

# The Tasman Masked Booby *Sula dactylatra tasmani* of Nepean and Phillip Islands in the Norfolk Island Group

Peter Coyne<sup>1</sup>, Beryl Evans<sup>2</sup>, Owen Evans and Honey McCoy<sup>3</sup>

<sup>1</sup>PO Box 3296, Belconnen DC ACT 2617, Australia

<sup>2</sup>PO Box 305, Norfolk Island 2899, South Pacific

<sup>3</sup>PO Box 56, Norfolk Island 2899, South Pacific

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Tasman Masked Booby *Sula dactylatra tasmani* pulli were banded in breeding colonies on two islands five kilometres apart in the Norfolk Island Group from 1975 to 2010: 7755 young were banded on Nepean Island and 3372 on Phillip Island. The number of pulli banded was used to estimate colony size for Nepean Island. The size of this breeding colony in the early years of the study was greater than all previously published estimates. However, colony size declined towards the end of the study. Of the pulli banded on Nepean Island, 1490 individuals were recaptured a total of 2085 times. Within the Norfolk Island Group breeding adults appeared mainly faithful to their natal colonies. While non-breeding birds from Nepean Island used Phillip Island as a roost, the reverse was less common. Thirty-two individuals banded on Nepean Island were recovered away from the Norfolk Island Group. The range of these Norfolk Island birds was found to overlap those of this subspecies from other breeding sites and that of the subspecies *S. d. personata*.

## INTRODUCTION

The supposedly extinct Tasman Booby *Sula tasmani* was described in 1988 from subfossil remains from Lord Howe and Norfolk Islands (van Tets *et al.* 1988). O'Brien and Davies (1990) recognised the extant Masked Boobies of Lord Howe, the Kermadecs and Norfolk Island as a subspecies of *Sula dactylatra* which they named *S. d. fullagari*. Holdaway and Anderson (2001) considered *Sula tasmani* to be that subspecies, with the name *Sula dactylatra tasmani* taking precedence over that of the recognised living subspecies. Steeves *et al.* (2010) confirmed the extant Masked Boobies of these islands were the same as the 'extinct' Tasman Masked Boobies. They showed that the fossil and modern boobies have identical mitochondrial DNA sequences, and overlapping morphometric characteristics. Furthermore, Tasman Masked Boobies were shown to be genetically isolated from Masked Booby colonies elsewhere in the Indo-Pacific (Steeves *et al.* 2010; Ismar *et al.* 2010). It is therefore of interest to examine the extent to which Tasman Masked Boobies from the Norfolk Island Group disperse throughout this region of the globe.

The Tasman Masked Booby *Sula dactylatra tasmani* breeds in the Lord Howe, Kermadec and Norfolk Island groups (Ismar *et al.* 2010), although its numbers and distribution have probably varied greatly in recent historical times. It was reported that in 1788 the species bred at Lord Howe Island in the thousands but that it was harvested quite intensively by the crews of ships which visited Lord Howe specifically to obtain fresh wild food (Garnett *et al.* 2011; Anon 1789). The most recent estimate of the population at Lord Howe Island, excluding Balls Pyramid, Gower Island and main island colonies, is at least 3100 pairs, based on extrapolation from 362 nests counted during December 2009 (Carlile and Priddel 2013 a, b, c, d; Carlile *et al.* 2013). In contrast, the populations of Tasman Masked Boobies on Nepean and Phillip Islands in the Norfolk Island Group have probably increased since Norfolk Island was settled in 1788. At the time of settlement, Nepean Island would have been unsuitable for

breeding Tasman Masked Boobies owing to the presence of a dense stand of Norfolk Island Pines *Araucaria heterophylla*, which was later harvested during a second convict settlement period (1825–56) (Holloway 1977). The island, in 1835, was described as 'very sterile' by Backhouse (1843). To this day Nepean Island remains treeless, providing habitat suitable for breeding Tasman Masked Boobies. Phillip Island, five kilometres from Nepean Island, has also changed dramatically since 1788; having been stripped of vegetation by feral grazing animals it has recently hosted breeding Tasman Masked Boobies exceeding some 300 pairs (Priddel *et al.* 2010).

