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YELLOW-EYED PENGUIN ON CAMPBELL ISLAND

by

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SUMMARY

1. The population of the yellow-eyed penguin (*Megadyptes antipodes*) on Campbell Island in 1987-88 was estimated as 1600-2000 (560-700 breeding pairs). This represents 35% of the estimated total population of 4600-5600 birds. With the continuing decline of the species on the South Island, Campbell Island is probably now the most populous locality. However, more accurate population estimates are required for the Auckland and Stewart Island groups.

2. The main centres of population were Northwest Bay (448), Northeast Harbour Perseverance Harbour (261) and Southeast Harbour (260), which together comprised 79% of the penguins counted.

3. A total of 172 landing sites were found, with a mean count of 9.4 birds per site (range 1-143). Sixty-one percent of landing sites were at shingle / small boulder beaches and 39% were on rocky shores.

4. The highest counts of penguins at landing sites were in February (late in the chick rearing period) and May (post-moult). The proportion of breeding birds at the Middle Bay study area was 70-80%. During any individual count in winter approximately 80% of birds were seen because the remainder stayed ashore.

5. Daily movements of penguins related to the time of sunrise and sunset. In winter they departed for sea over a short period at dawn and returned at dusk. The movements were more spread out during the day in the breeding season because penguins took turns with their partners to go to sea, or they took two trips to sea, depending on the stage of the breeding cycle.

6. Nests were isolated and scattered amongst the coastal scrub-shrubland associations, dominated by *Dracophyllum.* The density of nests was approximately 1.5 pairs/ha in penguin habitat (3.8 in Northwest Bay), or 44 birds per accessible kilometre of coastline. Most nests were within 500m of the shore. At Middle Bay the mean distance from the sea was 236m (82-433m) and the mean inter-nest distance was 22m (5-49m).

7. Mean hatching date was 26 November, approximately one or two weeks later than the South Island. Chicks fledged on average 108 days after hatching. Mean departure date was 13 March.

8. Breeding pairs were very successful:
   83% of eggs hatched and 70% fledged chicks;
   76% of nests produced chicks, at an average of 1.4 chicks per nest;
   85% of chicks fledged. Chicks that died did so at the beginning or end of the chick rearing period. This level of breeding success is comparable to mainland figures in good seasons, or in areas where predation is low. The success is higher than other penguin species which lay two eggs.

9. In February 141 chicks were banded and 12 were re-sighted as juveniles at landing sites during the year.

10. An estimate of adult survival at Middle Bay during the 12 month study was 74-85%. It may have been even lower because of the local effects of a predatory Hooker's sea lion *(Neophoca hookeri)*. Predation by sea lions is apparently rare.

11. Ticks (*Ixodes uriae*) were found on adults and chicks.

12. The size of yellow-eyed penguins was similar to figures from one mainland study. The mean length of the adult head was 138.9mm and the foot (to the mid-toe pad) was 126.5mm.

13. Chicks grew at a similar rate to those on the mainland. The fledging weight of was 800g less than the mainland average but was within the normal range of annual variation. The foot was the first dimension to reach asymptotal length, after only 35 days of age. Other dimensions, such as head and bill lengths did not begin to level off in growth until after 85 days.

14. It is recommended that the Campbell Island population be monitored regularly to determine future changes. Censuses should be conducted on the Auckland and Stewart Island groups.

CHAPTER 1. INTRODUCTION

The yellow-eyed penguin (*Megadyptes antipodes*), or hoiho, is one of the rarest of the world's 17 species of penguin. It is endemic to the southern New Zealand region, with an estimated population of about 5000 birds.

1.1 THE SPECIES

The yellow-eyed penguin has been described as the most generalised penguin species (Muller-Schwarze 1984). It is the only member of the genus *Megadyptes*, based on morphological and plumage differences between it and other species. Its relationships are not clear, although Jouventin (1982) suggests on the basis of behavioural comparisons that it is most closely related to *Eudyptes*, the crested penguins.

Adults are 72cm in length and weigh 5-6kg and are thus one of the largest species of penguin. This befits their scientific name *Megadyptes antipodes*, which in Greek means "large diver from the Antipodes" (Stonehouse 1970). Males are only slightly larger than females. Dorsal plumage is slate blue, ventral plumage white, and the feet are pink. They derive their common name from the yellow iris of the eye and the band of yellow feathers that passes from gape to gape through the eye and crest of the head. Immature birds do not obtain a yellow crest until the moult in their second year, and normally reach breeding condition at two to four years of age (Richdale 1957).

Unlike many species of penguin which nest in densely populated colonies, the yellow-eyed penguin is the only species where each pair nests separately, avoiding visual contact with their neighbours (Jouventin 1982). Hence, they nest in scattered aggregations in coastal forest and scrub. Solitary and secretive types of nesting behaviour are more prevalent in penguin species found north of latitudes 40-50 degrees (Stonehouse 1970). Another unusual feature is that adult yellow-eyed penguins remain at or near their breeding grounds throughout the year.

Studies on the mainland have shown the yellow-eyed penguin diet to include small (mostly less than 20cm) fish of several species which are known to dwell mainly in the upper portion of the water column, but also from the bottom (van Heezik 1988). Evidence for deep diving also comes from penguins being caught in fishing nets set between 50-150m in depth (J. Darby pers. comm.).

1.2 RESEARCH

In his pioneering 18-year study, L.E. Richdale (1951, 1957) studied the breeding biology and population dynamics of yellow-eyed penguins on the Otago Peninsula. Because of the magnitude of this work the species received little further attention until 1980, when J.T. Darby began a long-term study to determine the population status and breeding ecology of the mainland penguins. Further research was stimulated, principally PhD studies at Otago University, on growth and diet (van Heezik 1988) and behaviour and nest site selection (Seddon 1988). Prior to 1987-88 there had been no detailed work on yellow-eyed penguins in the subantarctic.

1.3 DISTRIBUTION AND POPULATION

In analysing the present distribution of yellow-eyed penguins, Smith (1987) found they inhabited coastline within close proximity of a reliable year-round food source. This related to the width of the continental shelf and the level of primary productivity of the ocean. The climate is also important because the species does not tolerate high temperatures on land, and therefore inhabits areas where mean summer temperatures are less than 16.5°C (Smith 1987).

The breeding distribution of the yellow-eyed penguin includes the south-east coastline of the South Island (from Slope Point to Oamaru, and Banks Peninsula), Stewart Island, Codfish Island, and in the subantarctic region, Auckland and Campbell Islands. Darby (pers. comm.) believes there were once 2000-3000 pairs of yellow-eyed penguins on the mainland, breeding in the traditional South Island coastal podocarp/hardwood forests. 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, there has been a population decline. Darby (1985) estimated that in areas of the Catlins, Southland, 60% of birds had disappeared since the 1940s.

In 1984, Darby (1985) put the total population at 1200-1800 breeding pairs, 550 of which were on the mainland. With improved censusing of the South Island, his estimate for the 1985-86 season (Darby in N.Z. Wildlife Service 1986) was 1500-2100 pairs, 600 of which were mainland pairs. Based on Richdale's (1957) figure of 40% non-breeding birds this put the overall population at 5100-7100 birds, and was considered at the time to be the world's rarest penguin.

A major collapse in the food chain in 1987 is believed to have been caused by the El Nino southern oscillation weather pattern, and resulted in a further reduction in the breeding population of yellow-eyed penguins on the mainland (Darby pers. comm.).

1.4 THE NEED FOR INFORMATION

Based on the categories designated by the Survival Service Commission of IUCN (King 1981), Bell (1986) defined the yellow-eyed penguin as rare (having a small world population that is at risk) and regionally threatened (likely to become endangered). Robertson and Bell (1984) identified the species as a top priority for population surveys and development of census methods. Similarly, Warham *et al.* (1986) stressed the need for base-line monitoring of penguins in the New Zealand region to understand the population trends and breeding ecology of each species.

Apart from the need to instigate management practices to halt or reverse the decline on the mainland it has become desirable to study the yellow-eyed penguin in other parts of its range where its status is less well known. In this way more reliable population estimates and trends over the entire range will put the mainland situation in perspective.

1.5 AIMS OF STUDY

In the past the main thrust of research on the yellow-eyed penguin has been on the mainland population. One of the main objectives of the Department of Conservation's expedition to Campbell Island in 1987-88 was to help redress this imbalance and determine the status of the species in this part of its subantarctic range.

There were three main aims of the Campbell Island study:

1. Obtain a population estimate and monitor the seasonal change in penguin numbers;
2. Determine the level of nesting success;
3. Obtain measurements of adults and the growth rate of chicks.

1.6 STRUCTURE OF REPORT

The report is divided into three main chapters:

2. Population
3. Breeding Biology
4. Size and Growth

Each chapter is dealt with in terms of background, aims, methods, results and discussion.

CHAPTER 2. POPULATION

2.1 BACKGROUND

Campbell Island lies about 660 km south of the mainland of New Zealand at latitude degrees South. It is over 11,000 ha in area with a coastline mainly of cliffs but with harbours dissecting the island, particularly in the east (Fig. 1).

The island was first discovered in 1810 and received several visits from scientific expeditions later that century. Yellow-eyed penguins were first reported on the island during the 1840 visit by Sir James Clark Ross on the Erebus and Terror (Westerskov 1960). In 1874 the species was described as being fairly numerous (Filhol 1885).

Sorensen was the first person on Campbell Island to observe yellow-eyed penguins in any detail. He was stationed on the island during the early 1940s as a coast-watcher for enemy ships, and later as officer in charge of the Meteorological Station. He identified the principal breeding areas as Perseverance Harbour, Southeast Harbour, Northeast Harbour, Rocky Bay, Northwest Bay (Bailey and Sorensen 1962) and Monument Harbour (Sorensen 1942-47). He noted that penguins were present year-round and usually spent the night ashore. Most yellow-eyed penguin sites occurred where gently sloping, scrub-covered land met the sea, but some penguins had to land among huge boulders or steep rock faces (Bailey and Sorensen 1962). Westerskov (1960) considered that Perseverance Harbour was the principal area, followed by Northwest Bay, and thought it unlikely that the population would exceed 200 pairs. Although this figure was not based on census data it was the only estimate available for Campbell Island and was used by Darby (1984, New Zealand Wildlife 1986) for his total population estimates.

A further refinement of the recorded range of the penguin on Campbell Island came when penguins were found at Smoothwater Bay (Taylor 1986), Shag Point and Antarctic Bay on the south coast (G. Taylor pers. comm.).

2.2 AIMS

In order to assess the status of yellow-eyed penguins on Campbell Island it was hoped to:

1. Census the population
2. Monitor seasonal trends in penguin numbers
3. Monitor the patterns of arrivals and departures of penguins to and from landing sites.
4. Estimate the proportion of breeding birds in the population.

These base-line data would allow future monitoring studies to detect changes in the population (see Appendix 11 for guide to low intensity monitoring of key landing sites).

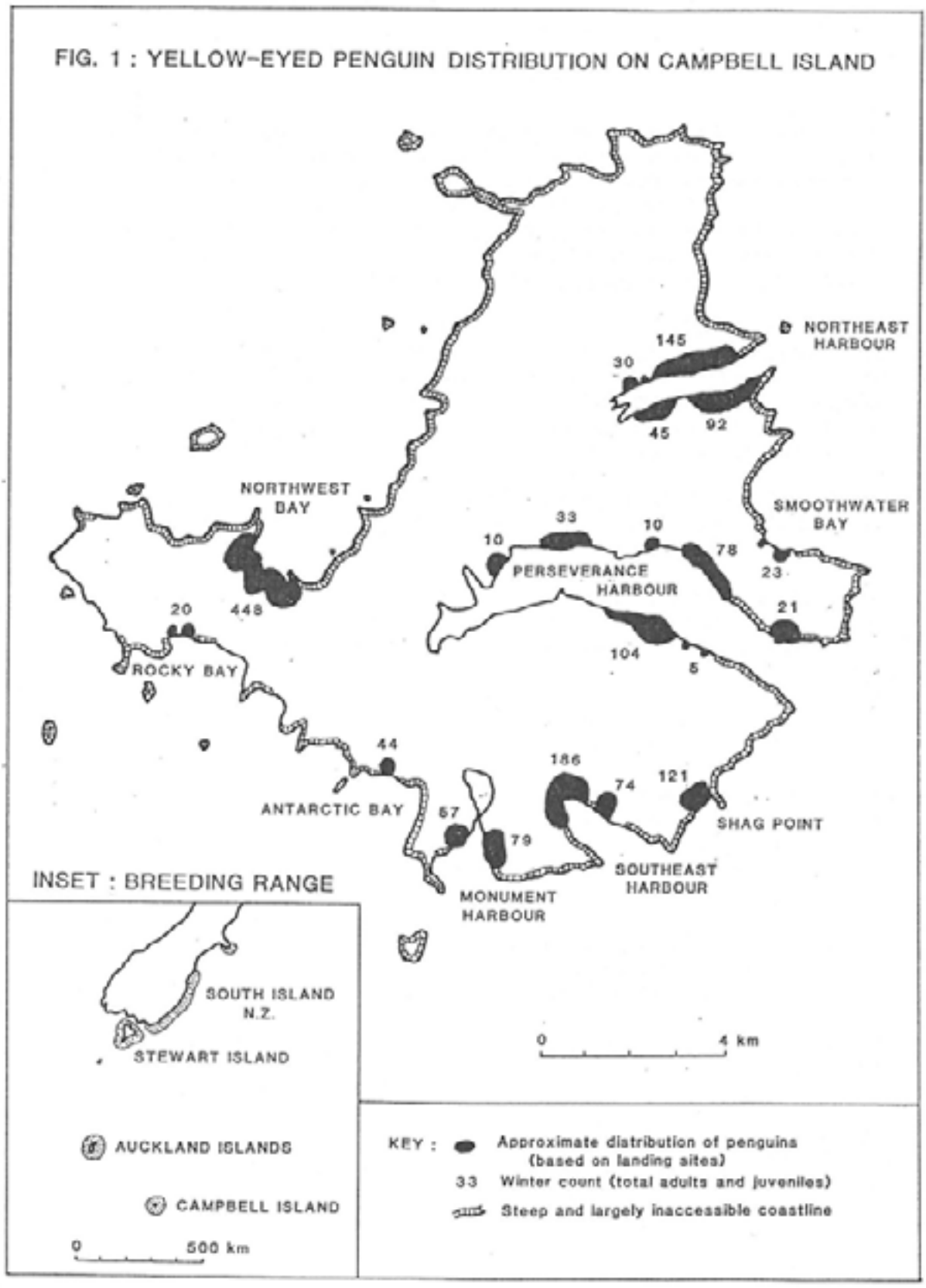


FIG. 1 : YELLOW-EYED PENGUIN DISTRIBUTION ON CAMPBELL ISLAND
NORTHEAST HARBOUR
145
30
45
92
NORTHWEST BAY
SMOOTHWATER BAY
33
10
10
78
23
PERSEVERANCE HARBOUR
21
20
448
104
5
ROCKY BAY
44
186
74
121
ANTARCTIC BAY
67
79
SHAG POINT
SOUTHEAST HARBOUR
MONUMENT HARBOUR
0
4 km
INSET : BREEDING RANGE
SOUTH ISLAND N.Z.
STEWART ISLAND
AUCKLAND ISLANDS
CAMPBELL ISLAND
0
500 km
KEY :
Approximate distribution of penguins (based on landing sites)
33 Winter count (total adults and juveniles)
Steep and largely inaccessible coastline

2.3 METHODS

2.3.1 Census

A survey of all the known yellow-eyed penguin areas on Campbell Island was conducted during the winter months of May to July 1988, and counts of penguins at all the landing sites were made to determine the total population size. Apart from some coastline in the south and west of the island, most of the accessible coastline was searched for penguin landing sites. The expression "landing site" used in this report refers to the part of a beach where penguins were seen arriving from or departing to sea. To a large extent these sites were favoured by penguins and were used every day.

Depending on the number of penguins encountered, counts were usually of two to three hours duration in the morning or evening to cover the time of peak departures or arrivals. Vantage points were chosen close to a landing site, and where possible neighbouring landing sites were counted at the same time. A few areas with difficult access were counted from a distant vantage point using a telescope or viewed from a boat or canoe. At some minor landing sites penguin footprints in snow were used to obtain counts.

Excluding counts at Middle Bay the winter survey took 43 days in total, with 111 separate counts and 244 hours of observation. The pain threshold for cold feet was exceeded for at least 184 hours of observation.

2.3.2 Counts at Major Landing Sites

Penguins were counted at eight landing sites in Northwest Bay and three sites in Southeast Harbour on four occasions during the year (November, February, May and August).

Excluding counts at Middle Bay and during the winter survey, the seasonal survey comprised 128 hours of observation on 10 days.

2.3.3 Counts at Middle Bay Study

Area The Middle Bay penguin counts were undertaken to determine the pattern of arrivals and departures of penguins from the landing sites on a seasonal basis and as a guide for interpretation of counts made elsewhere on the island.

Middle Bay (part of Northwest Bay) was selected for intensive study because of its good number of penguins, observation points and the close proximity of Northwest Bay Hut. The main landing site at the stream was monitored intensively, and a subsidiary site at a wave-cut platform 100m east of the stream was also monitored.

On two days, usually in the middle of each month, penguins were counted as they departed and arrived at the landing site. These counts were conducted on November; 6, 8 December; 12, 13 January; 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 26 October (preliminary count), on March (to observe chicks departing), on 2, 3 May (to determine the stage of the moulting period), and on 29 September (final count).

The counts were shared between two observers from before dawn till after dusk to see the first departure and last arrival of penguins for the day. Because of the seasonal change in daylight hours, the daily period of observation varied from 19.5 hours in January to 11 hours in July. The observations were made from vantage points adjacent to the beach. Times of arrival and departure at the beach were recorded for each bird or group. Adult penguins were banded as part of the breeding study, and whenever possible, their band numbers were read with the aid of binoculars or telescope.

The Middle Bay counts comprised 346 hours of observation on 30 days. Therefore, in total for the year, penguin counting took a cumulative 718 hours on 83 days.

2.4 RESULTS

2.4.1 Population Size of Yellow-Eyed Penguin in Winter

The census of yellow-eyed penguins on Campbell Island during May to July 1988 was 1625 individuals (Table 1). This total included 66 juveniles (4.1%). There were 172 landing sites identified, with a mean count of 9.4 birds per site, although 33 landing sites were where only one individual was seen. The penguins were found at most sheltered bays and harbours which allowed access to vegetation dominated by The mean density was approximately 44 birds per kilometre of accessible coastline. There are approximately 37 of such coastline, from an island circumference of about 120 km.

TABLE 1: NUMBERS AND DISTRIBUTION OF YELLOW-EYED PENGUINS IN WINTER 1988

AREA	NO. COUNTED			ESTIMATED POPULATION
	Adult	Juv.	Total	
Northwest Bay	438	10	448	564
Northeast Harbour	301	11	312	373
Perseverance Harbour	251	10	261	322
Southeast Harbour	242	18	260	327
Monument Harbour	129	7	136	171
Shag Point	118	3	121	152
Antarctic Bay	44		44	54
Smoothwater Bay	17	6	23	28
Rocky Bay	19	1	20	25
	1559	66	1625	2016

Key a: Counts of birds were increased by a factor, based on the proportion of banded birds seen at Middle Bay

A total population estimate can be made based on the proportion of banded birds that were seen during the counts at Middle Bay, compared with the original number banded and presumed to be still alive (see Chapter 2.4.6). The average percentage of banded birds seen during May, June and July 1988 was 79.4, 83.7 and 81.1 respectively (Appendix 8). It was also observed that not all penguins went to sea each day. It was therefore assumed that the same proportion of penguins were seen during the census elsewhere on the island, and the census for each area was adjusted accordingly (Table 1). Thus, the total population was estimated at 2000 birds. This represents 600-700 breeding pairs, assuming 60-70% of the population are breeders (see Chapters 2.4.6, 2.5).

2.4.2 Distribution

The main population centre of yellow-eyed penguins was at Northwest Bay, where 448 birds were counted (Fig. 1, Table 1). The penguins at the four main areas of Northwest Bay, Northeast, Perseverance and Southeast Harbours comprised 79% of the total number counted.

Northwest Bay also had the highest concentration at 249 birds per kilometre of accessible coastline (Table 2). The second highest concentration was at Shag Point (202/km). These two areas also had the highest mean counts per landing site of 26 and 40 birds respectively. The lowest concentrations were found at Perseverance Harbour and (14/km) and Rocky Bay (9/km).

TABLE 2: DENSITY OF YELLOW-EYED PENGUINS

	No. landing sites	Mean no. penguins per site	S.D.	Range	Est. length of accessible coastline (km)	Mean no. penguins per km
Northwest Bay	17	26.4	39.8	1-143	1.8	249
Northeast Harbour	68	4.6	4.4	1-22	7.6	41
Perseverance Harbour	54	4.8	5.8	1-33	19.3	14
Southeast Harbour	16	16.3	21.2	1-74	1.5	173
Monument Harbour	6	22.7	20.1	1-57	2.5	54
Shag Point	3	40.3	34.0	2-67	0.6	202
Antarctic Bay	1	44			0.4	110
Smoothwater Bay	4	5.8	5.2	1-12	0.7	33
Rocky Bay	3	6.7	3.8	4-11	2.3	9
Total	172			1-143	36.7	
Mean		9.4	17.6			43.7

Most landing sites, particularly the major ones, were permanent features in the sense that penguins usually landed in the same place each day, although closely adjacent landing sites were probably used as alternatives. The presence of Hooker's sea lions (*Neophoca hookeri*) in the water or on land near the landing site frequently delayed penguin movements to or from shore, and sometimes caused them to land away from their usual site.

The landing sites were generally in the most sheltered parts of bays 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, rocky wave-cut platforms, ramps and promontories. Of the 172 landing sites, 61% were boulder beaches and 39% were rocky shores.

Once on land the penguins usually walked directly inland on radiating and branching tracks. However, in rare cases, such as at Davis Point in Perseverance Harbour, penguins converged from a few adjacent landing sites to one track before heading inland. Tracks that had not been smoothed out by sea lions had obviously been used by penguins for a long time and had been worn down into small grooves in the soil. Most birds did not travel more than 500m inland or climb more than 60m above sea level. In some areas penguins roosted for the night on rocks close to the landing site.

Generally, penguins arrived at landing sites from the sea singly or sometimes in small groups, whereas it was more common for larger groups to gather on the shore before leaving in the morning. When travelling at sea, the penguins frequently porpoised above the water, and their movements indicated that they usually moved to fishing grounds outside the harbours and bays.

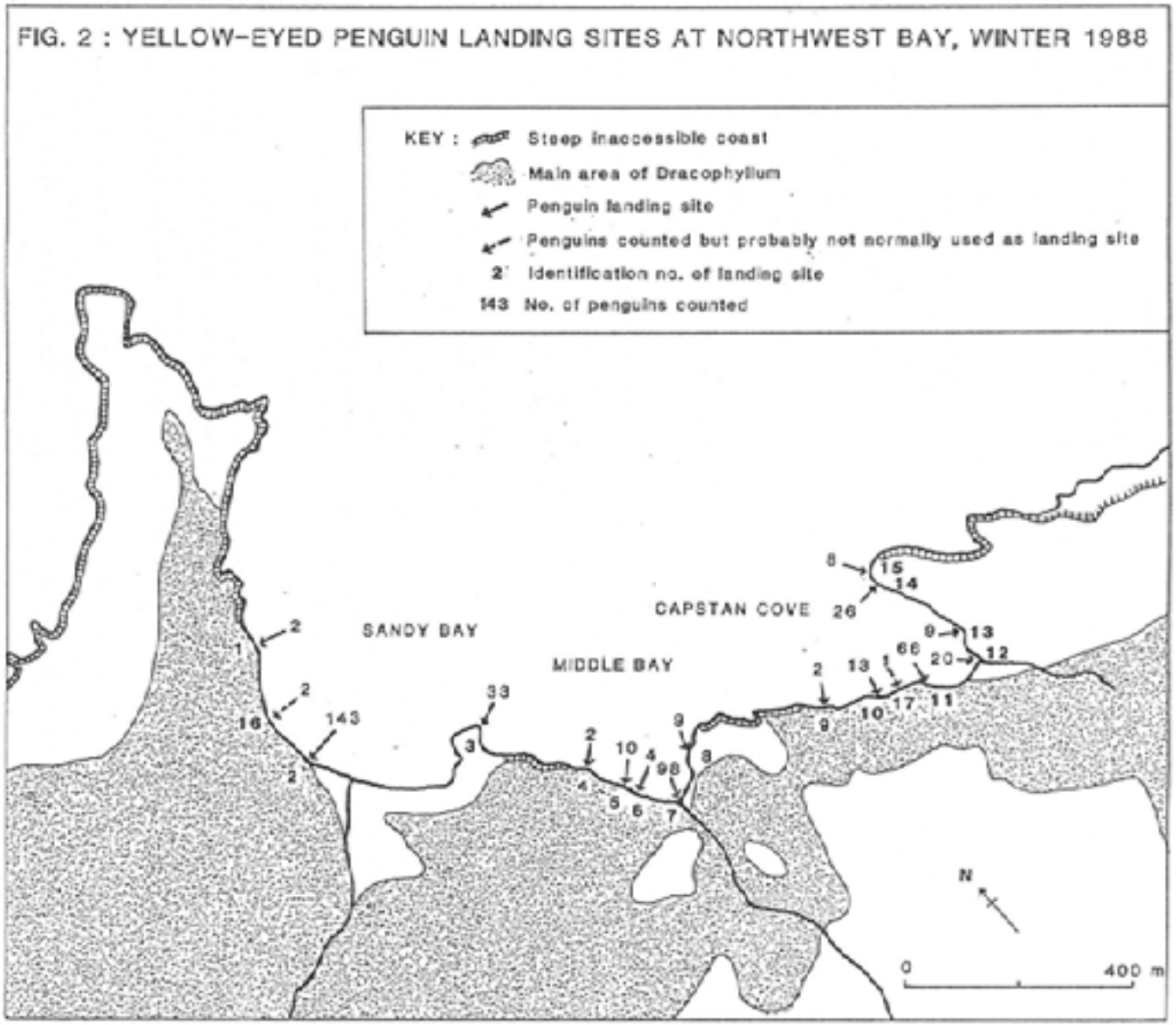
The areas where penguins were found (Fig. 1) are described below in anti-clockwise order around the island.

NORTHWEST BAY (Fig. 2)
Northwest Bay is sheltered from westerly weather by Complex Point. Three bays in the western half of the harbour are accessible to penguins and the shoreline is flanked by gentle slopes, mainly vegetated by mature *Dracophyllum* forest and scrub for up to a kilometre inland. The 448 penguins were counted at 17 sites, 15 of which were known to be used regularly. The most popular landing site on the whole island was at a boulder beach in Sandy Bay (143 birds). The other main landing sites were at the stream in Middle Bay (98) and at a wave-cut rock platform in western Capstan Cove (66).

ROCKY BAY
The smallest of five centres of population on the southern coast of the island was at Rocky Bay where there were three minor landing sites at the western end. The larger site where 11 birds landed was at a rock platform backed by a steep rock slope of about 8 metres in height which they scaled to reach their tracks.

ANTARCTIC BAY
One of the areas most exposed to open ocean swells is at Antarctic Bay, where 44 birds landed at a shallow notch in the rock of a peninsula. This was backed by cliffs so that only a small area of mega-herbs, fern and tussock was accessible to penguins. The area was counted from the top of the cliff by using a telescope.

FIG. 2 : YELLOW-EYED PENGUIN LANDING SITES AT NORTHWEST BAY, WINTER 1988



MONUMENT HARBOUR
The southern-most location of yellow-eyed penguins on the island was in Monument Harbour, where 136 birds were seen at six landing sites, giving a high average count of 23 per site. The main site (57 birds) was at a rocky promontory on the eastern side of the harbour. The vegetation in this area is dominated by *Poa* tussocks.

SOUTHEAST HARBOUR (Fig. 3)
The major centre for penguins on the south coast was Southeast Harbour which is flanked by a large expanse of *Dracophyllum* forest. The population of 260 birds was densely concentrated at 173 per kilometre of accessible coastline. Along the shingle and boulder beaches at the head of the harbour 15 penguin landing sites were identified, although most of the birds used 7 of these, particularly beside Southeast Stream (47) and near the eastern end of the beach (40). The main landing site (74) was further along the eastern side of the harbour, at a rock promontory below an old slip.

