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POPULATION ESTIMATES OF YELLOW-EYED PENGUIN *(Megadyptes antipodes)* ON CAMPBELL AND AUCKLAND ISLANDS 1987-90

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ABSTRACT

The seasonal change in Yellow-eyed Penguin numbers using a landing site (or part of the beach where penguins moved to or from the sea) at Middle Bay, Campbell Island, was monitored between November 1987 and September 1988. Numbers were low during the incubation phase of nesting (November) and rose to a peak during the chick-rearing period (December-March) when most breeding birds were travelling to sea each day. Numbers were low during the moult (April) as most birds were ashore. Peak numbers occurred in May but declined subsequently because of sea lion disturbance and pre-breeding behaviour. A census of 172 landing sites on Campbell Island during May-July 1988 found 1625 penguins, which may have represented a total of 2000 birds, or 490-600 breeding pairs. Decreases in penguin numbers at several landing sites between 1988 and 1990 suggest the population may have declined by about 45%. A census of 115 landing sites on part of the Auckland Islands in November-December 1989 found 934 penguins, which may have represented a population of 420-470 breeding pairs. Allowing for a possible sparse population on the east coast of Auckland Island, 520-570 pairs is a very conservative estimate for the islands. The total Yellow-eyed Penguin population in 1988-1989 was approximately 5930-6970 birds, with at least 56% in the subantarctic.

INTRODUCTION

The Yellow-eyed Penguin (*Megadyptes antipodes*), or hoiho, is endemic to the New Zealand region and is one of the rarest species of penguin (Darby 1985). The breeding distribution ranges from the south-east coast of the South Island to Stewart Island, Auckland Islands and Campbell Island (Turbott 1990; Figure 1). This distribution pattern relates to the presence of sizable and productive continental shelf feeding areas and areas on land where mean summer temperatures are less than 16.5 °C (Smith 1987).

Unlike many species of penguin which nest in densely populated colonies, each pair of Yellow-eyed Penguins nests away from their neighbours (Jouventin 1982, Darby 1985). As they nest in scattered aggregations in

