

RECOVERIES OF SEABIRDS Banded BETWEEN 1978 AND 1987 AT RAINE ISLAND, MACLENNAN AND MOULTER CAYS AND SANDBANKS No. 7 AND 8, NORTHERN GREAT BARRIER REEF, AUSTRALIA

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From 1979 to 1987, 7 080 birds, representing 17 species, were banded at Raine Island, and from 1979 to 1985, 849 birds, representing 3 species, were banded at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8. Almost half (45.5%, $n = 3\,609$) of the 7 929 birds were banded as adults; 20.6 per cent ($n = 1\,634$) were as chicks, 15 per cent ($n = 1\,223$) as pullus and 11 per cent ($n = 881$) as juveniles. Of the 7 929 banded birds, 1 096 (14%) were recaptured in subsequent surveys to the banding locations; 107 (1%) birds were recaptured away from their banding locations. Distances travelled ranged from 100 kilometres (Wallace Island) to 4 000 kilometres (Tuvalu); countries included: Australia (12), Caroline Islands (1), Indonesia (2), Kiribati (1), Papua New Guinea (87), Solomon Islands (2), and Tuvalu (2). The fates of the 107 birds recovered away from these banding locations were: 22 captured and released alive, 26 dead, 4 entangled in fishing line or hooks, 4 predated by: crocodiles (2), eagle (1) or large fish (1); 25 trapped for food, captivity or ceremonial purposes, and 26 unknown.

INTRODUCTION

Between 1844 and December 1982, 44 bird species were recorded at Raine Island (King 1983). Warham (1961) provided the first comprehensive list of birds at Raine Island and the surrounding islands. Warham (1977) also wrote the initial paper for the inclusion of Raine Island as a Seabird Island. In that publication, 11 bird species had been recorded breeding at the island. King (1986) published a revision to Warham's 1977 seabird island paper, providing information on three additional breeding species that had been noted and a banding programme that had been established.

Raine Island in the northern Great Barrier Reef has been the site for detailed studies of seabird and sea turtle populations since 1979 (Limpus *et al.* 2003; Batianoff and Cornelius 2005). Banding birds at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 began in 1979 and continued until 1985. In subsequent years, recaptures of banded birds back at the banding locations and from overseas have occurred.

Banding seabirds can potentially provide information on population structure, migration patterns, remigration intervals, fidelity to particular islands and mates, and movements to feeding and breeding areas, which is the focus of this paper. King (1986) briefly summarized this information in his revision of Raine Island as a Seabird Island. Brief summaries of band recoveries have been provided in annual reports to the Raine Island Corporation (Miller 1991, 1992, 1993, 1995) and other information passed by Brian King, former Project Leader for seabird studies at Raine Island (Limpus and Gyuris 1987). The objective of this project was to collate the seabird band recovery information collected up to 1998 and to review movement patterns.

STUDY LOCATIONS

Detailed descriptions of the five banding locations can be found in Barry and Rayment (1992), Gourlay and Hacker (1991), Lavery *et al.* (1980), King *et al.* (1983a,b,c), King and Limpus (1983), Spratt and Associates (1994) and Stoddart *et al.* (1981).

METHODS

Band recovery reports were sourced from the Australian Bird and Bat Banding Scheme (ABBBS), field notes from researchers, banding and live recovery schedules submitted to the ABBBS, band numbers recorded in Queensland Parks and Wildlife Service (QPWS) reports to the Raine Island Corporation, and Recovery Round-up information in issues of *Corella*.

For the purposes of this study, definitions of age classes follow those provided by the ABBBS and classifications used in the banding databases. All chicks, whether they were classified as small fluffy or large fluffy were classified as chicks for ease of grouping. Other definitions were used as follows: Pullus = a young bird, either in the nest or out of the nest which, although it may be fledged, is not yet able to fly; Juvenile = a young bird in juvenile plumage, which has left the nest site and is able to fly, $n+$ = a bird within its n th year of life or older (i.e. it is a free-flying bird of unknown age).

The numbers presented in this report were developed from a master database of all Raine Island, Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 banded birds held by the QPWS. Banding details from the ABBBS were then compared with the QPWS dataset. Where discrepancies were found between datasets, the QPWS database was used to generate values presented herein.

