

Movements of Little Penguins *Eudyptula minor* banded at Rabbit Island and the Seal Island Group, Wilsons Promontory, Victoria

F. I. Norman¹, P. Dann^{2,5}, S. Unthank³, and T. L. Montague⁴

¹Lot 11 Cullen Crescent, Plenty, Victoria 3090.

²Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Victoria 3922.

³133 Graydens Road, Tuerong, Victoria 3915.

⁴Department of Mathematics and Statistics, University of Melbourne, Parkville, Victoria 3052.

⁵Corresponding author. Email: pdann@penguins.org.au

Received: 23 December 2010

Between 1979 and 2002, 5044 Little Penguins *Eudyptula minor* were banded (4796 adults, 248 chicks) at Rabbit Island, Wilsons Promontory, Victoria. Recoveries of dead banded birds and recaptures away from the island of banded adult and fledging birds made up to June 2009 are reviewed: mention is also made of results obtained from banding smaller numbers of birds (823) on Seal, Rag and Notch Islands in the nearby Seal Island Group between 1991 and 2001. For birds originally banded at Rabbit Island, most recoveries were made to the west of the banding site, although some birds were found dead in New South Wales and in northern Tasmania. Recoveries were made in and out of presumed breeding periods, particularly during winter/early spring and mid-summer for adults, usually within 400 kilometres of Rabbit Island and less than five years after banding. While causes of death were rarely reported (if known), there was a substantial increase in recoveries following a die-off of Pilchards *Sardinops sagax* in southern Australian waters in 1995. Recoveries of banded birds from Rabbit Island and the Seal Island Group fit within a pattern shown by banding at other colonies, namely that those from colonies to the west and south tend to move to the coasts of western Victoria and South Australia whereas those to the east may move north and south. Such results suggest that Little Penguins disperse away from breeding colonies to areas of presumed increased productivity and prey availability.

INTRODUCTION

The Little Penguin *Eudyptula minor* breeds in New Zealand and around southern Australia, from south of Fremantle in Western Australia to the north coast of New South Wales. In Victoria, the larger colonies are found from Lady Julia Percy Island (38° 25'S, 141° 59'E) in the west to Gabo Island (37° 33'S, 149° 54'E) in the east (Marchant and Higgins 1990). The species shows strong philopatry and emigration to other colonies is relatively low (Dann 1992; Peucker *et al.* 2009). When breeding, birds undertake short foraging trips, usually of a day's duration (Collins *et al.* 1999; Preston *et al.* 2007; Hoskins *et al.* 2008). They may stay in and around colonies when adult, but they may also leave for two or three months in the non-breeding period (McCutcheon *et al.* 2011). Little Penguins from Phillip Island, particularly those fledging, disperse widely in non-breeding periods and most recoveries of first-year birds (c. 95% were found dead) are made to the west, with concentrations between Cape Otway and Port McDonnell (see Fig. 1 for place names). Almost all recoveries of second-year and older birds are also made to the west (Reilly and Cullen 1982; Dann *et al.* 1992). Adults are more likely to die to the west of Anglesea in January to March, along the central coast of Victoria in April to May, and in Port Phillip Bay between June and September (Dann *et al.* 1992). Such movements may result in the mixing of birds from different colonies with the prospect of different populations being affected by the same stochastic event (Norman *et al.* 1992; Dann and Norman 2006). Starvation, perhaps in association with storms and parasites, may be responsible for many deaths at sea (Harrigan 1992; Norman *et al.* 1992; Dann

et al. 2000). Most mortality of first and second-year Little Penguins occurs at sea, presumably since they are infrequently ashore until breeding two to three years after fledging; deaths of adults occur both at sea and on land (Dann 1992). For birds banded at Phillip Island, recoveries within Port Phillip Bay were much more numerous for older birds than those of pre-breeding age: most mortalities of first-year birds occur between January and June as is the case for the more dispersed second-year birds. Adults, however, tend to be recovered in winter and early spring (Dann *et al.* 1992).

