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THE STATUS OF QUEENSLAND SEABIRDS

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A survey was made of seabird populations and breeding islands from Cape York south to off Mackay between 1979 and 1990. These data are supplemented with that of others from the Gulf of Carpentaria, the Torres Strait, and other islands of the Great Barrier Reef and south of Mackay to the Queensland/ New South Wales border. Twenty-four species of seabirds breed principally on some 75 islands of the more than 1 000 in this vast area. These islands may be largely sand, mangrove, low wooded, continental or cays, vegetated or unvegetated. The influence of the vegetation of an island on the breeding of seabirds is discussed as are other factors influencing breeding success. Queensland, and in particular the Great Barrier Reef, has the largest and most diverse population of tropical seabirds in Australia, some of which is still relatively undisturbed. There is an international obligation to preserve and maintain this faunal resource.

*Brian King died in 1991 after a prolonged illness. In the latter stages, he was unable to do field work and eventually became bedridden. In spite of his incapacities, his determination to record and publish his data won the admiration of all of his colleagues. His contribution to ornithological studies of the Great Barrier Reef has been great.

It is fitting that this review of the whole region, an understanding of which he devoted so much of his life, be the sole article in this issue of *Corella*. It is the least we can do for one who contributed so much.

Unfortunately, Brian died during the final stages of preparing the manuscript for publication. I wish to thank Dr K. Hulsman for attending to the minor points that required clarification. I have added Appendix 2 to facilitate the location of information on all the islands of the region which have been published in the 'Seabird Island Series' of *Corella*. From this series I have selected photographs with appropriate captions. Brian was an ardent supporter of the Series, and it will be seen that he was sole, senior or co-author of 25 of the 62 descriptions which have been published or are in press. MDM Editor.

INTRODUCTION

The shallow expanse of sea that lies between the Queensland coast and the edge of the continental shelf of Australia has a large and diverse population of seabirds. This area contains over 1 000 islands, more than 900 of which are in the Great Barrier Reef region. A number of these islands have substantial seabird colonies. This area of coastline, reefs and islands has never been fully surveyed to determine the distribution and status of the species that make up its seabird population. The first offshore surveys of birds were made during the exploratory voyages of the early 19th Century and since then a considerable amount of information has been accumulated.

Summaries of the distribution and abundance of Queensland's seabirds have been made by Lavery and Grimes (1971) and Kikkawa (1976) for the Great Barrier Reef, Draffan *et al.* (1983) for Torres Strait and Blakers *et al.* (1985) for all of Queensland, using published records and new information available at the time of publication. However, because of the extent of the area to be covered and the logistical difficulties involved in surveying the more remote islands and areas, we have never had a full understanding of the distribution and abundance of Queensland's seabirds. Until recently, many areas had been rarely visited by ornithologists, others had not been visited for decades, and few attempts had ever been made to investigate seasonal differences in populations and breeding activities.

The formation of the Great Barrier Reef Marine Park Authority (GBRMPA) in 1975 and its management of the Marine Park through the Queensland National Parks and Wildlife Service highlighted the need for a much greater understanding of the distribution and abundance of seabirds and other island fauna. Support for island and seabird research from GBRMPA, the Raine Island Corporation, Queensland NPWS and other institutions has, in the last decade in particular, provided the resources needed to reach the less accessible parts of the Great Barrier Reef and other areas. In this period a number of new surveys have been made covering most of the Queensland coastline and seas, and a large amount of information about the seabirds and their areas of abundance has been recorded, particularly in the 'Seabird Islands Series' of Corella (Appendix 2).

Since 1979 I have surveyed seabird populations and breeding islands between Cape York and Bushy and Redbill Islands near Mackay. This account summarises information from my studies and other new records since 1976, reviews the knowledge of the distribution and status of Queensland's seabirds and their most important breeding islands, and considers the relative importance of different areas and islands for seabird breeding and conservation.

DEFINITIONS

OFFSHORE SECTIONS OF QUEENSLAND

The seas around Queensland can be divided into several geographical areas (Figs 1 and 2). For convenience, I have used some boundaries that correspond with those used by the Great Barrier Reef Marine Park Authority to delineate their Sections of the Great Barrier Reef Marine Park. The divisions are:

1. **The Gulf of Carpentaria:** Bordered in the west by a line north from the Queensland-Northern Territory border, in the south and east by the Queensland coastline, and in the north by a line west from Bamaga.
2. **The Torres Strait:** Bordered in the west by a line north from the Queensland-Northern Territory border, in the south by a line west from Bamaga and a line east from Cape York, in the north by the Australia-Papua New Guinea border, and in the east by the outer edge of the Great Barrier Reef.
3. **The Great Barrier Reef:** Bordered in the north by the southern boundary of Torres Strait (a line east from Cape York), in the west by the Queensland coastline, in the east by the edge of the Australian continental shelf, and in the south by a line between Sandy Cape and Lady Elliot Island.

The Great Barrier Reef has been subdivided into four Sections by the Great Barrier Reef Marine Park Authority (the Far Northern Section, Cairns Section, Central Section and Mackay-Capricorn Section). In terms of seabird distribution, this area can be more conveniently divided into three areas. These are the Northern Great Barrier Reef, the Central Great Barrier Reef, and the Southern Great Barrier Reef.

No.	Island name	Latitude	Longitude
GULF OF CARPENTARIA — GC			
1.	Manowar Island	16°17'S	139°16'E
2.	Rocky Island	16°19'S	139°17'E
TORRES STRAIT — TS			
3.	Bramble Cay	19°07'S	143°52'E
NORTHERN GREAT BARRIER REEF			
FAR NORTHERN SECTION — FNS			
4.	MacLennan Cay	11°22'S	143°48'E
5.	Cholmondeley Island	11°23'S	143°04'E
6.	Moulter Cay	11°06'S	144°00'E
7.	Wallace Island	11°27'S	143°02'E
8.	Raine Island	11°36'S	144°02'E
9.	Saunders Island	11°42'S	143°11'E
10.	Bird Islands	11°47'S	143°05'E
11.	Magra Island	11°51'S	143°17'E
12.	Ashmore Banks	11°53'S	143°38'E
13.	Piper Islands	12°14'S	143°12'E
14.	Quoin Island	12°24'S	143°29'E
15.	Chapman Island	12°53'S	143°36'E
16.	Sherrard Island	12°59'S	143°37'E
17.	Sandbank No. 8	13°22'S	143°58'E
18.	Sandbank No. 7	13°26'S	143°58'E
19.	Fife Island	13°39'S	143°44'E
20.	Pelican Island	13°55'S	143°50'E
21.	Stainer Island	13°57'S	143°50'E
22.	Davie Cay	13°59'S	144°27'E
23.	Tydeman Cay	13°59'S	144°30'E
24.	Sandbank No. 1	14°12'S	144°53'E
25.	Stapleton Island	14°20'S	144°52'E
26.	Combe Island	14°25'S	143°55'E
CAIRNS SECTION — CNS			
27.	Eagle Island	14°42'S	145°23'E
28.	Rocky Islet	14°51'S	145°29'E
29.	Michaelmas Cay	16°36'S	145°59'E
30.	South Barnard Islands	17°44'S	146°10'E
CENTRAL GREAT BARRIER REEF — CS			
31.	Purtaboi Island	17°55'S	146°08'E
32.	Brook Islands	18°09'S	146°17'E
33.	Holbourne Island	19°44'S	148°22'E
34.	Eshelby Island	20°01'S	148°37'E
35.	East Rock	20°20'S	148°52'E
SOUTHERN GREAT BARRIER REEF			
COASTAL AND MACKAY SECTION — CM			
36.	Redhill Island	20°58'S	150°05'E
44.	Pelican Rock and Akens I.	22°21'S	150°16'E
SWAIN REEF CAYS — SR			
37.	Bacchi Cay	21°38'S	152°23'E
38.	Thomas Cay	21°39'S	152°22'E
39.	Frigate Cay	21°44'S	152°25'E
40.	Bylund Cay	21°47'S	152°25'E
41.	Price Cay	21°47'S	152°27'E
42.	Bell Cay	21°49'S	151°15'E
43.	Gannet Cay	21°59'S	152°28'E
CAPRICORN-BUNKER CAYS — CB			
45.	North Reef Island	23°11'S	151°54'E
46.	Tryon Island	23°15'S	151°47'E
47.	Northwest Island	23°17'S	151°44'E
48.	Wilson Island	23°18'S	151°55'E
49.	Wreck Island	23°20'S	151°58'E
50.	Heron Island	23°26'S	151°57'E
51.	Erskine Island	23°30'S	151°46'E
52.	One Tree Island	23°31'S	152°05'E
53.	Masthead Island	23°32'S	151°44'E
54.	Hoskyn Island	23°48'S	152°17'E
55.	Fairfax Island	23°52'S	152°22'E
56.	Lady Musgrave Island	23°54'S	152°24'E
57.	Lady Elliot Island	24°07'S	152°43'E
SOUTH-EAST — SE			
58.	Mudjimba Island	26°37'S	153°07'E

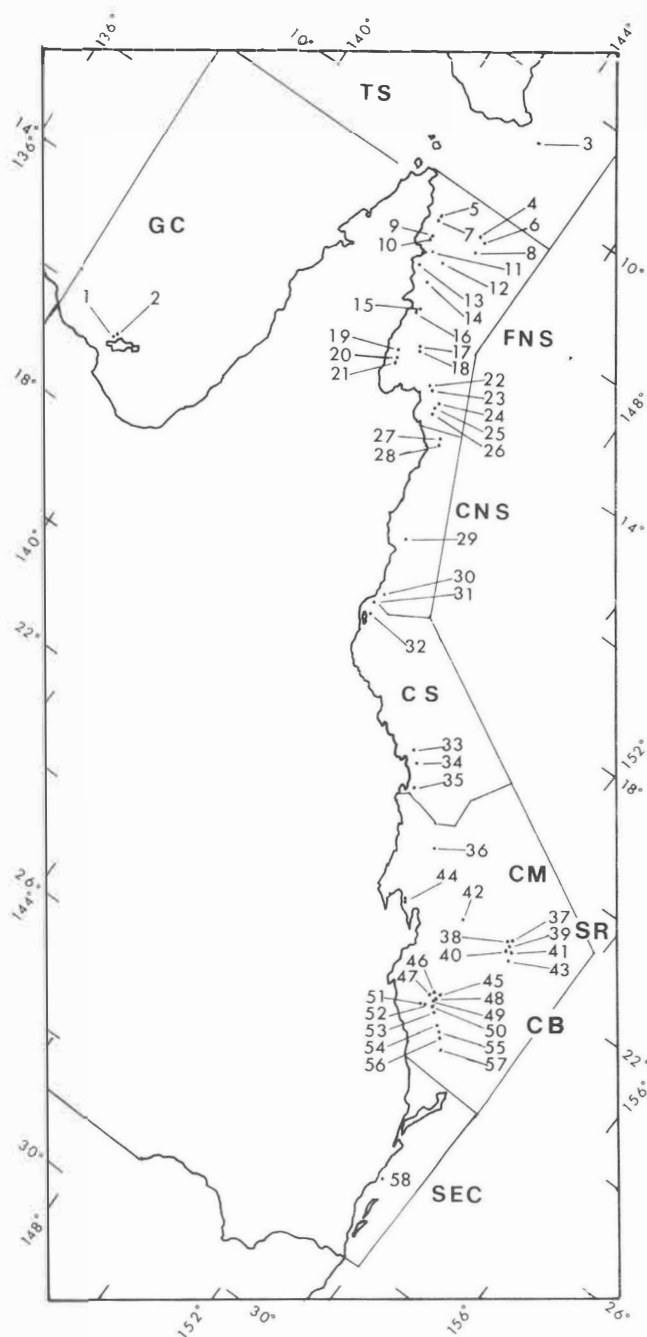


Figure. 1. Islands with significant seabird colonies in Queensland. (Map of islands listed in Table 1.)

