

Predation of white-flipped penguins (*Eudyptula minor albosignata*) by ferrets (*Mustela furo*) in Harris Bay, Banks Peninsula, New Zealand

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Abstract The white-flipped penguin (*Eudyptula minor albosignata*) population on Banks Peninsula, New Zealand, was extensively preyed on by mammalian predators during the 1980s and 1990s with the loss of many colonies and the reduction in size of others. This paper presents the results of a 20-year study designed to identify the predators primarily responsible for these losses. It was based on the monitoring of 9 colonies ranging in size from 2 to 37 nests on a 1.7 km section of rocky coastline. Predators were trapped in the largest colony to determine the species present and their relevant behaviour. The other colonies were left unprotected, 6 of which were accessible to predators and 2 were not. Predation of penguins was first observed in the area in 1981 and it occurred annually through to the end of the study in 1995. Five of the 6 unprotected colonies were lost in 1982 and 1983 while the inaccessible colonies were unaffected. The remains of penguins that had been preyed on were found in the 'protected' colony in 11 of the 15 years between 1981 and 1995. These had been taken during the second half of the moulting season in February, and during the non-breeding season from April to August. No predation was observed during September to January when the penguins were breeding. A total of 47 mustelids were trapped in the 'protected' colony of which 43 (91%) were ferrets (*Mustela furo*). Overall there were 16 instances of predation that could be attributed to ferrets and 1 that was attributed to a ferret although the predator was not caught. The onset and sustained period of penguin predation by ferrets followed an eruption in their numbers Banks Peninsula-wide. This was most likely triggered by a corresponding increase in the numbers of rabbits (*Oryctolagus c. cuniculus*), their primary prey.

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Keywords white-flipped penguin; *Eudyptula minor albosignata*; ferret; *Mustela furo*; predation; Banks Peninsula; New Zealand

INTRODUCTION

Little penguins (*Eudyptula minor*) have disappeared from most of their range on the New Zealand mainland since European settlement, and are in much reduced numbers where they have survived (Tennyson 1992). This has been attributed mainly to predation by introduced mammalian carnivores particularly domestic dogs (*Canis familiaris*), feral cats (*Felis catus*), ferrets (*Mustela furo*) and stoats

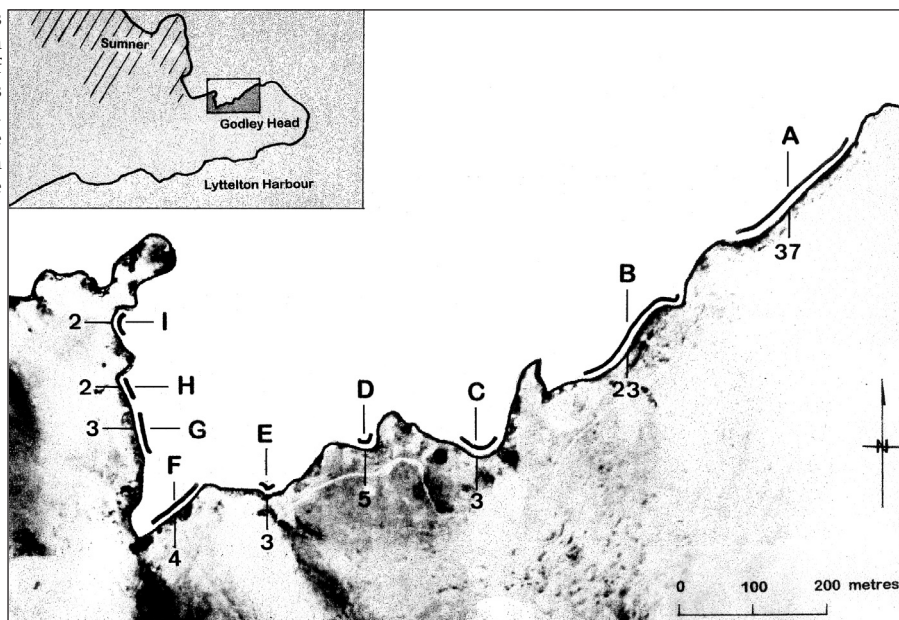
(*M. erminea*) (Taylor 2000a, b). Uncontrolled dogs are well known to kill adult penguins when they find them. The nature of predation by the other species and their relative impacts on little penguin populations is less clear.

