NEST-SITE SELECTION BY YELLOW-EYED PENGUINS *MEGADYPTES ANTIPODES* ON GRAZED FARMLAND

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SUMMARY

McKAY, R., LALAS, C., McKAY, D. & McCONKEY, S. 1999. Nest-site selection by Yellow-eyed Penguins *Megadyptes antipodes* on grazed farmland. *Marine Ornithology* 27: 29–35.

The viability of Yellow-eyed Penguins *Megadyptes antipodes* on South Island, New Zealand, is threatened through the loss of breeding habitat by land clearance and the loss of chicks to introduced predatory mammals. Penguin nests at Papanui Beach, Otago Peninsula, were spread through about 7 ha of grazed grassland and shrubland. Here farming and Yellow-eyed Penguin conservation were shown to be compatible through active management: the impact of farm stock was minimised by excluding cattle; predation was minimised by trapping; and disturbance by humans and dogs was minimised by prohibiting public access. Penguin nest sites varied from sites with total lateral concealment and overhead cover to fully exposed sites. Deaths attributed to avian malaria decimated the breeding population of 21 pairs in early 1990. Nest numbers recovered to 21 by the 1995/96 season but their distribution had changed. Nests lacking overhead concealment in grassland habitat increased from two (10%) in 1989/90 to 12 (57%) in 1995/96. Unexpectedly the new generations of breeders appeared to select open, relatively exposed sites in grassland in preference to sites in dense vegetation offered by shrubland. We have not yet found an explanation for this preference. However, a relatively large number of non-breeders congregated at pastures near the sea in the 1995/96 season with the vast majority in grassland rather than shrubland. The presence of clear areas may be important for the recruitment of breeders at this location.

INTRODUCTION

Most species of penguins in temperate latitudes have been recorded breeding in habitats altered by rural or urban development. Examples are African Penguins *Spheniscus demersus* in South Africa (Crawford *et al*. 1995), Magellanic Penguins *S. magellanicus* in Argentina (Stokes & Boersma 1991), Magellanic Penguins, Rockhopper Penguins *Eudyptes crestatus* and Macaroni Penguins *E. chrysolophus* at Falkland Islands (Woods 1970), Yellow-eyed Penguins *Megadyptes antipodes* in New Zealand (Darby 1985), and Blue Penguins *Eudyptula minor* in Australia (Dann 1992) and New Zealand (Dann 1994). The viability of Yellow-eyed Penguins on South Island, New Zealand, is regarded as threatened through the loss of breeding habitat by land clearance and the loss of chicks to introduced predatory mammals (Darby 1985, Darby & Seddon 1990, Marchant & Higgins 1990). In contrast to other surface-nesting penguins, nests of Yellow-eyed Penguins are widely spaced and hidden in vegetation. Before colonisation by Europeans through the 19th Century, coastal forest provided the nesting habitat believed necessary for successful breeding. Lateral concealment created a visual barrier between neighbouring nests and overhead shading decreased the air temperature (Seddon & Davis 1989, Darby & Seddon 1990). With the loss of original breeding habitat through the clearing of the forest for farmland, most nests are now in shrubland, open woodland and pasture (Seddon & Davis 1989, Darby & Seddon 1990, Marchant & Higgins 1990).

With the exception of bats (Chiroptera), New Zealand lacked terrestrial mammals before human colonisation. Concepts defining the impact of introduced mammals on Yellow-eyed Penguins can be divided into five inter-related categories. First, Ferrets *Mustela furo* and feral House Cats *Felis catus* prey on chicks, especially on farmland (Darby & Seddon 1990) where over 90% are taken in some locations and years (Marchant & Higgins 1990). Second, the abundance of these predators reflects that of lagomorphs (European Rabbits *Oryctolagus cuniculus* and Brown Hares *Lepus europaeus*), their main prey (Darby & Seddon 1990). Third, lagomorphs are most abundant on pastures grazed by farm stock (Darby & Seddon 1990). Fourth, trampling by cattle *Bos taurus* destroys nests and sheep *Ovis aries* also cause some damage (Roberts & Roberts 1973, Marchant & Higgins 1990). Fifth, Yellow-eyed Penguins on farmland are prone to disturbance by people and domestic Dogs *Canis familiaris* (Richdale 1957, Roberts & Roberts 1973), the only two species of terrestrial predatory mammals known to be capable of killing adults.

