SURVEY OF SEABIRD COLONIES IN THE CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK

II POPULATION PARAMETERS AND SOME MANAGEMENT OPTIONS

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by

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SUMMARY

The seabird community of the Capricornia Section of the Great Barrier Reef Marine Park was dominated by two species: Wedge-tailed Shearwater and Black Noddy. There were about 1 million shearwaters and 360 000 noddies, the bulk of which bred at North West, Masthead and Heron Islands. The reproductive output of shearwaters was not measured but noddies produced an estimated 73 000 fledglings.

The next most abundant species was the Bridled Tern. About 3 000 bred in the area. This population was more evenly distributed through the region than were those of shearwaters and noddies. The main Bridled colonies were at Tryon, One Tree, Masthead, Lady Musgrave, Lady Elliot and Hoskyn Islands. They produced an estimated 1 327 fledglings.

There were at least 2 160 Brown Boobies breeding at East Hoskyn and the Fairfax Islands. They produced 1 053 fledglings.

About 2 000 Crested Terns nested in the region. They nested at One Tree, North Reef, Lady Elliot and Masthead Islands and produced 964 fledglings.

Only 202 of the 900 Black-naped Terns were known to have nested. They nested at One Tree, Wreck, Tryon and Masthead Islands. They produced an estimated 83 fledglings.

Only 160 of the 700 Roseate Terns were known to have nested. The largest colony was at Wreck Island. Roseates produced an estimated 67 fledglings.

The Silver Gull occurred on all islands but nested on only 5 of them. The main colony was at Wreck Island where 100 pairs nested. There were large numbers of transient gulls at Heron and Masthead Islands during the summer.

The Common Noddy nested at Lady Elliot Island. Lesser Crested and Little

Terns did not breed in the region during 1982-83.

The distributions of shearwaters and noddies remain the same from year to year but the size of their colonies change. The distributions of Brown Boobies and Bridled Terns also remain the same from year to year but it is not known if the size of their colonies change.

The distribution of Crested Terns may change from year to year but the size of their colonies certainly do.

The distributions and size of colonies of Black-naped, Roseate and Lesser Crested Terns change from year to year. It seems that the breeding population of these three species of the Capricornia Section also nest outside the Marine Park.

There were seven or fewer sea-eagles in the region, none bred during 1982-83.

The transient species in the region were Greater Frigatebirds, Red-tailed Tropicbirds and Cormorants. The frigatebirds congregated at the colonies of the Brown Booby.

Two species of wader (Reef Heron and Sooty Oystercatcher) bred in the region the other 12 species were transients. The most common wader in the region was the Grey-tailed Tattler followed by Ruddy Turnstone, Reef Heron, Bar-tailed Godwit, Mongolian Sandplover, Whimberel and Eastern Golden Plover. There were very small numbers of Red-necked Stint, Sooty and Pied Oystercatchers and some sandpipers. One Tree Island supported the largest wader population but the waders were fairly evently spread among islands.

There appears to be some interchange of individuals of each species between colonies between years. Gulls seem to be the most transient of the breeding birds in terms of interchange between islands during the breeding

season. Overall it seems that while Black-naped and Roseate Terns do not nest they are extremely mobile.

Although aerial photographs provided reasonable estimates fo the overall numbers of shearwaters and Black Noddies (± 35%), the estimates for particular islands were grossly inaccurate (± 1000%). It was concluded that aerial photographs were useful in determining habitats to sample when estimating population sizes but not useful for direct estimates of population sizes.

The factors which affect the status of all species were the availability of suitable habitat to nest in, bad weather interfering with foraging and chilling of chicks, Pisonia seeds and predation by cats, rats, Reef Herons and Silver Gulls. On permanently and temporarily inhabited islands, man's activities affected the availability or indeed the suitability of potential nesting aras.

Most seabirds foraged within 10 km of their colonies. Shearwaters and Boobies tended to forage >16 km and > 24 km from their colonies respectively. However all species tended to forage within a few kilometres of coral reefs.

The theory of Island Biogeography can provide a basis for management of seabird populations. To maintain viable colonies of specific species, it is necessary to have source colonies within range of the dispersal powers of the species so that there is a reasonable likelihood of an island being successfully colonised.

However it will take 10 or more years to accumulate sufficient data to determine the powers of dispersal of each species. Until this information becomes available the main thrust of managing seabird populations should be increasing the public's awareness of what to do near seabird colonies.

RECOMMENDATIONS

1. Another survey of all seabird colonies in the Capricornia Section of the Great Barrier Reef Marine Park to be done during 1983-84 to determine if the population size of each species remains constant and is redistributed among colonies within or outside the boundaries of the Capricornia Section.

2. Continue the banding of seabirds in the area. Data from recoveries will reveal in time
   (a) where each species disperses to during the non-breeding season
   (b) age of first breeding
   (c) source of recruits

3. Measure the breeding success and so the reproductive output of at least the main colonies of each species. If one knows the major causes of mortality, it can help one develop an effective management plan. The fieldwork should start in early December therefore funding should be approved by mid November at the latest.

4. Eliminate the rats on Wreck and Fairfax Islands and the feral cats on North West Island.

5. Collect data on the nesting habitat of each species of seabird. This information is needed to develop a feasible management plan for specific islands.

6. Strictly control further development of Heron and Wilson Islands
   (a) any construction work, which is potentially damaging to breeding seabirds and their young, on islands should be done during the non-breeding season. (Resorts, research stations, local and state governments need to agree on this point).

(b) to minimise the area of vegetation cleared on islands, 2 storey buildings, not higher than the line of the canopy, should be preferred to single storey buildings.

(c) the extent of clearing vegetation around buildings should be restricted to what enables safe access to and from buildings.

(d) siting and orientation of buildings should be such that they do not cross flight paths of shearwaters.

7. Develop an education programme to increase

(a) people's appreciation of wildlife

(b) increase the public's awareness of the needs of seabirds to breed successfully.

Such a programme could benefit from the assistance of the ABC (Earthwatch and Natural History Unit) and Environmental Studies of Department of Education.

8. Determine the responses of each species of seabird in relation to the distance an intruder is from the colony. This information should be used in the education programme.

9. Control the size of the Silver Gull population indirectly. People should not feed the gulls and should dispose of food scraps in such a way that they are not available to gulls.

10. Consider each island's importance for nesting turtles as well as for nesting birds when re-examining the current zoning plan.

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INTRODUCTION

Increased usage of the Great Barrier Reef make it necessary to develop adequate management plans for seabird populations if people are to have reasonable use of the area and seabird populations are to remain viable.

The Capricornia Section of the Great Barrier Reef Marine Park (Fig. 1) is n important area for breeding seabirds as well as overwintering waders. The region has 6 principal colonies and 21 major colonies of seabird in Queensland (see Hulsman 1981).

MANAGEMENT OF SEABIRD POPULATIONS

To enable people to have reasonable use of the Great Barrier Reef and yet protect it, both human activity and wildlife have to be managed. Managers of the Marine Park require answers to the following types of questions.

What population size is necessary for the long term survival of each species of seabird that breeds in the region?

Which islands are needed as breeding grounds for the long terms survival of each species of seabird breeding in the region?

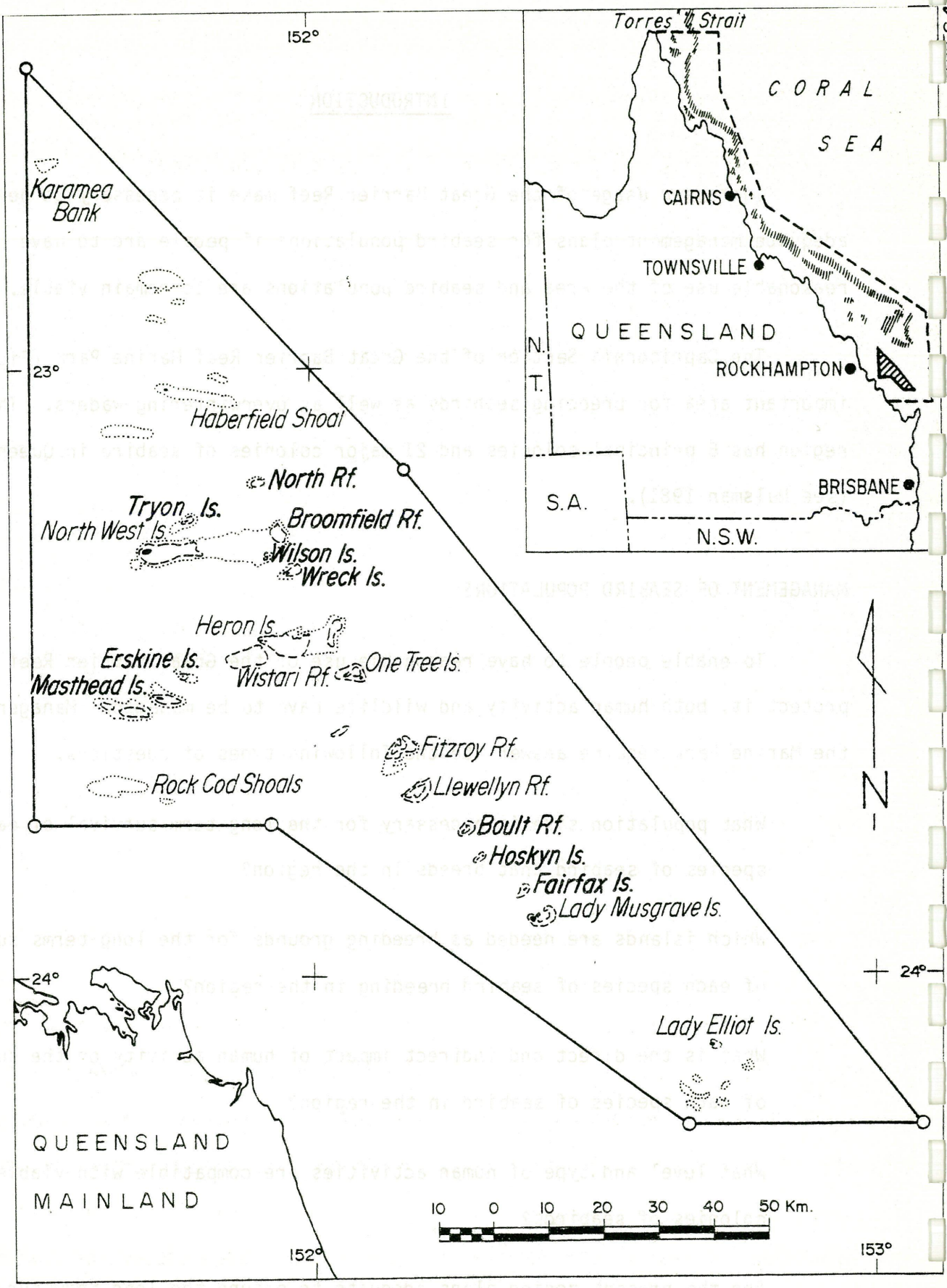
What is the direct and indirect impact of human activity on the survival of each species of seabird in the region?

What level and type of human activities are compatible with viable colonies of seabirds?

Are the present zoning plans adequate to ensure the long term survival of each species of seabird that breeds in the region?

To manage populations of seabirds, one needs data about the following

Figure 1. Map of islands and reefs of the Capricornia Section of Great Barrier Reef Marine Park.



aspects of each species:

1) size and distribution of the breeding population;
2) size and distribution of the non-breeding population;
3) the time of year the species nests;
4) duration of breeding season;
5) amount of suitable nesting area available;
6) breeding success of the population;
7) causes of mortality;
8) rate of mortality in each age class;
9) rate of recruitment to breeding population;
10) length of reproductive life;
11) movement of birds within colonies;
12) movement of birds between colonies;
13) dispersal of young and adults during non breeding season;
14) quantity of food needed by the population;
15) area of ocean around colony over which seabirds forage;
16) influence of human activity on the above.

The amount of suitable nesting area available and the food supply influence the size and distribution of the breeding population. The rate of mortality in each size class affects the recruitment rate to the breeding population and hence the size of the breeding population. The causes of mortality and the relative importance of each cause need to be determined so it is possible to control and if necessary manipulate to help control the size of the population. The time of year that each species nests and the duration of its breeding season must be known if some colonies need protection from certain human activities (Hulsman 1981).

The size of the non-breeding population (immatures) is the potential reserve that could be recruited to the breeding population. The size and age

structure of the non breeding population may give one an indication rate of mortality and dispersal of each age class of immature birds. The dispersal of young and adults during the non breeding season must be determined because it is inadeuqate to manage a population solely during its breeding season when it needs protection during its non breeding season. This is particularly important when species disperse to other countries and co-operation between the relevant governments is required (Hulsman 1981).

The functions of the Marine Park include conserving the Great Barrier Reef and yet allow for reasonable use of it. Therefore one must consider the influence of human activities on the populations of the seabirds. Then it is possible to take measures to minimize the impact of human activity on seabird populations.

This project was the first survey of all seabird colonies in the Capricornia Section during the same breeding season. To date, the number of breeding pairs of many species of seabird could have been overestimated because some species nest on different islands in sucessive years and may have been included more than once since estimates were based on a number of composite surveys to cover all islands.

AIMS

The aims of this project were:

1. census seabird colonies and waders
   (i) estimate the total population of each species of seabird and wader in the region
      (a) breeding population
      (b) non-breeding population
   (ii) determine the distribution of colonies of each species of seabird in the region.

2. Measure the reproductive output of colonies of each species of seabird and try to determine which colonies are producing excess young and seeding other colonies.

3. Initiate a banding programme to obtain information about the movements of birds between colonies.

4. Determine the reliability of using aerial photographs to estimate the size of populations of each species.

5. Measure the distances that each species forages from its colony.

METHODS

DISTRIBUTION AND ABUNDANCE

Wedge-tailed Shearwater Puffinus pacificus and Black Noddy Anous minutus numbers were estimated from quadrats (10 x 10m). The orientation of the belt transects comprising of continuous or, in some cases, discontinuous quadrats is given in Table 1. The actual distance between each transect differed from island to island. For example, on Wilson Island transects were 50m apart whereas on Masthead and Lady Musgrave Islands they were 150m apart. Only one transect was completed at North-West Island.

Numbers of occupied and unoccupied nests were counted to provide a measure of the occupation frequency of nests. One is faced with the problem of not knowing whether unoccupied nests are:

1. nests from an earlier breeding season;
2. trial nests built by pairs during courtship;
3. nests of pairs who have lost their eggs or chicks.

Occupied burrows only were counted. A burrow was considered to be occupied if footprints of shearwaters were in the entrance of it. This was more reliable than leaves etc. having been cleared from the entrance because frequently, burrows that had their entrances partially blocked with leaves etc. were occupied.

Counts of Bridled Terns Sterna anaethetus were made by flushing the birds from the vegetation and then counting the number of Bridleds flying.

Counts of other species of seabird were made in three ways;

1. All seabirds on an island were counted during high tide;
2. the number of seabirds in dubating eggs and brooding chicks were

Table 1. Number and orientation of transects on islands.

Island	#transects	distance between each transect (m)	orientation (degrees)
Tryon	4		140
North West	1	-	130
Masthead	5	150	180
Wilson	4	50	180
Heron	9	20-80	180
Lady Musgrave	2	150	180

Table 2. Number of transects made to count foraging seabirds.

Transect between	frequency censused
Heron - Wilson	5
Heron - Masthead	4
Heron - North West	3
Heron - One Tree	2
Heron - Fairfax	2
North West - North Reef	2
North West - Tryon	2
Wilson - Wreck	2
Wilson - Broomfield	1
Wilson - Tryon	1
Broomfield - Wreck	1
Heron - Tryon	1
Heron - Gladstone	1

counted;

3. the number of chicks were counted.

Breeding population

I assumed that for each incubating or brooding adult there was a mate. Therefore the number of incubating/brooding birds was doubled to estimate the total number of breeding birds.

Their number of chicks was considered to equal the number of breeding pairs assuming that each chick was produced by a pair. This underestimates the number of pairs because it does not take into account the number of eggs that did not hatch. This was necessary because not all the adults were present in the colony or on the island during the census because they were foraging.

On some islands it was possible to census the birds on consecutive days during high tide. This provided a measure of the accuracy of the counts or an indication of the amount of movement between islands.

The places where they roosted were recorded to give one an idea of the frequency particular spots were used as roosts.

Non-breeding Population

Whenever the number of adults of a species on an island was greater than the number of pairs required to produce the total number of eggs and chicks, the excess birds were regarded as non-breeding birds.

On islands where a species was not breeding, adults of that species were considered to be non-breeding birds.

All immature birds were regarded as non-breeding birds. Chicks were also regarded as part of the non-breeding population which was divided into at least

two categories: adults/sub-adults and chicks. For some species such as Silver Gulls Larus novaehollandiae and Brown Booby Sula leucogaster individuals were categorised into one of 5 or 7 classes respectively. Characteristics used to class each age group were as follows:

Silver Gull

Category 1 Adult with red eye ring, bill and legs;

Category 2 sub-adult with brown eye ring and brown to reddish brown bill and legs;

Category 3 immature with brown eye ring, bill and legs;

Category 4 juvenile with mottled bar on leading edge of wing and brown eye ring, bill and legs;

Category 5 chick mottled plumage with brown eye ring, bill and legs.

Brown Booby

1. Adult plumage: brown dorsal and head with white breast and underwings.
2. juvenile plumage: brown dorsal and head with light brown breast and underwings.
3. fledgling plumage: brown dorsal, some white down on head with light brown breast and underwings.
4. chick plumage: brown dorsal, white down on head and neck.
5. chick plumage: covered in white down with brown wing coverts, primaries and tail.
6. chick plumage: covered in white down and has brown primaries.
7. hatchling plumage: white down.

REPRODUCTIVE OUTPUT OF COLONIES

The number of fledglings produced by a colony, i.e. reproductive output was counted to obtain a measure of the viability of the colony. It was not possible to count the number of fledglings produced in each colony but the number of chicks (> 3 weeks old) were counted. Since mortality of chicks (> 3 weeks old) is small their number provide a good estimate of the reproductive output.

Breeding success of most species could not be measured because the fieldwork could not be started until after funding was approved in mid December.

MOVEMENT OF SEABIRDS

The amount of interchange of birds between colonies is to be determined by recovering banded birds. Some birds were banded with a colour band as well as a CSIRO metal one to indicate the colony where they were banded. This was done to enable one to identify where a bird was banded without having to spend time catching it.

Additional data about the movement of birds between colonies was collected on the basis of changes in the age structure of the population. This was done specifically for gulls which could be classed in 5 age classes. Unfortunately these data do not indicate to which colonies the birds had gone nor where they came from.

RELIABILITY OF USING AERIAL PHOTOGRAPHS TO ESTIMATE POPULATION SIZES OF SEABIRDS.

The details of the methods are given in Hulsman (1981).

In an effort to investigate the relationship between number of noddy

nests and tree physiognomy the following data were recorded for each tree in the samples.

1) species of tree
2) height of tree
3) girth at breast height (gbh)
4) basal girth
5) projected canopy area
6) number of occupied noddy nests
7) number of unoccupied noddy nests

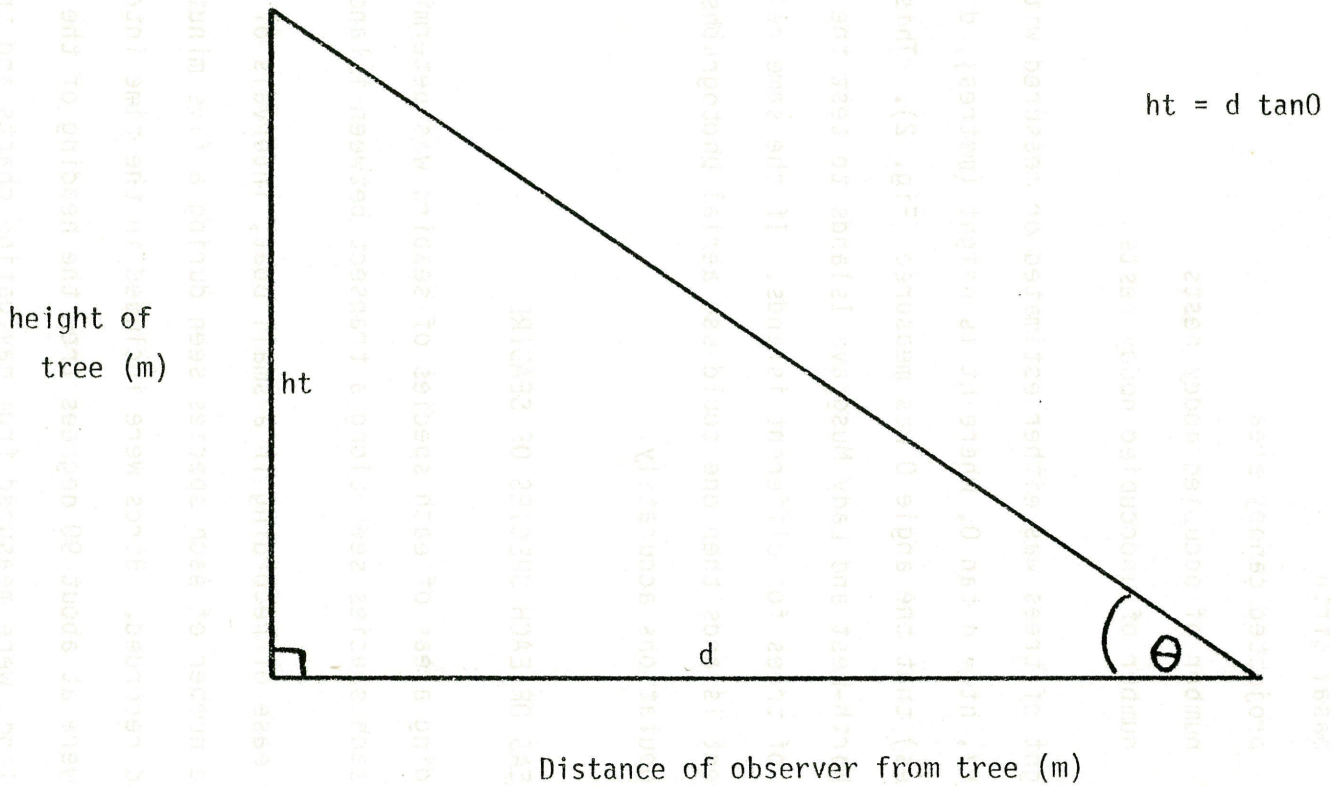
Height of trees was either estimated or measured with the use of trigonometry, ht = d tan 0, where ht is height (metres), d is distance from the tree (metres) that the angle 0 was measured (Fig. 2). This was done at Heron, Masthead, North-West and Lady Musgrave Islands to test the consistency of occupation of trees for different islands. If the same relationships held for the different islands then one could use aerial photographs to estimate the size of noddy populations accurately.

