598.2(GBR)

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

III POPULATION PARAMETERS AND MANAGEMENT STRATEGIES

BY

DR KEES HULSMAN
SCHOOL OF AUSTRALIAN ENVIRONMENTAL STUDIES
GRIFFITH UNIVERSITY
NATHAN QLD 4111

FOR

THE GREAT BARRIER REEF MARINE PARK AUTHORITY

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AUGUST 1984

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SUMMARY

Distribution of Wedge-tailed Shearwater, Brown Booby, Black Noddy, Bridled Tern, Crested Tern and Silver Gulls do not change from year to year; distributions of the other seabird species studied do.

Abundance of each species can fluctuate greatly from one year to the next.

Most species are extremely mobile and redistribute themselves among specific, or any islands e.g. Silver Gulls.

Reproductive output of all species, except Wedge-tailed Shearwater was greater during 1983-84 than during 1982-83. The number of fledglings produced were Boobies 3700, Noddy 152718, Roseate 217, Black-naped > 142 and Crested > 3000.

The management strategies suggested primarily involve increasing public awareness about the requirements of fauna for successful breeding so that people will minimise their adverse effects on the breeding animals.

Information can be disseminated to the public via publications, information sheets issued by NPWS/GBRMPA, posters, guided tours and TV and radio programmes.

Management in short-term should involve restricting the public to the large islands where their activities are less likely to disturb breeding seabirds. Some islands should be closed during the breeding season because species sensitive to human disturbance nest there. [North Reef, Erskine, Wreck, Hoskyn (East and West) Fairfax (East and West)]

Management in long-term will involve increasing people's access to most islands as the public's awareness of requirements of breeding seabirds increases. This approach will help achieve the objective of the GBRMPA to conserve the GBR and allow people reasonable access to and use of the region.

RECOMMENDATIONS

1. Marine Parks personnel continue to monitor
   (a) size of breeding populations
   (b) where each species breeds
   (c) reproductive output of each colony.

2. Eliminate rats from Wreck and Fairfax Islands and feral cats from North West Island.

3. Strictly control further development of Heron and Wilson Islands.
   (a) construction work potentially damaging to breeding seabirds and their young should be done during the non-breeding seasons;
   (b) minimise the area of vegetation cleared on islands, two-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.

4. Control size of gull populations indirectly. People should not feed the gulls and should dispose of food scraps in such a way that they are not available to gulls.

5. Consider each islands importance for nesting turtles as well as nesting birds when re-examining current zoning plan.

6. Restrict public to large islands (p24).

7. Some islands remain closed during the breeding season because these islands have important colonies of seabirds that are sensitive to disturbances by humans (p24).
   (a) Wreck, Fairfax and East Hoskyn be closed throughout the year;
   (b) Erskine be closed from 1 February to 31 May;
   (c) North Reef be closed from 1 October to 31 March.

8. Habitat of shearwaters at North West must be protected because 80% of Wedge-tailed Shearwaters on the east coast of Australia breed there.

9. Increase the public's awareness about the requirements of nesting seabirds and turtles (p21). This can be done by -
   (a) Marine Park's personnel speaking to campers and other users about seabirds and turtles (p22);
   (b) Guided tours on Heron, North West and Masthead Islands (p25);
   (c) Excursions supervised by Marine Park's personnel to Fairfax/Hoskyn Islands (p25).

INTRODUCTION

This is the final report on the survey of seabird and wader populations of the Capricornia Section of the GBR Marine Park.

This report is set out in the same way as the interim report but in this report I compare the results of 1982-1983 and 1983-84 breeding seasons.

The aims of the research are:

1. census seabird and wader populations;
   (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 and 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. Measure the distances that each species forages from its colony.

5. Use the preceeding information to develop some management strategies for seabirds in the region.

TABLE 1 Number and orientation of transects on islands.

Island	#Transects	Distance between each transect (m)	Orientation (degrees)
Tryon	4	-	140
North West	2	480	130
Masthead	4	150	180
Wilson	8	25	180
Wreck	6	50	180
Heron	9	20-80	180

TABLE 2 Number of transects between specific islands and/or mainland to count foraging seabirds.

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

METHODS

DISTRIBUTION AND ABUNDANCE

I used essentially the same methods in 1983-84 as in 1982-83. I used transects 10m wide to census shearwater and noddy populations when they co-occurred i.e. at North West, Masthead and Heron Islands. At Tyron Island the same quadrants were sampled in both breeding seasons. Transects 4m wide were used to census shearwaters at Wilson and Wreck Islands.

Terns, gulls and waders were counted during high tide when the rising tide had forced them to roost on the island.

REPRODUCTIVE OUTPUT

The number of chicks produced by noddies was estimated from the breeding success of a sample of nests. The number of pairs in 10 or more trees was counted early in the season and then again later in the season before chicks fledged.

Counts of chicks of each species during high tide enabled me to determine the minimum number of breeding pairs and their reproductive output.

FEEDING AREAS OF EACH SPECIES OF SEABIRD

During trips between islands and the mainland and islands I recorded the number of each species observed in each 1 minute interval. In 1982-83 I had used 5 minute intervals but this interval was not really satisfactory for plotting the distribution of species that hunt close to their colonies.

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.

Table 4 gives the results of transects used to calculate the numbers of breeding pairs of Black Noddy on islands with large colonies.

The distribution of breeding colonies Wedge-tailed Shearwaters, Black Noddies and Brown Boobies did not change from 1982-83 to 1983-84 but their abundance did (Tables 5 and 6).

The proportion of breeding pairs of shearwaters on North West and Masthead Islands was 89% in 1982-83 and 90.7% in 1983-84.

Brown Boobies bred on East and West Fairfax and East Hoskyn Islands again 1983-84. There were 3.5 times as many breeding in 1983-84 compared with those breeding in 1982-83.

The proportion of breeding pairs of Black Noddy on North West, Masthead and Heron Islands was 98% in 1982-83 and 98.7% in 1983-84. The population on Heron Island has continued to increase. In 1927 there were possibly a few hundred pairs given that 50 trees were used for nesting (see Kikkawa and Boles 1976). In 1965 there were 8500 pairs of noddies (Shipway 1969) and between 13000 and 25000 pairs by 1978 (Ogden 1979). There were about 35000 pairs in 1982-83 and 44000 pairs in 1983-84.

The number of Common Noddies at Lady Elliot Island was about the same during the two breeding seasons (Table 5 and 6).

The distribution and abundance of Bridled Tern were the same during the two breeding seasons. The number breeding on Tryon Island in 1982-83 was overestimated, a research assistant counted many birds at least twice. My own counts during 1982-83 indicated that there were about 300 Bridleds on Tryon. The largest colony of Bridleds is at One Tree Island with sizable

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 Great Barrier Reef Marine Park.

Island	Burrows/100m^2 Mean Nos.	s.d.	Nos. quadrats sampled (100m^2)	Area of island (ha)	Estimated nos. of pairs
North West	31.53	25.55	157	120	378,360
Masthead*	7.00	-	167	44	30,800
Wilson	13.50	-	58	5	6,525
Wreck	5.20	-	23	10	5,020
Tryon	7.1	6.7	139	10	7,100
Heron	4.9	6.8	96	16	7,840

* adjusted

TABLE 4 Summary of transect results used to calculate the number of breeding pairs of Black Noddy on three islands in the Capricornia Section of the Great Barrier Reef Marine Park.

Island	Nos. of nests Mean	s.d.	% occupancy	Nos. quadrats sampled ($100m^2$)	Area of island (ha)	Estimated nos. of pairs
North West	10.39	22.07	97	158	120	117,199
Masthead*	20.4	31.7	94.8	167	44	85,092
Heron	27.3	31.86	94.3	96	16	43,680

* adjusted

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	-	397*	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	130 240*	-	125 693*	-	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	955 930	2 160	361 085	112	2 628	160	202	-	1 928	-	384
Non-breeding	-	-	369			538	686	96	205	701	933

TABLE 6 Numbers of breeding and non breeding individuals of 11 species of seabird on each island in the Capricornia Section of the Great Barrier Reef Marine Park during the 1983-84 breeding season. These data do not include the numbers of chicks.

Island	Shearwater	Booby	Black Noddy	Common Noddy	Bridled	Roseate	Black-naped	Lesser Crested	Crested	Little	Silver Gull
North Reef	0	3	0		0	24*	41*	4	1510*	0	24
Tryon	14200*	0	90		397*	182	170*	9	10	58	119*
North West	756720*	0	234398*		0	0	0	31	31	137	33
Wilson	13050*	0	200		10*	312	82*	0	2	11	70*
Wreck	10400*	0	0		124*	160*	304*	9	12	30	221*
Masthead	61600*	0	169082*		492*	214*	104*	1	398	15	121*
Erskine	<1000*	0	14*		51*	184*	25	0	4	10	78
Heron	15680*	0	87360*		0	4	16	48	11	78	287
One Tree	0	0	506*		600*	9	164*	240*	165*	127	26
Hoskyn	13000*	900*	1328*		279*	96*	30*	1	30	0	40
Fairfax	<1000*	6500*	670*		6*			2	30	95	30
Lady Musgrave	15000*		3680*		349*	28*	170*	0		0	100*
Lady Elliot	<1000*	34	-	95*	318	0	16	0	6000*	0	12
Breeding	902650	7400	497038	95	2626	718	740	240	8073	0	478
Non-breeding	-	34?	290	-	-	507	382	105	130	561	623

* Breeding colony

colonies at Tryon, Masthead, Lady Elliot and West Hoskyn Islands (Tables 5 and 6).

Roseate Terns nested on seven islands during 1983-84, but three colonies contained fewer than 20 pairs (Table 6) as opposed to four during 1982-83 (Table 5). The largest colony (107 pairs) was at Masthead Island with 82 pairs at Wreck, 92 pairs at Erskine, 48 pairs at Hoskyn and 14 pairs at Lady Musgrave. There were 14 pairs nesting at North Reef and three pairs at One Tree Island.

The time of nesting was extremely variable, for example, they nested during November at Hoskyn and February/March at Erskine. There were 54 immature (sub-adults) Roseates with adults.

Black-naped Terns nested in seven islands during 1983-84 (Table 6). But like the Roseates the size of colonies varied greatly from 8 pairs at Hoskyn Island to 152 pairs at Wreck Island. There were 10 immature (sub-adult) Black-napeds seen in the region.

About 120 pairs of Lesser Crested Terns nested at One Tree Island during September 1983 (J. Veen pers. comm). They apparently did not nest on any other island in the area. Most of the pairs with young had left the region by the time the survey began in December 1983.

Crested Terns nested at the same four islands during both breeding seasons but their numbers in 1983-84 (Table 6) were for greater than in 1982-83 (Table 5). The population at One Tree Island had decreased greatly (73% decrease) but those at North Reef and Lady Elliot had increased (Tables 5 and 6). North Reef colony was 252% larger than the last season's.

Little Terns did not breed in the region and occurred on the same islands as they did in 1982-83 (Table 5 and 6). However there were 120 immature (sub-adult) birds present at One Tree on 23.1.84. They presumably were born outside the Capricornia Section.

Silver Gulls bred on size islands in the region in both breeding seasons, the largest colony (>100 pairs) being at Wreck Island Tryon had 54 pairs of gulls. Large numbers of gulls frequented Heron Island especially during November 1983 when there were 520 present (T. Walker pers. comm). The gull

population in 1983-84 was slightly smaller than it was in 1982-83 (Tables 5 and 6).

Waders

Tables 7 and 8 gives the numbers of each species of wader in each island in the Capricornia Section during 1982-83 and 1983-84 respectively.

In both summers the Ruddy Turnstone Arenaria interpres and Grey-tailed Tattler Tringa brevipes were the most common waders in the region (Tables 9 and 10).