- (a) The Northern Great Barrier Reef is bounded in the north by the boundary between Torres Strait and the Far Northern Section of the Great Barrier Reef Marine Park, in the west by the Queensland coastline, in the south by the southern boundary of the Cairns Section of the Great Barrier Reef Marine Park, and in the east by the outer edge of the Australian Continental Shelf.
- (b) The Central Great Barrier Reef is bounded in the north by the boundary between the Cairns and Central Sections of the Great Barrier Reef Marine Park, in the east by the Queensland coastline, in the south by the southern boundary of the Central Section of the Marine Park, and in the east by the edge of the Australian Continental Shelf.
- (c) The Southern Great Barrier Reef can be divided into three geographical sections. The Swain Reef Cays are a group of sand cays on the outermost area of the southern Great Barrier Reef Reefs; Bell Cay is included in this group (Figs 1 and 2). The Capricorn-Bunker Cays include the cays of the Capricorn and Bunker groups on detached reefs at the southern limit of the Great Barrier Reef. The Southern Coastal and Mackay area islands comprises the remainder of the southern area the islands of which are mostly along the coast and include some outer islands out from Mackay.
4. **The South-east:** Bounded in the north by the southern boundary of the Great Barrier Reef Region (a line between Sandy Cape and Lady Elliot Island), in the west by the Queensland coastline, in the south by a line east from the Queensland-New South Wales border, and in the east by the continental shelf of Australia.

ISLAND TYPES

I have classified Queensland's islands into six types, using a classification of Great Barrier Reef islands by Hopley (1982). The areas of Queensland's seas described above vary greatly in their numbers and proportions of each type of island, and in the vegetation communities that they possess. These differences are reflected to some

degree in the seabird populations found on islands in different areas. The six island types are as follows:

1. **Large Sand Islands:** Large islands composed mainly of silica sand with some inclusions of continental material. Their vegetation ranges from heath communities to closed vine forest. They are confined to the south-east and are South and North Stradbroke, Moreton, Bribie and Fraser Islands. They have no important seabird breeding areas.
2. **Mangrove Islands:** Intertidal banks, generally submerged at high water and composed of sedimentary matter and vegetated with mangrove communities. They are found in sheltered bays and estuaries along the entire Queensland coastline. This island type has not been fully surveyed for seabird breeding.
3. **Unvegetated Cays:** Cays of the Great Barrier Reef and Torres Strait, which are composed of coral sand or shingle, or a mixture of both. Many are submerged at high water or are overwashed by storm waves. They are often unstable and are liable to change their size, shape and position on the reef under the influence of tides, currents and wave action. They are found throughout the Great Barrier Reef.
4. **Vegetated Cays:** Cays of sand or shingle that tend to be larger and more stable than the unvegetated cays, though still subject to physical changes. Vegetation cover ranges from simple communities of grasses and shrubs to complex and sometimes extensive communities of shrubs and trees, including tropical vine forest. They are found throughout the Great Barrier Reef.
5. **Low Wooded Islands:** These are a complex island formation that is unique to the Great Barrier Reef and consists of a coral reef on which develops seaward shingle ramparts, a leeward cay and an area of mangroves in the lagoon or reef flat enclosed by them. They occur on a number of the inner reefs close to the north-eastern coast, between Cairns and Cape York.
6. **Continental Islands:** These are islands of mainland origin, some high and rocky, that occur mostly along the eastern coastline. Their

No.	Island name	Latitude	Longitude
GULF OF CARPENTARIA — GC			
1.	Crab Island	10°59'S	142°06'E
TORRES STRAIT — TS			
2.	Kusamet Island	10°11'S	142°05'E
3.	Booby Island	10°36'S	141°55'E
4.	Deliverance Island	09°32'S	141°34'E
5.	Anchor Cay	09°22'S	144°07'E
6.	East Cay	09°23'S	144°13'E
7.	Murray Island Sandbank	09°35'S	144°10'E
NORTHERN GREAT BARRIER REEF			
FAR NORTHERN SECTION — FNS			
8.	Frigate Cay	10°48'S	142°58'E
9.	Douglas Island	11°14'S	143°00'E
10.	Jardine Island	11°23'S	143°02'E
11.	Little Boydong Cay	11°29'S	143°02'E
12.	Sunday Island	11°55'S	143°13'E
13.	Kay Island	12°14'S	143°17'E
14.	Pipon Island	14°08'S	144°31'E
15.	Ingram/Beenley Island	14°26'S	144°54'E
16.	Howick Group	14°30'S	144°58'E
CAIRNS SECTION — CNS			
17.	Hope Islands	15°44'S	145°27'E
18.	Low Isles	16°23'S	145°34'E
19.	Upolu Cay	16°41'S	145°56'E
20.	Sudbury Cay	17°01'S	146°12'E
21.	Beaver Cay	17°51'S	146°29'E
22.	Taylor Cay	17°50'S	146°33'E
CENTRAL GREAT BARRIER REEF — CS			
23.	Eva Island	18°14'S	146°19'E
24.	Cordelia Rocks	18°59'S	146°41'E
25.	Double Cone Island	20°08'S	148°43'E
SOUTHERN GREAT BARRIER REEF			
COASTAL AND MACKAY SECTION — CM			
26.	Bushy Island	20°57'S	150°05'E
SWAIN REEF CAYS — SR			
27.	Distant Cay	21°06'S	152°29'E

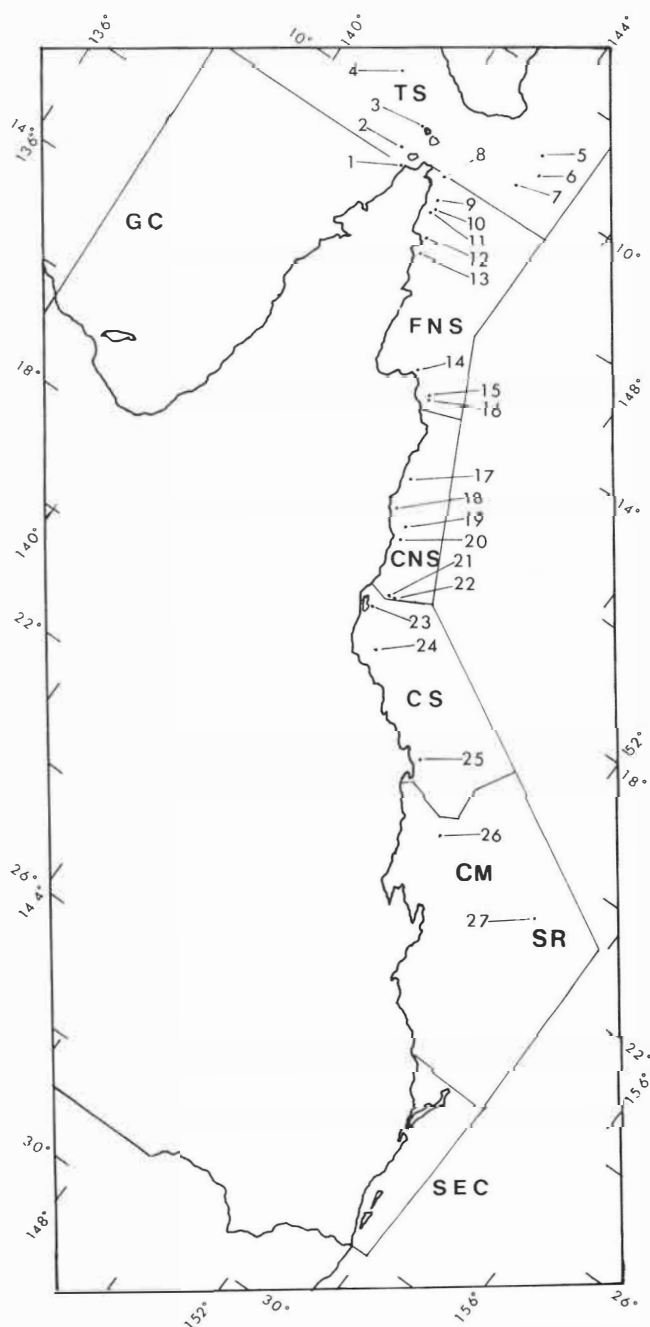


Figure 2. Minor seabird colonies in Queensland. (Map of smaller seabird colonies mentioned in the text.)

vegetation cover ranges from grasses and shrubs to dense vine forest. They occur in greatest numbers in the central and southern areas of the Great Barrier Reef.

A geographical subdivision can also be made for the Great Barrier Reef and Torres Strait cays, which can be grouped into the Inner Cays and Outer Barrier Cays. The Inner Cays are found on the reefs between the eastern coastline and the outer edge of the Great Barrier Reef. The Outer Cays occur in two groups, one a line of cays along the outermost reefs of Torres Strait, the far northern and Cairns Sections, and a second group in the Swain Reefs. The geographical differences between the Inner and Outer Cays are reflected in differences in their vegetation and seabird communities.

SEABIRD SPECIES

The term 'seabird' here refers to the 24 species for which breeding records have been obtained. These are members of the Families:

Diomedidae: Herald Petrel *Pterodroma arminjoniana*, Wedge-tailed Shearwater *Puffinus pacificus*;

Pelicanidae: Australian Pelican *Pelicanus conspicillatus*;

Phalacrocoracidae: Pied Cormorant *Phalacrocorax varius*, Little Pied Cormorant *P. melanoleucos*;

Sulidae: Red-footed Booby *Sula sula*, Masked Booby *S. dactylatra*, Brown Booby *S. leucogaster*;

Fregatidae: Great Frigatebird *Fregata minor*, Least Frigatebird *F. ariel*;

Phaethontidae: Red-tailed Tropicbird *Phaethon rubricauda*;

Ardeidae: Eastern Reef Egret *Egretta sacra*, Rufous Night Heron *Nycticorax caledonicus*;

Laridae: Silver Gull *Larus novaehollandiae*, Caspian Tern *Hydroprogne caspia*, Roseate Tern *Sterna dougalli*, Little Tern *S. albifrons*, Black-naped Tern *S. sumatrana*, Sooty Tern *S. fuscata*, Bridled Tern *S. anaethetus*, Crested Tern *S. bergii*, Lesser Crested Tern *S. bengalensis*, Common Noddy *Anous stolidus* and Black Noddy *A. minutus*.

I have included The Eastern Reef Egret because it is a common breeding species and the Rufous Night Heron is the only other member of

that Family recorded breeding offshore. Cormorants (Family Phalacrocoracidae) have also been included despite the paucity of breeding records on islands in Queensland. Recent breeding records of cormorants are limited to small colonies of Little Pied Cormorants on North Reef Island (Walker 1989c) and East Rock (Walker 1991) and Pied Cormorants on Pelican Rock (Walker *et al.* 1993) in the southern coastal area, and a small resident flock of Little Pied Cormorants on Fife Island in the northern GBR that has not yet been recorded breeding (King *et al.* 1991). Breeding records for the Ardeidae and Phalacrocoracidae should increase when the coastal areas and estuarine mangrove areas are fully examined.

RESULTS AND DISCUSSION

Table 1 gives details of the 58 major seabird breeding colonies on Queensland islands. Table 2 compares the 58 colonies by geographical location and type of island used for seabird breeding. Table 3 details the land tenure of these colonies. Table 4 compares the composition and numbers of species of seabirds breeding in Queensland seas.

I do not relate the significance of a colony to its size alone. Tables 1-4 include colonies on the basis of their relative importance to the area in which they occur, or on the relative abundance of the species they contain, as well as on the absolute size of their seabird populations. For example, a small colony in an area with few seabird islands would be important to that area, but not necessarily to all of Queensland. Similarly, a species that rarely breeds in Queensland, e.g. Caspian and Little Terns, may have every colony recorded, whereas a common and widespread species, e.g. Black-naped Tern, may not. I have also not included every breeding site for every seabird species in Table 1. Additional islands or coastal breeding areas with seabird colonies of small or unknown size are mentioned in the text for each Section and species.

In Table 1, I have not presented colony sizes as absolute numbers of breeding pairs, but have ranked them on a log 10 scale of 1-6. This gives an indication of the relative size of each colony and enables the rapid comparison of colonies. The counts or estimates of colony sizes on which these rankings were based can be obtained by

referring to the published sources listed for each island (Appendix 1).

DISCUSSION OF SECTIONS

1. Gulf of Carpentaria

The Gulf of Carpentaria has only two types of island, a small number of continental islands and some estuarine mangrove islands.

This Section has only two large seabird colonies, on Rocky and Manowar Islands in the Mornington Group and the Wellesley Islands. Least and Great Frigatebirds breed on Manowar Island in a mixed colony of over three thousand (Walker 1992), and formerly bred on Rocky Island as well (Garnett *et al.* 1987a,b). Rocky and Manowar Islands also have one of the three largest colonies of Brown Boobies in Queensland. The Wellesley Islands, to which Manowar Island, Rocky Island, the Bountiful Islands and Little Allen Island belong, have breeding populations of Australian Pelicans, Silver Gulls, Crested Terns, and Black-naped Terns (Walker, 1992). Crab Island has a seasonal aggregation of Rufous Night Herons in association with the nesting of Flatback Turtles *Chelonia depressa*, (Limpus *et al.* 1983), and these Herons are suspected to breed there, although this is not confirmed (C. J. Limpus, pers. comm.).

