

# Recoveries of Little Penguins *Eudyptula minor* banded on Gabo Island, Victoria

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Received: 8 December 2017

Accepted: 2 June 2018

Between 1972 and 1987, 4902 Little Penguins *Eudyptula minor* were banded on Gabo Island, off the eastern Victorian coast; 2261 were adults and 2641 chicks. The 70 reported recoveries of dead banded birds (50 banded as chicks, 20 as adults) found away from Gabo Island are examined here. Most recoveries were of birds reported as beach-washed corpses or dead at sea. Many were to the west of the banding site, found dead along the Victorian coastline or beyond: others had moved north to the southern coast of New South Wales, whilst some birds were found in Tasmania. Whilst average distances moved from Gabo Island to the recovery location were similar for birds banded as adults or chicks (295 and 319 km, respectively), the mean elapsed time differed (39 and 8 months, respectively) and the distance moved for banded chicks was significantly correlated with elapsed time. The pattern shown by the locations of these recoveries is consistent with the view that dispersal from the breeding colony is towards areas of enhanced food availability.

## INTRODUCTION

Previous studies based on recoveries (birds found dead) of flipper-banded Little Penguins *Eudyptula minor* (Reilly and Cullen 1982) or on the monitoring of birds with transmitters (Hoskings *et al.* 2008) have shown that there is considerable variation in patterns of movement away from the natal or breeding colonies, including differences between age groups and in the timing of such movements (Norman *et al.* 2012). Thus, adults from Phillip Island usually make foraging trips for relatively shorter periods during breeding, whilst at other times they may remain at or near colonies, but may also leave for extended periods (Collins *et al.* 1999; McCutcheon *et al.* 2011). Most recoveries of first-year birds and adults banded at Phillip Island were to the west, and adults often died within Port Phillip Bay in the June – September period (Dann *et al.* 1992). For Little Penguins (hereafter penguins) banded at Rabbit Island on the eastern coast of Wilsons Promontory, most recoveries were made to the west, usually within 400 km, although some were in New South Wales (NSW) and northern Tasmania (Norman *et al.* 2012). In contrast, penguins banded at colonies in western Victoria were usually recovered relatively close to their banding sites (Norman *et al.* 2017).

Causes of death of recovered penguins are rarely known. Certainly, starvation may cause mortalities, associated perhaps with storms and parasites (e.g. Harrigan 1992). Thus the 1986 ‘wreck’ of penguins on the western coast of Victoria after a storm involved birds banded at several sites (Norman *et al.* 1992). The die-off of sardines *Sardinax sagax* in 1995 caused increased mortalities of penguins banded around Wilsons Promontory (Norman *et al.* 2012), and affected breeding success and survival at Phillip Island (Dann *et al.* 2000). However, there was no increased mortality for birds banded at western Victorian colonies during this period (Norman *et*

*al.* 2017). Whilst younger (non-breeding) penguins usually die at sea, adult penguins may sometimes be found dead on land, such deaths often resulting from predation (Dann 1992). Small numbers may also be involved as bycatch in inshore fisheries (Norman 2000; Crawford *et al.* 2017). Here we examine the spatial and temporal distributions of penguins banded at Gabo Island, Victoria and subsequently recovered (found dead) away from the island. We summarise the distance, direction and elapsed times for the recovered birds and indicate causes of death when recorded.

## METHODS

### Study area

A granite-based island off the eastern coast of Victoria, Gabo Island (37°33'S, 149°5'E) occupies some 154 ha and rises to 50 m (Reilly 1977; Twyford *et al.* 2000). Whilst the island's vegetation is thought to have been dramatically altered since European settlement in response to changes in fire regimes and the introduction of grazing animals and pasture grasses, much of it (126.5 ha) remains vegetated (Fullagar *et al.* 1995). Gillham (1961) noted halophytes around the southern coast and low sand dunes around the north coast, an area extensively used by penguins; a complex herbland grades into scrub, including shrubs (e.g. *Acacia suaveolens*, *Banksia marginata*) and trees (e.g. *Acacia longifolia*, *Banksia integrifolia*), whilst coarse grasses and sedges occurred in wetter areas. Gillham (1962) considered that the ‘main’ section of the penguin colony on Gabo Island was in sand hills stabilised by *Carpobrotus rossii* and Buffalo Grass *Stenotaphrum secundatum*. Fullagar *et al.* (2008) described a general flora over the entire island as consisting of grass, sedge or heath, scattered shrubs and a *Banksia* – *Leptospermum* low forest. Earlier Reilly (1977) indicated that there were four main vegetation types: (1) a coastal fringe, (2) shrubland dominated by *Leptospermum*

*laevigatum*, including heathland, swamps and fern gullies, (3) sparsely vegetated dunes, and (4) grasslands. Twyford *et al.* (2000) also recorded open sedgeland in the south, with pastures (dominated by Kikuyu Grass *Pennisetum clandestinum* and *S. secundatum*) maintained by cattle in other areas.