FEEDING AREAS OF EACH SPECIES OF SEABIRD

Feeding areas of each species of seabird was determined by counting the number of each species seen along a transect between islands.

For ease of recording in a small boat, intervals of five minutes were the units. The number of each species seen during a five minute interval was tallied and recorded. Birds were included in the time interval that occurred when they were at about 90 degrees from the heading of the boat. Distances between islands were measured from navigation charts and the duration of the journey was recorded. From these three variables, the distance that a bird was from the reference islands could be calculated. Frequency distributions of the

FIGURE 2. Diagram of method used to measure height of trees



number of each species foraging against distance from their nearest colony were compiled. There were 27 transects which were censused, the actual details are given in Table 2.

RESULTS

DISTRIBUTION AND ABUNDANCE

Seabirds

The results of transects used to calculate the numbers of breeding pairs of Wedge-tailed Shearwaters on islands with large colonies are given in Table 3. Similarly Table 4 gives the results of transects used to calculate the numbers of breeding pairs of Black Noddy on islands with large colonies.

Approximately 89% of breeding pairs of shearwaters in the region nest on North West and Masthead Islands (Table 5). These same two islands have 79% of breeding pairs of Black Noddy. In fact 98% of breeding pairs of Black Noddy in the region breed on three islands North West, Masthead and Heron Islands (Table 5).

Brown Boobies breed on three islands only in the region. The islands are East and West Fairfax and East Hoskyn. The boobies seen on other cays in the region were probably resting between foraging bouts and had come from Fairfax or Hoskyn Islands. That is the reason why boobies counted on other islands were not considered non-breeding birds.

Common Noddy has a small breeding colony at Lady Elliot Island.

Although not particularly numerous, the Bridled Tern breeds on most islands in the region. The largest colonies are on Tryon and One Tree Islands with sizeable colonies on Masthead, Lady Musgrave, Lady Elliot and West Hoskyn Islands (Table 5). Bridled Terns did not nest on East Hoskyn and West Fairfax Islands.

Roseate Terns nested on four islands. The largest colony 60 pairs was at Wreck Island. Some 20 pairs nested at Erskine Island. Some breeding had

Table 3 Summary of transect results used to calculate the number of breeding pairs of Wedge-Tailed Shearwaters on six islands in the Capricornia Section of the GBR Marine Park.

Island	Mean nos burrows/100m²	s.d.	Nos quadrats (100m²) sampled	Area of Island (ha)	Estimated number of pairs
North West	30.19	29.44	160	120	362 280
Masthead	14.80	10.86	168	68	100 640
Wilson	13.73	12.90	82	5	6 865
Tryon	11.60	17.60	35	10	11 600
Heron	6.30	8.59	98	16	10 080
Lady Musgrave	4.70	10.30	146	16	4 700

Table 4 Summary of transect results used to calculate the number of breeding pairs of Black Noddy on four islands in the Capricornia Section of the GBR Marine Park.

Island	Mean nos	s.d.	Nos quadrats (100m²) sampled	Area of Island (ha)	Estimated number of pairs
North West	6.67	15.0	160	120	80 040
Masthead	9.02	9.52	168	68	61 336
Heron	21.74	21.28	98	16	34 784
Lady Musgrave	1.15	2.41	143	16	1 840

Table 5 Numbers of breeding and non breeding individuals of 11 species of seabird on each island in the Capricornia Section of the GBR Marine Park during the 1982-83 breeding season. These data do not include the number of chicks.
*breeding colony

Island	Species										
	Shearwater	Brown Booby	Black Noddy	Common Noddy	Bridled Tern	Roseate Tern	Black-naped Tern	Lesser Crested Tern	Crested Tern	Little Tern	Silver Gull
North Reef	-	5	5	-	-	6*	5	4	599*	1	20
Tryon	23 200*	-	44	-	761*	10	105*	-	19	28	78
North West	724 560*	-	160 080*	-	-	-	-	18	11	130	60
Wilson	13 730*	-	235	-	20*	241	199	2	63	153	48*
Wreck	13 000*	-	11	-	129*	150*	100*	8	9	20	214*
Masthead	100 640*	-	122 672*	-	456*	40	53*	7	312*	7	197*
Erskine	1 000*	-	58	-	54*	140*	47	2	7	22	29
Heron	20 160*	2	69 568*	-	-	94	149	15	63	109	357
One Tree	-	52	66*	-	600*	3	146*	40	614*	110	22
Hoskyn	13 000*	348*	1 328*	-	279*	8*	-	-	-	-	41
Fairfax	1 000*	1 810*	670*	-	26*	-	-	-	30	120	65
Lady Musgrave	15 040*	-	3 680*	-	349*	6	44	-	3	-	99
Lady Elliot	1 000*	21	16	112	318*	-	-	-	403*	-	87*
Breeding	926 330	2 160	358 064	112	2992	160	202	-	1 928	-	384
Non breeding	-	-	369			538	686	96	205	701	933

occurred at North Reef and East Hoskyn but the number of breeding pairs could not be accurately determined since breeding was almost completed and the few remaining chicks may have been stragglers. Given that Hoskyn was not visited until mid January and North Reef until early February it is quite feasible that more Roseates had nested there earlier in the season.

Black-naped Terns enjoyed as wide a distribution as Roseate Terns. The largest colony of Black-naped (72 pairs) was at One Tree Island. Despite the presence of 100 or more Black-napeds at Tryon and Wreck Islands fewer than 25 pairs nested there. According to the lighthouse keepers (Peter Harrison and Peter Allen) at Lady Elliot Island, Black-napeds bred in large numbers there during the previous 4 years.

Lesser Crested Terns apparently did not breed in the region during 1982-83 breeding season. They have been reported nesting on Masthead (Cooper 1948) and One Tree (Domm and Recher 1973; Hulsman 1977b) in previous seasons.

Crested Terns nested in colonies of 156-307 pairs on four of the islands in the region. The largest colonies were at One Tree (307 pairs) and North Reef (299 pairs). According to Harrison and Allen, the Crested colony at Lady Elliot Island was about a quarter of the size of those in the preceeding 4 years. If so then 1200 pairs would sometimes breed on Lady Elliot making it the largest reported Crested colony on the Great Barrier Reef.

Little Terns did not breed in the region but they were concentrated on 5 of the 13 islands in the region (Table 5).

Silver Gulls bred on 4 of the islands in the region. The largest colony was at Wreck Island (about 100 pairs). The next largest colony was at Masthead (about 54 pairs). A large number of gulls frequent Heron Island but they did not breed there (Table 5).

Sea-eagle Haliaetus leucogaster is known to breed at Erskine Island but there was no evidence of young being bred during 1982-83 season.

Greater Frigatebirds Fregata minor were common in the skies over East Hoskyn and West Fairfax. They did not breed in the region during 1982/83.

Red-tailed Tropicbirds Phaethon rubricauda were seen at West Fairfax but these were probably transients.

Aquatic birds

Three species of Cormorant, Little Pied Cormorant Phalacrocorax melanoleucos; Little Black Cormorant P. sulcirostris; and Pied Cormorant P. varius were seen in the region (Table 6) but they are not known to breed in the region.

Waders

Table 7 presents the number of each species of wader on each island in the Capricornia Section of the Great Barrier Reef Marine Park. The counts of numbers of Reef Herons Egretta sacra are incomplete because not all herons on islands were seen. Some counts accounted for as few as 30% of the total number of herons on an island. The Reef Heron and oystercatchers are the only waders known to breed in the region (Table 7).

The other species are from the Northern Hemisphere overwintering on the Great Barrier Reef. One of the most common waders in the region was the Ruddy Turnstone Arenaria interpres and it occurred on all islands. The Whimberel Numenius phaeopus was not numerous but occurred on all islands except Heron and Hoskyn Islands. (Table 7).

The Bar-tailed Godwit Limosa lapponica was not particularly common until a large group was seen at Tryon Island during February 1983 after the campers

Table 6 Numbers of each species of seabird or aquatic bird on each island in the Capricornia Section but did not breed during the 1982-83 season.

Island	Species					
	Sea-eagle	Greater Frigatebird	Red tailed Tropicbird	Little Pied Cormorant	Little Black Cormorant	Pied Cormorant
North Reef	-	-	-	13	2	1
Tryon	2	-	-	2	-	-
North West	-	-	-	-	-	-
Wilson	-	-	-	1	8	-
Wreck	1	-	-	43	3	-
Masthead	-	-	-	26	1	-
Erskine	2	-	-	-	-	-
Heron	1	-	-	11	-	-
One Tree	-	-	-	-	-	-
Hoskyn	-	118	-	-	-	-
Fairfax	1	70	3	-	-	-
Lady Musgrave	-	-	-	-	-	-
Lady Elliot	-	-	-	-	-	-
TOTAL	7	188	3	96	14	1

Table 7 Numbers of each species of wader on each island in the Capricornia Section of the GBR Marine Park during 1982-83.
*Breeding, + not all individuals counted, ? not counted.

Island	Species													
	Ruddy Turnstone	Whimberel	Bar-tailed Godwit	Grey-tailed Tattler	Red neck Stint	Broad tailed Sandpiper	Common Sandpiper	Eastern Golden Plover	Mongolian Sand Plover	Oriental Plover	Sooty Oystercatcher	Pied Oystercatcher	Reef Heron	White-face Heron
North Reef	41	10	19	125	-	-	1	1	1	-	-	-	26	-
Tryon	83	4	359	1	-	-	-	29	1	-	-	-	39*	-
North West	64	36	36	47	1	-	-	12	1	-	-	2	?	-
Wilson	44	9	-	126	15	-	-	8	17	-	-	-	64*	-
Wreck	112	13	19	124	3	-	-	3	21	-	1	-	57*	-
Masthead	67	19	23	108	-	-	-	15	19	-	10	5	10+	-
Erskine	32	13	1	100+	10	-	-	27	49	-	-	-	5	-
Heron	66	-	-	29	6	1	-	9	77	-	2	-	137*	-
One Tree	79	31	12	188	-	-	-	3	95	-	2	-	-	-
Hoskyn	22	-	-	15	-	-	-	1	-	-	2	2	63	-
Fairfax	34	5	25	56	-	-	-	13	-	-	3*	4	17	2
Lady Musgrave	71	3	2	4	-	-	-	10	-	-	2	-	19‡	-
Lady Elliot	73	5	1	1	-	-	-	10	-	3	4	10	8	-
Total	788	148	497	924+	35	1	1	141	280	3	26	23	507+	2

had left the island (Table 7).

The Grey-tailed Tattler Tringa brevipes was the most common wader in the region. Six of the 13 islands had 83% of the population.

Red necked Stint Calidris ruficollis, Broad tailed Sandpiper, Common Sandpiper Tringa hypoleucos and Oriental Plover Charadrius asiaticus veredus were rarely seen in the area.

Eastern Golden Plover Pluvialis dominica occurred in small numbers on all islands (Table 7).

Mongolian Sand Plover Charadrius mongolus occurred on all islands in the Capricorn Group but not on those in the Bunker Group or Lady Elliot Island. The largest number was found at One Tree Island (Table 7).

Sooty Oystercotchers Haematopus fuliginosus and Pied Oystercatchers Haematopus ostrolegus were not common on any island and co-occurred on four of 9 islands that had oystercatchers (Table 7).

Sooty Oystercatchers at Fairfax Island were with a fledgling. They are known to breed at One Tree Island (Domm and Recher 1973; Hulsman per obs.) and possibly on other islands.

White-faced Herons Ardea novaehollandiae were seen at Fairfax Island. They have been reported from One Tree Island (Domm & Recher 1973; Hulsman pers. obs.) and Lady Elliot Island (Harrison and Allen pers. comm.).

ROOSTING AND NESTING AREAS

North Reef

Brown Boobies perched in Argusia trees near the nesting area of the Crested Tern. Black-naped, Roseate, Lesser Crested and Little Terns stood near

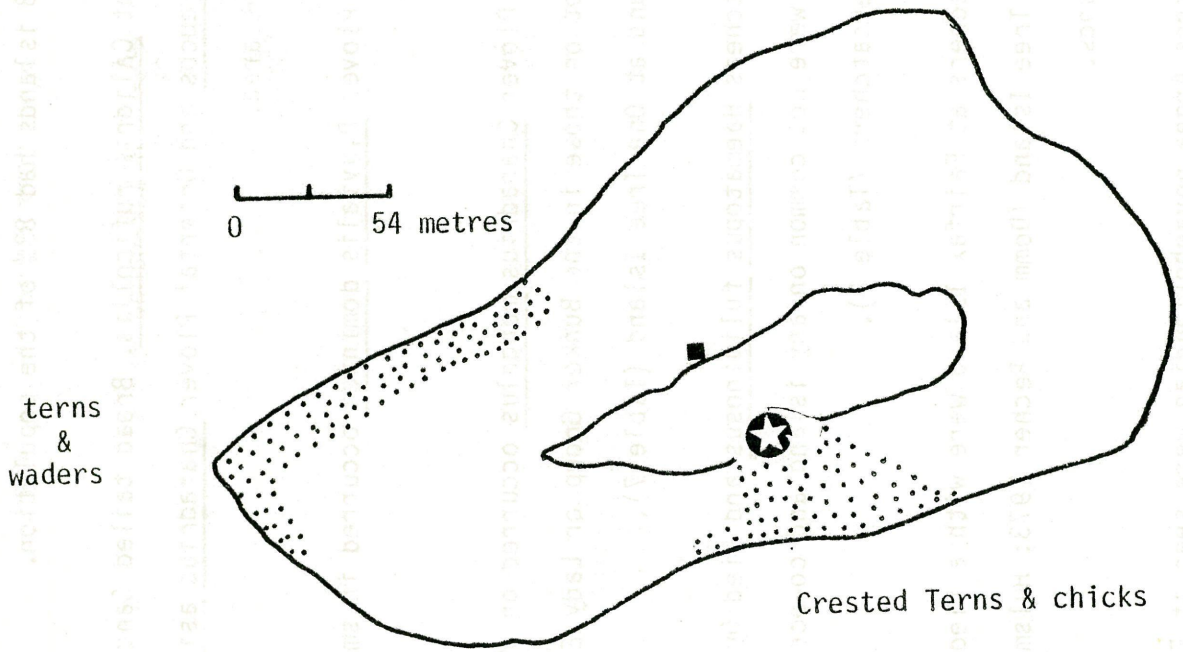


FIGURE 3. Roosting and nesting areas of birds at North Reef.

Legend for figures 3 to 15


Common Noddy


Black-naped Tern


Roseate Tern


Crested Tern


Silver Gull


building

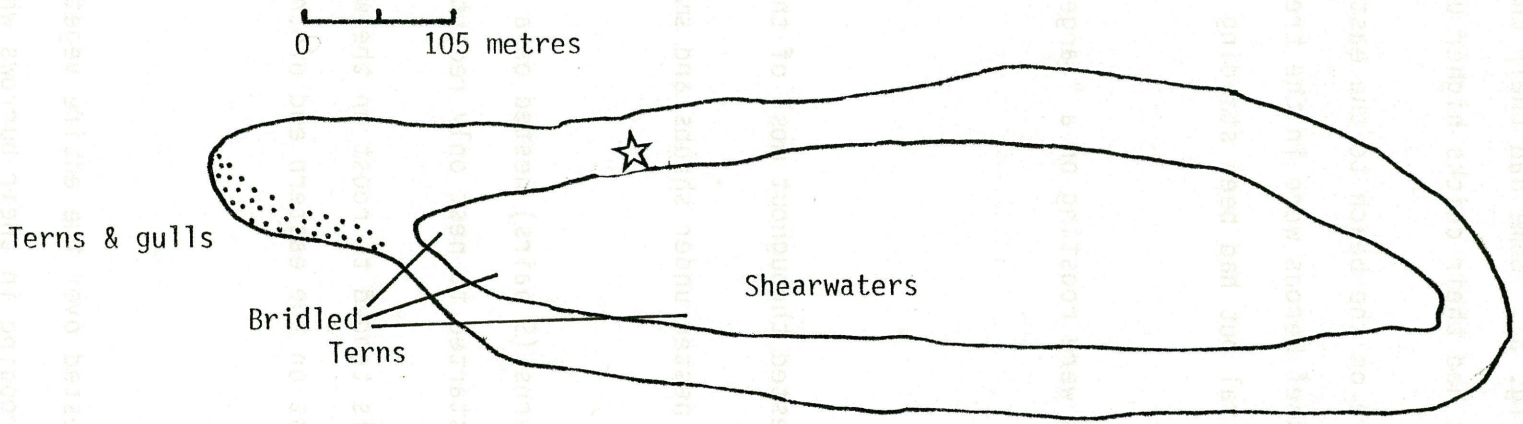


FIGURE 4. Roosting and nesting areas of birds at Tryon Island

the water's edge on the north-western side of the island (Fig 3). Silver Gulls stood with the terns at the water's edge.

Crested Terns were congregated near their nesting area on the southern side of the island (Fig. 3). Some had their chicks (> 2 weeks old) by the water's edge. Others had their chicks higher up on the beach.

Turnstones were on the beach to the east of the nesting area of Crested Terns. Tatters and Reef Herons were in the trees. Whimberels and Godwits were disturbed by our arrival but had been standing with the Black-napeds etc. at the water's edge.

The cormorants were roosting on a "large mooring bouy" near the reef crest.

Tryon Island

Shearwaters nested throughout most of the vegetated part of the island.

Bridled Terns nested under shrubs and small trees of the strand vegetation.

Black-naped Terns (9 pairs) nested on a shelf of beachrock (Fig. 4) apparently they had started to nest only recently.

Terns and gulls tended to roost on the western end of the island. The waders tended to roost on the eastern end of the island (Fig. 4).

North West Island

Shearwaters nested over the entire vegetated part of the island. They were incubating or brooding in their burrows while their mates were at sea. At night shearwaters were on the surface near their burrows courting, fighting,

sleeping, etc.

Noddies roosted in the trees in which they nested. They nested over almost the entire island in the Pisonia Forest. There were few terns on the island. However there were more than 100 birds, possibly Crested Terns on the bank about 1km east of the island. It is possible that small terns and gulls were also on the bank which is not covered during the neap tides. I do not know if the bank is covered by spring high tides.

Waders roosted along the northern beach of the island (Fig. 5). During low tide, Godwits and some other waders foraged on the exposed sand flats out from the south-western end of the northern beach.

Wilson Island

Shearwaters nested over more than three quarters of the vegetated part of the island. These were no burrows in the strand vegetation on the western side of the island. Noddies roosted in the Casuarina trees in the arc between the western and northern sides of the island.

Black-naped and Roseate Terns often roosted on the northern spit, during low tide and on the island adjacent to the spit during high tide. Both species also roosted near the Black-naped nesting areas on the eastern and south-eastern sides of the island (Fig. 6).

Crested, Lesser Crested and Little Terns roosted on the south western beach along with many silver Gulls and waders. About 10 pairs of gulls occupied their territories on the periphery of the vegetation.

Wreck Island

Noddies roosted in Argusia trees on the western end of the island.