There were slightly fewer Whimberels Numenius phaeopus in 1983-84 than in 1982-83, but there was a large decrease in the numbers of Bar-tailed Godwit Limosa popponica over the two summers (Tables 7 and 8).

More Red-necked Stints Calidris ruficollis were seen in 1983-84 than in the previous summer. A reasonable sized group was found at North Reef otherwise this species in uncommon throughout the region (Tables 7 and 8). No sandpipers and oriental Plovers Charadrius asiaticus were observed in the region during 1983-84. The very rare species during 1983-84 were the Greenshank Tringa nebularia, Large Sand Plover Charadrius leschenaultii and Knots Calidris canutus.

There were slightly fewer Eastern Golden Plovers Pluvialis dominica in the region during 1983-84 than during 1982-83 (Tables 7 and 8). They were not found on all islands in the region during 1983-84 as they were in the previous summer.

There were appreciably more Mongolian Sand Plovers Charadrius mongolus in the region during 1983-84 than during 1982-83. Some were seen on Lady Elliot during 1983-84 but not during the previous summer (Table 7 and 8).

The numbers of Sooty Oystercatchers Haematopus fulignosus and Pied Oystercatchers H. ostrolegus remained relatively constant over the two summers, but their distributions changed. For example, One Tree Island had both species present during 1983-84 whereas the island usually has only Sooty Oystercatchers (See Domm and Recher 1973, Hulsman 1979).

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-fa Hero
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

TABLE 8 Numbers of each species of wader on each island in the Capricornia Section of the Great Barrier Reef Marine Park during 1983-84.

Island	Ruddy Turnstone	Whimbrel	Greenshank	Bar tailed Godwit	Grey tailed Tattler	Red neck Stint	Large Sand Plover	Eastern Golden Plover	Mongolian Sand Plover	Oystercatcher Sooty	Oystercatcher Pied	Reef Heron	Kn
North Reef	68	34		26	40	58		1	6			10	
Tryon	89	42		14	180				15			57	
North West	95	59		39	137	3		29	130	1	5	53	
Wilson	35	0			71			2	14			44	
Wreck	55	1		22	8			1	1	2	1	53	
Masthead	51	0		23	157					4	4	25+	
Erskine	80	3		9	120		1	60	80			3	
Heron	75	0			74	2		29	49	3		92	
One Tree	21	40		2	56	10			203	2	5	85	
Hoskyn												25	
Fairfax	18				40					4	5	3	
Lady Musgrave										2			
Lady Elliot	137		2	1					8		2		
Total	724	179	2	135	883	61	1	122	506	18	22	50+	

Legend for figures 1 to 18


Common Noddy


Black-naped Tern


Roseate Tern


Crested Tern


Silver Gull


building

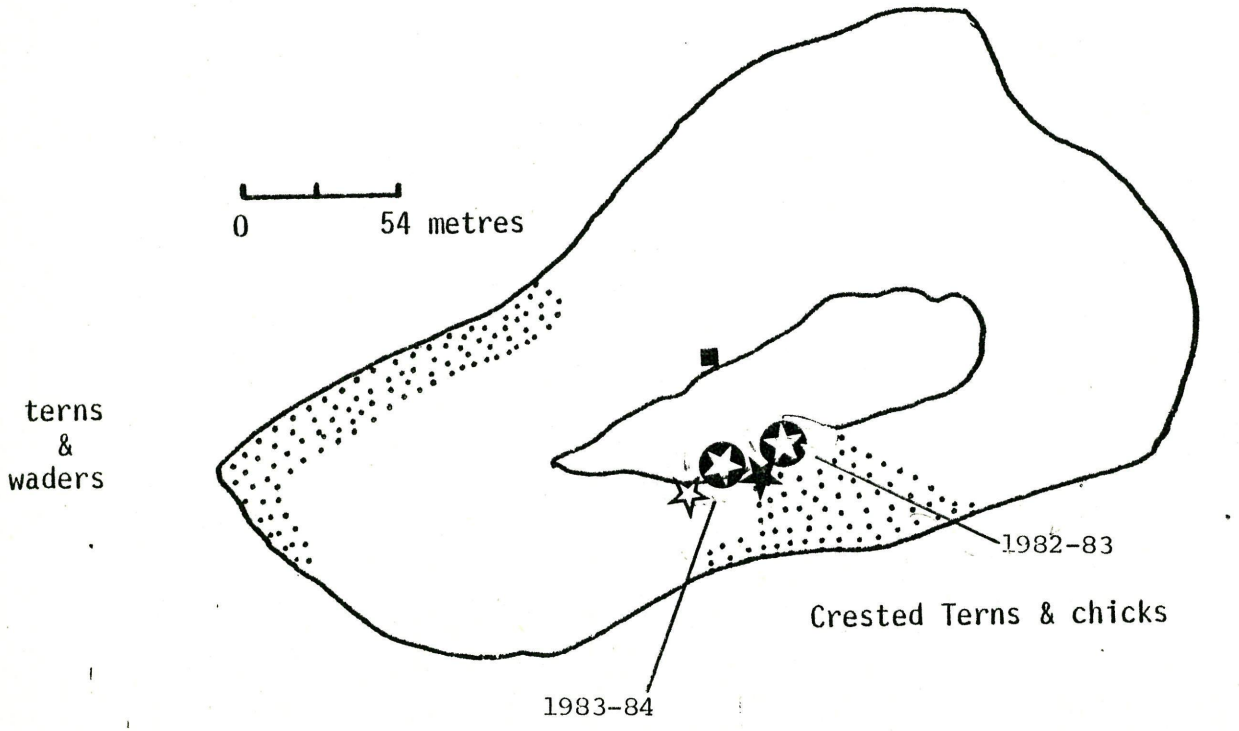


FIGURE 1 Roosting and nesting areas of birds at North Reef.

