THE DESIGN AND USE OF A NEST BOX FOR YELLOW-EYED PENGUINS *MEGADYPTES ANTIPODES* – A RESPONSE TO A CONSERVATION NEED

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SUMMARY

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Yellow-eyed Penguins *Megadyptes antipodes* are surface nesters which prefer dense vegetation. The clearance of coastal forest and its replacement with farmland has virtually eliminated natural breeding habitat at North Otago, South Island, New Zealand. At two localities on grazed farmland the vegetation associated with nests was divided into six categories. Only two categories provided the optimal concealment considered necessary for successful nesting. Domestic sheep destroyed most bush remnants during a drought in 1984. This loss was compensated by nest boxes that replicated the microhabitat of optimal sites. These nest boxes have a timber frame 1.2 m long, 0.6 m deep and 0.6 m high, cladded with plywood sides, back and roof. A wooden bar across the open front excludes domestic stock. Nest boxes have been in use for over 10 years and are preferred to natural sites by penguins on farmland. They also are suitable for temporary deployment in revegetation programmes.

INTRODUCTION

The status of Yellow-eyed Penguins *Megadyptes antipodes* on South Island, New Zealand is regarded as threatened through the loss of forest breeding habitat by land clearance and the loss of chicks to introduced mammalian predators (Darby 1985, Seddon & Davis 1989, Darby & Seddon 1990, Marchant & Higgins 1990). Public awareness of the plight of Yellow-eyed Penguins on South Island, initiated by Darby (1985), aroused an interest in the desire to protect the species and resulted in the creation of the Yellow-eyed Penguin Trust (NZ) in 1987. The Department of Conservation (1991) of New Zealand formulated a species recovery plan that envisaged the enhancement of breeding habitat on South Island by the elimination of farm stock together with revegetation to create nest sites and an encompassing vegetative barrier to exclude predators.

The annual breeding season of Yellow-eyed Penguins extends from egg laying in September–October to chick fledging in February–March (Richdale 1957, Darby & Seddon 1990, Marchant & Higgins 1990, Moore 1992). They are surface breeders, usually at sites concealed by vegetation. With the loss of forest breeding habitat along the south-eastern coastline of South Island, most nests are now in shrubland, open woodland and pasture (Darby 1985, Seddon & Davis 1989, Darby & Seddon 1990, Marchant & Higgins 1990). Overhead cover and lateral concealment are the most important factors influencing the selection of optimal sites and over 90% of nests are against a fairly solid vertical surface formed by vegetation or terrain (Seddon & Davis 1989). Chicks often abandon their natal nest sites during the latter half of their fledging period and become vulnerable to heat stress if overhead vegetation is lacking (Seddon 1990).

Yellow-eyed Penguins breeding on grazed farmland typically face a shortage or total absence of optimal nest sites. We describe two extreme examples from North Otago, South Island. Revegetation programmes produce nesting habitat after 5–10 years but do not meet the immediate need for nest sites. This problem has been resolved for burrow-nesting penguins by installing artificial nest sites, e.g. Little Penguins *Eudyptula minor* (Reilly 1983). We sought the same solution for Yellow-eyed Penguins: an artificial nest site suitable either for permanent use on grazed farmland or for temporary deployment in association with a revegetation programme.

METHODS

Our study involved two of the six breeding localities of Yellow-eyed Penguins at North Otago, South Island, New Zealand, listed for the 1989/90 breeding season in Marchant & Higgins (1990): Okahau Point (45º23'S, 170º52'E), on Moeraki Peninsula, and Bobbys Head (45º32'S, 170º46'E) (Fig. 1). Moeraki Peninsula was monitored annually from 1982/83 to 1992/93 by us or Department of Conservation staff and CL monitored Bobbys Head in two consecutive breeding seasons, 1983/84 and 1984/85, in association with Y.M. van Heezik (1988). Penguins were banded at both localities in 1983/84 and 1984/85 by Y.M. van Heezik. Experiments in the modification of nesting habitat were restricted to Okahau Point and elsewhere on Moeraki Peninsula.