Reilly and Cullen (1982), Marchant and Higgins (1990) and Priddel *et al.* (2008) reported on dispersal of Little Penguins banded as chicks at some sites in Victoria, New South Wales and Tasmania and found that movements varied in direction between colonies. Nevertheless, little is known of dispersal patterns of Little Penguins (whether adults or chicks) from other Victorian colonies although at St Kilda (Preston *et al.* 2007), Kanowna Island and Rabbit Island (Hoskins *et al.* 2008), some birds have been followed using satellite transmitters attached during the guard stage of breeding when chicks are usually less than two weeks old. At this time, birds moved a maximum of some 18.3 kilometres (compared with 16.9 km from Kanowna Island and 19.8 km from Phillip Island; Hoskins *et al.* 2008). Such studies relate to movements during breeding periods. Here we examine longer-term dispersal from Rabbit Island, Wilsons Promontory as indicated by the recovery or recapture of Little Penguins banded on the island between 1979 and 2002. Results obtained from banding a smaller number of Little Penguins at the nearby Seal Island Group are also summarised.



Figure 1. Recovery/recapture locations of Little Penguins *Eudyptula minor* banded at Rabbit Island, Wilsons Promontory, Victoria. Smaller circles are of adult penguins (> 1 year) recovered dead away from Rabbit Island and the four larger ones are of birds recovered dead within 12 months of being banded as chicks.

Satellite image courtesy of Google Earth

METHODS

Study areas

Rabbit Island (38°54'S, 146°31'E), some two kilometres off the north-eastern coast of Wilsons Promontory, Victoria, is a small, domed granite island (c. 32.4 ha) rising to about 60 metres above sea level. In general the island is covered by dense *Poa poiformis* tussock, with an included shrubland flora (dominated by *Acacia longifolia*, *Leucopogon laevigatum* and *Leptospermum parviflorus*) extending from behind the sand beach on the south-western coast upwards to the central area. The island's flora has increased, both in species recorded and cover, since European Rabbits *Oryctolagus cuniculus* were eliminated following myxomatosis and poisoning between 1966 and 1967. The removal of Rabbits has also resulted in an expansion of breeding areas occupied by Little Penguins and Short-tailed Shearwaters *Ardenna tenuirostris* (Norman *et al.* 2010).

Gillham (1961) considered that there were 'many hundreds' of Little Penguin burrows in 1959 and up to 500 were estimated in 1979 (Norman *et al.* 1980; Norman and Harris 1981). This was considered an underestimate by 1988 (Norman 1988) and visits between 1985 and 1988, when most Little Penguin nests were found on the western side of the island, above and at each end of the sand beach (although guano and occasional occupied nests were found elsewhere), suggested a burrow total of around 2500. By 1991 some 4000 burrows were estimated (Thoday 1991) although totals in 1995 and 1996 were considered lower (Thoday 1995, 1996). No later estimates are available.

Notch (38°56'S, 146°40'E), Rag (38°57'S, 146°40'E) and Seal (38°55'S, 146°39'E) islands, in the Seal Island Group some 15 kilometres to the east of Rabbit Island, are all small and have

varying vegetation cover containing differing numbers of Little Penguin burrows. Seal Island (c. 11 ha) held some 'hundreds of burrows' when visited in December 1978 (Harris and Deerson 1980a). The island was burnt in October 2005 and some 350 Little Penguins were killed (P. Dann pers. obs.). A similar number of burrows was reported at Rag Island (c. 3 ha; Harris and Deerson 1980c) whereas the smaller Notch Island (c. 2.5 ha) had an estimated 500 burrows (Harris and Deerson 1980b).

Banding

Little Penguins have been banded using Australian Bird and Bat Banding Scheme (ABBBS) 'flipper-tags' on Rabbit Island during numerous visits between 1979 and 2002. Some banding by S.G. Lane and H. Battam occurred during a visit in 1979 and was then continued between 1985 and 1988 by T.L. Montague. Further banding was undertaken by members of the Penguin Study Group (PSG) who banded during approximately annual visits, usually of 2–3 days duration, between 1991 and 2002. These visits were not necessarily at the peak of the breeding periods. While some birds were caught in burrows (both adults and chicks greater than six weeks old), most were intercepted as they moved onto the island at dusk. Many adults were sexed using bill measurements (Arnould *et al.* 2004), cloacal distension in females or by accepting the gender of previously tagged and sexed partners; however, breeding status was rarely determined.

Between November 1991 and January 2001, the PSG also banded Little Penguins at Rag Island, Notch Island and Seal Island during short annual visits employing the same methods used at Rabbit Island.