The breeding cycle of Yellow-eyed Penguins is summarised here from Marchant & Higgins (1990). Adults are sedentary. Typically they breed annually with two-egg clutches that hatch in November and one or two chicks that fledge in February or March. Juveniles are mobile and rarely seen ashore within six months after fledging. They moult into adult plumage at one-year old. First-time breeders are typically 2–4 years old and have a lower breeding success than that of experienced breeders (Richdale 1957).

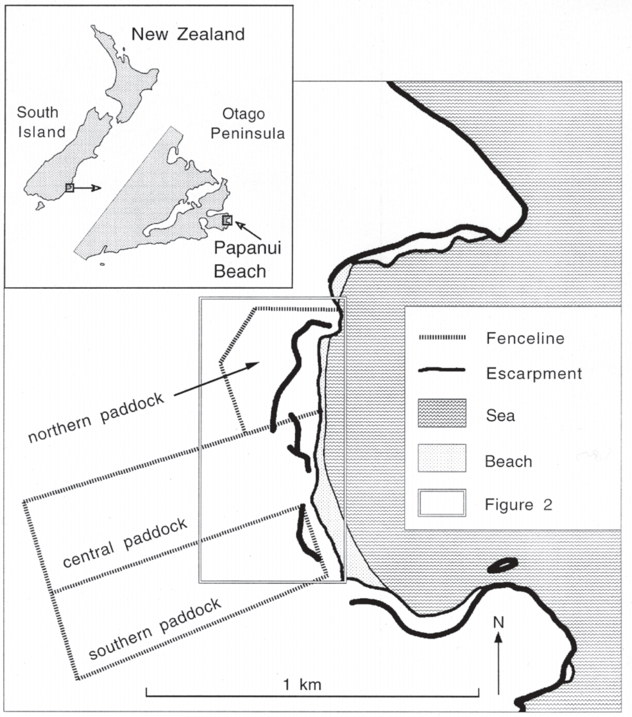

Fig. 1. *Papanui Beach showing location of the three paddocks on McKay land.*

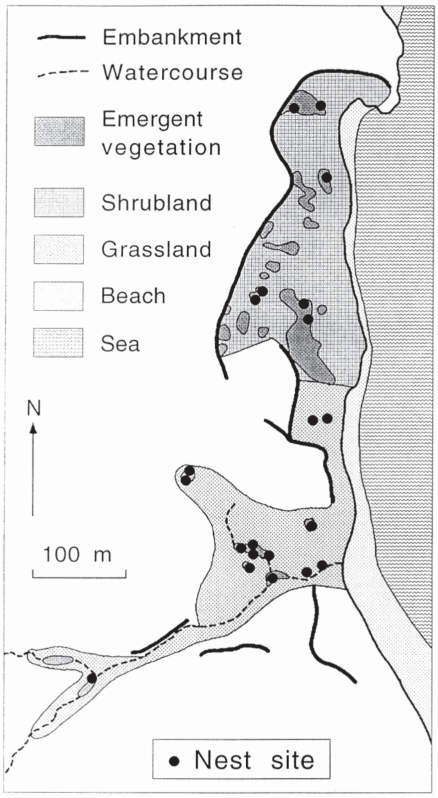

Fig. 2. *Breeding habitat on McKay land at Papanui Beach, showing nest sites occupied in the 1995–96 breeding season. See Fig. 1 for location.*

New Zealand's Department of Conservation (1991) produced a policy for the protection of Yellow-eyed Penguins, a species defined as unable to adapt to the rapid and radical alterations caused by people. This policy when applied to farmland habitat involved the removal of farm stock and the initiation of a planting programme to provide nesting habitat. The growth of rank grass in retired pasture bordering the breeding area was envisaged as a barrier to mammalian predators (Darby & Seddon 1990). An overall area of up to 100 ha was considered desirable (Department of Conservation 1991).

Papanui Beach, part of a privately-owned farm, is one of 17 locations designated by Department of Conservation (1991) as a breeding habitat for Yellow-eyed Penguins on Otago Peninsula, South Island. The loss of up to 100 ha would render the farm uneconomic and so alternative management methods were initiated. We show that Yellow-eyed Penguins can flourish on farmland at Papanui Beach with the application of predator control measures and appropriate stock regimes without detriment to the viability of farming.