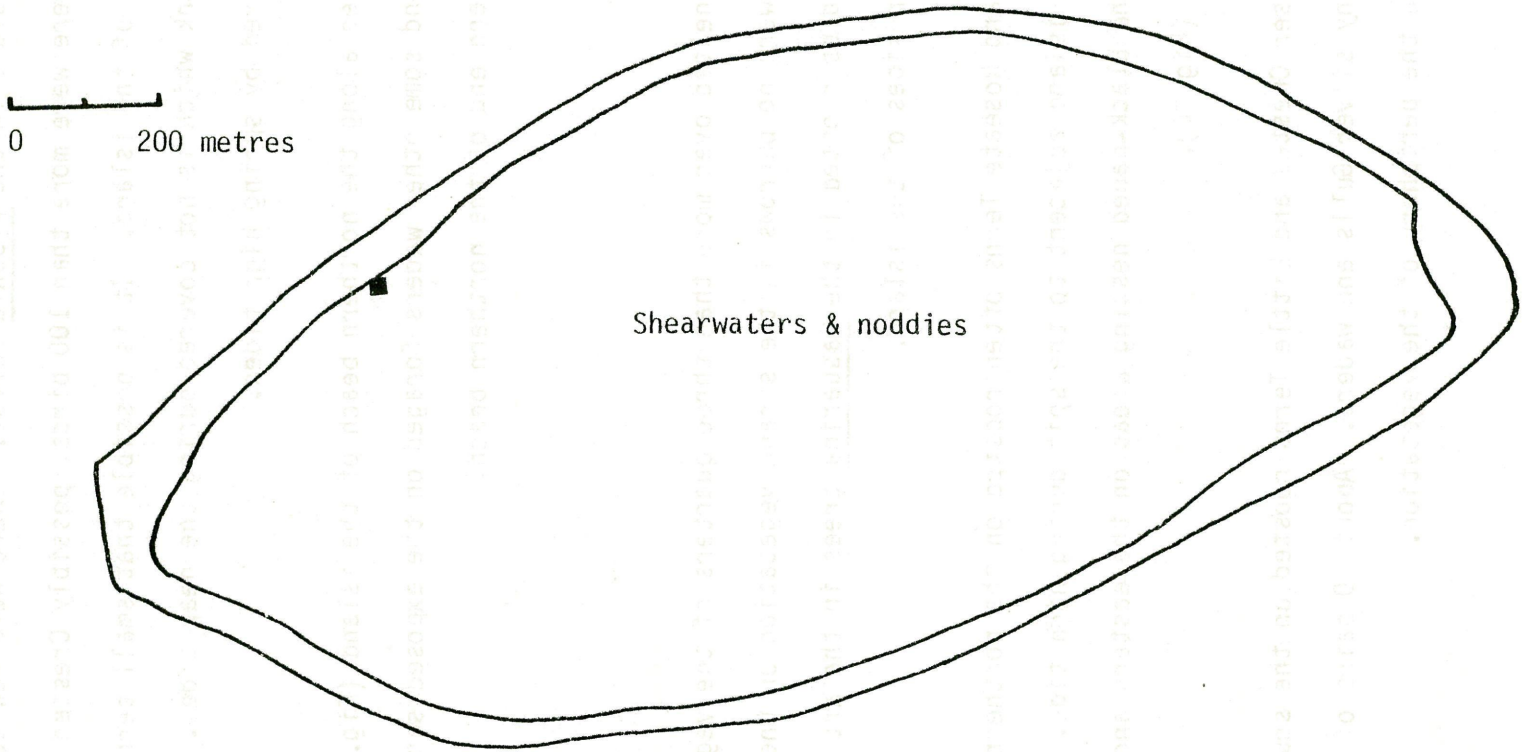


FIGURE 5. Roosting and nesting areas of birds at North West Island.

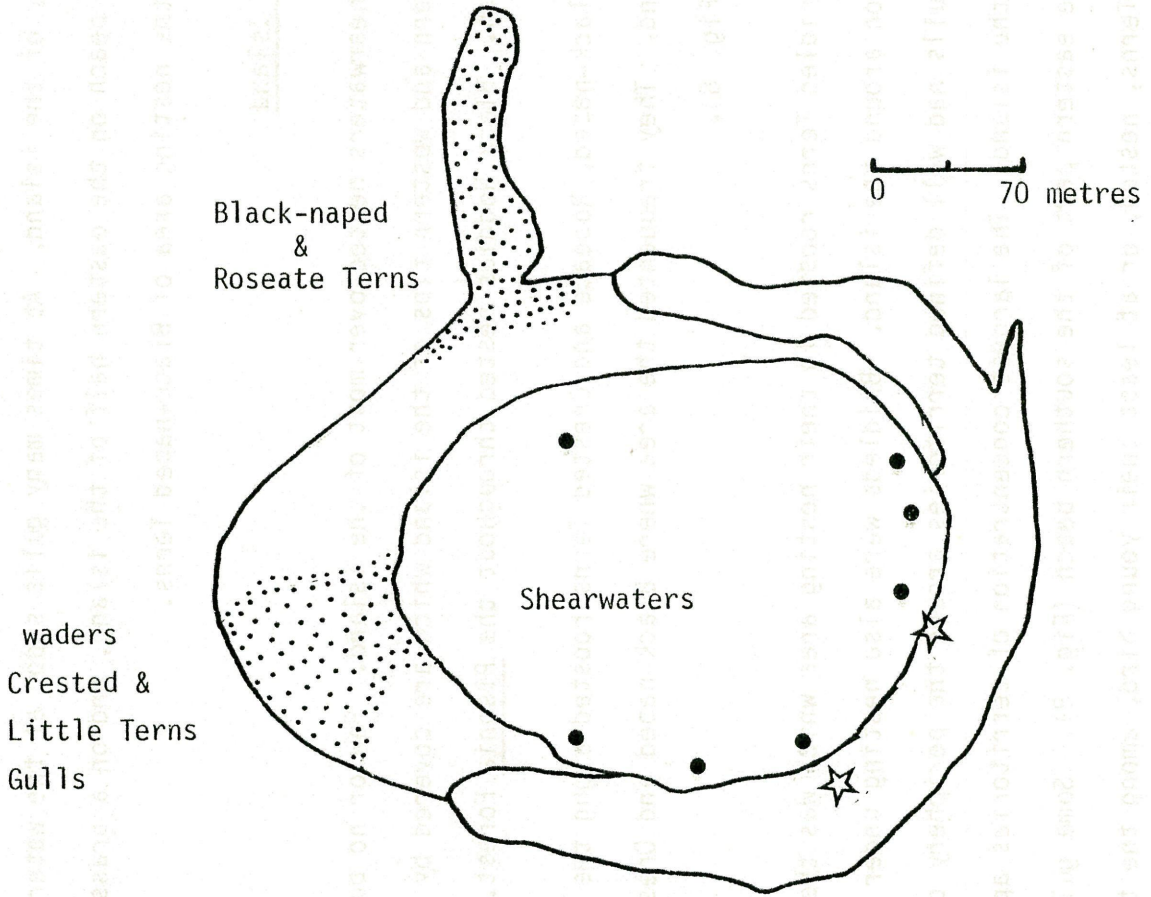


FIGURE 6. Roosting and nesting areas of birds at Wilson Island.

Black-naped Terns roosted near their nesting area on the southern beach (Fig 7). Crested and Little Terns roosted on the eastern end of the island along with cormorants and waders (Fig. 7).

Silver Gulls were most concentrated on the eastern half of the island. They often stood on the tops of Argusia trees particularly those towards the periphery of the island. At times many gulls stood at the water's edge on the northern beach on the eastern half of the island, and on a grassed dune to the west of the nesting area of Black-naped Terns.

Masthead Island

Shearwaters nested over most of the island. Few or no burrows were at the eastern and western tips of the island which are covered by strand vegetation. Black Noddies nested throughout the Pisonia Forest.

Black-naped, Roseate and Crested Terns roosted along the eastern end of the island. They frequented the area where Black-naped and Crested Terns had nested (Fig. 8).

Bridled Terns roosted in their nesting area which was the strand vegetation around the island. Bridleds were also nesting under the Opuntia. Silver Gulls had well defined territories around the periphery of the vegetated part of the island. The largest concentration of territories appeared to be along the eastern part of the southern beach (Fig. 8). Some gulls, like the Bridled Terns, nested, or at least their young bird, among the thick clumps of Opuntia.

Tattlers sometimes roosted in the trees along the northern beach and at other times in those along the fringe of the southern beach. Where they roosted seemed to be influenced by people walking along the beach. They were readily flushed by people from their roosting place.

FIGURE 7. Roosting and nesting areas of birds at Wreck Island.

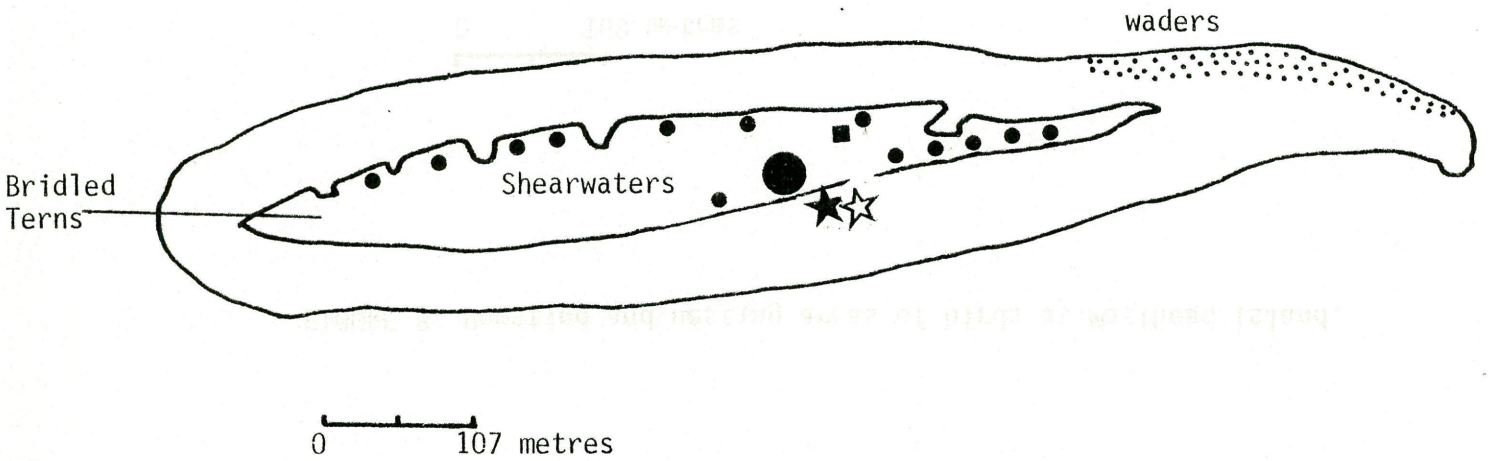
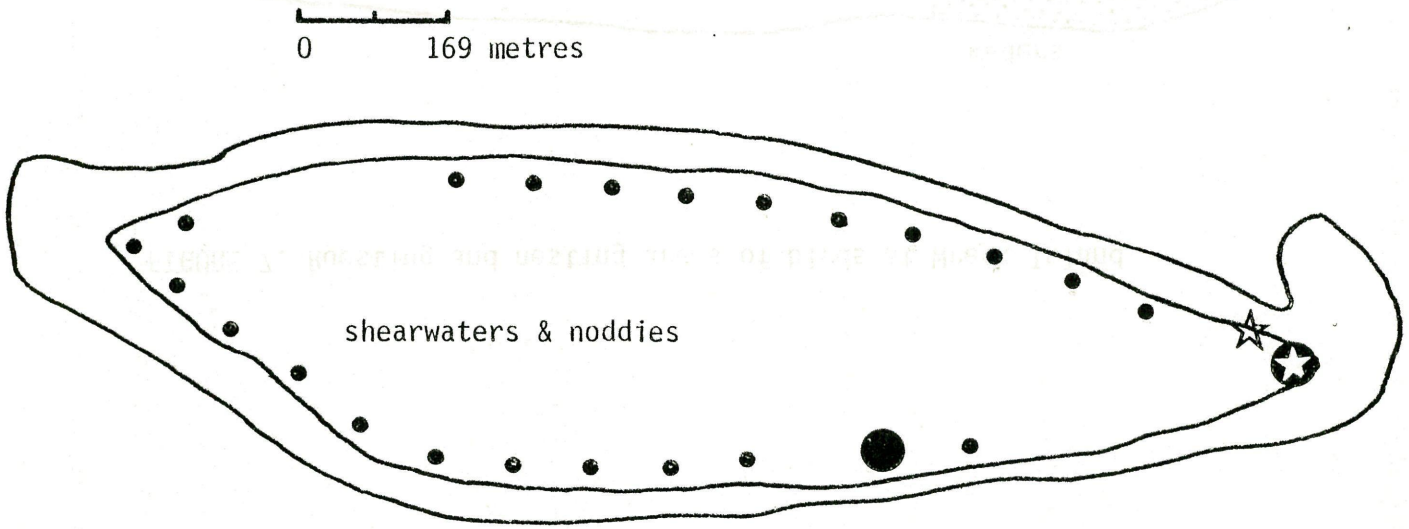


FIGURE 8. Roosting and nesting areas of birds at Masthead Island.



Whimberels roosted on the beach rock on the southern shoreline of the island.

Erskine Island

Shearwaters nested in the herb zone of the island. Noddies do not nest on the island and roost in the Argusia trees along the north-western edge of the island. All tern species presented, except the Bridled Tern, roosted on the western beach (Fig. 9) along with the waders.

Heron Island

Shearwaters nested over the entire vegetated part of the island except in the outer area which is disturbed by nesting turtles. Noddies nested in the Pisonia Forest, Strand Forest on the southern side of the island and in trees around the research station and tourist resort.

Brown Boobies that visited the island roosted on the wreck at the entrance of the harbour. Black-naped Terns also roosted and nested on the wreck. Generally Black-naped, Roseate, Crested, Lesser Crested and Little Terns roosted near the water's edge on the south-western beach (Fig. 10). Black-naped and Roseate Terns also roosted on a punt moored on the reef flat; the punt was about 100m from the water's edge.

Silver Gulls roosted on the helipad before the first helicopter of the day arrived. They roosted along the beach near the revetment wall to the west of the helipad (Fig. 10). They also frequented the grassed area under the Casuarina trees on the western tip of the island (Fig. 10). Fifty or more gulls frequented the beer garden and at times outside the doors of the restaurant. Thus most gulls roosted on the western end of the island.

Ruddy Turnstones and Mongolian Sand Plovers roosted with the terns near

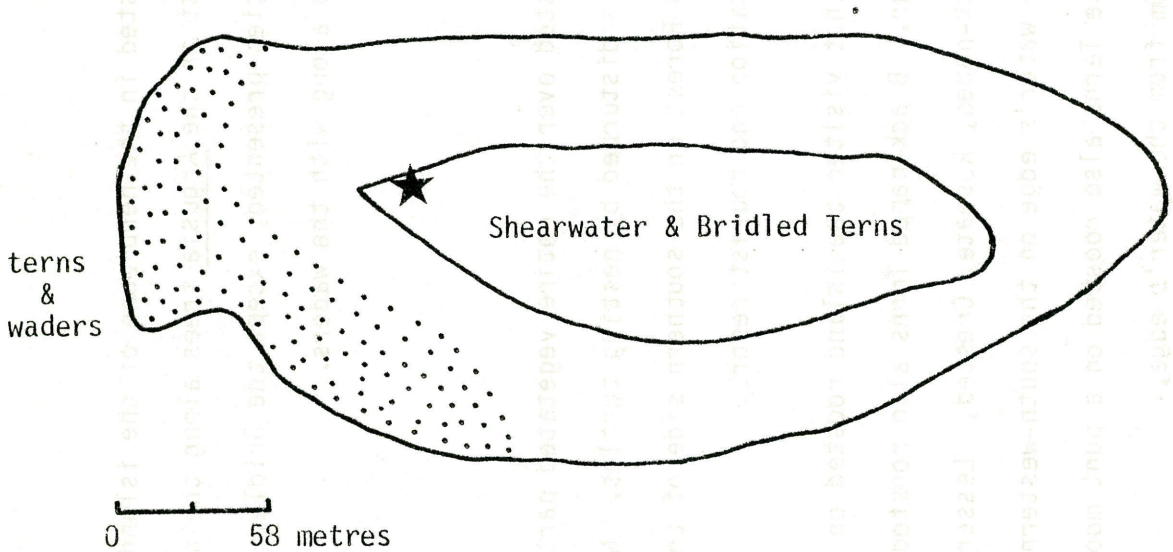


FIGURE 9. Roosting and nesting areas of birds at Erskine Island.

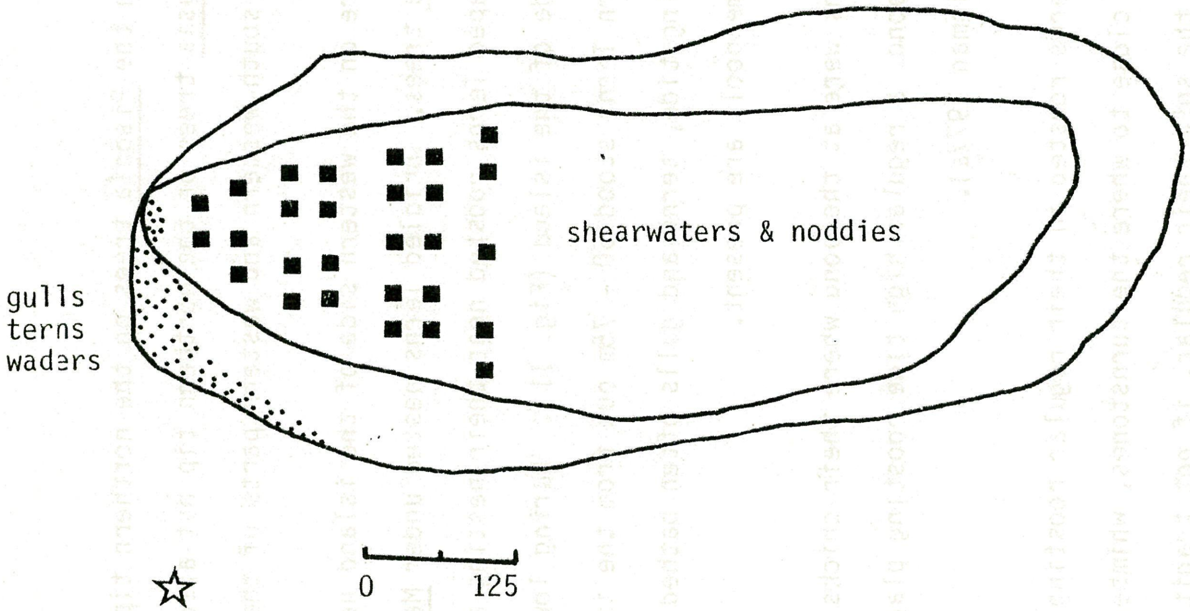


FIGURE 10. Roosting and nesting areas of birds at Heron Island.

the waters edge. Grey-tailed Tatters usually roosted on top of the two storey laboratory building of the research station.

One Tree Island

Noddies nested in the Pisonia trees on the northern tip of the island. They roosted in the Argusia trees on the northern tip but also in the Pisonia clumps on the southern, south-western and western parts of the island.

Brown Boobies were on the western side of the island near the south western clump of Pisonia trees. Bridled Terns nested under Melanthera over most of the island. Black-naped Terns roosted near their nesting area on the northern end of east side of the island (Fig. 11). During low tide Black-naped, Bridled and some Crestern Terns stood 50 - 75m out from the island on the reef crest. During the falling tide, terns and gulls often bathed on this section of the reef crest where some pools are present.

Most Crested Terns were at the pond where their chicks were. Silver Gulls were also at the pond, a regular high tide roosting place for them throughout the year (Hulsman 1977a).

Lesser Crested Terns roosted in their regular roosting area, the upper ridge between the spits close to where the turnstones, whimberels etc. roosted. Little Terns roosted on the spit their regular, if not traditional, roosting area during high tide.

Most waders roosted on the spit and western tip of the island (Fig. 11). Tatters roosted in the Pisonia and Argusia trees to the east of where the other waders roosted.

Reef Herons roosted in all clumps of trees on the island. But the greatest number of herons were seen on the western side of the island.

