

## The yellow-eyed penguin (*Megadyptes antipodes*) on Stewart and Codfish Islands

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**Abstract** Recent estimates of the number of yellow-eyed penguin (*Megadyptes antipodes*) throughout its range have led to a revised figure for the total population of this species. The number of breeding pairs on Stewart and Codfish Is together with the Auckland Is remain the least well known. Ground searches in 1984-1994 on Stewart and Codfish Is suggested fewer birds than expected. The results of 102 ground searches of 61 localities and 118 beach counts (> 700 h of observations) support a lowering of earlier estimates to c. 170-320 pairs on Stewart Is and its outliers, and 50-80 breeding pairs on Codfish Is, giving a total of 220-400 pairs for this region. The relatively few breeding pairs found on Stewart Is, based on the length of coastline and hinterland area available, together with the small groupings, suggest that predation of adults and chicks may be a factor in the relatively low numbers of this species on Stewart Is itself.

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**Keywords** yellow-eyed penguin; *Megadyptes antipodes*; Codfish Is; Stewart Is; census; ground search; breeding; predation; habitat

### INTRODUCTION

The yellow-eyed penguin (*Megadyptes antipodes*) is one of the least abundant penguin species in New Zealand. Until recently, few conservation measures had been implemented, although since the mid 1980s it has enjoyed growing protection from several public and private agencies, who have focused their efforts on habitat protection and predator control in known breeding areas. The IUCN has listed it as an endangered species, though Hilton-Taylor (2000) suggests that efforts towards its conservation are likely to lead to its listing being downgraded to near threatened.

The survey of yellow-eyed penguins began on Stewart and Codfish Is in 1984 to estimate the number of breeding pairs there as part of an assessment of the status of the species throughout its range. In this paper, I attempt to bring together many of the earlier observations, including those by Ogilvie-Grant (1905), Falla (1935), Richdale (1942), Dell (1950), and Blackburn (1968), and surveys made in the 1980s as part of the writer's programme, and more recent surveys by the Department of Conservation (King 1991; Roberts 1992). Not all surveys covered the same areas and this paper attempts to bring together much of the scattered information.

The number of breeding pairs on the mainland islands of New Zealand has been documented

since 1980 (Darby 1984, 1985; Darby & Seddon 1990; Seddon *et al.* 1990; Marchant & Higgins 1990; Moore 2001) and numbers for Campbell Is and the Auckland Is were estimated in 1987-1998 (Moore 1992, 2001). The Yellow-eyed Penguin Trust co-ordinated a nest search over the period 1999-2001 (Blair 2000; Anon 2002).

Richdale (1957) estimated that 60% of the yellow-eyed penguin population were breeding birds. Hence, the number of birds can be estimated by counting nests, or by counting birds crossing the beach (Darby 1985; Moore 2001), although neither method is straightforward.

The pre-European breeding habitat of this species was primarily in coastal podocarp/hardwood forest and mixed-species scrub on slopes above landing areas. Very little coastal forest remains on the east coast of the South Island (Forrest 1963) though it remains the dominant habitat in breeding areas south of the South Island. Yellow-eyed penguins are secretive nesters that avoid visual contact between pairs at adjacent nest sites during the breeding season, so nests tend to be some distance apart and well hidden. Unlike most other penguins, the yellow-eyed is not colonial. Nests are usually a minimum of 4-6 m apart in habitats such as New Zealand flax (*Phormium tenax*) that maximise visual barriers between pairs, but more usually 30-250 m apart in relatively unmodified coastal forest habitat. Single isolated pairs are known, often many

kilometres from their nearest neighbours, and some birds nest at least 1 km inland.

## METHODS

Data from ground surveys, beach counts, sightings, unpublished, and anecdotal reports from several individuals were compiled to document the distribution and number of birds breeding in the area. Surveys usually entailed walking coastlines looking for penguin sign: distinctive footprints on sandy beaches; signs of penguin faeces can be seen on the ground at entrances to forest and scrub-covered breeding areas above high-tide mark on rocky beaches; and distinctive claw marks in mud on slopes. Adult penguins are on or near their breeding grounds all year (Darby & Seddon 1990) though, in years when food supplies are poor, some adults may migrate north with juveniles in Feb–May (pers. obs.). During the breeding season (Sep–Mar), surveyors attempted to locate nests and, where appropriate, noted the stage of breeding.