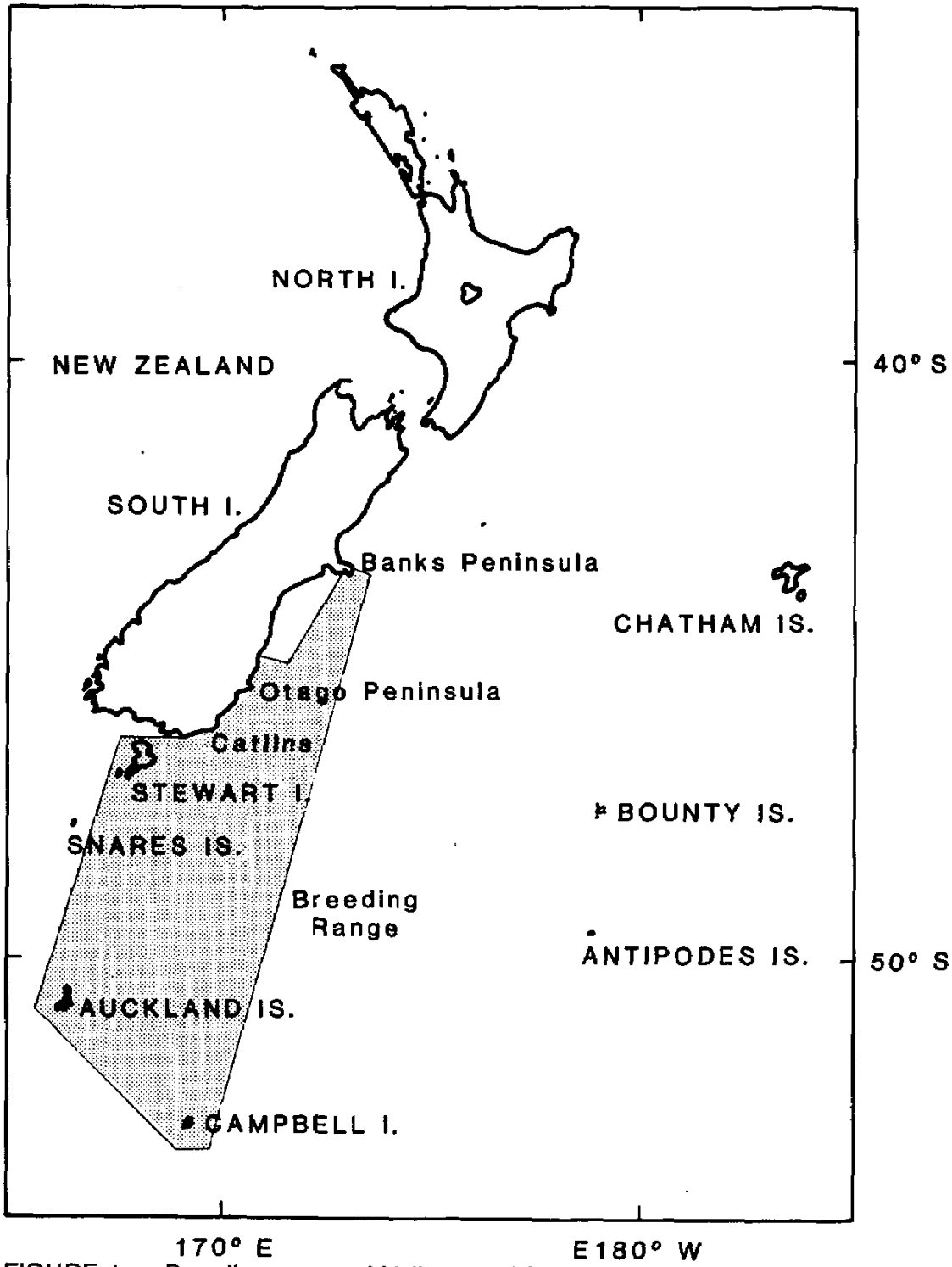

FIGURE 1 — Breeding range of Yellow-eyed Penguin in the New Zealand region

coastal forest and scrub, their numbers are difficult to assess (Darby 1989). Another unusual feature is that adult Yellow-eyed Penguins remain at or near their breeding grounds throughout the year (Richdale 1951, Seddon & Davis 1989).

Before human settlement, Yellow-eyed Penguins were probably in their thousands on the South Island. With the gradual clearance of the coastal forest breeding habitat, predation by feral cats, ferrets and dogs, disturbance

by stock and people, and occasional crashes of the food supply, the South Island population has been in decline (Darby & Seddon 1990).

Yellow-eyed Penguins received little scientific attention in the subantarctic after their discovery there in 1840 (Cassin 1856, Hombron Jacquinot 1841 & Gray 1844), apart from the collection of specimens for museums. Westerskov (1960) considered that there were fewer than 200 pairs on Campbell Island. In 1972 R. Nilsson and R. Russ of the New Zealand Wildlife Service estimated the total population at the Auckland Islands to be 80-150 pairs [1]. Based mainly on visits to Enderby Island, this estimate was revised to 200-250 pairs (Darby & Seddon 1990) and later to 250-350 pairs (J. Darby *in* Marchant & Higgins 1990).

In 1985-86, J. Darby[2] estimated that the total population of Yellow-eyed Penguins was 1544-2130 breeding pairs. Based on Richdale's (1957) figure of 40% non-breeding birds, the overall population was put at 5146-7100 birds, and the species was considered at the time to be the world's rarest penguin.

By 1987, Yellow-eyed Penguin numbers had been counted accurately only on the South Island. Population trends there had been monitored closely since 1981 by J. Darby, who developed a censusing technique based on simultaneous counts of penguins at landing sites by a large team of volunteers. These counts were made during October (incubation period) and December (chick guard stage) (J. Darby, pers. comm., Darby 1989). A reliable assessment of the subantarctic Yellow-eyed Penguin populations was obviously needed. This was essential to understanding the overall status of the species, especially as the mainland numbers had been declining. The collection of baseline data would also allow future counts to detect changes in the population.

In 1987-88 I spent one year on Campbell Island studying the Yellow-eyed Penguin population, and in 1989 I spent six weeks on the Auckland Islands to assess the status of the species there.

METHODS

I visited Campbell Island, which lies at 52° south latitude and about 660 km south of the South Island of New Zealand, from October 1987 to October 1988. I chose a study area at Middle Bay, part of Northwest Bay (Figure 2) to record the numbers of Yellow-eyed Penguins using the main landing site. I marked 78 breeding adults at 39 nests with metal flipper bands. Usually, penguins depart for sea in the morning and return in the evening.

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[1]. Darby, J.T. 1984. Interim report on the status, distribution and conservation of the Yellow-eyed Penguin *Megadyptes antipodes* in New Zealand together with a detailed summary of population numbers and distribution on the South-east Otago and Southland coasts. Unpublished report, Otago Museum, Dunedin.

[2]. *In* NZ Wildlife Service 1986. Yellow-eyed Penguin *Megadyptes antipodes*. Draft Species Recovery Plan. Department of Internal Affairs, Dunedin.