METHODS

Study area

Papanui Beach (45°52'S, 170°44'E), Otago Peninsula, South Island, New Zealand, is a sand and boulder beach that is 1 km wide and eastward-facing (Hawke 1986, Beentjes 1989, Fig. 1). Both ends of the beach are bounded by headlands rising to an altitude of 80 m that offer some shelter from the prevailing southerly and north-easterly winds.

The original vegetation to the west of the embayment was Broadleaf *Griselinia littoralis* forest. When D.W. McKay (pers. comm. to RMcK), father of RMcK and grandfather of DMcK, arrived in 1920 this land was in pasture but burnt Broadleaf trees lay where they had been felled. This indicated a relatively recent clearance of forest, perhaps between 1900 and 1915. Land abutting the beach was cleared in pre-European times by Maori. A settlement at Papanui Beach targeting moas (Aves: Dinornithidae) and New Zealand Fur Seals *Arctocephalus forsteri* was occupied continually for 200–300 years until the 17th Century when local seal rookeries were exterminated (Anderson 1989, Smith 1989). Yellow-eyed Penguins were eaten by Maori (Millener 1990, McGovern *et al.* 1996) and therefore were unlikely to have been contemporary here given the proximity of human hunter-gathers. However, Yellow-eyed Penguins were breeding at Papanui Beach in 1920 (D.W. McKay, pers. comm. to RMcK).

The McKay family owns a 350-ha pastoral farm that runs 2 600 Romney sheep and 170 cattle. The seaward boundary of this farm is delineated by the foreshore of the central 750 m of Papanui Beach (Fig. 1). The land abutting this foreshore is divided into three paddocks: a 10-ha northern paddock, a 20-ha central paddock and a 20-ha southern paddock. Introduced pasture species predominate throughout, especially Perennial Ryegrass *Lolium perenne* and White Clover *Trifolium repens*.

Shrubland and grassland breeding habitats

Yellow-eyed Penguins ashore on the McKay farm at Papanui Beach during the 1995/96 breeding season were spread through about 7 ha of the three seaward paddocks (Fig. 2). This area was divisible into two halves by differences in terrain and vegetation: a northern shrubland habitat and a southern grassland habitat. The boundary between these two habitats was approximately delineated by the fence between the northern and central paddocks (Fig. 1).

The shrubland habitat occupied by penguins consisted of a seaward plateau up to 50 m wide bounded by slopes rising to an altitude of 30–40 m. A distinct inland border was formed by an escarpment 50–150 m inland that encompassed a plan area of *c*. 3.5 ha. A secondary growth of clumps of shrubs and trees, total plan area *c.* 0.5 ha, was scattered throughout but concentrated in gullies. This shrubland was dominated by Tree Nettle (Ongaonga) *Urtica ferox*, a native shrub up to 2 m high. Larger clumps included stands of Elderberry *Sambucus nigra*, an introduced tree up to 5 m high, bordered with thick growths of Pohuehue *Muehlenbeckia* sp., a native climbing vine.

The grassland habitat occupied by penguins lacked a distinct inland border. Instead, rolling hills to an altitude of 40 m were divided by watercourses and penguins penetrated up to 350 m inland and were spread through *c.* 4 ha. Clumps of a native rush J*uncus gregiflorus* and a native sedge *Carex appressa*, each up to 1 m high, were scattered in the vicinity of watercourses. These clumps totalled *c.* 0.1 ha within the area used by penguins. This grassland lacked shrubs and trees with the notable exception of one 50-m^2 clump of Tree Nettle.

Tree Nettle was susceptible to sea spray and suffered temporary die-back following rare easterly storms that occurred no more than once a year. However, the extent of emergent vegetation varied only slightly through time and no substantial change was recorded through the study period.

Farming regime

The foreshore of McKay land was unfenced and the three seaward paddocks were separated by wire fences that did not impede the passage of penguins. Cattle were excluded from these paddocks throughout the year, a practice instigated about 1980, and grazing by farm stock was restricted to sheep. Sheep were present only seasonally from after ewes were tupped in April until lambs were weaned in December. These paddocks were then spelled to allow pasture growth for winter grazing.

No degradation of emergent vegetation was apparent in the shrubland habitat through the study period. However, the stands of trees lacked any substantial undercanopy, presumably the result of trampling and browsing. The presence of sheep in the grassland habitat rarely affected rushes but sedge was often cropped.