SHAG POINT
The bay in the lee of Shag Point is comprised of a short 600m stretch of rocky coastline which is exposed to open ocean swells. Almost all the 121 penguins landed at two sites on projections of the rock shelf where wave action was the least violent. This confined landing area thus had the highest average count per site (40) and second highest coastal density on the island (202/km).

PERSEVERANCE HARBOUR (Fig. 4)
The largest harbour on the island is Perseverance Harbour, extending about 9km inland from the eastern coast. The slopes are mainly cloaked by *Dracophyllum* scrub, although there are large areas of grasses and ferns on old slips on the southern side. As an area of importance for penguins on the island it ranked third with a count of 261. The birds were widely dispersed at 54 landing sites (4.8/site, 4/km) and only one individual was seen at ten of these sites.

The main concentration of penguins on the southern side was 3-4km from the harbour entrance, where 92 birds were counted at six adjacent landing sites along a sloping rock shore. There were 33 penguins at the most popular landing site. The shore becomes increasingly inaccessible towards the harbour entrance, with steep rugged slopes and bluffs, and few penguins were seen. Despite the easy access for penguins there was no sign of landing sites beyond Shoal Point or at the head of the harbour. The penguins furthest from the open ocean (about 7km) were near Lookout Bay on the northern shore. The other concentrations were around Boyack Point, east of De la Vire Point and at Davis Point.

SMOOTHWATER BAY
A small number of penguins was counted at Smoothwater Bay. Most of the 23 birds were at two landing sites on rock promontories at the southern part of the bay.

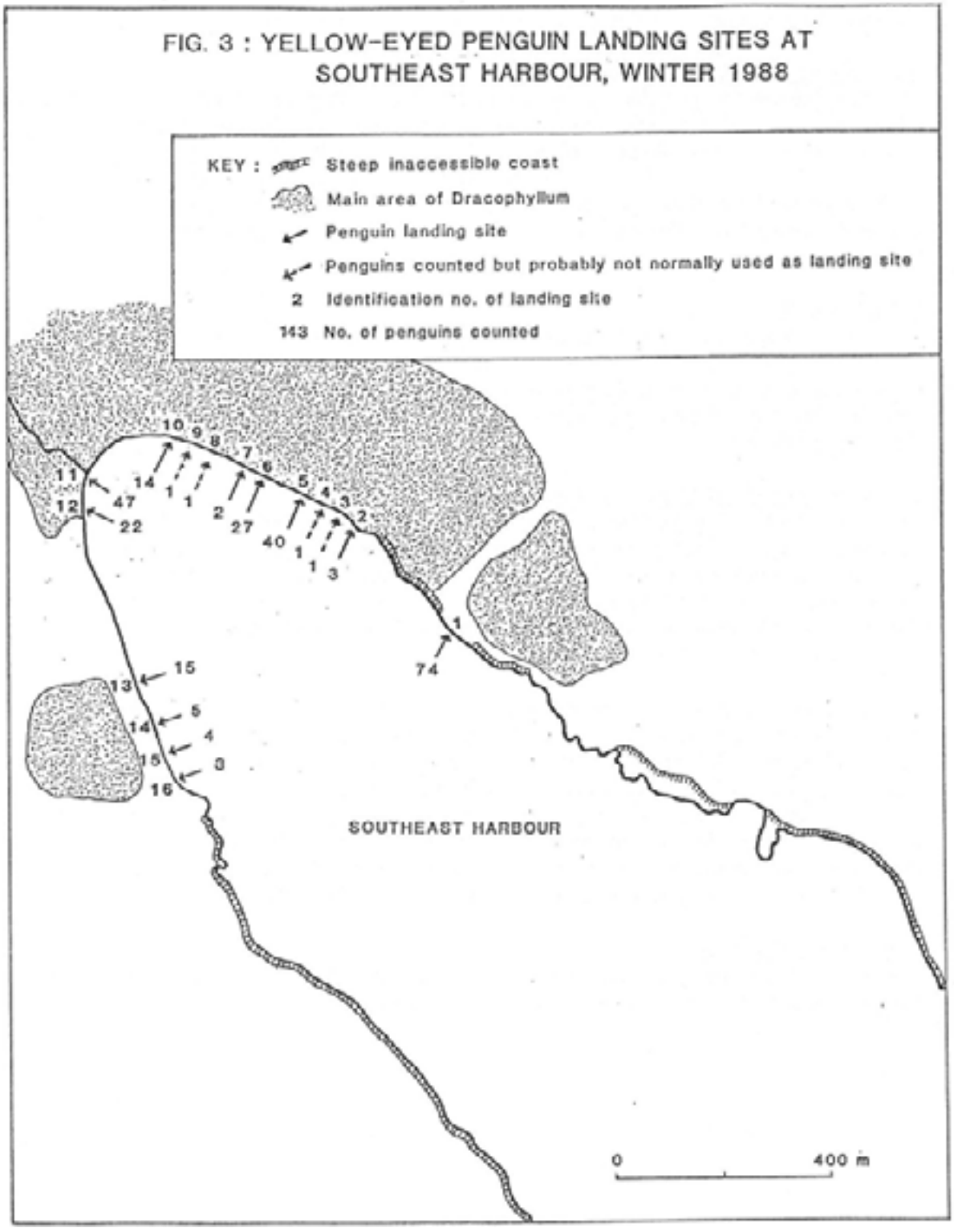


FIG. 3 : YELLOW-EYED PENGUIN LANDING SITES AT SOUTHEAST HARBOUR, WINTER 1988
KEY : Steep inaccessible coast
Main area of Dracophyllum
Penguin landing site
Penguins counted but probably not normally used as landing site
2 Identification no. of landing site
143 No. of penguins counted
10 9 8 7 6 5 4 3 2
11 12
14 1 1 2 27 40 1 1 3
47 22
1
74
13 14 15 16
15 5 4 0
SOUTHEAST HARBOUR
0 400 m

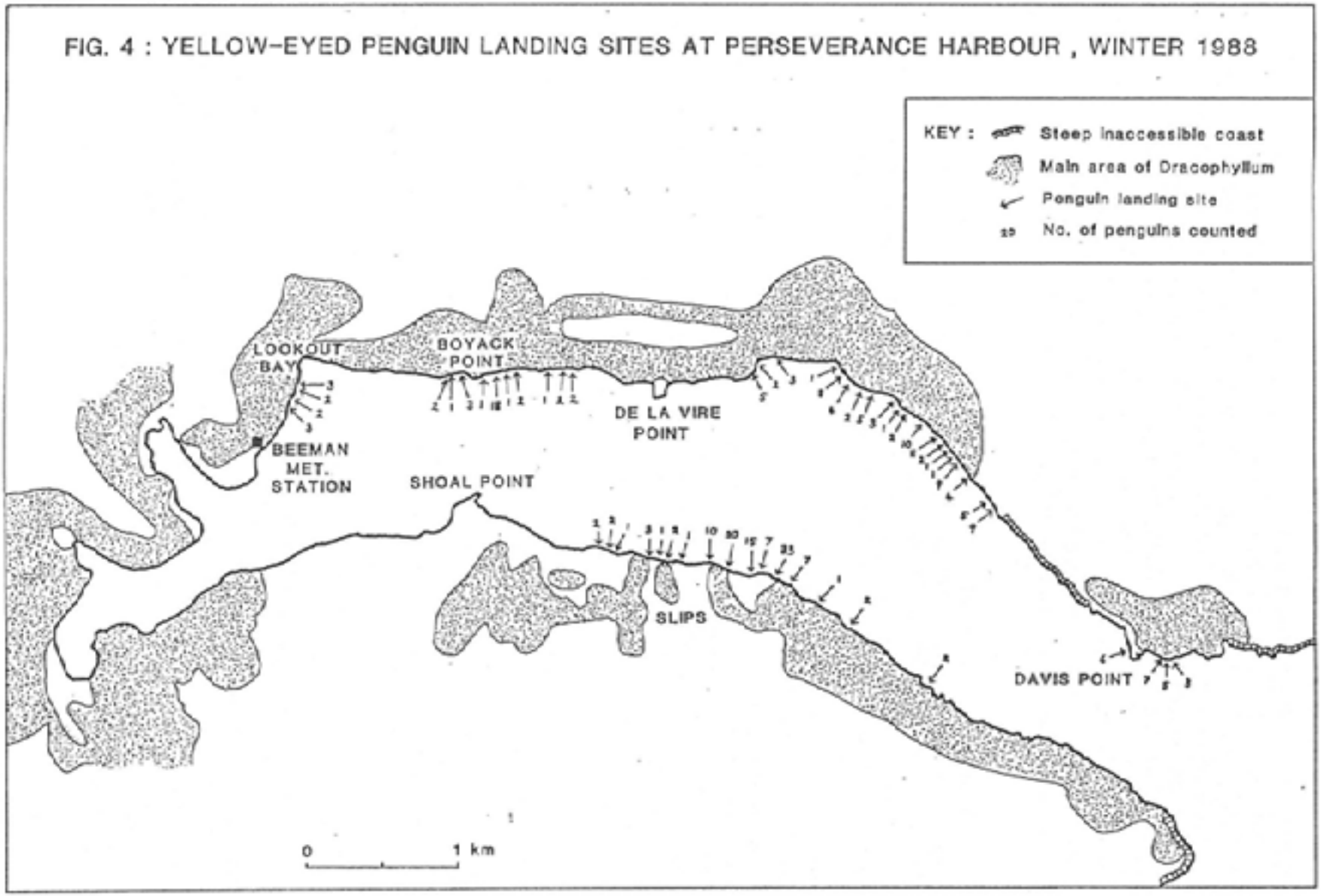


FIG. 4 : YELLOW-EYED PENGUIN LANDING SITES AT PERSEVERANCE HARBOUR , WINTER 1988
KEY :
Steep inaccessible coast
Main area of Dracophyllum
Penguin landing site
No. of penguins counted
LOOKOUT BAY
BOYACK POINT
DE LA VIRE POINT
BEEMAN MET. STATION
SHOAL POINT
SLIPS
DAVIS POINT
0
1 km

NORTHEAST HARBOUR (Fig. 5)
As with Perseverance Harbour, Northeast Harbour extends inland from the east coast, but it is much smaller at only 3.5km in length. The coastal vegetation is largely a continuous cover of *Dracophyllum* scrub. Shingle beaches in the inner harbour gradually change to boulder beaches and then rock shelves for the final kilometre. The harbour supported the second largest population of penguins on the island (312), but they were well dispersed (41/km) at 68 landing sites. The harbour has the lowest average count (4.6/landing site), with 15 sites where only one individual was seen. The landing sites were spread the length of both shores except for the western 500m at the head of the harbour. More penguins were counted within 2km of the open ocean than further up the harbour.

2.4.3 Numbers of Penguins at Northwest Bay and Southeast Harbour

The seasonal changes in numbers of yellow-eyed penguins at several landing sites at Northwest Bay and Southeast Harbour are shown in Fig. 6 (Appendices 1 and 2). The locations of these landing sites are shown in Figs. 2 and 3. Both harbours show similar trends in numbers, with lowest counts in November and highest counts in May.

In November, the eight sites monitored in Northwest Bay yielded a count of 195 adults, which was 51% of the number counted six months later. This was a result of one bird of each breeding pair in November taking a trip to sea while the partner incubated the eggs. In February, the count of 369 adults was close to the maximum because chicks were left unguarded and most adults went to sea every day. The maximum count of 384 adults occurred in May, when all birds had finished moulting and were travelling to sea almost every day, presumably to recoup their body reserves. The August count of 250 adults was low, possibly as a result of less frequent trips to sea and disturbance to penguin behaviour by the predatory activity of at least one sea lion (see Chapter 2.4.4).

At Southeast Harbour the minimum count of 63 adults was in November, followed by increases to 86 in February and 106 in May, and a subsequent decline again to 86 in August.

Juveniles showed an opposite trend in numbers from the adults. At 12 landing sites in Northwest Bay in November 37 juveniles (14.1% of the total 262 penguins) were counted and in May only 7 (1.6%) juveniles were counted. The total number of juveniles counted around the whole island during winter was 66 (4.1%). Observations of banded juveniles in winter indicated a dispersal phase when they did not favour particular landing sites and sometimes landed away from the sites used by adults.

2.4.4 Numbers of Penguins at Middle Bay

The seasonal pattern of numbers of yellow-eyed penguins at Middle Bay is shown in Fig. 7 and Appendix 3. Each monthly bar generally represents the average of four counts (two sets of departures and arrivals) at the main landing site (site 7, Fig. 2) during two complete days of observation (from before dawn till after dusk). The additional counts made in March, May and September were not for complete days but covered the main period of departures or arrivals. These counts are plotted to show the change in numbers around the moulting period and the beginning of the breeding season.

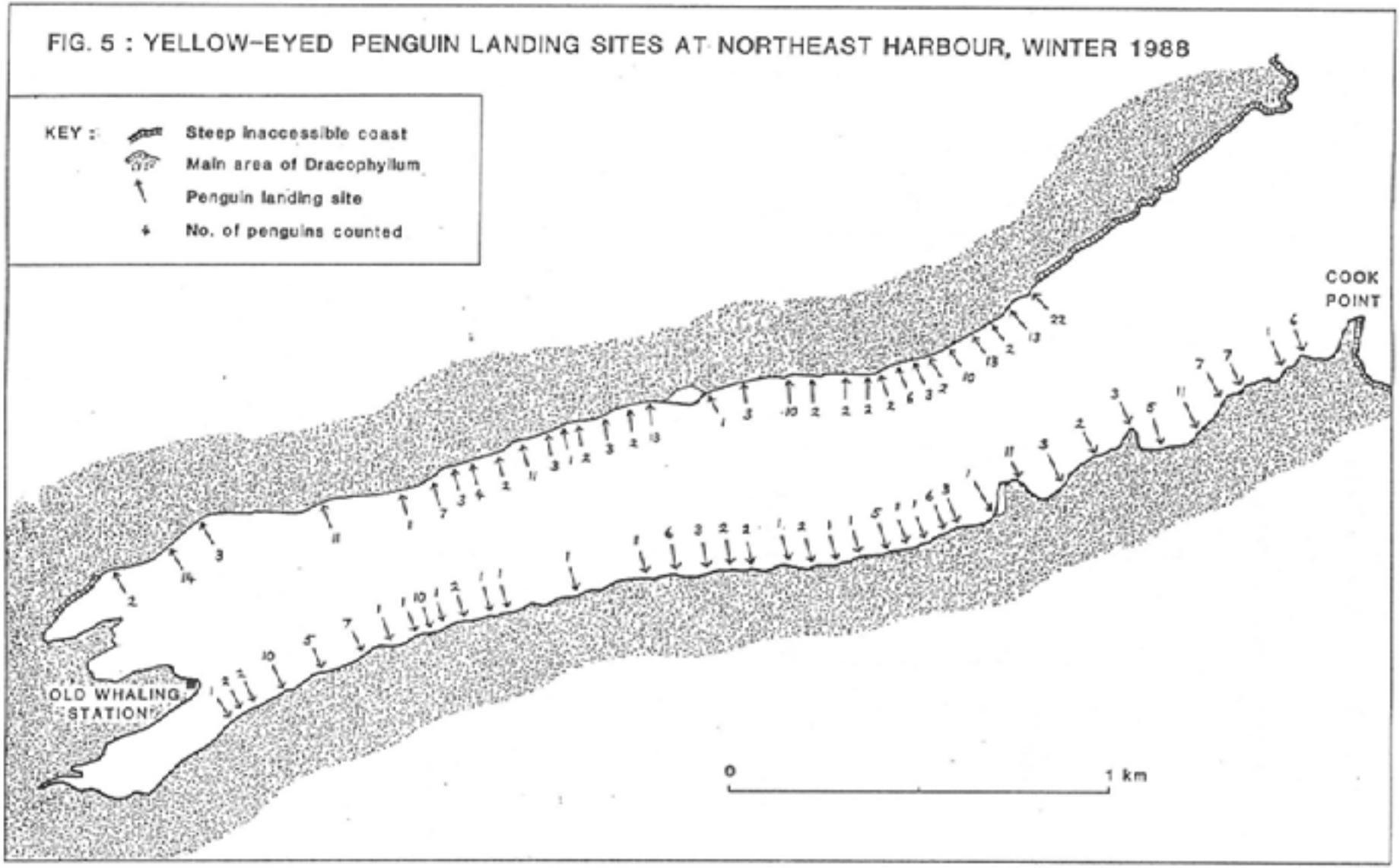


FIG. 5 : YELLOW-EYED PENGUIN LANDING SITES AT NORTHEAST HARBOUR, WINTER 1988
KEY :
Steep inaccessible coast
Main area of Dracophyllum
Penguin landing site
No. of penguins counted
COOK POINT
OLD WHALING STATION
0
1 km

FIG. 6 : SEASONAL CHANGE IN PENGUIN NUMBERS AT MAJOR LANDING SITES

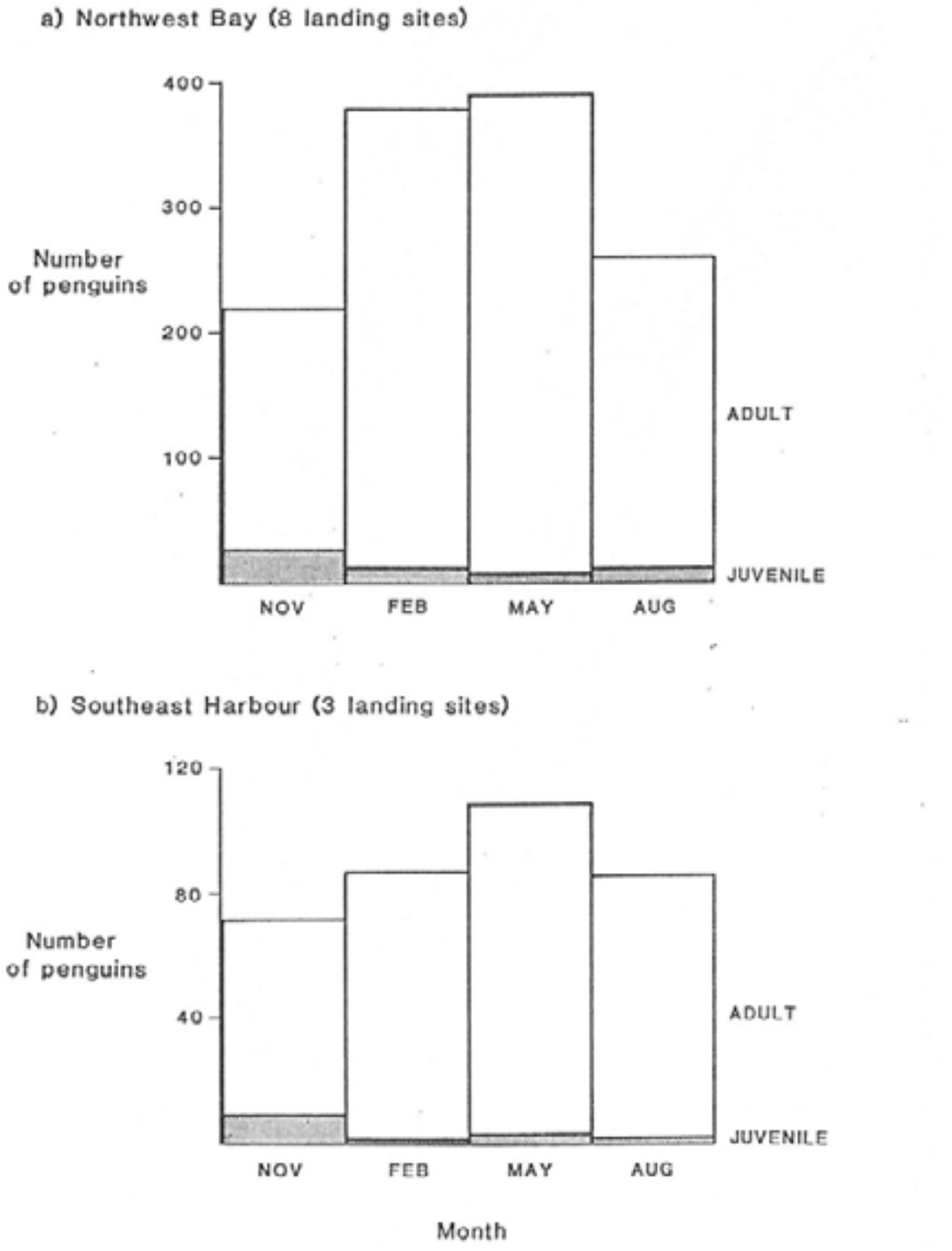
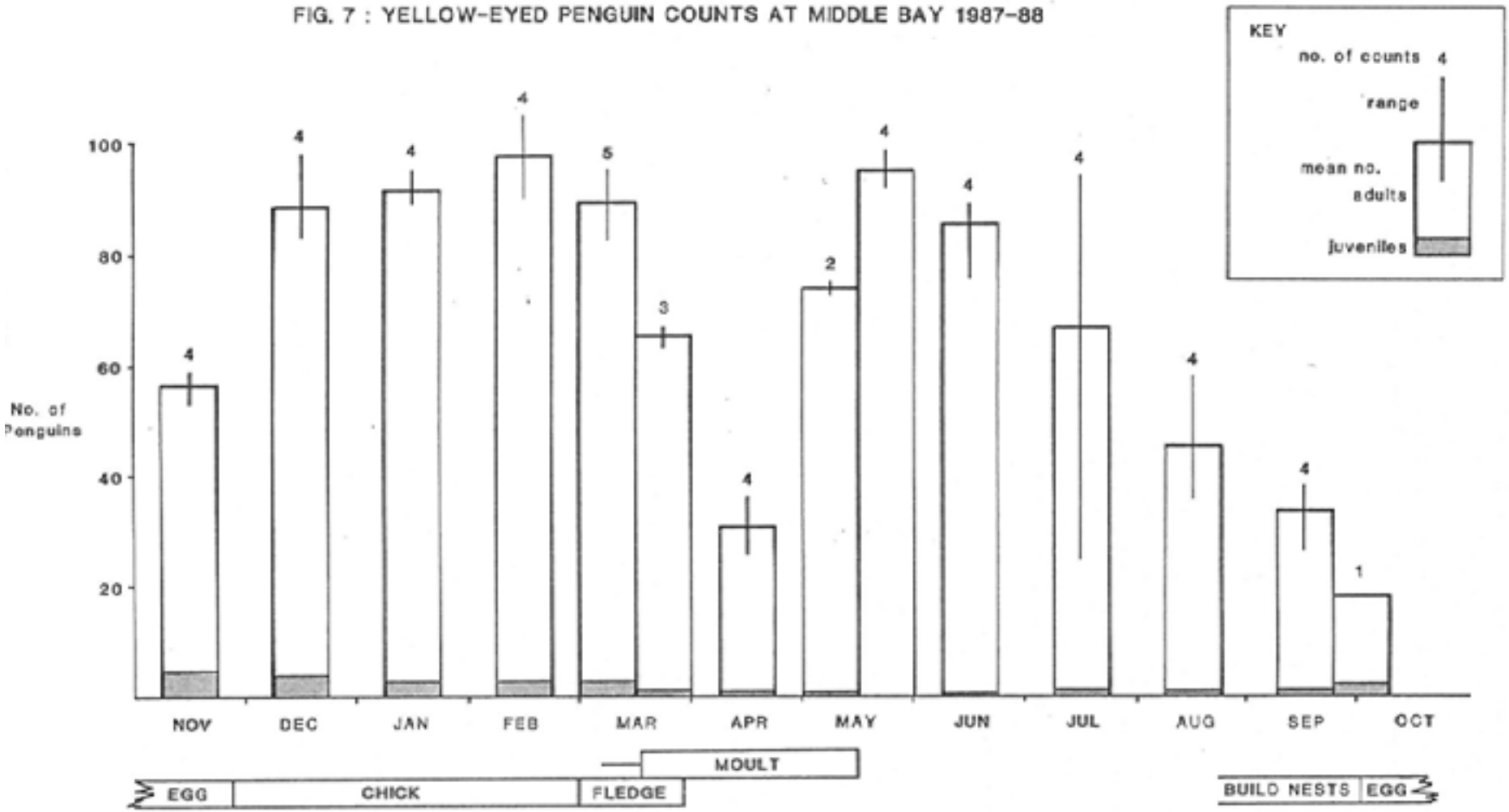


FIG. 7 : YELLOW-EYED PENGUIN COUNTS AT MIDDLE BAY 1987-88



Also shown in Appendix 3 are counts of birds landing on rocks at the eastern end of the bay, 100m away from the main landing site (site 8, Fig. 2). A few birds used this site as an alternative, especially in winter. Until May the observations of birds using the eastern landing site were only in the evening because they could not be viewed easily from the observation point used in the morning. Subsequently they were monitored in the morning also.

In November, when there was always one bird of each breeding pair at the nest, the mean count was 57 birds. This count represented about half the number of breeding birds and most of the non-breeding birds, 2-6 of these being juveniles. A maximum of six juveniles was seen at Middle Bay during the year.

Once the chicks had hatched, the counts from December to mid-March reflected the fact that most adults of breeding pairs were both at sea each day. Thus, the counts in these months approach the highest for the year. In December (89[1]) adults were taking alternate trips to sea on the same day, whereas by mid-January (91) many nests were at the end of the guard stage and both adults were at sea simultaneously. February (97) had the highest average count and the highest individual count of 105, however 4-8 of these birds were probably counted twice, as they made two trips to sea each day (this was confirmed for some of the banded adults). In mid-March (89) half the chicks had fledged while the remainder were still being fed by parents, 3-5 of which were making two trips each day.

The moult began in March. A juvenile in the early stages of moult was found inland from Middle Bay on 6 March, and six were seen moulting on 16 March. By 21-26 March the average count of penguins moving to or from the landing site had dropped (64), with non-breeders and failed breeders staying ashore to moult. The lowest counts of the year occurred in April (31) when most breeding adults were moulting and the recently moulted non-breeders and failed breeders were travelling to and from the sea again. Counts were increasing again in early May (74) because most adults had finished moulting, and by May (95) all had done so.

The mid-May average count (95) was the highest for the winter months. The June (86) and July (67) counts were lower because 2-21 birds were landing on the rocks at the eastern end of Middle Bay and spending the night there. Prior to June, it was rare to see more than one or two birds land at the eastern landing site. The greater use seemed to be mainly a result of the increasing presence of sea lions, with up to 60 gathering on the sandy part of the beach, which made the penguins very wary of departing and arriving at the main landing site. From May to July the maximum number of birds seen at both landing sites was similar, at 96-98.

In August (45) numbers had continued to decline. This was at least due in part to disturbance by a sea lion which was observed preying on penguins at Middle Bay. It lay in ambush behind a rock in the shallows near the landing site and was seen killing at least two penguins and pursuing others as they came ashore. Several penguin skins were found washed ashore, which had not been observed in earlier months. In September (33) predation seemed to be continuing since several skeletons and pieces of penguin

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[1] Numbers in brackets in this Chapter section refer to mean counts at the landing site (Appendix 3).

skins were found on the beach. There were also penguins inland during the day courting and preparing to nest.

2.4.5 Daily Movements at the Landing Site

The seasonal change in times of departures and arrivals of yellow-eyed penguins at the landing site at Middle Bay is shown in Fig. 8 (Appendix 4).

The mean departure and arrival times follow a similar pattern to the seasonal change in sunrise and sunset times (Fig. 8), particularly from April to September when most penguins left for sea around dawn and returned at dusk. This relationship is less clear during the breeding season (November to March) because of the wide range in times that penguins used the landing site. The identification of banded birds in these months showed that there were actually two overlapping peaks of departures and corresponding arrival peaks each day (Appendix 4, also see Figs. 9-12), relating to breeding partners taking turns to feed at sea or making two trips a day. Hence the peak of first departures (OUT-1) and last arrivals (IN-2) for December to March relate more closely to the sunrise and sunset times (Appendix 5) than do the mean times depicted in Fig. 8. The earliest observed time of departure was 66 minutes before sunrise in January, and the latest arrival was 91 minutes after sunset in July.