2. Torres Strait

Torres Strait has a large number of cays and continental islands. The cays include unvegetated sandbanks and vegetated cays with a range of vegetation communities from simple grass/herb communities (e.g. Bramble Cay, Murray Island Sandbank) to more complex communities of grasses, shrubs and trees. Continental island vegetation ranges from grassland and shrubs to closed vine forest.

Torres Strait has only one substantial seabird colony, at Bramble Cay (Elvish and Walker 1991). Two small seabird colonies have been documented at Kusamet Island (Garnett 1987) and Booby Island (Garnett *et al.* 1988). Colonies of undetermined significance are at Anchor Cay, East Cay and Murray Island Sandbank. Booby Island no longer has Brown Boobies breeding, but still has some terns nesting. Deliverance Island (Draffan *et al.* 1984) has a nesting population of Rufous Night Herons.

Seabirds, mainly terns, breed in small numbers on many Torres Strait islands, but all islands are affected by egg-harvesting, which is a widespread traditional practice in this area. Harvesting of seabird eggs and chicks has generally reduced the breeding seabird population of Torres Strait and has caused a considerable reduction in the colony at Bramble Cay, where Brown Boobies no longer breed successfully (Elvish and Walker 1991), and might have destroyed the former Brown Booby colony on Booby Island (Garnett *et al.* 1988).

3. The Northern Great Barrier Reef

The Northern Great Barrier Reef has coastal mangrove islands, cays, continental islands and low wooded islands. Most of the low wooded islands have extensive mangrove forests and their cay portions have a mixture of grassland and forest. Vegetation of the continental islands ranges from grassland with scattered shrubs, open forests, to closed vine forests. Many have extensive areas of fringing mangrove forest. Outer cay vegetation ranges from none (Sandbank No. 7) to grasses with herbs and low shrubs (Sandbank No. 8, Raine Island). The inner cays have a much greater range of vegetation types from open communities of grasses, herbs and shrubs (Saunders Island, Magra Island) to closed forest. Douglas Island has the most northerly forest of *Pisonia grandis* on the Great Barrier Reef and has a roosting population of Black Noddies. Rocky Islet is a continental island with a *Pisonia grandis* forest on a sandflat. Low Isles is the southernmost of the low wooded islands of the Great Barrier Reef.

The Northern Great Barrier Reef has 26 of the 58 seabird colonies on record, the largest number for any area in Queensland (Table 2). In addition it has the largest number of breeding seabird species in Queensland, with 23 of the 24 recorded (Table 4). Recent surveys have revealed significant populations of Least Frigatebird, Red-footed Booby, Brown Booby, Masked Booby, Sooty Tern, Bridled Tern, Crested Tern, Lesser Crested Tern, Common Noddy and Rufous Night Heron. The colonies of Australian Pelicans on Pelican, Stainer, Combe, Stapleton and Ingram Islands have all been reduced by human disturbance and are now each smaller than the colony at Pelican Rock and Akens Island in Shoalwater Bay. However, the total population of Pelicans in the northern breeding area might still exceed that

TABLE 1

The major seabird breeding islands of Queensland, showing land tenure and relative population sizes.

Island type: C Cay, u (unvegetated), vs (vegetated sand), vr (vegetated rubble); CT Continental; LW Low Wooded. Island tenure: DD Dept. of Defence Training Reserve, FR Fauna Reserve, L Crown Leasehold, LH Commonwealth Lighthouse Reserve, NP National Park, VC vacant Crown Land.

Species of breeding seabirds: HP Herald Petrel, WS Wedge-tailed Shearwater, AP Australian Pelican, PC Pied Cormorant, LPC Little Pied Cormorant, GF Great Frigatebird, LF Least Frigatebird, RB Red-footed Booby, MB Masked Booby, BB Brown Booby, RTB Red-tailed Tropicbird, RH Eastern Reef Heron, RN Rufous Night Heron, SG Silver Gull, CST Caspian Tern, ST Sooty Tern, BT Bridled Tern, RT Roseate Tern, BNT Black-naped Tern, LT Little Tern, CT Crested Tern, LCT Lesser Crested Tern, CN Common Noddy, BN Black Noddy.

Breeding Status (pairs): 1, <10; 2, 10 to <100; 3, 100 to <1 000; 4, 1 000 to <10 000; 5, 10 000 to <100 000; 6, 100 000 to 1 million;

* — large roosting population; + — present but not breeding.

Island	Type	Tenure	Species of breeding seabirds																										
			HP	WS	AP	PC	LPC	GF	LF	RB	MB	BB	RTB	RH	RN	SG	CST	ST	BT	RT	BNT	LT	CT	LCT	CN	BN			
GULF OF CARPENTARIA																													
Manowar	CT	VC						1	4									3		1									
Rocky	CT	VC							2									4			?				1				
Bountiful	CT			1																		3			5	2			
Little Allen																						3							
TORRES STRAIT																													
Bramble	Cvs	LH																	2							3	4-5		
NORTHERN GREAT BARRIER REEF OUTER CAYS																													
Moulter	Cvs	FR								1	2	3								2			4	2		2	1	3	
MacLennan	Cvs	FR										3																	
Raine	Cvs	FR	1	4					1	4	3	4	4	3						3	1	3	3	3		2		4	*
Ashmore	Cvs	VC																					3			1		3	
Sandbank 8	Cvs	NP																					4			2	1	4	
Sandbank 7	Cu	NP																								4-5	2		
Davie	Cvs	VC																										3	
Tydean	Cvs	VC																										3	
Sandbank 1	Cu	VC																										3	
INNER ISLANDS																													
Cholmondeley	Cvs	NP																										3	3
Wallace	Cvs	NP																										2	3
Saunders	Cvs	NP																											
Magra	Cvs	NP																											
North Bird	LW	NP																											4
Piper Group	LW	NP																											4
Quoin	CT	NP																											4
Chapman	LW	LH																											4
Sherrard	LW	VC																											3
Fife	Cvs	LH																											3
Pelican	Cvs	NP																											3
Stainer	Cvs	VC																											3
Stapleton	Cvs	NP																											4
Island	Type	Tenure	HP	WS	AP	PC	LPC	GF	LF	RB	MB	BB	RTB	RH	RN	SG	CST	ST	BT	RT	BNT	LT	CT	LCT	CN	BN			

B. R. King: Status of Queensland seabirds

Corella 17(3)

Island	Type	Tenure	Species of breeding seabirds																								
			HP	WS	AP	PC	LPC	GF	LF	RB	MB	BB	RTB	RH	RN	SG	CST	ST	BT	RT	BNT	LT	CT	LCT	CN	BN	
Combe	Cvs	NP		3	2										1		3	2					2		3	*	
Eagle	Cvs	VC														1		1	2	2	3		4	3			
Rocky	CT	NP		4														3		1		1		*	*		
Michaelmas	Cvs	NP													1		5	1	1	2	+	4	4	5	1		
CENTRAL GREAT BARRIER REEF																											
South Barnard	CT	NP																3	3	2	1	2	3				
Purtaboi	CT	NP																2	1	3				2			
Brook	CT	NP, LH																3	1	3							
Holbourne	CT	NP, LH													2			1	2	2		1					
Eshelby	CT	LH													1			4					4				
East Rock	CT	VC						2						1		2				1			3				
SOUTHERN GREAT BARRIER REEF																											
COASTAL AND MACKAY AREA ISLANDS																											
Redbill	CT	VC													1	1			3								
Pelican Rock/Akens	CT	DD			3	1									1	1	2						1				
Skull	CT	DD															2										
SWAIN REEF CAYS																											
Bylund	Cvs	VC																				3		2			
Gannet	Cvs	VC																	3							3	
Price	Cvs	VC																	2				3	1	3		
Frigate	Cvs	VC							2									2	3	1	1		2		3		
Bell	Cvs	VC								3								1	2				3		4		
Bacchi	Cvs	VC																2	2				2	3			
Thomas	Cu	VC																2	2				2	3			
CAPRICORN-BUNKER CAYS																											
One Tree	Cvr	L													3	1		3	2	3		3	3			3	
Tryon	Cvs	NP		5															2	2							
Northwest	Cvs	NP		6																						6	
Wreck	Cvs	NP		4															2	3	3						
Masthead	Cvs	NP		5															3	3	2		3			5	
Heron	Cvs	NP, L		4																2						5	
Hoskyn*	Cvs, vr	NP		4															3	2	2					3	
Lady Elliot	Cvs	LH, L		3															3	2	2		4		2	3	
North Reef	Cvs	LH						1												2	2		3				
Erskine	Cvs	NP		3															1	1			3	2			
Wilson	Cvs	NP, L		4															2	2	2		3				
Lady Musgrave	Cvs	NP		4															2	2	2					4	
Fairfax*	Cvs, vr	NP		3															4				1				
SOUTH-EAST																											
Mudjimba	CT	L		4																							

*Two islands.

TABLE 2

Numbers of significant seabird colonies on Queensland islands.

SE — South-east; SGBR — Southern Great Barrier Reef; CGBR — Central Great Barrier Reef; NGBR — Northern Great Barrier Reef; TS — Torres Strait; GC — Gulf of Carpentaria; SW — Swain Reef cays; C-B — Capricorn-Bunker cays; QCMK — Coastal and Mackay area; OC — outer cays; II — inner islands.

Island type	SE	SW	SGBR	CMK	Area	NGBR		TS	GC	TOTAL
			C-B		CGBR	OC	II			
Cays — unvegetated	0	0	0	0	0	2	0	0	0	2
Cays — vegetated	0	7	13	0	0	7	11	1	0	39
Continental islands	1	0	0	2	6	0	2	0	2+	13
Low wooded islands	0	0	0	0	0	0	4	0	0	4
Total	1	7	13	2	6	9	17	1	2	58

of the southern colony when both populations have been fully surveyed. The Northern Great Barrier Reef has the largest populations of the Lesser Crested Tern and Roseate Tern in the Great Barrier Reef. The Roseate Tern colony at Wallace Island, estimated at over 5 000 pairs in March 1986 (King *et al.* 1989), is the largest breeding colony on record for this species. Jardine Island, Kay Island and Little Boydong Cay also have seabirds breeding, but the size and composition of these colonies is not known.

Raine Island has one of the largest and the most diverse colonies of tropical seabirds in Australia. It has 17 of the 24 seabird species recorded here as breeding on Queensland islands (Tables 1, 4), and contains several species uncommon in Australia, i.e. the Herald Petrel, Red-footed Booby and Red-tailed Tropicbird. It is the most northerly breeding island of the Wedge-tailed Shearwater in Queensland. It also has large roosting populations of the Common Noddy and Black Noddy. It was formerly the only breeding island for the Red-tailed Tropicbird in eastern Australia, until the establishment of a few pairs at Lady Elliot Island in 1983. It is the breeding site for a migratory New Guinean population of the Rufous Night Heron in association with summer nesting of Green Turtles *Chelonia mydas*. It also has Queensland's largest populations of Red-footed, Masked and Brown Boobies and Least Frigatebirds.

The nine outer cays of the Northern Great Barrier Reef have simple vegetation communities of grasses, herbs and shrubs and are breeding sites for large numbers of oceanic seabirds, i.e.

Red-footed Booby, Masked Booby, Brown Booby, Great and Least Frigatebirds, Red-tailed Tropicbird and Sooty Tern. The inner islands have large populations of inshore seabirds, including Australian Pelican, Eastern Reef Egret and several species of terns. Three cays, Stapleton Island, Combe Island and Michaelmas Cay, have mixed populations of oceanic and inshore seabird species. Michaelmas Cay is the southern limit of Sooty Tern breeding in the Great Barrier Reef, and is the southern end of the northern group of large seabird colonies.

The seabird colony at Michaelmas Cay is often visited by tourists, and is under strict management controls to prevent damage to the colony. Upolu Cay formerly had a substantial tern colony similar to that of nearby Michaelmas Cay (Lavery and Grimes 1971), but it has been reduced by cyclonic activity to a small, unvegetated sandbank that now rarely has any seabirds nesting. Smaller seabird colonies of unknown significance are on Hope Islands, Low Isles and Sudbury Cay.

4. The Central Great Barrier Reef

The central portion of the Great Barrier Reef has a small number of cays which are mostly unvegetated. Continental islands are numerous. Their vegetation cover ranges from grasses and shrubs (Eshelby Island) to closed vine forest (Brook Islands). In the wetter northern portion the islands all have tropical closed vine forest, while in the southern portion they have a range of vegetation from grasses and shrubs to open forests with pockets of closed vine forest.