Farm dogs were not allowed to free range. They were only present at mustering when they were under strong verbal control. None chased or killed penguins. Public access onto McKay land was prohibited thus minimising disturbance by people and domestic dogs. Also, Papanui beach was over 8 km from the nearest urban area, a distance unlikely to be travelled by roaming domestic dogs.

Predator control

An investigation of the breeding success of Yellow-eyed Penguins at Papanui Beach in the early 1980s by J.T. Darby (pers. comm. to RMcK) indicated that a large proportion of chicks were taken by introduced mammalian predators. In an attempt to curb this loss of chicks, the McKay family instigated predator control measures with the deployment of spring traps in 1986. These kill traps targeting introduced predators were deployed annually by RMcK and DMcK from November to January in pairs in 12 wooden tunnels baited with sheep liver.

The spatial deployment of traps did not follow a set pattern. About half were near the penguin nests considered most vulnerable to predation. The remainder were spread around the perimeters of nesting habitats, including between nests and the foreshore, often at the junctions of sheep trails. The sites of traps near nests varied annually but sites of perimeter traps remained relatively static.

Through the years the traps caught Ferrets, European Hedgehogs *Erinaceus europaeus*, young cats, rats *Rattus* sp., European Rabbits and Brushtail Possums *Trichosurus vulpecula*. In addition, cats were shot whenever encountered by RMcK and DMcK while checking traps.

Lagomorphs were rare throughout the McKay farm and numbers were kept low by shooting. Very few were scored at Papanui Beach in a survey of the comparative abundance of lagomorphs at breeding locations of Yellow-eyed Penguins on Otago Peninsula in 1991 and 1992 (Nick Alterio, University of Otago, pers. comm. to DMcK & CL).

Predator control measures appeared successful. The cumulative total of 41 nests monitored in the five breeding seasons 1991–1996 produced evidence for only one predation event: both chicks at the nest in the only clump of Tree Nettle in grassland habitat were lost in November 1995.

Study design

The study period encompassed seven breeding seasons, 1989/90 to 1995/96, by Yellow-eyed Penguins on McKay land at Papanui Beach. All nests in the 1989/90 season were found by RMcK and CL in early November 1989 but their fates were not monitored. Through the next five seasons CL monitored nests in grassland at 2–4 week intervals. In the 1995/96 season CL and SMcC monitored all nests in the late afternoon at weekly intervals from 28 October 1995 to 5 January 1996.

The numbers of non-breeding adults and juveniles ashore were counted on nine of the nest monitoring rounds in the 1995/96 breeding season. For both these age categories, the minimum number of birds was calculated as the sum of the number of banded birds and the maximum count of unbanded birds. Penguins at Papanui Beach were last banded in the mid 1980s.

An aerial vertical photograph taken in 1988 by John McMecking, Department of Conservation, Dunedin, was used to create maps and calculate plan areas. The areas for breeding habitats included all land occupied by Yellow-eyed Penguins above the foreshore in the 1995/96 season. The distance walked by penguins between nests and the sea was measured from the high tide mark with a pedometer following known or suspected penguin pathways. Inter-nest distances were measured with tape except for a solitary outrider that was measured off maps.

In statistical comparisons, 1-tailed *t*-tests were applied to linear or normalised population means with population standard deviations. Consistent and comparable parameters for breeding success are a prerequisite for temporal and spatial comparisons. Here we follow the comprehensive presentation of Moore (1992). Identifications and names of plants followed Wilson (1982) and names of mammals followed King (1990).

RESULTS

Number and dispersion of nests

In the 1989/90 breeding season there were 21 Yellow-eyed

TABLE 1

Annual nest numbers and breeding success in grassland habitat

Breeding season	Total number of nests	Nests failed at egg stage	Nests failed at chick stage	Successful nests	Chicks fledged per nest	
					Mean	S.D.
1989/90	2	0	0	2	2.00	0.00
1990/91	0			0		
1991/92	3	0	0	3	2.00	0.00
1992/93	4	1	0	3	1.50	1.00
1993/94	6	0	0	6	1.83	0.34
1994/95	7	1	0	6	1.71	0.65
1995/96	12	2	2	8	1.17	0.86

Penguin nests on the McKay farm at Papanui Beach. Seventeen were at natural sites in shrubland habitat in the northern paddock and two were at natural sites in grassland habitat in the central paddock. The other two nests were in the central paddock but their sites defied simple categorisation: one was in the only clump of Tree Nettle in the grassland and the other was in a nest box built in 1989. The former was allocated to shrubland habitat and the latter was excluded from analyses.