The difference between mean departure and arrival times relates to the length of time penguins spent at sea. This has been compared with the day-length in Table 3. In the breeding months of December to March the day-length declined from about 16.5 to 12.5 hours, and the penguins spent comparatively more of the daylight hours at sea, the difference declining from 8.5 to 1 hour less than the available daylight period. If the difference between OUT-1 and IN-2 is considered (right-hand columns, Table 3), the time at sea also becomes closer to the actual day-length. In December, which was the month of maximum day-length, the difference between the first penguin departure and second arrival peaks was 14 hours 16 minutes (0458-1914 Hours NZ Standard Time) with a range of 18 hours 11 minutes (0342-2153 Hours). In contrast, in the winter months of May to July when day-length decreased to around 8 hours, penguins their time at sea and spent up to 24 minutes longer, on average, than the day-length. For example, in June the mean time at sea was 8 hours 11 minutes (0837-1648 Hours) with a range of 10 hours 3 minutes (0749-1752 Hours).

FIG. 8 : DEPARTURE AND ARRIVAL TIMES OF YELLOW-EYED PENGUINS AT MIDDLE BAY IN RELATION TO SUNRISE AND SUNSET TIMES 1987-88

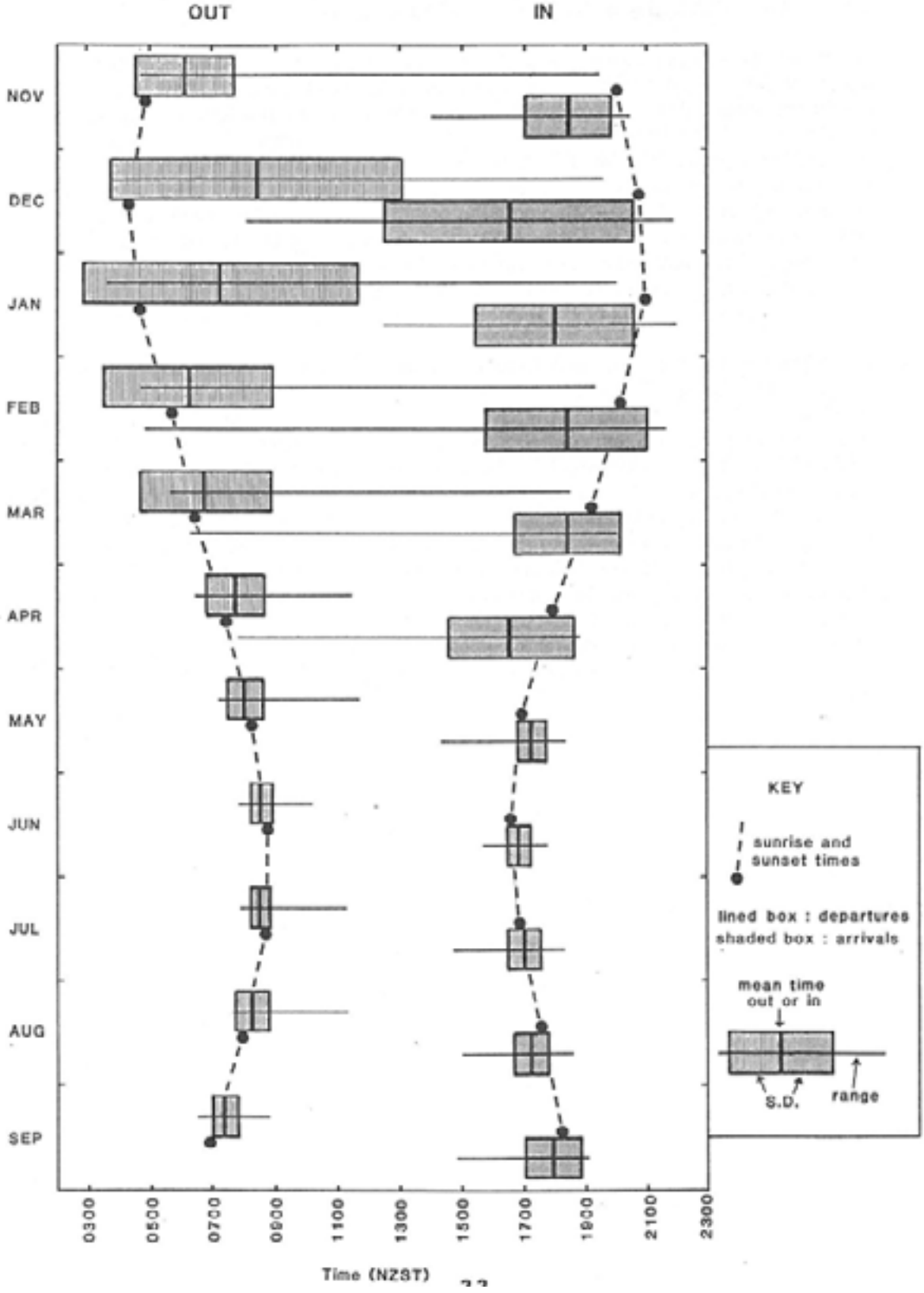


TABLE 3: DAY-LENGTH AND MEAN TIME YELLOW-EYED PENGUINS SPENT AT SEA, MIDDLE BAY 1987-88

	DURATION (Hours:Minutes)				
	DAY-LENGTH	MEAN[a] TIME AT SEA	DIFFER-ENCE[b]	MAX[c] TIME AT SEA	DIFFER-ENCE[b]
NOV	15:12	12:25	-2:47	1416	-2:15
DEC	16:13	7:56	-8:35	1322	-2:55
JAN	16:17	10:41	-5:36	1324	-1:02
FEB	14:26	12:19	-2:07	1212	-32
MAR	12:44	11:37	-1:07		
APR	10:34	8:49	-1:45		
MAY	8:46	9:10	+24		
JUN	7:48	8:11	+23		
JUL	8:09	8:27	+18		
AUG	9:38	8:55	-43		
SEP	11:35	10:35	-1:00		

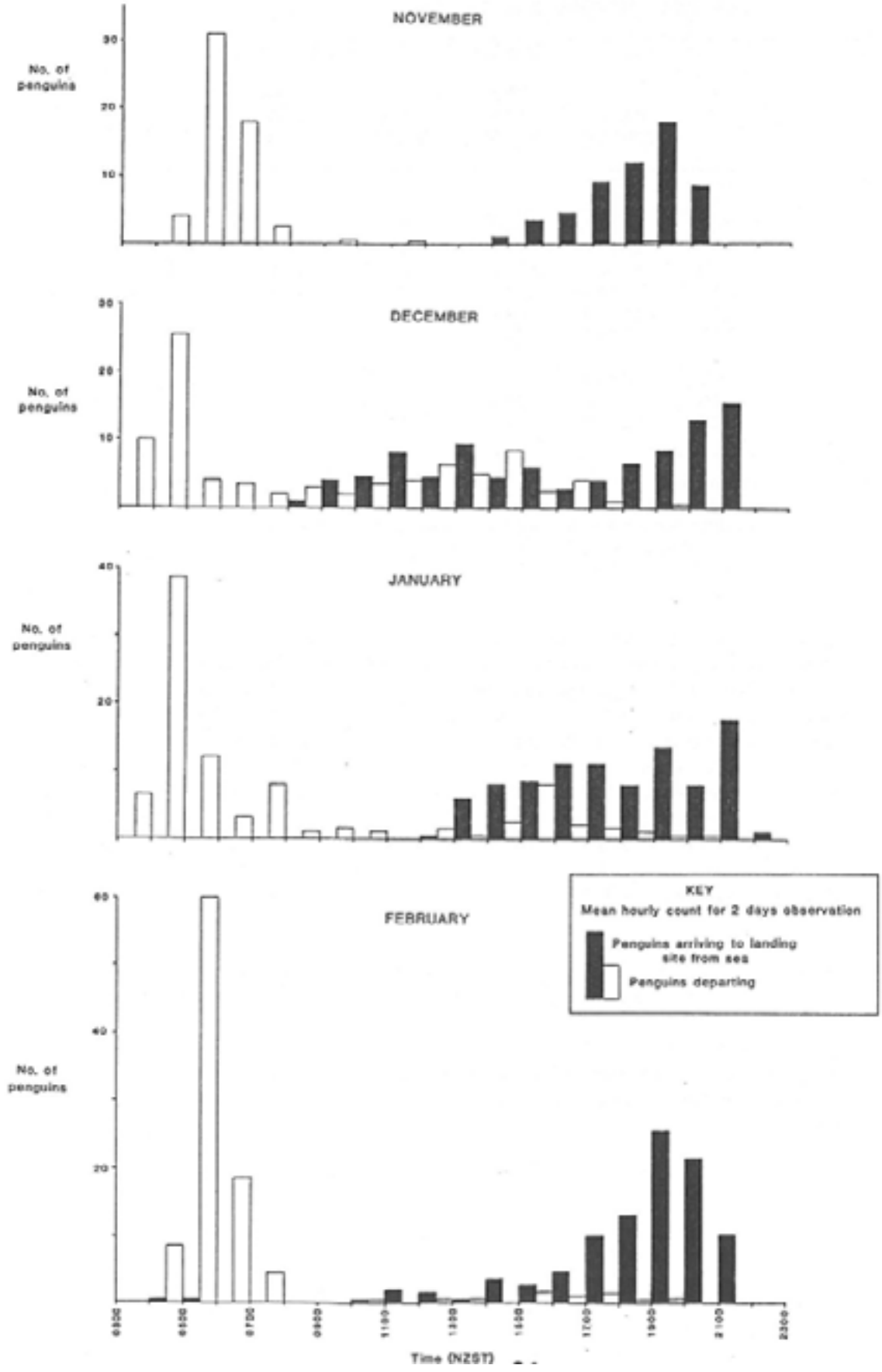
KEY a: Duration based on the interval between mean depature and mean arrival times (Appendices 4 & 5)
b: Time difference between the time spent at sea and the day-length
c: Time based on the interval between the first depature (OUT-1) and the second arrival (IN-2) peaks (Appendices 4 & 5)

The above assumption that the difference between mean departures and arrivals relates to the time that the penguins spent at sea was born out by the direct observations of the band numbers of banded birds. These data have not been presented in detail because of low sample sizes for some months, particularly in winter when the light was often poor for reading band numbers with binoculars. They also tend to under-estimate the average time spent at sea because there is a higher chance of reading a band number of a bird which leaves late in the morning and then returns early in the evening. Nevertheless, the trends are shown. For example, in February the mean observed time that banded penguins spent at sea was 12 hours 47 minutes (S.D=121min. N=19). By June the time at sea was only 7 hours 12 minutes (S.D.=13min. N=5). The maximum observed trip at sea was an individual in February which was seen returning to the landing site 15 hours 50 minutes after it left in the morning.

Figures 9-12 show the counts of yellow-eyed penguins at Middle Bay in more detail. These are hourly counts averaged for the two days of observation each month (Appendix 6).

NOVEMBER (Fig. 9)
During this month the pattern of movements showed the usual pattern of early morning peak departures and evening peak arrivals.

FIG. 9 : HOURLY COUNTS OF YELLOW-EYED PENGUINS AT MIDDLE BAY NOVEMBER 1987 TO FEBRUARY 1988



DECEMBER
By December, chicks had hatched and there were adults crossing the beach throughout the day. These movements have been interpreted as four peaks (as discussed earlier) based on the positive identification of banded breeding birds that arrived at the beach during the middle of the day, travelled inland to relieve their partners at the nest, who then departed to sea. These birds returned at the end of the day with others which had spent the whole day at sea.

JANUARY
In January many chicks were left unguarded by their parents, which were at sea simultaneously. There was still a distinct second peak of departures (OUT-2 in Appendix 4) with some adults taking turns at sea with their partners.

FEBRUARY
In February the main departure and arrival peaks were more well defined than previous months. This was because all the chicks were left unattended and both parents fed at sea during the day. Two unidentified birds arrived at first light, presumably having spent the night at sea or away from their normal landing site. The few late departures were by about six birds which were making two trips a day to sea to collect food for their chicks.

MARCH (Fig. 10)
Penguin movements showed a similar pattern to February, although the peaks were further accentuated. Departures were largely over in one hour. At this stage half the chicks had fledged, so only a few parents were making two trips to sea and travelling outside the peak periods.

APRIL
The birds in April spent less time at sea than expected from the trends shown in Table 3. These penguins had completed their moult and may have had insufficient insulation for long trips to sea. One bird which had not completely replaced its feathers returned to the beach after only 15 minutes at sea. The peaks were low because many adults were still moulting.

MAY TO SEPTEMBER (Figs. 10-12)
The hourly counts in the winter months showed a similar pattern of sharp departure and arrival peaks with no birds travelling during the middle of the day.

2.4.6 Numbers of Breeding Birds
Forty-two pairs of yellow-eyed penguins were known to have bred at Middle Bay (see Chapter 3). As the study area did not encompass all of the potential breeding area available to the penguins, the total number of breeding birds using the landing site was probably higher than 84. The evidence at Middle Bay is used below to estimate the proportion of breeding birds in the population.

FIG. 10 : HOURLY COUNTS OF YELLOW-EYED PENGUINS AT MIDDLE BAY MARCH TO MAY 1988

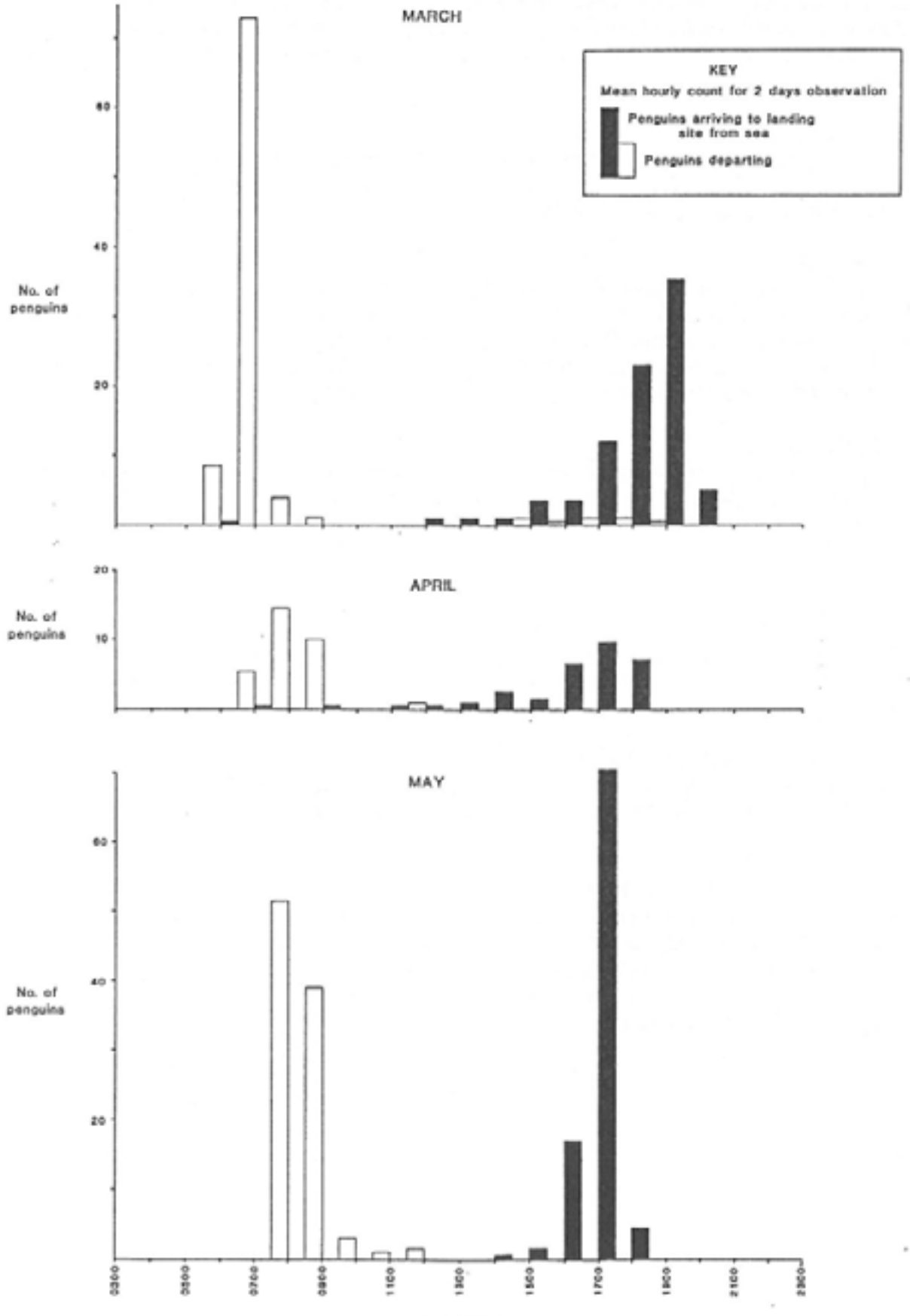


FIG. 11 : HOURLY COUNTS OF YELLOW-EYED PENGUINS AT MIDDLE BAY JUNE TO JULY 1988

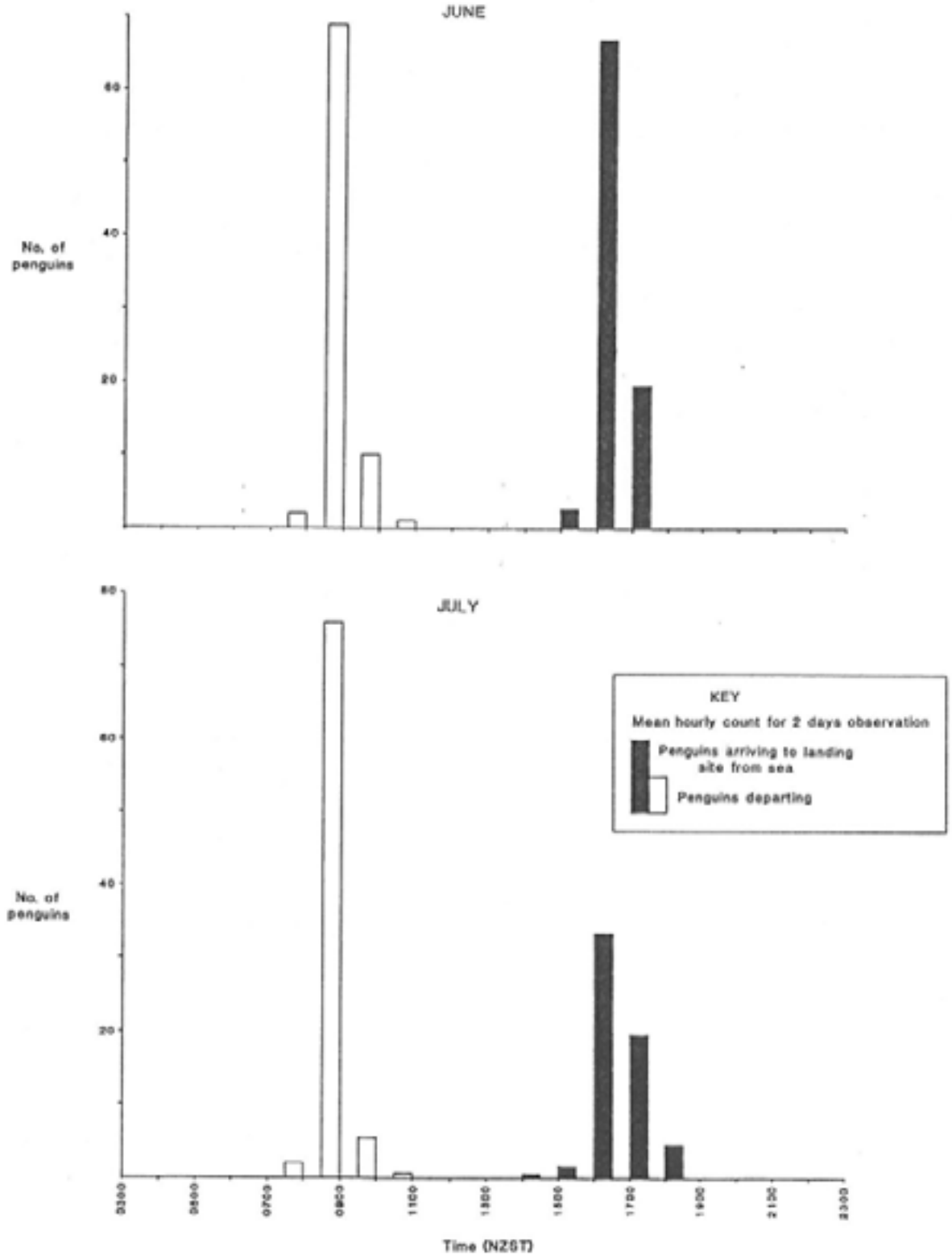
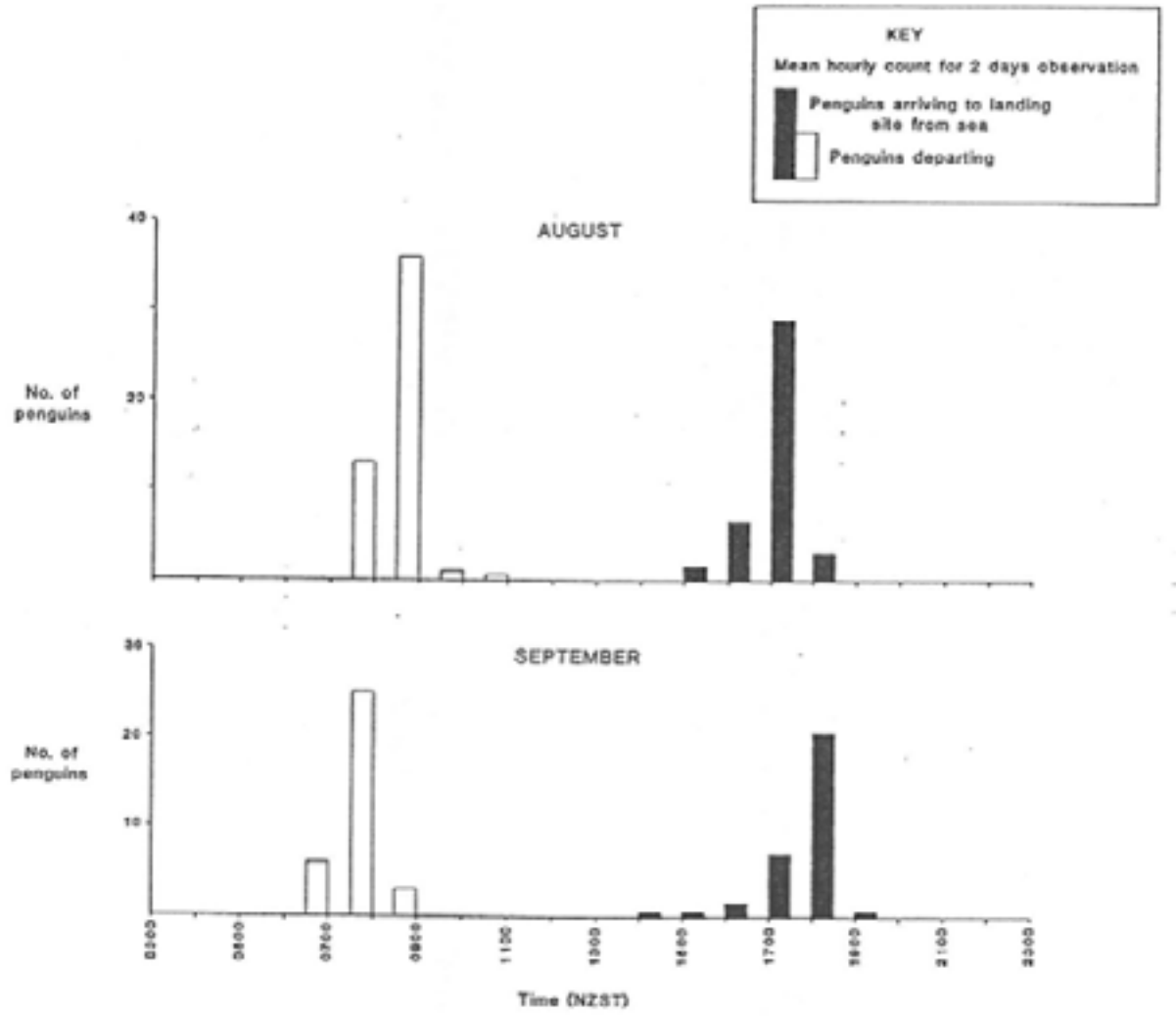


FIG. 12 : HOURLY COUNTS OF YELLOW-EYED PENGUINS AT MIDDLE BAY AUGUST, SEPTEMBER 1988



The earliest count that was made at the Middle Bay landing sites during the breeding season was on 3 November, when 54 adults and 6 juveniles were seen (Appendix 8). The fact that this included 31 banded adults, and 62 birds had been banded by this date helped confirm that breeding birds were taking alternate trips to sea on different days from their partners. The proportion of non-breeding adults in the count of 54 adults was up to 12, because there were at least 42 breeding pairs. This gives an estimated total population at Middle Bay of 102, with 84 (82%) breeding birds, 12 (12%) non-breeding adults and 6 (6%) juveniles.

During the December counts, most breeding birds were feeding chicks that were about two weeks old, and most partners were taking turns at sea on the same day. Therefore, the numbers of birds travelling in the first arrivals and second departures should have related to the number of nests. Of the original 39 nests with banded adults, 33 were successfully rearing chicks at the time of the counts at the landing site. About 29 banded adults were observed travelling outside peak times and about 7 unbanded birds were travelling at the same times. If it is assumed these were breeding adults also, the relationship of 29 banded adults from 39 nests can be used to extrapolate the 36 adults (29+7) to 48 nests. This means that there may have been 96 breeding individuals at the beginning of the breeding season.

The average count in May of 95 (92-98) probably represented the winter population of adults at Middle Bay, however, the counts of banded birds represented only 79% of the number known to be still alive (Appendix 8, column D). Presumably 21% of adults were staying ashore each day since none were seen away from Middle Bay. If this was true for all the birds at Middle Bay, the count of 95 represented 118 adults living there. If this total is related to the estimated number of breeding birds earlier that season (84-96, see above), the percentage of breeding birds in the population was 71-81%.

Another way of looking at the data is to consider the proportion of banded birds (i.e. known breeding adults) in each monthly count (column A, Appendix 8). From December to March the proportion was around 70% with a maximum of 77.8% for one March count. The September figures were around 60%, presumably a result of mortality of banded adults combined with an input of unbanded adults after the moulting period.

A further indication of the proportion of breeders is that a figure of 80% is the most reliable factor to use to extrapolate back from counts made at Northwest Bay in May to those the previous November. The assumption here is that only half the number of breeding birds was counted in November, as one bird of each pair was at the nest.

e.g. Northwest Bay (12 sites)

May count 437

437 x 0.80 = 350 breeding birds
= 175 breeding pairs
437 - 350 = 87 non-breeding birds

November count 262

Estimate from May figures
= 175 + 87
= 262

In summary, a conservative estimate of the proportion of breeding birds at Middle Bay was at least 70%. Thus, the population of 1600-2000 birds on Campbell Island in 1988 included about 560-700 breeding pairs.

2.5 DISCUSSION

The census of yellow-eyed penguins on Campbell Island during winter of 1988 revealed 1625 individuals. Although all major landing sites were found there may have been some minor sites in remote areas that were overlooked. For instance, the western coast below the cliffs of Mount Paris and Yvon Villarceau are accessible to rockhopper penguins, but visits by other workers have indicated that yellow-eyed penguins do not land there (P. Moors, D. Cunningham pers. comm.). Similarly, although lacking much suitable nesting habitat, there may be small areas available to penguins between Rocky Bay and Antarctic Bay or on the coastline north-east of Northwest Bay.

Middle Bay data suggested that only 80% of birds at any landing site were counted because not all birds travelled to sea each day. Therefore it is estimated there were about 2000 birds in total. This is substantially more than the 200 pairs (or 600 individuals) that Westerskov (1960) considered to be the likely maximum based on his visits to the main penguin areas. However, Westerskov did no actual counting as he states "An estimate of their numbers was not attempted and would be a very time consuming although rewarding study…'.