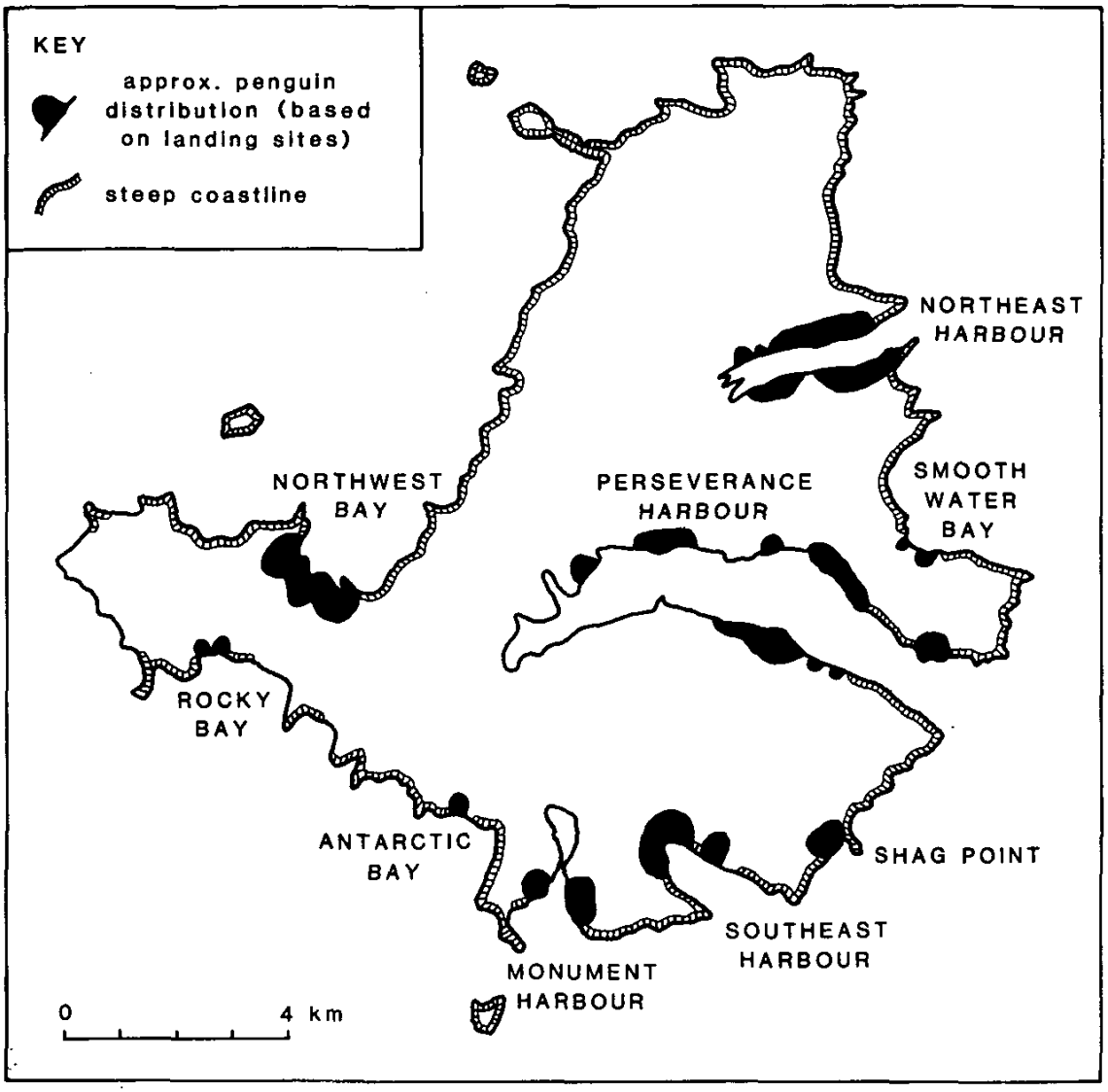

FIGURE 2 — Yellow-eyed Penguin distribution on Campbell Island

For two days each month, penguins were counted at the landing site from before dawn until after dusk. Thus, birds were counted during two sets of departures and two sets of arrivals (four counts in all) each month. The counts, shared between two observers, were made on 3, 13 November 1987; 6, 8 December; 12, 13 January 1988; 14, 16 February; 10, 15 March; 14, 15 April; 15, 16 May; 14, 15 June; 14, 15 July; 14, 15 August; 14, 15 September. Additional counts of morning departures or evening arrivals were made on 11, 21, 25, 26 March (to observe chicks departing), on 2,3 May (to determine the stage of the moulting period), and on 29 September (final count of the study). The counts were made from before dawn to after dusk so as to include the earliest departures and latest arrivals.

In addition to the Middle Bay counts, penguins were counted at seven major landing sites at Northwest Bay and three at Southeast Harbour (Figure 2) during November 1987, February, May and August 1988. I used the seasonal pattern of penguin numbers to interpret counts made elsewhere on Campbell Island.