White-flipped penguins (*E. m. albosignata*) were considered very common around Banks Peninsula, Canterbury, New Zealand, in the late 1800s (Potts 1882) and early 1900s (Oliver 1955). Since then the population has decreased in size and become fragmented with the loss of nearly all the colonies that were accessible to predators. Penguins

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Fig. 1. Map of Harris Bay showing the location and shoreline extent of the 9 penguin colonies referred to in the text. The numerals are the number of nests in each at the beginning of the study.



disappeared from the heads of most bays on the Peninsula around the 1950s (C.N. Challies *unpubl. records*), and from the remaining accessible parts of the coastline during the 1980s and 1990s. The numbers of nests in monitored colonies decreased overall by an estimated 60–70% between 1980 and 1993 (Challies 1998), and 83% between 1981 and 2000 (Challies & Burleigh 2004). By 2000 the peninsula-wide population had been reduced to c. 2100 breeding pairs (= c. 5870 birds) in 108 mainly small colonies situated below coastal bluffs (Challies & Burleigh 2004). This paper describes the predator-prey regimen primarily responsible for these reductions in penguin numbers.

This study was an adjunct to a long-term study of the population biology of the white-flipped penguin undertaken in Harris Bay on the north side of Godley Head on Banks Peninsula east of Christchurch City. The main study was initiated in 1976 and has continued to the present. The largest colony in the Bay (colony A, Fig. 1) has been closely monitored at the individual-bird level with an emphasis on demography and aspects of year-round behaviour. It has also been used to trial research and conservation techniques including the translocation of chicks. To facilitate these studies the penguins were provided with artificial nest boxes and all breeding birds and their fledglings were banded with numbered metal flipper bands. Early in the study provision was made to trap predators entering the colony, and the details of those caught and the penguins found preyed on were recorded. The numbers of penguins nesting each season in the unprotected colonies in Harris Bay (colonies B–I, Fig. 1) were also recorded.

Penguins were preyed on in Harris Bay from 1981 until after the end of this study in 1995. This paper describes the nature of this predation including when and where it occurred, its impact on penguin numbers, the numbers and age groups of penguins taken, and the predator species responsible and their related behaviour. Supporting information about the penguins and their predation elsewhere on Banks Peninsula was obtained from the results of the main study and surveys of other colonies (C.N. Challies *unpubl. data*). This has been included without separate acknowledgement.

METHODS

Study area

Harris Bay has a 1.7 km rocky shoreline comprising a series of small embayments separated by rock outcrops. These are backed by near vertical coastal bluffs up to 35 m high below which there are narrow, rocky debris slopes that are eroded on their seaward side. Most of the embayments can be reached over land by way of rough tracks through gaps in the bluffs. The vegetation below the bluffs consists mainly of boxthorn (*Lycium ferocissimum*) and boneseed (*Chrysanthemoides monolifera*) shrubs with a ground cover of the native succulent (*Disphyma australe*) and introduced grasses and herbs.

In the mid 1970s there were c. 82 pairs of white-flipped penguins nesting in Harris Bay in 9 discrete groups or colonies of from 2 to 37 nests. The locations, initial sizes and lettering used to identify these colonies are shown in Fig. 1. Observations