This paper reports primarily on the Nepean Island booby colony, with some additional information for Phillip Island where relevant, given that boobies on the two islands were not mutually exclusive. Estimates of colony size for Nepean Island have been historically few as access to the island is problematic. Consequently, detailed study of the colony to obtain accurate breeding estimates and information on the dispersal of young has been difficult. The earliest published appraisal of colony size appears to have been by Tarburton (1981) who estimated 200 breeding pairs during single-day visits to Nepean Island in December 1978 and December 1979. The banding study reported here was commenced on Nepean Island in 1975 and Phillip Island in 1978 and continued on Nepean Island for some 33 years. Banding on Phillip Island is continuing. It aimed to provide information on: the number of pulli produced per year at Nepean Island as a surrogate for estimating the breeding population size there; the dispersal of birds from Nepean to Phillip Island, the nearest breeding location, and to other locations; and the dispersal of birds from Phillip Island to Nepean Island.

## METHODS

### Location Description

Nepean Island is located about 800 metres south of Norfolk Island (168°E, 29°S) and is approximately 10 hectares in area. The island is very difficult to access and traverse as it is surrounded

by 30-metre high coastal cliffs with a lack of protected landing sites. Unlike Norfolk and Phillip islands, Nepean Island is not of volcanic origin, but was formed from wind-blown sand dunes. It was originally vegetated with Norfolk Island Pines and an understorey of coarse grasses and sedge (Norfolk Island Parks and Forestry Service 2003). Following clearing in the 1820s, the vegetation now consists of salt tolerant coastal herbs and forbs such as Pigface *Carpobrotus glaucescens*, Chaff Plant *Achyranthes aspera*, Native Spinach *Tetragonia tetragonioides* and *T. implexicoma*, Native Rush *Cyperus lucidus*, Native Flax *Phormium tenax*, Coastal Fern *Asplenium difforme*, Native Couch Grass *Sporobolus virginicus* and White Oak *Lagunaria patersonia* growing to less than 2 metres high. It also includes non-native Kikuyu *Pennisetum clandestinum* and Buffalo Grass *Stenotaphrum secundatum* (Norfolk Island Parks and Forestry Service 2003). A population of the introduced House Mouse *Mus musculus* occurs on the island.

Phillip Island is situated six kilometres south of Norfolk Island. It is the second largest island in the Norfolk Island Group with an area of 190 hectares. In 1788 it was largely clad in subtropical rainforest similar to that of Norfolk Island (Coyne 2009). However by 1860 it was almost devoid of vegetation, largely due to overgrazing by introduced herbivores: European Rabbit *Oryctolagus cuniculus*, pig *Sus scrofa* and goat *Capra hircus*. The slopes and valleys of Phillip Island were significantly eroded and provided a dramatic landscape. Rabbits were the final herbivore eradicated in 1986 and there are currently no resident mammals. Phillip Island has been rapidly revegetating in recent years with a mix of native and weed species, with low forests of native White Oak or African Olive *Olea europaea* ssp. *cuspidata* and a dense mixture of ground covering species, that includes the following native species: *Achyranthes aspera*, *Wollastonia biflora*, *Cyperus lucidus*, *Phormium tenax* and *Ficinia nodosa*. Weeds include species such as *Paspalum dilatatum*, *Conyza bonariensis*, *Phytolacca octandra*, *Sonchus oleraceus* and *Gomphocarpus physocarpus* (Coyne 2010).

#### Banding and recapture

Banding on Nepean Island began in 1975 and continued until 2007 while on Phillip Island banding began in 1978 and is continuing. Trips to Nepean Island were undertaken by chartered boat only under favourable sea and weather conditions. Long gaps between suitable conditions occurred, thus preventing the banding of all chicks in some seasons. Boat charters to Nepean Island have been unavailable since 2007. Access to Phillip Island was less constrained but was still dependent on suitable weather and sea conditions.

Banding occurred systematically across Nepean Island with an attempt made to band all chicks produced each season. Banding on Phillip Island has been less complete, largely due to inaccessibility of many parts of the island. Between 1978 and 2007 the number of banding days on Nepean Island in a season ranged from 0 to 8. In most seasons banding occurred across each season such that most of the young produced in the season were banded; except in 1983–84, 1990–91 and 1993–94 when the number of trips were curtailed. Generally only pulli were banded with individually numbered alloy metal rings supplied by the Australian Bird and Bat Banding Scheme (ABBBS) and the band numbers of all recaptures were recorded. Recapture of adults was not systematic or randomised, so recapture records were obtained from opportunistic encounters with banded

adults, during the banding work of young birds, supplemented by three intense overnight surveys: 14 December 1985 on Nepean Island, 7 December 1985 and 26 December 1986 on Phillip Island. Similarly, whether a recaptured bird was breeding was not always noted so the number of birds recorded breeding is incomplete. A relatively small number of birds (93) were banded by other banders as adults, or as 'age unknown'. Where a bird was recaptured more than once on the same island during a season only the latest recapture of the season was used. If a bird was recaptured on one island and later on another during the same season, both were retained. Live recaptures of chicks on their natal island during the season in which they were banded have been ignored.