For beach counts, observers selected a commanding view over a beach or landing site, and counted the birds leaving and entering the water over a given period. Outside the breeding season, birds were counted from early afternoon until darkness. The duration of the counts varied with season. Counts during the breeding season (Sep–Mar) were made over 8–14 h, those during Apr–Aug, 4–6 h. Most counts used here were made in early Oct (incubation) and early Dec (guard stage) (Darby 1985), although Moore (1992; Moore *et al.* 2001) successfully used counts made outside the breeding season to estimate numbers on Campbell Is. Where there are many breeding pairs, beach counts are a reasonably reliable method of estimating the number of birds (Darby 1985; Moore 1992).

The data presented here include areas searched in which penguins were not found as well as where they were found. It is important to know where penguins are not found, especially for future survey work.

## RESULTS

### Historical reports and surveys 1942–1968

The 1st report by a European of yellow-eyed penguins on Stewart Is was by J.G. Black in 1872 (Richdale 1942). Reischek (1888), when storm-bound in Evening Cove in Port Pegasus Harbour in Jan 1888, recorded them breeding. Mr J. Bragg (pers. comm.) reports that yellow-eyed penguin eggs (white eggs only), were collected from Pikaroro, Chew Tobacco, Little River, and Bungaree in the 1920s and 30s, “a kerosene tin was filled”. Oliver (1926) recorded it ashore twice, at Old Neck, and near Horseshoe Point. According to Falla (1935), E.F. Stead found them on the Big South Cape Is and Codfish Is. However, Stead, informed Richdale (1942) that they were not on the South

Cape group, but confirmed that they were on Codfish Is. Guthrie-Smith (1914) provided an account of their breeding behaviour, and there were additional records by Oliver (1926, 1930) and Falla (1935). Falla considered them abundant where there were landing places and cover. It was not until Richdale visited Stewart Is in 1938 that an attempt to estimate the number of breeding pairs in the area was made.

Richdale (1942) reported them on Bench Is, The Neck, Ocean Beach, Paterson Inlet, Evening Cove (near Halfmoon Bay), on the north-east end of Stewart Is, at Ernest Is at the southern end of Mason Bay, and at Port Pegasus. When Richdale was camped on Bench Is from 17 to 24 Dec 1938, he found many chicks, and what he considered to be an unusual number of empty nests: after 6 days he had recorded 27 nests, 19 with 1 chick, and 8 with 2 chicks, and estimated that there were 50 pairs on the island. Anderson (1981) visited Bench Is in Dec 1979 and recorded that both yellow-eyed penguins and blue penguins (*Eudyptula minor*) were common. E. Spurr (pers. comm.) visited Bench Is in Dec 1979, Sep–Oct 1980, Mar 1981, Jun 1981, and Nov 1982 and estimated that the population was c. 50 pairs.

Codfish Is (1400 ha) now has no introduced predators after weka (*Gallirallus australis*), brush-tailed possum (*Trichosurus vulpecula*), and kiore (*Rattus exulans*) having been progressively removed over the past 23 years. Dell (1950) recorded that the yellow-eyed penguin was a common nesting species, with concentrations especially near beaches and streams, from which pathways radiated inland, usually along ridges, forking constantly, so that the nests were widely dispersed, and sometimes well inland. All nests examined contained 2 eggs. Although Dell agreed with Falla that the penguin was common (Dell 1950), he noted that the numbers on Codfish may have declined, without giving an explanation for that view.

During a visit of 11 days in Dec 1966, Blackburn (1968) observed several nest sites already vacated by the young birds – except 1 with 2 half-grown nestlings – in a deep dry creek bed with high overhanging banks. The site, judging from a sketch map, was apparently in Penguin Bay.