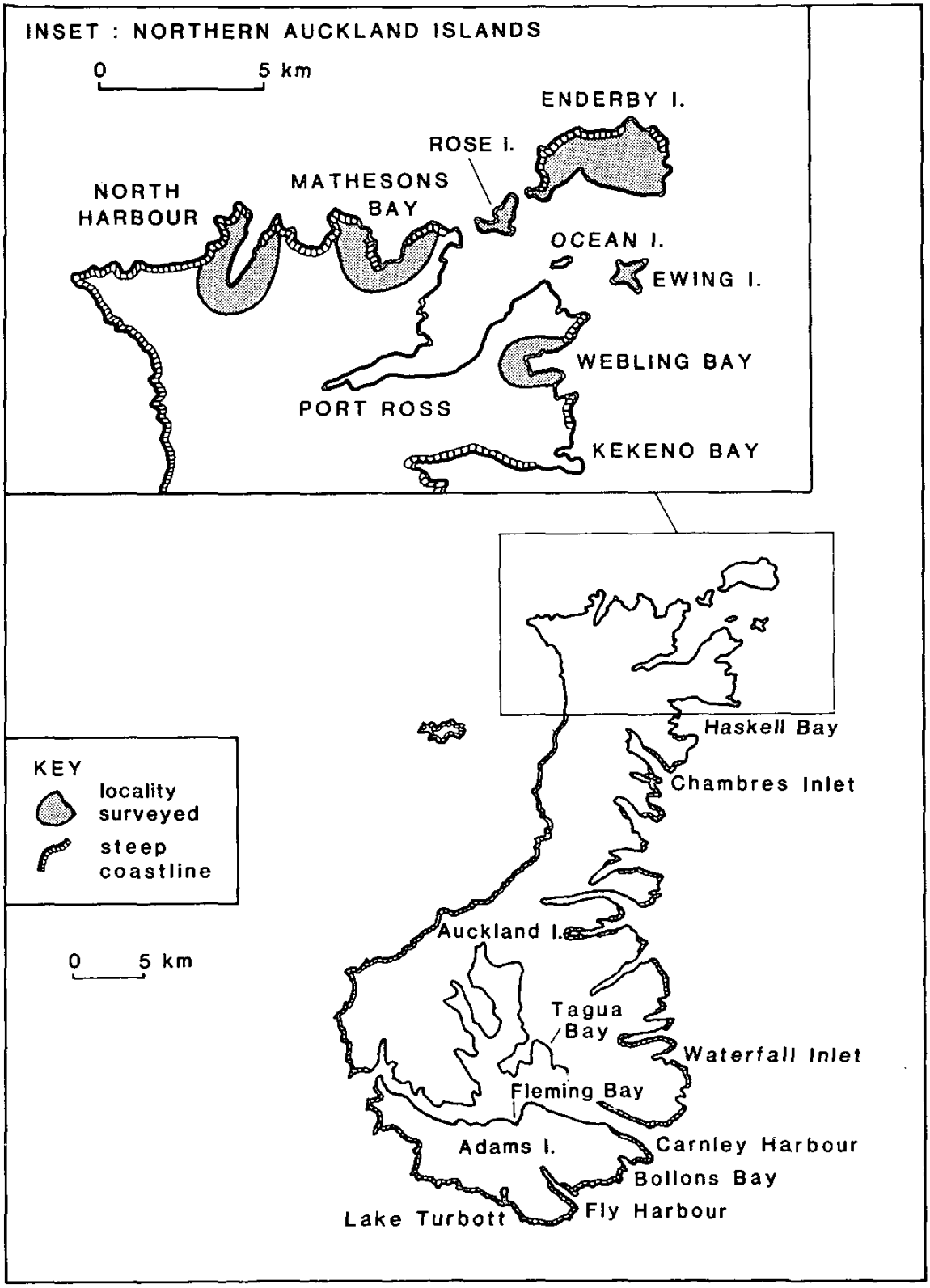

FIGURE 3 — *Locations surveyed for Yellow-eyed Penguin on the Auckland Islands, November-December 1989*

In winter 1988, a full census was made of Yellow-eyed Penguins at Campbell Island landing sites. Counts were usually for 2-3 hours at dawn or dusk to cover the peak times of departure or arrival of penguins. Vantage points were chosen close to a landing site, and whenever possible neighbouring landing sites were counted at the same time. A few areas with difficult access were counted from a distance by telescope or viewed from a boat or canoe. At some minor landing sites footprints in snow were used to count penguins. The winter survey, which took 43 days from May to July to complete, consisted of 111 separate counts and 244 hours of observation. Including the index counts at Middle Bay and other landing sites, penguin counting on Campbell Island took a cumulative 718 hours on 83 days.

The Auckland Islands lie about 290 km north-west of Campbell Island and 460 km south of the South Island, at 50° south latitude. I visited the islands between 31 October and 8 December 1989. The numbers of Yellow-eyed Penguins were counted at landing sites on Enderby, Ewing and Rose Islands, and at North Harbour, Mathesons Bay and Webling Bay at the north of Auckland Island (Figure 3). Landing sites at Port Ross, Ocean Island, some north-eastern harbours and Tagua Bay (Carnley Harbour) were noted but full counts were not made. Usually two, and occasionally three, people took part in the survey. A fourth observer surveyed part of the Adams Island shoreline. The counts were timed to cover the peak times of departure and arrival, usually the first three hours after dawn and the last five hours before dusk. Sixty-seven counts were made over 314 hours of observation. To assist with the interpretation of results, two counts were made throughout the daylight hours of 10 November and 3 December 1989 at Sandy Bay, Enderby Island.