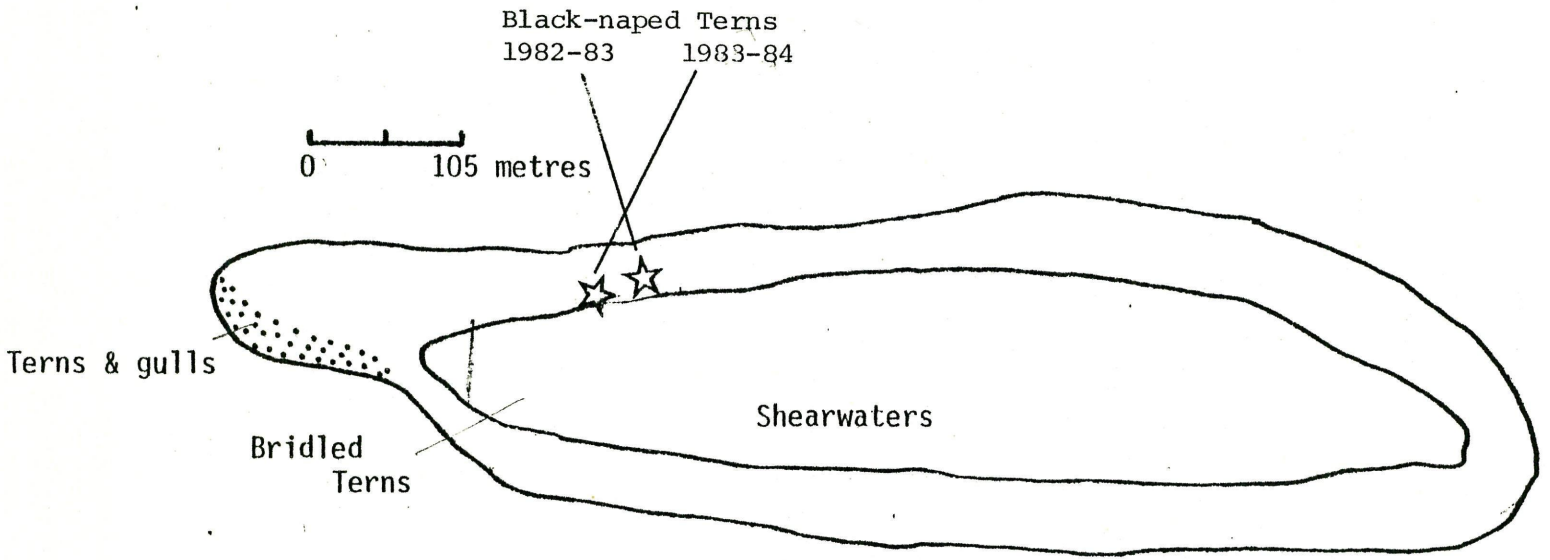


FIGURE 2. Roosting and nesting areas of birds at Tryon Island

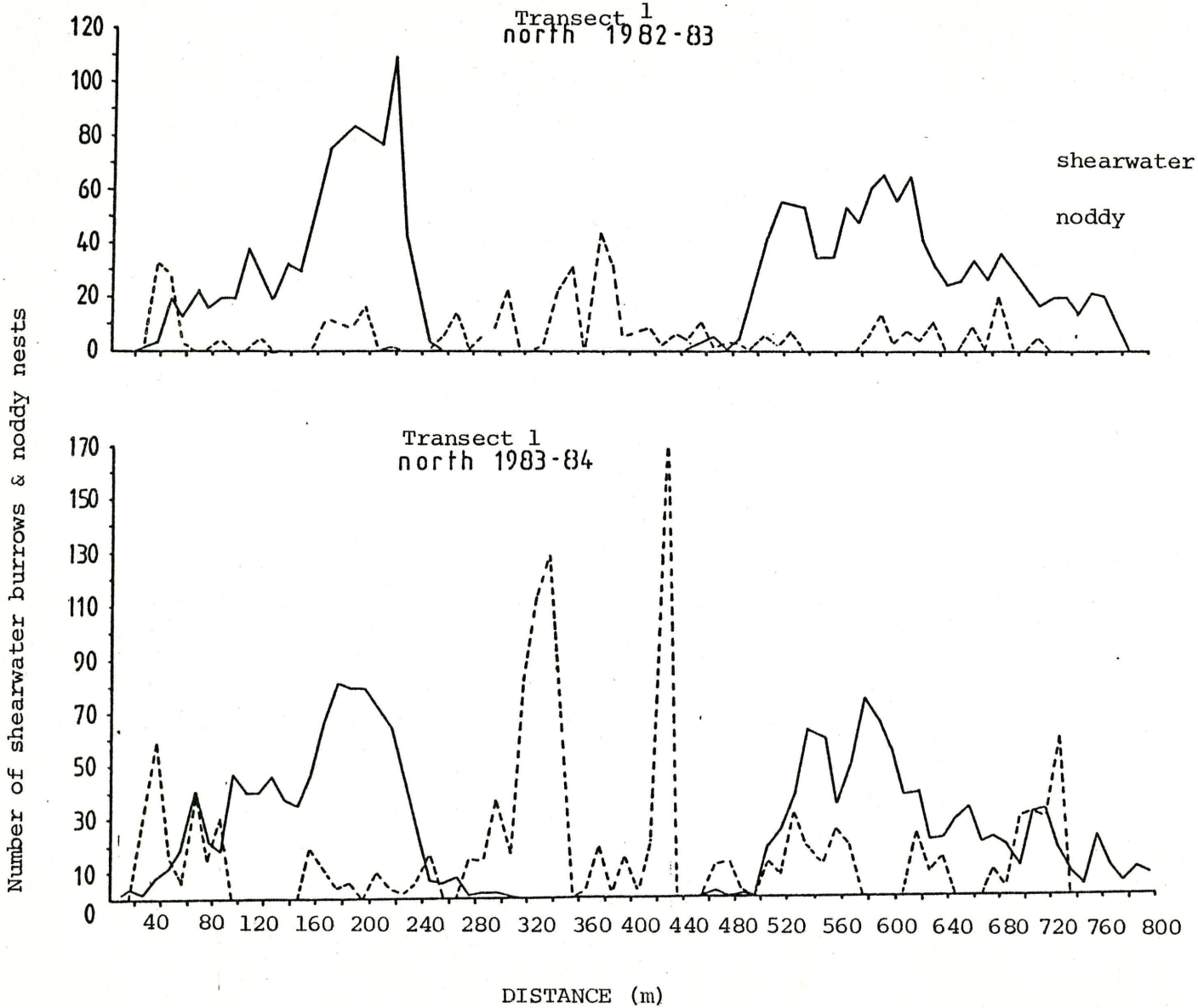
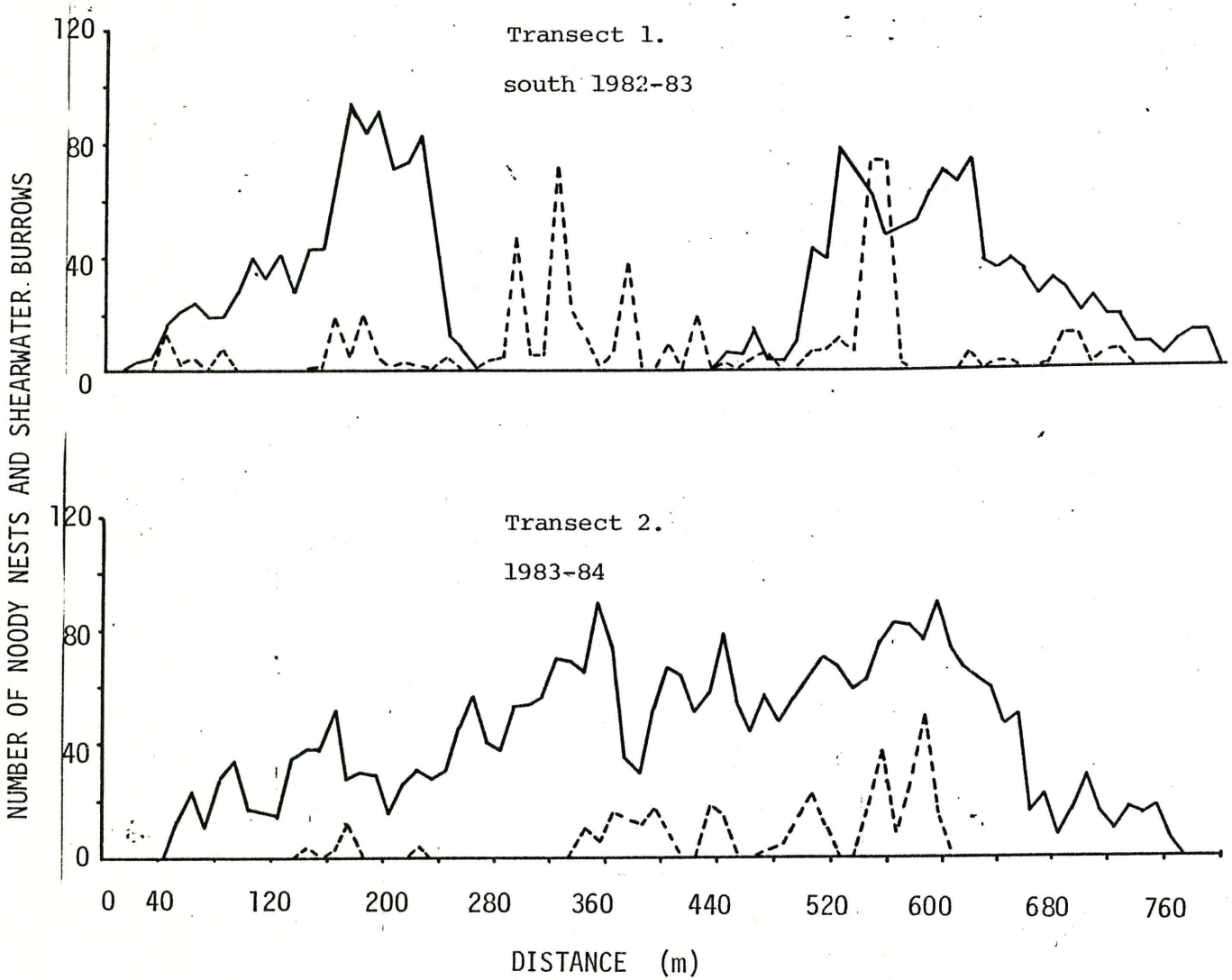

Transect 1
north 1982-83
shearwater
noddy
Transect 1
north 1983-84
Number of shearwater burrows & noddy nests
DISTANCE (m)

FIGURE. 3. Distibution of shearwater burrows on North West Island 1983-84



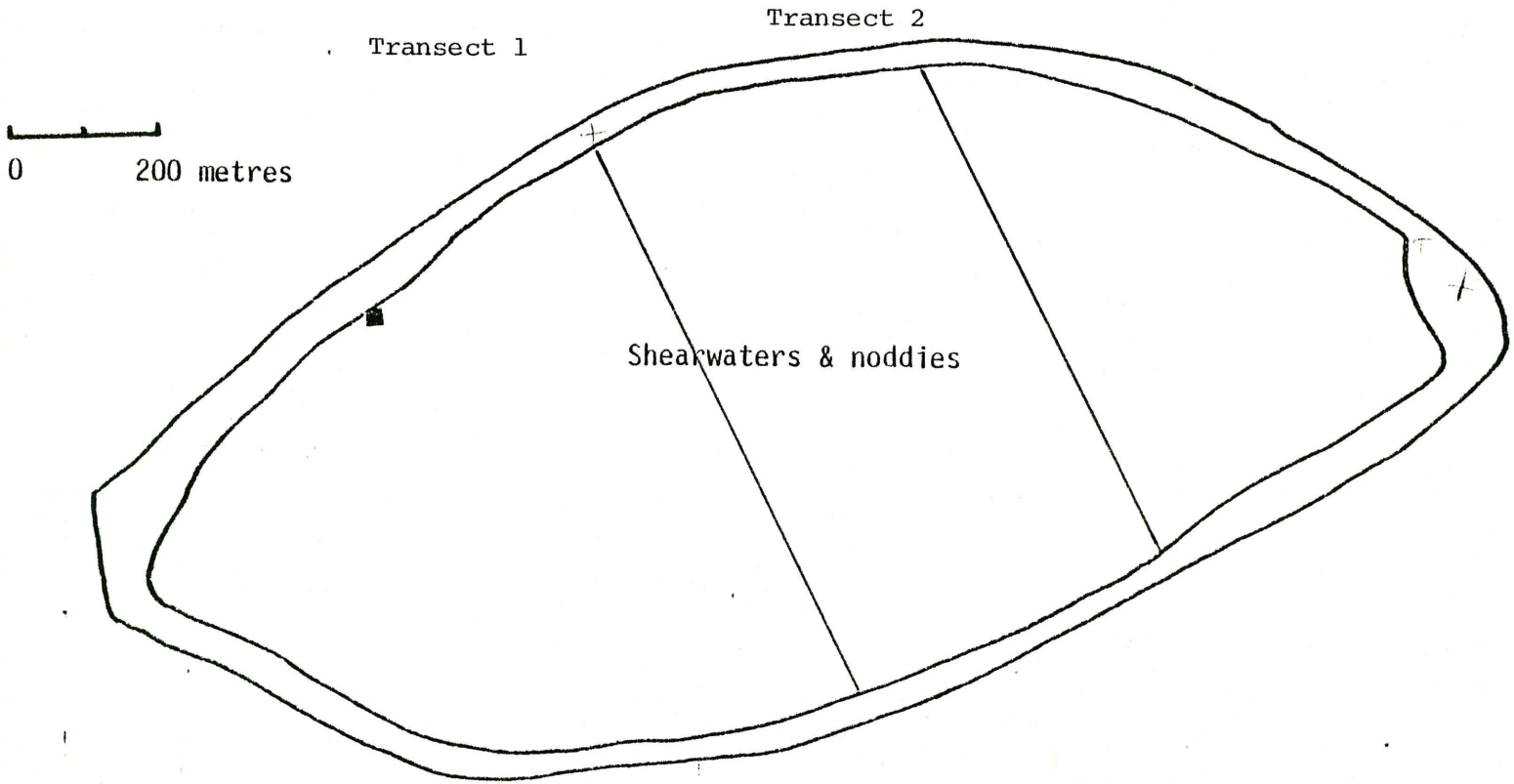


FIGURE 4. Roosting and nesting areas of birds at North West Island.

The numbers of Reef Herons Egretta sacra were underestimated in both summers.

Roosting and Nesting Areas

North Reef

Roseate and Black-naped Terns nested on the edge of the Crested colony. Cresteds nested within 25m of where they nested in 1982-83 but this time on an grassed area.

The terns and gulls roosted in the same places as they had in 1982-83 (Fig. 1).

The waders roosted in the trees.

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 (Fig. 2). Black-naped Terns (min. 14 pairs) nested on a shelf of beachrock about 30m from where they had nested in 1982-83.

Terns and gulls tended to roost on the western end of the island. The waders roosted on the eastern end of the island (Fig. 2). Gulls nested in groups in grassy areas along the high dune (Fig. 2).

North West Island

Shearwaters nested over the entire vegetated part of the island. The distribution of burrows on the transect measured in both summers shows that it remained unchanged although the density of burrows did change (Fig. 3). The position of transects are shown in Fig. 4.

The lack of burrows between 280 and 440m is because the "soil" is too shallow for shearwaters to burrow into, man used the area to mine the guano. So until the "soil" becomes deep enough shearwaters will not burrow in that part of the island. Shearwater's burrows are found across the entire island where it has not been disturbed by mining (see Fig. 3). Shearwaters that nest at the centre of the island have to walk 400m before

taking to the air for a day's fishing. They normally do not have to walk far on their return because like the Short-tailed Shearwater P. tenuirostris in Bass Strait, they drop through the vegetation in the vicinity of their respective burrows.

Noddies roosted in the trees in which they nested. The distribution and abundance of noddies on the transects are shown in Fig. 3. The greatest densities of noddies occur towards the centre of the island where Fig and Celtis trees occur in the Pisonia Forest. It is more obvious at North West than at Masthead and Heron Islands that nesting centres on large accessible Fig trees and spills over into into neighbouring Pisonia trees. The relationships between noddy nesting and Forest type found to exist at Masthead (Dale et al 1984) also apply to noddy nesting at Heron and North West Islands. North West is less saturated with noddies than either Heron or Masthead Islands. In other words North West has the potential for a far larger noddy population than it currently has.

The gulls tended to roost along the northern beach where people camp. Terns, whimberels and godwits roosted on the western end of the island whereas tattlers, plovers, knots and little terns roosted on the northern edge of the island (Fig. 4). These were the same places these species roosted during the previous summer.

Wilson Island

Shearwaters nested over more than 3/4's of the vegetated part of the island (Fig. 5). There were no burrows in the strand vegetation on the western side of the island. That is the Casuarina Forest where the bar-b-que areas are. However there are large numbers of shearwaters nesting throughout the Pandanus Forest next to the Casuarina Forest.

Noddies roosted in the Casuarina trees along the western and northern shores of the island.

Black-napeds (20 pairs) nested on the western side of the island, where the boat from Heron Island lands guests. After this nesting attempt failed Black-naped and Roseate Terns roosted along the southern shore (Fig. 5). Black-napeds with juveniles possibly from Wreck Island roosted along the north-eastern beach (Fig. 5).