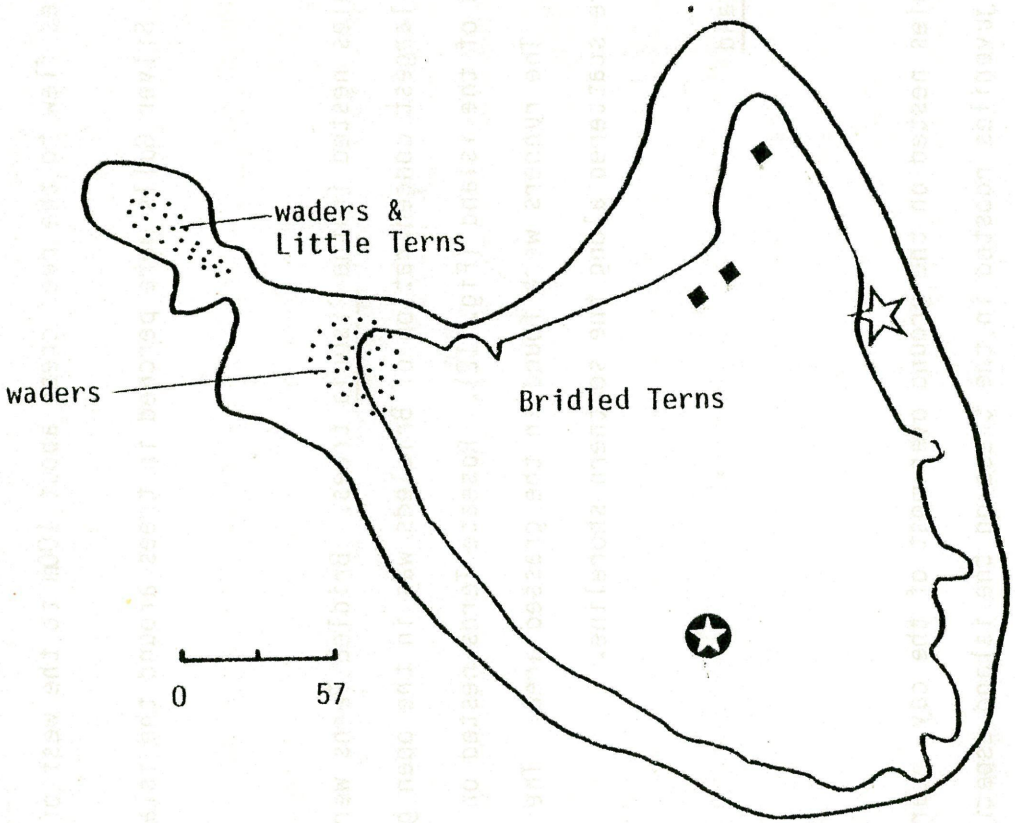


FIGURE 11. Roosting and nesting areas of birds at One Tree Island.

Hoskyn Island

East Cay

This cay was almost solely occupied by Brown Boobies and their young while Greater Frigatebirds hung overhead. The Boobies roosted in the trees mainly on the northern side of the island. When we disturbed them, the adults and juveniles flew to the reef crest about 100m to the west of the island.

Some Silver Gulls were perched in trees around the island.

West Cay

Noddies nested in the Pisonia trees. Bridled Terns were in the nesting area. The largest concentration of Bridleds was in the open glade toward the western end of the island (Fig. 12). Roseate Terns nested on the eastern end of the island. The runners were found in the grassed area. The waders that were present were scattered along the southern shoreline.

Fairfax Island

East Cay

Boobies nested on the ground over most of the cay. Large numbers of adults and juveniles roosted in the trees on the island especially those along the northern shoreline. Bridled Terns, Black-naped, Roseate, Crested and Little Terns roosted on the western end of the east cay (Fig. 13).

West Cay

Boobies roosted in trees along the northern side of the island but they also were scattered on the ground throughout the Pisonia Forest. Greater Frigatebirds roosted in the trees on the southern part of the cay, especially in the tall Casuarina.

FIGURE 12. Roosting and nesting areas of birds at Hoskyn Island.

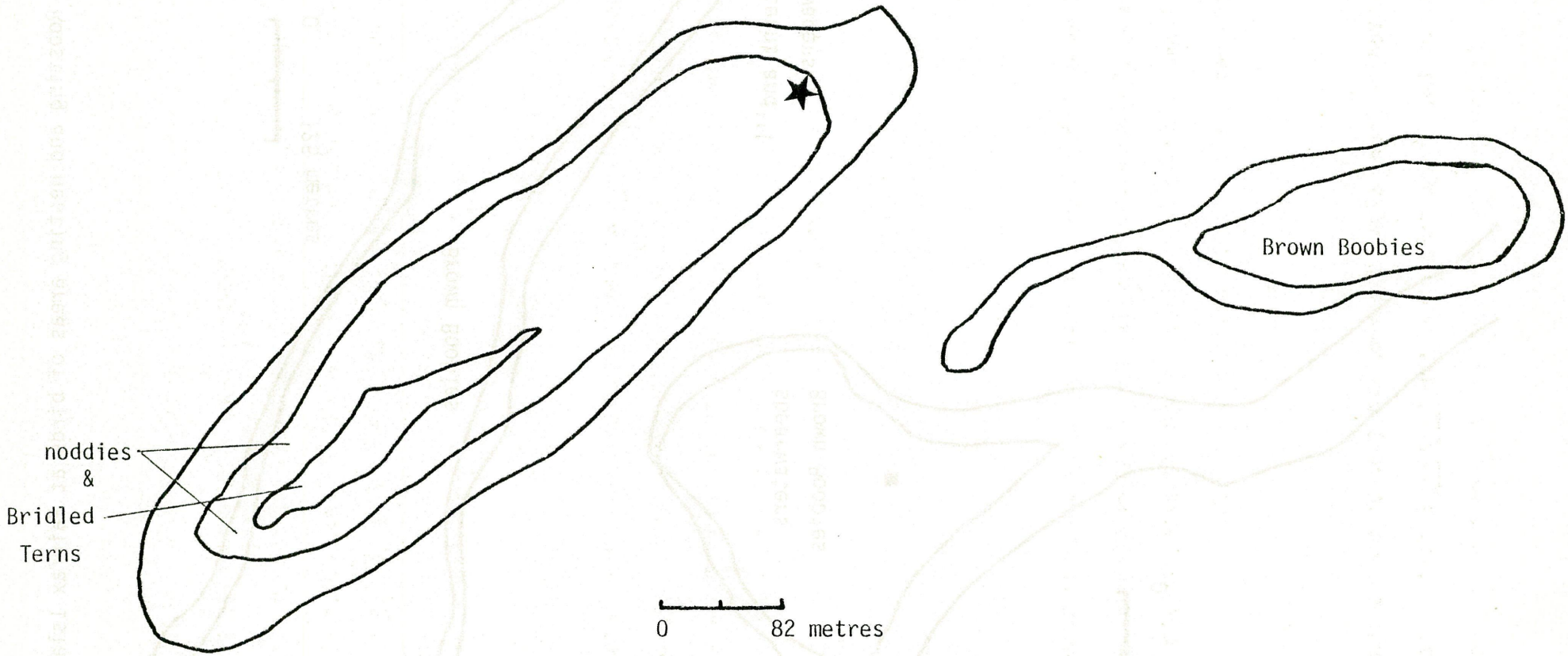
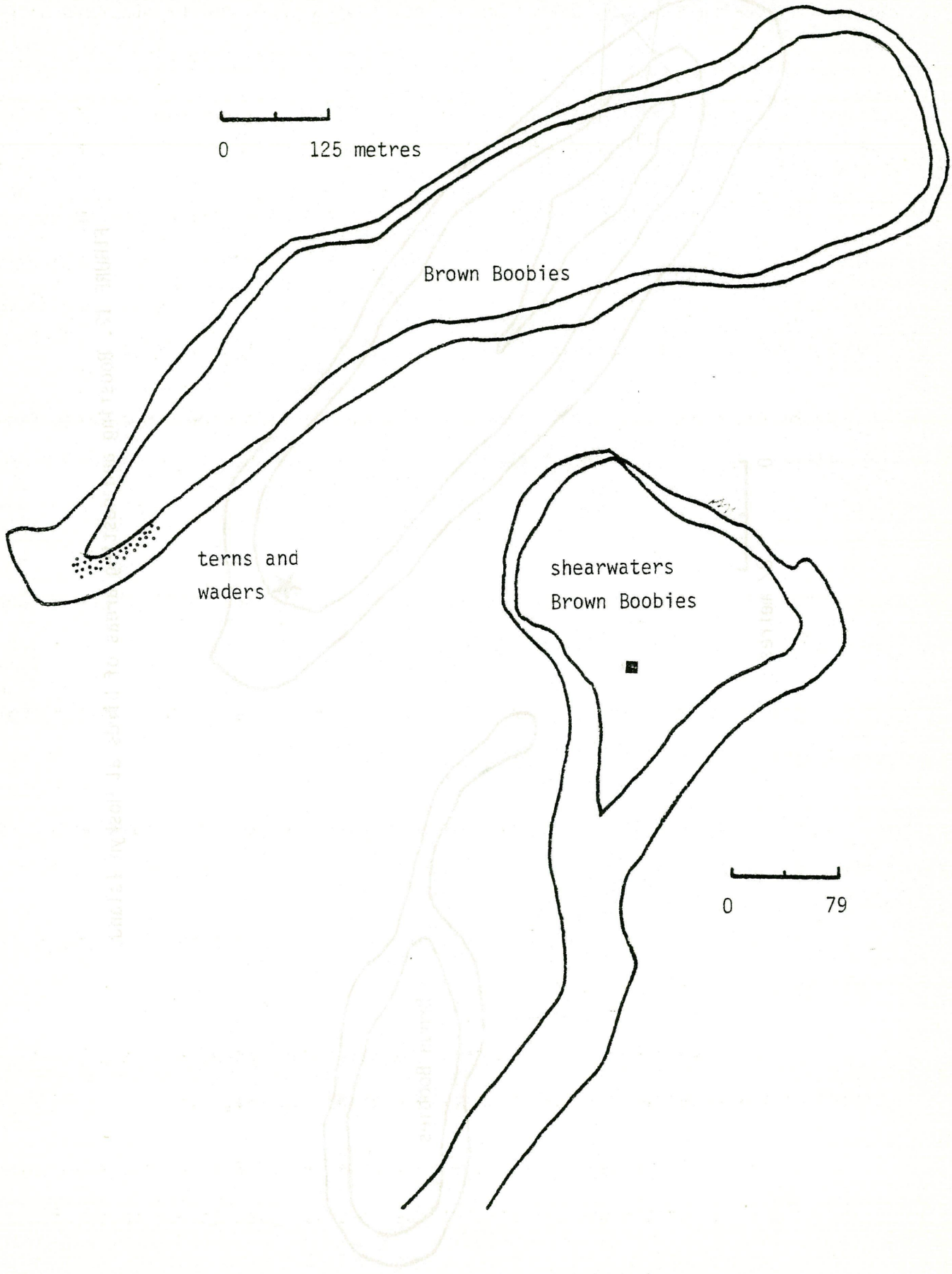


FIGURE 13. Roosting and nesting areas of birds at Fairfax Island.



Lady Musgrave Island

Shearwaters nested mainly under the Pisonia trees on the northern side of the island (Fig. 14) but they did nest over most of the island. I do not know if they nested under the bracken. Noddies nested in the Pisonia Forest which was concentrated in the northern half of the island.

Bridled Terns nested under the bracken and in the strand vegetation. Black-naped and Roseate Terns frequented the beach towards the southern end of the island. Silver Gulls roosted near their nest-areas near the automatic light (beacon) or on the beach of the northern part of the island (Fig 14).

Waders were seen on the beach rock on the eastern to south-eastern side of the island.

Lady Elliot Island

Shearwaters nested towards the northern and southern ends of the islands as well as near the airstrip. (Fig. 15).

Common Noddies were in two patches one either side of the northern end of the airstrip. (Fig. 15).

Bridled Terns nested in three areas either side of the airstrip. (Fig. 15).

Black-naped Terns have nested in previous years on a rubble ridge on the north east point (P. Harrison and P. Allen pers. comm.).

Crested Terns nested inland from the north-east point and took their chicks to the water's edge near the north east point. (Fig. 15).

Silver Gulls nested between the nesting areas of Black-naped and Crested Terns as well as on the western side of the airstrip just to the south of one of

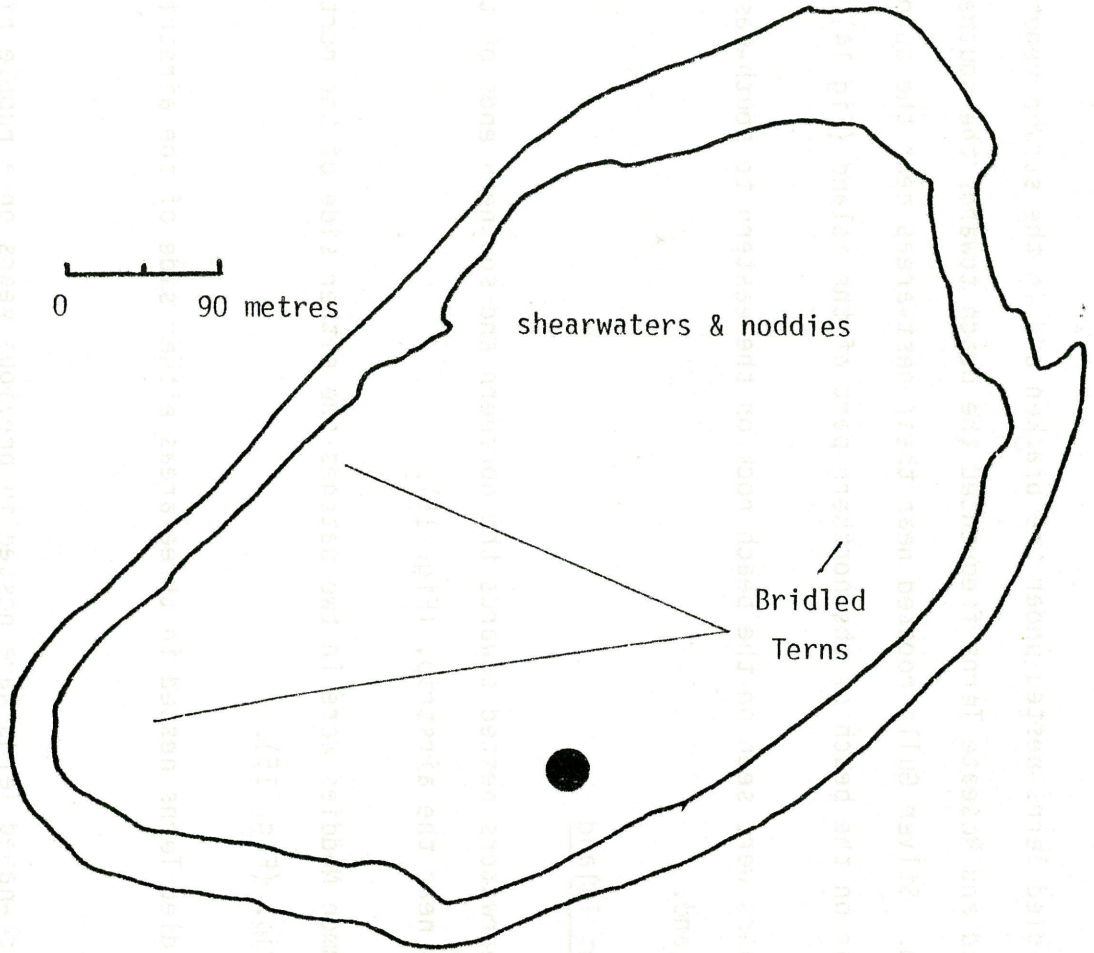


FIGURE 14. Roosting and nesting areas of birds at Lady Musgrave Island.

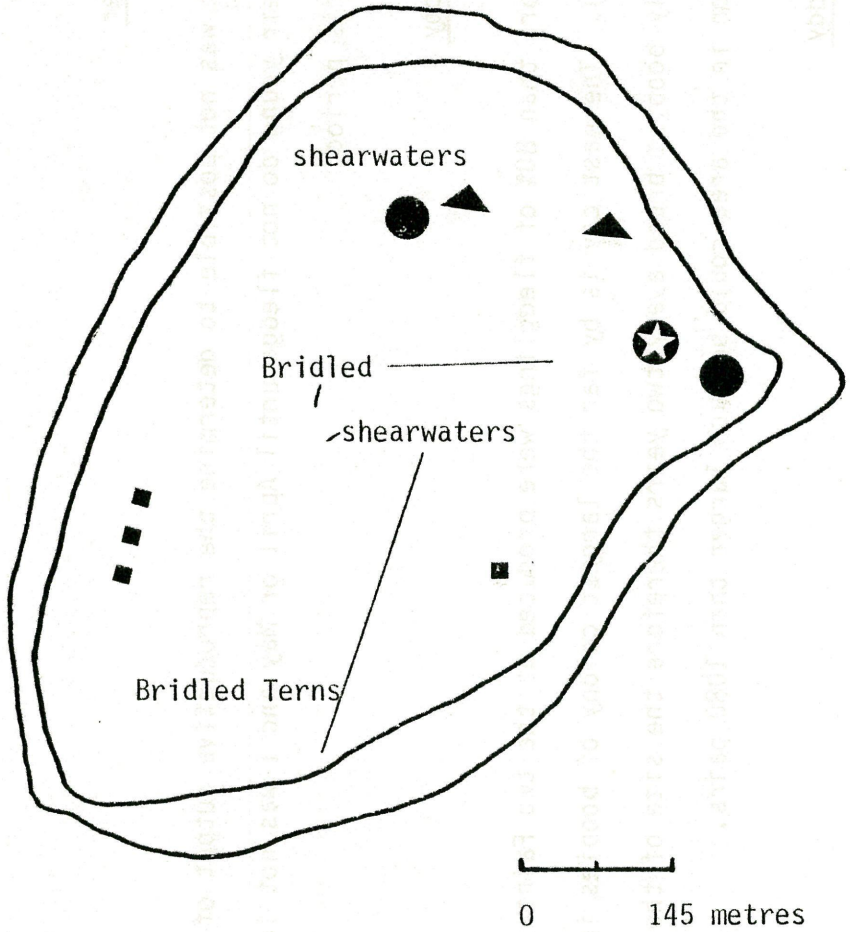


FIGURE 15. Roosting and nesting areas of birds at Lady Elliot Island.

the Common Noddy areas. (Fig. 15).

REPRODUCTIVE OUTPUT

Breeding success of most colonies of seabirds was not determined because the survey started too late in the season to count the number of eggs laid. However it was possible to estimate the number of fledglings produced at most colonies.

Shearwater

It was not possible to determine the reproductive output of shearwaters since their young do not fledge until April or May and I was not in the field during this period.

Brown Booby

More than 80% of fledglings were produced at the two Fairfax Islands (Table 8). The east cay is by far the largest colony of boobies in the region. Presumably boobies breed every two years therefore the size of the breeding population in the area could be much larger than 1080 pairs.

Black Noddy

The bulk of the noddy fledglings were produced at North West, Masthead and Heron Islands (Table 9). The causes of low fledging sucess of noddies will be discussed in the Section on Mortality.

Bridled Tern

Bridled Terns enjoy a high breeding success higher than most other tern species especially those species that nest in the open e.g. Black-naped, Roseate and Crested Terns (Hulsman and Langham ms). If Bridled Terns at all colonies in the area enjoy as high a breeding success as they do at One Tree Island then the

Table 8 Minimum number of breeding pairs of Brown Booby and the number of young produced at each of its colonies.

Colony	Min.nos pairs	Nos of young
Fairfax East	671	644
Fairfax West	234	234
Hoskyn East	175	175
Total	1080	1053

Table 9 Number of breeding pairs of Black Noddy and number of fledglings produced at each colony. Breeding success at colonies is assumed to be the same as that at Heron Island 41.03%.

Colony	Nos pairs	Nos fledglings
Northwest	80 040	32 840
Masthead	61 336	25 166
Heron	34 784	14 272
Lady Musgrave	1 840	755
Hoskyn West	644	264
One Tree	33	14
Total	178 677	73 311

Table 10 Number of breeding pairs of Bridled Tern and the number of fledglings to produced at each colony.
Breeding success is assumed to be 90% Clutch size is 1 egg.

Colony	Nos pairs	Nos fledglings
Tryon	380	342
One Tree	300	270
Masthead	228	205
Lady Musgrave	175	158
Lady Elliot	159	143
Hoskyn West	140	126
Wreck	65	59
Erskine	27	24
Total	1474	1327

Table 11 Minimum number of breeding pairs of Black-naped Tern and the number of fledglings produced at each Colony Breeding success is assumed to be 50%.
Mean clutch size is 1.5 eggs.

Colony	Min.nos pairs	Nos eggs	Nos fledglings
One Tree	72	108	54
Wreck	20	30	15
Masthead	14	21	14
Wilson	9	13	0
Total	114	172	83

Table 12 Minimum number of breeding pairs of Roseate Terns and the number of fledglins they produced at each colony.
Breeding success is assumed to be 50%.

Colony	Min.Nos pairs	Nos eggs	Nos fledglings
Wreck	60	90	45
Erskine	20	30	15
Hoskyn West	4	?	4
North Reef	3	?	3
Total	80	127+	67

majority (61.6%) of fledglings come from three colonies - Tryon, One Tree and Masthead Islands. However it is possible that their breeding success at Tryon and Hasthead Islands is less than that at One Tree Island because they are disturbed more often by people (campers) at Tryon and Masthead than at One Tree. Lady Musgrave and Lady Elliot Islands are also frequently visited and Bridled Terns could be disturbed frequently which can decrease breeding success. East Hoskyn Island has a minimum of 140 pairs which may have a high breeding success if it is not visited as often as Lady Musgrave and Lady Elliot Islands.

Black-naped and Roseate Terns

These two species often nest together therefore I shall discuss them together. At One Tree Island both Black-naped and Roseate Terns have had very poor breeding success because of predation on eggs and/on chicks by gulls and flooding of nesting areas (Hulsman 1977b). One third of the nests of Black-naped at Wreck Island were flooded during January 1983 (C. Limpus pers. comm.). The 9 pairs that nested at Wilson Island during December 1982 failed to rear any young.