In censusing penguins on the mainland J. Darby (pers. comm.) finds a combination of a count in October (incubation phase) with one in December (chick guard stage) the most reliable method for determining the number of breeding pairs. Time and labour constraints did not allow a full census of Campbell Island in these months.

Darby uses the assumption that the number of pairs with two chicks can be estimated from the number of birds going out to sea during the second departure period. Thus, if two-thirds of nests rear two chicks (Richdale 1957) then the original number of breeding pairs can be predicted (Darby pers. comm.).

The above assumption was not valid for Campbell Island. When counts were made in December, 33 of the original 39 nests (with banded adults) had chicks, and 29 of these nests had two chicks while four had one chick. In all four of the one-chick nests, on both days of observation, one partner was identified arriving during the day followed by a departure of its mate. Thus, without the detailed information available the assumption that the birds travelling in the second departure peak represented two-thirds of breeding pairs would have overestimated the breeding population.

Nevertheless, there is still a relationship between birds counted and number of nests, and the various ways of looking at the information available revealed that at least 70% of birds were breeders at Middle Bay in 1987-88. This is higher than the 60% figure of (1957). Recent studies on the mainland also suggest the proportion of breeding birds in most years is higher than 60%, however the data has not been analysed (Darby pers. comm.)

Table 4 gives an estimate of the total population of the yellow-eyed penguin throughout its range. This should be treated as provisional as more reliable figures for most areas are needed. A figure of 70% breeding birds has been used to obtain the total population estimate of 4600-5600. If 60% is used the number of non-breeders increases the total to 5400-6500.

TABLE 4: YELLOW-EYED PENGUIN POPULATION ESTIMATE

Figures other than for Campbell Island are from Darby (pers. comm.)

	Population Estimate	Proportion of Total
BREEDING PAIRS on		
South Island	380-400	21-24%
Stewart Island	350-450	22-23%
Codfish Island	120-150	7-8%
Auckland Islands	200-250	12-13%
Campbell Island	560-700	35-36%
TOTAL	**1610-1950**	
BREEDING INDIVIDUALS	3220-3900	
NON-BREEDERS (30%)	1380-1670	
TOTAL INDIVIDUALS	**4600-5570**	

The available information suggests that the Campbell Island population represents a substantial proportion (an estimated 35%) of the world population of yellow-eyed penguins. The only other reliable figures are from the mainland South Island, although even there the situation is currently unclear. In after a dramatic disappearance of many breeding pairs the population on the mainland was thought to be only 200-300 pairs. With the reappearance of many birds in 1988-89 the latest estimate is 380-400 pairs (Darby pers. comm.).

The Stewart Island figure was mainly from density estimates with some counting in 1983-84, and the Codfish Island figure came from a partial census in 1983 (New Wildlife Service 1986). Some recent counts have also been conducted on Stewart and Codfish Islands. The Islands estimate was based mainly on a 1972 estimate by R. Russ of 80-150 pairs (Darby 1984) and an estimate for Enderby Island of 140 pairs (Darby 1986). There may be few birds on the main Auckland Island because of pigs (Challies 1975). Casual observations can be very misleading, for example Bartle and Paulin (1986) state that the population on Enderby Island "must be many thousands", and actual counts are the only solution to the problem.

On Campbell Island, the main centres of population were in the sheltered harbours which allowed easy access from the breeding grounds to the sea. Evidence from the prey items selected by yellow-eyed penguins off the mainland of New Zealand suggest the penguins travel away from the coast before beginning to feed over the continental shelf. This relates to a feeding range of less than 15 km offshore (van Heezik 1988). This probably explains why penguins were not found more than 7km up Perseverance Harbour, and why greater concentrations were found in the outer part of this harbour and Northeast Harbour.

Campbell Island lies at the southern end of the Campbell Plateau, a huge continental shelf less than 1000m below sea level. The bathymetry closer to the island shows a large expanse of shelf less than 200m deep and the 125m isobath is up to 9km offshore (Cullen 1971). Smith's (1987) analysis of yellow-eyed penguin distribution showed Campbell Island to be a very favourable area. The large area of continental shelf has very productive seas compared with other parts of the species' range. In addition, the requirements of a "cool" climate and suitable breeding habitat are well satisfied. These factors further confirm the importance of Campbell Island as a population centre for yellow-eyed penguins.

Although often referred to as the world's rarest penguin (e.g. Darby 1985), at present the yellow-eyed penguin may be second in rarity to the Galapagos penguin (*Spheniscus mendiculus*). In 1985 its population was only 1500-3000 birds (Valle 1986). At that time the population had recovered by 50% from 1984 levels (Valle and Coulter 1987), having suffered a severe decline after the 1982-83 El Nino Southern Oscillation weather phenomenon. Prior to that the population had been estimated at 6,000-12,000 birds (Valle 1986), so potentially the species could recover to that level and outnumber yellow-eyed penguins.

The seasonal change in yellow-eyed penguin numbers on Campbell Island was presented in some detail in this report to allow interpretation of population estimates and provide base-line data for future work. It would appear that May-June was a good period to conduct a census, particularly May, as this was after the moult when adults were replenishing their body reserves by going to sea on most days. Thus, counts were close to the maximum for the year. This may be a consideration when plans to census areas such as the Auckland Islands are made.

An indication of annual variation in penguin numbers is given by Table 5. The counts in 1987 and 1988 were very similar. The 1989 count at Sandy Bay was higher because more juveniles were seen. At Middle Bay in 1989 the count was less than half what it had been in previous years and in November 1988 only 6 birds were seen (P. Hatfield pers. comm.). It is probable that the sea lion predation and disturbance at the end of our study continued to affect the study area.

TABLE 5: ANNUAL COUNTS OF YELLOW-EYED PENGUINS AT NORTHWEST BAY

Area	Landing site No.	No. of penguins May-June 1987[1]	May 1988[2]	May 1989[3]
Sandy Bay	2	141	143	155
	3	33	33	
Middle Bay	7	100	98	41
Capstan Cove	11	62	66	

Key 1: R. Moffat
2: this study
3: P. Hatfield (N.Z. Meteorological Service)

Jouventin (1982) suggested that the yellow-eyed penguin's high degree of wariness of humans compared with other penguin species has probably preserved it from extinction. This trait was thought to be a late adaptation, since A. Wright of the N.Z. Wildlife Service had reported that penguins on Campbell Island were much less afraid of people than in New Zealand. In contrast, during this study we found that although some individuals were unafraid of humans, they were usually wary, particularly at the beaches, in the open or if the people were moving. Most penguins, however, were quite approachable at the nest, just as they are on the mainland (Darby pers. comm.).

CHAPTER 3. BREEDING BIOLOGY

3.1 BACKGROUND

The subantarctic members of the yellow-eyed penguin population have received little attention from scientists, apart from the recording of their presence and collection of specimens by various expeditions last century and early this century. This is partly because the penguins nest at low densities in dense vegetation, making study difficult and time consuming in comparison with colonial species.

The only detailed observations of nesting yellow-eyed penguins on Campbell Island were made by J. Sorensen in the 1942-43 season. He followed the progress of one nest in particular in Perseverance Harbour, and found in general that nesting occurred one to two weeks later than on mainland New Eggs were laid from early to mid October and chicks fledged in mid to late March (Bailey and Sorensen 1962). Filhol (1885) found chicks on 15 November 1874. The only other references to nesting have been anecdotes by Westerskov (1960).

3.2 AIMS

To determine the:
1. Timing of the breeding cycle
2. Nesting habitat
3. Level of breeding success.

3.3 METHODS

Middle Bay of Northwest Bay was chosen as a study area to follow the 1987-88 breeding season of the yellow-eyed penguin on Campbell Island. Searches for nests were conducted inland from the landing site at the stream in Middle Bay. Care was taken not to search too far either side of the landing site to avoid encroaching on breeding areas associated with other landing sites. The main searching period was 23-27 October and 12 November 1987.

Nests were mapped in the study area by measuring distances and orientations between them. To aid the re-finding of nests, routes were marked of red trail tape.

Nests were initially visited every few days to record their contents. At the peak of hatching, visits were every two days, and subsequently every five days until chicks fledged. From 23 October 1987 to 31 March 1988 39 visits were made to nests in the study area using a minimum walking/crawling circuit of 2.5 The progress of an additional eight nests elsewhere in Northwest Bay and one in Perseverance Harbour were monitored on a more irregular basis.

Adults were flipper-banded at the nest. Movements of the adults to and from the nests were monitored at the landing site.

Ectoparasitic ticks were collected for identification from penguins in the study area.

3.4 RESULTS

3.4.1 Nesting Habitat

During the main searching period of 23-27 October 33 nests were found in the study area. Another six nests were found two weeks later, one more on 26 November, and two broods near their nests in early January, bringing the total of known nests in the area to 42.

The study area (Fig. 13) was approximately 10.9ha in extent, being 400m at the widest point and extending 450m up the Middle Bay stream. The slopes of Menhir Peak flanked the western border of the area. The density of the 42 nests was 3.8 nests/ha. Table 6 shows that the average walking distance from the landing site at the beach to the nest was 236m. The furthest inland that a nest was found was 433m. Most nests were 20-60m above sea level. Generally, the nests were dispersed and isolated from their neighbours, on average 22m away from the closest neighbour (Table 6).

TABLE 6: DISTANCE FROM SEA AND NEIGHBOURS OF YELLOW-EYED PENGUIN NESTS AT MIDDLE BAY

	DISTANCE (m)				
PROXIMITY TO	MEAN	S.D.	MIN.	MAX.	N
THE SEA	236	84.9	82	433	42
NEIGHBOURS	22	10.7	5.4	49	42

Vegetation in the study area ranged from stands of tall (up to 5m) mature *Dracophyllum* scrub (a mixture of *D. longifolium* and *D. longifolium x scoparium* hybrids), particularly near the coast, to shorter (203m) and denser pole stands of *Dracophyllum* scrub further inland. Scattered throughout the younger scrub and small clearings were divaricating shrubs (1-2m tall), mostly *Myrsine divaricata*, with some *Coprosma cileata* and *C. cuneata*. One large grassland clearing in the western part of the study area included *Poa literosa* and other grasses, *Carex, Bulbinella rossii* and *Histiopteris incisa*.

The nesting habitat is broadly summarised in Table 7. *Dracophyllum* was the main plant cover for nests. Many nests were in areas of closed canopy but several were found close to the edge of clearings or under isolated plants in clearings. Nests were also found under *Myrsine divaricata* and the less common *Coprosma* shrubs. A few nests were under *Poa* tussocks or the fronds of ferns, mainly hardfern (*Polystichum vestitum*) or in one case *Histiopteris incisa.*

FIG. 13 : YELLOW-EYED PENGUIN STUDY AREA, MIDDLE BAY

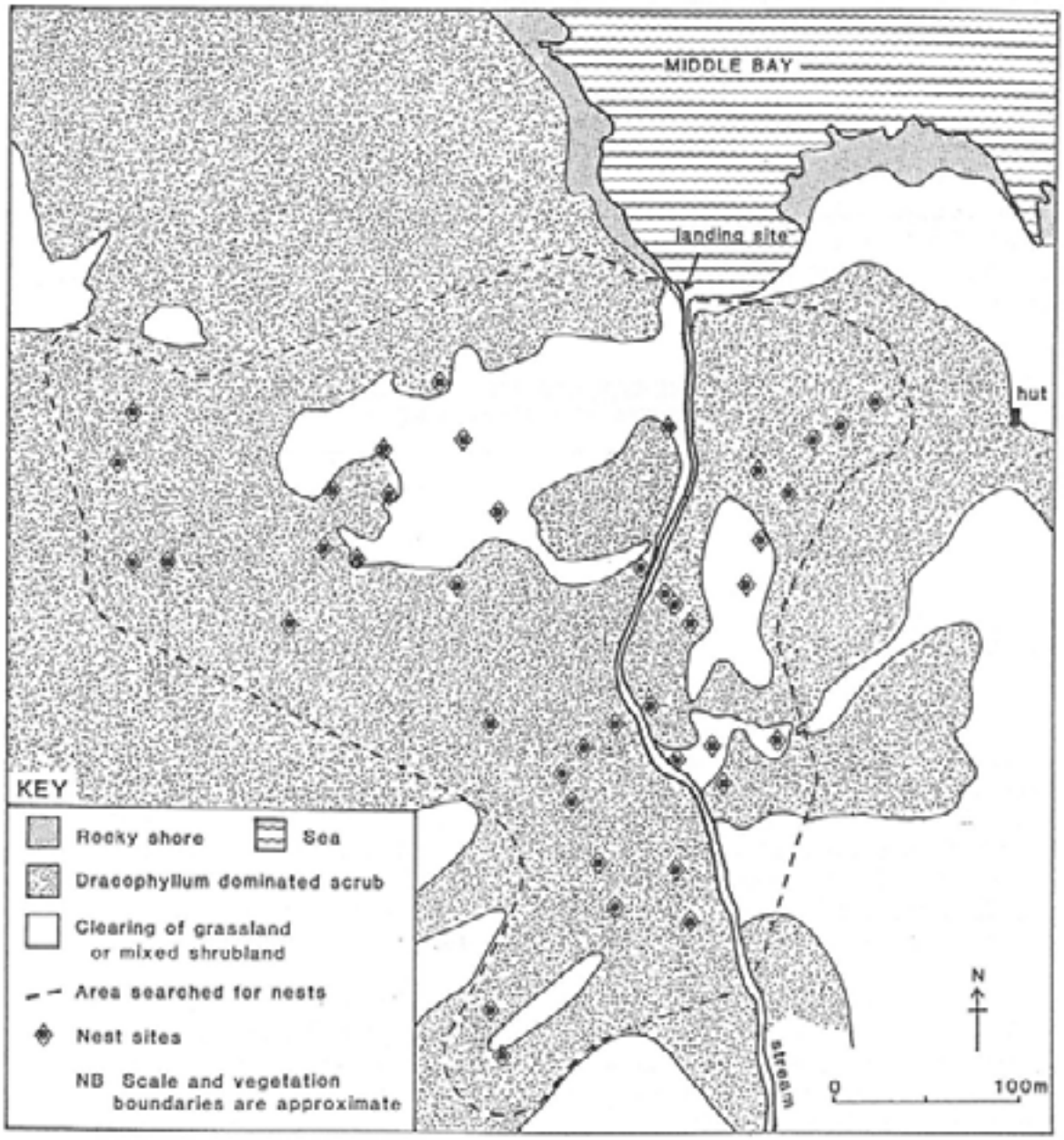


TABLE 7: NESTING COVER OF YELLOW-EYED PENGUIN AT MIDDLE BAY

PRIMARY VEGETATION COVER OF NESTS	NO. OF NESTS	%
Dracophyllum	17.5	44
Myrsine	10	25
Coprosma	5.5	14
Poa	3	7
Fern	4	10
	40	

The main factor in nest choice was probably shelter, since 58% of nests were built against a solid backing of some sort. These included banks up to 50cm tall or were formed by and roots at the base of *Dracophyllums.* Many nests were actually overhung by trunks and in some the nest site was virtually a hole. The remaining nests had either a dense backing of vegetation or close cover above the nest. In general, therefore, the nests were sheltered on three sides and above, leaving one side open as an entrance:

3.4.2 Breeding Success

The breeding success of the yellow-eyed penguin at Middle Bay is presented in Table 8. The 33 nest sample gives the best estimate of nesting success at the egg stage, and for overall success from egg to fledgling, since they were all found early in incubation. The 40 nest sample includes the same 33 nests and the additional 7 nests which were followed from hatching to fledging. This larger sample provides a better estimate of chick fledging success.

TABLE 8: BREEDING SUCCESS OF YELLOW-EYED PENGUIN AT MIDDLE BAY

	33 NEST SAMPLE				40 NEST SAMPLE			
	Nest no.	%	Egg/chick no.	%	Nest no.	%	Egg/chick no.	%
NESTS	33				40			
EGGS			64				78	
HATCHING SUCCESS	**29**	**88%[a]**	**53**	**83%[b]**	36	90%	66	85%
CHICK SUCCESS								
For nests that hatched chicks	25	86%	45	85%	**32**	**89%[c]**	**56**	**85%[d]**
For all nests	**25**	**76%[e]**	**45**	**70%[f]**	32	80%	56	72%
OVERALL SUCCESS								
Chicks per nest			**1.4[g]**				1.4	
PRODUCTION[h]								
2 chicks	20	60.6			24	60.0		
1 chick	5	15.2			8	20.0		
0 chicks	8	24.2			8	20.0		

Success Definitions
a : Percent of nests that had chicks
b : Percent of eggs that hatched
c : Percent of nests with chicks that fledged chicks
d : Percent of chicks that to fledge
e : Percent of the original nests that fledged chicks
f : Percent of the original eggs that fledged chicks
g : Mean number of chicks per nest
h : Percent of nests which produced two, one or no chicks

EGGS

Of the 33 nests that were found early in incubation, 31 (94%) had two egg clutches, while the other 2 (6%) had only one egg. Chicks were hatched successfully in 29 (88%) of the nests (Table 8). In three of the failed nests, one parent disappeared and the nest was abandoned by the remaining bird. The eggs at the fourth failed nest were incubated for more than two months before being abandoned. Also, one of the eggs failed to hatch in four of the successful nests, leaving 53 (83%) of the original 64 eggs to hatch successfully.

CHICKS

By the time of hatching in November there were 40 study nests, 36 of these having successfully hatched 66 chicks (Table 8). The mean hatch date was 26 November days), with a 14-day range of 20 November to 3 December. The hatching dates of 14 eggs from eight nests that were monitored outside the study area fell within this range except for one nest, which hatched on 12 December. Allowing for an incubation time of 43.5 days (Richdale 1957), the mean laying date for Middle Bay would have been

15 October (range 8-21 October). Therefore, most of the first 33 study nests were found at the early stages of incubation. The following season (1988-89) three nests were found with freshly laid single eggs on 29, 30 September and 3 October.

The guard stage lasted for 46 days on average (N=32, SD=7.9, range=32-63), after which chicks were usually unattended during the day. Ten of the 34 broods at Middle Bay were regularly found with neighbouring chicks. These involved no more than three broods, although on one occasion 7 chicks were found together at Sandy Bay.

CHICK SURVIVAL

The survival of 66 chicks was followed. During the first 10 days after hatching six chicks died, causing the failure of four nests. Subsequently, there were no confirmed deaths until days 94 and 108, during the fledging period. However, there were two early disappearances of chicks on day 70 and 86, which were probably deaths. Their siblings departed 31 and 20 days later respectively.

Thus, 56 (85%) of the original 66 chicks which hatched to leave the breeding area, and 32 (89%) of the 36 nests with chicks were successful (Table 8). The overall success of each nesting attempt was 76%, with 70% of all eggs leading to a fledged chick. The average number of chicks surviving per breeding pair was 1.4. Nearly two-thirds (61%) of nests produced two chicks, 15% produced one chick, while 24% failed completely.

When a chick disappeared from the study area we assumed it had departed for sea. Although some may have died without being found, only two corpses were discovered during the fledging period. Two other chicks became very emaciated. One declined from 4.8kg on day 65 to 3.0kg on day 110 when it was last seen. The other chick was 3.5kg on 3.7kg on day 91. Their siblings were heavier, but still relatively light for their age, being respectively 4.0kg on day 100 and 3.8kg on day 81. Despite extensive searches no corpses of these chicks were found. If they had died before entering the sea the minimum fledging success for Middle Bay would have been 52 (79%) of 66 chicks hatched, 41 chicks (64%) of 64 eggs laid, 23 nests (70%) of 33 nesting attempts and 1.24 chicks per nest.

Three of the four early nest failures occurred after the disappearance of one of the adults. Both the confirmed chick deaths late in the breeding season also coincided with an adult disappearing. At least one of the remaining adults was able to rear a single offspring as the chick was later seen as a juvenile. One of the broods which lost weight was also a result of the death of a parent. Therefore, of 10 broods that did poorly, six had apparently become single-parent nests.

Most chicks had a few parasitic ticks on their heads or body. These were *Ixodes uriae* (pers. comm. A. Heath, Wallaceville Animal Research Centre, M.A.F. Upper Hutt).

CHICK DEPARTURE

The average age of chicks at departure to sea was approximately 108 days with a range of 97 to 119 days. Only two chicks could be assigned to an exact day of departure. The others were estimated on the basis of fresh sign and the interval between the last sighting and the next visit to the study area five days later. Therefore the error was +/- 2.5, if not more for some chicks which eluded observation with their increasing

mobility close to fledging. The difference in departure of siblings was approximately 3 days (S.D.=4.3), with a range of 0-13 days. The overall mean date of departure was 13 March (S.D.=7.9), with a range of 30 days from 28 February to 28 March.

JUVENILE SIGHTINGS

During mid-February, when chicks were approximately 80 days old, flipper bands were applied to 141 chicks. Banding totals were 63 chicks at Middle Bay, 65 elsewhere in Northwest Bay, 10 at Southeast Harbour and three at Perseverance Harbour.

Twelve juveniles that were banded as chicks were seen between April and September. Three were seen twice, and another was seen six times during Middle Bay beach counts. Apart from five unidentified banded chicks leaving for their first swim at Middle Bay, there were only two sightings of unidentified banded juveniles.

At Middle Bay, if 56 (94.1%) of 59 banded chicks fledged, we can assume that 133 of the 141 banded chicks entered the sea. Thus 12 sightings of juveniles represents 9.0% of the fledglings. Of the Middle Bay chicks 7 (12.5%) were later seen as juveniles.

Most sightings of juveniles were in Northwest Bay, usually at or within 400m of their natal landing sites. One Perseverance Harbour juvenile was also near its natal area. The most distant records were of two Middle Bay juveniles at Southeast Harbour in June, a distance of 24km by sea from their natal area.

3.4.3 Adult Survival

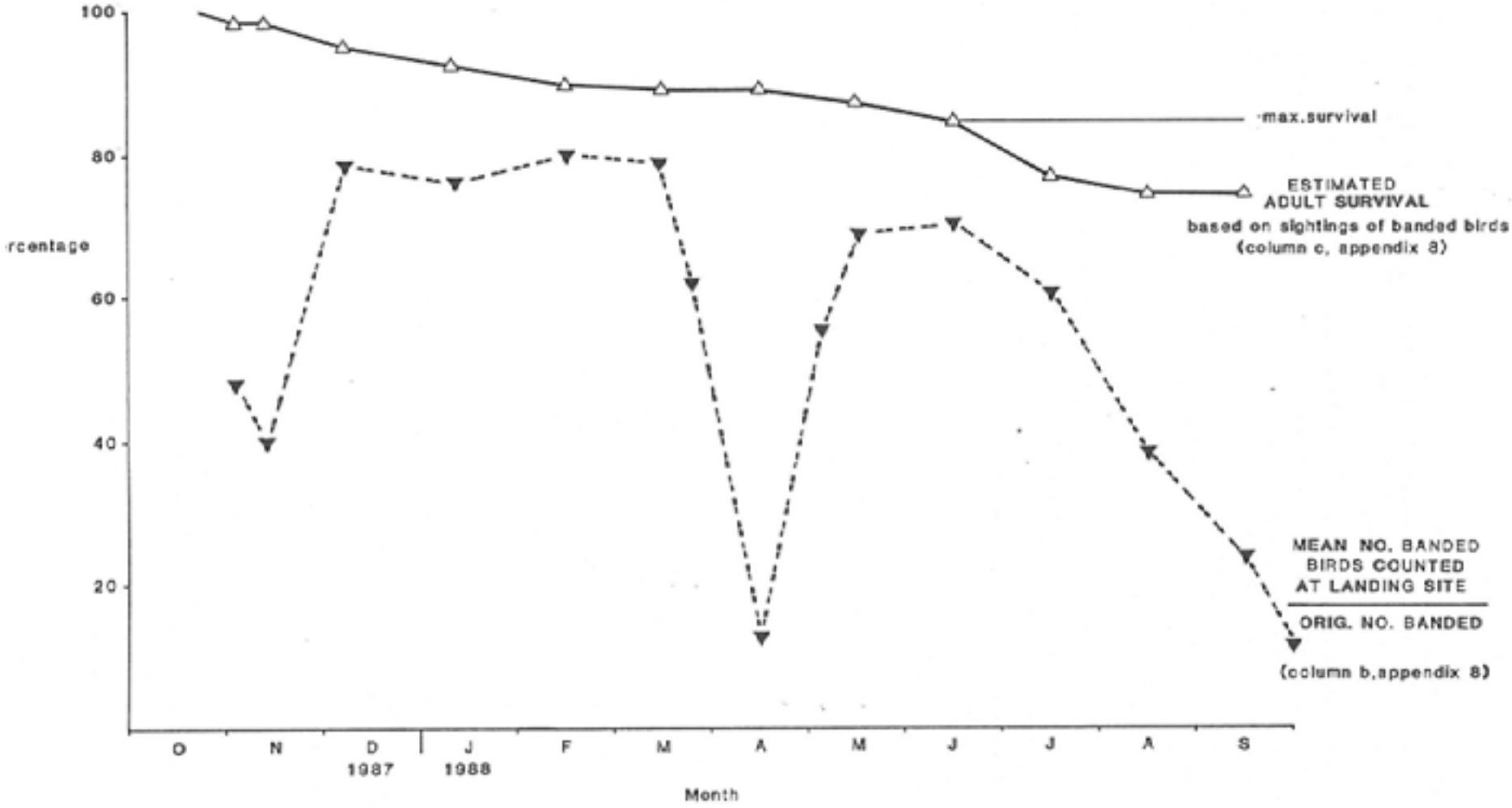
There was only one confirmed death of a banded adult during the study. This was found dead in February on the track leading to its nest. Its stomach was almost empty and at it was lkg lighter than it was in October.

An estimate of adult survival (Fig. 14, Appendix 7 and 8 -column C) was attempted by reading the band numbers of birds moving to and from the beach at Middle Bay. From October to March this was supplemented by sightings at the nests, particularly in the first half of the breeding season before the guard stage ended. Therefore disappearances became readily apparent. Band records became less reliable after March as they only came from the two days of observation each month. April's records were particularly poor because most birds were inland moulting at the time. Subsequently, 32-56 birds were positively identified each month. Banded birds were very faithful to the two Middle Bay landing sites and none were recorded elsewhere until August when sea lion disturbance caused some birds to land at other sites in Northwest Bay. These individuals were later recorded back at Middle Bay.

During the year every banded bird was missed for at least one set of monthly counts as it was not possible to read the bands of all the birds (Appendix 7). Of the 78 adults banded, 33 were missed for only one month at a time, 20 for two consecutive months, 12 for three and 13 for four or more months (up to a maximum of 11 months).

One estimate of is to assume that a bird missing for three or more consecutive months of counts was dead. Thus, at the end of the study, birds missing in July, August and September or in earlier months were dead. This gives an estimate for survival from October 1987 to September 1988 of 58 (74.4%) of the original 78 banded adults.

FIG. 14 : SURVIVAL ESTIMATE OF BANDED YELLOW-EYED PENGUINS AT MIDDLE BAY 1987-88



This is possibly an underestimate because during the year four birds were re-sighted after a three month gap and another after a four month gap, although all these incorporated April into their period out of the record, when few birds were identified anyway.

A more conservative estimate of mortality would be up to June when 12 birds had disappeared and were not subsequently recorded. Thus 66 (84.6%) birds had survived 12 months. There is evidence, however, that the mortality rate may have accelerated from July to September because a sea lion was seen preying on penguins at Middle Bay in August and fresh remains were found in September. Thus, even the 74.4% survival estimate may actually be an overestimate for the year as it cannot account for mortality in August and September. The numbers of penguins at Middle Bay remained very low in 1989 (P. Hatfield pers. comm.).

The top line in Fig. 14 illustrates the adult survival or disappearance rates that have been described above. The dashed line shows the proportion of the number originally banded (column B, Appendix 8). The trend downwards between the peaks in February-March and June is similar to the estimated survivorship curve. The low points occurred in November (half the birds were ashore incubating during any one count), April (most adults were ashore moulting) and September (adults were nest building and/or disturbed by sea lion activity).

Two birds banded as chicks in February 1984 were recorded during the study. One bred successfully at Capstan Cove in 1987-88 and nested at the same site the following season.