The number of breeding pairs was estimated from the number of chicks banded, corrected for the proportion of the banding season not banded (based on aggregated data across all years), and multiplied by 1.3 to allow for pairs which did not produce a chick old enough to band. The 1.3 factor is based on 22 percent failure to hatch and 49 percent failure to fledge (reported by Priddel *et al.* (2005). This factor attempts to allow for clutches which either failed to hatch or which hatched but the chicks did not survive to be banded. The proportion of chicks in a banding season not banded (due to lack of access late in the season) was less than six percent in 13 of the 17 years for which estimates are provided.

## RESULTS

Seven thousand, seven hundred and fifty-five (7755) Tasman Masked Boobies were banded on Nepean Island and 3372 on Phillip Island to 2010. Of the 7755 birds banded on Nepean Island, 56 pairs of twins and one set of triplets were recorded. Based on estimates of twins and triplets a total of 7697 nests were recorded during this study.

There were a total of 2085 recaptures of Nepean Island birds representing 1490 individual birds. The intense overnight surveys in 1985 and 1986 produced 924 recoveries. Nine hundred and thirty-four (934) recoveries were made on Nepean Island, including 13 recaptures of birds banded on Phillip and Norfolk Islands. Only 209 of these recaptures were recorded as breeding.

#### Seasonal and annual variation in banding

The breeding season was protracted on Nepean Island with young birds available for banding from July until April (Table 1). The greatest number of pulli available for banding was typically in September with a mean of 259 birds banded per day during September compared to 95 per day in August and 73 per day in October, with much lower banding rates during other months. Data pooled from across years indicates 57 percent of all the birds were banded in September. Breeding on the two islands was not synchronised, however. On Phillip Island the greatest number of young birds banded was in November (Table 1).

The number of birds banded on Nepean Island each season from 1975 to 2007, the estimated number of breeding pairs between 1978 and 1995 based on the proportion of the breeding season sampled, the number of recoveries, and the number of individual birds recovered for each season are provided in Table 2. The greatest number banded in a season was 819 in the 1980–81 season. Between 1978 and 1984 the numbers banded exceeded 350 pulli per season, while other significant bandings occurred in 1987, 1988, 1993 and 1995. From 1996 to 2007 however,

**Table 1**

The number of banding days per month on Nepean and Phillip islands, the number of Tasman Masked Booby pulli banded, the percentage of the total of birds banded in any one month, and the mean number of birds banded per day. Data were aggregated from 28 years of study for Nepean Island and 31 years for Phillip Island.

Month	Nepean Island				Phillip Island			
	No. of days	No. banded	% of birds banded	Mean no. of birds per day	No. of days	No. banded	% of birds banded	Mean no. of birds per day
July	1	32	<1	32	2	6	<1	3
August	4	379	5	95	2	28	<1	14
September	17	4410	57	259	2	2	<1	1
October	24	1758	23	73	25	471	14	18.8
November	20	731	9	37	54	1159	34	21.5
December	13	241	3	19	55	862	26	15.7
January	7	123	2	18	44	458	14	10.4
February	4	51	1	13	28	261	8	9.3
March	2	16	<1	8	9	18	<1	2
April	1	14	<1	14	2	15	<1	7.5
May	–	–	–	–	4	72	2	18
	93	7755	100		227	3372*	100	

\* Includes 20 birds banded on unknown dates

the numbers banded were low compared to earlier in the study, suggesting a general decline in the breeding population size.

Although the opportunity to recapture birds from each succeeding season declined as the program progressed, that opportunity was similar for the earlier seasons. For the 1978–79, 1979–80 and 1980–81 seasons 549, 427 and 819 birds respectively were banded. Of those, 201, 195 and 178 respectively were recaptured, about half during the three intensive overnight surveys.