So as not to pre-empt the results of an on-going study, only recapture information about Red-tailed Tropicbirds banded prior to the commencement of the study in 1995 are presented.

RESULTS

Banding history

Seven thousand and eighty birds were banded at Raine Island during the period 1979 to 1987, comprising 17 species (Table 1a). Nearly 30 per cent of the banding ($n = 2\,109$ birds) occurred in 1981, although not all species

were banded in each year. Most banding occurred on three species, Brown Booby *Sula leucogaster* (27.5%, $n = 1\ 947$), Masked Booby *Sula dactylatra* (28.3%, $n = 2\ 007$) and Red-tailed Tropicbirds *Phaethon rubricauda* (12.1%, $n = 860$). Other species were banded only when time permitted or when circumstances were appropriate.

A total of 849 birds were banded at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8, comprising three species (Table 1b): Brown Booby (84.8%, $n = 720$), Masked Booby (6.4%, $n = 54$) and Sooty Tern *Sterna fuscata* (8.8%, $n = 75$).

Twenty-five birds that were banded and subsequently recaptured at Raine Island, but for which no information could be found regarding their original banding date were designated 'R?' in the database. In the absence of being able to further clarify original banding dates, the recapture dates were treated as banding dates and as recaptures at the same time.

One band number '110 88721' had more than one species associated with the number in the database and further examination of the data could not resolve the species identification. The band was listed as being applied

TABLE 1

Number of birds banded at (a) Raine Island between 1979 and 1987 and (b) Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 between 1979 and 1985. Species: BB = Brown Booby; BBR = Buff-banded Rail; BN = Black Noddy; BNT = Black-naped Tern; BT = Bridled Tern; CN = Common Noddy; CT = Crested Tern; GFB = Great Frigatebird; HP = Herald Petrel; LFB = Lesser Frigatebird; MB = Masked Booby; NNH = Nankeen Night Heron; RFB = Red-footed Booby; RT = Ruddy Turnstone; RTTB = Red tailed Tropicbird; SG = Silver Gull; WTS = Wedge-tailed Shearwater.

Species	Year									Total
	1979	1980	1981	1982	1983	1984	1985	1986	1987	
BB	285	283	444	105	0	319	133	356	22	1 947
BBR	0	0	8	46	35	32	17	0	0	138
BN	0	0	111	84	0	0	0	0	0	195
BNT	0	0	0	0	0	0	5	0	0	5
BT	0	0	1	0	0	7	0	0	0	8
CN	0	0	263	122	0	24	0	0	11	420
CT	0	0	0	0	0	0	1	0	0	1
GFB	0	1	0	0	0	0	0	0	0	1
HP	0	0	3	2	8	0	0	0	0	13
LFB	0	0	163	138	0	20	0	0	0	321
MB	24	722	479	26	0	234	152	359	13	2 009
NNH	0	0	0	2	61	33	0	0	0	96
RFB	0	88	134	62	0	160	40	0	39	523
RT	0	0	0	0	10	0	0	0	0	10
RTTB	23	127	99	98	124	231	96	4	58	860
SG	0	0	0	0	3	4	0	0	2	9
WTS	0	0	404	82	0	38	0	0	0	524
Total	332	1 221	2 109	767	241	1 102	444	719	145	7 080

(b)

Location	Species			Total
Banding year	Brown Booby	Masked Booby	Sooty Tern	
Moulter Cay				
1980	102			102
1981	41	1		42
1982	124	25		149
1985	23	28		51
MacLennan Cay				
1980	14			14
1981	21			21
1982	28		75	103
Sandbank No. 7				
1981	42			42
1982	2			2
Sandbank No. 8				
1979	99			99
1981	133			133
1982	91			91
Total	720	54	75	849

to a Red-footed Booby *Sula sula* (19/6/80) and to a Nankeen Night Heron *Nycticorax caledonicus* (9/12/84). In examining the sequence of band numbers used in the studies, the band preceding '110 88721' was used to band a Red-footed Booby in 1980 and the band proceeding '110 88721' was used to band a Nankeen Night Heron in 1984. Determining which species band '110 88721' was placed on could not be further clarified; therefore, both values were kept in the database. Either the total number of Red-footed Boobies banded in 1984 or the number of Nankeen Night Herons banded in 1984 is incorrect. However, one record incorrect in either case was not considered significant for the overall presentation of these data.

