate of 150 nests on Open Bay Is (McLean & Russ 1991), for a total of 2,260 (2,352).

Numerous reviewers have requested comments on the accuracy and repeatability of the counts reported in the series of articles that constitute the complete survey of Fiordland Crested Penguins (see Literature Cited). Some have also requested validation and/or calibration of our counts. What we can offer is the following.

The counts represent a minimum estimate. Double counting of nests was unlikely as all recording was by one person who confirmed the location of each nest while the group moved steadily through the colony. Our emphasis on minimum disturbance meant that we did not double-count colonies (we walked through the colony once only). However, at some locations the terrain required us to walk back through the colony. It was rare to find previously unrecorded nests when this occurred.

Time, cost and logistic constraints meant that validation of the counting procedure was never a viable option. Rather, we focussed on using a simple procedure that was quickly learned by inexperienced personnel. This procedure should give comparable counts at different times and places as long as the surveying personnel do as we did: have one person assigned to record the count, move slowly as a band just once through the colony, and complete the count in 30-60 mins (for a colony of 10-20 nests spread

along a drainage channel). The discrepancy in counts between Eason and Heppelthwaite *et al.* in 1995 on Yates Point (Table 2) may seem an indication that the counting procedure has low repeatability. Working on his own, Eason spent about the same amount of time conducting the count as the four people making up Heppelthwaite *et al.*, yet he found 58% more nests. The discrepancy can be explained by three factors: 1.) weather: Eason's count was made in ideal conditions after a dry period, and he searched areas on the flax-covered flats that were rejected as "too wet" by Heppelthwaite *et al.*, who made their count in atrocious conditions; 2.) habitat structure. The nests at Yates Point are only loosely organised in colonies in large areas of dense scrub, including kiekie and flax that are virtually impenetrable; 3.) experience. Eason was more experienced at finding Tawaki nests than Heppelthwaite *et al.* were, and any difference in experience is most likely to affect the count in habitats such as at Yates Point.

We have not attempted to validate the counting technique, primarily because of the problem of disturbance. Minimising disturbance was always our highest priority, and validation requires repeated movement through a colony, preferably every time a new party begins work. Without validation, we cannot assess the level of confidence in the counts we provide and no estimate of variance can be attached to our population estimates. Logistically, validation would have been difficult even if the required disturbance was deemed acceptable, because of the number of people involved in the surveys. With respect to this survey, we can provide no solution to the validation issue. Future surveys would best be conducted by one small party that targets the areas we have identified as containing most penguins. Unfortunately, the scale of the enterprise makes such an exercise unlikely.

We only counted nests that were being used, except for a few occasions when a pair of birds were not clearly established at a nest site. Also, the methodology should have eliminated double counting. Thus our counts are much more likely to underestimate than overestimate the true total because some nests were presumably missed (particularly at sites like Yates Point), some small colonies and isolated nests have presumably not been found, and a few areas of coastline have not been visited. We consider it unlikely that >10% of nests are missed at colonies in habitat where counts are straightforward. We also consider it unlikely that we have missed >10% of the breeding locations for the species, or that we have missed any major breeding locations. For sites where counting is difficult (eg. Yates Point, the north side of Long Reef Point, some parts of Breaksea and Taumaka Is, parts of the coast south of Jackson Head) it is impossible to estimate how many nests were missed using currently available information.

As a first attempt at providing a final count of nests for the species, we assume undercounting by 20%, resulting in a final estimate of 2,712 (2,822) nests for the species annually. Realistically, it appears that there are 2,500-3,000 nests annually.

We believe that all the major nesting areas of Tawaki (>100 nests) have now been identified. These are, from south to north: Codfish I., Solander I., Breaksea and adjacent islands, Shelter Is (Doubtful Sound; D. Eason obtained higher counts there than the Southern Heritage/University counts reported in McLean and Russ 1991), Yates Point, Cascade Point and the coast north, Jackson's Head, the Open Bay Is,

and the coast south of the Paringa River. Additionally, there are good numbers of birds, approaching 100 nests, south of Hope River, south of Gorge River, and at Martins Bay. Many smaller isolated colonies have been identified.