3.5 DISCUSSION

The former nesting habitat of the yellow-eyed penguin on the mainland of New Zealand was the cool coastal podocarp/hardwood forests (Seddon 1988). Forest clearance has led to a variety of alternative nesting habitats such as scrub or flax. These are possibly sub-optimal habitats because of higher levels of heat stress experienced by penguins (Darby pers. comm.). On Campbell Island there has never been a forest cover, and the main nesting habitat for yellow-eyed penguins is the coastal scrub associations, dominated by *Dracophyllum*. Heat stress is not a problem there because of the cool climate and density of the scrub.

Because nesting yellow-eyed penguins require visual isolation from their neighbours (Seddon 1988), the density of nests is determined by the degree of concealment provided by the vegetation. Thus, the mean density of 1.6 pairs per hectare (Darby 1985) varies between 1/ha for unmodified forest to 4/ha for flax pasture/tussock (Darby pers. comm.).

The Middle Bay density of 3.8 pairs/ha is at the high end of the mainland scale. Northwest Bay (including Middle Bay), at 249 birds per accessible kilometre of coastline, was the densest population on Campbell Island. Using the ratio between these two figures, other dense areas, such as Southeast Harbour and Shag Point would have accommodated 2.6 and 3.1 pairs/ha. The dispersed populations at Northeast and Perseverance Harbours would have been 0.2-0.6 pairs/ha. Thus, the mean for the populated parts of the island may have been about 1.5 pairs/ha which is similar to the mainland figure. Seddon (1988) found nesting densities highest in scrub (mean inter-nest distance 11.6m) and lowest in forest (31.8). The Middle Bay figure of 22 m between

nests falls between these two extremes, presumably because the Campbell Island scrub provided less lateral concealment between nests than the scrub in Seddon's study (i.e. it was more forest-like).

Most penguins on Campbell Island nested within 500m of the shore, as they do on the mainland (Seddon 1988), although there are records of nests up to 1.6km inland (Darby pers. comm.). Seddon (1988) also found that over 90% of nests had some sort of solid back to them, and it was the form of the plant cover rather than the species that was important.

The breeding season of yellow-eyed penguins on Campbell Island was similar in structure but one or two weeks later than on the mainland. The mean hatching date of 26 November compares with 9 November (Richdale 1957) or 18 November (van Heezik 1988). Allowing for an incubation period figure of 43.5 days (Richdale 1957), Campbell Is. laying dates would have ranged from 8-21 October. However, at the beginning of the 1988-89 season some eggs were laid as early as 29 September. Variation in dates is expected with the incubation period ranging from 39-51 days (Seddon 1988). Also, mean laying dates on the mainland can vary between seasons by up to 10 days and range from 11 September to 22 October (Darby pers. comm.). The average Campbell Island chick departure day of 108 days was similar to mainland figures of 106 days (Richdale 1957) and 103 days (Darby pers. comm.).

Breeding success on Campbell Island is compared with available figures from the mainland in Table 9.

TABLE 9: COMPARISON OF BREEDING SUCCESS OF YELLOW-EYED PENGUIN ON CAMPBELL ISLAND AND THE MAINLAND

SUCCESS CATEGORY	A	B	C	D	E	F
% NESTS WITH 2 EGGS	94				97	93
% EGGS THAT HATCH	83	78	79		85	82
% EGGS THAT FLEDGE CHICKS	70		53			45
% CHICKS THAT FLEDGE	85	76	67		87	54
% NESTS THAT FLEDGE CHICKS	76		70	80		
MEAN NO. CHICKS/NEST	1.4	1.1#		1.1	1.4	0.9

Refs.			
	A: Campbell Island,	1 season 1987-88	40 nests
	B: Richdale (1957),	16 seasons 1936-52	1073 eggs
	C: Roberts and Roberts (1973)		
		1 season 1970-71	19 nests
		chick success up to 10 weeks only	
	D: Lalas (1985)	2 seasons 1983-84	159 nests
	E: Darby (pers. comm.)	4 seasons 1981-84	404 nests
	F: Seddon (1988)	2 seasons 1985-86	622 nests

Yellow-eyed penguins on Campbell Island in 1987-88 were relatively successful compared with most statistics available from the mainland. Comparable figures occurred in relatively good seasons, or in areas where predation was low. For example, 1942-43 was Richdale's most successful season, with 88% eggs hatching and 91 % of chicks being reared. In contrast, in 1938-39 82% of eggs hatched but only 45% of chicks survived. Darby's (pers. comm.) figures from the early 1980's were also high and occurred at a time when predation levels were low. In following seasons in some of the same study areas Seddon (1988) found a lower level of breeding success. He attributed this to heavier grazing by stock favouring rabbits, which in turn allowed a population increase of their predators, particularly ferrets. As a consequence, predation on yellow-eyed penguin chicks increased. The Campbell Island figure of 1.4 chicks per nest probably reflects a lack of predation by cats, which are rare, or rats, which do not appear to be a problem. Although there was no evidence of predation at Middle Bay, one pair of birds at Sandy Bay was found incubating a decapitated corpse and the adjacent nest soon lost its chicks without trace.

Richdale (1957) described chick mortality factors as crushing by parents in the first week, excessive rain, stoats and ferrets, dogs (in the post-guard stage) and food shortage. On Campbell Island most losses were probably a result of accidents at the nest, poor parenting, parental death or disappearances, and starvation.

The survivorship of Campbell Island chicks showed that 9% died in the first 10 days, none were lost up to 70 days and a final 6% were lost up to departure. Richdale (1957) found that 21% of chicks were lost in the first 7 weeks and the other 3% loss occurred after 11 weeks. Similarly Seddon (1988) found 43% of chicks died in the first 6 weeks and 2% died subsequently. The main difference on Campbell Island was the high survival rate of chicks during the guard stage. Chicks on the mainland are most vulnerable to predation during this period (Seddon 1988).

Ten of the 34 broods at Middle Bay regularly gathered together with neighbouring chicks during the post-guard stage. These aggregations, or creches, are considered to be rare on the mainland (Darby pers. comm.).

The yellow-eyed penguin's level of production of 1.4 chicks per breeding pair is high compared with other penguin species which normally have two eggs. For example, Adelie penguins produce 0.8 chicks per pair (Ainley *et al*. 1983), royals 0.5 (Carrick 1972), gentoo 0.7 (Croxall and Prince 1979) or 1.0 (Robertson 1986), and rockhoppers 0.5 (pers. obs. 1987-88 season, Campbell Island).

During the Campbell Island study estimated adult was 74-85%. Richdale's (1957) annual survival level was 87%, although in some years it was as low as 76%. In his particular study areas there was an increase in nests from 36 in 1938 to 82 in 1952, largely a result of a period of particularly high adult survival and breeding success (Richdale 1957). This may explain why survivorship was higher than a stable population of Adelie penguins, which had a 70% survivorship level (Ainley and DeMaster 1980). This low survivorship level of Adelies was partly a result of higher levels of predation than experienced by yellow-eyed penguins.

Survival of adults at Middle Bay was probably low as a result of the local effects of a Hooker's sea lion (*Neophoca hookeri*) that had learnt to ambush penguins in the shallows as they came ashore. Chases by other sea lions were very rare and in all cases the penguins managed to avoid capture using greater manoeuvrability rather than speed. Previous reports of predation of yellow-eyed penguins by sea lions are very infrequent (Ainley and DeMaster 1980).

The influence of parasitic ticks on yellow-eyed penguins is unknown. They have never been found on adults on the mainland but rarely the tick *Ixodes eudyptidis* is found on chicks where nests are close to other penguin species (Darby pers. comm.). In contrast, the tick *I. uriae* was commonly found on chicks and adults on Campbell Island. This species is found in the New Zealand subantarctic and has been recorded previously from yellow-eyed penguin hosts on Campbell Island (Dumbleton 1953). Potentially, ticks can spread viruses amongst birds (A. Heath pers. comm.) but there was no evidence of disease on Campbell Island in 1987-88.

CHAPTER 4. SIZE AND GROWTH

4.1 BACKGROUND

Studies of yellow-eyed penguins on the mainland of New Zealand have involved collecting morphometric data of adults (Richdale 1951, Darby unpub. data) and growing chicks (Richdale 1957, van Heezik 1988).

Male and female yellow-eyed penguins are similar in body size and therefore difficult to tell apart visually. Richdale (1951) found that the sex of yellow-eyed penguins could not be distinguished by plumage characteristics and the only certain way was to examine the vents of pairs during egg deposition. He described 11 criteria which were useful indications of sex, such as weights or nesting behaviour, depending on the time of the year. From the end of the incubation period to mid-winter small birds are usually females and large birds are males, but measurements and weights overlap. By analysing the measurements of dead penguins (sexed by dissection) Darby (pers. comm.) has found that the head length (from back of head to tip of bill) and foot length (from back of heel to tip of mid-toe pad) are reliable measurements for determining sex in the field. Males have significantly larger proportions than females although there is some overlap (Darby unpub. data).

4.2 AIMS

Two aims of the study of yellow-eyed penguins on Campbell Island were to collect information on the size of adults to allow comparison with the mainland birds, and similarly, determine the rates and extent of chick growth. This information is of value in helping to determine the status and productivity of the population.

4.3 METHODS

4.3.1 Adult Measurements

Adults were captured at the nest and morphometric data collected using vernier calipers for:

Bill length - length of upper mandible (culmen);
Bill width -maximum width of culmen;
Bill depth - depth of bill at the point of diversion of the two lower mandibular rami;
Head length -length from bill tip to occipital condyle of skull;
Foot length (to pad) -length of foot from back of heel to end of pad of middle toe (i.e. tarsus + middle toe);
Foot length (to claw) -as above, to the end of the claw;
Flipper length -length of extended flipper from the ball of the humerus to tip of wing, measured using a tape measure;

Additional measurements were taken of some birds but were discontinued to reduce disturbance of birds. These measurements were:

Tarsus length - bottom of heel to proximal end of tarsus;
Mid-toe length -length of toe to end of claw;
Weight - measured with spring balance;

Both adults of each breeding pair were measured, usually on separate visits to the nest.

4.3.2 Egg Measurements

Maximum lengths and widths of eggs were measured for several clutches, but only at selected study nests to limit disturbance.

4.33 Chick Growth

The growth of 25 chicks from 14 nests were monitored from the time of hatching to approximately 100 days of age. Measurements taken were bill length, width and depth, head length, flipper length, foot length (to claw) and weight. These data were collected every 5 days until about 80 days after hatching, and subsequently every 10 days.

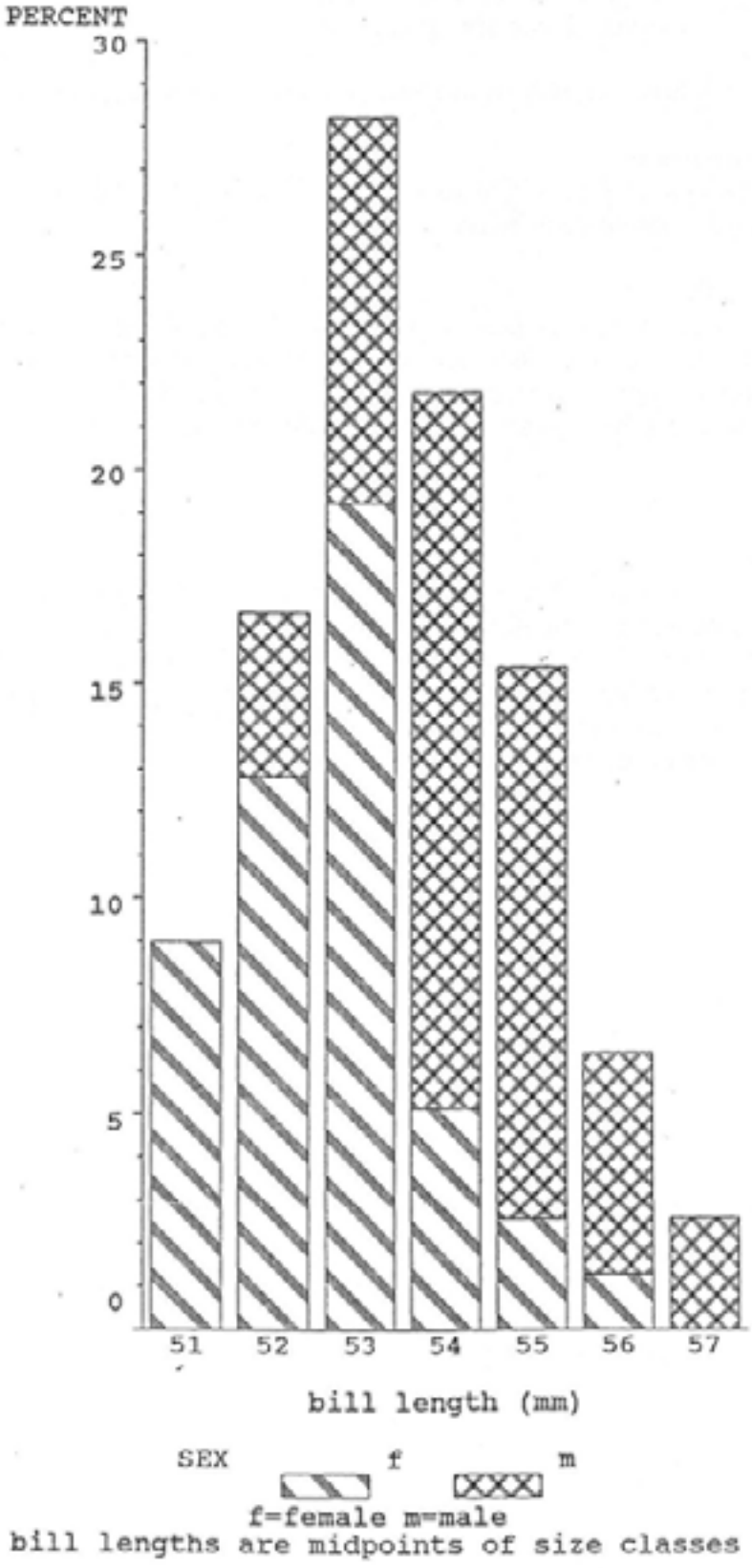
4.4 RESULTS

4.4.1 Adult Size

The dimensions of 78 adult yellow-eyed penguins are shown in Table 10, Figs 15-20 and Appendix 9. Observations early in the breeding season to identify the sex of each bird was not possible. Therefore it was assumed that of each breeding pair the bird with the larger dimensions was male, as is generally the case on the mainland (Darby pers. comm.). This gives an indication of the range of sizes and the degree of difference for each sex in the dimensions measured.

Fig. 15: BILL LENGTH

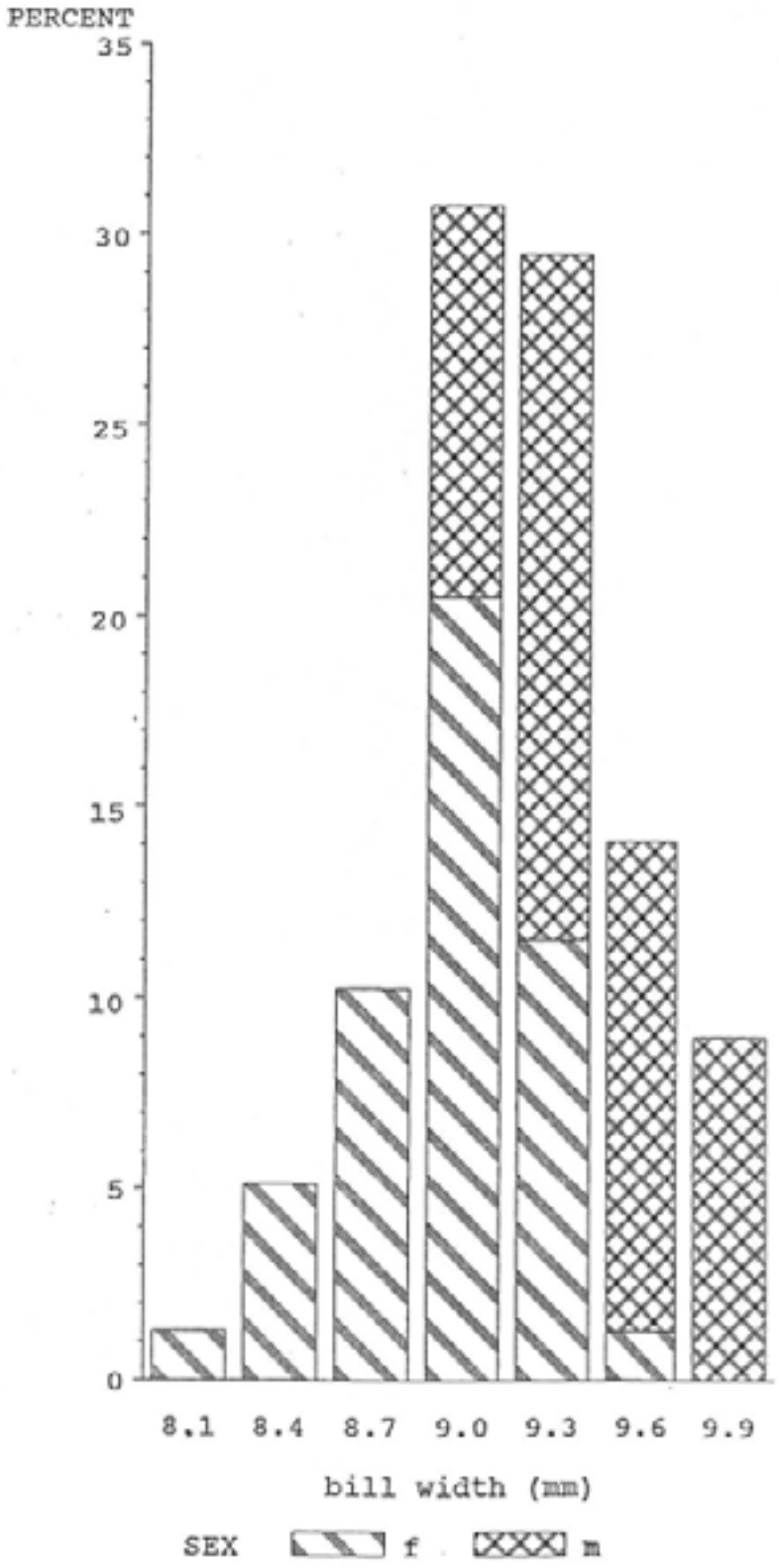
COMPARISON BETWEEN MALE AND FEMALE
YELLOW-EYED PENGUIN



bill lengths are midpoints of size classes

Fig. 16: BILL WIDTH

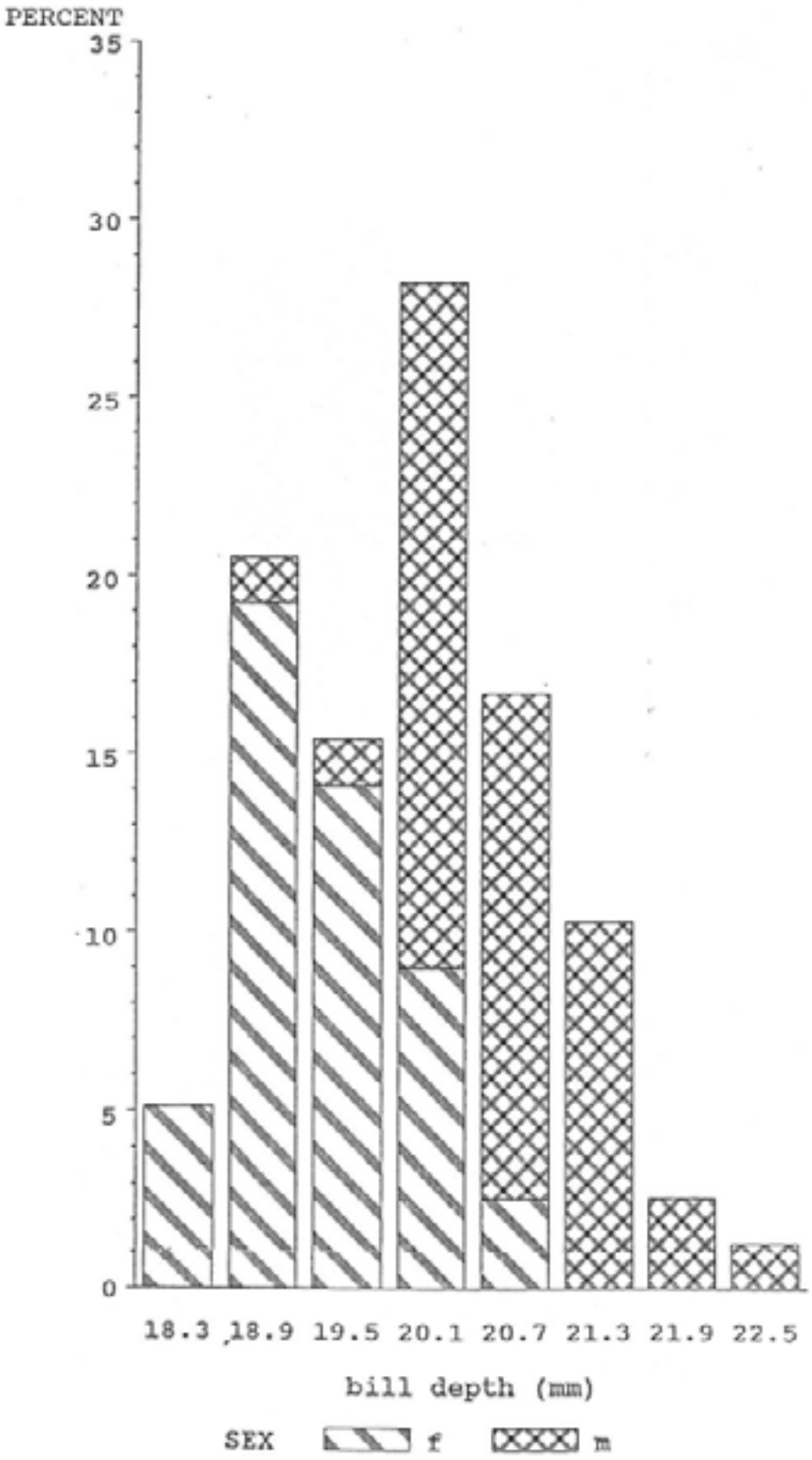
COMPARISON BETWEEN MALE AND FEMALE
YELLOW-EYED PENGUIN



f=female m=male
bill widths are midpoints of size classes

Fig. 17: BILL DEPTH

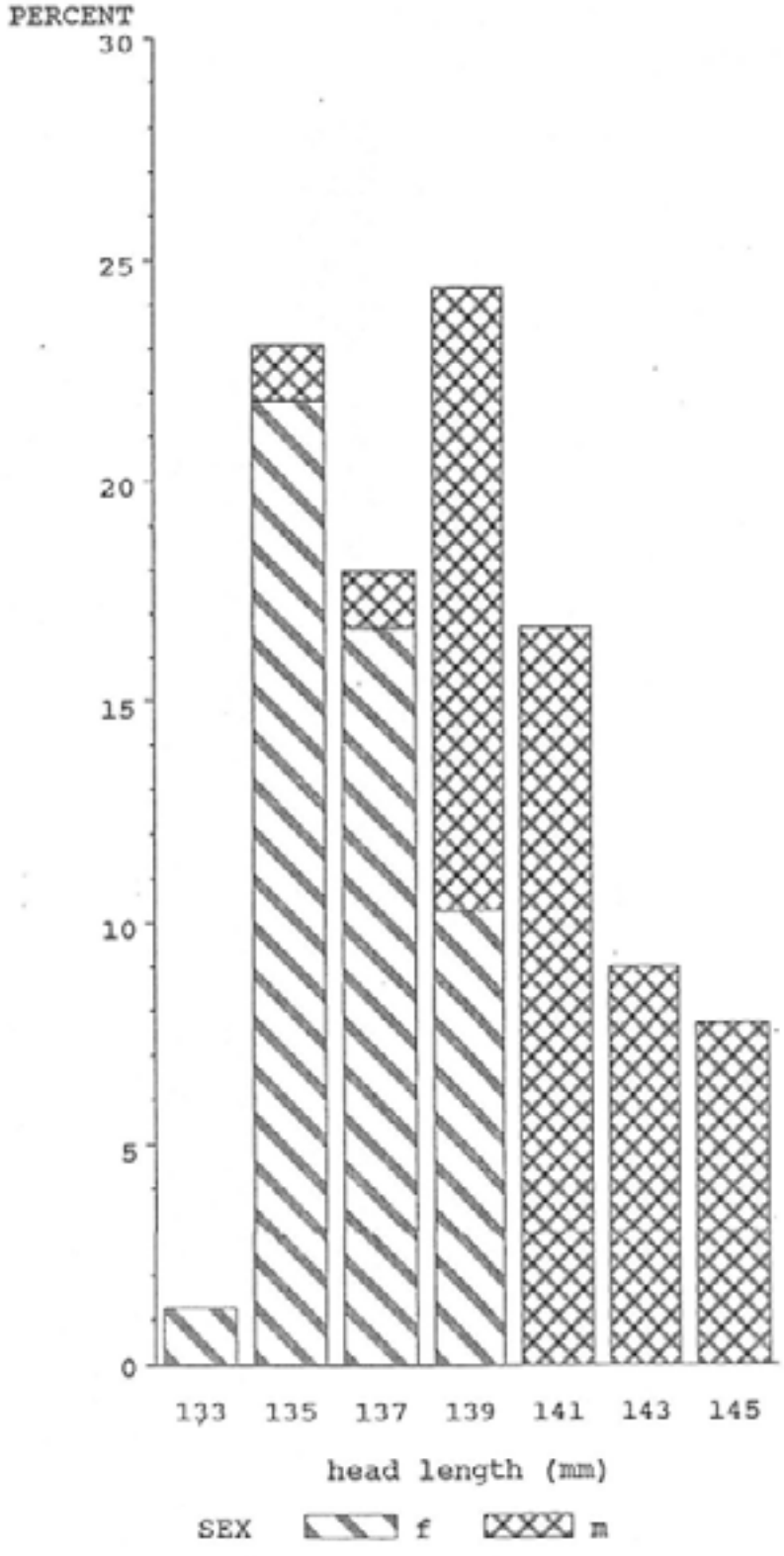
COMPARISON BETWEEN MALE AND FEMALE
YELLOW-EYED PENGUIN