TABLE 3

Tenure of Queensland islands with significant seabird colonies.

SGBR — Southern Great Barrier Reef; VC — Vacant Crown Land; L — Crown Leasehold; LH — Commonwealth Lighthouse Reserve; DD — Department of Defence Reserve; NP — National Park; FR — Fauna refuge.

Area	VC	L	LH	DD	NP	FR	Total
South-east	0	1	0	0	0	0	1
Southern GBR:							
Swain Reef Cays	7	0	0	0	0	0	7
Capricorn-Bunker Cays	0	1	2	0	10	0	13
Coastal and Mackay area	1	0	0	1	0	0	2
Central GBR	1	0	1	0	4	0	6
Northern GBR:							
Outer Cays	4	0	0	0	2	3	9
Inner Islands	3	0	2	0	12	0	17
Torres Strait	0	0	1	0	0	0	1
Gulf of Carpentaria	2	0	0	0	0	0	2
Total	18	2	6	1	28	3	58

TABLE 4

Comparison of the species composition of the seabirds breeding in areas of Queensland seas.

Areas: GC — Gulf of carpentaria; TS — Torres Strait; NGO — Northern Great Barrier Reef outer cays; NGI — Northern Great Barrier Reef inner islands; CCB — Central Great Barrier Reef; SGM — Southern Great Barrier Reef; Coastal and Mackay area; SGS — Southern Great Barrier Reef; Swain Reef cays; SCB — Southern Great Barrier Reef; Capricorna and Bunker cays; SE — South-east.

Breeding species	CG	TS	NGO	NGI	Area				
					CGB	SGM	SGS	SCB	SE
Herald Petrel			×						
Wedge-tailed Shearwater			×	×				×	×
Australian Pelican	×			×		×			
Pied Cormorant						×			
Little Pied Cormorant				×	×			×	
Red-footed Booby			×						
Masked Booby			×				×		
Brown Booby	×	×	×	×			×	×	
Great Frigatebird	×		×	×			?		
Least Frigatebird	×		×	×			×		
Red-tailed Tropicbird			×					×	
Eastern Reef Egret	×			×	×	×		×	
Rufous Night-Heron	×	×	×	?					
Silver Gull	×		×	×	×	×	×	×	
Caspian Tern				×	×	×			
Roseate Tern				×			×	×	
Black-naped Tern	×	×	×	×			×	×	
Sooty Tern		×	×	×			?		
Bridled Tern	×	×	×	×	×	×	×	×	
Little Tern				×					
Crested Tern	×	×	×	×	×	×	×	×	
Lesser Crested Tern			×	×			×	×	
Common Noddy		×	×	×			×	×	
Black Noddy			×	×				×	

The South Barnard Islands have a colony with several species of terns, including breeding Little Terns. Beach-nesting terns on Purtaboi Island have been almost eliminated by visitor disturbance but some still nest there and the Bridled Terns in the rocky and vegetated areas have been less affected. Small seabird colonies are located on Beaver Cay, Taylor Cay and Sand Cay.

The Central Great Barrier Reef has only six seabird colonies of any size, at South Barnard Islands, Purtaboi Island, Brook Islands, Holbourne Island, Eshelby Island and East Rock. Eshelby Island has the largest colony (Walker and Hegerl 1986), which contains the largest colony of Bridled Terns on record for Queensland. Cordelia Rocks has Silver Gulls breeding (six pairs in April 1986; B. R. King, pers. obs.) and there are also unconfirmed reports of Brown Boobies and Crested Terns breeding there. Double Cone Island has a colony estimated at over 50 pairs of Silver Gulls (K. R. MacDonald, pers. comm.). Small seabird colonies of undetermined size and significance are on Eva Island (Bridled Terns breeding in 1974; J. W. Winter, pers. comm.), and on a number of islands in the southern portion of the area.

5. The Southern Great Barrier Reef

The Southern Great Barrier Reef has a number of cays in its southern outer portion and a large number of continental islands close to the coast. Continental island vegetation ranges from grassland and open forest to closed vine forest. Cay vegetation ranges from simple grass and herb communities (Swain Reef cays) to closed forests of *Pisonia grandis* (Capricorn-Bunker cays).

In the northern portion of the Coastal and Mackay Areas, Bushy Island has a large roosting population of Black Noddies in its *Pisonia grandis* forest. Adjacent Redbill Island is a rocky continental island with a colony of Bridled Terns (Walker 1989a). Further south, Pelican Rock and adjacent Akens Island in Shoalwater Bay have Queensland's largest offshore colony of breeding Australian Pelicans. Caspian Terns breed on a few coastal islands, including a colony of 50+ pairs on Pelican Rock and Akens Island (Walker *et al.* 1992), and Skull Island (C. J. Limpus, pers. comm.).

The Swain Reef cays may be considered as outer cays and have similar vegetation to the

northern outer cays. They are used by a number of species of oceanic seabirds, and have small populations of Masked Boobies, Brown Boobies, Least Frigatebirds and Great Frigatebirds.

The Capricorn-Bunker cays also have Brown Boobies breeding on Hoskyn Island and Fairfax Island, which has one of the largest colonies in the Great Barrier Reef. A few pairs of Red-tailed Tropicbirds have nested on Lady Elliot Island since 1982. The area has substantial populations of Roseate, Black-naped and Crested Terns (Walker 1989a, 1988a,b) and also of Bridled Terns, Lesser Crested Terns and Eastern Reef Egrets. The Capricorn-Bunker cays have the largest populations of the Wedge-tailed Shearwater and Black Noddy in the Great Barrier Reef and Queensland. This area also has the largest breeding population of Silver Gulls in the Great Barrier Reef, with colonies on Wreck, Masthead, Tryon, Hoskyn, Wilson and Lady Musgrave Islands. Elsewhere, Silver Gulls nest mostly as isolated pairs or in small colonies. Outside of the Capricorn-Bunker cays, there are only two records of colonies exceeding 20 pairs on the Piper Islands and Lizard Island group in the northern Great Barrier Reef and one of over 50 pairs on Double Cone Island in the central Great Barrier Reef.

6. The South-east

The South-east has mangrove islands, continental islands and the five large sand islands. The continental islands are vegetated with grasslands, open forests and fringing mangrove forests. The sand islands have a range of vegetation communities from heath to closed vine forest.

This section has only one seabird colony, a small colony of Wedge-tailed Shearwaters on Mudjimba Island.

DISCUSSION OF SPECIES

Herald Petrel *Pterodroma arminjoniana*

Recorded only on Raine Island, where it has recently been shown to breed (King 1984; King and Reimer 1991). The Raine Island population is very small and my counts have never exceeded a dozen individuals. All other eastern Australian records are of birds at sea or of beachwashed individuals. However, other largely unexamined cays in the Coral Sea to the east of the Great

Barrier Reef might have a breeding population that would link the Raine Island birds to the population of the south-western Pacific islands.

Wedge-tailed Shearwater *Puffinus pacificus*

Breeds on 17 islands in eastern Queensland, with over 95 per cent of the population on 11 cays in the Capricorn-Bunker Groups, where it nests in burrows in the coral sand substrate under mature *Pisonia grandis* forests. Three of these colonies, on Tryon, Northwest and Masthead Islands, are extremely large and contain scores of thousands of pairs. Outside of the Capricorn-Bunker cays there are small nesting populations on only six islands, on Mudjimba Island in the south-east and on Rocky Islet, Combe, Stainer, Fife and Raine Islands in the Northern Great Barrier Reef.

Australian Pelican *Pelicanus conspicillatus*

Breeds in small colonies on eight Queensland islands. Pelican Rock and adjacent Akens Island in Shoalwater Bay have the largest colony with over 100 pairs each. Breeding numbers appear to have declined in the group of Northern Great Barrier Reef colonies that includes Stapleton, Combe, Ingram, Stainer and Pelican Islands. There may be other Pelican colonies in this same area, on other islands in the Howick Group. There is one other Pelican colony on a Queensland Island, on Rocky Island in the Gulf of Carpentaria.

Red-footed Booby *Sula sula*

Breeds only on Raine Island and nearby Moulter (formerly Pandora) Cay, where it breeds all year with a total breeding population of over 100 pairs. There is a large population breeding on a number of cays in the Coral Sea, and the Raine/Moulter population is the western extremity of this group. One case of interchange has been recorded, when a bird banded as a juvenile on Raine Island in 1981 nested as an adult on Willis Island in 1984 and 1986 (B. R. King, unpubl. data).

Masked Booby *S. dactylatra*

Breeds in small numbers on seven Swain Reef cays and in the north on Raine Island, Moulter Cay and Sandbank No 1, all of which are remote

from the coastline. Raine Island has the largest population, with about 2 000 pairs nesting annually.

Brown Booby *S. leucogaster*

Breeds on 33 islands, all of which are well separated from the Queensland coastline. The largest populations are found on Raine Island in the Northern Barrier Reef (with over 5 000 pairs), Fairfax Island in the Capricorn-Bunker cays (with over 3 000 pairs) and Rocky Island in the Gulf of Carpentaria (with over 3 000 pairs). The Torres Strait population has suffered a severe decline since records were first made, with no nesting now at Booby Island and little or no successful breeding in the few dozen pairs still using Bramble Cay.

Great Frigatebird *Fregata minor*

Recorded breeding in very small numbers on three islands, on Raine Island and Quoin Island in the Northern Great Barrier Reef and on Rocky Island in the Gulf of Carpentaria. They nest as isolated pairs on the ground in colonies of Least Frigatebirds, and can be expected to occur on other islands where Least Frigatebirds breed. The Coral Sea cays have large numbers of Great and Least Frigatebirds nesting in trees, and it appears that while the Least Frigatebird will adapt to ground nesting on treeless islands, the Great Frigatebird rarely does so.

Least Frigatebird *F. ariel*

Breeding on seven islands, all well offshore. Permanent colonies are on Manowar Island in the Gulf of Carpentaria, Raine Island, Quoin Island in the northern Great Barrier Reef and Bell Cay in the Swain Reefs. Impermanent colonies have been recorded at Rocky Island in the Gulf of Carpentaria, Frigate Cay in the Northern Great Barrier Reef and Frigate Cay in the Swain Reefs.

Least Frigatebirds nest on the ground on all seven breeding islands. On Quoin Island, where trees and shrubs are available, they are not used for nesting and nests are built on the ground instead, on the grassy slopes. Most of the tree cover on this island is *Pisonia grandis*, whose brittle branches might not be suitable for frigatebird nests. A single *Argusia* shrub on Quoin Island was used for nesting prior to its

removal by a cyclone in April 1984 (King and Buckley 1985a).

Eastern Reef Egret *Egretta sacra*

Not found in the South-east, but elsewhere a common species of most islands, with the exception of the remote Swain Reef cays and Northern Great Barrier Reef outer cays, where it is rarely seen. Breeding has been recorded in recent years on a total of 21 islands in all areas where it occurs except Torres Strait. It has two main breeding populations, one in the Capricorn-Bunker cays where it currently breeds on eight islands, and the other in the inner islands of the Northern Great Barrier Reef where it breeds on nine islands. No large colonies have been reported on any islands, with most colonies consisting of fewer than a dozen nests.

Rufous Night Heron *Nycticorax caledonicus*

Breeds in numbers on at least three northern islands, at Deliverance Island in Torres Strait (Draffan *et al.* 1984), and on Moulter Cay and Raine Island in the Far Northern Section. There is also a large seasonal feeding aggregation of Night Herons on Crab Island in the Gulf of Carpentaria (Limpus *et al.* 1983). On all four islands the Night Herons are seasonal visitors that use the eggs and hatchlings of nesting sea turtles as their main food source, and on three of these islands (Raine, Moulter and Deliverance), the herons also breed. At Raine and Moulter there are Green turtles nesting from October to April, and on these islands the herons are summer nesters. At Crab and Deliverance Island, the herons predate the breeding of Flatback turtles, which nest all year with a peak of hatching in mid-year. Night Heron nesting was reported on Deliverance Island in June 1980 (Draffan *et al.* 1984), but nesting was not confirmed at Crab Island (C. J. Limpus, pers. comm.). Populations of this species therefore might vary their breeding times to coincide with the period of abundance of their food source.

Rufous Night Herons banded as nestlings on Raine Island in 1983 and 1984 have been recovered in southern New Guinea, indicating that this population is migratory between Raine Island and New Guinea (B. R. King, pers. obs.).