#### *Recaptures in the Norfolk Island Group*

Of the birds banded on Nepean Island, 934 were recovered on Nepean Island, 1097 on Phillip Island, eight on offshore rock stacks on the north coast of Norfolk Island, 12 on Norfolk Island itself and two were recovered at sea, 10 and 16 kilometres from Norfolk Island. Only one bird was recorded breeding on Nepean Island and recaptured on Phillip Island later in the same season. Another 33 Nepean Island birds were recorded breeding on Phillip Island. The other 1063 recaptures of Nepean Island birds on Phillip Island were apparently unconnected with breeding. However, 93 percent of Phillip Island recaptures occurred in either December (74%) or February (19%), so their timing did not exclude birds which had bred on Nepean Island during the same breeding season. In contrast, movement of banded birds from Phillip to Nepean Island was rarely observed with just five birds banded on Phillip Island later recaptured on Nepean Island; one of these was recorded breeding on Nepean Island.

In general (i.e., considering both Nepean and Phillip Islands), there was a peak in the number of recaptures of birds from ages 2 to 7 years, with a maximum at 3 years (Table 3). The majority (99.2%) of birds recovered 3 years or less after banding were non-breeding birds. The youngest bird recorded breeding occurred 1 year 40 days after banding. Two other birds were found breeding two years 81 days after banding and seven birds were recorded breeding between three and four years after

banding. The greatest number of birds recorded breeding were 5–11 years old (Table 3). The oldest bird recorded breeding was found with a chick (on 4 October 1993) nearly 18 years after it had been banded (on 21 November 1975).

The age profiles of birds banded on Nepean Island and then recaptured either on Nepean and Phillip Islands were different (Figure 1). Of Nepean Island birds younger than four years old, 516 were recaptured on Phillip Island but only 76 on Nepean Island. After the age of 4, the number of recaptures on Phillip Island declined each year, whereas the greatest number of recaptures on Nepean Island was between six and eight years old. Only 33 of the 1097 Nepean birds recaptured on Phillip Island were breeding. In contrast, 919 birds banded on Nepean Island were recaptured on Nepean Island, 198 of which were recorded breeding.

#### *Recaptures away from Norfolk Island*

Thirty-two recaptures banded originally on Nepean Island occurred away from the Norfolk Island Group (Table 4). Overseas recaptures were almost all north or east of Norfolk Island. Most were northwards, with eight in New Caledonia (approximately 165° E, 21° S) and 13 in Vanuatu (approximately 168° E, 18° S); eight were eastwards, in the Kermadecs (approximately 178° E, 30° S); and two were north-east — one each in Tonga and Fiji. One bird was recaptured to the north-west, at Price Cay in the Swains Reef area of the Great Barrier Reef (approximately 152° E, 21° S). A similar number of birds (31) originally banded on Phillip Island were recaptured to the north, northwest and east of Norfolk Island (Priddel *et al.* 2010; Table 4). No movements from Phillip Island were recorded to Fiji or Tonga.

## DISCUSSION

O'Brien and Davies (1990) reported that no detailed breeding study of Masked Boobies had been undertaken at Lord Howe Island, the Kermadecs or Norfolk Island. However this has been partially redressed by a detailed study in 2001–02 of

**Table 2**

Seasonal break-down of the Tasman Masked Booby pulli banded on Nepean Island, estimated number of breeding pairs (1978–1995), recoveries of birds banded in each season (multiple recoveries and also individual birds) and the number of individuals recovered on both Nepean and Phillip Islands. Recoveries in each season are also listed.

Banding Season	No. of banding days	No. banded on Nepean Island	Estimated No. of pairs	No. recoveries	No. of individual birds recovered	No. of birds recovered in each season
1975	1	100		49	29	0
1976	1	20		19	10	0
1977	2	168		91	58	0
1978	6	549	710	285	201	7
1979	5	427	560	337	195	3
1980	6	819	1090	271	178	34
1981	3	479	630	109	88	61
1982	5	665	880	282	192	116
1983	1	353	1020	160	127	20
1984	3	628	840	211	166	54
1985	6	111	140	17	14	604
1986	5	193	250	17	16	434
1987	3	490	640	76	64	83
1988	3	718	990	104	96	37
1989	2	100	140	9	9	11
1990	2	62	270	2	2	198
1991	3	202	270	25	25	243
1992	1	115	200	1	1	2
1993	3	525	1000	4	4	142
1995	5	431	600	5	5	0
1996	4	46		2	1	0
1997	0	0				1
1999	0	0				2
2000	2	57		1	1	1
2001	4	140		2	2	1
2002	4	48		1	1	0
2003	1	129		1	1	1
2004	8	104		4	4	1
2005	3	41		0	0	5
2006	0	0				3
2007	1	35		0	0	1
2008		0				7
2009		0				12
2011		0				1
Total	93	7755		2085	1490	2085

**Table 3**

Number of Tasman Masked Booby pulli banded on Nepean Island and recaptured on both Nepean and Phillip Islands, those that were reported breeding and the percentage reported breeding at each age.