The 50% breeding success is generous for both species. I suspect that the reproductive output was fewer than the total number of fledglings specified in Tables 11 and 12. Nesting so late in the season (February and March) would not favour a high breeding success or enhance the chances of survival during the youngs' first winter.

Crested Tern

Relatively large numbers of fledglings were produced at each of the four Crested colonies (Table 13). At One Tree Island in previous years breeding success has varied from 0.5 to 58.9% but in good years it seems to be about 50% (Langham & Hulsman in prep.). On the basis of a breeding success of 50% the

Table 13 Minimum number of breeding pairs of Crested Tern and the number of fledglings produced at each colony.

Colony	Min.nos pairs	Nos fledglings
One Tree	307	307
North Reef	299	299
Lady Elliot	202	202
Masthead	156	156
Total	964	964

Table 14. Number of breeding pairs of Silver Gull and number of fledglings produced at each colony.

Island	# pairs	#fledglings
Wreck	100	9+
Masthead	54	15
Wilson	11+	?
Lady Musgrave	15+	?
Lady Elliot	12	4+
Σ	192	28+

number of breeding pairs would be 1928.

Silver Gull

The reproductive output of Silver Gulls was difficult to determine accurately. They tend to be secretive with their young. Therefore when I could not locate chicks two weeks after having seen them at the nest I was not sure if they were hiding elsewhere or had died.

Furthermore three other factors confound measuring reproductive output, these are:

(i) gulls have a protracted nesting period such that on most islands small numbers (e.g. <20 pairs) nest at any one time.

(ii) gulls do not nest in colonies on the coral cays. They nest in their respective territories which can be far apart.

(iii) gulls apparently leave the natal colony with their young shortly after they have fledged (Shortly here meaning about 20 days).

FACTORS INFLUENCING REPRODUCTIVE OUTPUT

Man-Related Factors

Bridled, Black-naped,Roseate, Lesser Crested and Crested Terns are easily disturbed by the activities of people near nesting areas. These five species go through a social and an individual phase of courtship (see Hulsman 1977c). The Social phase involved Collective Upflights and Fish Flights whereas the individual phase involves High Flights, ground displays, nesting and rearing young (Hulsman in press b, c, d). Disturbances to a colony during the social phase are less detrimental to the breeding success of these species than disturbances during the individual phase.

I am not sure of the effects on selecting a nesting area if seabirds are

disturbed at their prebreeding gathering areas. Terns do not move into their nesting areas until 7 days or less before laying the first egg. Before they move into their nesting area, they congregate at a site within a few kilometres of the intended nesting area. I suspect that the impact of a disturbance at this site depends on the distance that it is from the intended nesting area. This could be a problem on the small islands of the Capricornia Section of the Great Barrier Reef Marine Park.

At One Tree Island, Crested Terns often congregated within 100m of their nesting area before moving in and start egg laying immediately. Black-naped Terns, on the other hand, gather near their foraging grounds where females are courtship fed by their mates (Hulsman 1977c). At One Tree Island this prebreeding gathering ground was 1 to 1.5 km from the nesting area. At Wilson Island it was within 200m of the nesting area. Black-naped Terns move into their nesting area up to 7 days before egg laying and males continue to feed their respective mates until the clutch is complete.

Ground nesting terns are most susceptible to disturbance and most likely to desert if they are disturbed when they are selecting a nesting area, just before egg laying and soon after the eggs are laid. Desertion of a potential nesting area and/or eggs and chicks is an antipredator behaviour. Most terns select areas free from terrestrial predators to nest in because their eggs and young are extremely vulnerable to being predated by terrestrial predators. Since man is regarded by the birds as a potential predator it is not surprising that ground nesting terns and gulls no longer nest on Heron Island. In addition the presence of feral cats on North West Island accounts for, in part, why ground nesting terns and gulls do not nest there. The presence of rats at Fairfax Islands accounts for the lack of ground nesting terns and gulls on both islands. There are a few pairs of Bridled Tern nesting on the eastern cay but I think that they will be wiped out or forced to leave by the rats. I understand

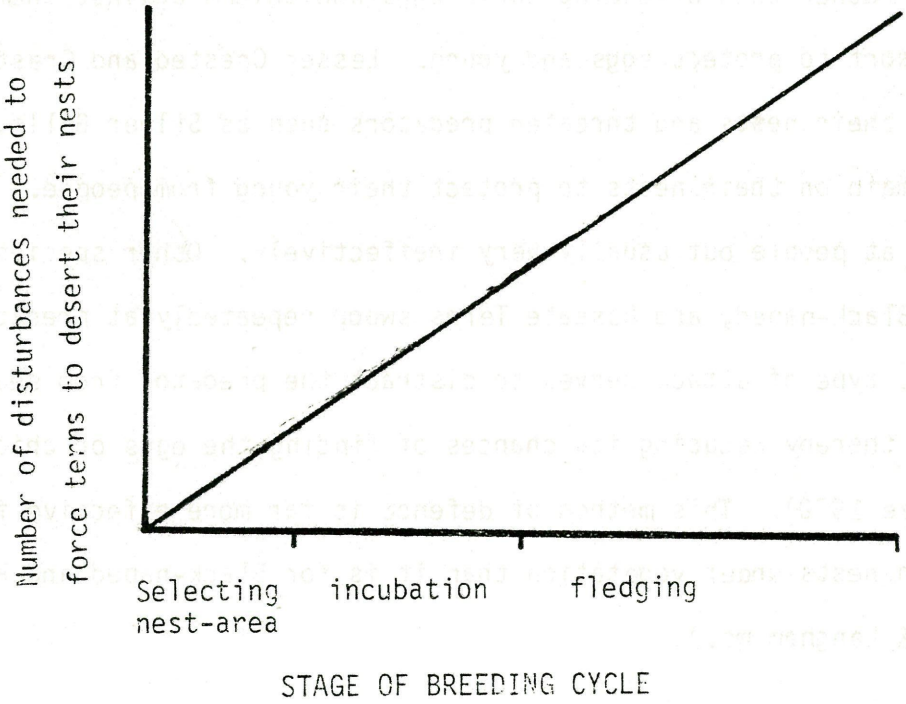
that rats used to be on the western cay only (S. Domm and G. Mercer pers. comm) but are now on both cays (pers. obs). The increase in the use of Wreck Island in recent years by ground nesting terns could be related to the decline in the rat population. NPWS should exterminate all the rats on Wreck Island and try to do the same at Fairfax Island. This policy would greatly increase the suitability of these islands for nesting by ground nesting terns.

Seabirds seek protection from predation primarily through avoiding predators rather than defending their eggs and chicks against them. Defence is a last resort to protect eggs and young. Lesser Crested and Crested Terns remain on their nests and threaten predators such as Silver Gulls, however they do not remain on their nests to protect their young from people. They fly up and swoop at people but usually very ineffectively. Other species such as Bridled, Black-naped, and Roseate Terns swoop repeatedly at predators including man. This type of attack serves to distract the predator from searching an area carefully thereby reducing its chances of finding the eggs or chicks (see Cullen 1960, Croze 1970). This method of defence is far more effective for the Bridled Tern which nests under vegetation than it is for Black-naped and Roseate Terns (Hulsman & Langham ms.).

Although aerial predators can force terns to desert their nesting areas, terns seem to tolerate a greater amount of disturbance from aerial predators than from terrestrial ones. However, nocturnal predation by birds can cause desertion of a nesting area in days (Nisbet 1975).

Fortunately the likelihood of birds deserting their eggs/chicks decreases with the greater amount of time that parents have invested in rearing their young. In other words, terns tolerate more disturbances later in the nesting period than they do earlier (Fig. 16). However I must stress that chicks of terns are still vulnerable to predation by gulls. Chicks of some species are vulnerable to predation by gulls until they can fly e.g. Black-naped and Roseate

FIGURE 16. Diagram of susceptibility of terns to disturbance by potential predators (including man) in relation to stage of breeding cycle.



Terns whereas others are safe by the time they are two weeks old e.g. Crested Terns.

Although disturbances may not occur often enough to cause seabirds to desert their nest permanently, they can appreciably lower the breeding success and hence reproductive output of a colony. Whenever a colony is disturbed and the adults fly up, Silver Gulls are attracted to the scene. Gulls are less frightened of people than are the terns therefore the gulls land before the terns do and break eggs or steal chicks from the effectively unprotected nests. Gulls are known to break many eggs during a disturbance not stopping to eat them. They return to eat them later because terns do not sit on broken eggs and therefore the eggs are still available to the gulls after the disturbance (Hulsman 1977b, c).

Disturbances can render terns "nervous" and they do not defend their eggs and/or young from gulls as well as they do in undisturbed colonies. Even though the colony may no longer be disturbed by people, the terns remain extremely "jittery" or "nervous".

Another cause of mortality of eggs/chicks during disturbances of a colony is exposure. Eggs need to be kept at a constant temperature hence they are incubated/shaded depending on the ambient temperature. Similarly hatchlings cannot thermoregulate and must be brooded or shaded by their parents. If incubating/brooding parents are disturbed eggs and hatchlings can die from heat exhaustion or chilling depending on the ambient temperature. Therefore people are strongly advised not to disturb colonies because it can increase the mortality of young.

In some cases disturbances can cause mortality through drowning. Black-naped Terns often nest in very small numbers on wreck at the entrance to the harbour at Heron Island. On 27 December 1982 there were 7 chicks about 2 to

3 weeks old on the wreck, by the 3 January 1983 there were none. During that period a group of Japanese tourists climbed onto the wreck. Since the chicks were too young to fly they probably escaped from the people by jumping overboard and drowned because their plumage becomes waterlogged quickly. People need to be aware of the implications of their actions then they will become more conscious of their effects on their surroundings. I am sure that people do stupid things around seabird colonies through ignorance rather than malice. I will discuss this in more detail in the Section about Public Education.

There are less obvious ways in which people can lower the breeding success of seabirds. One is by disturbing the birds while they are selecting a nesting area. Such disturbances may force the birds to nest at a less favourable site in all respects except for disturbances by people. The breeding success of the colony may be much less at the site chosen than it would have been if they had been able to nest at the more favourable site.

Gulls

A large number of gulls occur at Heron Island. As it was noted earlier it is a transient population although some individuals remain throughout the summer. The gull population at Lady Elliot Island is increasing (Harrison and Allen pers. comm.). Human habitation produces garbage including food scraps which the gulls feed upon. A group of 50 to 60 gulls often congregated outside the dining room at the resort where they were fed by adults as well as children. Also a group of 20 gulls congregated outside the kitchen and dining room facilities at the research station when school or university groups were in residence. People tend to feed gulls on islands directly and indirectly. Even fishermen when cleaning fish tend to throw the offal to the gulls. Some 200 or more gulls followed the garbage boat of the resort out into Wistari Channel and fed on the food scraps thrown overboard. Some of these scraps were later washed up on the beach. The research station may also dump food scraps into the sea.

It is a practice that should stop, food wastes should be returned to the mainland and buried; they must not be available to gulls.

The reason for this is that the predation rate of eggs and chicks of seabird by gulls increases with the size of the gull population. The amount of predation and kleptoparasitism by gulls on Crested Terns and their young is much less at One Tree Island with 20 gulls compared with that when 70 gulls were resident on the island.

Predation on noddy chicks by gulls and Reef Herons upsets guests of the resort (B Edmonds pers. comm.). Guests often complained to the manager of Heron Island Pty Ltd about gulls and Reef Herons preying on noddy chicks and expected the manager to do something about it (B Edmonds pers. comm.). Guests were not impressed when the manager told them that he could do nothing about it. I believe it is possible to make use of people's aversion to predation on eggs and chicks to educate them in the do's and do nots around seabird colonies. I am convinced that people would stop feeding gulls if they realised that their feeding the gulls increased the predation on eggs and chicks of other seabirds. Some of the university students that I spoke to about not feeding the gulls thought that the gull was a natural predator of the terns and therefore they were not interfering with nature by feeding them. It was not until they were told how man is artificially keeping the numbers of gulls in region high did they start to accept that they should not feed the gulls.

Other Factors

Another area of concern is Roseate Terns nesting very late in the season. Roseates usually nest in December and January. Their young have fledged by February or March. However during the 1982-83 season Roseates nested in February and March 1983. (P. Fisk, S. Domm and T. Walker pers. comm). Therefore their young would fledge during April or May 1983. Terns have a

prolonged period of parental care (Ashmole and Tovar 1968; Hulsman 1977c). But the highest mortality occurs during their first winter. Young that fledge early in the season have more time to build up reserves and develop fishing skills to a higher degree than those that fledge late in the season. Therefore it is highly likely that late fledglings have a higher rate of mortality during winter than do early fledglings, especially during winters when food is scarce and the parents cannot collect sufficient for themselves as well as their young.

AGE STRUCTURE OF SOME POPULATIONS

Brown Booby

On 9 to 12 January 1983, more than 50% of the Brown Booby chicks were in age classes 2 to 4 (Table 15). Tne development period of boobies from egg tyo fledgling is 175 days (Fig. 17). Therefore breeding would have started on all three cays by 19 July 1982. The last young of the 1982-83 breeding season will probably fledge by the end of June 1983 or just before the nest cohort of breeding nest starting the 1983-84 season. the boobies and their fledglings tend to remain at their breeding colonies. Their pattern or time of dispersal is not known.

Silver Gull

Heron Island was the only island in the Capricornia Section to have the full range of age groups of gulls, except for runners or chicks. This is not surprising since gulls do not breed at Heron Island but it provides food for them. There is a very transient population of gulls on Heron Island. Evidence for this assertion is the large changes in the age structure of the gull population over a very short time. It is impossible for a category 5 bird (fledgling) to change to a category 4 bird (12 to 18 months old) within a month. Similarly it is impossible for any bird in a category to change to another

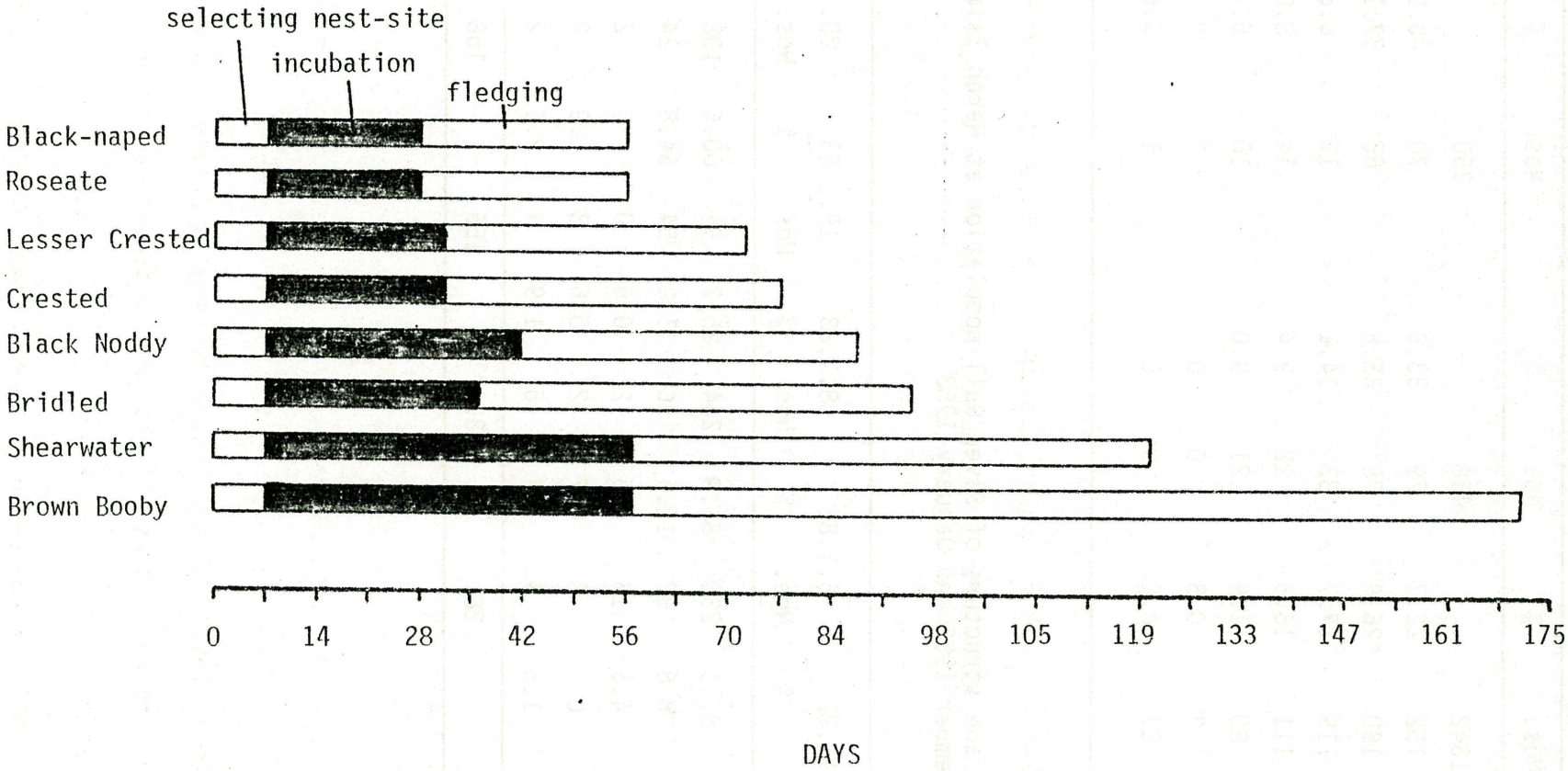


FIGURE 17. Duration of incubation and fledging periods of each species of seabird that breeds in the Capricornia Section .

Table 15 Age structure of Brown Booby populations at Fairfax and Hoskyn Islands during January 1983.

Age class	Fairfax East		Fairfax West		Hoskyn East	
	Nos.	%	Nos.	%	Nos.	%
1	1342		468		350	
2	152	22.7	79	33.8	70	40.0
3	180	26.8	79	33.8	65	37.1
4	119	17.7	33	14.1	15	8.6
5	111	16.5	22	9.4	14	8.0
6	80	11.9	21	9.0	10	5.7
7	2	0.3	0	0	0	0
Eggs	27	4.0	0	0	1	0.6

Table 16 Changes in age structure of Siver Gull population at Heron Island during December 1982 and January 1983

Age class	23.12.82		5.1.83		18.1.83		19.1.83		20.1.83	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1	115	87.1	230	81.9	264	85.2	94	60.6	138	82.1
2	9	6.8	32	11.4	36	11.2	54	34.8	24	14.3
3	6	4.5	13	4.6	2	0.6	0	0	2	1.2
4	0	0	2	0.7	2	0.6	3	1.9	2	1.2
5	2	1.5	4	1.4	6	1.9	4	2.6	2	1.2
TOTAL	132		281		310		155		168	

category within such a short time, unless the bird is in the transition from one category to another. There were very few birds that could have been classed as being in a transition stage.

It is feasible to conclude that these changes result from dispersal of gulls. The movements of gulls are clearly noticeable among categories 2, 3 and to a lesser extent categories 4 and 5 (Table 16). On two occasions I watched groups of 17 gulls leave Heron Island at dusk during high tide and fly toward One Tree and Wreck Islands respectively. The group that flew towards Wreck Island flew past the reef crest and were lost from view soon after. Assuming that gulls fly at 48 kph, they would take 17 minutes to fly the 13.4 km from Heron to Wreck Island. The trip to One Tree Island would take about 23 minutes. Most of the islands are within easy commuting distance of Heron Island, for example, the flight to Masthead would take 26 minutes whereas one to North West would take about 32 minutes.

Fluctuations in the numbers of gulls at Heron Island occurred daily (Table 16). I am extremely confident that I located all gulls at Heron Island during my high tide censuses. Therefore the fluctuations in numbers are real and not a product of not locating all the gulls on the island.

Other Species

Other species of seabird showed fluctuations in their numbers over several weeks; the two most noticeable were Black-naped and Roseate Terns. For example, there were 149 Black-napeds on Heron Island on 17.1.83 and only 51 three days later (20.1.83). Similarly for Roseate Terns there were 2 present on 23.12.83, 111 on 19.1.83 and 59 present the next day (20.1.83). However the numbers of these species did not flucuate so greatly at their breeding colonies.

DESCRIPTIONS OF NESTING AREAS

Shearwater

Shearwater burrows were present over most of vegetated parts of islands on which they occurred. There were no burrows in the zone used by turtles for nesting. Obviously the substrate is a very important factor in determining the siting of burrows. Wherever the substrate is interlaced with roots that bind it rendering it suitable for burrowing ten large numbers of burrows per unit area occur. The greatest densities of shearwater burrows often occurred in areas where Abutilon albescens or thick clumps of Pandanus (< 4m tall) were growing. Shearwaters are unable to dig very far into coral rubble and so do not occur on rubble islands: One Tree, East Hoskyn and East Fairfax Islands.

M. Vanek, Department of Geography, University of Queensland, is studying the factors which influence the distribution and abundance of shearwater burrows on islands in the Capricorn Group. His work will provide a detailed analysis of the factors that affect the abundance of burrows. The data that I have collected on vegetation in relation to nesting birds on transects across islands will be analysed in the same manner so that noddy and vegetation data collected at Masthead Island. The results of the analyses will be presented in the report due in July 1984.