Maps and plan areas for Okahau Point were prepared from Survey Office Plans 21241 and SO 22901 and for Bobbys Head from a vertical aerial photograph taken by CL in April 1985. The plan areas for breeding habitats included all land occupied by Yellow-eyed Penguins above the foreshore. Occupation of grassland was judged largely from the presence or absence of penguin droppings and the results for areas were realistic but over-precise.

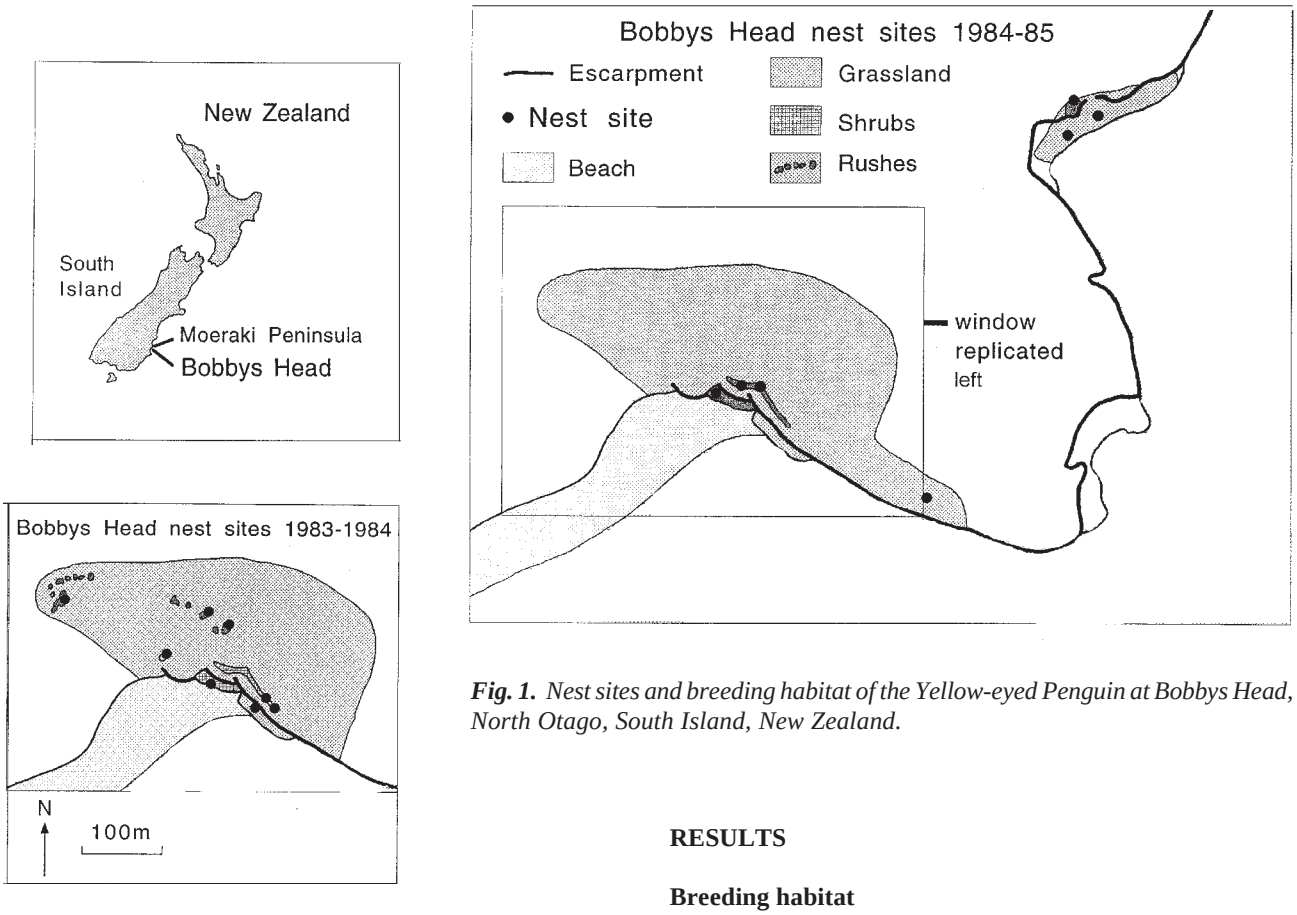

Fig. 1. *Nest sites and breeding habitat of the Yellow-eyed Penguin at Bobbys Head, North Otago, South Island, New Zealand.*

Twenty-six of the 32 breeding locations of Yellow-eyed Penguins on South Island listed in Marchant & Higgins (1990) were visited in the 1983/84 or 1984/85 breeding seasons by CL while employed by the New Zealand Department of Lands and Survey. The features of optimal sites matched those presented by Seddon & Davis (1989) and formed the basis of specifications for a design of nest box.