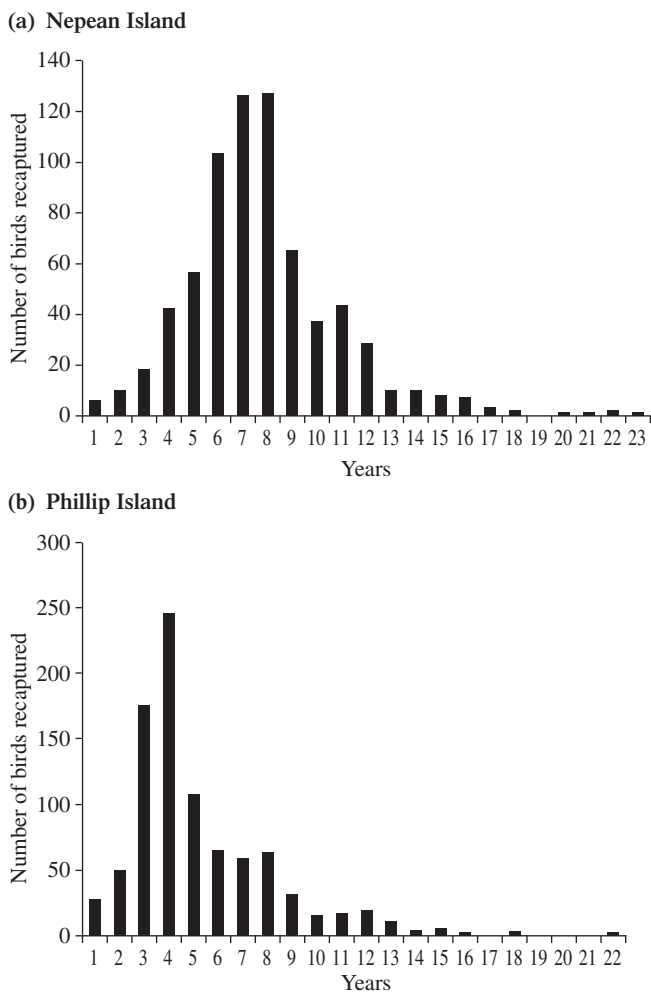
Age	Number recaptured	Number Breeding	% of birds breeding
0	59		
1	72	1	1.4
2	201	2	1
3	306	7	2.3
4	196	11	5.6
5	192	17	8.9
6	209	25	12
7	231	17	7.4
8	132	19	14.4
9	74	13	17.6
10	80	23	28.8
11	72	20	27.8
12	31	4	12.9
13	26	13	50
14	18	7	38.9
15	14	7	50
16	5	0	0
17	7	1	14.3
18	0	0	
19	1	0	
20	1	0	
21	5	0	
22	1	0	
24	1	0	
	1934	187	

**Table 4**

Numbers of Tasman Masked Booby recaptured at locations remote from Norfolk Island following banding as pulli on Nepean and Phillip islands.

Recovery location	Nepean Island	Phillip Island (after Priddel et al. 2010)	Combined
Fraser Island	0	1	1
Middleton Reef	0	1	1
Swains Reef	1	3	4
New Caledonia	8	4	12
Vanuatu	13	17	30
Fiji	1	0	1
Tonga	1	0	1
Kermadecs	8	5	13





**Figure 1.** Frequency distribution by age of the number of birds banded on Nepean Island and subsequently first recaptured on (a) Nepean Island and (b) Phillip Island.

the breeding biology of a colony of Masked Booby (Tasman Masked Booby) on Mutton Bird Point, Lord Howe Island (Priddel *et al.* 2005). Hermes *et al.* (1986) have also listed the number of Tasman Masked Boobies banded on Nepean Island each year from 1977 to 1985, in addition to citing dates for eggs, chicks and fledging on Phillip Island.