Silver Gull *Larus novaehollandiae*

Present on almost all islands with widespread breeding over the Great Barrier Reef, also on islands in Torres Strait. Breeding distribution has not been fully documented throughout its range, and there are no breeding records from the Gulf of Carpentaria. In the Great Barrier Reef the main breeding area is on some of the Capricorn-Bunker cays, where the largest colonies are on Wreck Island (110+ pairs), Masthead Island (60+ pairs), Tryon Island (60+ pairs) and Lady Musgrave Island (50+ pairs) (Hulsman 1984). Elsewhere, Silver Gulls nest mostly on inner islands as isolated pairs or in small scattered groups. The largest northern colonies are 50+ pairs on Double Cone Island (K.R. MacDonald pers. comm.), 20+ nests in the Lizard Island group (Smith 1991b), and 26+ pairs and 70 birds on Farmer Island (Piper Islands) in May 1988 (King and Limpus 1991).

Silver Gull populations in the Great Barrier Reef are largest near coastal towns, where ample food is available from garbage dumps and sewage plants. Where human activities and associated edible refuse expand out to islands, the gulls follow the food source as scavengers, thereby increasing their populations on tourist islands and becoming a problem as opportunistic predators in nearby seabird colonies as well. Elsewhere, on seabird islands with little human visitation, Silver Gull populations are small, e.g. the large seabird colony on Raine Island supports only a small resident population of about 30 Silver Gulls (B. R. King, pers. obs.).

Caspian Tern *Hydroprogne caspia*

Widespread on inner islands and on coastal beaches. It breeds as isolated solitary pairs on the inner islands of the Far Northern Section and the Mackay-Capricorn Section. The only colonial nesting is on Skull Island in Shoalwater Bay, where 50+ nests were recorded in April 1990 (C. J. Limpus, pers. comm.). Since 1980 it has been recorded breeding on eight inner cays of the Far Northern Section and on two coastal islands, Skull and Akens Islands in Shoalwater Bay. No breeding has been recorded in Torres Strait (Draffan *et al.* 1984) or in the Gulf of Carpentaria.

Roseate Tern *Sterna dougallii*

Not breeding in the Gulf of Carpentaria or Torres Strait, nor in the South-east. It breeds throughout the Great Barrier Reef, with two main breeding concentrations. A southern population breeds on at least seven Capricorn-Bunker cays and two cays in the Swain Reef area, which also has a large number of non-breeding individuals. The northern population has not yet been fully surveyed, but breeding has been recorded on seven inner cays of the Northern Great Barrier Reef. In addition, breeding has been recorded on four islands of the Central Great Barrier Reef. It is a nomadic species, showing no preference for particular islands or parts of islands for breeding sites.

In 1985/86, Walker (1988a) recorded a large non-breeding population of 12 000–16 000 Roseate Terns in the Southern Great Barrier Reef, most of which were on the Swain Reef cays. Breeding was then in progress on five islands, with the largest colonies on Wreck Island (520 pairs), Masthead Island (450 pairs), Hoskyn Island (156 pairs) and Holbourne Island (50 pairs). The southern population has been recorded breeding on a total of seven Capricorn-Bunker cays and two Swain Reef Cays.

The northern population has not been fully documented, but observations there suggest that breeding occurs in winter as well as summer and that breeding numbers might greatly exceed those of the southern breeding population (e.g. August 1982, Cholmondeley I: 900+ dead chicks (King *et al.* 1989); March 1987, Wallace I: 5 000+ pairs (King *et al.* 1989). There is, however, no evidence of a large non-breeding population comparable to that of the Southern Great Barrier Reef.

Little Tern *Sterna albifrons*

Occasionally recorded breeding on the inner Great Barrier Reef islands, e.g. one pair in October 1986 on Stephens Island (South Barnard Islands) (Walker and Oldroyd 1991), two pairs in January 1991 on Thomas Island (Whitsunday Islands) and 10+ pairs nesting on Camp Island at the Elliot River mouth in 1991 (D. Cameron, pers. comm.). Non-breeding flocks are occasionally recorded on inner Great Barrier Reef islands. Nesting also takes place on isolated mainland beaches, e.g. 20+ pairs nesting on a beach near

the mouth of Cattle Creek near Townsville in December 1985 (B. R. King, pers. obs.), but the extent and distribution of this has not been fully documented. A large flock of over 200 birds resting on a sandspit at Cape Bowling Green in March 1991 (D. Cameron, pers. comm.) might indicate either a migration route or a non-breeding population in coastal eastern Queensland.

Black-naped Tern *Sterna sumatrana*

A common species, breeding on inner and outer islands throughout the Great Barrier Reef, Torres Strait and the Gulf of Carpentaria. It is a nomadic species, with no favoured breeding sites or islands, and flocks appear to vary their choice of breeding site from year to year. Colony sizes are also variable, ranging up to over 100 pairs.

Walker (1986a) recorded breeding on 14 out of 173 islands in the southern Barrier Reef between Holbourne and Lady Elliot Islands in 1985/86.

Sooty Tern *Sterna fuscata*

An oceanic species, breeding on at least two outer islands of Torres Strait (Bramble Cay and Murray Island Sandbank), on seven outer cays (MacLennan Cay, Moulter Cay, Raine Island, Sandbank No 8, Sandbank No 7, Davie Cay and Tydeman Cay) and on three isolated inner cays (Stapleton Island, Combe Island and Michaelmas Cay) of the Northern Great Barrier Reef. There are no breeding records for the Southern Great Barrier Reef, apart from one record of three chicks of this species on Bell Cay in the Swain Reefs (Moseley 1985) and a chick on One Tree Island (Hulsman 1979).

At Michaelmas Cay the Sooty Tern has a sub-annual breeding cycle of 8–9 months (King *et al.* 1991), but this has not been investigated on other islands. As discussed below (see 'Seasonality of Breeding'), the available records suggest there might be a subannual breeding cycle for the Sooty Tern at Bramble Cay but annual mid-year breeding for the islands between it and Michaelmas Cay (excepting Murray Island Sandbank for which insufficient records are available).

Bridled Tern *Sterna anaethetus*

Widely distributed on a large number of vegetated islands in all areas except for the

South-east. The largest colony on record is on Eshelby Island in the Central Section, with 1 000+ pairs.

Crested Tern *Sterna bergii*

Widely distributed in Queensland waters and breeding on many islands in all areas except for the South-east. Walker (1988b) recorded breeding on 11 out of 173 islands south of Holbourne Island in 1985-86, with the largest colonies on Eshelby Island (3 600 pairs) and Lady Elliot Island (3 500 pairs). The largest colony on record is 3 960 nests at Michaelmas Cay in February 1983 (King 1985d). They are a nomadic breeder, showing variation in colony size and choice of nesting island from season to season.

Lesser Crested Tern *Sterna bengalensis*

Widely distributed in all areas with two main breeding populations: a smaller southern one breeding on three Swain Reef cays and two Capricorn-Bunker cays; and a larger northern one breeding on at least four islands in the Cairns Section and on five inner cays and three outer cays of the Far Northern Section (Table 1). The largest breeding colonies on record are 2 800+ pairs on Pelican Island in November 1976 (C. J. Limpus: King *et al.* 1985), and 1 000+ pairs on Michaelmas Cay in October 1983 (King 1985d). Like the Crested Tern, it is a nomadic species.

Common Noddy *Anous stolidus*

A widely distributed species, breeding on many islands in two areas. A southern population breeds in the Swain Reefs and on some Capricorn-Bunker cays, and a northern population breeds on the outer and inner vegetated cays from Michaelmas Cay northwards into Torres Strait. There is a gap in its breeding distribution from Michaelmas Cay south to the Swain Reef cays. It shows differences in the time of year at which it breeds in different areas of the Great Barrier Reef (see 'Breeding Seasons' below).

Black Noddy *Anous minutus*

A widespread species, breeding on islands in two areas of the Great Barrier Reef, but not in the South-east, Torres Strait or in the Gulf of Carpentaria. It has two main breeding populations, a smaller northern one in the Northern

Great Barrier Reef and a much larger southern one on seven of the Capricorn-Bunker cays. There is a gap in breeding distribution between Combe Island in the north and Tryon Island in the south, which includes the Swain Reef cays.

The major portion of the southern breeding population is in the mature *Pisonia grandis* forests of Northwest, Masthead, Heron and Lady Musgrave Islands, with smaller populations on Hoskyn, One Tree and Lady Elliot Islands. The smaller northern population has colonies on Wallace Island, Bird Islands, Piper Islands, Quoin Island, Chapman Island and Sherrard Island. There is also a large roosting population in the north that uses several islands, including Douglas Island, Bird Islands, Raine Island, Sandbank No 8, Stapleton Island, Combe Island and Rocky Islet (Far Northern Section), and Bushy Island (Central Section). On Raine Island I have estimated the mixed roosting population of Common and Black Noddies to exceed 100 000 birds (King 1986a).

In the Northern Great Barrier Reef, the roosting population greatly exceeds the breeding population, and a large proportion of these birds that I have observed and banded at Raine Island are immature individuals. These might be young birds that move to this area from the south. So far there has been only one recovery of a Black Noddy banded as a nestling on a Capricorn-Bunker cay that was recovered at Michaelmas Cay within three months of banding (Ogilvie and Humphrey-Smith 1989). There is also a substantial breeding population on some of the Coral Sea cays to the east, and young birds from this area might also be moving to the Northern Great Barrier Reef.

THE INFLUENCE OF ISLAND TYPE AND LOCATION ON SEABIRD BREEDING

The recent records show that a total of 24 species of tropical seabirds have substantial breeding colonies on at least 58 Queensland islands (Table 2). Of these 58 colonies, 54 are within that area of the Great Barrier Reef between the southern boundary of Torres Strait and the southern boundary of the Great Barrier Reef. Of these islands, the cays are the most important islands for seabird breeding with 40 colonies, while the continental islands have 10 colonies and the low wooded islands four. Torres Strait has one large colony at Bramble Cay, the

Gulf of Carpentaria has two on continental islands on Manowar and Rocky Islands, and the South-east has one colony on continental Mudjimba Island. None of the Large Sand Islands or Mangrove Islands have breeding colonies of any of the seabird species under consideration.

The seabird populations and species composition of islands are also related to their geographical location. The Great Barrier Reef has two main areas for seabird breeding, the northern islands that lie between Bramble Cay and Michaelmas Cay, and the southern cays of the Swain Reefs and the Capricorn-Bunker group. The area between has very few seabird colonies, the largest of which are Eshelby Island and the South Barnard Islands.

The islands of the Northern and Southern Great Barrier Reef are Queensland's main seabird breeding areas. They have the largest number of colonies, with the highest diversity of species and the largest populations of breeding birds of both oceanic and inshore species. Within these two areas, the northern Great Barrier Reef, with 26 colonies and 23 breeding species, has the largest number of colony islands and the most breeding species of breeding seabirds. The southern area has 22 colonies and 18 species of breeding seabirds, but has a much larger number of seabirds with its extremely large populations of Wedge-tailed Shearwaters and Black Noddies. The Northern Great Barrier Reef islands have a number of species uncommon in the Great Barrier Reef region, i.e. Herald Petrel, Great Frigatebird, Red-footed Booby and Red-tailed Tropicbird. The two areas between them have substantial populations of Least Frigatebird, Roseate Tern, Lesser Crested Tern, Masked Booby and Brown Booby.

A difference in seabird composition can be seen between the inner and outer cays of Torres Strait and the Northern Great Barrier Reef, and between the cays of the Swain Reefs and the Capricorn-Bunker group in the south (Table 4).

In the north, the outer cays are Bramble Cay, Anchor Cay, East Cay and Murray Island Sandbank in Torres Strait, plus Moulter Cay, MacLennan Cay, Raine Island, Sandbank No 8, Sandbank No 7, Davie Cay, Tydeman Cay and Sandbank No 1. The outer cays are all sparsely vegetated with a small number of plant species, which provides a suitable nesting habitat for

ground-nesting seabirds. Their distances offshore (from 20 to over 100 kilometres) and their positions on or close to the edge of the continental shelf make them accessible to oceanic seabirds like the Herald Petrel, frigatebirds, boobies, Red-tailed Tropicbird and Sooty Tern. This difference was also noted by Lavery and Grimes (1971) and Kikkawa (1976). MacLennan Cay and the Ashmore Banks are remote cays inside the outer barrier reefs, but their vegetation and seabird communities are typical of the outer cays. Stapleton and Combe Islands have mixed seabird populations, with species typical of the outer cays (Brown Booby, Sooty Tern) and of the inner cays (Australian Pelican, Caspian Tern). Michaelmas Cay also has characteristics of an outer cay, with its large population of Sooty Terns.