A total of 13 adults was found dead ashore at Papanui Beach from 1 January 1990 to 12 February 1990. These known deaths corresponded to 30% of the local breeding population of 42 birds.

No penguins nested in grassland in the following breeding season (1990/91) although adults occupied the two nest sites used in the previous year (1989/90). Nest numbers in grassland habitat then increased gradually from three to seven, all with two-egg clutches, through the next four breeding seasons (1991/92 to 1994/95). Breeding success was high through this period. Chicks were fledged at 18 of the cumulative total of 20 nests and the other two nests failed to hatch eggs (Table 1). All but one of the 36 chicks hatched were fledged. The only death was a chick in the 1993/94 season.

Nest numbers in grassland habitat then almost doubled between the 1994/95 and 1995/96 breeding seasons with a concomitant drop in breeding success (Table 1). However, this change in the mean number of chicks fledged per nest was not statistically significant (1-tailed t-test: $t = 1.35$, $P > 0.05$).

In the 1995/96 breeding season there was a total of 21 Yellow-eyed Penguin nests on the McKay farm at Papanui Beach (Fig. 2). Seven were at natural sites in shrubland habitat in the northern paddock. Twelve were at natural sites in grassland habitat: 11 in the central paddock and one in the southern paddock. The other two nests were at the same sites in the central paddock that were difficult to categorise in the 1989/90 breeding season: one in the only clump of Tree Nettle in the grassland (allocated to shrubland habitat) and the other in a nest box (excluded from analyses).

TABLE 2

Parameters for nest positions in 1995/96 for grassland and shrubland habitats

Distance from nest (m)	Nests in grassland			Nests in shrubland			1-tailed *t*-test	
	n	Mean	S.D.	n	Mean	S.D.	*t*	*P*
To clear pasture								
Linear	12	0.33	0.56	8	1.31	0.89	2.26	<0.05
Walk to sea								
Linear	12	172	86	8	77	15.5	n.a.	n.a.
Square root transformation	12	12.6	3.33	8	8.7	0.95	3.06	<0.005
To nearest neighbour								
Linear								
All	12	38	67	8	35	17	n.a.	n.a
Excluding outrider	11	17	8.6	8	35	17	n.a.	n.a.
Square root transformation								
All	12	4.95	3.61	8	5.61	1.64	n.a.	n.a.
Excluding outrider	11	3.91	1.06	8	5.61	1.64	2.58	<0.01

The solitary nest beside the watercourse in the southern paddock (Fig. 2) marked the greatest penetration inland by breeders through the study period. Further movement inland was unimpeded by terrain and penguins were seen over 50 m upstream from this nest.

Concealment of nest sites

The degree of concealment of nests in the 1995/96 breeding season differed between the two habitats. All 12 nests in the grassland habitat were visible from adjacent clear pasture and all lacked complete overhead cover. Eight had some lateral concealment on three sides: five within rushes, two against clay banks bordered by rushes, and one against and partially under a log. The other four nests were in clear pasture without any substantial lateral concealment. However, all four had solid backs: two against clay banks, one against rock, and one against rushes.

Only one of the eight nests in the shrubland habitat was visible from adjacent clear pasture. All eight were totally concealed from their immediate surroundings on three sides and above by a dense growth of Tree Nettle or Pohuehue at ground level. In addition, a clay bank contributed to lateral concealment at one nest. The open front of seven nests faced an area enclosed under an overhead canopy. The exception was one nest that opened directly onto clear pasture.

The linear distance from the centre of a nest to the nearest area of clear pasture was 0–2.3 m for nests in grassland habitat, significantly less than the 0.3–2.8 m for nests in shrubland habitat (Table 2).

Positions of nests

The positions of the 21 nests in the 1995/96 breeding season are shown in Fig. 2. Distances between nests and the sea and between neighbouring nests differed between the two habitats. The distance walked by Yellow-eyed Penguins between their nests and the sea was significantly farther at grassland sites, range 51–361 m, than at shrubland sites, range 42–99 m (Table 2).