Gillham (1961) suggested that 'many thousands of penguins' bred on Gabo Island and later Reilly (1977) estimated that there were some 20 – 50 000 breeding pairs (varying seasonally) 'scattered over most of the island except in sown pastures, bogs and rocky areas.' However, by the 1977/78 breeding period, the estimated population was substantially less (Reilly and Kerle 1978), with Harris and Norman (1981) providing an estimate of 5 000 to 10 000 burrows in late 1978. Fullagar *et al.* (2006), who surveyed colonies on the island in late 1994, considered that there were c. 16 500 pairs, and Hemming (2009) estimated that there were 11 282 occupied burrows and 12 970 – 28 702 active and occupied nests. Cats *Felis catus* have been implicated in population declines on the island, but have now been eliminated (Twyford *et al.* 2000).

### Banding

At Gabo Island, Little Penguins were banded using 'flipper tags' provided by the Australian Bird and Bat Banding Scheme (ABBBS). Whilst some adults were caught at night away from burrows, chicks (considered older than six weeks) and other adults were removed from burrows for marking. As in previous studies, adult penguins were sexed using bill measurements (see Arnould *et al.* 2004), the extent of female cloacal distension, or by acceptance of the gender of their previously processed partners. The breeding status of marked birds was rarely determined and has not been considered further.

Analyses relating to banding totals, distance from banding site and elapsed time to recovery were made using a database maintained by Phillip Island Nature Parks (PINP). The non-parametric Kendall Tau b correlation coefficients (useful for small sample sizes) were obtained using SAS software (SAS 1989).

### Recoveries

Here we consider recoveries of penguins banded at Gabo Island and subsequently found dead away from the island and reported to the ABBBS. We have not examined details for birds recaptured (re-trapped) on Gabo Island or recoveries made on the island itself. Recovery details, including distances and directions from the banding site and the time elapsed since banding (proportions of months are calculated where appropriate), were provided by ABBBS and are summarised here, with means, standard deviations, ranges and sample sizes being indicated. Observers reporting recoveries rarely stated causes of death. For some analyses below, it has been considered that the breeding periods on Gabo Island resemble those at Phillip Island, where most egg-laying occurs between September and November and chicks fledge from December onwards (Dann *et al.* 2000). Hence, we consider that a breeding period extends from August to February, although it is accepted that local food resources may moderate its timing (e.g. Cullen *et al.* 1992). The resources themselves are presumably influenced by the extent of the Bonney Upwelling to the west, subsequent water temperatures, and larger scale climatic events (Berlincourt and Arnould 2015).

## RESULTS

### Banding

In general, Little Penguins were caught at Gabo Island during breeding periods, although some, in 1984 and 1987, were banded outside of such periods. Details of the banding totals between December 1972 and August 1987 are summarised in Table 1. In this period, 4902 penguins were banded; of these, 2641 were marked as chicks and 2261 as adults (1019 males, 856 females, 386 sex unspecified).

### Recoveries

Of the 2261 adults banded at Gabo Island, 20 (0.9%) have subsequently been recovered away from the island. Fifty, 1.9% of 2641 penguins banded as chicks, were similarly recovered away from the island. Most (67 or 95.7%) of the 70 recoveries of adults and chicks were reported as found dead at sea or as beach-washed carcasses. In one other instance, only the band was found and two recoveries involved birds reported as 'found dead'. In addition to these recoveries, one penguin was recorded as being exhausted near Georgetown, Tasmania (480 km southwest) three months after banding. Three others were taken into rehabilitation; of these, one died 16 days after banding (at Pambula, 71 km north), another (oiled, four months after banding) was released after treatment (at Port MacDonnell in South Australia, 810 km west) and one was rehabilitated at Towradgi Beach in NSW (29 months after banding, 380 km north-north east).