Recoveries

Recoveries and recaptures of marked penguins may be reported to the ABBBS by the public. Here we consider a recovery to be that of a dead bird with a band attached found by us or reported to ABBBS and a recapture to be that of a live bird away from the banding site. Only those made before 1 July 2009 are included here. Causes of death are infrequently indicated by those reporting recoveries. For those birds reported, distances and directions between banding site and recovery location are automatically generated by ABBBS. Not included here are recaptures of birds on the island, and two birds (with sequential band numbers, bands not returned) recaptured in burrows in South Australia; transposition of two digits suggest that they were previously banded at that colony. For the purposes of separating recoveries made in or outside breeding periods, it is assumed that Little Penguins on Rabbit Island have breeding periods similar to those at Phillip Island where, though variable and influenced by food availability (Cullen *et al.* 1992), most egg-laying occurs in September to November, with chicks fledging some three months later (Dann *et al.* 2000). Here we have considered a breeding period to extend between August and February. Differing totals in various analyses below reflect the absence of complete details for some recoveries.

RESULTS

Banding

Totals of Little Penguins banded on Rabbit Island between 1978 and 2002 are summarised in Table 1. In this period 5044 birds were banded; of these 4796 were adults (2376 males, 2222

females and 198 unsexed) and 248 were chicks. While 982 (415 adult males, 376 females, 151 unspecified, 40 chicks) Little Penguins were banded between 1985 and 1988, most birds were tagged subsequently.

Little Penguins were banded at Rag Island (2), Notch Island (23) and Seal Island (798) between 1991 and 2001. Of those banded at Seal Island, 655 were adults and 143 chicks (see Table 2 for details).

Recoveries

There have been 91 adults (1.9% of the 4796 banded between 1985 and 2002) reported as dead or recaptured away from Rabbit Island up to 30 June 2009. Of these, 40 (1.7% of 2376) were males and 46 (2.1% of 2222) females; five birds (2.5% of 198) were unsexed at banding. Similarly, five (2%) of the 248 Little Penguins banded as chicks were subsequently recovered. Most birds (81) were found dead in the sea, onshore as carcasses (including two considered to have died as a result of a storm) or as skeletal remains, including two at Rabbit Island. However, three adult Little Penguins were apparently recovered as a consequence of fishing activities, and another seven were recaptured and subsequently released or died in rehabilitation. The chicks recovered were all found floating on the sea or were beach-washed.

The locations of all recoveries of birds banded at Rabbit Island are shown in Figure 1. Although two birds were found dead on Rabbit Island, and others on the adjacent mainland or within Corner Inlet, results indicate that birds may undertake widespread movements away from the island, with some recoveries being made in southern New South Wales, Tasmania and South Australia. However, many recoveries were made along the Victorian coast to the west of Rabbit Island and to the west of the mainland promontory itself. Indeed, recoveries of adults away from Rabbit Island were mainly in the north-western quadrant (Fig. 2), as were five birds banded as chicks. Nevertheless, there were several birds of both sexes found to the east, where the more

extensive movements were made (Fig. 1; Table 3). For birds banded as adults the mean time between banding at Rabbit Island and recovery or recapture was 40.2 months ($sd = 33.4$; range 1–135; $n = 89$), and the mean distance between banding site and recovery location was 203.7 kilometres (152.0; 0–692; 91). Only three adult males were recovered greater than 400 kilometres from Rabbit Island, and the mean distance from banding site to recovery location for adult males was 176.3 kilometres (134.7; 0–680; 40) compared to 239.9 kilometres (162.9; 13–692; 46) for females, including five greater than 400 kilometres. The respective elapsed times were 48.6 months (37.5; 1–135; 39) for males, including three greater than 80 months, and 32.5 months (28.7; 1–122; 46) for adult females with one greater than 400 kilometres. Distances did not necessarily increase with elapsed time from banding (Figs. 3 and 4), and most recoveries were less than 400 kilometres from Rabbit Island and within five years of banding. For the five Rabbit Island chicks recovered, the mean movement distance was 427.0 kilometres ($sd = 287.8$; range = 152–872) and the elapsed time 12.7 months (21.5; 1–45).

Recoveries made in the assumed breeding period or outside it (Figs. 3 and 4) indicate that, for adult males, most recoveries in both periods were made within five years of banding (breeding period, mean elapsed time 48.3 months: $sd = 39.1$; range = 1–135; $n = 28$ – non-breeding period 49.4 months: 34.8; 7–114; 11), and less than 400 kilometres of Rabbit Island (breeding 184.6 km: 142.5; 0–680; 29 – non-breeding 154.5 km: 114.9; 23–431; 11). The three adult males recovered over seven years after banding were less than 300 kilometres from Rabbit Island. For adult females the majority of recoveries were similarly made within five years of banding (breeding period, mean elapsed time 34.2 months: 29.2; 1–122; 33 – non-breeding period 28.4 months: 28.1; 6–114; 13), and less than 400 kilometres of Rabbit Island (breeding 204.8 km: 152.6; 13–692; 33 – non-breeding 328.8 km; 159.5; 74–605; 13). More extreme movements (> 600 km) were made in (1, male), and out of (3, female), the breeding period and were reported some two years post-banding.