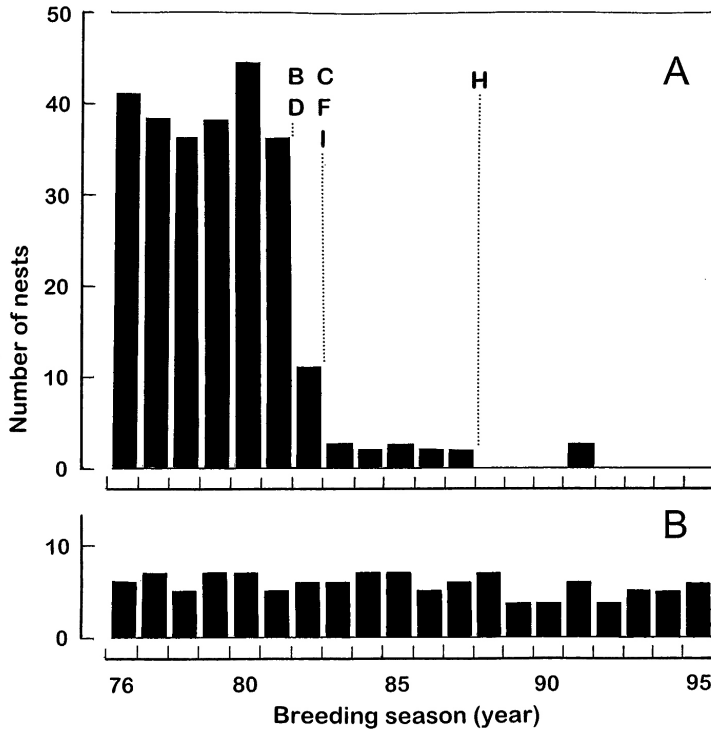


Fig. 2. Numbers of penguin pairs nesting in the unprotected colonies in Harris Bay each breeding season from 1976 to 1995: A, counts for the 6 accessible colonies (B, C, D, F, H & I) combined showing the interval between the counts when each was lost; and B, counts for the 2 inaccessible colonies (E & G) combined.

during the 4 years prior to the study (1972-75) showed little inter-seasonal variation in the numbers and distribution of nests. No evidence was seen of penguins having been preyed on during this period despite the presence of semi-feral cats. These disappeared early in the study when they were no longer being fed by a nearby bach owner.

Predators were trapped in colony A (see Fig. 1) as part of this study, while the other 8 colonies in Harris Bay were left unprotected. Of these 6 proved to be accessible to predators (B, C, D, F, H & I), and 2 (E & G) that were not preyed on during the study were assumed to be inaccessible.

Field methods

Nest counts

The number of occupied nests in each colony was counted each breeding season from 1976 to 1995. Nests were considered occupied if they contained eggs or chicks when surveyed, or had been used earlier in the season but were by then empty. The latter could have been abandoned at the egg or chick stage or the chicks may have already fledged. All of the nest boxes and natural nest sites in colony A were checked frequently during the breeding season as part of the main study. The other colonies in Harris Bay were surveyed 3-5 times during October to December (*i.e.*, between the peak of laying and late in the chick stage).