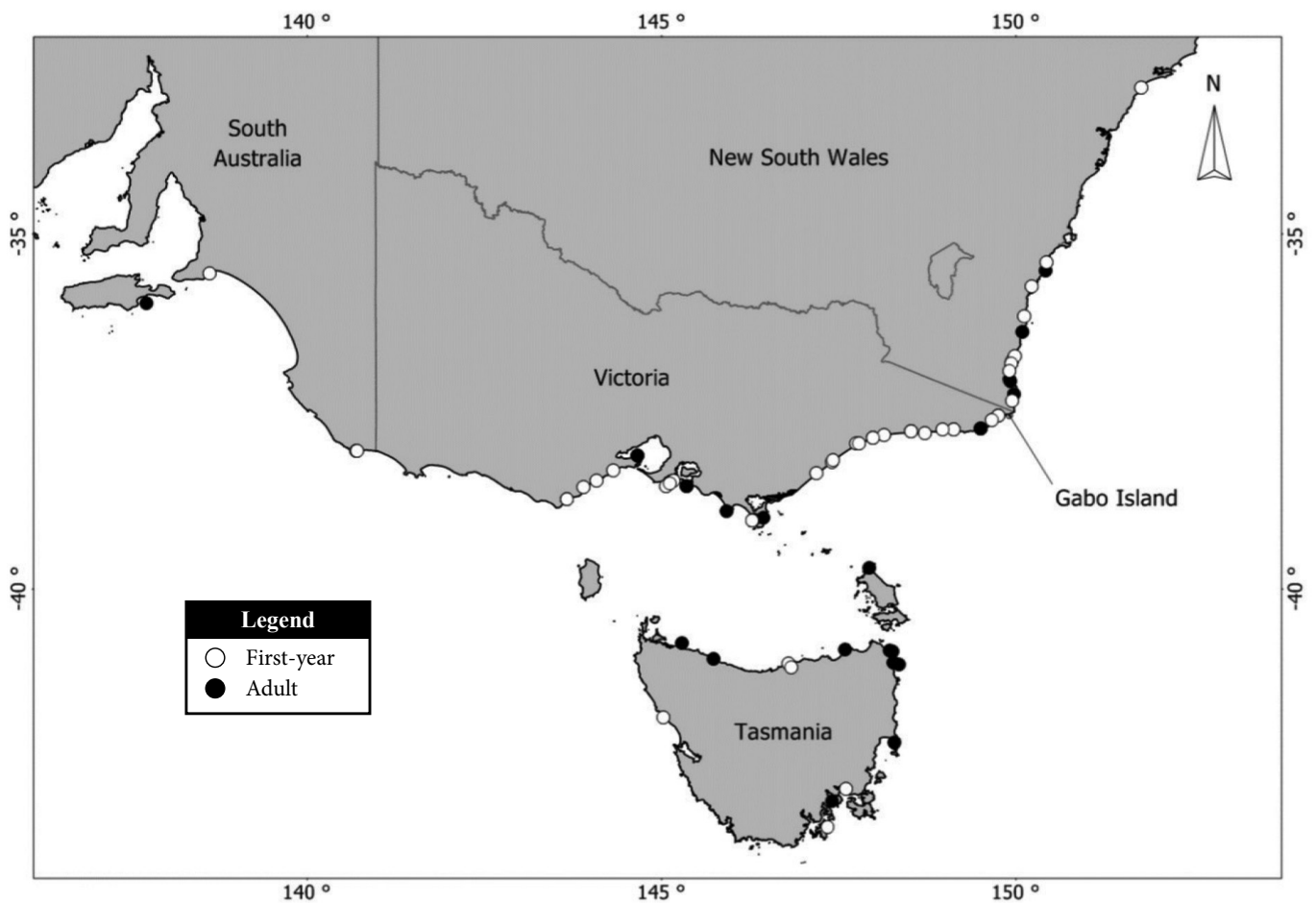
The locations of the recoveries of penguins banded at Gabo Island are shown in Figure 1. In general, most movements (as reflected by recoveries) were made within the south – west quadrant (56 penguins or 80% of recoveries) or to the north (13 or 18.6%). Many recoveries were made along the coast of eastern Victoria or southern NSW; smaller numbers were found on the northern coast of Tasmania or in the Hobart area. Whilst some birds were found close to the banding site, others clearly dispersed considerable distances. Thus, one penguin, marked as a chick, was found dead on Kangaroo Island, South Australia, almost 11 years post-banding, having moved 1099 km; another was recovered nearby, at Victor Harbour (1030 km, 7 months post-banding). For the 20 recoveries of penguins banded as adults, the mean distance to recovery points was  $295 \text{ km} \pm \text{sd. } 197.6$ , range 13–540) and the elapsed time averaged  $38.97 \pm 25.8$  months (range 2–84,  $n=19$ ). Many (8 or 40%) of the adults were recovered within 250 km of Gabo Island. In comparison, distances travelled by 50 recovered birds banded as chicks averaged  $319 \pm 267$  km (range 13–1099) and the mean elapsed time was  $8.1 \pm 19.6$  months (range 0.1–130.7). About half (54%) of the recoveries of birds banded as chicks were made within 250 km of the banding site, but of note was the large number (12 or 24%) recovered more than 500 km away compared with the smaller comparable total (3 or 15%) for adults. The recoveries of birds banded as adults showed no significant relationship between distance from banding site and elapsed time to reach the recovery location ( $\tau_b = -0.423$ ,  $p=0.068$ ,  $n=19$ ), but for those banded as chicks the correlation was positive and significant ( $\tau_b = 0.361$ ,  $p=0.0003$ ,  $n= 50$ ).