RESULTS

Seasonal variation in penguin numbers at landing sites

Figure 4 shows the seasonal pattern of Yellow-eyed Penguin numbers at Middle Bay, Campbell Island. In November 1987, the mean of penguins counted during two departure and two arrival periods at the landing site was 56.8 (range 53-60). At this time, during the incubation phase of nesting, most breeding birds were taking a trip to sea for a day, followed by a day at the nest (i.e. only about half the breeding adults were represented in each count). During the chick-rearing period of December to March, mean monthly counts were much higher, ranging from 88.5 to 97.0 penguins (overall range 83-105).

Most breeding adults were going to sea each day, initially taking trips alternately with their partner, but from mid-January onwards, chicks were left unguarded during the day. In February and March, 3-8 breeding adults made two trips to sea each day to collect food for their chicks, but most others took only one trip to sea.

In late March, the breeding season had ended and the moult had begun. The numbers of penguins dropped to a mean of 64.0 (range 61-67), with juveniles, non-breeders and failed breeders staying ashore to moult. In April,

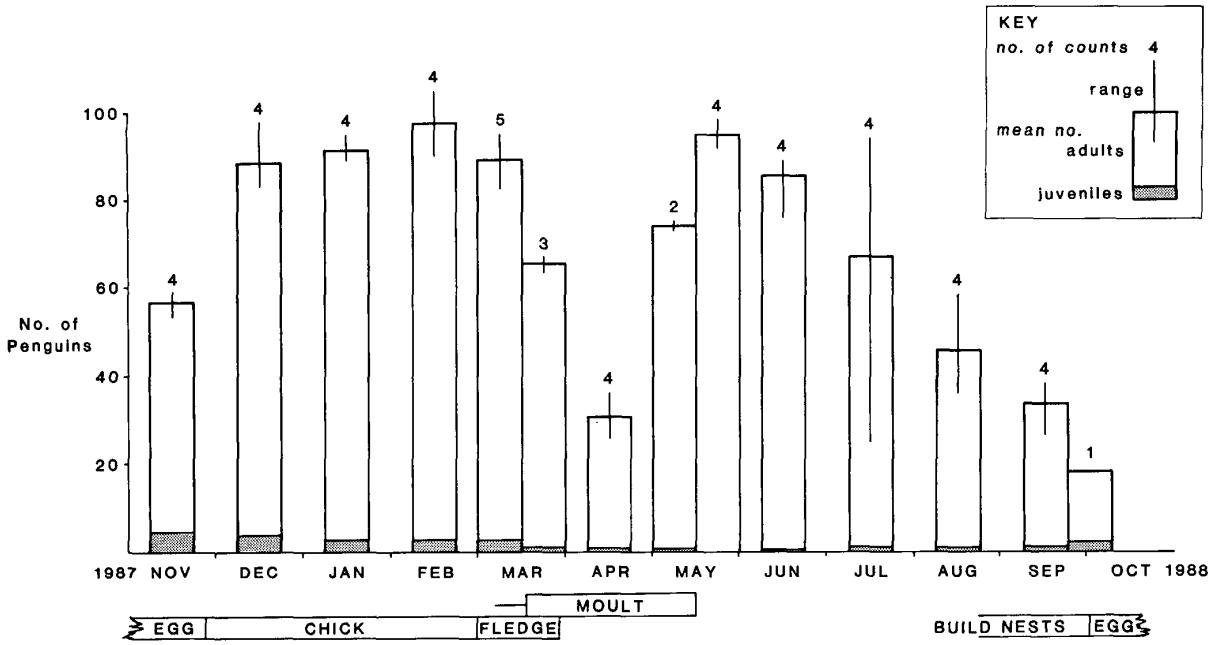

FIGURE 4 — Yellow-eyed Penguin counts at Middle Bay, Campbell Island, 1987-88. Counts of penguins at the Middle Bay landing site were conducted for at least two days each month, including two sets of departures and arrivals (i.e. number of counts = 4 for most months).

TABLE 1 — Counts of Yellow-eyed Penguins at major landing sites on Campbell Island 1987-88

Locality	No. of Landing Sites	No. of Penguins Nov	Feb	May	Aug
Middle Bay	1	57	97	95	45
Northwest Bay	7	160	263	293	203
Southeast Harbour	3	72	87	109	86

Middle Bay figures are means of four counts per month. Other totals are from single counts per landing site.