TABLE 1

Banding totals for Little Penguins *Eudyptula minor* at Rabbit Island, Wilsons Promontory, Victoria, 1979 – 2002. [Banding in 1979 by H. Battam and S.G. Lane; 1985 – 1988 by T.L. Montague; 1990 – 2002 by the Penguin Study Group].

Banding period	Adults			Chicks	Total
	Male	Female	Unspecified		
1979 (December)				11	11
1985 (November) to 1988 (March)	415	376	151	40	982
1990 (August) to 1991 (February)	121	74	2	18	215
1992 (March)	33	32			65
1992 (November)	219	239	3	10	471
1993 (October, November)	282	260	36	2	580
1994 (November)	296	300	1	17	614
1995 (August, October)	213	208	2		423
1996 (October, November)	169	134	1		304
1997 (November)	102	111	1	1	215
1998 (November)	143	126		5	274
1999 (November)	166	159	1	84	410
2001 (January)	85	77		31	193
2002 (January)	132	126		29	287
Totals	2376	2222	198	248	5044

TABLE 2

Banding of Little Penguins *Eudyptula minor* at Seal Island, Seal Island Group, Victoria between 1991 and 2001.

Period	Banding totals				
	Adult male	Adult female	Adult	Chick	Total
1991 (9 November)	43	37	1		81
1992 (13 March)	38	41	3		82
1994 (10 November)	31	28			59
1995 (27 October)	10	7			17
1996 (31 Oct – 1 Nov)	33	19			52
1997 (11 – 12 November)	59	52		2	113
1998 (17 – 18 November)	32	40		26	98
1999 (6 – 8 December)	62	62	1	71	196
2001 (22 – 23 January)	41	15		44	100
Totals	349	301	5	143	798

Separation of recoveries into monthly totals (Fig. 5) showed that 66 birds banded as adults (72.5% of 91) occurred within the presumed breeding period (August – February): 26 (28.6%) adult-banded birds were recovered in winter (40% of male recoveries and 43.5% of females) and a further 11 were reported in September. Of the 91 recoveries of adult birds, 25 were made in the June – September 1995 period, 51.0 per cent of the 49 reported in these months generally and 47.2 per cent of the recoveries made up to September 1995. Seven (of eight) chicks were recovered within four months of banding (December – April); the other recovery was made in July, 45 months after being banded in November.

Of the small numbers of Little Penguins banded at Rag and Notch Islands, only one bird (from Notch) has been recovered: an adult female was found at Moonlight Beach, Victoria (September, after 58 months, 299 km at 272°). To date there have been 10 recoveries (1.2% of 798) of the Little Penguins banded at Seal Island. Three (2.1%) of the 143 chicks banded there were found dead 200–794 kilometres to the northwest on the central Victorian coast and in South Australia, some 2–13 months after banding. Seven Little Penguins (1.1%) banded as adults were also recovered, mostly found beach-washed (although one was killed by a boat and another found dead after a storm). Four of these recoveries were to the northeast of Seal Island, with birds being found near Corner Inlet (2) and in New South Wales (433 km away), whereas the others were to the northwest, on central Victorian beaches or further west (504 km). The time between banding and eventual recovery varied (1–66 months); three adult birds were recovered within the breeding period assumed above and four outside it.

DISCUSSION

In the period 1979–2002, 5044 Little Penguins were banded on Rabbit Island, Wilsons Promontory, Victoria. A further 823 were banded on islands in the nearby Seal Island Group. Recoveries (and some recaptures) of banded Little Penguins (mainly adults of unknown age and breeding status) have been subsequently made along the Victorian coast, in South Australia, New South Wales and northern Tasmania. Most recoveries were made to the west, both in and out of an assumed breeding period, with birds generally being found dead

as beach-washed corpses within 400 kilometres of the banding site. The elapsed time to recovery was usually less than five years and movement did not necessarily increase with time. While there may be a potential bias due to human population distribution, the often westerly movement of water through Bass Strait (Gibbs 1992) could also have some influence on recoveries; however, movements found in other studies were similar whether at sea – observations, radio-tracking or band recoveries were used (Dann *et al.* 1992). In this study few birds were recovered within Port Phillip Bay, a marked contrast to the results found for adult Little Penguins from Phillip Island (Dann *et al.* 1992). Nevertheless, the increased incidence of recoveries of adults banded at Rabbit Island in the late winter – early spring period was similar to results obtained for Phillip Island birds (e.g. Dann *et al.* 1992).