The sex of 76 per cent ($n = 6\,031$) of banded birds could not be determined or was not considered essential to record at the time of banding (Table 2). However, of the 7 929 birds banded, 862 (10.8%) were identified as female and 1 036 (13.1%) were identified as male. Sex was not determined for any of the Masked Boobies banded at Moulter Cay.

Almost half (46%, $n = 3\,609$) of the 7 929 birds were banded as adults; 21 per cent ($n = 1\,634$) were chicks, 15 per cent ($n = 1\,223$) were pullus; 11 per cent ($n = 881$) were juveniles; the remaining 7 per cent were either immatures or able to be aged to a degree (Table 3). All of the adult Masked Boobies were banded at Raine Island; at Moulter Cay, Masked Boobies were banded either as chicks

TABLE 2

Sex of birds banded at Raine Island between 1979 and 1987 and at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 between 1979 and 1985.

Species	Female	Male	Unknown	Total
Brown Booby	403	551	1 713	2 667
Buff-banded Rail	0	0	138	138
Black Noddy	0	0	195	195
Black-naped Tern	0	0	5	5
Bridled Tern	0	0	8	8
Common Noddy	0	0	420	420
Crested Tern	0	0	1	1
Great Frigatebird	0	0	1	1
Herald Petrel	0	0	13	13
Lesser Frigatebird	30	41	250	321
Masked Booby	425	444	1 195	2 064
Nankeen Night Heron	0	0	96	96
Red-footed Booby	1	0	521	522
Ruddy Turnstone	0	0	10	10
Red-tailed Tropicbird	3	0	857	860
Silver Gull	0	0	9	9
Sooty Tern	0	0	75	75
Wedge-tailed Shearwater	0	0	524	524
Total	862	1 036	6 031	7 929

TABLE 3

Age classes of birds banded at Raine Island between 1979 and 1987 and Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 between 1979 and 1985. Numbers in parentheses are number of individuals recaptured back at Raine Island. Species: BB = Brown Booby; BBR = Buff-banded Rail; BN = Black Noddy; BNT = Black-naped Tern; BT = Bridled Tern; CN = Common Noddy; CT = Crested Tern; GFB = Great Frigatebird; HP = Herald Petrel; LFB = Lesser Frigatebird; MB = Masked Booby; NNH = Nankeen Night Heron; RFB = Red-footed Booby; RT = Ruddy Turnstone; RTTB = Red-tailed Tropicbird; SG = Silver Gull; ST = Sooty Tern; WTS = Wedge-tailed Shearwater.

Species	Age class									
	1+	2+	3+	4+	Chick	Immature	Pullus	Juvenile	Adult	Unknown
BB	9 (6)	0	0	0	1 077 (12)	0	554 (9)	63	961 (64)	3 (1)
BBR	53 (2)	0	0	0	0	0	1	10	74 (11)	2 (6)
BN	165 (1)	0	0	0	0	0	0	14 (2)	14	0
BNT	0	0	0	0	0	2	0	0	3	0
BT	0	0	0	0	0	0	0	0	8	0
CN	118 (2)	0	0	0	1	0	0	24	276	1
CT	0	0	0	0	0	0	0	0	1 (1)	0
GFB	0	0	0	0	0	1	0	0	0	0
HP	0	0	0	0	1	0	0	0	12 (3)	0
LFB	0	0	0	0	0	0	0	252	69	0
MB	2 (2)	0	0	0	336 (80)	1	579 (87)	93 (24)	918 (396)	135 (46)
NNH	0	0	0	0	63 (2)	0	12	20	1	0
RFB	23 (3)	0	19 (1)	0	8	19 (2)	70 (4)	136 (4)	246 (50)	1
RT	0	0	0	0	0	0	0	0	10	0
RTTB	9 (3)	9 (3)	0	1	145 (14)	0	6	192 (20)	491 (207)	7 (7)
SG	0	0	0	0	3	1	1	2	2 (1)	0
ST	0	0	0	0	0	0	0	75	0	0
WTS	0	0	0	0	0	0	0	0	523 (13)	1 (1)
Total	379 (19)	9 (3)	19 (1)	1	1 634 (108)	24 (2)	1 223 (100)	881 (50)	3 609 (746)	150 (61)

($n = 26$) or pullus ($n = 28$). Over one-third (37%) of the Brown Boobies banded at Raine Island were chicks, 33 per cent were adults, 27 per cent were pullus, 2 per cent were juveniles, less than 1 per cent were 1+ and less than 1 per cent were unknown. Collectively at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8, 48 per cent of the banded Brown Boobies were chicks, 45 per cent were adults; 3 per cent were pullus and 3 per cent were juveniles.