TABLE 2 — Annual variations in numbers of adult Yellow-eyed Penguins at some landing sites in Northwest Bay and Southeast Harbour, Campbell Island

Locality & Landing Site	Date	No. of Adults at Landing Site 1987	1988	1990	% Change 1987-1990	1988-1990
Northwest Bay						
A	Feb		114	130		+14
A-B	May-Jul[1]	161	172	150	-7	-13
A	Aug		109	137		+26
A	Nov	61		67	+10	
C-E	Feb		170	42		-75
C-E	May-Jul[1]	178	158	38	-79	-76
C-D	Aug		51	16		-69
C	Nov	52		3	-94	
Southeast Harbour						
F-H	Aug		84	53		-37
F-H	Nov	63		30	-52	

Key: [1] Where possible, counts in the closest corresponding month were used for the comparison
Data Source: May - July 1987, Feb - Aug 1990 (R. Moffat, pers. comm.), Nov 1987 - Aug 1988 (this study)

the successful breeders were moulting, and so a mean of only 30.5 (range 26-36) birds was counted. By mid-May, all birds had finished moulting, and the mean count of 95.0 (range 92-98) was close to the maximum for the year. From June to September, mean counts of penguins declined from 85.5 (range 76-89) to 33.0 (26-38). In June and July, Hooker's sea lions (*Phocarctos hookeri*) gathered in increasing numbers on the sandy part of Middle Bay beach. Their presence close to the landing site, on land or offshore, caused up to 21 penguins to land at an adjacent landing site where, previously, rarely more than two penguins landed. In August and September, there was an unusually high level of predation by a sea lion (Moore & Moffat 1992). At the same time some penguins remained ashore during the day courting and preparing to nest, and therefore were not counted at the beach.

Counts of penguins at other major landing sites at Northwest Bay and Southeast Harbour showed a similar pattern to that at Middle Bay in that penguin numbers increased between November and February-May and decreased again by August (Table 1). In all areas, the numbers of juveniles were highest in November. For example, at the seven monitored landing sites in Northwest Bay, 19 juveniles (12% of total) were counted in November, but only 7 (2%) were seen in May.

Annual variation in penguin numbers at landing sites

Counts of Yellow-eyed Penguins using major landing sites in Northwest Bay were made in 1987-1990 (Table 2). Between May-July 1987 and May-July 1988 penguin numbers changed little, but by 1990 at Middle Bay (landing sites C-D) and Capstan Cove (E) the numbers had fallen by at least 69%. I attributed this to the local effects of disturbance and predation by sea lions at Middle Bay, but I do not know whether the adjacent Capstan Cove was similarly affected. Some minor landing sites also appeared to be used by fewer penguins than previously (R. Moffat, pers. comm.). The counts at Sandy Bay (landing sites A-B) suggest a stable population there, because counts fluctuated within the normal range of daily variation (0-15%) that was recorded at Middle Bay in 1987-88. Overall, the counts at the five Northwest Bay landing sites (A-E, Table 2) during winters of 1987-1990 declined from 339 to 188 adults (45%). At Southeast Harbour (landing sites F-H, Table 2) there were also major changes in penguin numbers, with indications that other landing sites were similarly affected (R. Moffat, pers. comm.).

Population estimate on Campbell Island in 1988

From May to July 1988, 172 landing sites were surveyed on Campbell Island (Figure 2) and 1625 birds were counted, 66 juveniles comprising 4.1% of the total (Table 3). The mean number of birds per landing site was 9.4 (s.d. = 17.6, range = 1-143, n = 172). The index counts at Middle Bay (Figure 4) and other landing sites (Table 1) suggested that May was a period of peak abundance for the year. However, not all birds travelled to sea every day and others were probably at sea for more than a day at a time. Comparing the numbers of banded birds counted at Middle Bay with the numbers known to be alive (i.e. using the landing site) I estimated that a mean of 81.4% (s.d. = 13.5, n = 12) birds was seen at each count during May-July. Assuming this was true for the whole of Campbell Island, the total count

TABLE 3 — Numbers and distribution of Yellow-eyed Penguins on Campbell Island, winter 1988

Area	Month	No. Landing Sites	No. Birds Counted		
			Adult	Juv.	Total
Northwest Bay	May	17	438	10	448
Northeast Harbour	June	68	301	11	312
Perseverance Harbour	July	54	251	10	261
Southeast Harbour	May	16	242	18	260
Monument Harbour	May	6	129	7	136
Shag Point	May	3	118	3	121
Antarctic Bay	July	1	44		44
Smoothwater Bay	July	4	17	6	23
Rocky Bay	June	3	19	1	20
Total		**172**	**1559**	**66**	**1625**

1625 represented a population of about 2000 birds. The population of 1625-2000 birds represented about 490-600 pairs if 60% of the population were breeding birds (Richdale 1957).