RESULTS

Breeding habitat

In the mid 1980s Bobbys Head and Okahau Point represented the most extreme examples of the impact of land clearance on the breeding habitat of Yellow-eyed Penguins on South Island. Penguins were spread through paddocks of grassland grazed by domestic sheep. The terrain was similar at both localities: rolling hills abutted cliffs that restricted landing sites to specific strips of sandy beach or rocky shore.

TABLE 1

Categories of vegetation associated with nests at two North Otago breeding locations in grassland

	Vegetation category	Typical species	E=exotic N=native	Degree of concealment of nest		Typical nest back
				Overhead	Lateral	
1.	Grassland	*Holcus lanatus*	E			rocks
		Dactylis glomerata	E	zero	zero or low	embankments
		Lolium perenne	E			fallen logs
2.	Shrubs:	*Phormium tenax*	N			plant stems
	Cliff-edge scrub remnant	*Hebe elliptica*	N	usually low	usually low	plant foliage
		Myoporum laetum	N			embankments
3.	Woodland:	*Coprosma propinqua*	N			embankments
	Open woodland remnant	*Myoporum laetum*	N	usually high	usually low	plant stems
		Fuchsia excorticata	N			fallen logs
4.	Rushes	*Juncus*	N			plant foliage
		Scirpus	N	usually low	usually high	embankments
5.	Shrubs:	*Coprosma propinqua*	N	usually	usually	plant foliage
	Paddock scrub remnant	*Coprosma crassifolia*	N	high	high	embankments
6.	Shrubs:	*Lycium ferocissimum*	E	usually	usually	plant stems
	Invasive species	*Ulex europeus*	E	high	high	plant foliage

Initial monitoring by JJ and PRJ at Okahau Point in the 1982/83 breeding season indicated high losses of Yellow-eyed Penguin chicks attributable to predation by introduced mammalian carnivores. An annual trapping programme targeting potential predators was instigated in the 1983/84 season. This ongoing programme eliminated losses attributable to predation through most subsequent years. In contrast, no evidence of chick loss to predation was detected at Bobbys Head through the two seasons of study and so no predator control measures were implemented.

Vegetation within penguin breeding habitat at Bobbys Head and Okahau Point was divided into six categories ranked in order of the degree of overhead cover and lateral concealment offered to nest sites (Table 1). Only two of these categories offered potential nest sites that perhaps could be regarded as optimal. Neither category was represented at Bobbys Head. At Okahau Point paddock scrub remnants consisted of small clumps of Mingimingi *Coprosma propinqua* and *C. crassifolia*, divaricating shrubs up to 1 m high that offered some concealment to nests. Two species of invasive shrubs or trees were present. Patches of Boxthorn *Lycium ferocissimum* to 4 m high were restricted to steep slopes at cliff edges and talus. Patches of Gorse *Ulex europeus* to 2 m high offered the most concealed potential nest sites at Okahau Point.

The area of Yellow-eyed Penguin breeding habitat and the spread of nests through the six categories of vegetation varied between two consecutive breeding seasons and differed between locations (Table 2). The only shared feature in the microhabitat of all nests was a solid back formed by vegetation or terrain.

All eight nests at Bobbys Head in the 1983/84 breeding season were at the southern corner of the headland, with four in cliff-edge scrub remnant and three in rushes (Fig.1, Table 2). A one-year drought that began in mid 1984 resulted in poor grass growth and hungry sheep. Grazing, browsing and trampling by sheep all but destroyed the patches of rushes and severely cropped the cliff-edge scrub remnants by the beginning of the 1984/85 breeding season. The area occupied by penguins expanded but the number of penguin nests at the southern corner was halved to four (Fig. 1, Table 2). However, in October 1984 during the incubation period, non-breeding adults were found at another five sites, including three that had been nest sites in the previous year. In addition, a new locality was colonised with three nests at the northern corner of the headland. These included one breeding pair that had nested at the southern corner in the previous season.