Time to recovery

All recaptures are detailed in Table 4. The longest time between recoveries, 17 years, was of a Masked Booby originally banded on 19 June 1980 and recaptured back at Raine Island in late January/early February 1997. The shortest time between recoveries was one day, when a Buff-banded Rail *Gallirallus philippensis* was found dead the day after being banded. The longest recovery times

have been from Boobies (Brown, Masked and Red-footed) and the Red-tailed Tropicbirds (Table 4).

Recaptures at banding locations

Twelve of the 17 species banded at Raine Island have been recaptured during subsequent surveys of the island (Table 5). The five species not recaptured were: Black-naped Tern *Sterna sumatrana* ($n = 5$), Bridled Tern *Sterna anaethetus* ($n = 8$), Great Frigatebird *Fregata minor* ($n = 1$), Lesser Frigatebird *Fregata ariel* ($n = 321$), and Ruddy Turnstone *Arenaria interpres* ($n = 10$). Up to 1994, it is not known if equal effort was placed to recapture banded birds on all 17 species. Since 1995, the only intensive effort to read band numbers at Raine Island has been the ongoing studies of Red-tailed Tropicbirds. Three Masked Boobies were recaptured at Raine Island after 1987, but no information could be found on their original banding place. These three birds have not been included in any of the year totals in Table 1; however, they are represented in the total number of birds recaptured at Raine Island.

One thousand four hundred ninety-two birds were recaptured at Raine Island between 1979 and 1997 (Table 5), representing 1 090 individuals (15% of 7 080 banded). Most of these recaptured birds were Masked Boobies (60.7%, $n = 905$) and Red-tailed Tropicbirds (23.5%, $n = 351$). The recaptures at Raine Island represented 817 birds recaptured once (81 Brown Boobies, 18 Buff Banded Rails, 3 Black Noddies *Anous minutus*, 2 Common Noddies *Anous stolidus*, 1 Crested Tern *Sterna bergii*, 2 Herald Petrels *Pterodroma arminjoniana*, 463 Masked Boobies, 2 Nankeen Night Herons, 49 Red-footed Boobies, 181 Red Tailed Tropicbirds, 1 Silver Gull *Larus novaehollandiae*, 14 Wedge Tail Shearwaters *Puffinus pacificus*); 184 twice (11 Brown Boobies, 1 Buff Banded Rail, 1 Herald Petrel, 107 Masked Boobies, 11 Red-footed Boobies, 53 Red

TABLE 4

Minimum and maximum time between banding and recovery of birds banded at Raine Island between 1979 and 1987. d = days, y = years.

Species	Range	Number of recaptures
Brown Booby	0–15.5 y	170
Buff-banded Rail	0–4 y	14
Black Noddy	251–371 d	3
Black-naped Tern	4 y	2
Common Noddy	1–6 y	5
Crested Tern	15 d	1
Herald Petrel	1–2 y	4
Masked Booby	0–17 y	922
Nankeen Night Heron	59–187 d	6
Red-footed Booby	0–14 y	102
Red-tailed Tropicbird	0–14 y	351
Wedge-tailed Shearwater	0–11 y	14
Total		1 594

TABLE 5

Recaptures of banded birds at Raine Island and recovered at Raine Island. BB = Brown Booby, BBR = Buff-banded Rail, BN = Black Noddy, CN = Common Noddy, CT = Crested Tern, HP = Herald Petrel, MB = Masked Booby, NNH = Nankeen Night Heron, RFB = Red-footed Booby, RTTB = Red-tailed Tropicbird, SG = Silver Gull, WTS = Wedge-tailed Shearwater.