High densities of burrows occur in disturbed areas where trunks, branches of fallen trees provide support for the entrances of burrows (M. Vanek pers. comm.).

Black Noddy

Analysis of the habitat of Black Noddies is based primarily on data collected at Masthead Island and to a much lesser degree on those collected at Heron Island.

There seems to be some differences between the relative abundance of each

species of tree at Masthead and Heron Islands. Based on quadrats sampled, Pisonia is the dominant tree species on both islands but Argusia seems to be relatively more numerous at Heron than at Masthead Island (Table 17). Celtis and Ficus constitute a greater proportion of the tree community at Masthead than at Heron (Table 17).

The percentage of noddy nests occupied in each species of tree was greater at Heron than at Masthead (Table 18). In addition densities of occupied nests were generally higher at Heron than at Masthead (Table 18). Only Celtis at Masthead supported a higher density than it did at Heron. Admittedly the sample size of Celtis at Heron Island was small and could be a biased sample and so account for the difference. Pisonia and Argusia supported the highest densities of nests at Heron Island whereas Pisonia and Celtis had the highest densities of nests at Masthead Island (Table 18).

Noddies seem to prefer specific species of tree of specific height. At Masthead Island, noddies preferred Pisonia trees > 7m and Ficus and Celtis trees < 10m tall (Table 19). I have not yet determined if similar preferences were exhibited by noddies at North West and Heron Islands.

The similarity of preferences by noddies for specific species of tree of specific height at the main colonies of noddies will be presented in the report due in July 1984.

Brown Booby

Brown Boobies nest in the open, under Abutilon or other shrubs and on ground in Pisonia Forest.

Bridled Tern

Bridled Terns nested under shrubs or grass in the strand vegetation. At One Tree Island most nests were at the base of shrubs Melanthera biflora

Table 17 Number of each species of tree in quadrats sampled on Masthead and Heron Islands.

Species	MASTHEAD IS.		HERON IS.	
	Number of trees	% of total nos.	Number of trees	% of total nos.
Pisonia	515	52.3	313	57.4
Celtis	128	13.0	18	3.3
Ficus	112	11.4	20	3.7
Argusia	24	2.4	51	9.4
Pandanus	142	14.4	71	13.0
Cordia	9	0.9	0	0
Pipturus	25	2.5	14	2.6
Casuarina	28	2.8	32	5.9
Scaevola	0	0	26	4.8

Table 18 Percentage and mean number of occupied noddy nests in each species of tree of Masthead and Heron Islands.

Species	MASTHEAD IS.			HERON IS.		
	% occupancy	Mean nos. of occupied nests	n	% occupancy	Mean nos. of occupied nests	n
Pisonia	43	8.3	41	58.2	16.8	25
Celtis	39	8.7	28	68.4	3.3	4
Ficus	44.8	6.8	6	68.6	11.2	20
Argusia	34.9	5.6	9	82.0	18.3	12
Pandanus	50.0	5.5	2	85.4	7.1	20

TABLE 19 Percentage and total number of noddy nests in specific height classes of each species of tree.

Species	HEIGHT Low <6 m	Medium 7-8 m	Medium 9-10 m	Tall >11 m	Total No. of nests
	% of Total Nests				
Pisonia	6.3	9.9	16.1	17.3	1871
Ficus	8.0	7.3	10.3	1.3	1015
Celtis	6.6	7.7	4.9	1.0	763
Argusia	1.2	.8	-	-	78
Pipturus	.7	.3	-	-	35
Cordia	.2	-	-	-	8
All species	23.0	26.0	31.3	19.6	3770

(Hulsman and Langham ms). Some nests were under Argusia trees and the few in unvegetated areas were under large slabs of coral ruble. At Wreck and West Hoskyn Islands Bridled mostly nested under Melanthera.

On other islands such as Masthead and Tryon they nested among the grass Sporobolus maritima and to a lesser extent under Melanthera. At Lady Musgrave Island Bridleds nested under strand vegetation but also undre a Casia-like bush with large protective spines. Many Bridleds also nested at the base of Opuntia at Masthead Island.

A few pairs nested in or under trunks of wind thrown Pisonia trees at Masthead and Lady Musgrave Islands.

Black-naped Tern

Black-naped Terns nested in the open or very sparsely vegetated areas of Spinifex. At One Tree Island they nested on the ridge above the mean high water mark. At Tryon Island they nested high on the northern teach slope near the base of some beach rock. At Wreck Island their nesting area was on a small ridge, which was sparsely covered by Sporobolus, shielded by an area of beach rock. At Masthead Island the chicks sought shelter in the Sporobolus of the strand zone. Nesting areas at One Tree and Wreck Islands were on the windward side but at Tryon and Masthead Islands they were on the leeward side.

Roseate Tern

Roseate Terns often nest with Black-naped Terns but usually slightly higher above the high water mark.

Lesser Crested Tern

Lesser Crested Terns nest in open vegetated or unvegetated areas. Vegetation in nesting areas usually are herbs. At One Tree Island, Lesser

Cresteds have nested on the second and third rubble banks. Domm & Recher (1973) reported their nesting and near the pond on Sesuvium.

Crested Tern

Crested Terns often nest in vegetated aras especially among grass e.g. Sporobolus at Masthead and Lady Elliot Island, on Sesuvivium or nest to Melanthera as at One Tree Island.

At North Reef, Cresteds nested on the sand. The nesting area was well above the mean high water mark.

Silver Gull

Silver Gulls nested on grass, under shrubs, small trees and Opuntia. Gulls nested under small Pandanus trees, on the roots of Pandanus and trunks and/or branches of Argusia but nests were within 1m of the ground, this was particularly evident at Wilson Island. At Masthead and Lady Musgrave Islands, gulls nested among grass, under shrubs. At Masthead they also nested among Opuntia and Melanthera. Some nests were extremely difficult to find whereas others were easily located.

USE OF AERIAL PHOTOGRAPHS TO ESTIMATE POPULATION SIZE

The use of the average nesting density and the total area of each island can lead to some large errors in estimates of population sizes of Shearwaters and Black Noddies on some islands. For example the errors associated with estimates of shearwater populations varied from -8.4% to +306.5% (Table 20). However overall, the error of the estimate was -35.4% (Table 20). Gross errors were made in estimates of noddy populations on some islands (Table 21). But as with the shearwaters overall the error of the estimate was +35.9% (Table 21).

This method gives a remarkably accurate estimate of the population sizes

Table 20 Comparison of population estimates of shearwaters based on actual and average (13.55) nesting densities.

Colony	Nesing density (burrows/100m²)	Area (ha)	Estimated Pop size (pairs)	% error
North West	30.19	120	362 280	-55.1
	13.55		162 600	
Tryon	11.60	10	11 600	+16.8
	13.55		13 550	
Masthead	14.80	68	100 640	- 8.4
	13.55		92 140	
Heron	6.3	16	10 080	+115.1
	13.55		21 680	
Wilson	13.73	5.7	7 826	- 1.3
	13.55		7 724	
Fairfax West	3.33	3	1 000	+306.5
	13.55		4 065	
Lady Musgrave	4.7	16	7 520	+188.3
	13.55		21 680	
		Actual	500 946	- 35.4
		Estimated	323 439	

Table 21 Comparison of population estimates of Black Noddies based on actual and average (9.65) nesting densities.

Colony	Nesting densities (nest/100m²)	Area (ha)	Estimated Pop - Size (pairs)	% error
North West	6.67	120	80 040	+ 44.7
	9.65		115 800	
Tryon	0	10	0	+
	9.65		9 650	
Masthead	9.02	68	61 336	+ 6.9
	9.65		65 620	
Wreck	0	10	0	+
	9.65		9 650	
Heron	21.74	16	34 784	- 44.4
	9.65		15 440	
Hoskyn West	0.64	10	644	+1248.6
	9.65		9 650	
Fairfax West	0.52	3.0	155	+1767.7
	9.65		2 895	
Lady Musgrave	1.15	16	1 840	+ 739.1
	9.65		15 440	
		Actual	178 892	+ 35.9
		Estimated	243 180	

of shearwaters and noddies nesting in the region. The disadvantage of the method is that the distribution of the population is grossly inaccurate. This disadvantage makes the method useless for developing zoning plans because these are based on the distribution as well as abundance of the species. One needs to census the seabird colonies on each island there does not seem to be any short cuts available.

There were significant regression equations describing the relationship between the number of occupied nests and bas girth (bg) of Ficus trees at North West and Heron Isands.

North West Island # nests = 0.060 bg - 2.16, df 14, $P < 0.002$

Heron Island # nests = 0.044 bg - 5.01, df 34, $P < 0.001$

There was no significant difference between their slopes ($t = 0.593$, $P > 0.05$).

There was a significant regression equation describing the relationship between the number of occupied nests and basal girth (bg) of Pisonia trees at Heron Island but not at North West or Masthead Islands.

Heron Island # nests = 0.036 bg + 5.179 df 23, $P < 0.01$

North West Island # nests = 0.006 bg + 5.999, df 8, $P > 0.05$

Masthead Island # nests = 13.519 - 0.5244 bg, df 12, $P > 0.05$

These types of differences between nesting densities of noddies on different islands make it difficult to use physiognomic characters to help one determine the number of breeding pairs on any island.

FEEDING AREAS OF EACH SPECIES

Shearwater

Largest numbers of shearwaters were seen foraging between North West

Island and North Reef. The majority of shearwaters (98.6% n = 4806) were foraging between 16.8 and 22.4 km from their nearest colony (Fig. 18).

However along the transect between Heron and Hoskyn Islands 69.5% of shearwaters foraged between 16.8 and 31 km from their nearest colony (Fig. 18). Ordinarily shearwaters were seen hunting singly but near North Reef a large flock were seen hunting.

Brown Booby

Brown Boobies ranged over large distances from these colonies; they were found at North Reef about 90 km from their nearest colony at Hoskyn Island. They were also often seen at Lady Elliot Reef some 46 km to the south of their nearest colony Fairfax Islands. The largest concentration of Boobies was found near One Tree Reef (Fig. 19).

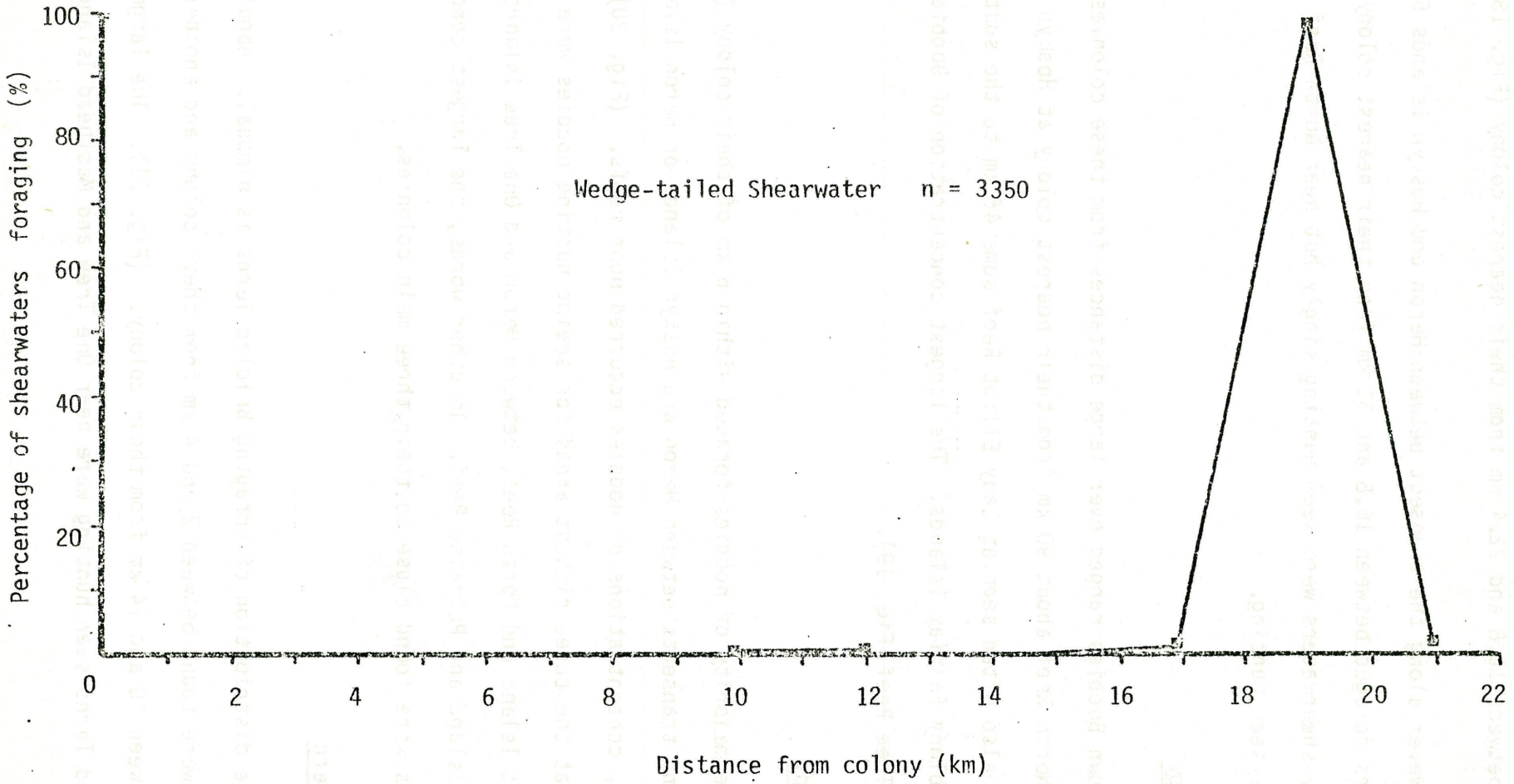
Black Noddy

The majority of noddies foraged within 6 km of their colony (Fig. 20). On the long transects between Heron and Hoskyn Islands or Heron Island and Gladstone, concentrations of noddies occurred near reefs. (Fig. 20). I hasten to add that the three richest areas for seeing hunting noddies were between North West Island and North Reef, between Heron and One Tree Islands and between Masthead Island and Polmaise Reef. In other words, the largest concentrations of noddies were found close to their three main colonies.

Bridled Tern

The distribution of foraging Bridled Terns is bimodal. About 36% of Bridleds were found between 2 and 4 km from their colony and another 36% were found between 10 and 14 km from their colony. (Fig. 21). The largest numbers of Bridled Terns seen hunting were near One Tree and Masthead Islands.

FIGURE 18. Distribution of foraging shearwaters in relation to distance from their nearest colony.



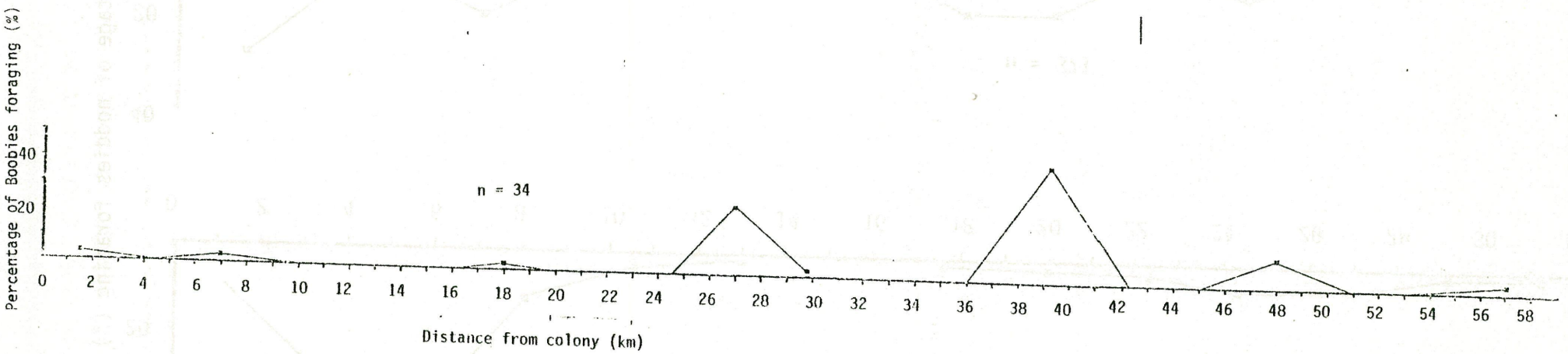


FIGURE 19. Distribution of foraging Brown Boobies in relation to distance from their nearest colony (km).

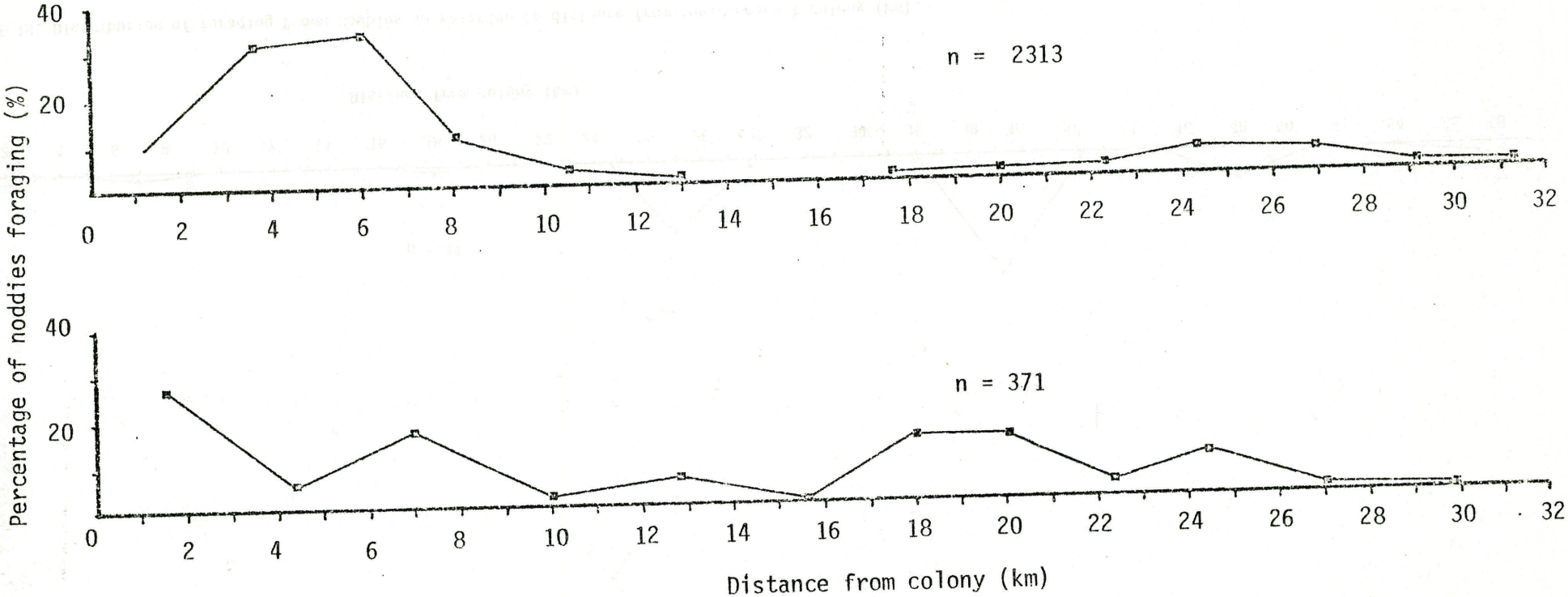
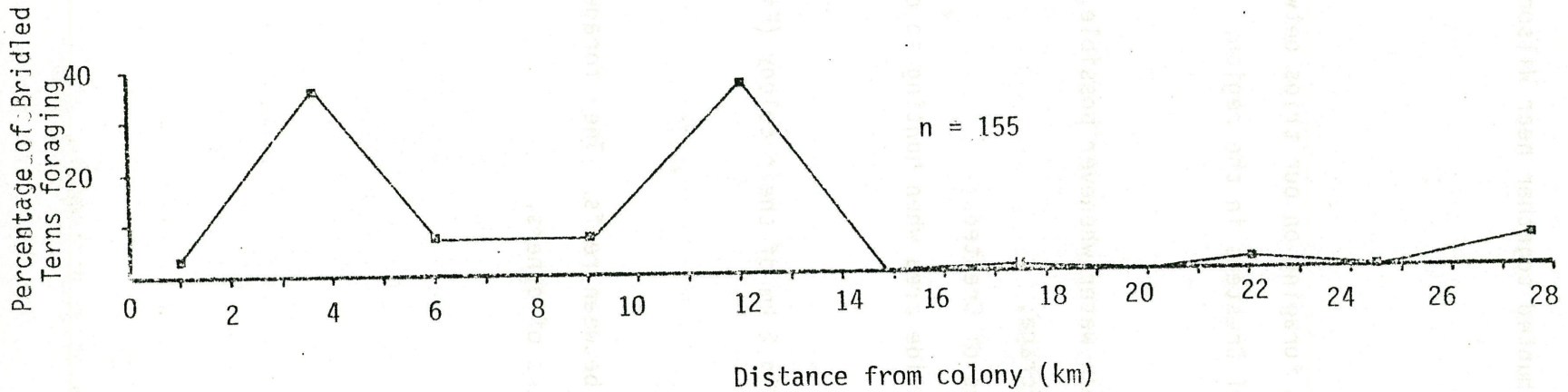


FIGURE 20. Distribution of foraging Black Noddies in relation to distance from their nearest colony (km)

FIGURE 21. Distribution of foraging Bridled Terns in relation to distance from their nearest colony.