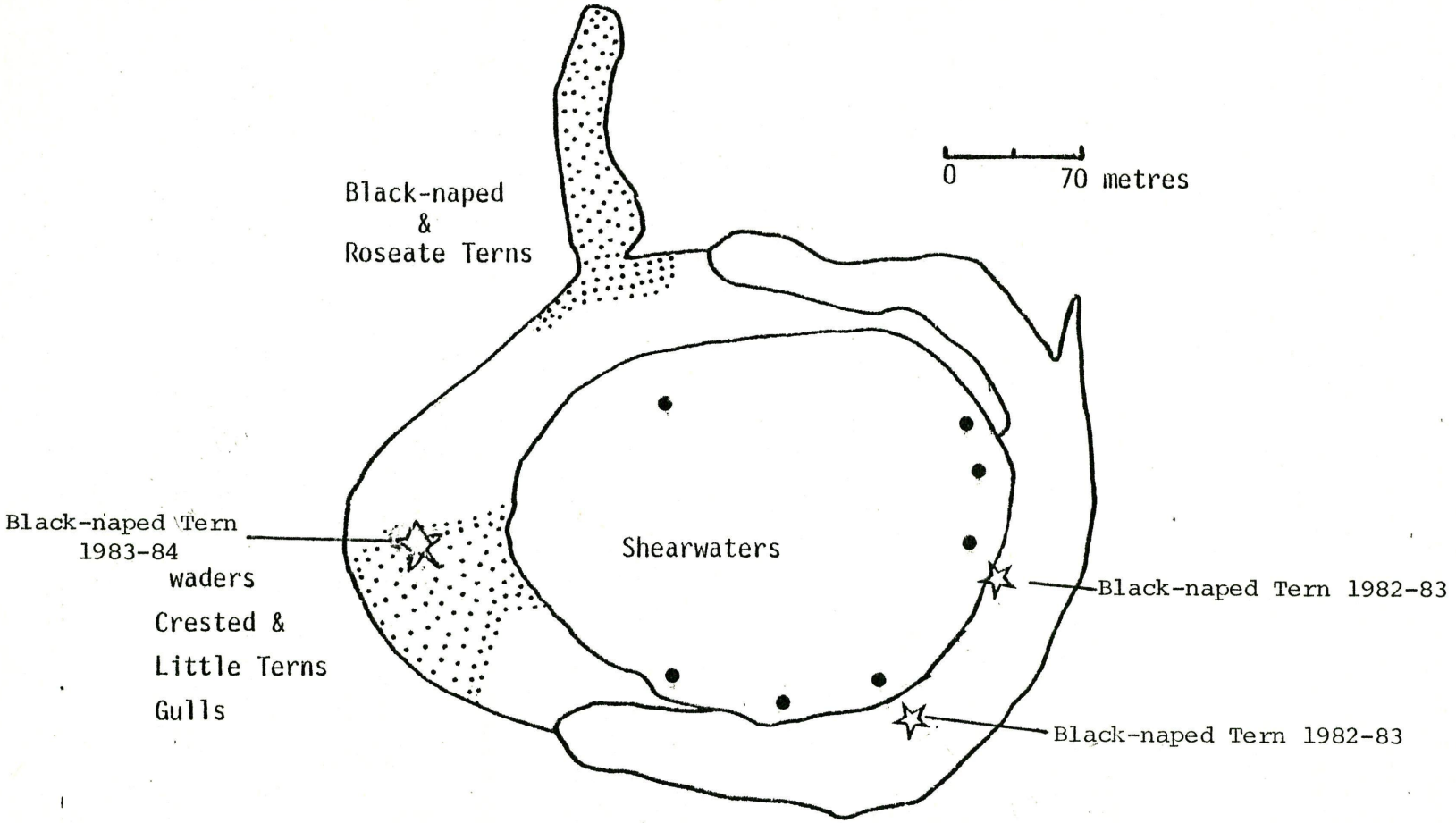


FIGURE 5. Roosting and nesting areas of birds at Wilson Island.

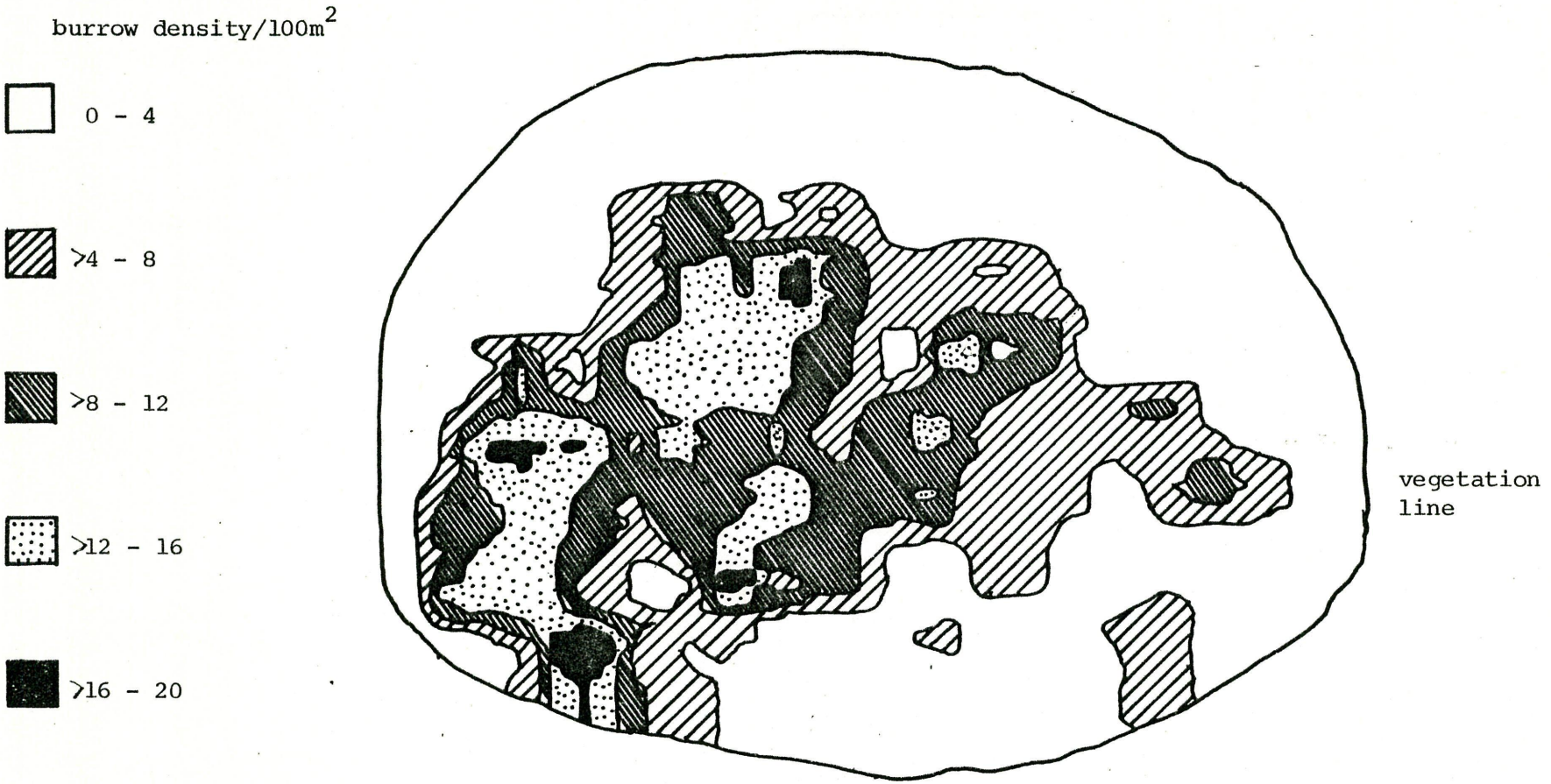
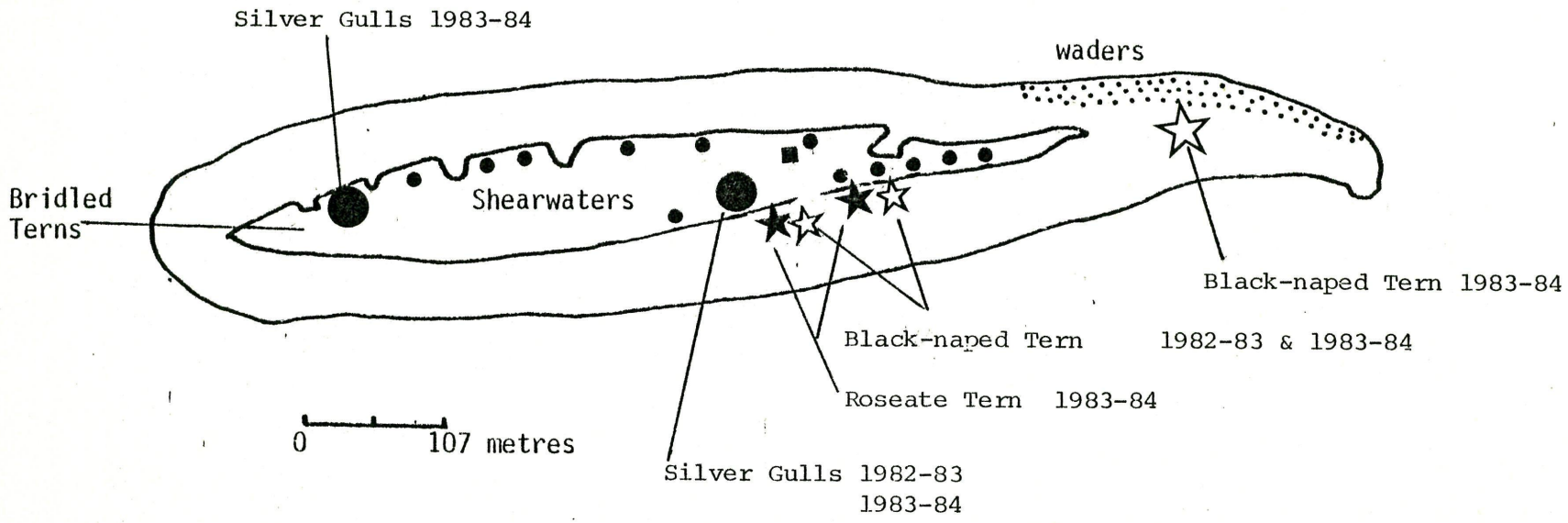


FIGURE 5. Distribution of shearwater burrows at Wilson Island 1983-84.

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



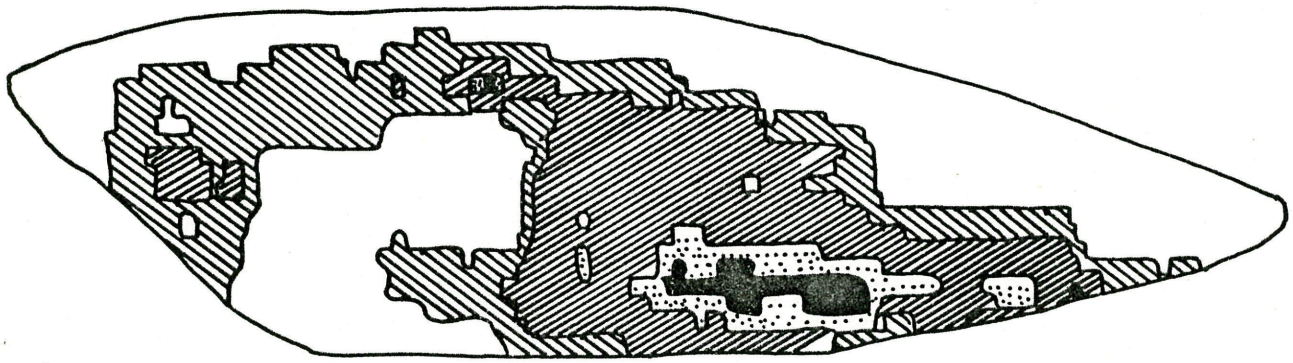


FIGURE 7. The distribution of shearwater burrows at Masthead Island 1983-84.