### Recent surveys: 1980–1992

The 1st formal surveys on Stewart Is took place in 1984–85, with the assistance of Richard de Hamel and Ted Oakes. Department of Conservation staff (led mostly by Sandy King) have made several surveys. One in 1989–1991 involved land searches of c. 50 km of coastline from Ocean Beach to Big Kuri Bay and included 48 areas. More recently the Yellow-eyed Penguin Trust surveyed Stewart Is in 1999–2000 (Anon 2002).

**Table 1** Location (latitude and longitude, decimal degrees) and number of yellow-eyed penguins (*Megadyptes antipodes*) on Stewart Is and Codfish Is, between 1980 and 2002. Min pairs, minimum estimated number of breeding pairs found; Max pairs, maximum number of breeding pairs over all counts; No. beach counts, total counts; Years counted, These are supported by ground searches carried out in the years noted in Col 8. Full details of actual times, dates of censuses and nest searches have been lodged with the Department of Conservation, Stewart Island.

Locality	Lat.	Long.	Min pairs	Max pairs	No beach counts	Years counted	Ground search
Long Harry Bay	46.6915S	167.7906E	6	12	13	1987,88,89,90,92	1984,85,85,93,94.
West Smoky Beach	46.7028 S	167.8441E	5	11	2	1990,92	1984,85,
East Smoky Beach	46.6954 S	167.8594E	6	10	0		1985
Yankee River	46.7062S	167.8906E	6	11	3	1987,92,93	1984,85,92,93
Lucky Beach	46.7115S	167.9364E	1	2	0		1990,92
Rollers Beach	46.7695S	167.9883E	6	12	0		1984,92
Murray Beach	46.7888S	168.0017E	5	10	2	1990, 92	1984,85,
Golden Beach	46.8034S	168.0195E	5	10	1	1992	1990,91,92,93,94.
Big Bungaree Beach	46.8138S	168.0341E	3	5	0		1984,1985
Sawyers Beach	46.8333S	168.0823E	1	2	0		1985,87,92.
The Neck	46.9622S	168.1871E	3	5			1985,89,90
Ocean Beach	46.5916S	168.3111?E	6	10			1935,42,84
Chew Tobacco Bay	47.0113S	168.2092E	6	12	8	1989	1985,85,89,91.
Pikaroro Bay	47.0416S	168.2126E	3	6	3	1989,91	1989,90,91.
East Kaika	47.0839S	168.1825E	2	4			1990
Shelter Point	47.0985S	168.2293E	7				1985,91
Big Kuri Bay	47.1198S	168.0459E	2	4			1984,85
Port Pegasus	47.2174S	167.6994E	2	4			1888,1938,90
Pigeon House	47.2262S	167.6510E	4	7			1991
Broad Bay	47.2613S	167.5933E	6	10			1985,91
Doughboy Bay	47.0372S	167.6829E	4	8			1985
Masons Bay	46.953S	167.7041E	4	8			1985,
<b>Sub total</b>			<b>88</b>	<b>168</b>			
Edwards Island	46.8356S	168.2210E	5	10			1985
Bunkers Island	46.8666S	168.2684E	12	18			1935,1941
Bench I	46.9105S	168.2340E	30	50			1935,38,79,80,81,82
Ulva Island	46.9348S	168.1316E	3	5			1984,85
Tommy Island	46.9556S	168.1336E	4	8	6	1987,87,88,89,89,89	1984,85
Bravo Islands	46.9658S	168.1361E	6	10			1985
Weka Island	47.0614S	168.2195E	4	6	1	1991	
Noble Island	47.2162S	167.6547E	3	6			1985,91.
Anchorage Island	47.2124S	167.6762E	3	6			1991
Putauhinu Island	47.2172S	167.3797E	3	5			1991
Ernest Islands	47.2415S	167.6645E	3	6			1934,38,91
Ruapuke Island	46.7661S	168.5063E	6	12		1991,92	
Goose Island	47.1767S	167.5295E	2	4			1991
<b>Sub total</b>			<b>84</b>	<b>146</b>			
<b>Codfish Island</b>							
North West Bay	46.7532S	167.6248E	16	28	23	1983,87,89,90	
Penguin Bay	46.7875S	167.6578E	14	24	33	1983,87,88,89,90	
Sealers Bay	46.7618S	167.6515E	18	26	24	1983,87,89,90,91	1991,92,93.
<b>Sub total</b>			<b>48</b>	<b>78</b>			
<b>Grand total</b>			<b>220</b>	<b>392</b>			