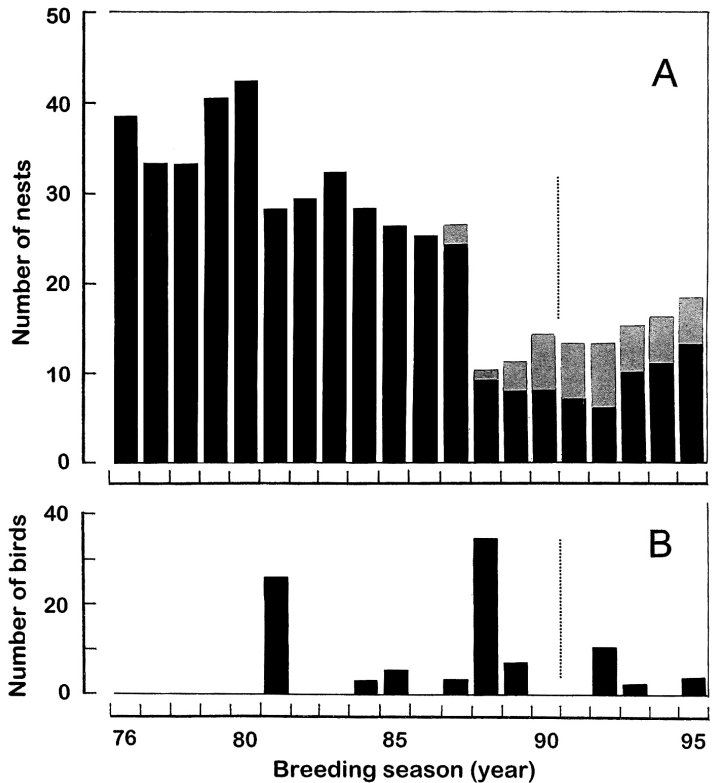
Penguins preyed on

Penguins found dead were examined for evidence they had been killed by a mammalian predator. Those that had obvious bite marks on the back of the neck and/or skull were considered to have been preyed on. Where there was doubt the head and neck of the corpse was collected, cleaned and checked for broken bones and punctures in the back of the skull. All penguins preyed on in colony A had been banded and were being monitored as part of the main study. The actual or minimum ages of these birds were known as were the sexes of those of breeding age (*i.e.*, ≥ 2 or 3 years old). Comparable information was available for most of the penguins found dead in the other colonies from 1985.

Predator trapping

Colony A was checked on average 47 (range 35-62) times a year from 1976 to 1995 as part of the main study. When penguins were found preyed on efforts were made to catch the predator(s) responsible using Mk6 Fenn traps in purpose-built run-through trap boxes baited with sardine-based cat food. Initially 2-3 traps were set near where predation had occurred and checked and baited each visit for 4-6 weeks. From 1991, traps were left set year-round at 4 sites within the colony and baited each visit. Records were kept of the species, sex and date trapped of all the predators caught. Trapped mustelids were separated into young of the year and

Fig. 3. Effects of predation on colony A, Harris Bay: A, numbers of penguin pairs nesting in the colony each season from 1976 to 1995 - the shaded parts of the bars were pairs in which the male was a translocated bird; and B, estimates of the numbers of penguins preyed on each year. The vertical broken lines show when the predator trapping changed from reactive to proactive.



adults (*i.e.*, < 1 and >1 year old) using a combination of skull characters (Ragg 1997), beculum length for males, and nipple size for females.

Nature of data

The figures presented here are actual counts with 1 exception. Estimates of the numbers of penguins preyed on are the numbers of breeding age birds disappearing between one breeding season and the next less 13% for unrelated mortality. This estimate is based on the average annual loss of adult birds of 13.0% (range 11.5-14.2%) from colony A during 6 years (1977-80, 1986 & 1990) when no predation was detected. These are minimum estimates which do not take into account any juvenile birds preyed on.

RESULTS

Impact on unprotected colonies

Accessible colonies

During the first 6 breeding seasons (*i.e.*, 1976 to 1981), the 6 accessible colonies remained at about the size they were in the early 1970s. The seasonal totals over this period averaged 39 nests (range 36-44). This pattern changed suddenly with the complete loss of colonies B and D between the 1981 and 1982 breeding seasons, and the further loss of colonies C, F and I the following year (Fig. 2A). The

remaining colony (H) was lost between the 1987 and 1988 seasons. Following these losses there were only 3 nesting attempts in these areas, one each at the sites of colonies B, D and F. All 3 nesting attempts were during the 1991 breeding season. None of the adult penguins associated with these nests was seen in subsequent years.

The decayed and dried remains of 47 penguins were found at or near the sites of the 6 colonies that had been lost. Of these, 42 (89%) had skull punctures and/or broken neck bones typical of having been preyed on by a small carnivore. While most were killed during the main period of colony loss in 1982 and 1983, 13 were found dead later in the study at sites where penguins were no longer nesting. Six of these penguins had been banded in colony A, 4 as chicks and 2 as non-breeding visitors. They were all either known or assumed from their behaviour to be 2 or 3-year olds (*i.e.*, young birds reaching breeding age).