The linear distance between neighbouring nests was 8–49 m in shrubland and 6–268 m in grassland. The average spacing between nests was similar in both habitats (Table 2). When the solitary outrider (Fig. 2) was excluded, the maximum inter-nest distance in grassland dropped to 37 m. The concomitant average spacing then dropped to half that between nests in shrubland, a difference that was statistically significant (Table 2).

TABLE 3

Comparisons of breeding success in 1995/96 between grassland and shrubland habitats

Success category	Grassland		Shrubland	
	n	%	n	%
Nests	12		7	
Eggs	24		14	
Chicks	16		13	
Two-egg clutches	12	100	7	100
Nests that hatched eggs	10	83	7	100
Nests that fledged chicks	8	67	6	86
Eggs that hatched	16	67	13	93
Eggs that fledged chicks	14	58	11	79
Chicks that fledged	14	88	11	85

Breeding success

Weekly monitoring of the 21 nests in the 1995/96 breeding season ceased on 5 January 1996 when chicks were 7–8 weeks old. No dead chicks were seen while checking traps through January 1996. Also, none was found during a thorough search on 5 March 1996 at the end of the fledging period. Consequently, all chicks alive on 5 January 1996 were assumed to have fledged.

The analysis compared the impact of nest-site vegetation on breeding success, and here excluded from Tables 3 and 4 the nest in a nest box and the nest that suffered losses attributable to predation. In the former one egg did not hatch, but one chick was fledged.

There was indication that breeding success was different between the two habitats (Table 3), but population sizes were too small to produce statistically conclusive results. The mean fledging rate in shrubland was higher than in grassland but this was not statistically significant (Table 4). The rate of failure to hatch eggs was significantly higher for nests in grassland (Table 4). This accounted for the difference in fledging rates because chick survival rates were similar in both habitats (Table 4).

The lower mean fledging rate for nests in grassland in the 1995/96 breeding season was not attributable to the four nests that lacked overhead cover and any substantive lateral conceal-

TABLE 4

Statistical parameters for breeding success in 1995/96 for grassland and shrubland habitats

Nest success category (mean per nest)	Nests in grassland			Nests in shrubland			1-tailed *t*-test	
	n	Mean	S.D.	n	Mean	S.D.	*t*	*P*
Chicks fledged per nest	12	1.17	0.86	7	1.57	0.67	1.01	>0.05
Eggs that failed to hatch	12	0.67	0.71	7	0.14	0.35	1.72	0.05
Chicks that died	10	0.25	0.41	7	0.29	0.65	0.12	>0.05

ment. Three were south facing and in direct sunlight only in the early morning. Two of these sites were occupied throughout the six-year study period except in 1990/91 when none nested (Table 1) and the other was occupied for the last three years. These three sites typically fledged two chicks annually, including 1995/96. In contrast, the fourth site was used only in 1995/96, was east facing in direct sunlight for most of the day, and failed to fledge chicks.

Non-breeders

An average of nine non-breeding Yellow-eyed Penguins were seen ashore during nine late-afternoon counts in the 1995/96 breeding season at Papanui Beach. Counts ranged between 3–15 juveniles and 0–6 adults and totalled at least 33 individuals: 21 juveniles, including 13 banded, and 12 adults, including 8 banded. Ninety percent of juveniles and 75% of non-breeding adults were in the grassland habitat.

DISCUSSION

Yellow-eyed Penguins flourished on grazed paddocks at Papanui Beach when three factors detrimental to breeding success were minimised. First, predator control by trapping and shooting resolved the immediate problem of continual high losses of chicks to introduced carnivores. Second, the exclusion of cattle and the restriction of farm stock to sheep appeared to resolve the problem of long-term degradation of remnant nesting habitat. Third, the practice of prohibiting public access minimised the sporadic problem of disturbance by people and dogs.

The conservation management technique proposed in Department of Conservation (1991) specified the isolation of potential Yellow-eyed Penguin habitat within a 100-m border. Three scenarios exist for the area of McKay land lost from farming if this policy were adopted. First, encompassing the existing penetration of 350 m inland would require 35 ha. Second, encompassing a potential penetration of perhaps 600 m inland would require 55 ha. Third, 100 ha could be considered desirable. These scenarios respectively account for 10%, 15% and 30% of the 350 ha farm. The implementation of any of these scenarios would have rendered the farm uneconomic.