The impact of sheep on the vegetation at penguin nest sites during the 1984 drought was less severe at Okahau Point because most emergent foliage was either beyond reach (woodland) or impalatable (invasive shrubs). Also in contrast to Bobbys Head, the area occupied by penguins was similar in both breeding seasons (Fig. 2, Table 2). Although the number of nests increased in the 1984/85 breeding season (Fig. 2, Table 2), the vegetative cover of the two nests in paddock scrub remnant was largely destroyed. This prompted us to design, build and deploy nest boxes not only to compensate for the degradation of the microhabitats of natural nest sites but also to increase the number of available sites on farmland at Okahau Point.

Specifications for a nest box

We aimed to produce a nest box that replicated the features of an optimal nest site. Specifications here are listed in order of importance.

1. Overhead and lateral concealment

A nest box should have a solid roof, back and sides and an open front.

2. Sufficient area to shelter four grown penguins

The minimum size, as judged from natural sites in confined surroundings for example under shrubs or within rock crannies, would be an open-fronted cube $0.4 \times 0.4 \times 0.4$ m, floor area 0.16 m^2. We estimated that a nest box would need a much larger floor area of at least 0.5 m^2 in order to hold two grown chicks and their parents throughout the fledgling period.

TABLE 2

Nest dispersion between vegetation categories in two consecutive years during a period of habitat degradation

Vegetation category	Bobbys Head				Okahau Point			
	1983/84		1984/85		1983/84		1984/85	
	Area (ha)	No. nests	Area (ha)	No. nests	Area (ha)	No. nests	Area (ha)	No. nests
1. Grassland	5.8	1	7.0	3	2.8	0	2.8	0
2. Scrubs: Cliff-edge scrub remnant	0.04	4	0.03	4	0.01	0	0.01	0
3.Woodland: Open woodland remnant	0	0	0	0	0.12	2	0.12	1
4. Rushes	0.05	3	0	0	0	0	0	0
5. Scrubs: Paddock scrub remnant	0	0	0	0	0.01	2	0.01	2
6. Shrubs: Invasive species	0	0	0	0	0.10	0	0.11	2
Totals	**5.9**	**8**	**7.0**	**7**	**3.0**	**4**	**3.0**	**5**