Recoveries of penguins, whether banded as chicks or adults, occurred throughout the year. However, 44 of the 70 recoveries (62.9%) were made between January and April, including 14

**Table 1**

Banding totals for Little Penguins *Eudyptula minor* on Gabo Island, Victoria, 1971-1987. Details within square brackets are from outside breeding periods

Banding period	Adults			Chicks	Total
	Unspecified	Male	Female		
1972 (December)	57		1	50	108
1975 (December)				71	71
1977 (January)				420	420
1977 (December) to 1978 (January)				5	5
1979 (January)				566	566
1979 (December) to 1980 (February)		10	11	8	29
1980 (November) to 1981 (January)				280	280
1982 (January)	273	41	41	615	970
1983 (January)	7	229	125	297	658
1983 (November) to 1984 (January)	17	352	271	101	741
1984 [April to July]	3	53	59		115
1984 (August)	14	1			15
1985 (January)		184	155	151	490
1986 (December) to 1987 (January)	3	110	144	77	334
1987 [May to July]	12	35	46		93
1987 (August)		4	3		7
<b>Totals</b>	<b>386</b>	<b>1019</b>	<b>856</b>	<b>2641</b>	<b>4902</b>



**Figure 1.** Locations of recoveries of Little Penguins banded at Gabo Island, Victoria. Distinction is made between birds banded as adults (>1 years old; solid circles) and those marked as chicks and recovered in their first year (open circles).

(70%) of the 20 adults. Further, 30 (60% of 50) birds banded as chicks were found in this period. Although the numbers involved were usually small ( $\geq 2\%$  of those banded in the preceding breeding period), the recovery rate in the January – April period after the 1982-1983 breeding period was somewhat higher (4.4%). For those chicks recovered immediately post-fledging ( $\geq 1$  month post-banding;  $n=24$ ), the mean distance to point of recovery was  $162 \pm 133.7$  km (range 13–570), considerably less than the average for banded chicks recovered later ( $483.8$  km  $\pm 277.7$ , range 42–1099,  $n=20$ ). Recoveries of adults (13 or 65%) made in the assumed breeding period (August – February) were at a mean distance of  $239.9 \pm 193.9$  km (range 13–526,  $n=13$ ), with a mean elapsed time of  $44.9 \pm 22.9$  months (range 6.5–84,  $n=12$ ), whereas corresponding data for those recovered outside the breeding period (March – July) were  $397.7 \pm 172.0$  km (range 7–540,  $n=7$ ) and  $29 \pm 29.3$  months (range 2–74).