Hoskins *et al.* (2008) found that, while involved in chick-rearing at Rabbit Island, Little Penguins undertook foraging trips with a maximum of some 18 kilometres away from the colony. These were generally to the northwest, particularly around the entrance to Corner Inlet. There appeared to be a selection for a restricted range of sea surface temperatures, perhaps reflecting localised prey distribution (Hoskins *et al.* 2008). Short-range dispersal when breeding has been found in previous studies but foraging may be extended when resources are low; however, outside this period they may disperse widely (Dann *et al.* 1992; Weavers 1992; Collins *et al.* 1999; Preston *et al.* 2007). Recoveries of banded birds from Rabbit Island and the Seal Island Group also showed wide-ranging movement, a dispersal, which did not necessarily increase with time.

As in other studies, causes of death were rarely noted (if indeed apparent) and, though some were involved in fishing activities or died during rehabilitation, most Little Penguins were merely reported as floating or beach-washed corpses. Starvation, associated with storms and parasites, may be a major mortality factor (Harrigan 1992; Norman *et al.* 1992). Band recovery rates in this study were relatively high for adults (c. 2% compared with 0.7% for birds at Phillip Island, Dann *et al.* 2000) and were influenced by a substantial number made between June and September 1995. Just before this period, there had been a widespread mortality of pilchards in southern Australian waters (e.g. Griffin *et al.* 1997), one previously

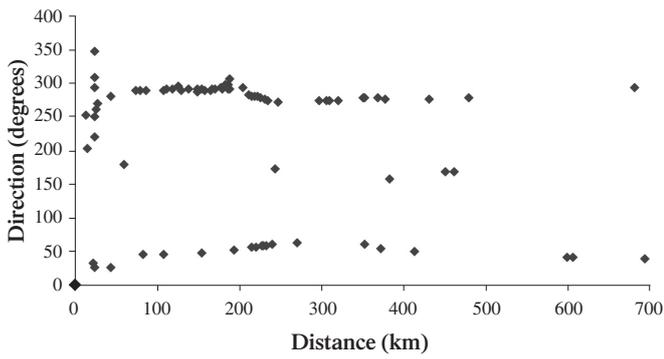


Figure 2. Distances to recovery/recapture locations (km) and direction (degrees) for adult Little Penguins *Eudyptula minor* banded at Rabbit Island, Wilsons Promontory, Victoria.

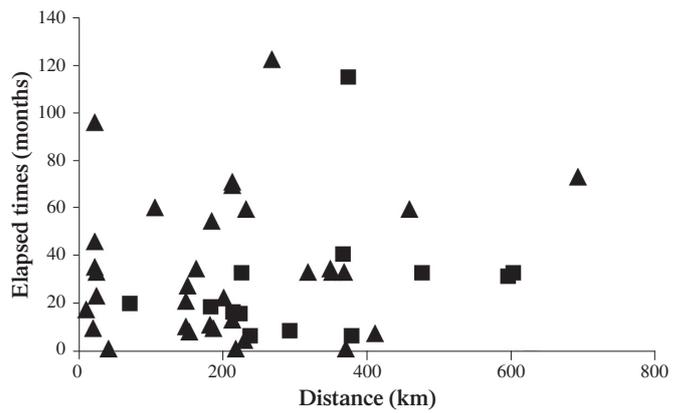


Figure 4. Distances to recovery/recapture locations (km) and elapsed time (months) for Little Penguins *Eudyptula minor* banded as adult females at Rabbit Island, Wilsons Promontory, Victoria and separated into those made within (▲) or outside breeding periods (■).