Inaccessible colonies

Both of the colonies that were inaccessible to predators survived the 20 years of the study with only small fluctuations in size (Fig. 2B). Their seasonal totals averaged 5.8 nests (range 4-7). This would have required the recruitment of *c.*29 breeding birds to offset natural adult mortality of 13% per annum. A total of 12 new penguins was found nesting in these

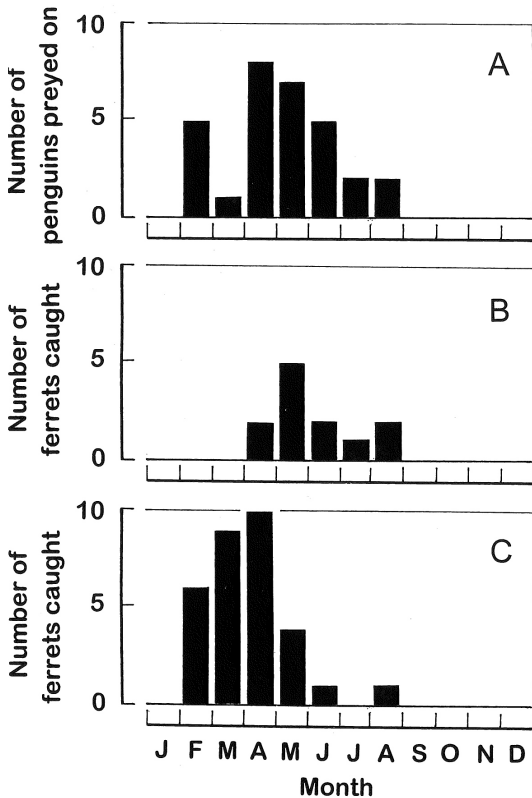


Fig. 4. Monthly occurrence of predation and predators in colony A, Harris Bay: A, numbers of penguins found preyed on between 1981 and 1995; B, numbers of ferrets caught during the period of reactive trapping (1981 to 1990); and C, numbers of ferrets caught during the period of proactive trapping (1991 to 1995).

colonies during the last 10 years of the study after the nearby colonies had already been lost. Of these, 5 had hatched in Harris Bay, 2 each in colonies A and E, and 1 in colony H. The other 7 birds were not banded when first seen, and so their natal colony was likely to have been outside the Bay.

Impact on protected colony

The remains of penguins that had been preyed on were found in colony A during 11 of the 15 calendar years between 1981 and 1995. The numbers found each year ranged from 1 to 7 and the 11-year total was 30 birds (Table 1). Most were inside or adjacent to nest boxes with a few amongst rocks along the shoreline. All had been bitten on the back of the neck close to the base of the skull. They were near fresh and usually entire when found with only a few having been partly eaten. In these cases some neck or breast muscle had usually been taken.

The penguins were preyed on during the period from the second half of the moulting season in

Table 1. Numbers of penguins found preyed on and the identity of predators trapped in colony A each year from 1981 to 1995.

Year	Number of penguins preyed on	Number of predators trapped		
		Ferrets	Stoats	Weasels
1981	7	3	1	-
1982	1	1	1	-
1983	2	1	-	-
1984	1	2	-	-
1985	-	1	-	-
1986	-	-	-	-
1987	1	1	-	-
1988	7	2	-	-
1989	1	1	-	-
1990	-	-	-	-
1991	1	6	-	-
1992	5	10	1	-
1993	1	3	-	-
1994	-	2	-	1
1995	3	10	-	-
Total	30	43	3	1

February through the non-breeding season till August (Fig. 4A). Most of the predation occurred during April to June when adult penguins often return ashore. All 24 birds preyed on between April and August and 4 of the 6 taken during the moult were ≥ 2 years old. Of these, 10 males & 15 females had bred in the colony on 1 or more occasions. The other 2 birds killed when moulting were 1-year olds. No predation was observed during the months September to January when the penguins were breeding.