f=female m=male
bill depths are midpoints of size classes

Fig. 18: HEAD LENGTH

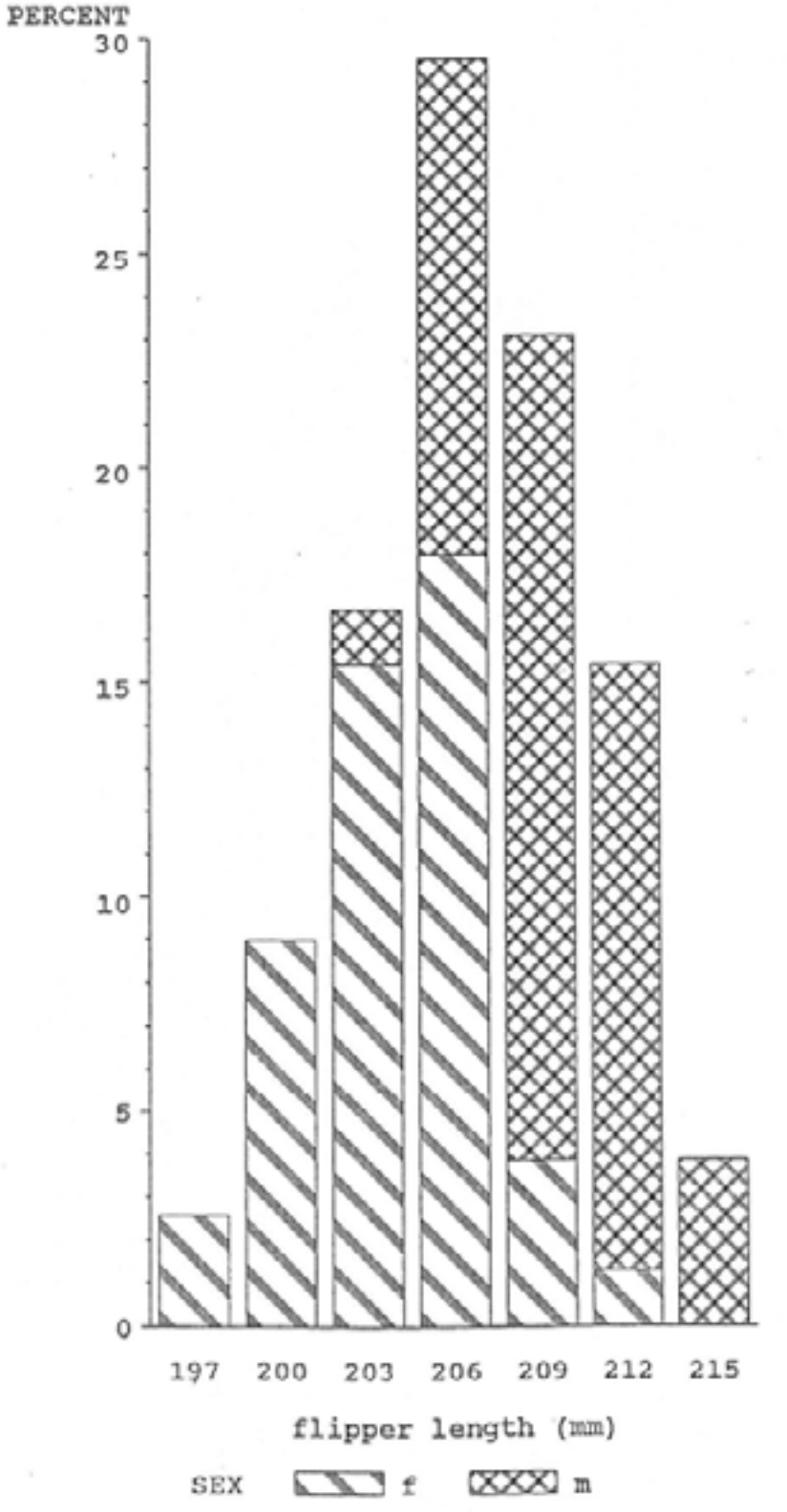
COMPARISON BETWEEN MALE AND FEMALE
YELLOW-EYED PENGUIN



f=female m=male
head lengths are midpoints of size classes

Fig. 19: FLIPPER LENGTH

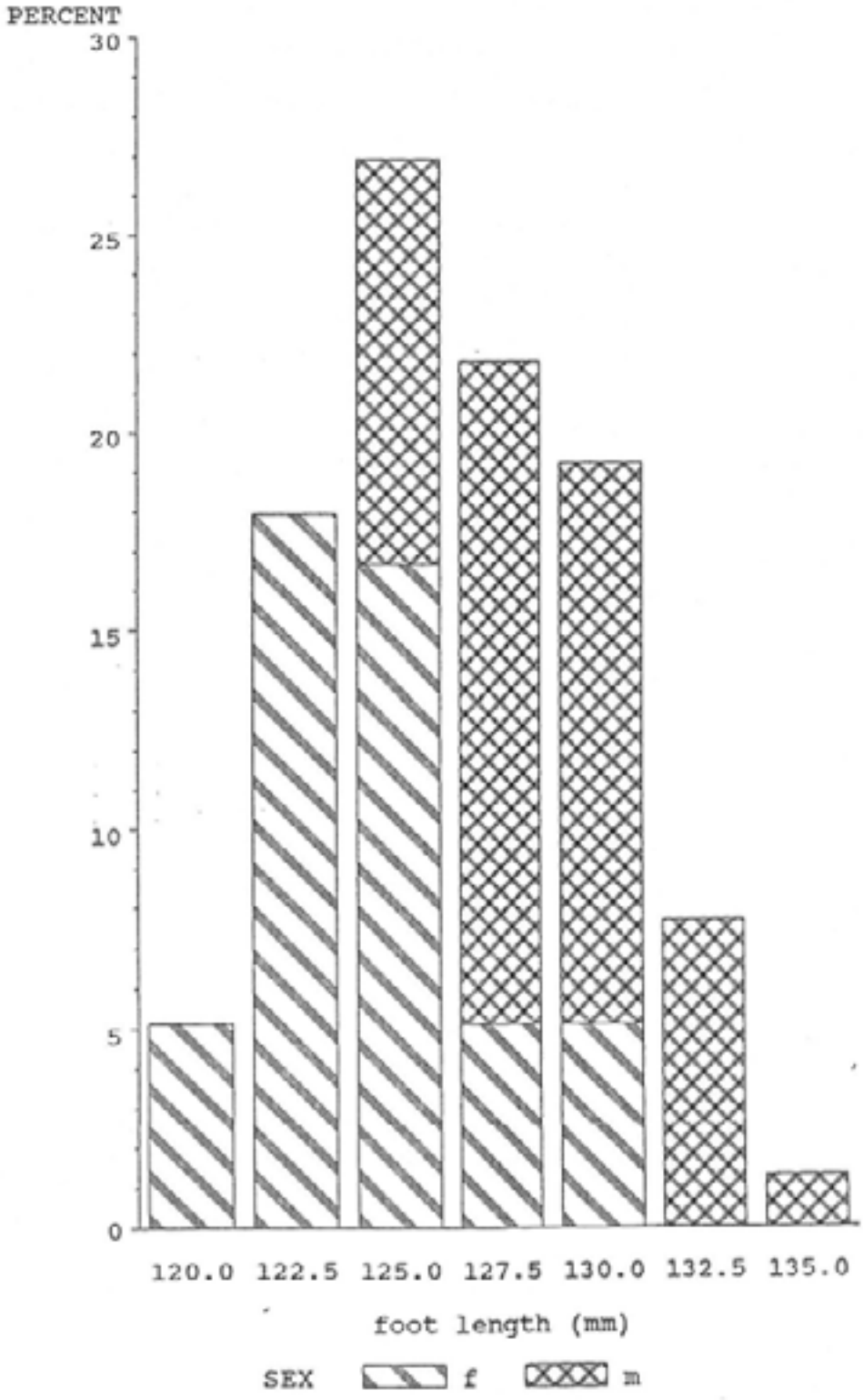
COMPARISON BETWEEN MALE AND FEMALE
YELLOW-EYED PENGUIN



f=female m=male
flipper lengths are midpoints of size classes

Fig. 20: FOOT LENGTH

COMPARISON BETWEEN MALE AND FEMALE
YELLOW-EYED PENGUIN



f=female m=male
foot lengths were to the end of the mid-toe pad
and graphed as midpoint of size classes

TABLE 10 : ADULT YELLOW-EYED PENGUIN MEASUREMENTS, MIDDLE BAY

	DIMENSIONS (mm)								
	MALE *			FEMALE*			TOTAL		
MEASURE	MEAN	S.D.	N	MEAN	S.D.	N	MEAN	S.D.	N
Bill length	54.4	1.3	39	52.8	1.2	39	53.6	1.5	78
Bill depth	20.7	0.7	39	19.4	0.7	39	20.0	0.9	78
Bill width	9.4	0.3	39	8.9	0.3	39	9.2	0.4	78
Head length	141.4	2.4	39	136.4	1.6	39	438.9	3.2	78
Flipper length	209	2.5	39	2.4	3.2	39	207	3.9	78
Foot length (pad)	128.7	2.5	39	124.3	2.6	39	126.5	3.3	78
Foot length (claw)	134.2	2.9	39	130.4	2.7	39	132.3	3.4	78
Tarsus length	60.1	1.3	7	58.1	1.2	7	59.1	1.5	14
Toe length	92.2	2.6	7	88.1	2.2	7	90.2	3.2	14
Weight (kg)	5.4	0.2	8	4.5	0.3	9	5.0	0.5	15

Key * : sex assumed from the comparison of dimension between partners of a breeding pair, males having the larger dimensions.

The data for the 39 males and 39 females were compared using two-tailed t-tests. For the seven main variables and the weight the sexes showed significant differences ($p<0.001$), did the toe ($p<0.01$) and tarsus ($p<0.05$) measurements.

From data collected while studying chick growth, where nearly full-grown individuals were measured regularly, it was found that the least accurate measurements were the flipper and the foot. These needed to be extended fully for the measurement.

4.4.2 Egg Size

Twenty-one eggs from 11 nests were measured on 23-24.10.87. The mean dimensions were:
length 75.0mm (S.D.= 1.72, range 71.7-77.4);
width 57.0mm (S.D.=1.48, range 53.0-58.9);

4.4.3 Chick Growth

Twenty-five chicks were chosen for the growth study. Twelve hatched on the same day and the other 13 hatched on a variety of days. In the analysis to produce the growth graphs (Figs. 21-28) the means represent data grouped into five day intervals (Appendix 10), except for the first data point which represents 0-2 days after hatching. Thus, the groupings are 3-7 (= day 5), 8-12 (= day 10), 13-17 (day 15) etc. After day 80 the sample sizes become smaller than 25 because measurements were taken at 10 day intervals instead of five, some chicks fledged earlier than others, some died, disappeared, or were not located on a particular visit.

Table 11 shows the mean values for the final measurements of all 25 chicks, irrespective of their age, to give an idea of weights and measures at fledging. These figures actually correspond closely to the means in Figs. 21-28 at day 100, which was close to the mean departure day.

Table 11: FLEDGING MEASUREMENTS OF YELLOW-EYED PENGUIN CHICKS

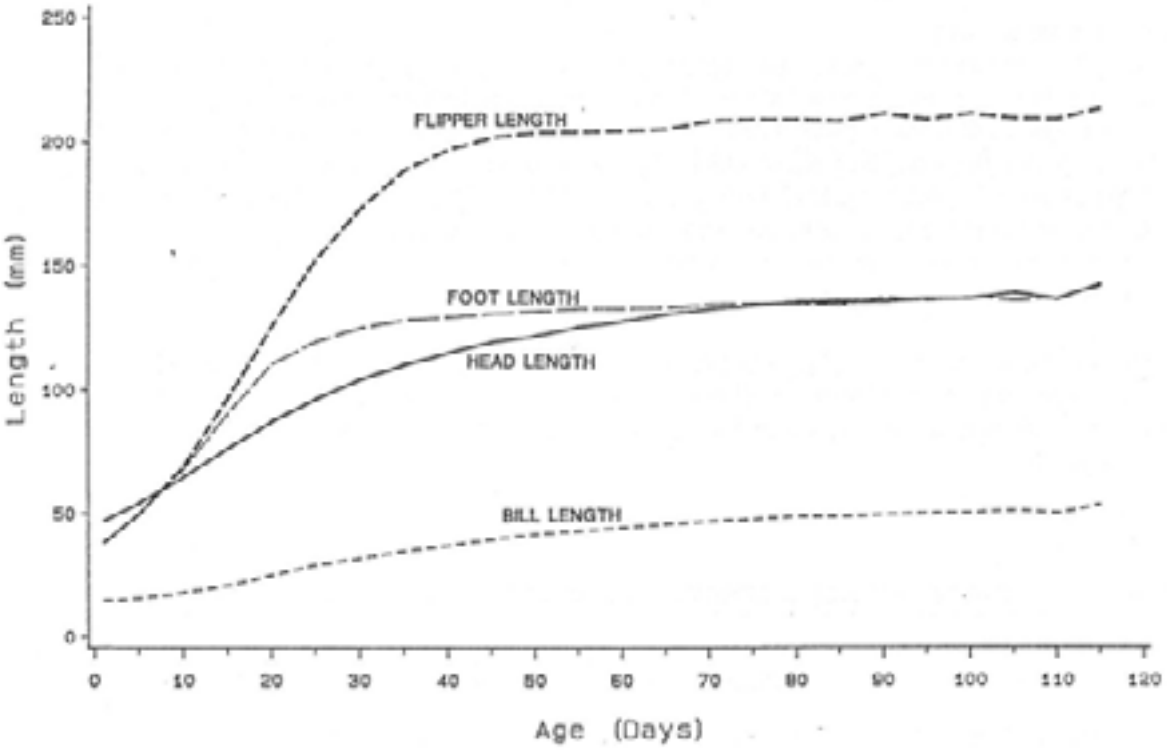
	Final measurement of 25 chicks before fledging		
Dimension	MEAN	RANGE	S.D.
Bill length (mm)	50.1	45.7 -53.8	2.0
Bill depth (mm)	18.3	16.5 -19.6	0.7
Bill width (mm)	8.7	7.8 -9.6	0.4
Head length (mm)	136.7	130.4 -143.1	3.7
Flipper length (mm)	209.4	203.0 -216.0	3.8
Foot length (mm)	136.0	130.2 -141.3	3.3
Weight (kg)	5.1	3.0 -6.2	0.7

A comparison of the growth rates of four body dimensions of yellow-eyed penguin chicks is shown in Fig. 21. Foot length was first to reach an asymptote after 35 days. Flipper length began to slow in growth rate by 50 days, whereas head and bill lengths tended to grow at a more even rate, which slowed after 85 days. The bill measurements continued to increase in length up to fledging.

BILL LENGTH (Fig. 22)

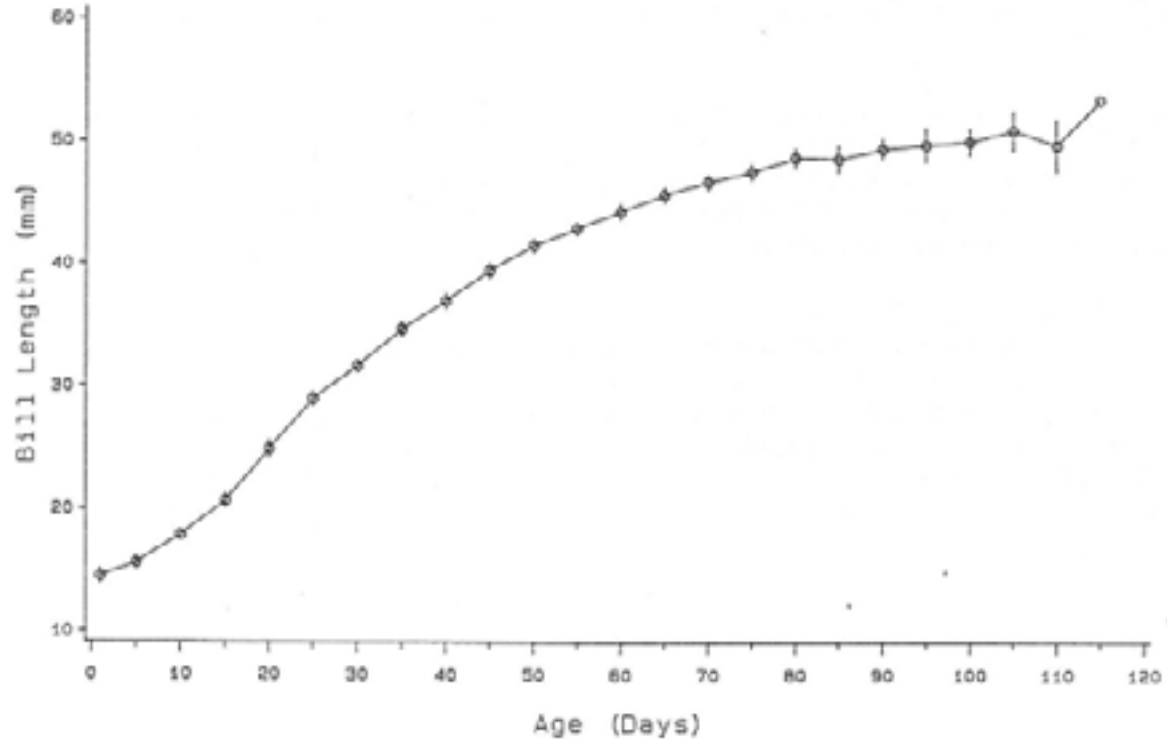
The growth curve for bill length is a shallow sigmoidal curve. The most rapid period of exponential growth was between days 5-20, averaging 0.62mm/day. The curve shows a gradual slowing of the rate of growth and by day 80 the mean length of 48.7mm was approaching an asymptote. The mean final measurement for the 25 chick sample was 50.1 (Table 11), which compares with the mean adult measurement of 53.6 mm (Table 10).

Fig. 21: Yellow-eyed penguin chick growth



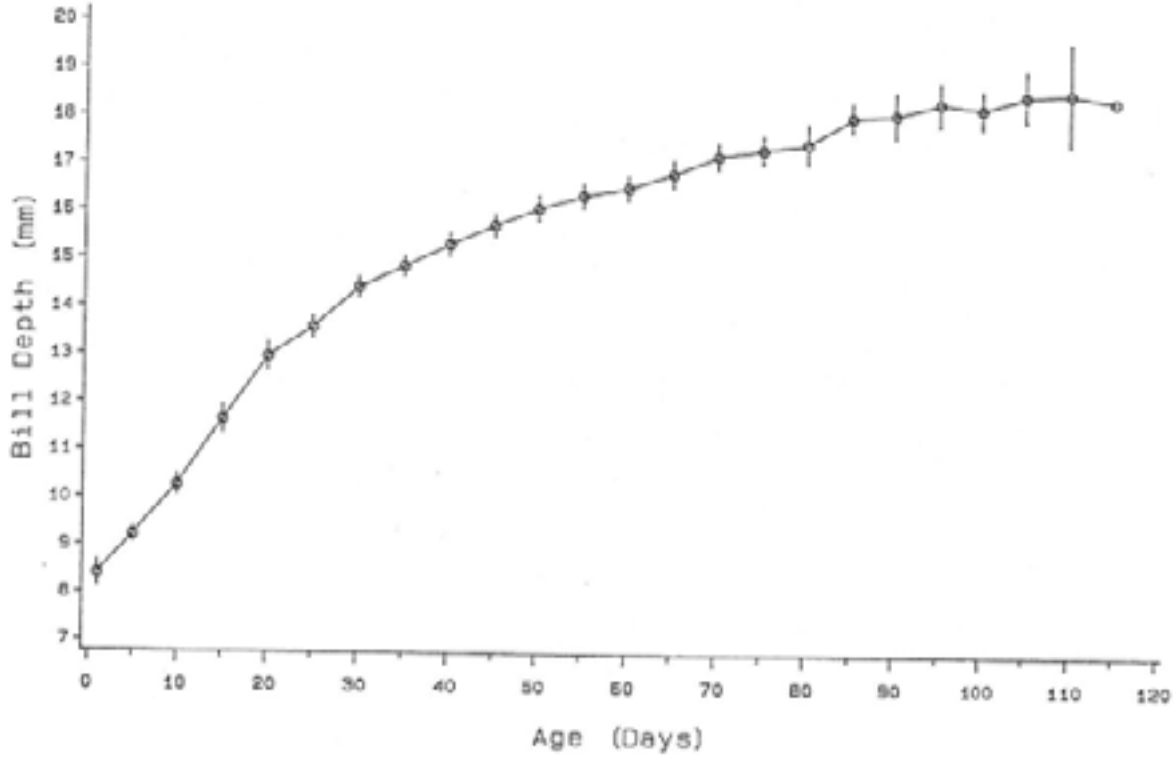
Plot of main measurements. See Figs. 22-28 and Appendix 10 for details

Fig. 22: Yellow-eyed penguin chick growth: BILL LENGTH



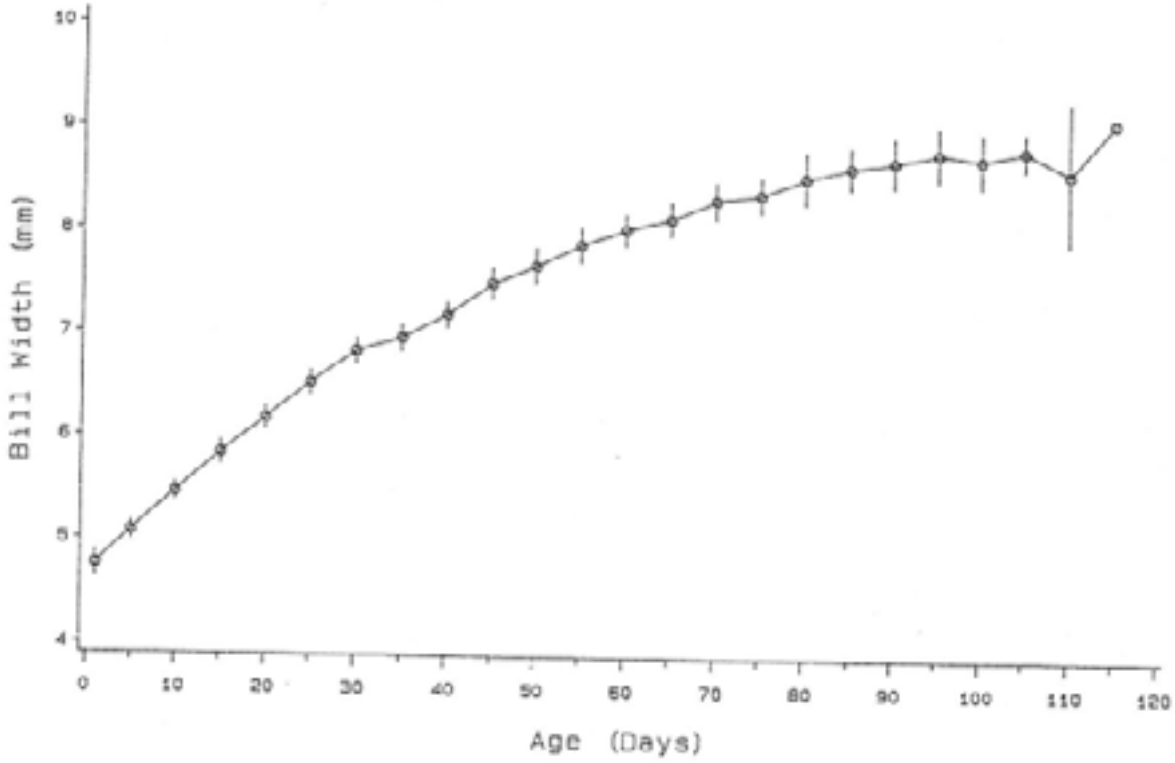
Plot of mean bill length +/- standard errors for 5 day intervals

Fig. 23: Yellow-eyed penguin chick growth: BILL DEPTH



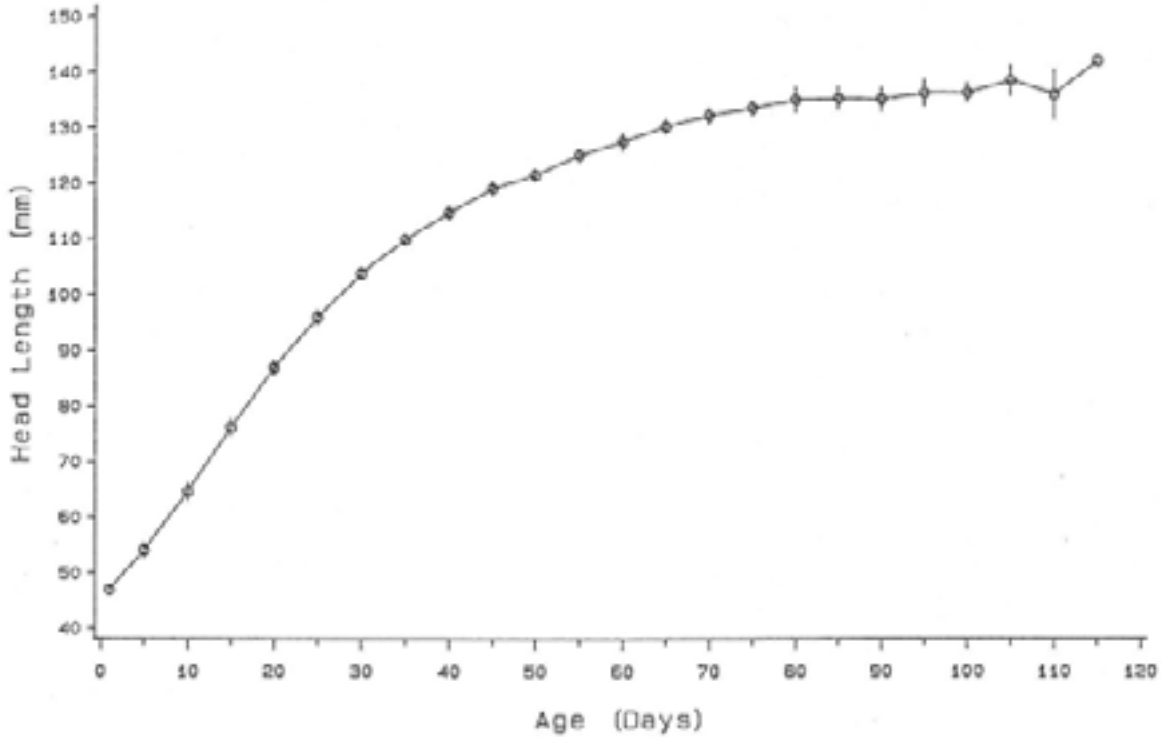
Plot of mean bill depth +/- standard errors for 5 day intervals

Fig. 24: Yellow-eyed penguin chick growth: BILL WIDTH



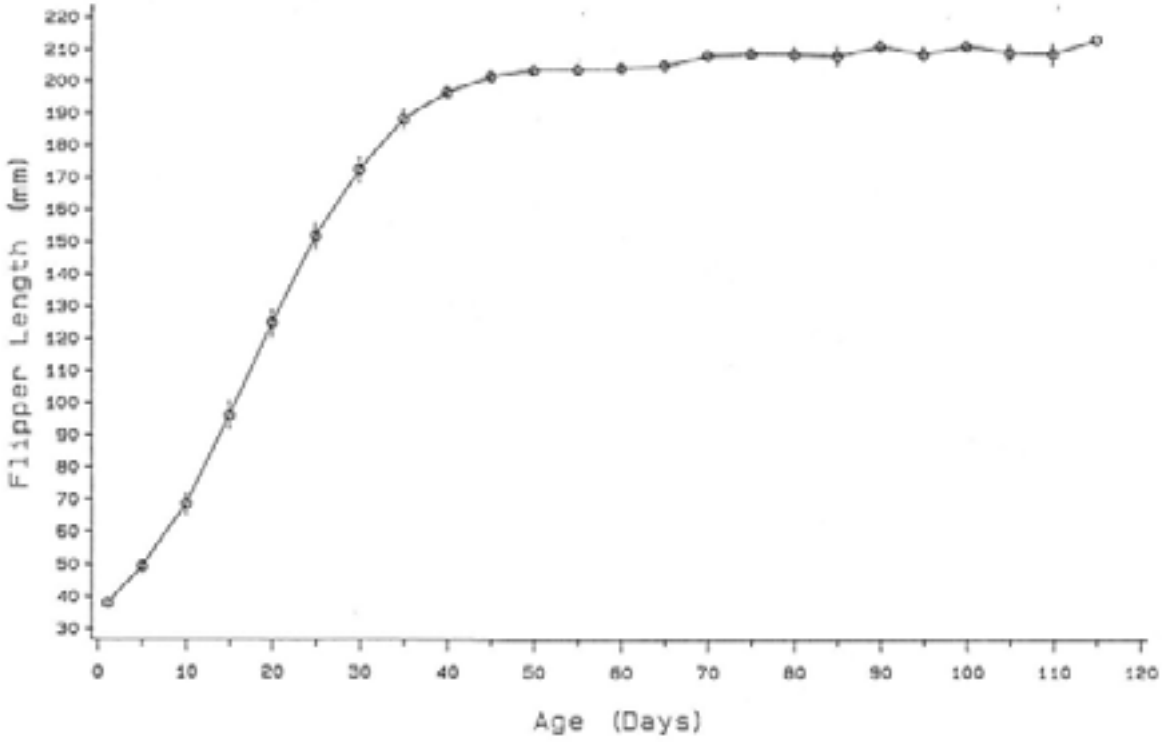
Plot of mean bill width +/- standard errors for 5 day intervals