Similarly, the Swain Reef cays lie a long distance offshore and are sparsely vegetated, and these cays attract three ground nesting oceanic species, the Masked Booby and Brown Booby, and the Least Frigatebird which can adapt to ground nesting in the absence of trees. Red-tailed Tropicbirds have also recently colonized Lady Elliot Island, the most remote of the Capricorn-Bunker cays. A number of the remainder of these two inner groups of cays have *Pisonia* forests and have large numbers of tree-nesting Black Noddies and burrow-nesting Wedge-tailed Shearwaters.

THE INFLUENCE OF ISLAND VEGETATION ON SEABIRD BREEDING

The presence or absence and the structure of vegetation communities have a strong effect on the species composition and numbers of seabirds that breed on islands (Figs 3, 4 and 5). The amount and density of ground cover limits the availability of open space to ground-nesting seabirds. The outer cays of the Great Barrier Reef lack a dense vegetation cover and this limits their populations of oceanic seabirds to those species that normally nest on the ground or are able to adopt this habit.

Sooty Terns nest in scrapes on the ground on remote oceanic islands. However, in the Great Barrier Reef region they do not use any of the unvegetated outer cays, but instead use vegetated cays, where they nest on the sand among clumps of *Lepturus* grass and *Boerhavia* herb. This enables them to coexist with Common Noddies who nest on these plants and avoid bare sand.

The breeding distribution of three oceanic species, Great and Least Frigatebirds and the Red-footed Boobies, is influenced by the lack of trees and tall shrubs on the outer cays of the Great Barrier Reef. Great Frigatebirds are rarely found breeding on Great Barrier Reef islands. Some Coral Sea cays with forests or shrub thickets have large populations of breeding Frigatebirds and on these, Great Frigatebirds exceed Least Frigatebirds in number (P. Ogilvie, pers. comm.). On the Queensland islands Raine Island, Quoin Island, Bell Cay (Great Barrier Reef) and Rocky Island (Gulf of Carpentaria) there are colonies of almost entirely Least Frigatebirds with rare occurrences of Great Frigatebirds. Least Frigatebirds are apparently able to tolerate nesting on the ground but Great Frigatebirds are almost exclusively tree nesters and this habit restricts nearly all of them to the Coral Sea cays.

Red-footed Boobies are common on those Coral Sea cays with tree or shrub cover, but nest only on Raine and Moulter Cay in the Great Barrier Reef. Raine Island has low shrubs of *Abutilon indicum* and *Sesbania cannabina* on which over 100 pairs nest through the year. On Moulter Cay, less than 20 pairs nest, mostly on *Abutilon* shrubs but occasional nests are also found on large clumps of the grass *Lepturus repens*.

The Common Noddy does not nest on the ground, but nests close to it on ground cover vegetation, and shows a preference for siting its nests on clumps of the grass *Lepturus repens*. At Michaelmas Cay, *Lepturus* is used for most nest sites and clumps of the herb *Boerhavia repens* are used less often, while a patch of *Spinifex hirsuta* grass is rarely used for nesting.

The strongest association between a breeding seabird and a plant species is that of the Black Noddy and the tree *Pisonia grandis*. *Pisonia* forests support large colonies of tens of thousands of Black Noddies on the Capricorn/Bunker cays of the Southern Great Barrier Reef. However, few of the northern islands have *Pisonia* forests and on northern islands the Black Noddy nests in small colonies of a few thousand pairs each in mangrove forests on the Bird Islands, Piper Islands, Chapman Island and Sherrard Island. *Pisonia* is used for breeding only on Quoin and Wallace Islands, which have small colonies of a few hundred pairs each, while apparently suitable

stands of *Pisonia* trees on Rocky Islet and Douglas Island are used only for roosting, as is a similar forest on Bushy Island in the Central Section. In addition, on the low wooded islands Bird Islands and Farmer-Fisher Island of the Piper Islands, stands of *Pisonia* on the cays are used for roosting while thousands of pairs breed in mangroves a short distance away.

Pisonia forests also provide the habitat for another important nesting association. Wedge-tailed Shearwaters nest in their greatest numbers in burrows in the sandy soil under *Pisonia* forests on the Capricorn/Bunker cays. However, in the Northern Great Barrier Reef they breed on some islands with different vegetation, e.g. in sand under grasses and shrubs on Raine Island, Combe Island and Fife Islands, and in sand under *Pisonia* only on Rocky Islet.

BREEDING SEASONS

In this discussion, the term "breeding period" refers to the length of time taken for a pair of birds to complete a full breeding cycle from pre-nesting behaviour to fledging of the young, while "breeding season" refers to the length of time taken by all members of a colony or population to breed.

A major problem in clearly describing breeding seasons in the Great Barrier Reef is the lack of multiple observations at any site to cover all months of the year. The most complete set of observations is at Michaelmas Cay where our continuous monthly monitoring counts, begun in April 1984, have now been in progress for over seven consecutive years. We now have detailed records of the breeding of four species, the Sooty Tern, Common Noddy, Crested Tern and Lesser Crested Tern, and the results of our first six years of counts have been published (King *et al.* 1992). In addition, at some Capricorn-Bunker cays, and in the north at Eagle, Raine, Moulter, Sandbank No 8 and Bramble Cay, there are a number of observations spread over several years and covering the summer and winter periods.

Differences in the breeding seasons among populations of the same species nesting in the southern and northern portions of the Great Barrier Reef have been previously discussed by Serventy *et al.* (1971), Lavery and Grimes (1971) and Kikkawa (1976). Lavery and Grimes



Figure 3. Sherrard Island (looking west). A low wooded island of the inner reefs of the Northern Great Barrier Reef, consisting of a small coral reef with seaward shingle ridges at the north-eastern end, a small cay of coral sand with low vegetation at the north-western end, and an area of mangroves in the lee of the shingle ridges. Three lines of beachrock lie on the reef flat near the southern edge of the cay. Bridled Terns breed in the vegetated area and Lesser Crested Terns on the sand of the cay. Black Noddies nest on the branches of the mangroves (King 1991b).

Photo: B. R. King



Figure 4. Seabirds on beach of Thomas Cay, an unvegetated sand cay of 170 m by 70 m upon which Masked and Brown Boobies, Silver Gulls, Crested Terns and Lesser Crested Terns breed. The surface of the cay is less than 2 m above high water and is susceptible to overwash and erosion by the sea during storms. Seawater overwash may be partly responsible for the absence of vegetation (Walker et al. 1989).

Photo: T. A. Walker

considered that most species were summer breeders, with many species extending their northern breeding seasons into the winter and a few changing to winter breeding.

Changes in the length of the breeding season for a species can be most easily explained by changes in the degree of synchrony among the breeding cycles of the members of breeding populations in different areas, i.e. the lower the synchrony, the longer the breeding season. However, within the Great Barrier Reef, a number of breeding regimes appear to be operating. The most recent information has helped to clarify the situation a little, but more observations on each species at a number of sites are required before the differences can be fully understood.

Two species, the Wedge-tailed Shearwater and Lesser Crested Tern, are strict summer breeders, showing little or no variation in the length of their breeding season from south to north. Two others, the Masked and Brown Booby are annual summer breeders with long breeding cycles that exceed seven months, resulting in an extended breeding season in which pairs may be nesting in all months of the year, but with a marked summer peak in numbers.

Two species, the Herald Petrel and Caspian Tern, are strict annual winter, or mid-year breeders. Two others, the Least and Great Frigatebirds, have their incubation periods in mid-year, but have long breeding cycles that exceed twelve months. As a result, pairs that successfully raise young to independence can only breed every second year. Breeding cycles are highly synchronised, so that each year, courtship begins in early April and egg-laying is completed by the end of May by pairs that have no dependent young from the previous season.

The Red-footed Booby, appears to breed in all months of the year on Raine Island and Moulter Cay, with no discernible peak in numbers.

Several species change from an annual summer breeding season in the south to a more extended season in the north, e.g. Roseate Tern, Black-naped Tern and Crested Tern. The Bridled Tern has annual summer nesting through most of the Great Barrier Reef but appears to nest in all months on at least one northern outer cay, Raine Island. The Black Noddy breeds in summer on the Capricorn-Bunker cays in the south, but has

an extended season on two northern islands, Quoin Island and Wallace Island, with the peak of breeding in summer but some pairs still nesting in mid-year. In addition, I have recorded lone pairs of Black Noddies nesting in July on Raine Island, Combe Island and Michaelmas Cay. The breeding season of the Red-tailed Tropicbird changes from annual summer breeding on Lady Elliot Island in the south to year-round breeding with a winter peak at Raine Island in the north. At Raine Island, a small number of Red-tailed tropicbirds who failed to breed successfully in October and November returned in the following June and July to re-nest, in the process changing from a summer breeder to a winter one (B. R. King, pers. obs.).

The Silver Gull is a winter breeder in the north, but extends its season in the south to include some of the summer months. The Australian Pelican is a winter breeder in the south with an extended season in the north that includes the summer months.

Two species, the Common Noddy and Sooty Tern, show unusual changes in the timing and lengths of their breeding seasons in the Barrier Reef. In the Swain Reef cays the Common Noddy has year-round breeding with a summer peak. At Michaelmas Cay it also has annual year-round breeding with a peak of breeding in summer (King *et al.* 1992). To the north, from Stapleton Island to MacLennan Cay, it is a strict winter breeder, with no summer breeding. However, on Bramble Cay at the northern extremity of the Barrier Reef, large numbers breed in summer (there are no winter records from this island for comparison). T. A. Walker (pers. comm.) has suggested that the Bramble Cay population of the Common Noddy might be a separate one from those elsewhere in the Great Barrier Reef, with feeding areas to the west in the Gulf of Carpentaria and the Arafura Sea, but this has yet to be confirmed.

At Michaelmas Cay, the Sooty Tern population has a sub-annual breeding cycle, breeding at intervals of about 8.5 months, with some pairs breeding in every month of the year (King *et al.* 1992), but there are insufficient records from other colonies to give such a precise indication of breeding cycle length elsewhere in the Great Barrier Reef. However, records over several

years from Stapleton Island, Tydeman Cay, Davie Cay, Sandbank No 8, Raine Island, Moulter Cay and MacLennan Cay show no summer nesting of Sooty Terns and suggest that on these islands it is an annual winter breeder. Further north again at Bramble Cay, there are records of breeding in progress in October 1979 and ending in January 1980 then resuming again in March 1980, plus other records from November 1978 to November 1988, which led Elvish and Walker (1991) to suggest a sub-annual breeding cycle for this island also.

In the Sooty Tern, therefore, we appear to have a situation of year-round sub-annual breeding with an 8.5 month cycle at the southern end of its range, with annual winter breeding further north, and sub-annual year-round breeding further north again. In the Common Noddy, there appears to be annual summer breeding in the southern part of its range, year-round annual summer breeding at Michaelmas Cay, then annual winter breeding further north and annual breeding in at least summer further north again. In both species the changes in timing of their breeding occur in the same areas, with the change to annual winter breeding beginning at Stapleton Island, then changing again at Bramble Cay. The reasons for this are not yet known.

While changes in the length and timing of breeding seasons are evident for several seabird species along the length of the Great Barrier Reef, we do not know whether there are changes in these from one side of the Great Barrier Reef to the other. There is still insufficient data to examine this in detail, but I suspect that for most species the Barrier Reef region is too narrow for any changes to occur across it in either breeding periodicity or breeding season. However, in the Northern Great Barrier Reef, Bridled Terns are summer nesters on the inner islands but might nest all year on the outer cays Raine Island and Moulter Cay. Other areas that could be examined are the inner and outer cays of the Far Northern Section, also the Capricorn/Bunker and the Swain Reef cays. Equally interesting would be a comparison between the breeding seasons of seabirds in the Great Barrier Reef islands and the Coral Sea cays.

CONSERVATION

Queensland's seabird populations are affected by two main factors, environmental influences

and human interference. The environmental influences are numerous and are often inter-related.

In a six-year study of population numbers of four species at Michaelmas Cay, (King *et al.* 1992), we found that breeding populations of the Sooty Tern, Common Noddy, Crested Tern and Lesser Crested Tern were affected by summer cyclones from November to April and by winter gale periods from May to October. The effects were multiple. Eggs and chicks were lost from direct exposure to wind, rain, lowered temperatures, wave inundation and erosion. During cyclones the adults deserted, losing all eggs and young. Indirectly, massive losses of chicks sometimes took place during gale periods from adults being unable to capture prey fish because of rough sea conditions or from prey moving too deep for the shallow-diving terns to reach them. This resulted in a food shortage, leading to desertion by adults and deaths of young from starvation and exposure. I have recorded similar population crashes on other Northern Great Barrier Reef islands.