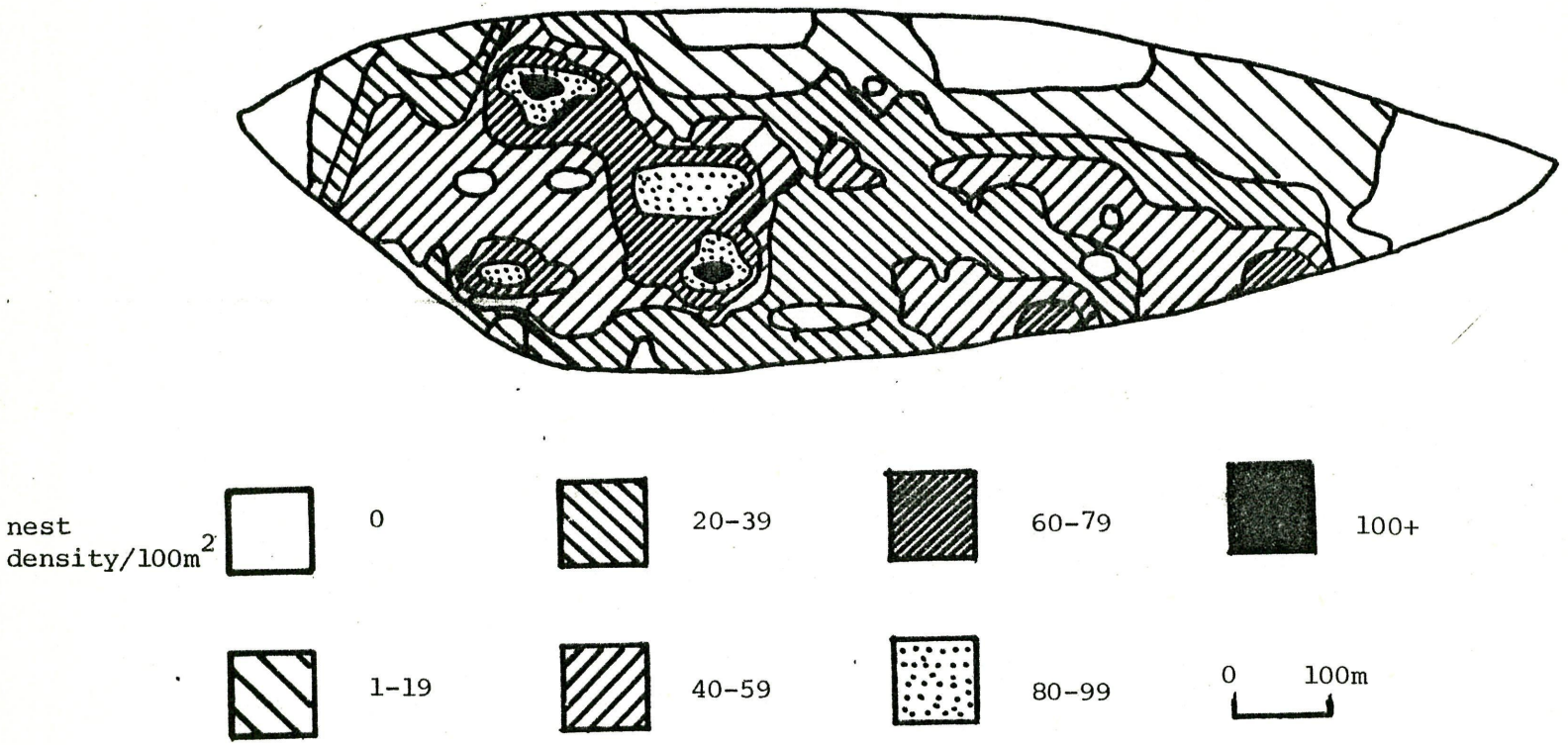
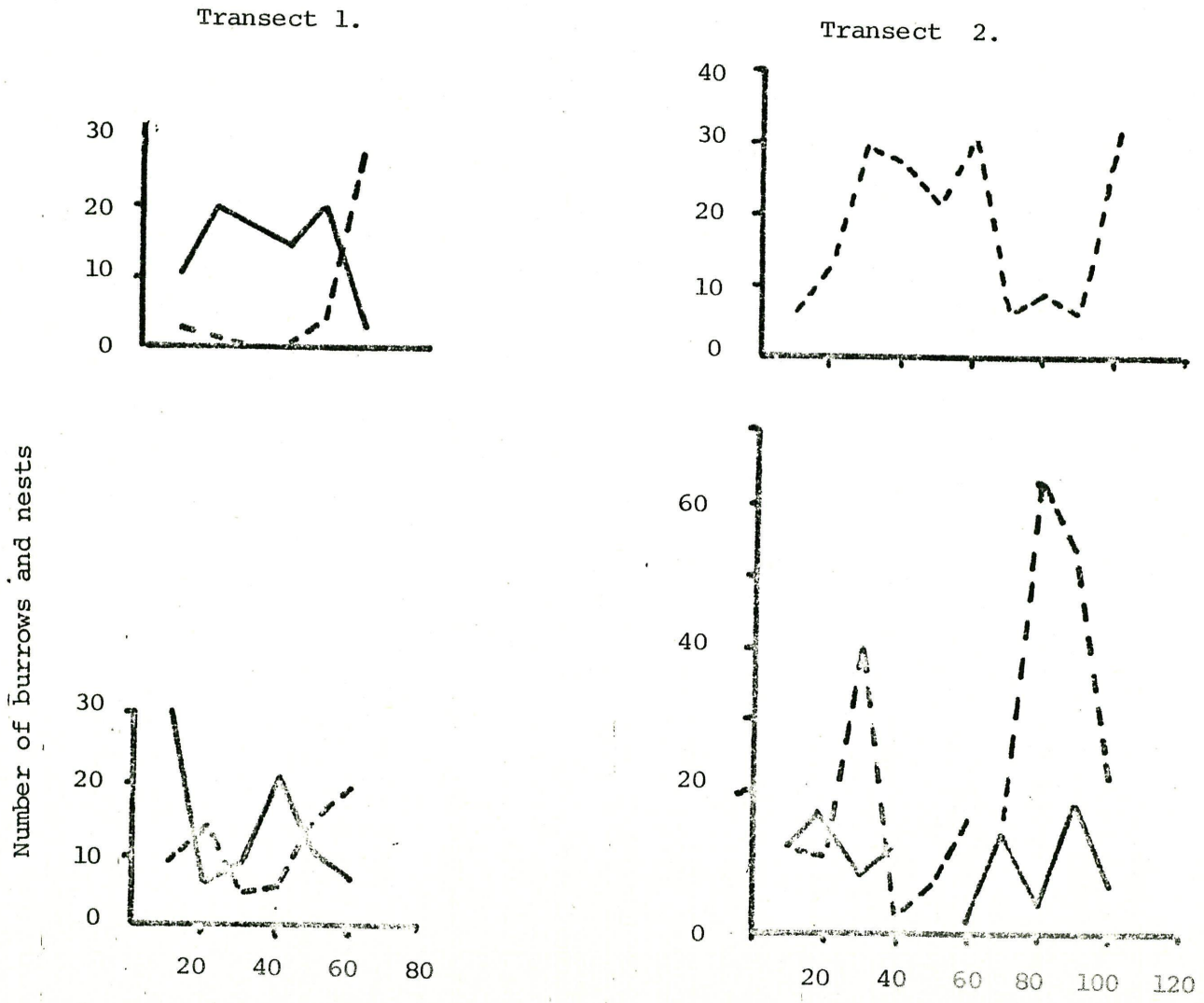


FIGURE. 8a. Distribution of noddy nests at Masthead Island 1983-84.

FIGURE.8b. Transects showing the distribution of shearwater burrows and noddy nests on Masthead Island 1982-84

(Shearwaters ——— , noddies - - -).



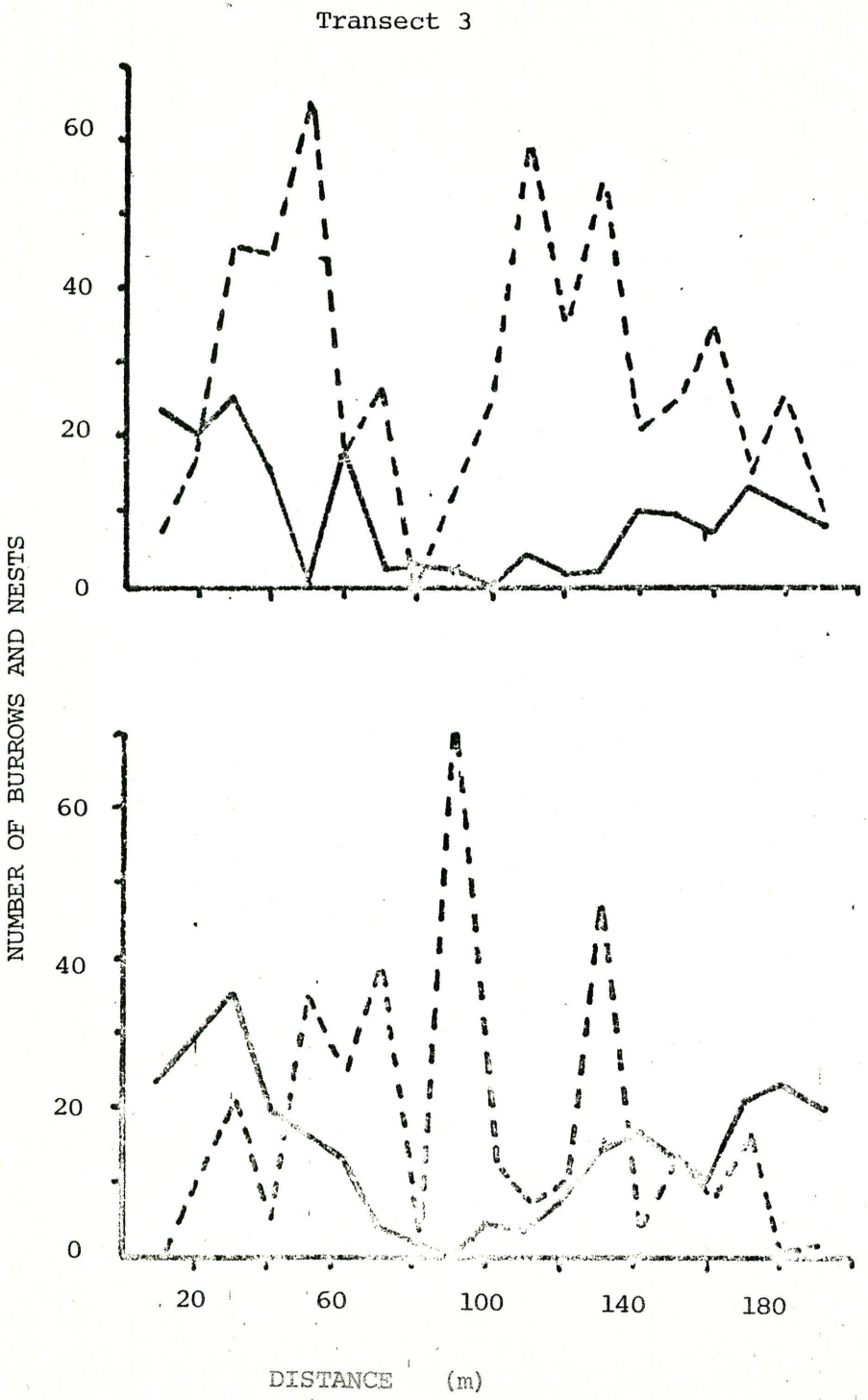


FIGURE. 8b continued.

shearwater ——
noddy – – –

FIGURE 8b continued.