Year	Species												Total
	BB	BBR	BN	CN	CT	HP	MB	NNH	RFB	RTTB	SG	WTS	
1980	3	0	0	0	0	0	55	0	1	3	0	0	62
1981	6	0	0	0	0	0	70	0	7	22	0	0	105
1982	12	8	2	0	0	0	81	0	10	34	0	12	159
1983	1	1	1	0	0	2	6	2	0	55	0	0	68
1984	22	6	0	1	0	0	94	0	32	108	0	0	264
1985	8	5	0	0	1	2	67	0	15	72	1	0	171
1986	17	0	0	0	0	0	101	0	0	1	0	0	119
1987	7	0	0	1	0	0	135	0	12	24	0	0	179
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	2	0	0	0	0	0	77	0	0	0	0	0	79
1991	4	0	0	0	0	0	83	0	0	2	0	0	88
1992	7	0	0	0	0	0	48	0	0	0	0	0	55
1993	4	0	0	0	0	0	23	0	8	11	0	2	48
1994	9	0	0	0	0	0	13	0	0	0	0	0	22
1995	1	0	0	0	0	0	0	0	0	7	0	0	8
1996	0	0	0	0	0	0	0	0	0	10	0	0	10
1997	0	0	0	0	0	0	52	0	1	2	0	0	55
Total													
recaptures	103	20	3	2	1	4	905	2	86	351	1	14	1 492
No. birds	92	19	3	2	1	3	635	2	64	254	1	14	1 090
% banded	4.7	13.8	1.5	0.5	100	23.1	31.6	2.1	12.2	29.5	11.1	2.7	15.4

Tailed Tropicbirds); 63 three times (43 Masked Boobies, 5 Red-footed Boobies, 16 Red Tailed Tropicbirds); 20 four times (16 Masked Boobies, 4 Red Tailed Tropicbirds); four Masked Boobies each recaptured five times; one Masked Booby recaptured six times, and one Masked Booby recaptured seven times. The sex of recaptured birds was only recorded at the time of banding for about half of the Brown (24% male, 36% female, 40% unknown) and Masked Boobies (27% male, 30% female, 43% unknown). Age class was recorded, usually at time of banding, for 94 per cent of the 1 090 birds recaptured at Raine Island: 68 per cent adults; 10 per cent chicks, 9 per cent pullus; 4 per cent juveniles; 1.7 per cent 1 year or older; less than 1 per cent 2 years or older; less than 1 per cent immatures and less than 1 per cent 3 years or older (Table 3).

Each of five female Brown Boobies and one unknown sex Masked Booby banded at Moulter Cay were recaptured once at Moulter Cay in subsequent surveys. No birds were recaptured at MacLennan Cay, Sandbank No. 7 or Sandbank No. 8.

Recoveries away from banding locations

Seven of 17 species banded at Raine Island and two of three species banded at Moulter Cay, MacLennan Cay, and Sandbank No. 8 have been recovered at sites other than the banding locations (Table 6). No bird banded at Sandbank No. 7 has been recovered away from that site. Four Masked Boobies originally banded at Raine Island were recaptured at Moulter Cay (87 km north, north-west of Raine Island).

Of the 7 929 birds banded, 107 (1.3%) have been recovered away from their banding place, most ($n = 87$)

in Papua New Guinea (Table 6). The elapsed time between sightings has ranged from 12 days to 15.5 years. The general trend of movements has been for the banded birds to travel north and east from their banding location, with distances covered ranging from 100 kilometres (Common Noddy recovered at Wallace Island) to 4 000 kilometres (Brown Booby recovered in Tuvalu) (Table 6). Two of the recoveries have been the longest movements recorded for the species: Brown Booby recovered in Tuvalu (4 000 km), Red-footed Booby recovered on South Island in the Willis Island Group (829 km), Coral Sea Islands Territory. Generally, Brown Boobies moved farther than the other species recovered.

The fate of the 107 birds recovered away from the northern Great Barrier Reef was not always able to be determined (Table 7). Although the ABBBS attempted to contact the band finder, this was not always possible. Twenty-two of the birds were captured and then either released alive after the band numbers had been recorded and/or the bands removed. Eleven of the 26 birds recorded dead had died from injuries or sickness. Rehabilitation was attempted on some of these birds, but was successful only once; a Brown Booby was released after it regained its health. Of the three birds entangled in fishing lines/hooks, both Brown Boobies survived, while the Masked Booby died. Two Brown Boobies were preyed upon by crocodiles, another by an eagle and a Masked Booby was consumed by a large fish. Bands from these birds were found in the stomachs of the predators. Three of the 25-trapped birds were kept for aviaries, 11 were either killed for food, their feathers or for a ceremonial purpose or died from being trapped; the fate of the remaining trapped birds was not reported.