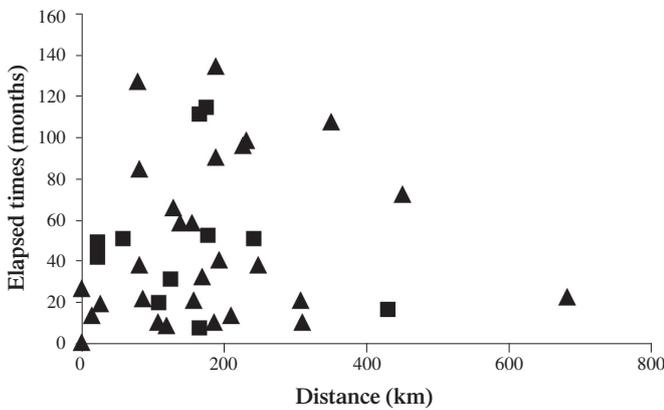


Figure 3. Distances to recovery/recaptures locations (km) and elapsed time (months) for Little Penguins *Eudyptula minor* banded as adult males at Rabbit Island, Wilsons Promontory, Victoria and separated into those made within (▲) or outside breeding periods (■).

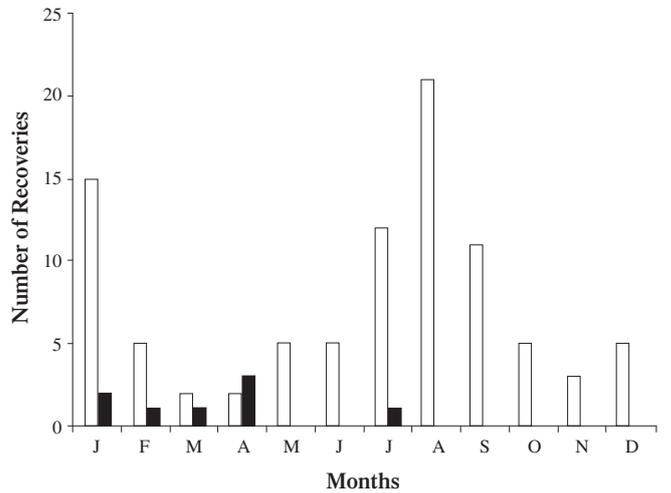


Figure 5. Months of recoveries of banded Little Penguins *Eudyptula minor* (adult □ and <1 year old ■) made away from Rabbit Island, Wilsons Promontory, Victoria.

associated with mortality and breeding failure in Little Penguins around Victoria (Dann *et al.* 2000). Following this event, band recovery rates of adult Little Penguins from various Victorian sites were three to five times higher than previously recorded (Dann *et al.* 2000). In this regard, Thoday (1995, 1997) commented on reduced numbers of Little Penguins found during visits in 1995 and 1996.

Most adult mortality recoveries were made in January or July/August, the latter period being not dissimilar to the peak at September/October for Phillip Island birds (Dann 1992). The majority of juvenile recoveries were made in the first half of the year at both Rabbit and Phillip Islands (Dann 1992).

Reilly and Cullen (1982) found that dispersal of Little Penguins banded as chicks varied between sites, with most recoveries being made to the west (from Phillip Island; see also Dann *et al.* 1992), west and north west (Chalky and

Bruny Islands, Tasmania), east and west (Port Campbell, Warrnambool), nearby or west (Gabo Island) and north and south (New South Wales). Marchant and Higgins (1990) also indicate similar, varying dispersal from these and other colonies. To some considerable extent, results from this study on Rabbit Island fit the series, with predominance in movement to the north-west but including a small number of recoveries to the east and south, and movements of birds banded in the Seal Island Group were similar. Since Bass Strait waters are nutrient poor (Gibbs 1992), perhaps dispersal patterns from all Victorian (and other) colonies are related to nutrient concentrations at or near upwellings (and hence increased productivity and prey) to the west (i.e. Bonney upwelling, Middleton and Bye 2007) and east (summer upwellings, Newell 1961; Prince 2001). Certainly this study has indicated that Bass Strait waters off the western Victorian coast are particularly important for adult and juvenile Little Penguins banded on Rabbit Island, despite the energetic costs involved in reaching them.

ACKNOWLEDGEMENTS

We are indebted to all who have banded penguins at Rabbit Island and the Seal Island Group. Clearly this note has depended on their activities in the past, on those finding banded birds and reporting the recoveries (and recaptures) to the Australian Bird and Bat Banding Schemes which, in turn, has made them available to us; we thank all involved. We are also grateful to the Department of Sustainability and Environment and Parks Victoria for permits to work on these islands and for logistical support and to Michael Scroggie (Department of Sustainability and Environment) for his assistance in developing Figure 1.

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