Estimates of the breeding population in the larger breeding areas were compiled from data collected over several years and therefore reflect minimum and maximum numbers over the period in which estimates were made. Estimates were based on beach counts, nest searches, and historical and anecdotal reports.

#### Summary of beach counts and ground surveys

A total of 37 breeding areas (Table 1) were identified on and around Stewart Is between 1984 and 2002.

Areas searched where penguins were not found are listed in Table 2. There were 22 breeding areas on Stewart Is itself. An additional 16 were on islands close to Stewart Is, including the larger islands of Bench, Codfish, and Ruapuke. There are 3 major sites on Codfish Is: North West Bay; Penguin Bay; Sealers Bay. Estimates based on ground searches and beach counts suggest that there are 88-168 breeding pairs on Stewart Is, 84 - 146 pairs on the smaller islands surrounding Stewart Is, and 48-78 pairs on Codfish Is.

**Table 2** Location (latitude and longitude, decimal degrees) of areas searched in the Stewart Is area in which nesting yellow-eyed penguins (*Megadyptes antipodes*) were not found.

Locality	Lat.	Long.
Little Bungaree Beach	46.8206S	168.0422E
Sawyers beach	46.8333S	168.0823E
Lee Bay	46.8621S	168.123E
Halfmoon Bay	46.8920S	168.1527E
Ackers Point	46.8982S	168.1664E
Native Island	46.9174S	168.1549E
Faith, Hope and Charity I	46.9094S	168.1082E
Groper Island	46.9539S	168.1461E
Big Glory Bay	46.9839S	168.0996E
Salty Beach	47.0619S	168.1738E
Kellys Beach	47.0725S	168.1719E
Tikototahi Bay	47.0886S	168.1482E
Lords River	47.1045S	168.1058E
Horomamae Island	47.1256S	168.1625E
Albion Inlet	47.1711S	167.6714E
Bens Bay	47.1803S	167.6696E
Cook Arm	47.1971S	167.6147E
Shipbuilders Cove	47.2171S	167.6049E
Sylvan Cove	47.2343S	167.5591E
Kundy Island	47.1208S	167.5387E
Three Legged Woodhen	47.117S	167.5746E

## DISCUSSION

Although the estimates for yellow-eyed penguins on Stewart Is and its outliers are subject to unknown errors, the results presented here provide a baseline for future monitoring. By Jun 1991, the coast from Ocean Beach to Big Kuri Bay had been surveyed as well as possible. In the c. 50 km of coastline, 48 areas were checked during the 1989-91 breeding seasons, and penguins were found only in 10 areas (King 1991). Similarly, the Yellow-eyed Penguin Trust survey found penguins at only 7 sites (Blair 2000).

Not all areas where yellow-eyed penguins may be breeding around Stewart Is have been located yet or are accessible. Ground searches and beach counts are both subject to errors. Experience on the South Is has shown that ground search for nests in forested areas may underestimate the resident population by as much as 20-30%, including breeding areas that were missed as well as nests within breeding areas (author's unpubl. data). Extensive searches in South Is study sites has shown that only when searchers are very familiar with an area – nests sites have been identified from previous years' searches or searchers spend 2 or more days and nights in an area – can the error in a ground search be reduced to  $\leq 10\%$ . Estimates from beach counts also have errors, especially in areas that have  $< 8$  breeding pairs (author's unpubl. data). The month and time of day of a count also need to be taken into account when using beach counts to estimate the size of a

penguin population. Only frequent replication of counts can reduce this error.