TABLE 6

Distances and locations travelled by birds banded at Raine Island, Moulter Cay, MacLennan Cay, and Sandbank No. 8 and recovered away from those banding locations.

Species	Banding locations	Recovery locations	Distance (km)	Number of recaptures
Black-naped Tern	Raine Island	Papua New Guinea	440	1
Brown Booby	MacLennan Cay	Papua New Guinea	265–431	2
		Papua New Guinea	400–1 064	4
		Australia (Herald Island)	864	1
		East Caroline Island	2 600	1
		Indonesia	1 200	1
		Kiribati	3 505	1
		Papua New Guinea	290–1 276	42
		Solomon Islands	1 567	1
		Tuvalu	4 000	1
		Indonesia	1 968	1
	Sandbank No. 8	Papua New Guinea	480–1 380	10
		Tuvalu	3 800	1
Common Noddy	Raine Island	Australia (Cape Grenville)	100	1
		Papua New Guinea	430	1
Masked Booby	Moulter Cay	Papua New Guinea	400–1 064	2
		Australia (Bell Cay)	1 374	1
	Raine Island	Australia (Green Island)	610	1
		Papua New Guinea	353–1 002	19
		Solomon Islands	1 739	1
Nankeen Night Heron	Raine Island	Papua New Guinea	285–463	3
Red-footed Booby	Raine Island	Australia (Bramble Cay)	300	1
		Australia (Coral Sea Islands Territory)	813–829	7*
		Papua New Guinea	410–450	2
		Papua New Guinea	255	1
Red-tailed Tropicbird	Raine Island	Papua New Guinea	255	1

*Represents four Red-footed Boobies: two recaptured once, one recaptured twice, one recaptured three times.

TABLE 7

Fates of birds recovered away from Raine Island, Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8.

Species	Captured/ Released	Dead	Entangled	Predated	Trapped	Unknown	Total
Brown Booby	12	19	3	3	12	17	66
Black-naped Tern	0	1	0	0	0	0	1
Common Noddy	0	2	0	0	0	0	2
Masked Booby	2	4	1	1	9	7	24
Nankeen Night Heron	0	0	0	0	2	1	3
Red-footed Booby	7	0	0	0	2	1	10
Red-tailed Tropicbird	1	0	0	0	0	0	1
Total	22	26	4	4	25	26	107

DISCUSSION

Raine Island is one the most significant seabird-breeding sites within the Great Barrier Reef (King 1986, 1993; Ogilvie and King 1990; Taplin and Blaber 1993; Batianoff and Cornelius 2005), especially in terms of number of breeding seabird species ($n = 14$) at one location. Also, recent research indicates that the Wedge-tailed Shearwater population should be treated as a distinct management unit from the shearwater population that breed at Heron Island (Peck and Congdon 2002). There has been extensive research on the island's birds, resulting in numerous publications and reports (many unpublished Queensland Government departmental reports; Warham 1961, 1977; King 1986; Taplin and Blaber 1993; Batianoff and Cornelius 2005). Much of the information presented in the unpublished departmental reports provided only information on the band numbers and counts of birds recorded during the surveys with little discussion about the biology of the species. The bird banding information summarized in this report includes recoveries from other nations, minimum distances travelled by some birds, and the life expectancy of the bands used on the seabirds indicating their longevity.

The purpose and timing of field surveys to Raine Island, Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 have not been consistent over time; however, seabird and/or marine turtle surveys have usually figured prominently, with vegetation and invertebrate surveys and tower restoration (at Raine Island) also being investigated since the late 1970s. As a result, effort to band and recover banded birds has not been consistent over the study years and may have influenced the results reported here. For example, 18 banding trips were made to Raine Island from 1979 to 1987. These trips usually occurred in November or December, but trips also occurred in January, March, April, May, July, and August. In addition, efforts to read band numbers at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 since the 1990s has usually only involved a one to two night stopover in conjunction with marine turtle surveys. During this time, effort changed from being concentrated on reading band numbers of Boobies (Brown, Red-footed, Masked) to concentrating on Red-tailed Tropicbirds only at Raine Island. In the late 1990s, many Boobies with bands were observed, although band numbers were not read (John Cornelius, QPWS, pers. comm.).