A total of 187 breeding age birds were lost from the colony between 1980 and 1995. This was 91 more than could be accounted for by the estimated 'natural' mortality of 13% per annum, and 3 times the number of penguins found preyed on. The largest losses of individual birds and resulting reductions in the numbers of breeding pairs occurred in 1981 and 1988 (Fig. 3A&B). An estimated 26 penguins were lost to predation in the first half of April 1981, and a further 35 were lost during a similar event in May 1988. It is likely the predators cached some of these birds out of sight in rock piles, and others may have been killed on the foreshore and their remains either overlooked or washed away. Breeding age birds were also lost from the colony at >13% per annum in 7 other years (Fig. 3B) in which predators were known to have been present (Table 1).

The assumed predation affected the surviving penguins indirectly by breaking pair bonds and skewing their sex ratio in favour of males. Those that lost their mate usually found a new one and bred the following season largely nullifying these effects. For example, of the 26 pairs that nested in colony A in 1987 only 1 female and 9 males returned for the 1988 season. All but 1 of the males bred in 1988, 1 with the surviving female and 7 with birds that were not banded when first seen and therefore likely to have been recruited from colonies outside of Harris Bay. By 1995 19 (56%) of the 34 breeding birds in the colony were immigrants.

Predator trapping

A total of 47 mustelids were trapped in colony A between 1981 and 1995 of which 43 (91%) were ferrets. One or more ferrets were caught during 13 of the 15 years including all of those in which penguins were found preyed on (Table 1). Most were trapped within 5-10 days of penguins being found dead, and up to 15 days after when there were several ferrets present. Overall there were 16 instances of predation that could be attributed to ferrets, and 1 that was attributed to a ferret although the predator was not caught. In addition, 5 ferrets were trapped at times when penguins were not known to have been preyed on. As the 3 stoats (Table 1) were caught about the same time as ferrets it was not possible to separate their effects.

All of the ferrets were caught between February and August with the monthly frequencies for the 2 trapping regimes differing markedly (*cf.* Fig. 4B&C). During the period of reactive trapping (1981-1990) small numbers of ferrets were caught in most years (Table 1) between April and August when predation had occurred. By contrast, during the period of proactive trapping (1991-1995) larger numbers were caught (Table 1) between February and May also usually at times when there had been some predation. Together these show ferrets entered the colony from late summer and if not trapped could have remained a threat to the penguins through autumn and winter.

The ferrets trapped were predominately adult females and young of the year of both sexes (11 adult females and 29 young – 14 male and 15 female). Most of those caught in the colony between February and April were trapped in groups of up to 6 individuals. In February 1995, for example, 2 females and 4 young were caught within 6 days of a penguin being found preyed on, and 3 weeks later another female and 3 young were caught over 5 days. Similarly, in April 1991, 4 young ferrets were caught in the same area in 6 days. The largest number caught together in May was 2, and all those trapped from June to August appeared to have been alone. In addition, 3 adult males were caught separately between April and June.

DISCUSSION

The penguins on Banks Peninsula have been at risk of being preyed on by dogs, cats, ferrets and stoats since these species were introduced into Canterbury in the mid and late 1800s (Bull 1969). While some predation undoubtedly occurred during the first 100 years of European settlement white-flipped penguins remained common and widespread until the mid 1900s (Oliver 1955; O'Brien 1940). Since then there have been 2 periods when predators have had a noticeable effect on numbers. During the 1950s and early 1960s penguins disappeared from around the heads of many of the bays on the Peninsula most noticeably where there was human habitation (C.N. Challies *unpubl. records*). Substantial reductions in their numbers were also observed at this time in some of the eastern bays (Harrow 1971), Okains Bay (G.A. Tunncliffe, *pers. comm.*) and Te Oka Bay (A.K. Quentin-Baxter, *pers. comm.*).