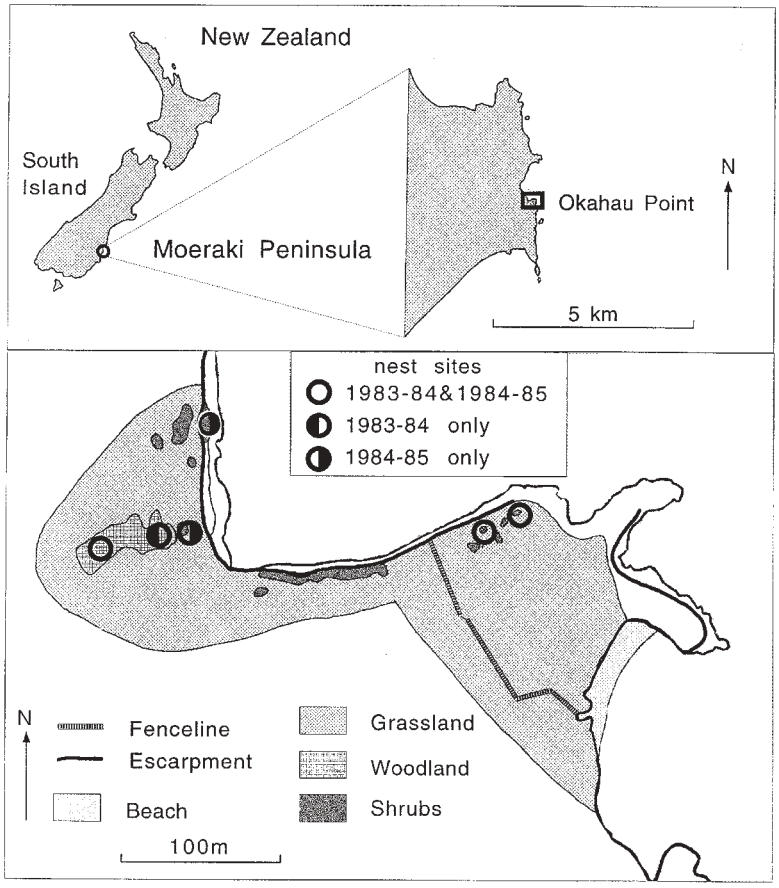

Fig. 2. *Nest sites and breeding habitat of the Yellow-eyed Penguin at Okahau Point, North Otago, South Island, New Zealand.*

3. Durability

We wanted nest boxes constructed from materials that would last 10–20 years. The structure would also need to endure interference by domestic animals and possible vandalism by people.

4. Portability

Portability would allow nest boxes to be relocated if initial sites prove unsuitable or, if deployed in association with a revegetation programme, they became redundant.

Nest box design, construction and maintenance

Dimensions: a rectangular box 1.2 × 0.6 × 0.6 m with an open front and solid sides, back and roof. Floor area is 0.7 m².

Materials: Cost:1996 New Zealand dollars 60–80.
Frame: 9.5 m of 50 × 50 mm dressed tanalised pine.
Cladding: 1800 × 1200 mm of 9–12 mm tanalised plywood. (Tanalised timber is treated with copper naphthenate to protect against rot and insects.)
Attachment: quantity of 50 mm, 75 mm and 100 mm galvanised flat-head nails.
Method: Four pieces of ply (roof and back each 1200 × 600 mm and two sides each 600 × 600 mm) are nailed onto a pine frame, leaving front and bottom open. Boxes should be constructed in multiples of four, where three sheets of 2400 × 1200 mm ply are sufficient for four boxes.
Site preparation: The open bottom of the box is sited on flat ground flush with the outside of the open front.
Security: The box is nailed to one or two steel spikes driven into the ground.
Stock exclusion: A horizontal 1.2 m length of 50 × 50 mm timber nailed midway across the front of the box excludes domestic animals.
Ventilation: Air flow through a box is enhanced by two to three horizontal slots, 1–2 cm wide, sawn through the plywood back.
Frontal concealment: The open front can be concealed from the immediate surroundings by a vertical screen 0.5 m high set 0.5–1 m in front of the box. This can be connected with a lateral wing to one side of the box.
Nesting material: A dearth of nest material can be resolved with the provision of dry plant material, especially leaves of Cabbage Trees *Cordyline australis*.
Annual cleaning: With continual use, a solid crust forms over the floor of the nest box. This must be broken up and removed annually.
Durability: Boxes deployed continuously for 11 years have not deteriorated structurally.

Effectiveness of nest boxes

Deployment at Okahau Point was initiated with four boxes in mid 1985. They were not placed at sites where penguins were known to have nested previously. Instead, we chose sites that we guessed were appropriate except for a lack of vegetative concealment. Only one of the four boxes was used in the following 1985/86 breeding season. The occupants were an experienced pair that had nested locally in the previous two

years and they successfully fledged chicks. Domestic stock continued to degrade the vegetation at natural sites at Okahau Point and so in mid 1986 two boxes were moved to established nest sites. Three of the four boxes were used in the following 1986–87 season and all successfully fledged chicks. Boxes were added periodically and totalled about 15 in 1995, typically set 10–20 m apart. All nests at Okahau Point were in nest boxes for the nine years from 1987/88 to 1995/96 with up to eight nest boxes occupied annually.

Nest boxes were also deployed elsewhere along the Moeraki Peninsula. In the 1983/84 breeding season, Okahau Point with four nests and a site one kilometre to the north with two nests accounted for the peninsular total of six nests. Annual nest numbers fluctuated but gradually increased with a concomitant southward spread through subsequent years. In the 1995/96 breeding season numbers for Moeraki Peninsula totalled 16 nests, all in nest boxes (K. Pearce pers. comm.).

Three trends in the pattern of use of nest boxes were apparent but not quantified. Firstly, in practically all cases the box into which eggs was laid was used as an overnight roost by adults and chicks throughout the fledgling period. Secondly, established pairs tended to nest in the same box each year. Thirdly, established pairs tended to occupy their nest box throughout the year, including during the annual moult.