Surveys are still required of the coastline between Sandrock Bluff and Gorge River, on Awarua Point (south side, near Crayfish Rock), between Madagascar Beach and Martins Bay, on the south coast of South I. east of Puysegur Point, and the west coast of Stewart I. including the Titi Is. In October, 1995, during a sampling trip throughout Fiordland to collect blood for a species-wide genetic survey, we located two previously unknown small colonies in Doubtful Sound and sign of two old colonies (now vacant) in Dusky Sound. Clearly, there will be other small colonies that we have not located in the southern fiords, but these are unlikely to yield large numbers of nests.

Although mainland Tawaki colonies tend to occur on points, there are some curious gaps in distribution along the mainland coastline. For example, few or no colonies were found between Gorge River and Awarua Point (where a colony remains to be confirmed), and the surveyed section between Martins Bay and Yates Point. Many drainage channels through forest occur in these areas suggesting that Tawaki are not limited by nesting habitat. More likely is that they are limited by unknown factors offshore, possibly compounded by problems onshore, such as predators. Whether Tawaki are subject to significant mortality from introduced predators is not known, although we have received anecdotal reports of adults and chicks being attacked by mustelids.

Many Tawaki are protected by virtue of their isolated and inaccessible nesting locations. However, with respect to management, the biggest area of concern is the coast north of Cascade Point where large concentrations of nests occur in areas accessible to people and dogs (people who take dogs to beaches usually have no interest in seeing penguins).

Increasing interest from tourists to see penguins is resulting in disturbance at a few accessible colonies, although it is not yet known if that disturbance will have any long-term impact. If the colonies fail, then the tourists will presumably go elsewhere. Thus, it would be better to manage frequently-visited colonies to balance the needs of penguins and tourists, than to have the colonies fail because disturbance levels are too high. Unfortunately, not enough information is available on tolerance of humans by Tawaki for informed management decisions to be made. DoC has begun a long-term monitoring programme designed to assess general population trends for Tawaki, information from the genetic survey will be available soon, and the species-wide survey provides a baseline for future analyses of abundance and distribution. However, the most immediate need is to ensure that the somewhat conflicting needs of tourism and protection are rationalised.

ACKNOWLEDGEMENTS

We thank Daryl Eason (Department of Conservation, Te Anau) for providing unpublished reports and allowing us to cite his results. Shirley Russ (Southern Heritage Expeditions) has provided extensive administrative assistance during the entire Tawaki survey. Dept. of Conservation surveys were conducted by the field centre staff at Fox Glacier and Haast, with assistance from many sources. We thank Air Fiordland and Southern Lakes Helicopters for transport. Various locals, especially Robert Long (alias Beansprout), shared their Tawaki experiences with us. Funding was provided by the New Zealand Lotteries Board, the University of Canterbury, Southern Heritage Expeditions and the Department of Conservation.

LITERATURE CITED

- McLEAN, I.G.; RUSS, R.B. 1991. The Fiordland Crested Penguin survey, stage I: Doubtful to Milford Sounds. *Notornis* 38: 183-190.
- McLEAN, I.G.; STUDHOLME, B.J.S.; RUSS, R.B. 1993. The Fiordland Crested Penguin survey, stage III: Breaksea Island, Chalky and Preservation Inlets. *Notornis* 40: 85-94.
- RUSS, R.B.; McLEAN I.G.; STUDHOLME, B.J.S. 1992. The Fiordland Crested Penguin survey, stage II: Dusky and Breaksea Sounds. *Notornis* 39: 113-118.
- ST CLAIR, C. 1992. Incubation behavior, brood patch formation and obligate brood reduction in Fiordland Crested Penguins. *Behav. Ecol. Sociobiol.* 31: 409-416.
- ST CLAIR, C.; McLEAN, I.G.; MURIE, J.O.; PHILLIPSON, S.; STUDHOLME, B.J.S. *in press* Fidelity to nest site and mate in Fiordland Crested Penguins. *Marine Ornithology*
- STUDHOLME, B.J.S.; RUSS, R.B.; McLEAN, I.G. 1994. The Fiordland Crested Penguin survey: stage IV, Stewart and offshore islands and Solander Island. *Notornis* 41: 133-143.
- WARHAM, J. 1974. The Fiordland Crested Penguin *Eudyptes pachyrhynchus*. *Ibis* 116: 1-27.

Received 20 May 1996, revised 17 January 1997, accepted 24 January 1997