#### Size of the Nepean Island colony

Simmons (1973) commented that the breeding biology of boobies requires long-term observation because of substantial variation from year to year. Published estimates of the population of Tasman Masked Boobies on Nepean Island have been remarkably consistent at either 200 pairs or 200 birds (Tarburton 1981; Fitzherbert 1986; Garnett and Crowley 2000; SPRAT 2013). The earliest estimate for Nepean Island appears to have been by Tarburton (1981) who stated the population was 200 breeding pairs, based on observations during one-day visits to the island in December 1978 and December 1979. However 549 and 427 chicks were banded on Nepean Island in the 1978 and 1979 breeding seasons respectively, during the study described here. The pronounced peak in chick numbers in September, coupled with the long period to fledging, indicates pairs cannot raise more than one brood per breeding season. Consequently the population of breeding birds in these years,

estimated in this study as 710 and 560 breeding pairs in 1978 and 1979, was considerably greater than the 200 pairs reported by Tarburton (1981). Furthermore the 819 birds banded in 1980 suggests that the breeding population was considerably higher (estimate 1090 breeding pairs) in this peak season (Table 2). Even if these estimates of breeding pairs are reduced slightly because of the occurrence of twins from some broods and because the multiplier could be inaccurate, the population numbers are substantially higher than any previously published estimates, with estimates of more than 500 breeding pairs in 11 years between 1978 and 1995. This study has confirmed substantial variation in breeding numbers from year to year.

#### Timing of Breeding

The timing of breeding seasons of Masked Booby varies widely throughout their range (Mansoor 2004). Hull (1910 in van Tets *et al.* 1988) suggested that breeding at Lord Howe Island occurred from September to January with most eggs laid during October, while in 2001 eggs were laid between 31 May and 15 September (Priddel *et al.* 2005). At Phillip Island, eggs have been laid from early July (Priddel *et al.* 2010). The earliest banding on Nepean Island occurred in late July, suggesting a date for laying during the first three weeks of May. Numbers banded on Nepean Island reached a considerable peak in September, after which they declined until the latest banding in April. O'Brien and Davies (1990) noted that even for Nepean and Phillip Islands, just five kilometres apart, breeding was not synchronised. This study suggests that peak breeding occurs about two months earlier on Nepean Island compared to Phillip Island, being in September and November respectively, and is longer than the estimated 3–4 weeks mentioned by Priddel *et al.* (2010).

#### Recoveries

The age profile of Nepean Island birds recaptured for the first time on Phillip Island is conspicuously different from the age profile of birds first recaptured back on Nepean Island (Figure 1). On Phillip Island the highest numbers of first recapture are between two and four years old, whereas the peak numbers on Nepean Island were between five and eight years old. Consequently the great majority (87%) of Nepean Island birds younger than four years old were recaptured on Phillip Island. More Nepean Island birds were recaptured on Phillip Island than on Nepean Island. Phillip Island birds do not display any similar inclination to settle on Nepean Island. Of the 1097 Nepean Island birds recaptured on Phillip Island only three percent were recorded breeding whereas 22 percent of the 919 birds recaptured on Nepean Island were recorded as breeding. These data suggest that Phillip Island is used by non-breeding birds from both Nepean and Phillip Islands as a roosting site as well as being the main breeding site for Phillip Island birds. The non-breeding colony on Phillip Island has not been observed in recent years (HMcC, pers. obs. 2014). Most of the birds hatched on Nepean Island appear to return to that island to breed, while birds hatched on Phillip Island rarely roost or breed on Nepean Island. This suggests that the populations of Nepean and Phillip Islands, although intermixing, generally remain separate. This is consistent with a report by Jones *et al.* (2005) that large numbers of non-breeding birds roost on Frigate Cay (in the Swain Reefs, Great Barrier Reef) in summer instead of being equally distributed between that and nearby Price Cay.

The oldest bird recovered in this study, 24 years and 300 days after it was banded, was recaptured in New Caledonia and released alive. This appears to be the oldest Australian

record for a Masked Booby *Sula dactylatra* of any subspecies. A record of a Masked Booby banded in Oceania and released alive after recapture at the age of 25 years and three months, and a record of a Brown Booby *Sula leucogaster*, banded after its hatching year, which was shot 26 years and two months later (US Geological Survey 2013), suggests this is not extraordinary. These ages are considerably younger than the oldest recorded recovery of a Northern Gannet *Morus bassanus* at 34 years and four months (British Trust for Ornithology 2012).

Based on recoveries away from Norfolk Island it appears there is little difference between the dispersal of birds from Nepean and Phillip Islands. Most of the long distance recoveries came from Vanuatu, but there was considerable dispersal of birds north and east. In comparison, Priddel *et al.* (2010) found that Phillip Island recoveries were spread more widely, both west and south, although recaptures were still most concentrated in Vanuatu.

This project has shown considerable overlap between the ranges of populations of Tasman Masked Boobies from different islands across the Pacific Ocean. However the data suggest that there may be little mixing between breeding islands, particularly for Norfolk Island. High levels of natal philopatry may contribute to sub-speciation in this booby.

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