Nest boxes as part of a revegetation programme

We carried out an intensive revegetation programme to compensate for the lack of optimal nest sites and the continued degradation of scrub remnants at Okahau Point. A standard five-wire fence that excluded stock but allowed unhindered passage for Yellow-eyed Penguins was constructed by PRJ in 1987 (Fig. 2). This fence isolated 1.6 ha of coastal strip where we planted *c.* 4 000 native grasses, herbs, shrubs and trees through four years from 1987 to 1990.

In the 1995/96 breeding season there were eight Yellow-eyed Penguin nests and *c.* 15 nest boxes within the revegetated area (D. Houston pers. comm.). The planted vegetation was up to eight years old with an almost continuous ground cover and trees to over 3 m high. Although all nests were in nest boxes, an inspection by CL and K. Pearce in mid 1996 indicated an abundance of potential natural sites.

DISCUSSION

Although the lack of optimal nest sites for Yellow-eyed Penguins in grazed habitats has been emphasised (Darby 1985, Seddon & Davis 1989, Darby & Seddon 1990), the patterns of nest dispersion between different categories of vegetation have not been documented previously. Bobbys Head and Okahau Point in the mid 1980s represented the most extreme examples of Yellow-eyed Penguin breeding habitat on grazed farmland. Only paddock scrub remnants and invasive shrubs or trees offered potential nest sites that could be considered optimal and the scrub remnants were vulnerable to episodic degradation by domestic stock.

A marked deterioration in the vegetation around nest sites occurred between consecutive years at Bobbys Head. The area of shrubs and rushes accounted for only a paltry 1.5% of penguin breeding habitat in the 1983/84 breeding season. This was further reduced by two-thirds as the result of grazing, browsing and trampling by sheep during a drought in 1984. Some pairs did not breed in the 1984/85 season and nest numbers dropped even though the area occupied by penguins expanded and one pair moved to a new location 500 m away. Decreases continued through subsequent years. Nest numbers halved from eight in 1983/84 to four in 1995/96, of which three were at the location first colonised in 1984/85 (D. Houston pers. comm.). Although habitat degradation was probably the major cause of the decline, kills of adult penguins by domestic dogs also had an impact and predation of chicks by introduced mammals was suspected (D. Houston pers. comm.).

Degradation of breeding habitat was also recorded at Okahau Point on Moeraki Peninsula in 1984. However, through the subsequent 12 years the number of Yellow-eyed Penguin nests on the Moeraki Peninsula more than doubled from six to 16. This increase was attributed mainly to an ongoing trapping programme to minimise predation and to the deployment of nest boxes to provide nest sites. The initial design fulfilled our specifications and penguins preferred nest boxes to natural sites on grazed grassland. Boxes were not only used as overnight roosts by adults and chicks throughout the fledgling period but also they were occupied throughout the year by breeding pairs.

Deployment of boxes in association with a revegetation programme provided for secluded nests during the *c.* 10 years of growth required for planted shrubs and trees to develop natural sites. Nest boxes were still structurally sound and could be moved elsewhere. However, we struck a peculiar problem in that although natural sites became available within the replanted area, penguins remained in nest boxes. We plan to remove nest boxes only after penguins begin nesting at natural sites.

The function of nest boxes is to provide instant nest sites at locations lacking optimal nest-site microhabitats. They are typically placed at exposed sites in clear surroundings. The occupants therefore are likely to be subject to a higher thermal stress and a higher rate of interaction with other penguins than would be expected for the occupants of concealed nest sites. We were unable to quantify the effectiveness of nest boxes because we lacked a control sample population: everyone was in nest boxes. A valid statistical test would require an intra-annual comparison of breeding success at one location with half the nests in nest boxes and half at natural sites. The nest boxes would need not only to be dispersed randomly but also to be placed at realistic sites.

The situation at Bobbys Head has become less morbid in recent years. The Yellow-eyed Penguin Trust purchased the headland, excluded stock and began a revegetation programme in 1993. The Department of Conservation also became involved with the deployment of nest boxes that began in 1994 and annual trapping targeting potential predators that began in 1995.

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