During the period of the Stewart Is surveys (1983-94), the number of breeding pairs on the South Is ranged from 130 to 550. There is some evidence that trends in the South Is population are reflected by those on Stewart and Codfish Is. The mean weight of 12 chicks on Codfish Is on 20 Jan 1990 was 3.9 kg, and 7 days later it had declined to 3.7 kg (author's unpubl. data). The normal weight for chicks at this stage is 5-6.5 kg (Darby & Seddon 1990). A similar pattern was observed in the South Is populations with ultimately only 2 chicks, both hand-reared, surviving from the 1989-90 cohort (Gill & Darby 1993).

On Campbell Is, the penguin population declined by 45% between 1988 and 1992 (Moore 1992; Moore *et al.* 2001). However, at least some of the decline was attributed to predation by Hooker's sea lions (*Phocarctos hookeri*) (Moore & Moffat 1992). Further, it should be noted that the Department of Conservation census of Stewart Is in 1989-1991 (King 1991) was done at a time when breeding numbers on the South Is were very low (Darby *et al.* 1991).

The estimate of a combined population of 220-400 breeding pairs on Stewart and Codfish islands is the likely minimum and maximum number of breeding pairs that may be present in this region. Previous estimates were probably too high. Darby (1984) based his estimate on anecdotal reports of the species' abundance on Stewart and Codfish islands (Oliver 1926, 1930; Falla 1935; Richdale 1942; Dell 1950; Blackburn 1968), factoring in a likely density of breeding pairs of 0.64 pairs ha<sup>-1</sup> (based on a survey of the only remaining forested breeding site on the South Is). Early, unsubstantiated estimates of 470-600 pairs have been used in conservation planning documents (e.g., McKinlay 2001), which has led to concerns about declines in numbers of penguins on Stewart Is (Anon 2001; Mayston 2001). Other estimates have been more conservative: 350-450 breeding pairs (Darby & Seddon 1990), and a further reduction to 300-400 pairs (Marchant & Higgins 1990).

One of the most obvious findings from the present series of surveys is the lack of large breeding areas on the main Stewart Is in contrast to the relatively large breeding areas on nearby Codfish Is. There are at least 3 areas on Codfish Is with  $> 20$  pairs of yellow-eyed penguins. Other than Bench Is, in no other part of the Stewart Is area have  $> 12$  breeding pairs been recorded over the past 20+ years. Bench Is does not provide a useful comparison other than its area is c. 120 ha, but as with Stewart I. much of it is inaccessible to birds landing from the sea.