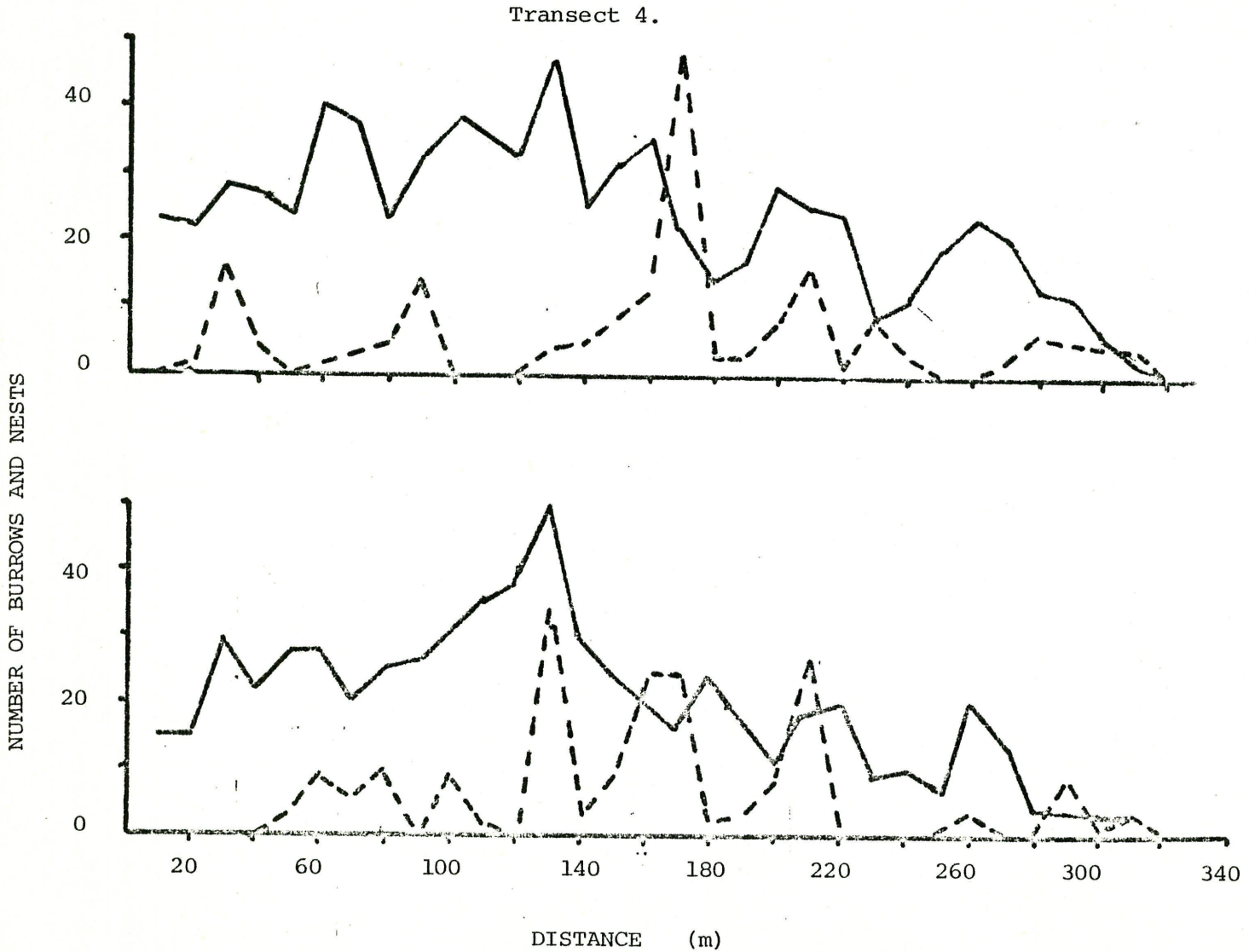


FIGURE.8b continued.

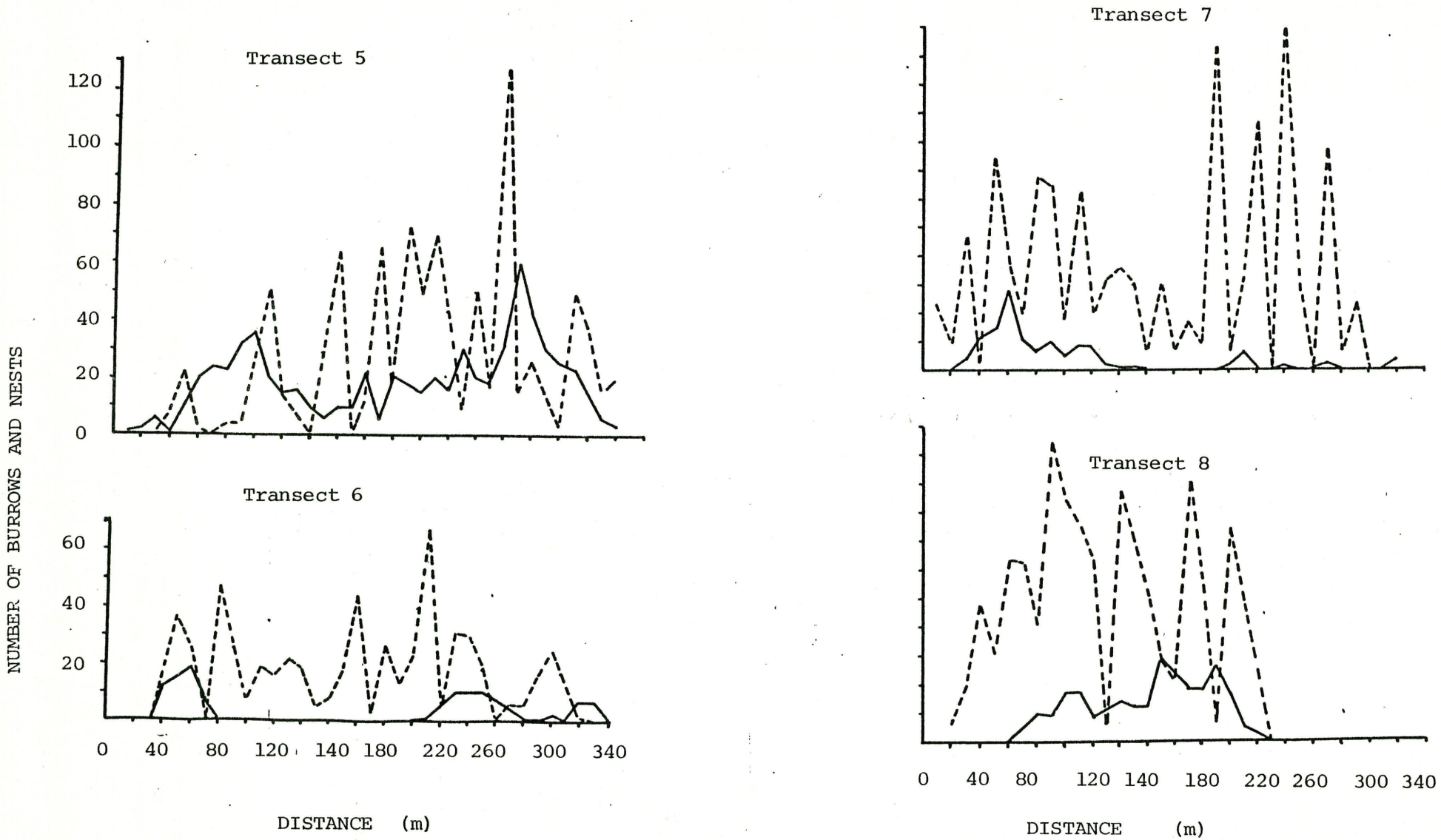
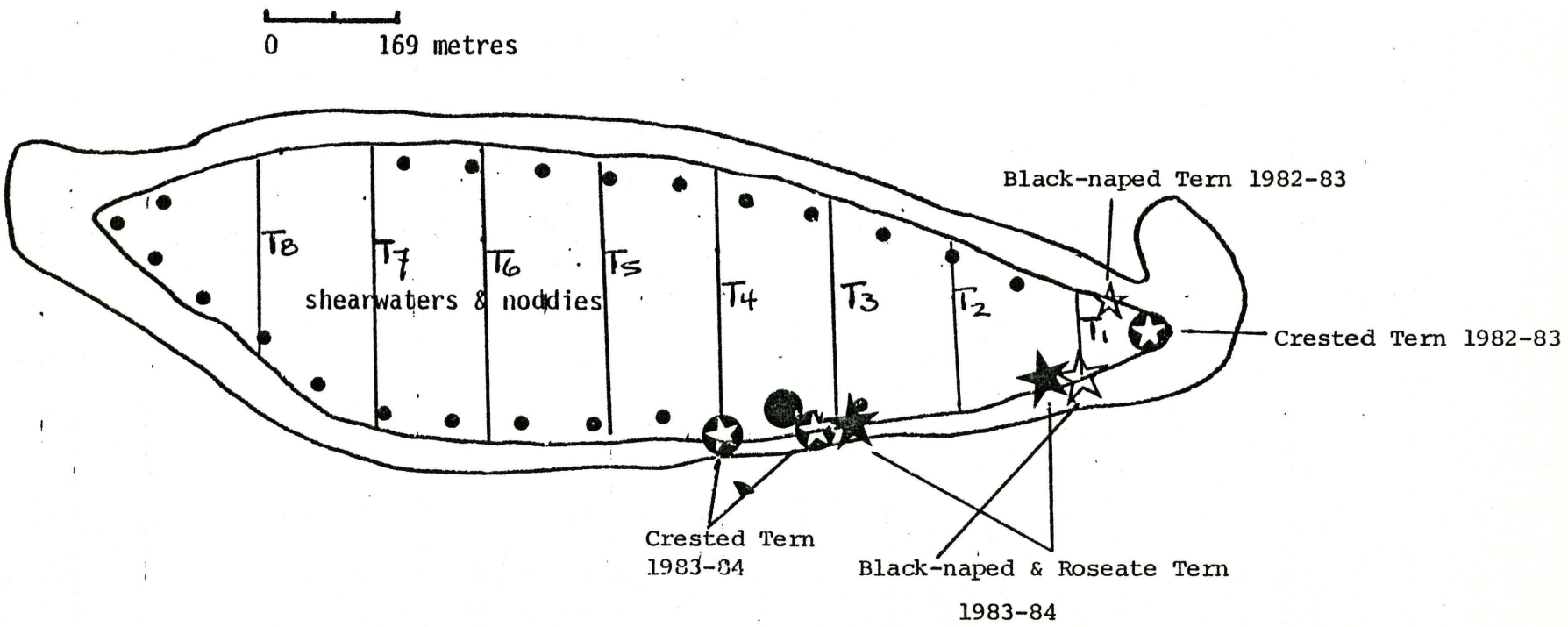


FIGURE 9. Roosting and nesting areas of birds at Masthead Island.



Other species of terns, gulls and waders roosted on the west to south-western part of the island (Fig. 5). Gulls nested around the edge of the island as they did in 1982-83 but nests were not in the same sites in both summers.

Wreck Island

Shearwaters nested over most of the island except those areas disturbed often by turtles.

Bridled Terns nested amongst the Melanthera. The density of Bridleds was greatest where shearwater were not common.

Black-naped and Roseates nested together although the main Black-naped nesting area was on the spit on the eastern end of the island and the main Roseate nesting area was along the southern beach where Black-napeds had nested during the previous summer (Fig. 6).

Gulls nested in groups on Wreck Island on the high dune and the western end of the island where there were few shearwaters (Fig. 6).