Nesting by Yellow-eyed Penguins on the McKay farm was spread through two contrasting habitats. Optimal nest sites with overhead cover and lateral concealment from the immediate surroundings (Seddon & Davis 1989, Darby & Seddon 1990) were offered in shrubland habitat. In contrast, nest sites in grassland habitat lacked overhead cover and were relatively exposed laterally.

The deaths of at least 30% of the breeding population at Papanui Beach was part of a mortality outbreak specific to adult Yellow-eyed Penguins and unprecedented in records for the species. The cause was attributed to avian malaria (Graczyk *et al.* 1995) that was restricted to Otago Peninsula where at least 130 birds died and few bred in the following season (Gill & Darby 1993). This disastrous event offered the opportunity to document the selection of breeding habitats and nest sites through a period of repopulation at Papanui Beach.

Immediately preceding the die-off, 20 of the 21 nests could be categorised by habitat with 90% in shrubland and 10% in grassland. Six years later numbers had recovered to 21 nests, of which 20 could be categorised by habitat – 40% in shrubland and 60% in grassland. No substantial changes in vegetation were detected through the study period and so the reduction in the number of nests in shrubland could not be attributed to a loss of nest sites. Unexpectedly the majority of breeders appeared to select relatively exposed sites in grassland instead of the supposedly-preferred, secluded sites offered by shrubland. No obvious hypothesis is forthcoming for this result. However, future monitoring will reveal if this trend continues and perhaps offer an explanation.

Nests in grassland averaged 170 m walking distance from the sea, more than double the distance for nests in shrubland. If the solitary outrider was excluded, then inter-nest distances in grassland averaged 17 m, half that between nests in shrubland. These features of the dispersion of nests in grassland were unlikely to have been detrimental to breeding because they were normal for the species. Nests of Yellow-eyed Penguins on average are 100–200 m from the sea and 10–30 m apart (Seddon & Davis 1989). Their distance from the sea can exceed 700 m (Darby & Seddon 1990), approximately double the maximum recorded at Papanui Beach, and so a penetration farther inland is feasible.

Eggs from nests in grassland had a lower hatching rate than those in shrubland in the 1995/96 breeding season. Incubating adults in grassland may have been exposed to greater heat stress than those in shrubland (Seddon & Davis 1989, Darby & Seddon 1990). However, this explanation appeared doubtful for Papanui Beach because three of the four nests that lacked any overhead cover each raised two chicks. A second option seemed more likely. First-time breeders have a lower breeding success than experienced pairs (Richdale 1957) and the relatively low hatching rate coincided with an almost doubling of nest numbers. Future monitoring will include the deployment of maximum-minimum thermometers in order to monitor the micro-climate at nests.

The relatively large number of non-breeders were seen ashore during the 1995/96 season portended a continued increase in nest numbers at Papanui Beach. The vast majority of non-breeders was in grassland rather than shrubland. Future monitoring of nest numbers will indicate if the recorded trend towards preferential recruitment into grassland is real or coincidental. Perhaps large areas of clear ground on foreshore slopes clearly visible from sea attract pre-breeders ashore. These penguins may then remain to breed, a result that would be relevant to the conservation management of the species.

Our results do not detract from the concept presented in Department of Conservation (1991). Practically all of the original coastal vegetation has disappeared within the South Island range of Yellow-eyed Penguins (Darby 1985). For example, our study found that emergent vegetation in penguin breeding habitat accounted for only 2% of the grassland and only 15% of the shrubland occupied at Papanui Beach in contrast to the envisaged near 100% forest cover before human colonisation. We have shown that conservation measures for Yellow-eyed Penguins need not compromise the viability of coastal farms and that extensive replanting programmes may not be essential. Although management can produce viable populations of target species of wildlife on farmland, patches of coastline must be isolated from introduced species to maintain and enhance the biodiversity of indigenous species.

ACKNOWLEDGEMENTS

We are indebted to Heather McKay whose desire always to have penguins at Papanui Beach motivated the start of conservation measures. Thanks also to Sarah McKay and Fiona Bennett for their support, to Carol Sutherland and Peter Krygsman for help with monitoring, to Robert Ardern for help in the preparation of maps, to Steve Dawson for advice on statistics, and to reviewers Martin Fortescue and Philip Seddon for constructive comments on the manuscript.

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