Erosion due to wind, wave action, high tides and changing current patterns can remove large areas of seabird nesting habitat. Because they are composed of coral sand and reef sediments, sand cays are unstable, often highly so, and are at the mercy of these forces that cause erosion and accretion of their substrate. Erosion can remove nesting habitat and also destroy large numbers of nests and their contents. Erosion of one portion of a cay is often matched by the accretion of new sand deposits on another part, so that new nesting habitat is created for ground-nesting seabirds. At the same time, this process causes many sand cays to move slowly about on their parent reef. An extreme case of this process is taking place at Bramble Cay in Torres Strait, where constant erosion and accretion has moved the cay to the edge of its reef where sand is gradually falling from the reef into the channel. As this sand cannot be recovered, in time the entire cay may disappear. Former movements of Stainer Island (King 1985a) and Combe Islands (King *et al.* 1985) in the Northern Great Barrier Reef have left these cays beside lines of beachrock that once enclosed them.

Occasionally, cay erosion can be exacerbated by human interference with the process. Erosion

at Heron Island was created by the excavation of a deep channel and boat harbour through the reef. This altered the drainage patterns of the reef and caused strong currents to flow past the cay and out to sea through the channel with the outgoing tide, and this in turn caused erosion on both sides of the cay. Attempts to halt the erosion by constructing rock walls have only served to shift the erosion to the beach beyond the end of the wall.

Human activities also affect seabird islands by altering or damaging habitat. On Queensland islands at present, this is mostly by the human use of islands for camping, or by the removal of vegetation cover in association with construction of resort or other facilities. The beche-de-mer trade of the last century removed all combustible vegetation from islands where these holothurians were processed. Guano was mined on several Barrier Reef islands early in this century and this greatly altered a number of islands, including Raine and Lady Elliot Islands. The Raine Island seabird colony seems to have recovered with no ill effects and today still has all of the breeding species that were there in early accounts. Masked Boobies on Raine Island have probably benefited from the flat, exposed areas created by the excavations, and frigatebirds now nest on the slopes of the rockpiles left by the miners. The mining at Raine Island only removed the compacted fresh guano, but a proposal in 1964 to remove the deposit of phosphate rock from this island would have had a drastic effect on the cay and its birds, by removing the stable rock base and also opening up the whole island to turtle nesting. The low rock cliff at the edge of the phosphate rock cap prevents most wandering turtles from gaining access to the main seabird nesting area in the centre of the cay.

At Lady Elliot Island the devegetation from mining was exacerbated by the introduction of goats, which prevented the revegetation of the cay until their removal in the 1970s. Since then, shrubs have re-established and the seabird population is increasing and changing as tree-nesting species use the developing habitat. Other animals introduced to Queensland seabird islands include domestic cats and fowls on Northwest Island and rats *Rattus rattus* on Heron, Wreck and Fairfax Islands. Rats prey on all ground-nesting birds, but have been removed from Heron Island. Until their recent removal, the cats on

Northwest Island were a major predator of Wedge-tailed Shearwaters.

Human predation on seabirds in Queensland is almost totally restricted to egg predation. Brown Booby chicks were taken from Bramble Cay up to 1980 (D. Carter, pers. comm.) and any still produced there probably still are. Egg harvesting is still carried out in Torres Strait as a traditional activity and this has depleted the Bramble Cay colony and others in the area, but there is little of this activity elsewhere in Queensland. Crews of pearling, trochus and beche-de-mer vessels formerly lived partly off the seabird islands, but this has ceased with the collapse of these industries and outside of Torres Strait the populations have recovered. Commercial egg harvesting at Michaelmas Cay ceased more than forty years ago.

Human disturbance in seabird colonies is a problem on islands in all major tourism areas of Queensland, in particular on Michaelmas Cay, the Whitsunday islands and the Capricorn-Bunker cays (Fig. 5). Recent expansion of tourist activities over much of the Queensland coast has meant that visitors are now reaching the most remote parts of the Great Barrier Reef in increasing numbers and seabird disturbance is an increasing problem.

Predation of eggs and chicks by Silver Gulls in seabird colonies is increased by human disturbance causing birds to leave their nests exposed to the elements or to predators. This is a problem on islands where visitation is high and frequent, e.g. on the Capricorn-Bunker cays and Michaelmas Cay. The dumping of garbage on islands or at sea and feeding fish from tour vessels provide a food source for scavenging gulls, resulting in an increased population in the area. This in turn leads to increased Silver Gull predation in nearby seabird colonies, especially where the seabirds are being disturbed by visitors.

Protection of seabirds and seabird colonies can only be provided by a combination of legislation, education and enforcement. Regulations and protective land tenure are useless unless given an adequate backup. Under Queensland's wildlife legislation, the strongest form of protection available is the Fauna Refuge, followed by the National Park Scientific Area, to which access is only allowed by permit, and the National Park to which a greater degree of public access is allowed

under regulations. In addition, all areas of Crown Land in Queensland are classed as Fauna Sanctuaries, which gives nominal protection. The National Parks and Wildlife Act of Queensland provides for National Parks to provide for public recreation purposes in National Parks, and this often conflicts with wildlife management. Queensland, unlike Great Britain, has no legislative provision to put conservation values ahead of recreation in situations of conflict.

Additional tenures exist under other Queensland State legislation that could also be used to protect land areas or islands, e.g. the Departmental and Official Purposes Reserve of the Lands Act. However, designating land required for conservation purposes to a multitude of Government departments and individuals merely adds further confusion to the issue. Public access is also denied to Commonwealth Department of Defence Reserves and Lighthouse Reserves, and the provisions of the Commonwealth Great Barrier Reef Marine Park Act, Marine Park zoning and management plans apply to all Commonwealth islands. However, colonies on lighthouse islands are subjected to occasional disturbance from visits by lighthouse maintenance crews. These tenures provide at least nominal protection to seabird colonies on islands, but all depend on the level of enforcement of regulations and ultimately on the sympathy of a political party in Government towards conservation and management of natural resources.

Of the 58 islands in Queensland with significant seabird colonies, there are a total of three Fauna Refuges and 28 National Parks, plus six Commonwealth Lighthouse Reserves and one Defence Reserve (Table 3). Of the remainder, two are under Crown Leasehold and 18 are Vacant Crown Land. Both Heron and Wilson Island have developed leasehold areas within National Parks, while Lady Elliot Island has Lighthouse Reserve and leasehold areas. Heron and One Tree Islands have research stations on leasehold areas, and Raine Island, Moulter and MacLennan Cays are designated as research areas.

Some form of protective tenure thus covers most of Queensland's main seabird islands, but some areas require further attention from conservation authorities and legislators. All seven of the Swain Reef cays are Vacant Crown Land. In the Cairns Section, Eagle Island is Crown Land.

In the Far Northern Section, The five largest seabird colonies of the outer cays are either Fauna Refuges or National Parks, and in the inner cays 11 of the 14 seabird colonies are National Parks. Consideration should be given to converting Ashmore Banks, Davie Cay, Tydeman Cay, Sandbank No 1 and Stainer Island to National Park status. The only substantial colony in Torres Strait is Bramble Cay, which has Lighthouse Reserve status, but is subjected to egg-collecting. In the Gulf of Carpentaria, both Rocky and Manowar Islands are Vacant Crown Land and require conversion to National Park status.

The need for adequate protection and management of Queensland's tropical seabird colonies and populations has been highlighted by surveys in the southern Pacific Ocean that indicate a substantial and continuing decline in breeding seabird populations over much of the Indo-Malayan and southern Pacific regions (de Korte 1984; Barnett 1984). This has been largely caused by the pressure of human activities, through the over-harvesting of seabirds, eggs and chicks and associated disturbance in colonies, by human intrusion into seabird islands, by competition for island space, by changes in vegetation and land usage for agriculture, and by the introduction of feral animals to islands.

Queensland, and in particular the Great Barrier Reef Region, has the largest and most diverse population of tropical seabirds in Australia. In addition, the Great Barrier Reef and Coral Sea have a large, diverse and relatively undisturbed stock of breeding tropical seabirds, one of the last and possibly the largest remaining in the south-western Pacific and Indo-Malayan regions. Australia has an international obligation to preserve and maintain this faunal resource.

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APPENDIX I — Sources of Information

In the last fifteen years, and particularly during the last decade, the amount of interest in the seabirds and islands of Queensland has been substantial, as the following list of surveys and published material will indicate. Recent surveys of Queensland seabirds include the following:

The Gulf of Carpentaria:

Wellesley Is: Walker (in press); Rocky I: Garnett and Crowley (1977a); Manowar I: Garnett and Crowley (1987b); Crab I: Limpus *et al.* (1983); unpublished surveys by C. J. Limpus.

The Torres Strait:

Kusamet I: Garnett (1987); Booby I: Ingram *et al.* (1986); Garnett *et al.* (1988); Bramble C: Elvish and Walker (1991); Surveys by Ingram (1976). Draffan *et al.* (1984); unpublished surveys by C. J. Limpus, J. Parmenter and T. A. Walker.

The Northern Great Barrier Reef:

MacLennan C: Limpus (1980); King, Limpus, Seton and Tomes (1983a); Cholmondeley I: King, Hicks and Oldroyd (1989); Moulter (formerly Pandora) C: King, Limpus, Seton and Tomes (1983b); Wallace I: King, Limpus, Hicks and Oldroyd (1989); Raine I: Warham (1977); Stoddart, MacLean and Hopley (1981); King (1984); King and Reimer (1991); Saunders Island: (King and Limpus (1989); Bird Islands: King and Limpus (1985); Magra I: King (1989); Ashmore Banks: King and Limpus (1983a); Piper Islands: King and Limpus (1991a); Quoin I: King and Buckley (1985a); Chapman I: King (1991); Sherrard I: King and Limpus (1991b); Sandbank No 8: King, Limpus and Seton (1983); Sandbank No 7: King and Limpus (1983b); Fife Island: King, Limpus and Walker (1991); Pelican I: King, Buckley and Limpus (1985); Stainer Island: King (1985a); Davie C: King and Buckley (1985b); Tydemann C: King and Buckley (1985c); Pipon I: Warham (1967); King (1986b); Sandbank No 1: King (1985b); Stapleton I: King (1985c); Combe I: King, Godwin and Rees (1985); Eagle I: Domm (1977); Smith (1987); Smith (1991a,b); Smith and Buckley (1986); Rocky It: Domm (1977); Smith and Ogilvie (1989); Lizard I: Domm (1977); Nymph I: Smith (1993); Michaelmas C: King (1985d); King *et al.* (1991); South Barnard Is: Walker and Oldroyd (1991); and Purtaboi I: Walker (1993). Surveys (published and unpublished) by B. R. King, R. C. Buckley, C. J. Limpus, T. A. Walker, D. L. Stoddart (1978); G. C. Smith, and Old NPWS; population monitoring of Michaelmas Cay (monthly counts for six years, 1984–1990) (King *et al.* 1991).

The Central Great Barrier Reef:

Brook Is: Thorsborne and Thorsborne (1986); Holbourne I: Walker (1989b); Eshelby I: Walker and Hegerl (1986).

The Southern Great Barrier Reef:

(a) The Southern Coastal and Mackay area Islands:

East Rock: Walker (1992); Bushy I: Walker (1987); Redbill I: Walker (1989a); Pelican Rock and Akens I: Walker *et al.* (1993); and unpublished surveys by S. Domm, C. J. Limpus, T. A. Walker, K. R. MacDonald, and B. R. King.

(b) The Swain Reef Cays:

Distant C: Lane (1989); Lane and Heatwole (1991); Frigate C: Walker and Jones (1986a); Bylund C: Walker and Jones (1986b); Price C: Walker and Jones (1986c); Bell C: Walker and Jones (1986d); Gannet C: Walker and Jones (1986e); Bacchi C: Walker *et al.* (1989a); Thomas C: Walker *et al.* (1989); Surveys by Costello (1978); C. J. Limpus, Limpus and Lyon (1981); Limpus and King (1985); Hill (1984); Moverly (1985); Corben and Stokes (1986); Walker (1986a,b); and surveys in progress by H. Heatwole.