The greatest concentration of penguins was at Northwest Bay (Figure 2). Landing sites were generally in the most sheltered parts of bays and harbours, where wave action, surges and kelp density were at a minimum and where sea lion activity was low. The penguins landed on beaches of shingle or small boulders (61% of landing sites) or rocky wave-cut platforms, ramps and promontories (39%). Observations at Middle Bay and other parts of Northwest Bay suggested that landing sites were traditional because most penguins landed at the same place each day. Occasionally, penguins used a closely adjacent site if they were disturbed by sea lions. Once on land the penguins usually walked inland on radiating and branching tracks, which had been worn down into small ruts over long periods of use. The populated areas were mainly in *Dracophyllum* forest, which dominates the coastline of most harbours, and areas of scrub such as *Myrsine divaricata*. Some areas of *Poa litorosa* were also inhabited, for example, at Monument Harbour. Most birds did not travel more than 500 m inland or climb more than 60 m above sea level. In some places penguins roosted for the night on rocks close to the landing site. Observations of penguin movements suggested that they usually foraged outside the harbours and bays. The densest numbers at the larger harbours (Northwest and Perseverance) were closest to the open sea, and no penguins were seen landing in the inner part of Perseverance

TABLE 4 — Numbers and distribution of Yellow-eyed Penguins at the Auckland Islands, Nov-Dec 1989

Locality	No. Landing Sites	No. Birds Counted		
		Adult	Juv.	Total
Enderby I.	25	581	12	593
Ewing I.	21	59	2	61
Rose I.	13	40	1	41
Ocean I.	1	2+		2+
North Harbour	12	86	2	88
Mathesons Bay	6	43		43
Port Ross (north)	7	13+		13+
Webling Bay	9	25	1	26
Tagua Bay	2	3+		3+
Adams I.	19	62	2	64
Total	**115**	**914**	**20**	**934**

KEY + full surveys were not conducted but minimum estimates of penguin numbers were made based on the number and importance of landing sites that were found.

Harbour (Figure 2). In these larger harbours, the penguins were very dispersed and used a large number of landing sites.

Population estimate on the Auckland Islands in 1989

In November to early December 1989, 934 Yellow-eyed Penguins, including 2.1% juveniles, were counted at 115 landing sites at the Auckland Islands (Table 4, Figure 3). The mean number of birds per landing site was 8.7 (s.d. = 16.2, range = 1-143, n = 105, excluding landing sites at Port Ross, Ocean Island and Tagua Bay, which were not surveyed in detail). The counts were mostly during the incubation phase, with some made during the early chick-rearing period. Based on index counts at Sandy Bay, Enderby Island, the total of 934 penguins was adjusted to 1000 birds to account for birds using the landing sites outside the survey periods. Assuming that 60% of the population were breeding birds, that 94% of pairs would still be incubating eggs at the late incubation stage (Campbell Island data), and that only one bird of each pair was counted, I estimated that at least 420 breeding pairs were in the area surveyed. Because not all breeding birds alternate with their partners at the nest on a strict day-on day-off basis, I assumed that each count represented about 89% of breeding pairs (Campbell Island data, November 1987). Thus the population estimate would be 470 pairs in the area surveyed.

The unsurveyed coastline of Auckland Island is extensive (Figure 3), with at least 13 major bays and harbours likely or known to accommodate penguins. A brief reconnaissance of bays immediately south of Webling Bay showed few or well dispersed penguins there. If that was true for the whole east coast, a very conservative estimate would be perhaps another 100 pairs, raising the Auckland Islands total to 520-570 pairs.

Landing sites were spread along coastline giving access to breeding habitat, which was mostly southern rata (*Metrosideros umbellata*) forest and scrub vegetation such as *Myrsine divaricata*. Other habitat used for breeding included *Olearia lyallii* forest (Ewing Island) and *Poa litorosa* tussockland. The landing sites varied from rocky shores (64%) to boulder beaches (32%) and sandy beaches (4%).

Enderby Island (Figure 3) supported the most penguins, 63% of the total counted, or an estimated 260-290 pairs. In several parts of the island, penguins had to walk at least 500 m across coastal sward before reaching suitable nesting habitat. On the northern coast of Auckland Island, North Harbour had the greatest concentration of penguins. Some parts, such as Mathesons Bay, had few possible landing sites for penguins. Incidental observations of penguins and their tracks at Port Ross and at some north-eastern harbours south of Webling Bay indicated that the penguins were few or well dispersed. On Adams Island, the penguins were dispersed along the northern shore, the rest of the coast being largely inaccessible to them.

DISCUSSION

The seasonal change in Yellow-eyed Penguin numbers at Middle Bay was used to interpret the census of Campbell Island. The assumptions that were used to estimate total breeding numbers may not have been appropriate for the whole island or for the whole survey period, but the estimates provided an approximation of the population level. The winter survey showed that at least 1625 penguins were on the island in 1988. May-July appeared to be a good time for a census because most birds seemed to be travelling to sea every day. Although all major and most minor landing sites were found, some minor sites in remote areas may have been overlooked. However, although the coastline at the western end of the island is accessible to Rockhopper Penguins (*Eudyptes chrysocome*), other workers have not seen Yellow-eyed Penguins there (P. Moors, D. Cunningham, pers. comm.).