Fig. 25: Yellow–eyed penguin chick growth: HEAD LENGTH



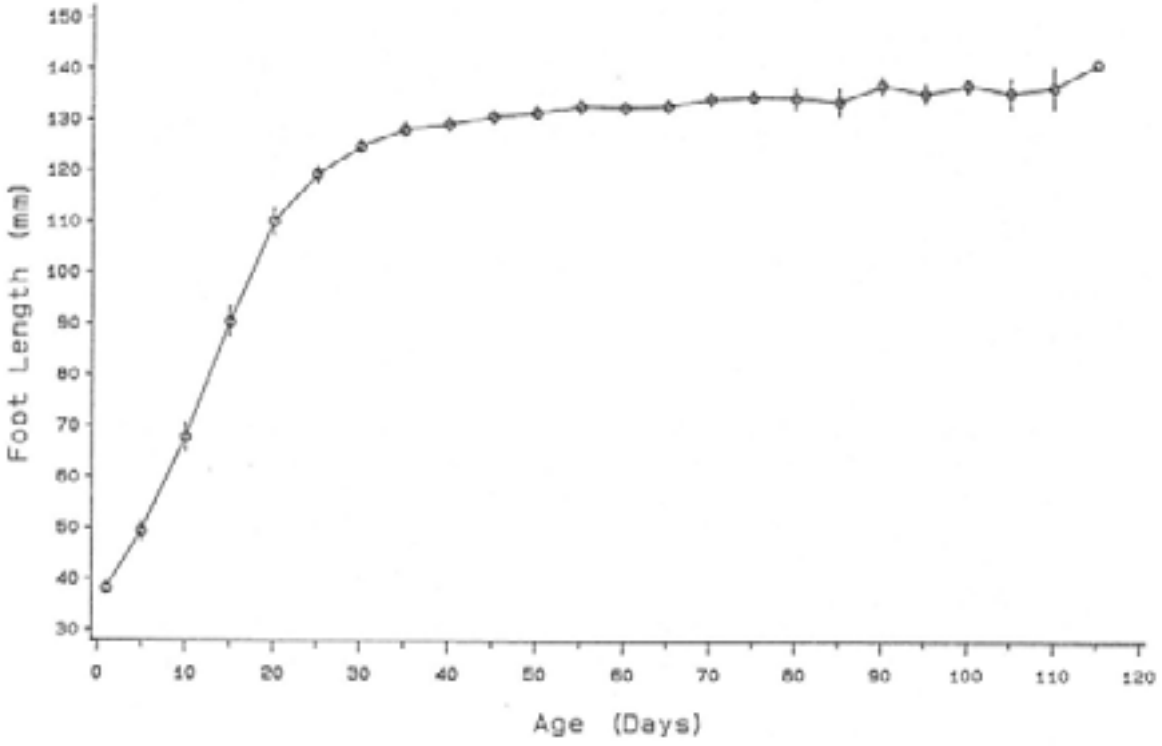
Plot of mean head length +/- standard errors for 5 day intervals

Fig. 26: Yellow–eyed penguin chick growth: FLIPPER LENGTH



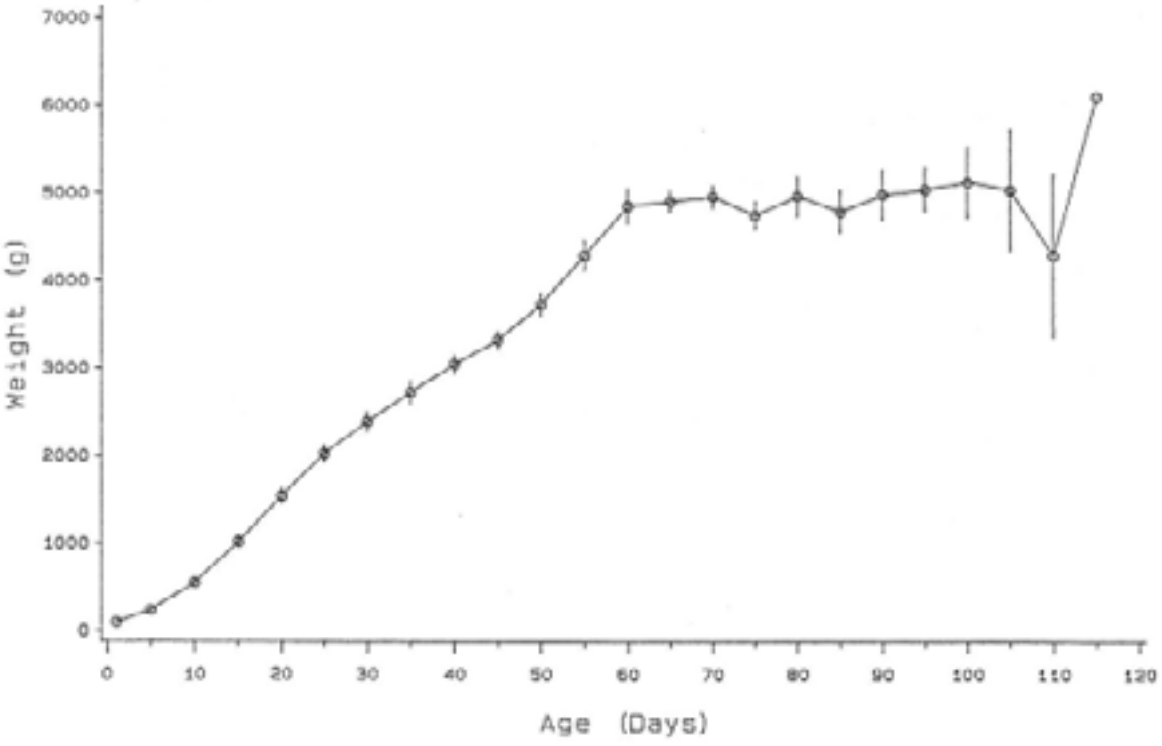
Plot of mean flipper length +/- standard errors for 5 day intervals

Fig. 27: Yellow-eyed penguin chick growth: FOOT LENGTH



Plot of mean foot length +/- standard errors for 5 day intervals

Fig. 28: Yellow-eyed penguin chick growth: WEIGHT



Plot of mean weight +/- standard errors for 5 day intervals

BILL DEPTH (Fig. 23)
Exponential growth in bill depth was up to day 20, with daily increments of from day 5. There was a gradual decrease in growth rate until fledging. Thus, by day 110 bill depth was 18.6mm and the final measure of (Table 11) compares with the adult average of 20.0mm.

BILL WIDTH (Fig. 24)
The increase in bill width was more linear than the other measures, and by 105 days the average was 8.8mm. The mean final measure of all 25 chicks was 8.7mm compared with the adult average of 9.2mm.

HEAD LENGTH (Fig. 25)
Rate of head growth was a classic sigmoid curve. The exponential growth between days 5-20 was 2.2mm/day. There was a consistent slowing in rate until 80 days, when was close to an asymptote. By day 100 the average length was 136.3 and the final measure was 136.7, which compares with the mean adult value of 138.9mm.

FLIPPER LENGTH (Fig. 26)
The flipper was quite close to an asymptotal length of 204mm by day 50. The fastest growth period was between days 10-20 when 5.6mm/day were incremented. There was only a small amount of growth in the last 50 days, with some variation in the five day means of towards the end of the fledging period. The mean final measure was 209mm, which was actually longer than the adult mean of 207mm. This was possibly a result of inaccurate measuring or a difference in the rigidity of the flippers between adults and chicks. Because of the problem of straightening out the flipper for measurement, some individual errors of up to 3mm occurred during the period of slow growth close to fledging.

FOOT LENGTH (Fig. 27)
The foot approached an asymptotal length of 128.2mm at only 35 days after hatching. The fastest growth of 4.0mm/day occurred from day 10-20. In the next 65 days only 9mm or so was added, and was reached after 100 days. The mean final measure was 136.0mm (Table 11), which was longer than the average adult measure of 132.3mm, presumably because of lack of wear of chick claws. As with the flipper, the need to flatten out the foot carefully for measurement led to individual errors but generally they were only 1mm.

WEIGHT (Fig. 28)
The most variable measure taken was the weight as this depended on the time since feeding for any individual. Chicks were weighed in the same order at a similar time of day each visit to limit some of the potential variation.

As with most of the above measures, exponential growth occurred in the first 20 days, and the rate for days 10-20 was 99g/day. From 20-45 days weight gain slowed gradually (71g/day overall) to a mean weight of 3.3kg. This may have been caused by a period of poor feeding for the adults, since some chicks actually lost 50-100g over a five day interval. Over the next 15 days to day 60 there was accelerated growth of 103g/day to an asymptotal level of 4.9kg. From days 60-100 mean weights fluctuated between 4.8-5.1kg. The range during the final period was from 3.0kg (on day 110 for a bird that declined from 4.8kg on day 65) to 6.15kg (for another individual on day 101). Although most individuals showed a decline from a peak weight at about day 65, before increasing in weight before fledging, some did not show this final increase. The mean final weight for all 25 chicks was 5.1kg (Table 11).

4.5 DISCUSSION

A comparison of the available data of adult size is given in Table 12. The evidence for similarity, or otherwise, between birds on Campbell Island and mainland New Zealand is conflicting because of the variability of results between different studies.

The head and feet measurements made by Darby (unpub. data) are very similar to the Campbell Island data of this study. So too are bill measurements made by A. Garrick (unpub. data) on Campbell Island in 1984, although his bill width measurements (not presented in Table 12) do differ. Other studies on the mainland present figures that are mostly longer than the results found in this study. If it is assumed that Darby's figures are the most reliable, because of his considerable experience in curating at Otago Museum, then the evidence suggests that there is no difference in adult size between Campbell Island and the mainland. The other differences may reflect variations in measuring technique between the observers.

Although there seems to be no morphometric separation, there is recent evidence that the Campbell Island yellow-eyed penguin population is genetically distinct from both the Auckland Islands and the mainland populations (Triggs and Darby 1989). They showed that there are very low migration rates between the subantarctic and the mainland. This has important management implications when considering the population decline on the mainland. Because the sub-populations are essentially isolated from each other, the mainland will not be "topped up" with birds from the subantarctic. The relationship of Stewart Island and Codfish Island yellow-eyed penguin populations is yet to be tested (Triggs and Darby 1989).

Patterns of growth of chicks on Campbell Island were similar to that found by Richdale (1957) and van Heezik (1988). Van Heezik found that the speed of development was fastest for the foot, followed by the flipper, head, bill and weight in descending order. Although van Heezik's data for foot+claw length (mean=137.7mm, S.D.=4.4) and bill depth (18.0mm, S.D.=0.7) were very similar to the Campbell Island results (Table 11), bill length (53.8mm, S.D.=1.7) and head length (142.9mm, S.D.=40) were significantly longer. Flipper lengths were also much longer but probably because her measurements were taken from the body rather than from the proximal bulge of the humerus.

TABLE 12: COMPARISON OF RESULTS OF YELLOW-EYED PENGUIN MORPHOMETRIC STUDIES

		ADULT MEASUREMENT (mm)					
		Campbell Island			South Island		
	Reference	A	B	C	D	E	F
BILL LENGTH	Male	54.4		55.1*			
	S.D.	1.3		1.5			
	N	39		66			
	Female	52.8		53.8**			
	S.D.	1.2		1.8			
	N	39		70			
	Total	53.6	53.2			55.3***	
	S.D.	1.5	1.7			1.9	
	N	78	18			119	
BILL DEPTH	Total	20.0	19.9			19.6**	
	S.D.	0.9	1.0			0.9	
	N	78	18			121	
HEAD LENGTH	Male	141.4			142.1		145***
	S.D.	2.4			1.9		2.6
	N	39			61		15
	Female	136.4			135.2		137
	S.D.	1.6			1.8		1.7
	N	39			61		15
	Total	138.9			138.7	142.3***	
	S.D.	3.2			1.9	4.4	
	N	78			122	118	
FOOT LENGTH	Male	128.7			129		
(to pad)	S.D.	2.5			2.6		
	N	39			61		
	Female	124.3			124		
	S.D.	2.6			2.4		
	N	39			61		
	Total	126.5			126.5		
	S.D.	3.4			2.5		
	N	78			122		
FOOT LENGTH	Total	132.3				135.1***	
(+ claw)	S.D.	3.4				4.2	
	N	78				110	

Key: * significantly different ($p<0.05$) from Campbell Island 1987-88 results
** ($p<0.01$)
*** ($p<0.001$)

References
A: this study
B: Garrick (unpub. data, 1984)
C: Richdale (1951)
D: Darby (unpub. data)
E: van Heezik (1988)
F: Seddon (1988)

The graphs of chick growth presented in this study should provide reliable estimates of chick ages for future workers on Campbell Island. Comparisons of weights at these ages would also be possible because van Heezik (1988) found that the growth rates of morphometric parameters varied very little between seasons, even when there were large variations in average weights.

On the mainland there was no difference in growth rates between siblings or between one and two-chick broods (van Heezik 1988). This seems to be the case on Campbell Island also, although there were only three single chicks in the 25 chick sample studied.

Van Heezik (1988) suggested that the yellow-eyed penguin has adapted to a predictable and abundant food supply. This is shown by the fact that in years of poor food supply the rates of chick growth do not change and broods are still mostly of two chicks rather than one. Therefore, yellow-eyed penguins cannot compensate for the occasional collapse of their food supply, which has apparently occurred more frequently in recent years. Recovery in subsequent seasons is inhibited by other pressures on the dwindling mainland population.

Although the fledging success of Campbell Island chicks was relatively high compared with the mainland (Chapter 3), the mean departure weight of 5.1kg (range 3.0-6.2kg) was significantly less ($p<0.05$) than the mainland average of 5.9kg (4.3-7.0, S.D.=0.7, N=73) (Darby unpub. data). Richdale's (1957) study also found a fledging weight for "normal" chicks of 5.9kg (4.2-7.3, N=24). There are variations between seasons though, for example, in three seasons of study on the mainland average fledging weights declined from 6.1 to 4.4kg (van Heezik 1988). The proportion of juveniles seen the next season also declined, and survivors of the second season had fledged at a higher average weight than chicks that were not seen again. This lead van Heezik to suggest that chicks that fledge at less than 4.0kg are unlikely to survive, although she could not prove a threshold weight existed. In contrast to these results, in 1987-88 (the same season as this study) on the mainland, there was a low fledging weight of 4.8kg (S.D.=0.7) but higher than usual juvenile survival of about 50% (Darby unpub. Data).

It is possible that low fledging weights maybe a feature of the subantarctic. For example, Darby (pers. comm.) found low chick weights on the Auckland Islands in 1986. However, in February 1984 on Campbell Island A. Garrick (pers. comm.) found chicks which were about 1 kg heavier than those at a comparable stage in 1988. These data and the earlier discussion indicate that the 1987-88 fledging weights on Campbell Island were part of the normal annual variation. They may have been low enough to affect juvenile survival if other factors such as a poor winter food supply occurred.

CHAPTER 5. CONCLUSIONS

The Campbell Island population of yellow-eyed penguins would appear to be in a healthy state, although data from one year of study can only provide a basis for comparison with future work.

The estimated population of 1600-2000 birds is substantially more than previously predicted for the island. With the decline and instability of the South Island population, the Campbell Island component has become very important and represents about 35% of the estimated total population.

Breeding success of the penguins was relatively high compared with the mainland, probably as a result of low levels of predation.

Adult measurements and patterns of chick growth were similar to that found on the mainland.

CHAPTER 6. RECOMMENDATIONS

6.1. POPULATION TRENDS

Campbell Island yellow-eyed penguin population trends need to be monitored. Counts of key landing sites should be made regularly, preferably in November and May, to compare with results from 1987-88. Small-scale monitoring could be achieved by keen, reliable Meteorological Station staff (see Appendix 10 for guidelines). More intensive counting should be conducted every few years to gauge changes in the population.

6.2. BREEDING SUCCESS

Further monitoring of penguin breeding success would show any annual variation. Banding of chicks would give information on recruitment, survival and possible movements to other parts of the species range. Survivorship of birds banded in 1987-88 should be monitored.

6.3. DIETARY ANALYSIS

No diet studies were conducted in 1987-88. There is a need to determine the foods of Campbell Island birds to see if they differ from that eaten in the South Island and if there is any potential competition with rockhopper penguins or other birds.

6.4. POPULATION MONITORING IN OTHER PARTS OF RANGE

More complete surveys of Auckland, Stewart and Codfish islands are essential to determine the overall population and breeding status of the species. It is important have good baseline data to detect population changes and to determine the extent of the decline that is occurring on the mainland.

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APPENDICES

APPENDIX 1: NUMBERS OF YELLOW-EYED PENGUINS AT NORTHWEST BAY 1987-88

LANDING SITE	COUNTS OF PENGUINS NOV Ad	NOV J	NOV Tot	FEB Ad	FEB J	FEB Tot	MAY Ad	MAY J	MAY Tot	AUG Ad	AUG J	AUG Tot
NW-1							2		2			
NW-2 *	61	6	67	114	1	115	140	3	143	109	3	112
NW-3 *	20	8	28	24	2	26	32	1	33	22	3	25
NW-4	1		1				2		2			
NW-5	6		6				10		10			
NW-6							4		4			
NW-7 *	54	6	60	99	6	105	98		98	57	1	58
NW-8 *	5		5	1		1	9		9	2		2
NW-9							2		2			
NW-10 *	7	1	8	7		7	13		13	11	2	13
NW-11 *	35	2	37	75	1	76	64	2	66	33	2	35
NW-12 *	6	2	8	31		31	19	1	20	13		13
NW-13 *	7		7	7		7	9		9	3		3
NW-14	16	11	27				26		26			
NW-15	7	1	8				8		8			
NW-16								2	2			
NW-17								1	1			
SUB-TOTAL	195	25	220	369	11	380	384	7	391	250	11	261
TOTAL (all sites)							438	10	448			

KEY Sub-total *: sites (*) that were counted four times during year
Total : all the landing sites in May

Ad : Adult
J : Juvenile
NW-11 : Landing site identification number (Fig. 2)

APPENDIX 2: NUMBERS OF YELLOW-EYED PENGUINS AT SOUTHEAST HARBOUR 1987-88

LANDING SITE	COUNTS OF PENGUINS NOV Ad	NOV J	NOV Tot	FEB Ad	FEB J	FEB Tot	MAY Ad	MAY J	MAY Tot	AUG Ad	AUG J	AUG Tot
SE-1							70	4	74			
SE-2							3		3			
SE-3							1		1			
SE-4								1	1			
SE-5 *	12	3	15	21		23	40		40	21	1	22
SE-6							24	3	27			
SE-7							2		2			
SE-8							1		1			
SE-9							1		1			
SE-10							11	3	14			
SE-11 *	40	4	44	50	1	51	47		47	47		47
SE-12 *	11	2	13	13		13	19	3	22	13	1	22
SE-13							13	2	15			
SE-14							4	1	5			
SE-15							3	1	4			
SE-16							3		3			
SUB-TOTAL	63	9	72	86	1	87	106	3	109	84	2	86
TOTAL (all sites)							242	18	260			

KEY Sub-total * : sites (*) that were counted four times during year
Total : all the landing sites in May

Ad : Adult
J : Juvenile
NW-11 : Landing site identification number (Fig. 2)

APPENDIX 3: YELLOW-EYED PENGUIN COUNTS AT MIDDLE BAY 1987-88

		COUNTS AT MAIN LANDING SITE				EAST ROCKS	COMBINED TOTALS BOTH SITES	
DATE		ADULT	JUV	TOT	MEAN	ADULT	TOT	MEAN
3.11.87	OUT	54	6	60				
	IN	54	6	60	57		60	57
13.11.87	OUT	52	2	54				
	IN	49	4	53			53	
6.12.87	OUT	83	5	88				
	IN	93	5	98	89	2	100	93
8.12.87	OUT	80	3	83				
	IN	83	2	85			85	
12.01.88	OUT	86	5	91				
	IN	87	2	89	91	2	91	94
13.01.88	OUT	89	1	90				
	IN	92	3	95		2	97	
14.02.88	OUT	99	6	105				
	IN	100	2	102	97		102	97
16.02.88	OUT	91		91				
	IN	87	3	90		1	91	
10.03.88	OUT	91	4	95				
	IN	88	1	89		4	93	
11.03.88	OUT	91	3	94	89			93
15.03.88	OUT	83	3	86				
	IN	81	2	83		9	92	
21.03.88	OUT	64	2	67				
25.03.88	IN	61		61	64	5	66	66
26.03.88	OUT	63	1	64				
14.04.88	OUT	25	1	26				
	IN	28	1	29	31		29	30
15.04.88	OUT	35	1	36				
	IN	31		31			31	
2.05.88	IN	75		75	74	2	77	77
3.05.88	OUT	72	1	73		1		
15.05.88	OUT	94		94				
	IN	92		92	95		92	94
16.05.88	OUT	98		98				
	IN	96		96			96	

APPENDIX 3 continued

		COUNTS AT MAIN LANDING SITE				EAST ROCKS		COMBINED TOTALS BOTH SITES	
DATE		ADULT	JUV	TOT	MEAN	ADULT	JUV	TOT	MEAN
14.06.88	OUT	75	1	76		10		86	
	IN	89		89	86	10		99	94
15.06.88	OUT	88		88		10		98	
	IN	89		89		5		94	
14.07.88	OUT	92	2	94		2		96	
	IN	72	1	73	67	10		83	78
15.07.88	OUT	75	1	76		10		86	
	IN	25		25		21		46	
14.08.88	OUT	43		43		7	1	51	
	IN	43	1	44	45	1	1	46	51
15.08.88	OUT	57	1	58		2		60	
	IN	35	1	36		12		48	
14.09.88	OUT	33	1	34		4		38	
	IN	37	1	38	33	1		39	35
15.09.88	OUT	34		34		1	1	36	
	IN	26		26		1	1	28	
28.09.88	IN	16	2	18		1	1	20	

APPENDIX 4: DAILY MOVEMENTS OF YELLOW-EYED PENGUINS 1987-88

	DEPARTURES Mean Time Std Dev N			ARRIVALS Mean Time Std Dev N			MEAN TIME AT SEA (Hour: Minute)			
	OUT-1	OUT-2	OUT-T	IN-1	IN-2	IN-T	OUT-1 to IN-1	OUT-2 to IN-2	OUT-3 to IN-3	OUT-T to IN-T
NOV			0603 96 114			1828 87 113				12:25
DEC	0458 87 99	1339 121 81	0837 278 171	1216 123 72	1914 142 111	1633 241 183	7:18	5:35	14:16	17:56
JAN	1521 106 148	1600 92 33	0718 268 181	1452 101 33	1843 131 151	1802 154 184	9:31	2:43	13:22	10:41
FEB	0537 42 184	1618 114 12	1616 162 196	1315 229 14	1901 120 178	1836 158 192	7:38	2:43	13:24	12:19
MAR	0623 23 173	1617 85 8	0649 126 181	1522 83 8	1836 96 164	1826 103 172	8:59	2:18	12:12	11:37
APR			0743 54 62			1632 126 60				8:49
MAY			0806 38 192			1716 30 188				9:10
JUN			0837 23 164			1648 22 178				8:11
JUL			0833 21 170			1700 33 98				8:27
AUG			0819 32 101			1714 35 80				8:55
SEP			0722 27 68			1757 53 64				10:35

KEY : OUT-1 = Main departure of penguins
OUT-2 = Second departure
OUT-T = Mean departure
IN-1 = First arrival
IN-2 = Main arrival
IN-T = Mean arrival time
TIME = Hours New Zealand Standard Time
Std Dev = Standard Deviation
N = Sample size over two days of observation

The departure and arrival times in bold type are those graphed in Fig. 8.

APPENDIX 5: SUNRISE AND SUNSET TIMES COMPARED WITH YELLOW-EYED PENGUIN DEPARTURE AND ARRIVAL TIMES

	SUN-RISE TIME	MEAN TIME OUT	DEV.	FIRST TIME OUT	DEV.	SUN-SET TIME	MEAN TIME IN	DEV.	LAST TIME IN	DEV.
NOV	0453	0603	+70	0437	-16	2005	1828	-97	2030	+25
DEC	0420	0458	+38	0342	-38	2051	1914	-97	2153	+62
JAN	0444	0521	+37	0338	-66	2101	1843	-138	2207	+66
FEB	0545	0537	-8	0446	-59	2011	1901	-70	2140	+89
MAR	0631	0623	-8	0540	-51	1915	1835	-40	2017	+62
APR	0727	0743	+16	0630	-57	1801	1632	-89	1854	+53
MAY	0817	0806	-11	0712	-65	1703	1716	+13	1824	+81
JUN	0850	0837	-13	0749	-61	1638	1648	10	1752	+74
JUL	0845	0833	-12	0751	-54	1654	1700	+6	1825	+91
AUG	0800	0819	+19	0740	-20	1738	1714	-24	1840	+62
SEP	0653	0722	+29	0630	-23	1828	1757	-31	1909	+41

KEY

Time : NZ Standard Time
SUNRISE/SUNSET TIMES : provided by Carter Observatory, Wellington
MEAN TIME OUT/IN: times of penguin departure and arrivals for December to March are means for OUT-1 and IN-2 (Appendix 4). All other months refer to OUT-T.
FIRST TIME OUT : the earliest observed departure
LAST TIME IN : the latest arrival for each month.
DEV : The deviation in penguin departures and arrivals from sunrise and sunset times, expressed in minutes.