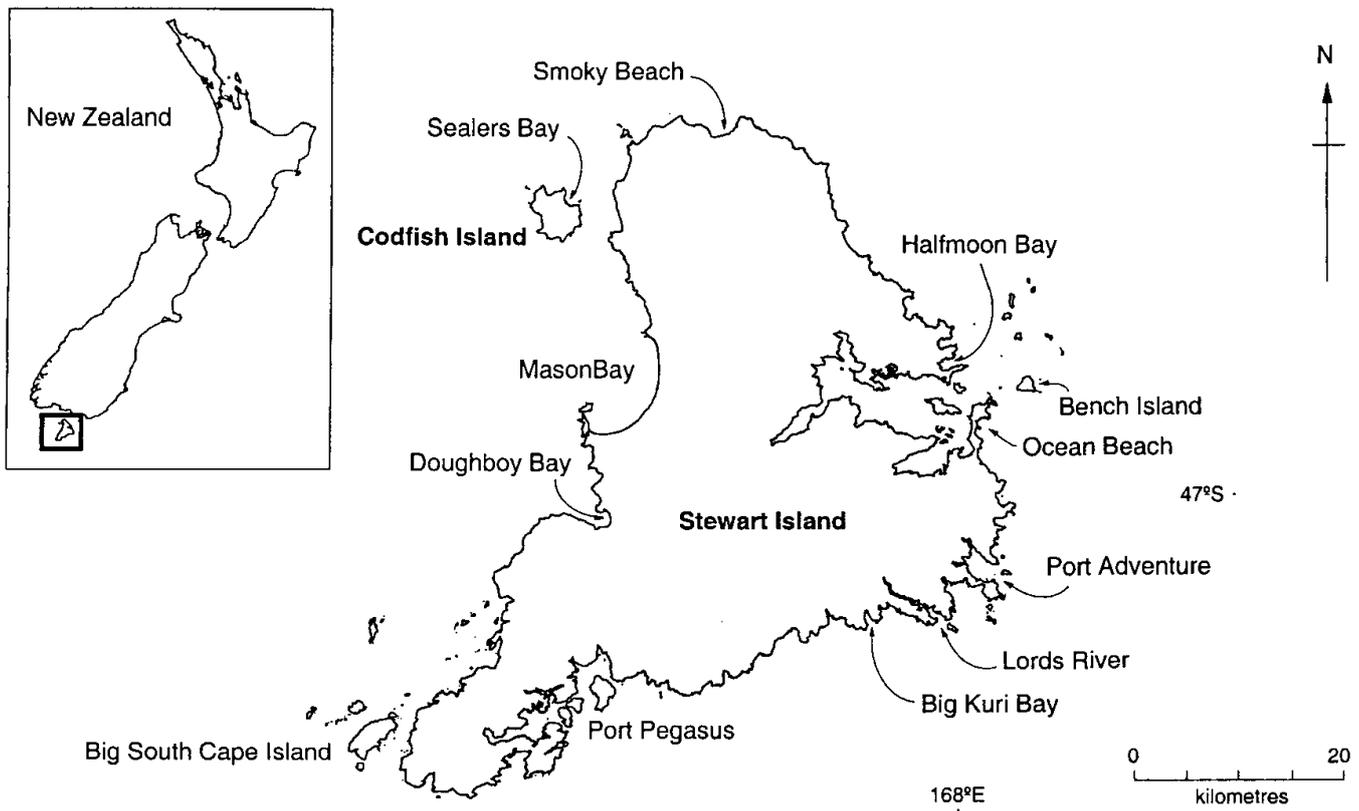


Fig. 1 Stewart Is, New Zealand, with localities mentioned in the text. Coastline length is >700 km.

The most likely reason for the lack of information on the yellow-eyed penguin population in the past is their unusual and little-understood nesting strategy. Nests have been found as far as 1 km inland and in forest are often  $\geq 250$  m apart. Nests are frequently well hidden in dense undergrowth in difficult and hilly terrain, which militates against gaining accurate estimates of the population. Populations of yellow-eyed penguins are known to fluctuate by  $-9$  to  $+17\%$  year $^{-1}$ , apart from the exceptional decline of 42% in 1990-91 (Efford *et al.* 1994).

Apart from natural fluctuations in a population, there are at least 5 factors that may influence the number of breeding pairs of yellow-eyed penguins on Stewart Is: predation on chicks and adults; habitat degradation by grazing mammals; accidental capture of birds in fishing nets; disease; and changes in the marine environment.

### Predation

It has been suggested that predation by cats (Anon 2001; Mayston 2001) may be a significant factor in the low number of yellow-eyed penguins on Stewart Is. This may well be so, but the argument was based on an outdated population estimate (McKinlay 2001), that made by Darby in 1984, rather than using the more recent and robust estimate of 300-400 pairs (Marchant & Higgins 1990). Cats are known to kill penguin chicks on the South Is, though the effect on the population has not been measured. They are, however, likely to

take penguin chicks on Stewart Is. The absence of large breeding aggregations on Stewart Is, as opposed to those on islands lacking predators, suggests that it would be valuable to investigate whether cats are limiting the population there.