Black-naped and Roseate Terns

The distribution of foraging Black-naped and Roseate Terns was similar in so far as the majority of both these species hunted within 1 km of their colonies (Fig. 22). They frequently hunted together near Wilson and Erskine Reefs.

Crested Tern

Crested Terns were rarely seen foraging on our trips between islands despite the relatively large number of Cresteds in the region. This may have been a result of;

1. our travelling during slack water whenever possible, a time at which Cresteds do not usually forage;
2. not locating feeding areas of Cresteds;
3. Cresteds disperse over a wide area when hunting so one mets few in any one place.

Most Crested Terns hunted within 2 km of their colony (Fig. 23).

Silver Gull

Silver Gulls were rarely seen between reefs. They foraged mostly on the reef crest and predated eggs and chicks of others.

FIGURE 22 Distribution of foraging Black-naped and Roseate Terns in relation to their nearest colony.

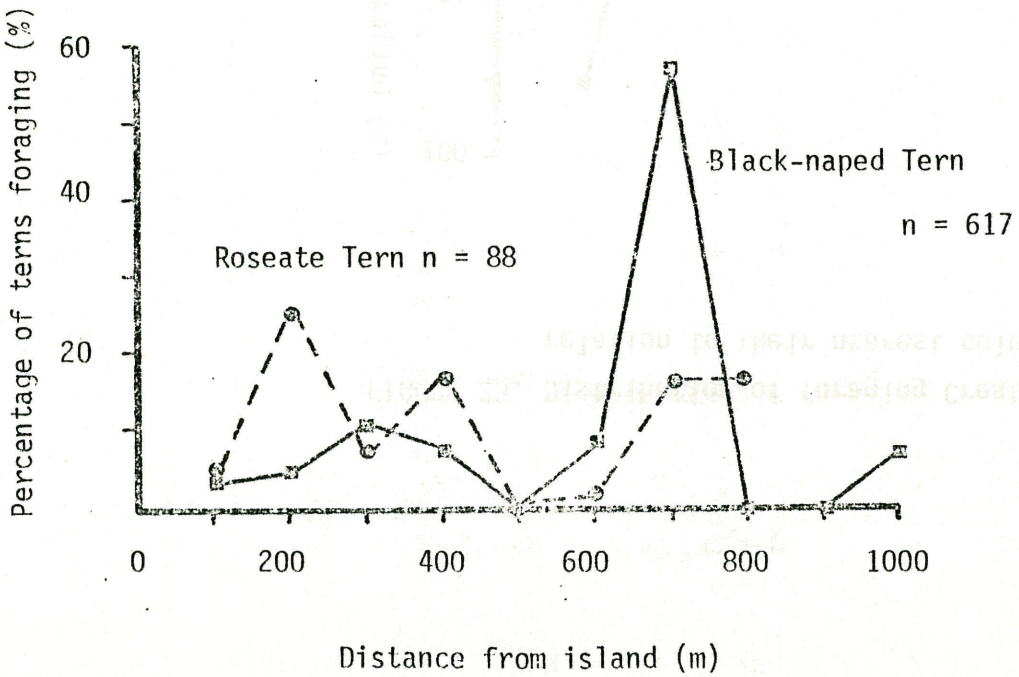
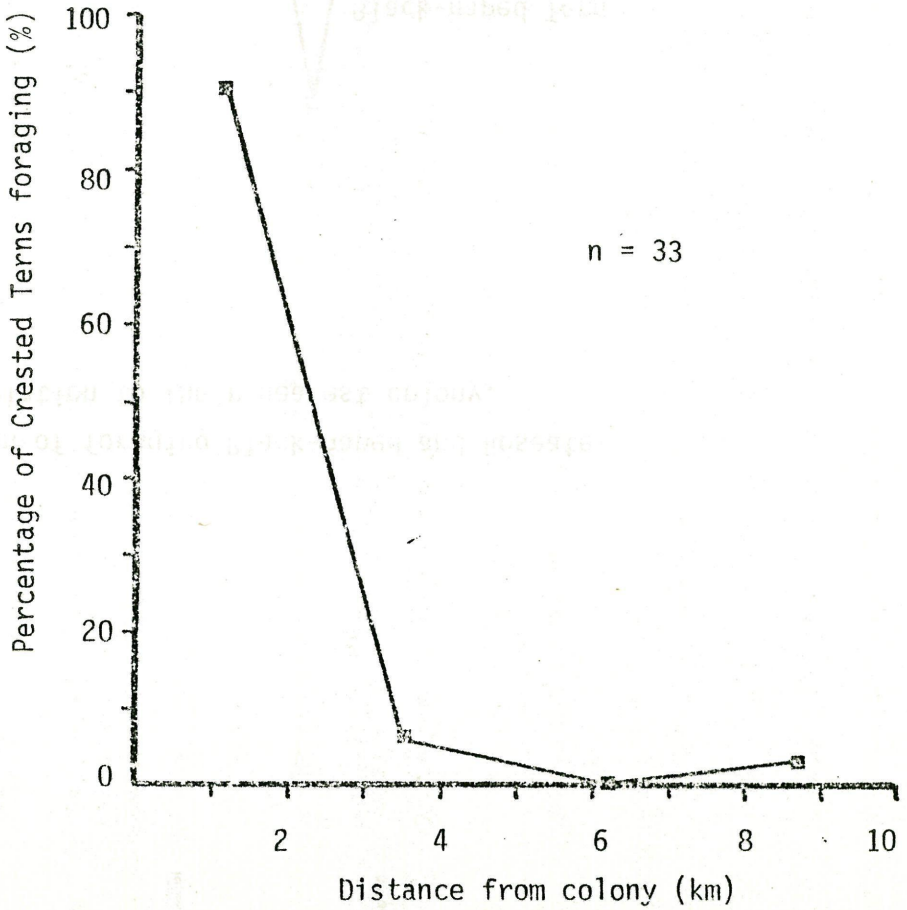


FIGURE 23. **Distribution of foraging Crested Terns in relation to their nearest colony**



DISCUSSION

DISTRIBUTION AND ABUNDANCE

Shearwater and noddy distributions do not change from year to year as do those of other seabirds. They tend to breed on the same islands year after year. The same can probably be said about Bridled Terns which seem to return to the same nest-areas each year (Hulsman & Langham ms). But the actual abundance of shearwaters at any one colony can fluctuate up to 25% from one year to the next (M. Vanek pers. comm.). The same could well be true for the Black Noddy. Certainly the number of noddies breeding at One Tree Island tends to fluctuate from one year to the next. The causes of these fluctuations in the numbers of breeding pairs are not known. Furthermore it is not known whether the pairs not breeding at the colony at which they last nested, breed elsewhere in the region or outside it.

The noddy population has been increasing at Heron Island since the turn of the century (see Shipway 1969; Kikkawa & Boles 1976; Ogden 1979). Counts during 1982-83 revealed that the population had increased since 1978. However the impression that many people including myself, who are regular visitors to the island, thought that were fewer noddies at Heron Island during 1982-83 than during 1979-80. If this is true then the noddy population at Heron Island has decreased slightly over the past two years. Possible reasons for the decrease in numbers of noddies are the loss of habitat near the centre of the island (Tall Pisonia Forest) and stabilisation of numbers after oversaturation of the habitat, i.e. numbers of noddies exceeded the carrying capacity of the island and have since returned to or below the carrying capacity. This is feasible because the nesting density of noddies at Heron Island was twice that at Masthead Island (Table 18). Counts of noddies at Heron Island during 1983-84 should indicate the direction of change in their numbers.

The large increase in the number of noddies at Heron Island during the last 5 years (40 000 in 1978 to 70 000 in 1982) coincides with a decrease in their numbers at Masthead Island. According to Jahnke (1975) there were 160 000 noddies at Masthead during 1972 whereas during 1982 there were 120 000. It could well mean that noddies are leaving Masthead for Heron Island. However this can only be determined by following the movements of marked or banded birds.

At this stage I do not know whether the breeding success of noddies at Masthead Island is the same, lower or higher than that at Heron Island. This needs to be measured during the 1983-84 season at both Masthead and North West Islands as well as at Heron Island again.

Other species of tern - Black-naped, Roseate, Crested and Lesser Crested - do not necessarily nest at the same island from year to year.

Black-naped and Roseate Terns nest at One Tree Island in some years but not in others (see Domm & Recher 1973; Hulsman 1977b). But One Tree Island frequently has Black-naped Terns nesting there. They nest less frequently at other islands; e.g. Masthead Island (see MacGillivray 1926; Cooper 1948; Jahnke 1975).

Roseate Terns often nest at Wilson Island but not every year (see Gilbert 1926; MacGillivray 1926). During January 1983 Roseate Terns wee preparing to nest at Wilson Island with the Black-napeds that had nested on the south-eastern side of the island. They were courship feeding mates in the potential nesting area, i.e. some pairs had already selected territories. However something happened between 2 and 17 January and the Roseate Terns deserted the area. In fact most Roseate Terns had left the island during that period. Although Roseate Terns nested at Wreck and Erskine Islands during February/March, I do not know if these islands will become regular nesting areas

for them. Colonies at Erskine Island are more likely to be disturbed by people than those at Wreck Island because Erskine is more accessible from the mainland. On 12 February 1983 a person disturbed the Roseates by walking along the beach near the nesting area of the Roseates at Erskine Island; the Roseates were in the air. Roseates could well use Wreck Island more often in the future if the rat population is exterminated.

The numbers of Roseate Terns are known to fluctuate greatly. During 1974 about 2000 Roseate Terns were at One Tree Island apparently looking for a suitable nesting area but left after a week or so. (A.E. & J. Chilvers pers. comm.). There were 2000 Roseates at Masthead Island during December 1981 (P. Ogilvie pers. comm.). But during 1982-83 fewer than 700 Roseates were found in the region. There may have been less because while terns are not nesting they are extremely mobile and readily travel between islands, therefore some Roseates may have been counted more than once. But even if Roseates were counted once there are some 1300 unaccounted for. If they nested, they did so outside the Capricornia Section of the Great Barrier Reef Marine Park. Hence it is possible that the geographical area in which the Roseates that breed in the Capricornia Section in some years is greater than that of the Capricornia Section.

Although Bridled Terns seem to return to the same island and indeed the same nest-area from one year to the next, there could be some interchange between colonies. This suggestion is based on colour of hatchlings on different islands. For example at One Tree Island between 1973 and 1976 all hatchlings that I found were dark grey, a colour which blended in very well with the dark grey of the weathered coral slabs throughout the nesting area whereas on other islands hatchlings were sand coloured. In 1979-80 I found a sand coloured hatchling on the island for the first time. Before this, I had thought that colonies of Bridled Tern were insular. There are several possible hypotheses

that would account for the presence of a sand coloured chick at One Tree Island.

1) an adult or pair from another colony nested at One Tree Island;

2) adults do not necessarily return to their natal colony to breed;

3) the chick was a genetic throw back.

If points 1 or 2 are correct then Bridled colonies are not insular, but if point 3 is correct then the colonies could be insular. Clearly it is a matter for further investigation and can be resolved by the recovery of banded Bridled Terns.

Lesser Crested Terns, like Roseate Terns, that breed in the Capricornia Section may breed outside the region is some years. There were more than 240 Lesser Crested Terns nesting at One Tree Island during 1973 but (Hulsman 1977b) only 96 in the entire region during 1982-83.

The numbers of Crested Terns are known to fluctuate greatly at One Tree Island (Langham & Hulsman ms) and also at Lady Elliot Island (P. Harrison & P. Allen pers. comm.). Although their numbers fluctuate greatly, they seem to use the same islands regularly for nesting. The frequency with which they use Masthead and North Reef has yet to be established.

My impression is that the numbers of Silver Gulls in the region are increasing rather than remaining constant and their distribution is changing. One gull banded when a chick at One Tree Island in 1979-80 was rcovered 50 km to the north of Townsville some six months after banding. The direction and distance of the dispersal of this juvenile is consistent with the direction and distance of dispersal of juveniles from the colonies in N.S.W. and Victoria. It could well mean that many of the young produced by colonies in the Capricornia Section disperse north along the coast, particularly to urban centres such as Townsville and Cairns where a good supply of food is guaranteed at garbage dumps, and recruits to the breeding population in the Capricornia Section come

from southern colonies. This is merely a possiblility and needs to be tested. Therefore it is important that gulls in the region are banded.

RELIABILITY OF USING AERIAL PHOTOGRAPHS IN ESTIMATING SIZE OF SEABIRD POPULATIONS

Hulsman (1981) pointed out that the reliability of estimates of potential population size of a species depends on the accuracy of

1) identification of vegetation types;
2) measuring the area of each vegetation type;
3) determining which vegetation types are suitable for a species of seabird to nest in;
4) determining the amount of suitable nesting area available to a species of seabird;
5) measuring the nesting density of the species.

The problem is determining the nesting density of a species that will provide good estimates of the number of pairs of a species nesting. This comes about because of the large differences in nesting densities of a species from one island to the next (Table 3 and 4).

Because the number of occupied nests was positively correlated with gbh of Pisonia trees at Heron Island (Ogden 1979) I thought that the number of occupied nests would be more highly correlated with projected canopy area assuming that it provided a better measure of the number of suitable places on which to build a nest. If this proved to be the case then projected canopy area could be measured from aerial photos and one could calculate the number of occupied noddy nests on the island. Of course one would need to know the following in order to do the calculation.

. the total number of trees on the island of each species;

- the proportion of trees in each size class;
- the equation describing the relationship between the number of nests and projected canopy area.

This possibility did not eventuate because the extent of the association between the number of occupied noddy nests and projected canopy area of Pisonia trees differed significantly from island to island.

There is a large amount of variation in the nesting densities of a species from one island to the next. At this stage I do not know the reasons for this large variation.

This problem coupled with the difficulty of determining what amount of suitable nesting habitat is available makes estimating potential population sizes of some seabird species from aerial photographs unreliable, e.g. Black-naped, Roseate and Crested Terns.

Overall estimates of the numbers of shearwaters and noddies in the Capricornia Section from aerial photographs were surprisingly close to the estimates based on field counts (36%). The disadvantage with the method is that the distribution of the birds was grossly inaccurate. For example some estimates of particular colony sizes were out by more than 1000%. This sort of error is unacceptable when one requires the accurate information about distribution as well as abundance of species that one is trying to manage. Zoning plans based on estimates of the number and distribution of shearwaters and noddies from aerial photographs could be totally inappropriate for the protection of these species. Therefore I strongly recommend that aerial photographs not be used to determine the numbers of breeding pairs of shearwaters and noddies on specific islands.

Aerial photographs can be used very effectively for estimating the size of seabird populations by helping one site transects or quadrats when censusing

large colonies. For example the nesting density of Black Noddies is related to habitat type (Hulsman *et al* under review). Therefore provided one samples each habitat type on the island, accurate estimates of population size of seabirds can be obtained from extrapolation based on area of each habitat type and the nesting density in that habitat type (see Hulsman 1981). It is, therefore, important to sample each habitat type. An effective means of ensuring this is done is to select sampling points from aerial photographs of the study area.

The preferences exhibited by noddies for specific habitats may well differ from island to island. Hulsman *et al* (under review) found that at Masthead Island the highest densities of noddy nests occurred in habitats of *Celtis* and *Ficus* mixed with *Pisonia*.

This may in part apply to nesting densities at Heron Island where *Ficus* supported a high mean number of nests but the highest mean nesting densities occurred in *Argusia* in the strand forest along the south-eastern part of the island.

A model of succession of four distinct types of *Pisonia* forest was put forward by Hulsman *et al* (under review). The suggested succession of *Pisonia* habitats is given in Table 22. These four habitat types were patchily distributed across Masthead Island. This patchy distribution may have resulted from local disturbances. The most likely cause of such disturbances to the vegetation would be strong winds and cyclones (Flood 1977) which would damage vegetation particularly on the windward side of the island (Hulsman *et al* under review). This hypothesis is consistent with our data because the earlier seral stages (Low and Low-Medium *Pisonia* Forests) tend to occur more frequently closer to the shore and in more exposed locations (Hulsman *et al* under review).

Since 57.3% of occupied noddy nests occurred in Medium *Pisonia* Forest disturbance to *Pisonia* Forest by cyclones could be important in maintaining

TABLE 22 Suggested succession of habitat types and the numbers of noddy nests in each habitat type.

Vegetation Type	Group 2 Low *Pisonia* Forest	Group 4 Medium *Pisonia* Forests		Group 3 Tall *Pisonia* Forest
		a Low-medium *Pisonia*	b Medium *Pisonia*	
Dominant sp.	*Pisonia* (>4-6m)	*Pisonia* (>6-8m)	*Pisonia* (>8-10m)	*Pisonia* (>10m)
Associated species in decreasing order of importance	*Celtis* (>4-6m)	*Celtis* (>6-8m)	*Ficus* (>4-6m)	*Ficus* (>6-8m)
	Ficus (>2-4m)	*Ficus* (>4-8m)	*Pipturus* (>2-4m)	*Celtis* (>8-10m)
		Pipturus (<8m)	*Celtis* (>4-6m)	
Number of attributes present in the group as a whole (excluding *Pisonia* attributes)	25	17	16	16
Nests	Few nests	Nests frequent	Nests present	Nests present
Succession	Early ----------> Late			

large numbers of noddies (Hulsman et al under review). This seems to be the case at Masthead Island but at present I do not know if it applies to North West and Heron Islands where the other important colonies of noddies occur.

FORAGING AREAS

Seabirds apparently partition their food supply, in part, through the distance that they hunt from their colonies (see Hulsman ms under review). All species are known to forage in mixed flocks feeding on bait fish driven to the surface by predatory fish (pers. obs.). Some species, (Shearwaters, Brown Boobies and Crested Terns) often hunt alone but at times they occur in flocks. For example, shearwaters occurred singly on all transects except between North West and North Reef where a flock of about 3000 Shearwaters were seen. In light of there being about ¾ million shearwaters at North West Island 3000 is negligible. Shearwaters probably disperse over a large area of ocean, they are certainly capable of it as they are at sea from dawn to dusk.

Most seabirds were found within 10 km of a reef. This may be because of the large concentration of nutrients around coral reefs and their scarcity increases with increasing distance from coral reefs.

Large flocks of noddies were often seen foraging within 3 km of their major colonies: North West, Masthead and Heron Islands. Black-naped and Roseate Terns formed loose flocks over the reef edge at both Wilson and Erskine Reefs during rising and falling tides. The movement of water might help them catch fish more efficiently than during still water.

MANAGEMENT

The function of a comprehensive zoning plan is to conserve the natural resources of the reef and still allow the public reasonable use of the region. In the zoning plan developed for the Capricornia Section of the Great Barrier Reef Marine Park, a balance of uses had to be sought if the plan was to meet its objectives because some uses are incompatible, e.g. recreation and maintenance of colonies of some species of seabird.

THEORY OF ISLAND BIOGEOGRAPHY

The Theory of Island Biogeography can be used successfully as a basis for managing seabird populations. The implications of the theory need to be developed with respect to retaining specific species rather than maintaining species diversity which ignores species composition of the community. For example, to maintain viable colonies of Roseate Terns in the region it will be necessary tohave colonies producing surplus young (i.e. a pair, during its reproductive life, producing more young that survive to reproduce successfully than are needed to replace itself) well within range of powers of dispersal of the species so that there is a reasonable probability of an island being colonised if the population on it becomes extinct. Thus colonies in the Capricornia Section could supply migrants to one another as required to receive migrants from colonies from outside the Capricornia Section to recolonise cays and maintain the viability of the colonies.

The current zoning plan is unsuitable for the conservation of at least four species of seabird because too few of their major colonies are adequately protected during the breeding season from disturbance by humans and/or predation by gulls (Hulsman in press a). The plan does not take into account the interdependence of colonies of some species. The viable unit may in fact be a number of colonies rather than a single colony because there is substantial

movement between islands (Hulsman in press a). In addition, national park status alone is not sufficient to protect colonies adequately; regulation have to be enforced.

The zoning plan must be developed with respect to the powers of dispersal and colonising abilities of the species that we are trying to protect. Unfortunately we do not know very much about the powers of dispersal of most species of seabird that breed in the region. All we know at present is that all species, except perhaps the Black Noddy, leave the region during the non-breeding season. It seems that we know more about their respective colonising abilities than their powers of dispersal. Species which frequently change their nesting areas from year to year seem to be better colonisers than species which frequent the same nesting areas from year to year. That is Black-naped, Roseate, Lesser Crested and Crested Terns because of their more opportunistic breeding behaviour tend to better colonisers than Black Noddies and Wedge-tailed Shearwaters. Species such as Black Noddies, and perhaps shearwaters, have an additional feature that renders them poor colonisers; that is, they seem to require the presence of a certain number of conspecifics before starting to breed. For example at One Tree Island at least 7 years elapsed before they started to breed on the island (Hulsman 1979).