(c) The Capricorn-Bunker Cays:

One Tree Island: Domm and Recher (1973); Hulsman (1979); Heron I: Kikkawa and Bowles (1976); Ogden (1979); Barnes and Hill (1979); Tryon I: Walker (1989c); Hulsman *et al.* (1993); North Reef I: Walker and Domm (1986); Lady Elliot I: Walker (1989d); Erskine I: Walker and Hulsman (1989); Tryon I: Hulsman *et al.* (1992); Fairfax I: Walker and Hulsman (1993b); Northwest I: Hulsman and Walker (in press); Wilson I: Walker and Hulsman (1993); Wreck I: Hulsman, Walker and Limpus (in press); Hoskyn I: Walker and Hulsman (unpublished data); Lady Musgrave I: Walker and Hulsman unpublished data; Surveys by Hulsman (1983, 1984a,b), Walker (1986a,b; 1988a,b,c), Walker *et al.* (1986, 1989); and unpublished surveys by C. J. Limpus and the Old National Parks and Wildlife Service.

The South-east:

Mudjimba I: Lane and Battam (1984, 1985).

APPENDIX 2

Queensland islands which have been described in the 'Seabird Island Series', listed in alphabetical order.

Number	Name	Authors	Year	Reference
129	Ashmore Banks	King, B. R. and Limpus, C. J.	(1983)	<i>Corella</i> 7(4): 74-75
194	Bacchi Cay	Walker, T. A., Jones, M. E. and Savage, F.	(1989)	<i>Corella</i> 13(2): 49-50
167	Bell Cay	Walker, T. A. and Jones, M. E.	(1986)	<i>Corella</i> 10(3): 95-97
150	Bird Islands	King, B. R. and Limpus, C. J.	(1985)	<i>Corella</i> 9(3): 73-74
180	Booby Island	Garnett, S. T., Draffan, R. D. W., Hindmarsh, R. W. H. and Williams, A. C.	(1988)	<i>Corella</i> 12(3): 69-71
211	Bramble Cay	Elvish, R. and Walker, T. A.	(1991)	<i>Corella</i> 15(4): 109-111
162	Brook Islands	Thorsborne, A. and Thorsborne, M.	(1986)	<i>Corella</i> 10(3): 84-86
165	Bylund Cay	Walker, T. A. and Jones, M. E.	(1986)	<i>Corella</i> 10(3): 91-92
208	Chapman Island	King, B. R.	(1991)	<i>Corella</i> 15(2): 55-56
190	Cholmondeley I.	King, B. R., Hicks, J. and Oldroyd, A.	(1989)	<i>Corella</i> 13(2): 41-42
158	Combe Island	King, B. R., Godwin, M. and Rees, G.	(1985)	<i>Corella</i> 9(3): 91-93
154	Davie Cay	King, B. R. and Buckley, R. C.	(1985)	<i>Corella</i> 9(3): 83-84
214	Distant Cay	Lane, S. G. and Heatwole, H.	(1991)	<i>Corella</i> 15(4): 117-118
161	Eagle Island	Smith, G. C. and Buckley, R. C.	(1986)	<i>Corella</i> 10(3): 81-83
213	East Rock	Walker, T. A.	(1991)	<i>Corella</i> 15(4): 115-116
196	Erskine Island	Walker, T. A. and Hulsman, K.	(1989)	<i>Corella</i> 13(2): 53-56
163	Eshelby Island	Walker, T. A. and Hegerl, E. J.	(1986)	<i>Corella</i> 10(3): 87-88
222	Fairfax Island	Walker, T. A. and Hulsman, K.	(1993)	<i>Corella</i> 17(5):
210	Fife Island	King, B. R., Limpus, C. J. and Walker, T. A.	(1991)	<i>Corella</i> 15(2): 59-61
164	Frigate Cay	Walker, T. A. and Jones, M. E.	(1986)	<i>Corella</i> 10(3): 89-90
168	Gannet Cay	Walker, T. A. and Jones, M. E.	(1986)	<i>Corella</i> 10(3): 98-100
15	Heron Island	Kikkawa, J. and Boles, W.	(1976)	<i>Austr. Bird Bander</i> 14(1): 3-6
199	Holbourne I.	Walker, T. A.	(1989)	<i>Corella</i> 13(4): 112-114
171	Kusamet Island	Garnett, S. J.	(1987)	<i>Corella</i> 11(3): 77-78
201	Lady Elliot I.	Walker, T. A.	(1989)	<i>Corella</i> 13(4): 118-121
127	MacLennan Cay	King, B. R., Limpus, C. J., Seton, D. H. C. and Tomes, G. R.	(1983)	<i>Corella</i> 7(4): 69-70
193	Magra Island	King, B. R.	(1989)	<i>Corella</i> 13(2): 47-48
169	Manowar Island	Garnett, S. J. and Crowley, G. M.	(1987)	<i>Corella</i> 11(3): 73-74
44	Masthead Island	Jahnke, B. R.	(1977)	<i>Corella</i> 1(3): 48-50
159	Michaelmas Cay	King, B. R.	(1985)	<i>Corella</i> 9(3): 94-96
	Moultar Cay — see	128 Pandora Cay		
138	Mudjimba Island	Lane, S. G. and Battam, H.	(1984)	<i>Corella</i> 8(5): 101-102
200	North Reef I.	Walker, T. A.	(1989)	<i>Corella</i> 13(4): 115-117
223	North-west Island	Hulsman, K. and Walker, T. A.	(1993)	<i>Corella</i> 17(5):
223	Nymph Island	Smith, G. C.	(1993)	<i>Corella</i> 17(5):
66	One Tree I.	Hulsman, K.	(1979)	<i>Corella</i> 3(3): 37-40
128	Pandora Cay	King, B. R., Limpus, C. J., Seton, D. H. C. and Tomes, G. R.	(1983)	<i>Corella</i> 7(4): 71-73
152	Pelican Island	King, B. R., Buckley, R. C. and Limpus, C. J.	(1985)	<i>Corella</i> 9(3): 78-80
219	Pelican Rock	Walker, T. A., Domm, S. B., Limpus, C. J. and Birtles, R. A.	(1993)	<i>Corella</i> 17(5):
207	Piper Islands	King, B. R. and Limpus, C. J.	(1991)	<i>Corella</i> 15(2): 53-54
160	Pipon Island	King, B. R.	(1986)	<i>Corella</i> 10(3): 78-80
166	Price Cay	Walker, T. A. and Jones, M. E.	(1986)	<i>Corella</i> 10(3): 93-94
218	Purtaboi Island	Walker, T. A.	(1993)	<i>Corella</i> 17(5):
151	Quoin Island	King, B. R. and Buckley, R. C.	(1985)	<i>Corella</i> 9(3): 75-77
43	Raine Island	Warham, J.	(1977)	<i>Corella</i> 1(3): 45-47
43/1	Raine Island	King, B. R.	(1986)	<i>Corella</i> 10(3): 73-77
198	Redbill Island	Walker, T. A.	(1989)	<i>Corella</i> 13(4): 110-111
170	Rocky Island	Garnett, S. J. and Crowley, G. M.	(1987)	<i>Corella</i> 11(3): 75-76
197	Rocky Islets	Smith, G. C. and Ogilvie, P.	(1989)	<i>Corella</i> 13(4): 107-109
156	Sandbank No. 1	King, B. R.	(1985)	<i>Corella</i> 9(3): 87-88
131	Sandbank No. 7	King, B. R. and Limpus, C. L.	(1983)	<i>Corella</i> 7(4): 78-79
130	Sandbank No. 8	King, B. R., Limpus, C. J. and Seton, D. H. C.	(1983)	<i>Corella</i> 7(4): 76-77

Appendix 2 — continued

Number	Name	Authors	Year	Reference
192	Saunders Island	King, B. R. and Limpus, C. J.	(1989)	<i>Corella</i> 13(2): 45–46
209	Sherrard Island	King, B. R. and Limpus, C. J.	(1991)	<i>Corella</i> 15(2): 57–58
212	South Barnard Is	Walker, T. A. and Oldroyd, A.	(1991)	<i>Corella</i> 15(4): 112–114
153	Stainer Island	King, B. R.	(1985)	<i>Corella</i> 9(3): 81–82
157	Stapleton Island	King, B. R.	(1985)	<i>Corella</i> 9(3): 89–90
195	Thomas Cay	Walker, T. A., Jones, M. E. and Savage, F.	(1989)	<i>Corella</i> 13(2): 51–52
220	Tryon Island	Hulsman, K., Walker, T. A. and Domm, S.	(1993)	<i>Corella</i> 17(5):
155	Tydeman Cay	King, B. R. and Buckley, R. C.	(1985)	<i>Corella</i> 9(3): 85–86
191	Wallace Island	King, B. R., Limpus, C. J., Hicks, J. and Oldroyd, A.	(1989)	<i>Corella</i> 13(2): 43–44
221	Wilson Island	Walker, T. A. and Hulsman, K.	(1993)	<i>Corella</i> 17(5):
224	Wreck Island	Hulsman, K., Walker, T. A. and Limpus, C. J.	(1993)	<i>Corella</i> 17(5):

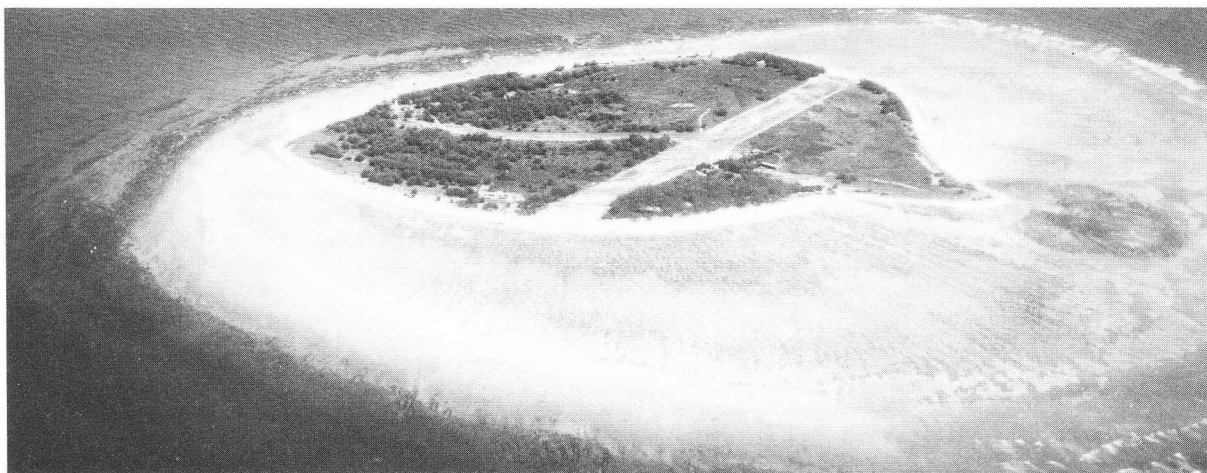


Photo: T. A. Walker

Figure 5. *Lady Elliot Island from the air (looking north-west). 'A coral cay situated at the north-western side of a rounded 180 ha reef. The surface consists primarily of phosphate rock with areas of rubble or sand. The rock surface is grooved and ridged following extensive guano mining. An airstrip and cross-runway were graded in 1969. At the eastern side of the cay there is a lighthouse and three houses built in 1872. At the south-eastern side of the cay there is a tourist resort with 20 buildings, all but two of which were constructed after 1984.'*

*'Guano mining was devastating to the cay. In 1819 it was wooded but the surface was stripped in the late 1800s and kept bare by goats until the late 1960s. A 1954 photo of the cay shows only a small stand of *Pisonia grandis* trees and grazed "lawn". Revegetation following the removal of the goats was initially slow but accelerated rapidly in the late 1970s and 1980s. There are no records of the bird fauna present before mining and the depositors of the guano are unknown.*

'Areas with shearwater burrows have been compacted for buildings and airstrips. The runway is kept free of nesting birds by daily air traffic and bird strikes occur during summer. Aircraft noise causes terns and noddies to fly off their nests but the impact on breeding is unknown. Predation on Crested Tern eggs by gulls is high, particularly when people disturb parents from their nests. Destruction of tern nests by laying turtles is negligible. Dogs were resident in the 1890s, 1960s and probably at other times. There is a report of a resident cat in the 1970s.

'Lady Elliot is the first Great Barrier Reef island encountered by seabirds coming from the south Coral Sea and this may explain why it is the only island in the region where Common Noddies and Red-tailed Tropicbirds nest.

'The cay is undergoing great change. Plants, seabirds, landbirds and people are increasing. Seabirds with an affinity for trees or people (e.g. Black Noddy, Silver Gull) should continue increasing while man-shy species that nest in open areas (e.g. Crested Tern) may decline.'

(T. A. Walker 1989d)