Masthead Island

Shearwaters nested over most of the island. Few or no burrows were at the eastern and western tip of the island which are covered by strand vegetation. The greatest densities of burrows occur on the southern side of the island (Fig. 7).

Noddies nest almost over the entire island but the greatest densities occur toward the western end of the island (Fig. 8).

Black-napeds nested on the southern side towards the eastern end of the island. Some Roseates nested with the Black-napeds but the majority were near the Crested colonies midway along the southern beach (Fig. 9). Roseates and Cresteds nested in more densely grassed areas than Black-napeds did. They nested on the eastern end of the island during the previous summer (Hulsman 1983).

Bridled Terns nested in the strand vegetation where gulls (38 pairs) had well defined territories. Both species nested in the same areas as they had in 1982-83.

Tattlers roosted in trees along the north-western section of the beach as they had done in 1982-83.

Erskine Island

All species occurred in the same areas as they had in the previous summer. Terns and waders roosted on the western end of the island (Fig. 10).

Heron Island

Shearwaters nested over the entire island except the outer area which is disturbed by nesting turtles (Fig. 11). Noddies nested over most of the island in the Pisonia Forest as well as in the strand vegetation. The greatest density occurred in the south-eastern shore in the Argusia strand (Fig. 12).

Black-napeds nested on the wreck. No other species of seabird nested on the island.

Terns, gulls and waders roosted on the wide beach near the harbour (Fig. 13). Silver Gulls aggregated around the helipad, cement wall and the grassed area on the western end of the island.

Tattlers roosted on the roof of the lab building of the research station.

One Tree Island

Noddies nested in the Pisonia and Argusia trees on the northern end of the island as well as on the western side (Fig. 14).

Bridleds nested under the Melanthera over most of the island (Fig. 14). Black-napeds nested in the south-eastern and southern beaches (Fig. 14).

Crested and their young were on the western side of the island between the spits (Fig. 14). Lesser Cresteds along with waders were in the same area as Cresteds. Most Reef Herons were on the western side of the island.

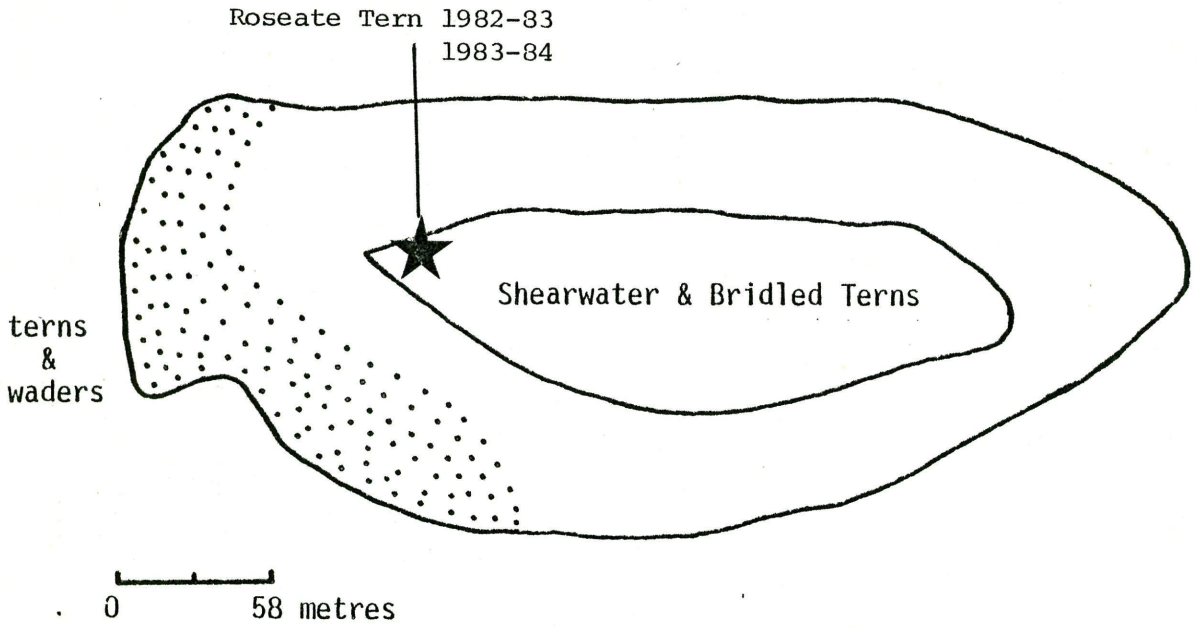
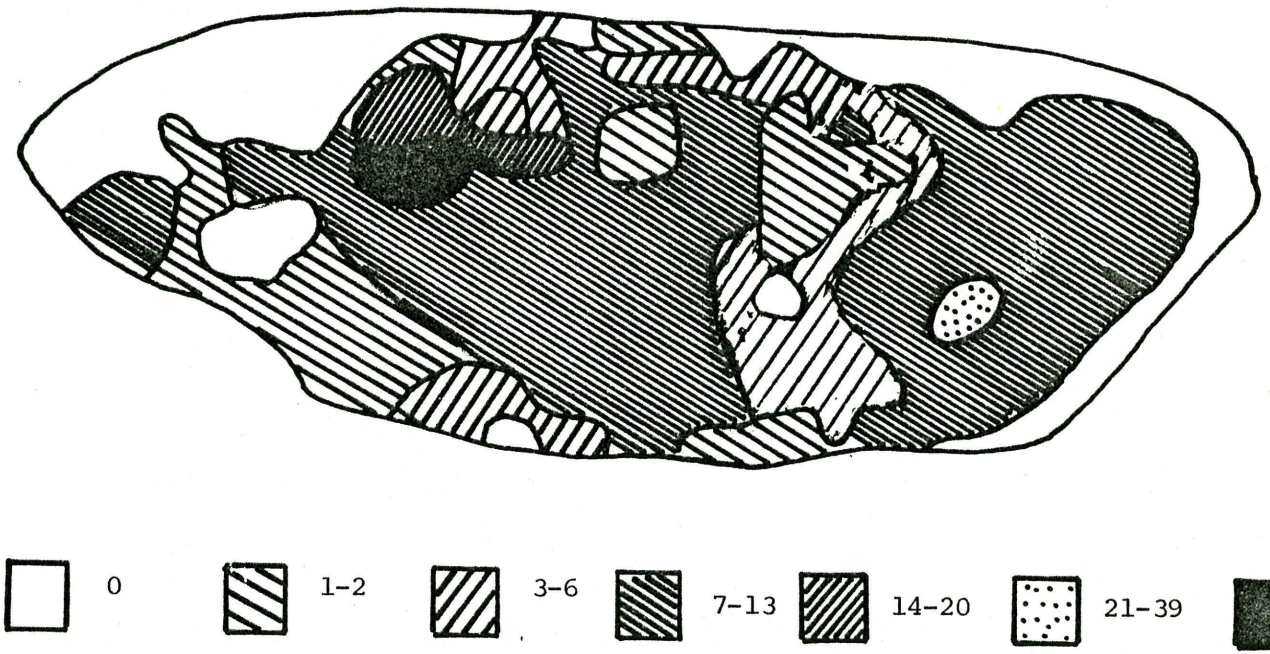


FIGURE 10 Roosting and nesting areas of birds at Erskine Island.

FIGURE 11. Distribution of shearwater burrows at Heron Island 1983-84.



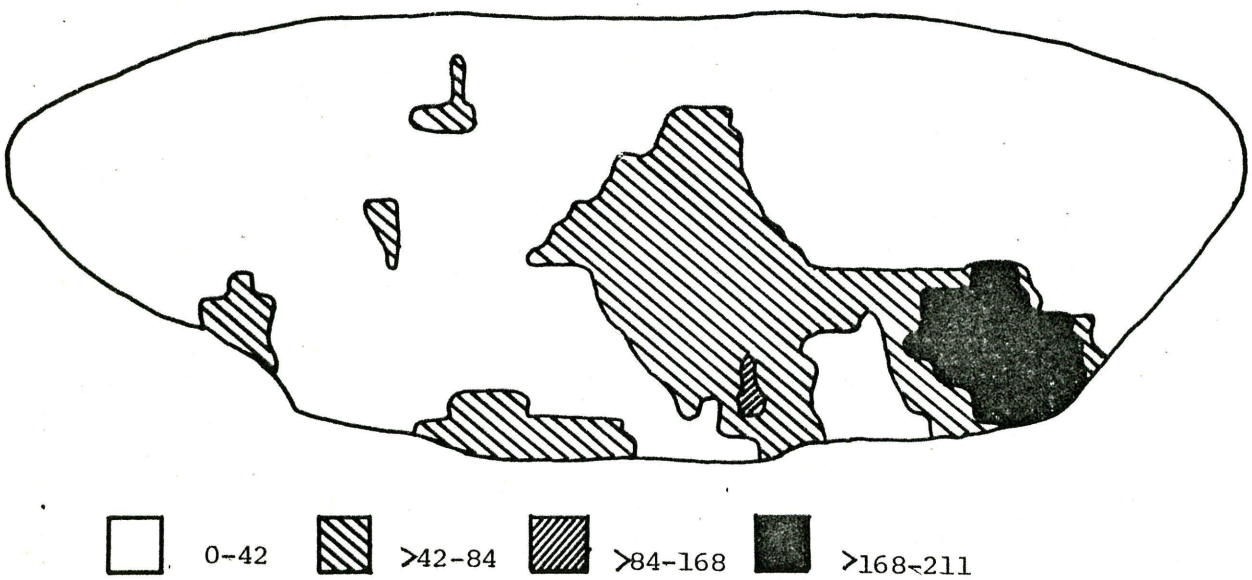
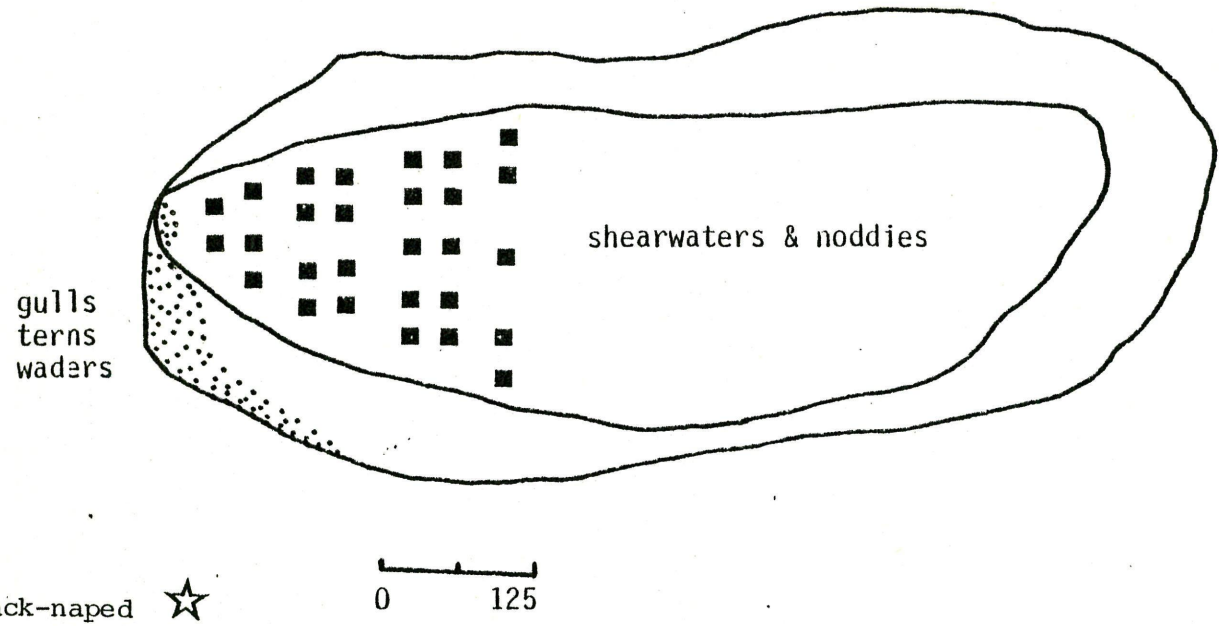


FIGURE 12. Distribution of noddy nests at Heron Island 1983-84.