There were few indications of the numbers of Yellow-eyed Penguins on Campbell Island before my estimate of 490-600 pairs in 1988. In 1874 they were described as "fairly numerous" (Filhol 1885). Westerskov (1960) thought there were fewer than 200 pairs. However, the secretive habits of Yellow-eyed Penguins make casual estimates of their numbers very unreliable and likely to give large underestimates. Westerskov did no counting because he stated "An estimate of their numbers was not attempted and would be a very time-consuming although rewarding study..." The species may have been less common during Westerskov's visit in 1958, although Bailey & Sorensen (1962) believed that "they are more common than has been supposed." Between 1988 and 1990 there were major decreases in penguin numbers in two parts of Northwest Bay but little change in a third area.

TABLE 5 — Yellow-eyed Penguin population estimate, 1988-1989

	Population Estimate	Prop. of Total
BREEDING PAIRS on		
South Island[1]	300-320	17-15%
Stewart Island[2]	470-600	26-29%
Auckland Island[3]	520-570	29-27%
Campbell Island[4]	490-600	28-29%
TOTAL	**1780-2090**	
BREEDERS	3560-4180	
NON-BREEDERS[5]	2370-2790	
TOTAL INDIVIDUALS	**5930-6970**	

1: Oct-Dec 1989 (Darby *in* Marchant 1990). The number of breeding adults on the Otago Peninsula declined dramatically late in the 1989-90 season, with 30-40% of adults dying (J. Darby, pers. comm.).
2: Dec 1988 (Darby & Seddon 1990). Based on anticipated densities, but some counts have been made, particularly on Codfish island. An estimate for the 1989-90 season was 300-400 pairs (Darby *in* Marchant & Higgins 1990), but an accurate census is still required.
3: Nov-Dec 1989 (this study), approximate estimates.
4: May-July 1988 (this study).
5: 40% of population (Richdale 1957).

Although some of this change was probably caused by sea lion predation and disturbance (Moore & Moffat 1992), the evidence from Southeast Harbour suggests a more widespread decline. If the change shown by the winter counts at Northwest Bay was as great as 45% elsewhere, the population in 1990 may have only 270-330 pairs. More intensive surveys are needed to clarify whether these number changes are short-term fluctuations or part of a long-term decline.

It is difficult to assess accurately the status of the Yellow-eyed Penguin on the Auckland Islands based on a brief and incomplete survey. Only a more thorough survey could show seasonal and daily variations in penguin numbers at landing sites. Although I have made some allowance for underestimation, based largely on my experience on Campbell Island, my estimates are deliberately cautious. Also, a full survey of the eastern coastline would probably reveal more than the 100 pairs allowed for in my estimate. It is assumed that most of the west coast is inaccessible to penguins because of cliffs, although penguins have been reported from the northern half of the coast (R. Russ, pers. comm.). It is probable, therefore, that my estimate

of 520-570 pairs on the Auckland Islands is very conservative. It is much more than previous estimates for the islands, which ranged from 80-150 pairs (Darby 1984[1]) to 250-350 pairs (J. Darby *in* Marchant & Higgins 1990), although they were based largely on information from Enderby Island. Further surveys are needed.

This study confirmed Enderby Island as a major centre of the Auckland Islands population, as noted by Taylor (1971). My estimate of 260-290 pairs was much higher than the 96-150 pairs estimated from nesting densities in 1986[1]. This may be because of different survey methods or penguin numbers may have increased greatly. Numbers on Auckland Island were also greater than suggested by Challies (1975), who felt that few penguins remained there because of predation by pigs and cats.

Campbell Island and the Auckland Islands appear to be very favourable for Yellow-eyed Penguins. The large Campbell Plateau continental shelf and highly productive seas provide a reliable year-round food source close to the islands (Smith 1987). There is not the problem of heat stress on land, which contributes to the northern limit of the species' range (Smith 1987, Seddon & Davis 1989), or the loss of breeding habitat which has occurred on the South Island (Darby & Seddon 1990). Predation levels are probably lower than on the South Island, where in some years on farmed areas predation of chicks exceeds 90% (Darby *in* Marchant & Higgins 1990). On Campbell Island, feral cats (*Felis catus*) are scarce (Dilks 1979) and although Norway rats (*Rattus norvegicus*) are abundant (G. Taylor pers. comm.), there is little evidence for predation. Similarly, on Auckland Island predation may affect adult numbers and chick production, but cats are in low numbers (Taylor 1975) and pigs (*Sus scrofa*), although widespread, are few compared with their eruptive phase last century (Challies 1975).

My approximate estimates of the number of breeding pairs of Yellow-eyed Penguins on the subantarctic islands can be used to assess the status of the species in general (Table 5). The Auckland Islands population estimate should be treated as provisional as that survey was incomplete. From the information available, the subantarctic islands may have had at least 56% of the total Yellow-eyed Penguin population, some 5930-6970 birds in 1988-1989. The decline in numbers on South and Campbell Islands illustrates the need for continued monitoring.

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