Few of the birds banded in this study have been recaptured back at their banding place. This is not

surprising as the effort put into banding birds and recording those already banded varied considerably between surveys. Recaptures of banded birds depended on a number of factors including: catchability of species (i.e. Brown Boobies were not as approachable as Masked Boobies), priorities of survey team (most recaptures were made by turtle researchers), time of year (breeding versus non-breeding season), and number of team members. The duration of survey at an island, the observer's interest in and skill at bird identification and the season of the year all affect the amount of information that is obtained on a given trip (Dobbs *et al.* 1997). Similar issues were raised by O'Neill *et al.* (1996), but also noted a population decline in Brown Boobies as reducing the number of recaptures.

The greater number of Masked Booby and Red-tailed Tropicbird recaptures most likely reflects more effort to recapture those species than the others as noted above. Because there was no consistent effort to recapture banded birds at any of the locations, comparing recapture rates among or within species is problematic. Also, sex was rarely recorded for banded birds, so comparing recapture rates with other studies could not occur. O'Neill *et al.* (1996) reported higher recapture rates for Masked Boobies than Brown Boobies in a ten year study in the Swains Reefs. This difference was possibly influenced by a population decline impacting Brown Boobies during the study (Heatwole *et al.* 1996). O'Neill *et al.* (1996) also reported that age class had a significant effect on recapture rate, with birds banded as adults more likely to be recaptured than birds banded as juveniles. This is similar to the results in this study, although given that most birds were banded as adults (45.5%), it may not be surprising.

A small proportion (15%) of birds have been recaptured at Raine Island, some at intervals of over a decade or more whilst others were recaptured one to seven times. Only four of the 7 080 birds banded at Raine Island were recaptured at Moulter Cay, the closest cay to the island. Banding has occurred at Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 but none of those bands have been recovered at Raine Island. These examples demonstrate the birds' strong site fidelity, similar to that reported by O'Neill *et al.* (1996) for Masked Boobies and Brown Boobies in the Swains Reefs.

An even smaller proportion (1.3% of 7 929 banded) of birds banded at Raine Island, Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 were recovered

elsewhere throughout the south-western Pacific, particularly Papua New Guinea. This pattern is similar to that exhibited by banded birds in the Swains Reefs (O'Neill *et al.* 1996) where Brown Boobies tended to migrate north and east to Papua New Guinea and the Solomon Islands. Numerous bird recoveries reported in this summary resulted from their capture to use as pets, for ceremonial purposes or for food, whereas many of the band recoveries from birds banded in the Swains Reefs were from dead beach-washed birds (O'Neill *et al.* 1996).

Green Turtles tagged on Raine Island (Limpus *et al.* 1992) have been recovered from the same countries as the seabirds reported here. This further links management of the northern Great Barrier Reef natural resources with south-western Pacific Ocean countries. These results emphasize the need for conservation agreements with neighbouring countries, such as those between Japan (Japan/Australia Migratory Bird Agreement) and China (China/Australia Migratory Bird Agreement), to protect migratory birds. All nations need to appreciate the migratory and dispersive behaviour of birds and to work cooperatively for their management.

The information collected about the bird life on Raine Island, Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 has proven useful to managers and scientists alike. The waters adjacent to Raine Island, Moulter Cay, MacLennan Cay, Sandbank No. 7 and Sandbank No. 8 are declared a Marine National Park Zone of the Great Barrier Reef Marine Park and the Queensland Great Barrier Reef Coast Marine Park and as such, extractive uses are controlled. Access to the waters around Raine Island is restricted except for non-tourist commercial charter for research, filming, photography, sound recording and management purposes (Great Barrier Reef Marine Park Authority 2003). The justification for such strict management controls stem from the area's significance for seabird and Green Turtle *Chelonia mydas* nesting (Limpus *et al.* 2003).

The number of birds utilizing Raine Island at survey times has not been quantified in recent years. Further analyses of seabird monitoring data collected at Raine Island contained within the unpublished departmental reports could provide information on the abundance and changes in population parameters, similar to reports for the Far Northern Great Barrier Reef (Blaber *et al.* 1998) and the Swains Reefs in the southern Great Barrier Reef (O'Neill *et al.* 1996) and could provide a basis for future monitoring including whether banding should be re-instated as part of the programme.

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