Most of the accessible penguin colonies on Banks Peninsula suffered from predation during the 1980s with the main exceptions being those in areas where feral cats remained the dominant predator (C.N. Challies, *unpubl. records*). The timing and impact of this closely matched that experienced in Harris Bay. For example, a colony of *c.*150 nests on Onawe Peninsula, Akaroa Harbour, disappeared between 1980 and 1984 (M.A.M. Meredith & P.A. Langlands, *pers. comm.*), and a colony of *c.*120 nests in Otanerito Bay was extensively preyed on in 1984 (J.R. Waas, *pers. comm.*). In both cases the observers saw evidence that ferrets were involved. This predation continued through until at least 2000 with colonies being lost progressively from sites less accessible to predators (Challies & Burleigh 2004).

The abrupt onset of predation in Harris Bay and the similar timing of the predation on Onawe Peninsula and in Otanerito Bay point to an eruption in the numbers of ferrets on Banks Peninsula in the early 1980s. This was most likely triggered by an increase in the numbers of rabbits (*Oryctolagus c. cuniculus*), their primary prey (Clapperton & Byrom 2005). Changes in the way rabbit control was prioritised and funded during the 1970s probably allowed rabbits to reach higher densities on at least parts of the Peninsula, but this could not be confirmed. On Godley Head the rabbit population increased noticeably through the 1980s and had reached high densities equivalent to ≥ 4 on the modified McLean Scale (Environment Canterbury 2005) by the early 1990s. The numbers of ferrets caught in colony A (Table 1) at this time suggested they were also numerous. This was confirmed when 49 ferrets (8.6/km²) were trapped in an intensive predator control operation on Godley Head between February and September 1995 (C.N. Challies *unpubl. data*).

Ferrets were trapped in Harris Bay seasonally (Fig. 4B&C) between their post breeding dispersal in

late summer through to just before the start of their next breeding season in September (Chapperton & Byrom 2005). Their apparent absence from colony A between September and January (Fig. 4C) when the penguins were breeding suggests they target rabbits at this time of the year. Young rabbits are most plentiful in spring and early summer (Norbury & Reddiex 2005) when the female ferrets are feeding their young. On Godley Head few rabbits were born after December and females were neither pregnant nor lactating in autumn (based on samples of rabbits collected during poison operations in March 1995 and 1996; C.N. Challies *unpubl. data*).

Unlike most colonial nesting seabirds little penguins return to their colonies outside the breeding season. They moult there for c.15 days in January or February and come ashore and socialise periodically through autumn and winter. Most of the penguins preyed on in Harris Bay were breeding age birds taken during their post-moult presence. This extends from mid April to early June which is when the ferrets were most often in the penguin colonies. All adult penguins came ashore at least once during this period and stayed for several days at a time at or near their previous nest site. Juveniles < 2 years old rarely come ashore during autumn and winter but are sometimes preyed on when moulting in February and possibly also just prior to the breeding season in August.

Ferrets are clearly capable of taking penguins ≥ 1.5 times their own body weight with apparent ease both in the open and at their nest sites. They effectively eliminated each of the unprotected colonies in Harris Bay between one breeding season and the next (Fig. 2), and rapidly reduced the sizes of larger colonies on Banks Peninsula. To do this the ferrets must have been persistent remaining in or around the colonies for extended periods and returning in subsequent years to kill any new birds prospecting for nest sites. Surplus killing also contributed to their impact. Of the 30 penguins found preyed on in colony A only a few had been partly eaten and none appeared to have been cached by the predator. Evidence of surplus killing was seen in other colonies on Banks Peninsula during summer surveys between 1991 and 2000. This comprised clusters of a few to >20 dead penguins that had apparently been killed a few months earlier and left uneaten.

POSTSCRIPT

The ferret population on Banks Peninsula declined after 2000 as the recently introduced rabbit haemorrhagic disease reduced rabbit numbers to low levels. This effectively reversed the positive trend in ferret and rabbit numbers evident during the 1980s. The numbers of ferrets trapped on Godley Head over this period dropped from a mean of 24/annum before 2000 to none after 2010. Since 2000 all

the monitored penguin colonies on Banks Peninsula have increased in size and some of those lost during the 1980s and 1990s have re-established (C.N. Challies *unpubl. records*).

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