Data on the powers of dispersal of each species of seabird that breeds in the region cannot be amassed quickly. These data accumulate slowly from recoveries of banded birds. Since the powers of dispersal of each species needs to be determined it is important for the banding of seabirds in the region to continue.

However it would be unwise to postpone the managing of seabird populations until sufficient is known about their powers of dispersal. Meanwhile, until more is known about their powers of dispersal, the main thrust of managing seabird populations in the region should be to increase the general

public's awareness of what can be done and not done near seabird colonies. This will be developed in the section about Public Education.

FACTORS INFLUENCING THE STATUS OF SEABIRDS

Inhabited Islands

Three islands in the region are inhabited by people all year round; these are Heron, One Tree and Lady Eliot Islands.

The status of shearwaters is influenced by man's activities at Heron Island. Man's presence on Heron Island has apparently affected the numbers of shearwaters breeding on the island. On the western third of the island, where there are many buildings, the mean density of burrows/100m^2 was 4.3 $\pm$ 9.5 (n = 30) on the middle third where there is a mixture of buildings trees and stacked trunks, the mean density was 7.3 $\pm$ 7.4 (n = 34) and on the eastern third (national park) where there has been the least disturbance to the vegetation, the mean density was 5.9 $\pm$ 6.4 (n = 34). Compaction of the substrate around roads, paths and frequency of use make some areas unsuitable for burrowing and therefore decrease the density of burrows. Buildings or at least their foundations and concrete slabs apparently provide the structural support needed for burrows, so in some cases buildings may increase the density of burrows.

People walking through the Pisonia Forest often fall into and collapse burrows if they do not remain on the tracks across the island.

There are few shearwaters at Lady Elliot Island and none at One Tree Island. The unsuitability of the substrate for digging burrows is the main factor determining the numbers of shearwaters on these two islands.

The status of the Black Noddy is also influenced by man but to a lesser extent than the ground nesting terns. The main threats to the noddy population

at Heron Island are the loss of habitat, mortality caused by Pisonia seeds, chicks having fallen out of their nests and predation on eggs and chicks by Silver Gulls and Reef Herons.

The major threat to the noddy is the loss of habitat. There are some signs that the effect of clearing trees in the resort and research station has on the numbers of noddies. On the western third of the island (resort) the mean number of nests/100m^2 was 16.1 $\pm$ 14.4 (n = 30), in the middle third (resort and research station) the mean density was 16.1 $\pm$ 30.9 (n = 30) whereas the mean density in the eastern third (national park) was higher 22.4 $\pm$ 24.0 (n = 33). The large variability in the number of nests in the national park is caused by high nesting densities in the Argusia and Pisonia on the windward side of the island and the low nesting densities in the Casuarina and Pandanus on the leeward side.

Predation by Silver Gulls on noddy eggs and chicks is related to man's activities in the whole geographical area: mainland as well as islands. As it was pointed out in the Section about factors influencing reproductive output (page 52) man's garbage is a food source for gulls. Even though gulls do not breed at Heron Island it has the largest population of them in the area.

One Tree Island is much smaller than Heron Island but it does not accommodate the high density of people that Heron Island does. The direct impact that people have on breeding seabirds at One Tree Island is small; species that are easily disturbed by man continue to nest on the island. This is because the rules regarding where people may walk during the breeding season of the birds are very restrictive. All activity on the island is restricted to the northern corner of the island. The indirect impact of man on the breeding success of terns has also decreased with the decrease in the number of gulls on the island, accordingly the incidence and success of predation and kleptoparasitism have decreased. The small number of Pisonia trees on the

island means that there is little suitable nesting habitat for noddies.

Lady Elliot Island is larger than Heron Island and does not cater for the large number of people that Heron Island does. While the resort remains small, the direct impact of man on breeding seabirds will also remain small provided of course that people are encouraged to stay more than 60m from the Crested colony and more than 80m from the Black-naped one. One area of concern is the increase in the number of gulls on the island and the accompanying increase in predation on eggs and chicks of seabirds.

Temporarily inhabited islands

Temporarily inhabited islands are Tryon, North West, Masthead and Lady Musgrave Islands. People may camp on these islands during the breeding season of the birds, unless seasonal enclosure is imposed. Masthead Island is the only one of these islands that can be closed during the breeding season.

The size of the island does influence the effect that inhabitation has on seabird colonies. On large islands man's effects on the flora and fauna are on a smaller scale than they are on small islands. There is obviously more scope on a large island for man and breeding birds to co-exist. For example people can walk around a large island and easily stay 60m from a Crested colony and so not disturb them. However on a small island people cannot walk around it without encroaching on the flight distance of the nesting seabirds.

The status of shearwaters at Tyron Island is probably influenced by Pisonia seeds and distrubance to their habitat by people. Noddies do not breed on the island. They may be sub-adults which will go the nest at North West Island when they mature.

North West Island is heavily used by campers during the school holidays. This use causes some destruction of nesting habitat. But camp sites seem to be

largely restricted to the northern side of the island. Shearwaters may collide with tents at night but they probably do not hurt themselves. Lights may confuse incoming shearwaters making it a little difficult for them to find their burrows. The main factors affecting the status of shearwaters are Pisonia seeds and cats. Pisonia seeds caused the deaths of more than 4000 adult shearwaters during 1982-83. Another source of mortality of adults and chicks could be people collapsing burrows when walking to the centre of the island or across it. From the evidence of the quantity of graffiti on the rocks and tree trunks and litter in the centre of the island it appears that people often walk into the interior of the island. Densities of burrows are extremely high, well in excess of 40 burrows/100m^2, 160m from the northern beach and people cannot walk across without collapsing some burrows, particularly if the substrate has dried out.

The status of shearwaters at Masthead Island seems to be affected by Pisonia seeds. It is possible that the loss of shearwater nesting habitat through Opuntia covering large tracts of the island could decrease the numbers of shearwaters on the island. This needs to be examined further.

The status of shearwaters at Lady Musgrave Island is also affected by Pisonia seeds and the small areas of suitable nesting habitat.

The status of noddies is affected by Pisonia seeds, bad weather and to a lesser extent cats, unless cats often climb trees. Pisonia seeds trap adults (most likely males) collecting nesting material and also chicks that have fallen out of their nests. I hypothesise that cats would not usually eat birds covered in Pisonia seeds because the sticky seeds would catch in their fur and be extremely difficult to remove. I suggest that cats would catch and kill birds with few or no Pisonia seeds on them. Members of the research team found noddies unable to fly because the few Pisonia seeds on them bound at least one of their wings to their bodies . Such birds would easily be stalked and caught by cats. Otherwise these noddies would starve to

death.

The status of noddies at Masthead Island is affected by Pisonia seeds and the age of Pisonia trees. The island is covered with very large (hence old) Pisonia trees. Noddies seem to avoid old trees possibly because they are brittle and readily break or be wind thrown (Ogden 1979).

At Lady Musgrave Island the status of noddies seems to be affected by Pisonia seeds, disease and predation by gulls. During January 1983 a large proportion of the adult population was found dead. The likely cause would be disease. The island has a fair amount of open areas enabling gulls to easily steal eggs and chicks from noddy nests.

The status of ground nesting terns at Tryon Island seems to be influenced by the presence of people during the birds' breeding season. Breeding success of Bridled Terns which nest near the camp sites may be lower than that of those which nest well away from the camp sites. The birds may not be fully habituated to human activity and loud noises from machinery (generators and compressors). If people over a long period regularly go close to nesting areas of Bridled Terns the terns habituate to it. They may utter alarm calls but they may not fly off.

The status of Bridled Terns at Masthead is affected by bad weather perhaps and Pisonia seeds. Some Bridled Terns were coverted with seeds but I suspect that it is a relatively rare event for this species. Bridled Terns are disturbed by people walking close to the strand vegetation.

The status of Bridled Terns at Lady Musgrave Island is influenced by the damage that the goats did to the vegetation. The largest concentration of Bridled Terns occurred in the area where a Casia like plant had overgrown the natural vegetation.

The status of other ground nesting terns seems to be affected by the presence of people during the birds' breeding season. For example Black-naped Terns did not nest at Tryon Island during the School holidays when people were there. But they did nest several weeks after the school holidays had finished. Nesting so late in the season could decrease the chances of young surviving their first winter.

The status of all ground nesting terns at North West Island is probably determined by the presence of cats. These terns seek free nesting areas. If the cats on the island were exterminated then ground nesting terns would probably nest on the island.

Their status at Masthead Island is most likely affected by man's presence particularly the status of the more timid species such as Black-naped and Roseate Terns. These species tend to nest on the periphery of the vegetation near the strand zone and likely to be disturbed by people walking along the beach. Crested Terns once nesting are more tolerant of people than Black-naped and Roseate Terns are. Also a large gull population gathers on the island while campers are there. This could increase predation on eggs and chicks of all species of seabird.

The status of ground nesting terns at Lady Musgrave Island, especially Black-naped and Roseate Terns is affected by the frequency of people's visits to the island. The island is often visited by folk who seek anchorage in the lagoon during storms from the south and south-east. The seemingly most suitable nesting area of the terns is near the beach where people land on the island. These would be too much disturbance for terns to raise their young successfully.

The automatic light is serviced once every six months. The frequent comings and goings of the lark from mothership to the light caused noddies, Bridled and Gulls to fly up from their nests. I am not sure of the extent to

the damage to nesting by this activity.

Uninhabited Islands

The uninhabited islands of the areas are North Reef, Wilson, Wreck, Erskine, Hoskyn and Faifax Islands. Three of these islands were previously inhabited; North Reef was inhabited by lighthouse staff, Wreck and Fairfax Islands were inhabited by Julie Booth.

Wilson Island is about to become a temporarily inhabited island during the non-breeding season with day visits once per week during the breeding season. Therefore the factors influencing the status of breeding seabirds will change. Erskine and Hoskyn Islands are visited from time to time but I do not know how frequently.

There is no suitable nesting habitat for either shearwaters and noddies at North Reef. There is little suitable nesting habitat for both species at Erskine, Hoskyn and Fairfax Islands.

The status of shearwaters at Wilson Island seems to be influenced by suitable substitute for burrowing, some areas have possibly too much rubble. The drying out fo the substrate causes burrows to collapse (M. Vanek pers. comm.) perhsps at Wilson with its tree and herbaceous cover the substrate does not dry out as quickly as less vegetated cays.

The status of shearwaters and other ground nesting seabirds at Wreck and Fairfax Islands is probably affected by rats. The decrease in the rat population will probably result in increases in numbers of all species that breed on these islands.

The status of shearwaters at West Hoskyn Island is unlikely to be affected by Pisonia seeds because there are few Pisonia on the island.

The status of noddies at Wilson Island is affected by lack of suitable nesting habitat. The island's vegetation is dominated by Pandanus and stunted Ficus trees. I do not know what affects the status of noddies at Wreck Island. It might be the lack of social facilitation that noddies seem to require before breeding and/or lack of suitable habitat to nest in.

I do not know why Brown Boobies nest only on East Hoskyn and Fairfax Islands, perhaps it is related to man's activities. Their status at these islands could be affected by kleptoparasitism by Frigatebirds and distances that they travel in search of food.

The status of Bridled Terns at North Reef, Wilson and Erskine Islands is affected by lack of suitable habitat to nest in. Their status at Wreck and Fairfax Islands is affected by rats. Possibly the sharing of some areas with shearwaters at Wreck Island limits the numbers of Bridled Terns since the occupation of space by shearwaters could force Bridled Terns out of certain areas. They seem to be more common where shearwaters are not common.

The status of Black-naped and Roseate Terns is possibly influenced by predation by gulls, flooding of nesting areas and at times people. Gulls and people might assume greater importance in the breeding of these terns at Wilson Island unless appropriate controls over people's activities on the island are enforced.

It is possible that nesting turtles and disturbances by people affect the status of ground nesting terns at Erskine Island. Nesting turtles most likely affect where ground nesting terns nest particularly at Wreck and Wilson Islands.

For example, the nesting areas of Black-naped and Roseate Terns seems to be in sites that are protected from turtles such as on a beachrock platform (Tryon), behind a beachrock wall (Wreck) on a ridge above an area of very rough terrain (Wilson and Erskine).

The status of Crested Terns at North Reef will be affected by nesting turtles and to a lesser extent visits by Commonwealth personnel to service the automatic light. The impact of their visits depends on the stage of the terns' nesting cycle.

SOME MANAGEMENT OPTIONS

The two most common species of seabird in the region are the Wedge-tailed Shearwater and the Black Noddy. The distribution of shearwaters is certainly affected by the suitability of the substrate for burrowing. Shearwaters do not nest on rubble islands in the region, i.e. One Tree, East Hoskyn and East Fairfax Islands. The distribution of Black Noddies seems to be affected by the distribution of Pisonia, Ficus, Celtis and Argusia trees of suitable sizes.

The main danger facing the populations of the shearwaters and Black Noddy is destruction of their habitat. Some may think that because these two species are so common in the region, they need no protection. For example it does not matter if a person collapses a burrow and directly or indirectly kills a shearwater. It is true that one shearwater is negligible relative to 800 000. But if each visitor to an island killed, accidently, one shearwater given the large numbers of people visiting these islands during summer, the impact on the shearwater population would be significant. Therefore it is necessary to provide walking tracks across islands so that people can cross an island and not fall into a shearwater burrow. This is necessary to protect people from the risk of breaking a limb, sprains etc. as well as protecting the birds.

It should be noted that the Capricornia Section is the stronghold of the Black Noddy on the eastern coast of Australia. If the colonies on North West, Masthead and Heron Islands are adversely affected then it could result in a major decline in the numbersof the noddies in the region without the possibility of recolonisation from populations outside the Capricornia Section. Since the noddy is tolerant of most of our activities, it would be irresponsible for us to

allow anything that decreased their breeding success to occur at their main colonies. Therefore it is important that large scale clearing of Pisonia Forst as has occurred recently at Heron Island not be permitted in the future. This comment applies to the research station as well as the tourist resort.

Disturbance to forest by cyclones is qualitatively and quantitatively different from that by man. Strong winds are more likely to topple or damage old brittle trees than younger more resilient ones (see Ogden 1979) and disturbances are localized, thus ensuring regeneration. In contrast, man to date on Heron Island, for example, tends to clear on a larger scale and more thoroughly than strong winds do when he clears for building sites, water tanks, bar-b-que areas, etc. Man's impact, it seems, is far greater than strong winds on the vegetation of coral cays. This impact in turn affects the numbers of some species of seabirds nesting on disturbed cays.

In drawing up management plans of Heron Island and Wilson Island for example, the responsible agencies (Lands Department and National Parks and Wildlife Service) should ensure that a minimum of tree and ground cover are removed to enable construction of buildings, safe access to them and so on.

An impression that many people get when visiting Heron Island is that too much of the island is covered with buildings and large open spaces. About half of Heron Island has been built upon. Space on the island seems to be used inefficiently. Perhaps the use of two storey buildings e.g. the laboratory facilities at the research station and the new units at the resort, with their roofs below the line of the canopy could make more efficient use of space. At present there are large areas within the research station and some of its buildings not being used, but still the research station is expanding into noddy and shearwater habitat, I believe that this is unnecessary.

Of course any construction of walking tracks must be done during the

non-breeding season of shearwaters (July - October). The cheapest and most effective way of constructing walking tracks is by repeated walking through an area along a particular heading collapsing any burrows along the line of the proposed track. Frequent walking along the track will compact the substrate and perhaps make it unsuitable for the shearwaters to dig into.

There is a need to retain as much of each species habitat as possible. Therefore when building, the area cleared should be sufficient for safe access for construction workers and materials, as well as sufficient for paths to and from buildings for people. Anymore clearing is simply unnecessary destruction of noddy and shearwater habitat. Visitors to coral cays usually like to have the birds nesting near their accommodation.

If one should want to create suitable habitat for the shearwaters to nest in at Heron Island, fallen Pisonia trunks, branches etc. should not be stacked but leave them scattered where they provide support for the entrances of burrows. This increases the density of shearwater burrows in an area (M. Vanek pers. comm.).

To effectively manage a very dynamic system one should retain flexibility. Unfortunately this is not feasible on many islands which have already been committed to develop or camping. The amount of time required for forward planning, e.g. granting permits to camp on islands is far greater than the amount of time many seabirds give in warning as to where they will nest. Some islands should be closed seasonally, namely those with Roseate and/or Black-naped colonies. On large islands for example Lady Elliot and Masthead, Crested Terns can nest without undue disturbance from people on the island, provided that people remain far enough away from colonies. On the other hand on small islands such as North Reef and One Tree, Crested Terns are readily disturbed unless there are severe restrictions on where people can walk etc. Black-naped, Bridled and Crested Terns continue to nest at One Tree Island

because people on the island are not permitted to walk more than 20m towards the west from the lab hut and not beyond the hut of the officer-in-charge. If people wish to walk they may do so on the reef crest keeping well away from the island. In addition people are not permitted to go past the line of the buildings towards the centre of the island.

PUBLIC EDUCATION

It is feasible to increase the public's awareness about man's impact on the flora and fauna of coral cays. In the main, people are willing to learn more about the wildlife on islands.

People tend to disturb breeding seabirds through ignorance. I have found that even people who were not interested in birds before visiting Heron Island develop an interest in them during their visit. People become eager for information about the birds. We should capitalise on people's motivation to learn more about nature; to educate them in terms of what to do and what not to do near seabird colonies.

There are several important elements in presenting this kind of information:

1) the amount of detail required to make the essential points.
   (a) People find it difficult to distinguish various species of tern.
   (b) It is probably easier to tell people what nesting seabirds do as one approaches a colony and therefore a person could determine if he/she was too close to a colony.

2) the information could be directed at a number of levels:
   (a) what to do near seabird colonies.
   (b) basic life history information about each species.

3) people should be told why they should behave in a specific way.

4) Wherever possible, information should be phrased positively rather than negatively. For example, "please keep at least 60m from seabird colonies" is preferable to "please do not go within 60m of seabird colonies."

The amount of detail concerning what to do near seabird colonies should be kept to a minimum. This information could be attractively presented on a brochure with illustrations and photos to help make the points. Although the format of the brochure might be like that produced by the Bird Observers Club in Victoria, I strongly recommend that the text and photos be appropriate to the Great Barrier Reef.

The content of a brochure should be something like:

1) a brief introduction to the importance of the Capricornia Section for breeding seabirds;
2) duration of the breeding season;
3) brief descriptions of habitats in which the birds nest. For example, Shearwaters nest in burrows often in Pisonia Forst, Black Noddies nest mainly in Pisonia trees whereas ground nesting terns nest in the vegetation near the beach;
4) walk on tracks provided;
5) distance people should remain from a colony of ground nesting birds;
6) sequence of behaviours that terns perform as an intruder approaches their colony;
7) what to do should you disturb nesting seabirds. For example if one collapses a burrow, please dig the bird under the sand out. If the entrance or tunnel is obstructed please clear it sufficiently to enable occupants to leave the burrow otherwise the bird will be trapped in the burrow and die from suffocation or starvation;
8) do not feed gulls and the reasons why;

9) take food scraps and garbage with them back to the mainland.

Should a person not notice a colony until the birds are flying low overhead and calling he/she should move away from the area as quickly as possible. One should go far enough to allow the birds to land at their nests and resume incubation duties etc.

The sequence of behaviours that terns perform as an intruder approaches their colony is:

1) if a person comes too close to a colony, the initial reaction of the birds is silence. Terns are usually noisy in their colony which is the focal point of their social behaviour;
2) if a person continues to approach the colony, the birds make alarm calls and raise their wings preparing to take off;
3) the next stage is the birds fly up calling loudly. Some birds will fly overhead and defaecate on or swoop at the intruder until he/she leaves the nesting area.

At anytime during the first two stages, the intruder can move away from the colony without causing the birds to leave their eggs or chicks.

The brochures could be distributed by NPWS when sending camping permits to people and while visiting islands, as well as by tourist resorts and research stations in the area.

Larger posters such as the ones on the Cairn's esplanade could be used to help people identify the seabirds and waders seen on the islands. These posters could be displayed at the resorts, research stations and Marine Park offices. Perhaps people could buy the poster from the GBRMPA and NPWS.

CONCLUSION

The development of a public education programme about seabirds should initially involve at least Marine Park Section (NPWS), GBRMPA and myself. The Environmental Studies Section of the Department of Education, Earthwatch and Natural History Unit of the ABC could contribute positively to increasing the public's awareness about seabirds.

I have not suggested any changes to the current zoning plan of the Capricornia Section nor have I suggested any management plans for specific islands. I propose to make those sorts of recommendations in the final report due in July 1984. I believe that any recommendations about overall mangement plans for area would be premature because another season's data are needed to resolve some questions about changes in the distribution and abundance of seabirds.

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M Gooch NYC	20/5/88	
~~G CHESTER~~	2/11/90	
~~ANCA Canberra~~	9/9/93	~~4/10/93~~
Alessandra Manzon	28/04/98	(volunteer)

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