## DISCUSSION

Banding activities at Gabo Island, eastern Victoria, between 1972 and 1987 resulted in the marking of 2641 chicks and 2261 adult Little Penguins. Of these, 50 (1.9%) and 20 (0.9%), respectively, were subsequently recovered away from Gabo Island, mainly along the Victorian coast to the west, with some birds found to the north along the southern NSW coast and smaller numbers to the south in Tasmania. Whilst average distances to recovery sites for chicks and adults were similar (many of the banded adults and, particularly, chicks were recovered within 250 km of Gabo Island), more banded and recovered chicks were found at distances of  $>500$  km (including two in South Australia). Distances from banding site to point of recovery for adults were greater when adults were recovered outside the assumed breeding period (August – February) rather than during it. All recoveries made to the west and north of Gabo Island were of birds moving against the generally prevailing currents (see Gibbs 1992); for penguins recovered beyond Wilsons Promontory, distances travelled to recovery points were presumably greater than calculated, as apparently was the case for recovered penguins banded at Rabbit Island, Wilsons Promontory (Norman *et al.* 2012).

Previous studies of movement indicated by recoveries of penguins banded at Victorian breeding sites have shown variations among sites. Chicks banded at Phillip Island tended to move westwards along the Victorian coast (Reilly and Cullen 1982; Dann *et al.* 1992) and those marked at Rabbit Island also moved to the west (as far as South Australia), but birds were also reported from northern Tasmania and NSW (Norman *et al.* 2012). In contrast, penguins banded as chicks at sites in western Victoria usually moved relatively short distances, but again often to the west and east (Reilly and Cullen 1982, Norman *et al.* 2017), whereas chicks banded at Tasmanian sites tended to move to the west and northwest and those banded in NSW moved both north and south (Reilly and Cullen 1982).

Recovered penguins were usually reported as floating or beach-washed corpses, and the causes of death were not obvious, as in previous studies (e.g. Norman *et al.* 2012, 2017). No temporal concentration of recoveries was apparent for the period of this study. Certainly, there were no ‘wrecks’ involving large numbers of banded birds (cf. that off western Victoria in

1986 involving post-fledging penguins, Norman *et al.* 1992) from Gabo Island, nor were concentrations of adult carcasses reported (cf. Port Phillip Bay in 1984 and 1985, Harrigan 1992). Further, apart perhaps from those fledging in 1982-1983, there was no obvious and major post-fledging mortality.

In general, the waters of Bass Strait are nutrient-poor, as are intrusions from the East Australia current, but they may be influenced by the incidence of richer subantarctic waters (Gibbs 1992). These water masses presumably influence foraging patterns during both the breeding and non-breeding periods. Norman *et al.* (2012) suggested that dispersal of penguins from Victorian sites was related to nutrient concentrations (from upwellings and the associated increased productivity and food resources) and that the Bonney Upwelling’s influence could extend to waters east of Portland (Norman *et al.* 2017). More recently, Berlincourt and Arnould (2015) suggested that the consequences of the Bonney Upwelling affected penguins breeding at Gabo Island, where foraging during the guard and post-guard periods was centred to the southwest of the island. Foraging location and frequency may be influenced by resource availability, itself reflecting prey and nutrient distribution, and there is some suggestion that increased mortalities and breeding failure occur at Gabo Island (and Phillip Island) resulting from a lack of food (Norman *et al.* 1996). Indeed, in penguins, almost 50% of the inter-annual variation in body mass and breeding success can be attributed to variation in the east-west sea temperature gradient (Mickelson *et al.* 1992). Food shortages may result in reduced breeding success, and ultimately affect population size (e.g. Dann and Norman 2006). In the various studies involving recoveries of banded penguins, it appears that movement differs among sites. Norman *et al.* (2012) suggested that birds from western and southern sites tended to move to the western coasts of Victoria and South Australia, whereas those from eastern sites moved north and south. For the birds banded on and recovered from Gabo Island, movement tended to be westerly, although some birds were found in Tasmania and along the NSW coast. Presumably such movements reflect dispersal to, or foraging in, areas with enhanced food availability.

## ACKNOWLEDGEMENTS

We are indebted to those (particularly Pauline Reilly, David Hollands and Ron Thoday, together with other members of the Penguin Study Group) who have banded Little Penguins on Gabo Island, Victoria. We also acknowledge the trouble taken by those finding marked penguins and reporting their demise to the ABBBS. We are grateful too to officers of the ABBBS for assistance in clarifying some data issues. Linda Watson of Monash University kindly conducted the statistical analyses. The banding was conducted under permits granted by the Victorian Department of Environment, Land, Water and Planning and the ABBBS.

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