The weka may be a significant predator on Bench Is where the population of these flightless rails is reported to be very high. Richdale (1942) recorded a pair of eggs being pierced by a weka's bill on Bench Is. St Clair & St Clair (1992) recorded that weka took 22 (19%) of 115 Fiordland Crested penguin eggs and 11 (20%) of 55 chicks that hatched on Taumaka, the larger of the Open Bay Is off the West Coast of the South Is. In all, weka were responsible for at least 30% of mortality assuming that all eggs were viable. Weka have been removed from Codfish Is and are reported to be absent from Stewart Is (P.J. McClelland pers. comm.). Predation of yellow-eyed penguins by Hooker's sea lions has been reported on Campbell Is (Moore & Moffat 1992) and on the South Is by Schweigman & Darby (1997). Sea lions may take penguins around Stewart Is though there are no reports.

### Habitat

The highest density of breeding yellow-eyed penguins is found on the South Is, where in many areas the dominant cover is New Zealand flax. Flax provides cover for nests and is an effective visual barrier between breeding pairs. It is harder for pairs to nest out of sight of each other in modified forests (pers. obs.) and it may be more

difficult in forests with populations of introduced herbivorous mammals as on Stewart Is. Less dense cover may be the reason for the low numbers breeding on Stewart Is. Houston (2002) commented on the recovery of the understorey on Codfish I. following the removal of possum and kiore, and Richdale (1942) commented on the impenetrability of Bench Is, which is also free of herbivores.

#### Accidental captures in fishing nets

Darby & Dawson (2000) reported that 72 yellow-eyed penguins had been captured in commercial gillnets. Most of the birds were recovered from South Is beaches. However, 2 were recovered from nets set off Stewart Is. The mortality of Stewart Is birds in nets may be under-reported Stewart Is (Darby & Dawson 2000), though accidental captures probably would affect both the Stewart Is and Codfish Is breeding populations. Drowning of penguins in gillnets is therefore unlikely to be a factor in the difference in density of breeding pairs between islands.

#### Disease

Investigations into the high mortality of adult yellow-eyed penguins in 1989-90 (Graczyk *et al.* 1995) suggested that avian malaria may have been implicated. Another investigation (S. McDonald – University of Otago, pers. comm.) suggested, however, that this may not be so, an observation which is supported by J. Gill (Invermay Research Station, pers. comm.). Ranum (1993) found low levels of parasites in the alimentary tract of yellow-eyed penguins and concluded that, under normal circumstances, the parasites would not affect the birds.

#### Marine conditions

The effects of El Niño and La Niña events resulting in perturbations of the marine environment are well known, particularly as the events relate to ocean productivity and the distribution of nutrients off the coast of South America. The flow-on effects on seabird populations, particularly penguins, has also been well documented (Boersma 1978, 1998; Hays 1986; Valle *et al.* 1987; Peacock 1995). A study by Perriman *et al.* (2001) of little penguins showed that in La Niña years, penguins bred later and that there were fewer double broods. Richdale (1942) also recorded substantial variation in numbers of breeding pairs of yellow-eyed penguins from year to year, as has the present study. Efford *et al.* (1994) reported that the adult population varied by -9 to +17% over the period 1982-92 with a single exceptional year (1989/90) when the population fell by 42%. Though it is unclear as to why such there was such a high mortality of birds that summer, population

declines have been associated with dietary shifts in this species (van Heezik 1990). Disease and predation aside, variation in ocean temperatures are likely to be the major causes of inter-annual population fluctuations and would tend to affect all areas.

Breeding areas with <5 breeding pairs appear to be particularly sensitive to oceanic conditions and have been known to be abandoned within a relatively short period on the South Is (pers. obs.). However, populations are sometimes re-established in such areas, up to 20-30 years later.

#### CONCLUSIONS

The lack of accurate historical records and the abundance of anecdotal reports are not sufficient reason to conclude that the yellow-eyed penguin population has declined on Stewart Is. The relatively few breeding birds located on Stewart Is compared to the relatively large aggregations on Codfish Is suggest that the reasons for the difference should be investigated. Predation by cats and severe depletion of the understorey by herbivores could be involved in any decline on Stewart Is. The fragmented breeding distribution on Stewart Is, with many small breeding aggregations contrasts with the few but large breeding areas on Codfish Is, and suggests that several factors, including habitat, may be limiting numbers on Stewart Is.

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