APPENDIX 6: HOURLY TOTALS OF YELLOW-EYED PENGUINS AT MIDDLE BAY

	NOVEMBER 1987						DECEMBER 1987					
Time	3.11		13.11		Mean		6.12		8.12		Mean	
(NZST)	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN
0300							10		10		10.0	
0400	1		7		4.0		28		23		25.5	
0500	44		18		31.0		4		4		4.0	
0600	14		22		18.0		7				3.5	
0700			5		2.5		1		3		2.0	
0800								2	6		3.0	1.0
0900			1		0.5		1	4	3	4	2.0	4.0
1000							5	5	2	4	3.5	4.5
1100			1		0.5		3	8	5	8	4.0	8.0
1200							5	7	8	2	6.5	4.5
1300							7	9	3	10	5.0	9.5
1400		2				1.0	8	6	9	3	8.5	4.5
1500		4		3		3.5	5	6		6	2.5	6.0
1600		7		2		4.5	3	1	5	4	4.0	2.5
1700		13		5		9.0		5	2	3	1.0	4.0
1800	1	15		9	0.5	12.0		11		2		6.5
1900		17		19		18.0	1	6		10	0.5	8.0
2000		2		15		8.5		18		8		13.0
2100								10		21		15.5
TOTAL	60	60	54	53			88	98	83	85		

	JANUARY 1987						FEBRUARY 1988					
Time	12.1		13.1		Mean		14.2		16.2		Mean	
(NZST)	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN
0300	3		10		6.5							
0400	38		39		38.5		11	1	6		8.5	0.5
0500	17		9		13.0		68	1	52		60.0	0.5
0600	6				3.0		16		21		18.5	
0700	8		8		8.0		1		8		4.5	
0800	2		1		1.5							
0900	1		1		1.0							
1000			2		1.0		1	1			0.5	0.5
1100								4				2.0
1200	2	1	1		1.5	0.5	1	1		2	0.5	1.5
1300		7	1	5	0.5	6.0			1	1	0.5	0.5
1400	4	10	1	6	2.5	8.0		6		1		3.5
1500	6	7	10	10	8.0	8.5	3	3		2	1.5	2.5
1600	3	11	1	11	2.0	11.0	1	4	1	5	1.0	4.5
1700		13	3	9	1.5	11.0	1	9	2	11	1.5	10.0
1800		8	2	8	1.0	8.0	1	16		10	0.5	13.0
1900		8	1	19	0.5	13.5	1	25		26	0.5	25.5
2000	1	8		8	0.5	8.0		21		22		21.5
2100		16		17		16.5		10		10		10.0
2200				2		1.0						
TOTAL	91	89	90	95			105	102	91	90		

	MARCH 1988						APRIL 1988					
Time	10.3		15.3		Mean		14.4		15.4		Mean	
(NZST)	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN
0500	14		3		8.5							
0600	68		78	1	73.0	0.5	4		7		5.5	
0700	6		2		4.0		15		14	1	14.5	0.5
0800	2				1.0		7		13		10.0	
0900										1		0.5
1000												
1100									2	1	1.0	0.5
1200				2		1.0		1				0.5
1300				2		1.0				2		1.0
1400		2	2		1.0	1.0		4		1		2.5
1500	1	4		3	0.5	3.5		2		1		1.5
1600	2	2		5	1.0	3.5		7		6		6.5
1700	1	9	1	15	1.0	12.0		7		12		9.5
1800	1	23		23	0.5	23.0		8		6		7.0
1900		39		32		35.5						
2000		10				5.0						
2100												
TOTAL	95	89	86	83			26	29	36	31		

	MAY 1988						JUNE 1988					
Time	15.5		16.5		Mean		14.6		15.6		Mean	
(NZST)	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN
0800	47		56		51.5		2		2		2.0	
0900	40		38		39.0		71		67		69.0	
1000	4		2		3.0		3		17		10.0	
1100			2		1.0				2		1.0	
1200	3				1.5							
1300												
1400		1				0.5						
1500		1		2		1.5		2		3		2.5
1600		22		12		17.0		68		66		67.0
1700		65		76		70.5		20		20		19.5
1800		3		6		4.5						
TOTAL	94	92	98	96			76	89	88	89		

Time (NZST)	JULY 1988 14.7 OUT	14.7 IN	15.7 OUT	15.7 IN	Mean OUT	Mean IN	AUGUST 1988 14.8 OUT	14.8 IN	15.8 OUT	15.8 IN	Mean OUT	Mean IN
0700	3		1		2.0				26		13.0	
0800	88		66		77.0		41		31		36.0	
0900	2		9		5.5							
1000							2				1.0	
1100	1				0.5				1		0.5	
1200												
1300												
1400		1				0.5						
1500		3				1.5		2		1		1.5
1600		47		10		28.5		11		2		6.5
1700		16		13		14.5		27		31		29.0
1800		6		2		4.0		4		2		3.0
TOTAL	94	73	76	25			43	44	58	36		

Time (NZST)	SEPTEMBER 1988 15.5 OUT	15.5 IN	16.5 OUT	16.5 IN	Mean OUT	Mean IN
0600			12		6.0	
0700	29		21		25.0	
0800	5		1		3.0	
0900						
1000						
1100						
1200						
1300						
1400		1		1		1.0
1500		1		1		1.0
1600		3				1.5
1700		7		7		7.0
1800		26		16		21.0
1900				1		0.5
TOTAL	34	38	34	26		

APPENDIX 7: BAND RECORDS OF YELLOW-EYED PENGUINS AT MIDDLE BAY 1987-88

NEST	BAND	MONTH O	N	D	J	F	M	A	M	J	J	A	S	CONSECUTIVE MONTHS MISSED
1.	J9138	*	*	*	*	*	*	*	*	*		*	*	1
	J9157	*	*	*	*	*	*	*	*		*	*	*	1
2.	J9136	*	*	*	*		*		*	*	*	*	*	1
	J9159		*	*	*	*	*		*		*		*	1
3.	J9112	*	*	*	*	*	*				*	*		3
	J9125	*	*	*	*	*	*	*	*	*	*			2
4.	J9111	*	*	*	*	*		*	*	*	*			2
	J9124	*	*	*	DEAD?									9
6.	J9137	*	*	*	*	*	*		*	*	*	*	*	1
	J9149	*	*	*	*	*	*		*	*		*	*	1
7.	J9109	*	*	*	*	*	*		*	*		*	*	1
	J9150	*	*	*	*		*		*	*	*	*		1
8.	J9108	*	*	*	*	*	*		*	*	*	*	*	1
	J9151	*	*	*	*	*	*		*	*	*	*	*	1
9.	J9107	*	*	*	*	DEAD?								8
	J9152	*	*	*	*		*					*	*	4
10.	J0102	*	*	*	*	*	*		*	*	*	*	*	1
	J9131	*	*	*	*	*	*		*		*	*	*	1
11.	J9103	*	*	*	*	*			*	*	*	*	*	2
	J9110	*	*	*	*	*	*		*	*	*			2
12.	J9140	*	*	*	*	*	*			*	DEAD??			3
	J9153	*	*	*	*	*	*			*			*	2
13.	J9139	*	*	*	*	*	*		*		*	*		1
	J9160		*	*	*	*	*		*	*		*		1
14.	J9154	*	*	*	*	*	DEAD?							7
	J9164		*	DEAD?										10
15.	J9101	*	*	*	*	DEAD								8
	J9130	*	*	*	*	*	*		*		*	*		1
16.	J9104	*	*	*	*	*	*		*	*	*			2
	J9105	*	*	*	*				*	*	*			3
17.	J9155	*	*	*	*	*	*		*	*	*	*		1
	J9161		*	*	*	*	*		*	*	*		*	1
18.	J9117	*	*	*	*	*	*		*	*	*	*	*	1
	J9118	*	*	*	*	*	*		*	*	*			2
19.	J9133	*	*	*	*	*	*		*	*		*	*	1
	J9144	*	*	*	*	*	*		*	*		*	*	1
20.	J9156	*	*	*	*	*	*		*	*		*		1
	J9163		*	*	*		*			*			*	2
21.	J9128	*	*	*	DEAD?									9
	J9145	*	*	*	*	*	*		*	*	DEAD??			3
22.	J9116	*	*	*	*		*	*	*	*		*	*	1
	J9129	*	*	*	*	*	*			*		*		2
23.	J9115	*	*	*	*	*	*		*	*	*		*	1
	J9146	*	*	*	*	*	*		*	*	*			2
24.	J9114	*	*	*	*	*	*		*		*	*	*	1
	J9126	*	*	*	*	*	*			*		*	*	2
25.	J9113	*	DEAD?											11
	J9127	*	*	*	*	*	*	*	*			*	*	2
26.	J9121	*	*	*	*	*	*	*	*	DEAD?				4

APPENDIX 7: ctd

NEST	BAND	O	N	D	J	F	M	A	M	J	J	A	S	CONSECUTIVE MONTHS MISSED
		MONTH												
26.	J9122	*	*	*	*	*	*	*		*	*	*		1
27.	J9134	*	*	*	*	*		*	*	*	DEAD??			3
	J9162		*	DEAD?										10
28.	J9147	*	*	*	*	*	*		*	*		*		1
	J9158	*	*	*	*	*	*		*	*	DEAD??			3
29.	J9135	*	*	*	*	*	*		*		*			2
	J9148	*	*	*	*	*	*			*		*	*	2
30.	J9132	*	*	*	*	*	*		*	*		*		1
	J9143	*	*	*	*	*			*		*		*	2
31.	J9119	*	*	*	*	*	*	*	*	*			*	2
	J9120	*	*	*	*	*	*	*	DEAD?					5
32.	J9106	*	*	*	*	*	*			*	*	*	*	2
	J9142	*	*	*	*	*	*		*		*	*		1
33.	J9123	*	*	DEAD?										10
	J9141	*	*	*	*	*	*	*	*	*	*	*		1
34.	J9165		*	*	*	*	*		*	*	*	*		1
	J9172		*	*	*		*		*			*		2
35.	J9166		*	*	*	*	*		*		*	*		1
	J9173		*	*	*	*	*		*	*	DEAD??			3
36.	J9167		*	*	*	*	*		*	*	DEAD??			3
	J9174		*	*	*	*	*			*	*	*	*	2
37.	J9168		*	*	*	*	*		*	*	DEAD??			3
	J9171		*	*	*	*			*		*			2
38.	J9169		*	*	*	*	*		*	*	*	*	*	1
	J9175		*	*	*	*	*				*			3
39.	J9170		*	*	*	*	*		*		*	*	*	1
	J9176			*	*	*	*		*	DEAD?				4
40.	J9177		*	*	*				*	*	*	*	*	3
	J9179			*	*	*	*		*	*	DEAD??			3
SURVIVED		78	77	74	72	70	69	69	68	66	58	58	58	

KEY
- * : identified by band number during counts
- DEAD : body found
- DEAD? : disappeared and assumed dead as not seen for more than 3 months
- DEAD?? : disappeared for 3 months or less at the end of the study

APPENDIX 8: PROPORTION OF BANDED YELLOW-EYED PENGUINS AT

		COUNTS			TOTAL ADULTS BANDED	PROP. COUNTED	ADULTS KNOWN TO BE ALIVE		PROP. COUNTED
		ADULTS no.	BANDS no.	% A	no.	% B	no.	% C	% D
03.11.87	OUT	54	31	57.4	62	50.0	61	98.4	50.8
	IN	54	30	55.6		48.4			49.2
	Mean			**56.5**		**49.2**			**50.0**
13.11.87	OUT	52	27	51.9	64	42.2	63	98.4	42.9
	IN	49	24	49.0		37.5			37.5
	Mean			**50.5**		**39.9**			**40.2**
06.12.87	OUT	83	58	69.9	77	75.3	73	94.8	79.5
	IN	95	64	67.4		83.1			87.7
08.12.87	OUT	80	60	75.0	78	76.9	74	94.9	81.1
	IN	83	62	74.7		79.5			83.8
	Mean			**71.8**		**78.7**			**83.0**
12.01.88	OUT	87	60	69.0	78	76.9	72	92.3	83.3
	IN	89	61	68.5		78.2			84.7
13.01.88	OUT	89	54	60.7		69.2			75.0
	IN	94	62	66.0		79.5			86.1
	Mean			**66.1**		**76.0**			**82.3**
14.02.88	OUT*	99(91)	72(67)	72.7	78	85.9	70	89.7	95.7
	IN*	100(92)	67(62)	68.0		79.5			88.6
16.02.88	OUT!	91(87)	66(64)	72.5		82.1			91.4
	IN!	88(84)	58(56)	65.9		71.8			80.0
	Mean			**69.8**		**79.8**			**88.9**
10.03.88	OUT#	91(86)	63(58)	69.2	78	74.4	69	88.5	84.1
	IN#	92(87)	69(64)	75.0		88.5			92.8
11.03.88	OUT	91	66	72.5		84.6			95.6
15.03.88	OUT+	83(80)	58(55)	69.9		70.5			79.7
	IN+	90(87)	61(58)	67.8		74.4			84.1
	Mean			**70.9**		**78.5**			**87.3**
21.03.88	OUT	65	46	70.8		59.0			66.7
25.03.88	IN	66	50	75.8		64.1			72.5
26.03.88	OUT	63	49	77.8		62.8			71.0
	Mean			**74.8**		**62.0**			**70.1**

KEY : * 8 (including 5 banded) made two trips to and from sea and were therefore counted twice. Bracketed figures are of individual birds.
! 4 (2 banded) made two trips
5 (5 banded) made two trips
+ 3 (3 banded) made two trips

APPENDIX 8 ctd

		COUNTS			TOTAL ADULTS BANDED	PROP. COUNTED	ADULTS KNOWN TO BE ALIVE		PROP. COUNTED
		ADULTS no.	BANDS no.	% A	no.	% B	no.	% C	% D
14.04.88	OUT	25	9	36.0	78	11.5	69	88.5	13.0
	IN	28	10	35.7		12.8			14.5
15.04.88	OUT	35	9	25.7		11.5			13.0
	IN	31	12	38.7		15.4			17.4
	Mean			**34.0**		**12.8**			**14.5**
02.05.88	IN	77	44	57.1	78	56.4	68	87.2	64.7
03.05.88	OUT	72	43	59.7		55.1			63.2
	Mean			**58.4**		**55.8**			**64.0**
15.05.88	OUT	94	53	56.4		67.9			77.9
	IN	92	52	56.5		66.7			76.5
16.05.88	OUT	98	52	53.1		66.7			76.5
	IN	96	59	61.5		75.6			86.8
	Mean			**56.9**		**69.2**			**79.4**
14.06.88	OUT	85	47	55.3	78	60.3	66	84.6	71.2
	IN	99	58	58.6		74.4			87.9
15.06.88	OUT	98	60	61.2		76.9			90.9
	IN	94	56	59.6		71.8			84.8
	Mean			**58.7**		**70.9**			**83.7**
14.07.88	OUT	94	60	63.8	78	76.9	60	76.9	100.0
	IN	82	53	64.6		67.9	58	74.4	91.4
15.07.88	OUT	85	50	58.8		64.1			86.2
	IN	46	27	58.7		34.6			46.6
	Mean			**61.5**		**60.9**			**81.1**
14.08.88	OUT	50	29	58.0	78	37.2	58	74.4	50.0
	IN	44	26	59.1		33.3			44.8
15.08.88	OUT	59	36	61.0		46.2			62.1
	IN	47	30	63.8		38.5			51.7
	Mean			**60.5**		**38.8**			**52.2**
14.09.88	OUT	37	21	56.8	78	26.9	58	74.4	36.2
	IN	38	24	63.2		30.8			41.4
15.09.88	OUT	35	21	60.0		26.9			36.2
	IN	27	19	70.4		24.4			32.8
	Mean			**62.6**		**27.3**			**36.7**
28.09.88	IN	17	9	52.9		11.5			15.8

APPENDIX 9: MEASUREMENTS OF ADULT YELLOW-EYED PENGUINS

NEST	SEX	BAND	DATE	BILL l	BILL d	BILL w	HEAD	FL	FOOT pad	FOOT claw	WT	TAR	TOE
1	m	J9138	26.10.87	54.5	20.2	9.1	141.9	215	132.1	138.0			
1	f	J9157	27.10.87	51.2	18.0	8.9	135.5	200	122.4	128.0			
2	m	J9159	2.11.87	55.3	21.1	9.2	142.0	212	127.5	132.8			
2	f	J9136	26.10.87	54.7	19.8	8.6	138.4	203	126.5	134.2			
3	m	J9125	25.10.87	54.5	20.7	9.1	140.6	209	131.7	135.1			
3	f	J9112	24.10.87	55.9	19.8	8.6	137.7	213	130.5	135.8	4.5	58.2	92.8
4	m	J9111	24.10.87	54.5	21.1	9.1	142.0	210	131.6	137.2	5.4	59.8	93.9
4	f	J9124	25.10.87	51.4	19.4	9.0	135.4	205	123.8	128.0			
6	m	J9149	27.10.87	55.5	20.8	9.9	139.9	211	129.8	135.5			
6	f	J9137	26.10.87	52.7	19.7	9.2	138.1	203	130.1	135.6			
7	m	J9109	24.10.87	52.2	20.6	9.5	138.6	214	128.8	134.0	5.6	60.3	92.4
7	f	J9150	27.10.87	52.3	20.0	9.2	134.1	197	121.1	129.0			
8	m	J9108	24.10.87	53.8	20.2	9.4	139.4	206	129.9	131.6	5.4	58.5	92.6
8	f	J9151	27.10.87	53.4	19.2	9.2	137.7	207	129.0	135.2			
9	m	J9152	27.10.87	54.0	20.7	9.2	143.4	211	128.1	132.8			
9	f	J9107	24.10.87	53.5	20.1	8.3	135.3	204	127.2	132.3	4.5	57.6	86.2
10	m	J9102	23.10.87	55.8	21.7	9.7	141.5	208	134.8	140.2	5.5	62.3	95.3
10	f	J9131	25.10.87	54.4	20.2	9.1	137.8	205	123.0	131.2			
11	m	J9110	24.10.87	52.7	20.0	9.0	135.6	209	128.2	134.2	5.6	60.9	90.9
11	f	J9103	23.10.87	52.4	20.8	8.0	135.4	206	125.0	131.2	4.8	60.0	86.6
12	m	J9140	26.10.87	53.1	21.0	9.9	142.5	210	129.8	136.0			
12	f	J9153	27.10.87	51.7	19.8	8.7	134.6	204	125.4	132.1			
13	m	J9139	26.10.87	53.3	20.1	9.7	139.6	208	129.2	133.5			
13	f	J9160	2.11.87	50.7	19.5	8.7	137.5	201	122.7	128.5			
14	m	J9164	12.11.87	54.5	20.4	9.2	141.8	207	124.6	131.8			
14	f	J9154	27.10.87	52.0	19.8	9.6	135.2	206	124.7	132.3			
15	m	J9101	23.10.87	53.6	20.3	9.1	139.5	210	131.9	135.4	5.5	59.1	87.3
15	f	J9130	25.10.87	52.5	18.6	9.1	136.2	208	121.6	127.0			
16	m	J9104	23.10.87	55.3	20.2	9.5	141.6	209	130.7	137.1	5.4	59.5	93.3
16	f	J9105	23.10.87	53.3	18.8	8.4	134.3	205	125.4	129.3	4.7	59.2	87.5
17	m	J9155	27.10.87	54.0	21.2	10.0	140.9	211	129.8	136.3			
17	f	J9161	2.11.87	55.1	19.1	9.1	137.3	207	123.9	128.3			
18	m	J9117	24.10.87	56.8	20.2	9.4	140.0	212	127.7	133.8			
18	f	J9118	24.10.87	51.6	19.0	8.5	132.5	205	124.5	127.7			
19	m	J9144	26.10.87	56.7	20.8	9.9	145.5	211	130.0	136.0			
19	f	J9133	25.10.87	53.8	18.8	9.2	138.1	206	124.4	128.9			
20	m	J9156	27.10.87	55.5	19.8	9.5	145.6	207	129.0	139.3			
20	f	J9163	9.11.87	51.0	18.2	8.5	135.6	201	122.5	133.5			
21	m	J9145	26.10.87	55.3	21.5	9.5	144.7	212	131.0	138.1			
21	f	J9128	25.10.87	53.6	19.4	9.4	136.0	206	127.8	135.6			
22	m	J9129	25.10.87	54.6	21.2	9.9	141.6	207	125.0	132.2			
22	f	J9116	24.10.87	53.4	20.0	9.0	136.4	200	120.7	125.0			
23	m	J9115	24.10.87	52.9	21.1	8.9	138.3	204	125.4	128.7			
23	f	J9146	26.10.87	52.2	18.7	9.0	136.0	203	124.3	128.1			
24	m	J9126	25.10.87	55.0	21.7	9.4	141.3	211	131.9	136.7			
24	f	J9114	24.10.87	53.2	18.9	9.4	136.7	204	126.2	130.7	4.5	56.7	87.6
25	m	J9127	25.10.87	54.3	20.0	9.6	140.7	208	128.1	133.3			
25	f	J9113	24.10.87	53.5	19.0	9.1	137.0	206	119.8	126.7	4.0	56.9	87.8
26	m	J9122	24.10.87	55.0	19.9	9.5	138.5	211	125.1	127.4			
26	f	J9121	24.10.87	52.3	20.8	9.4	135.1	205	127.0	130.1			

APPENDIX 9: ctd.

NEST	SEX	BAND	DATE	BILL l	BILL d	BILL w	HEAD	FL	FOOT pad	FOOT claw	WT	TAR	TOE
27	m	J9162	2.11.87	55.9	21.6	9.2	145.8	214	132.9	132.9			
27	f	J9134	25.10.87	50.8	20.3	8.7	134.7	204	122.0	127.4			
28	m	J9158	27.10.87	56.4	20.9	9.7	143.3	207	129.7	133.7			
28	f	J9147	26.10.87	52.6	18.0	8.9	135.0	206	121.0	129.6			
29	m	J9148	26.10.87	53.4	20.1	9.0	140.1	205	127.6	135.3			
29	f	J9135	25.10.87	52.7	19.0	9.0	138.1	198	123.6	130.4			
30	m	J9143	26.10.87	53.2	19.2	9.3	139.8	207	127.2	131.9			
30	f	J9132	25.10.87	52.3	18.7	8.7	135.0	199	122.2	130.1			
31	m	J9119	24.10.87	54.0	20.2	9.9	139.6	213	128.1	134.3			
31	f	J9120	24.10.87	52.0	20.0	9.1	135.7	203	124.5	128.9			
32	m	J9142	26.10.87	51.8	20.0	9.1	138.8	209	126.4	131.1			
32	f	J9106	23.10.87	52.8	20.1	8.9	136.6	207	123.7	128.4	4.5	58.4	87.9
33	m	J9123	25.10.87	51.6	20.0	9.3	136.7	208	125.0	129.0	5.0		
33	f	J9141	26.10.87	53.0	19.2	8.9	138.4	203	125.4	130.3			
34	m	J9165	14.11.87	55.1	22.7	9.9	145.3	206	126.1	133.6			
34	f	J9172	25.11.87	51.5	19.1	8.9	136.8	204	121.4	129.3			
35	m	J9166	14.11.87	55.6	20.7	9.3	142.1	207	124.4	130.4			
35	f	J9173	25.11.87	51.4	18.8	9.2	134.1	201	123.6	130.9			
36	m	J9174	25.11.87	53.1	20.3	9.3	140.8	208	125.7	131.5			
36	f	J9167	14.11.87	53.3	19.1	8.8	137.8	204	121.7	127.8			
37	m	J9168	14.11.87	54.4	21.0	9.3	143.7	210	128.1	136.6			
37	f	J9171	24.11.87	53.1	19.5	9.0	139.8	208	129.1	133.7			
38	m	J9175	25.11.87	54.5	20.6	9.4	142.6	210	128.4	136.7			
38	f	J9169	14.11.87	54.5	19.4	8.6	138.5	201	123.1	130.9			
39	m	J9170	16.11.87	55.3	20.9	9.6	144.3	211	128.1	135.6			
39	f	J9176	25.11.87	53.0	18.9	9.3	138.4	203	124.4	132.5			
40	m	J9177	26.11.87	54.1	21.3	9.4	143.0	208	128.5	133.3			
40	f	J9179	7.12.87	53.4	19.6	9.1	136.9	209	123.6	130.4			

KEY :
- BILL l = Bill length (mm)
- BILL d = Bill depth (mm)
- BILL w = Bill width (mm)
- HEAD = Head length (mm)
- FL = Flipper length (mm)
- FOOT pad = Foot length to mid-toe pad (mm)
- FOOT claw = Foot length to mid-toe claw (nm)
- WT = Weight (kg)
- TAR = Tarsus length (mm)
- TOE = Mid-toe length (mm)
- m = male
- f = female

APPENDIX 10 : AVERAGE MEASUREMENTS OF YELLOW-EYED PENGUIN CHICKS AT FIVE DAY INTERVALS AT MIDDLE BAY

AGE CLASS (days)	N	Means (bold) and S.D. BILL length (mm)	BILL depth (mm)	BILL width (mm)	HEAD length (mm)	FLIPPER length (mm)	FOOT length (mm)	WEIGHT (g)
1	9	**14.5**	**8.4**	**4.8**	**47.0**	**38.2**	**38.2**	**102**
		0.9	0.4	0.2	1.1	2.4	2.0	21
5	26	**15.6**	**9.2**	**5.1**	**54.1**	**49.5**	**49.5**	**241**
		1.2	0.4	0.2	3.3	4.5	4.8	77
10	25	**17.9**	**10.3**	**5.5**	**64.6**	**68.8**	**67.8**	**554**
		1.0	0.5	0.2	3.6	7.7	6.7	134
15	25	**20.7**	**11.7**	**5.8**	**76.2**	**96.2**	**90.4**	**1020**
		1.4	0.7	0.3	3.7	10.7	7.1	158
20	25	**24.9**	**13.0**	**6.2**	**87.0**	**124.9**	**110.2**	**1539**
		1.8	0.7	0.3	3.3	10.0	6.5	219
25	25	**29.0**	**13.6**	**6.5**	**96.0**	**152.0**	**119.3**	**2026**
		1.4	0.5	0.3	3.4	9.4	4.0	241
30	25	**31.7**	**14.4**	**6.8**	**103.9**	**172.6**	**124.9**	**2390**
		1.3	0.5	0.3	2.8	9.6	3.1	276
35	25	**34.7**	**14.9**	**7.0**	**110.0**	**188.5**	**128.2**	**2729**
		1.4	0.5	0.3	2.5	7.1	3.5	313
40	24	**37.0**	**15.3**	**7.2**	**114.8**	**196.8**	**129.3**	**3046**
		1.5	0.6	0.3	2.6	3.7	3.4	258
45	25	**39.5**	**15.7**	**7.5**	**119.2**	**201.6**	**130.7**	**3322**
		1.5	0.6	0.4	2.8	4.0	3.2	253
50	25	**41.5**	**16.1**	**7.7**	**121.6**	**203.7**	**131.6**	**3732**
		1.4	0.7	0.4	2.8	4.4	3.1	317
55	25	**42.9**	**16.4**	**7.9**	**125.2**	**203.9**	**132.9**	**4290**
		1.2	0.6	0.4	2.8	4.3	3.3	417
60	25	**44.3**	**16.5**	**8.0**	**127.6**	**204.4**	**132.7**	**4860**
		1.6	0.6	0.4	3.7	3.9	3.1	485
65	25	**45.7**	**16.8**	**8.1**	**130.3**	**205.2**	**133.0**	**4910**
		1.5	0.7	0.4	3.1	5.2	3.2	283
70	24	**46.7**	**17.2**	**8.3**	**132.3**	**208.3**	**134.4**	**4965**
		1.5	0.6	0.4	3.3	4.0	3.1	310
75	25	**47.5**	**17.4**	**8.4**	**133.6**	**208.8**	**134.7**	**4752**
		1.5	0.8	0.4	3.3	4.0	3.1	398
80	14	**48.7**	**17.5**	**8.5**	**135.1**	**208.6**	**134.6**	**4968**
		1.4	0.8	0.5	4.1	4.0	3.9	421
85	10	**48.6**	**18.0**	**8.6**	**135.3**	**208.0**	**133.8**	**4790**
		1.6	0.5	0.3	3.2	4.2	4.2	376
90	10	**49.4**	**18.1**	**8.7**	**135.2**	**211.0**	**137.0**	**4985**
		1.3	0.8	0.4	3.2	2.8	2.8	449
95	13	**49.7**	**18.3**	**8.8**	**136.3**	**208.5**	**135.4**	**5046**
		2.5	0.8	0.5	4.1	4.0	3.5	444
100	11	**50.0**	**18.2**	**8.7**	**136.3**	**211.0**	**137.0**	**5127**
		1.8	0.7	0.4	2.8	2.4	2.3	664
105	6	**50.9**	**18.5**	**8.8**	**138.5**	**209.0**	**135.5**	**5038**
		2.0	0.7	0.2	3.2	3.3	3.7	690
110	4	**49.7**	**18.6**	**8.6**	**136.0**	**208.8**	**136.7**	**4288**
		2.1	1.1	0.7	4.4	3.4	4.0	930
115	1	**53.4**	**18.4**	**9.1**	**142.1**	**213.0**	**141.3**	**6100**

APPENDIX 11: COUNTING YELLOW-EYED PENGUINS
A Guide to Meteorological Station Staff

AIMS: Monitor the population on Campbell Island
Monitor the survival of the banded birds.

METHODS

In 1987-88 the YEP at Middle Bay were intensively monitored. The most useful counts for Met. staff to undertake would be of birds landing at the main landing site (site 7, Figs. 2, 13) at the outlet of Middle Bay stream. The other important landing site is in Sandy Bay, near the western end of the beach (site 2, Fig. 2) where the human track over Complex Point begins. In Capstan Cove the major landing site (site 11) is at the end of the long sloping rock platform on the western side of the bay. At Southeast Harbour counts could be made at landing site 11 (Fig. 3) beside the stream.

The most useful times :

mid-November	1500-2100 NZ Standard Time
mid-May	1500-1830 NZ Standard Time

Conduct at least one count at the landing site. Choose a vantage point close to the landing site, preferably not too visible to the birds when they first land. Avoid bright clothing and keep still. At Middle Bay a good spot is on the bank to the west of the stream (a rough seat should be visible here). From here, the band numbers of the penguins can be read using binoculars. Remain until it seems obvious that no more penguins are coming home. A torch is useful to see the last penguins and to find the hut again.

Record :

a) the number of penguins in each group that land (some may go out also).
b) the time each individual or group lands (preferably write these times in NZST or note that the times are in Daylight time for the summer count).
c) note if adult or juvenile (these have only faint yellow feathers on the side of the head whereas adults have a bright yellow band across the back of the head.
d) note if banded, and what the number is (but only if you have no doubt).
e) total numbers for the count.

e.g.		Cumulative Total In
1540	1 Ad (59170) in	1 (1b)
1555	2 Ad (1 banded) in	3 (2b)
1603	1 Juv in	3 (2b) 1J
1608	3 Ad (2 banded) in via rocks	6 (4b) 1J
1610	2 land but retreat from sea lion	

Also record the band numbers of penguins elsewhere on the island. Preferably use binoculars for this because birds that are caught on beaches become wary of humans. Send results to Peter Moore, DOC, PO Box 10420, Wellington.