FIGURE. 13 Roosting and nesting areas of birds at Heron Island 1982-83 and 1983-84.



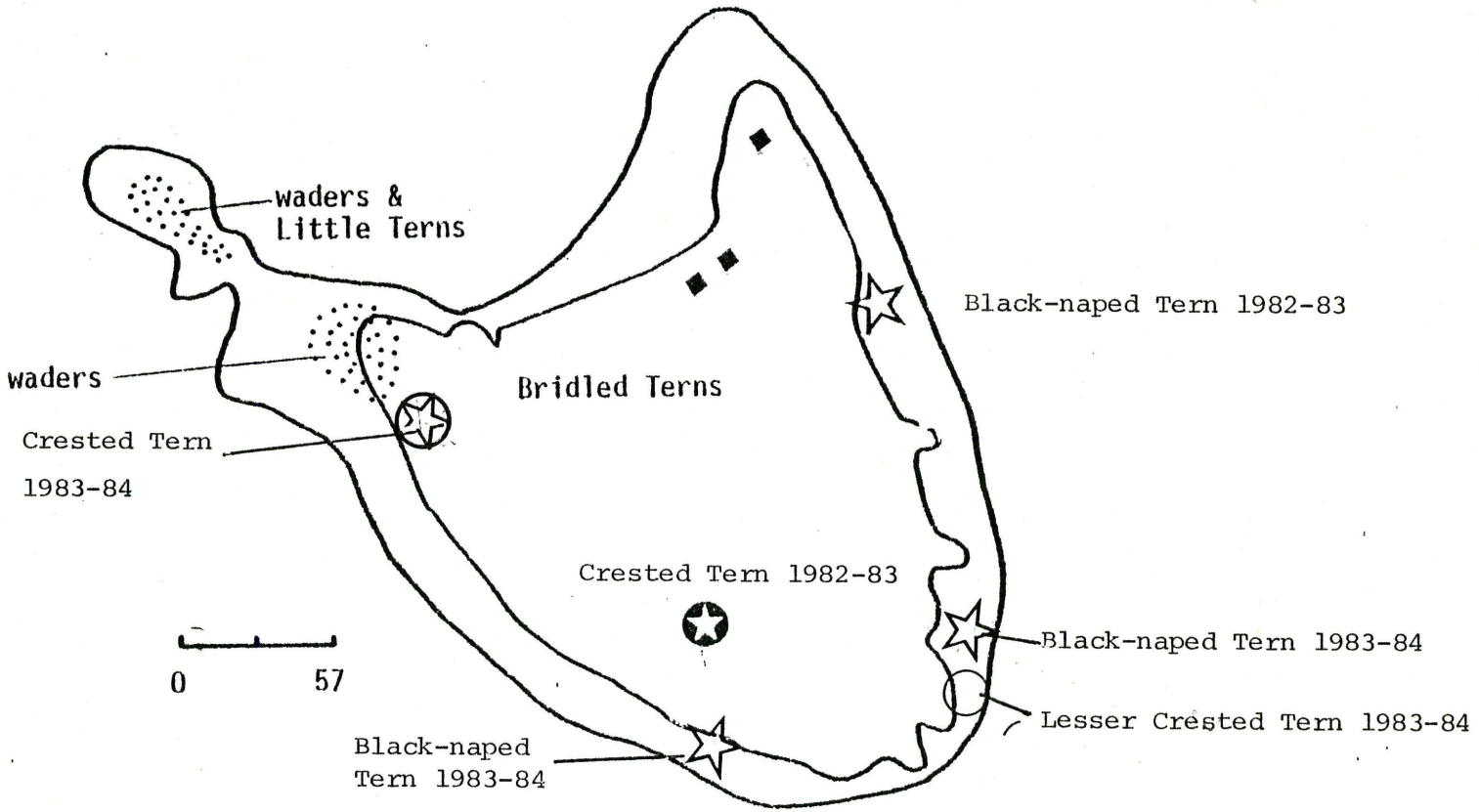


FIGURE 14. Roosting and nesting areas of birds at One Tree Island.

FIGURE 15. Roosting and nesting areas of birds at Hoskyn Island.

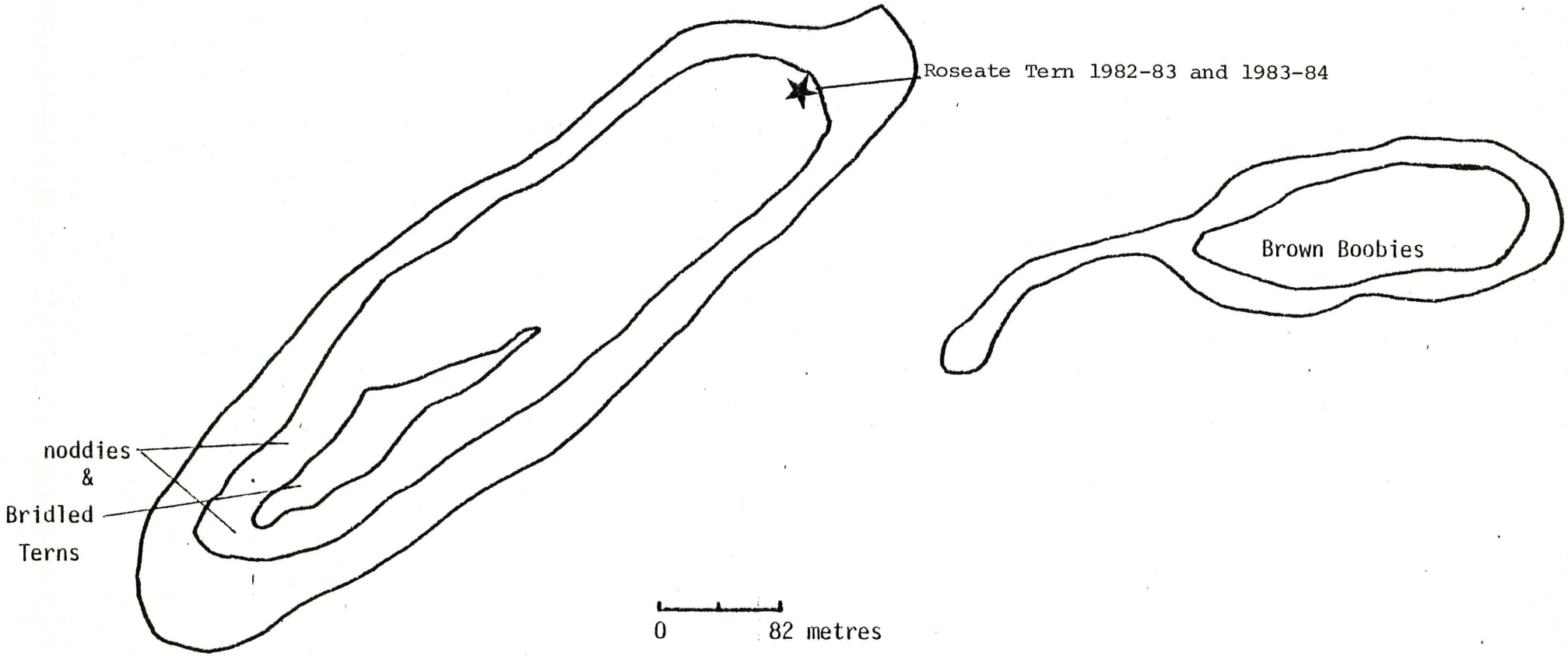
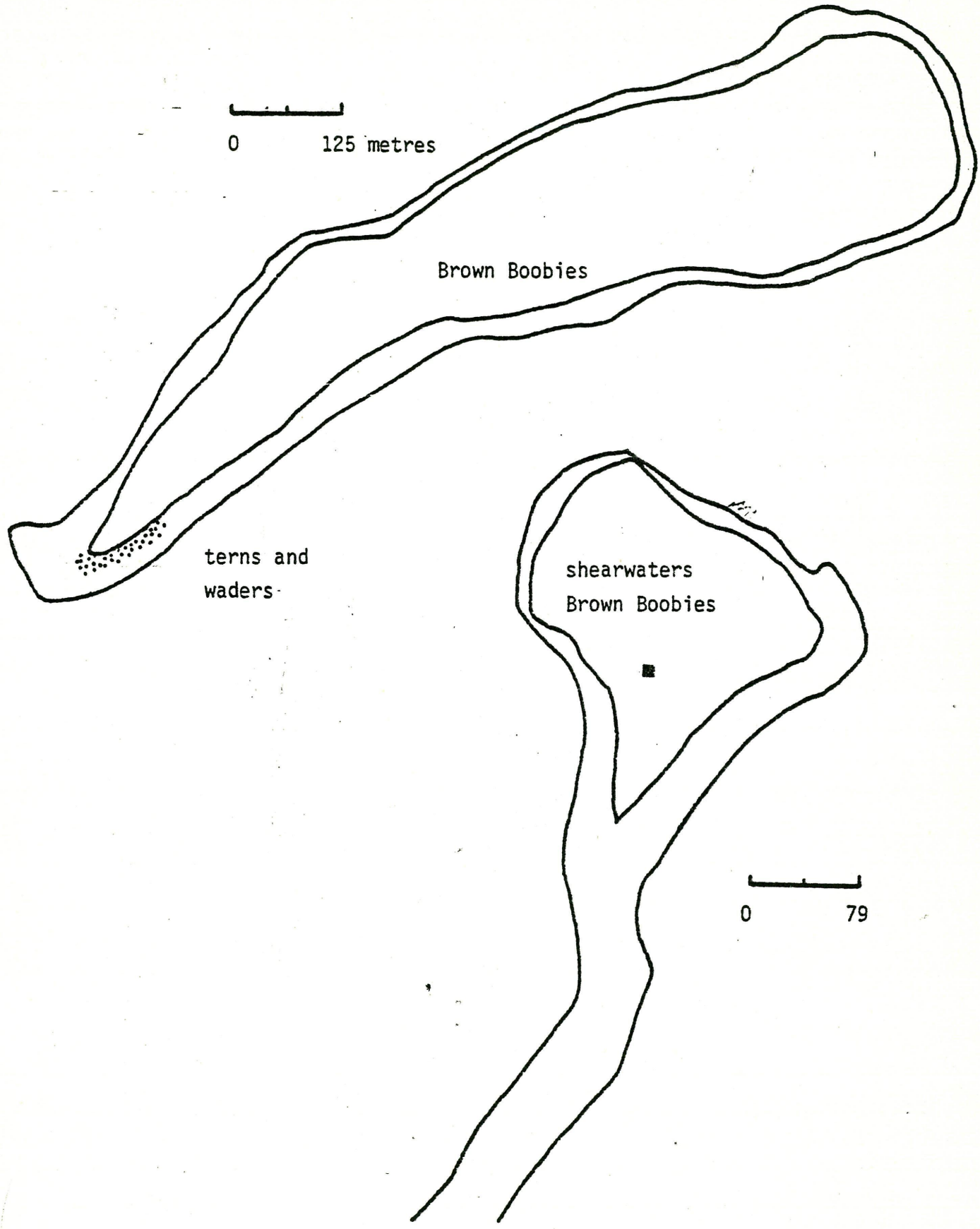


FIGURE 16. Roosting and nesting areas of birds at Fairfax Island.



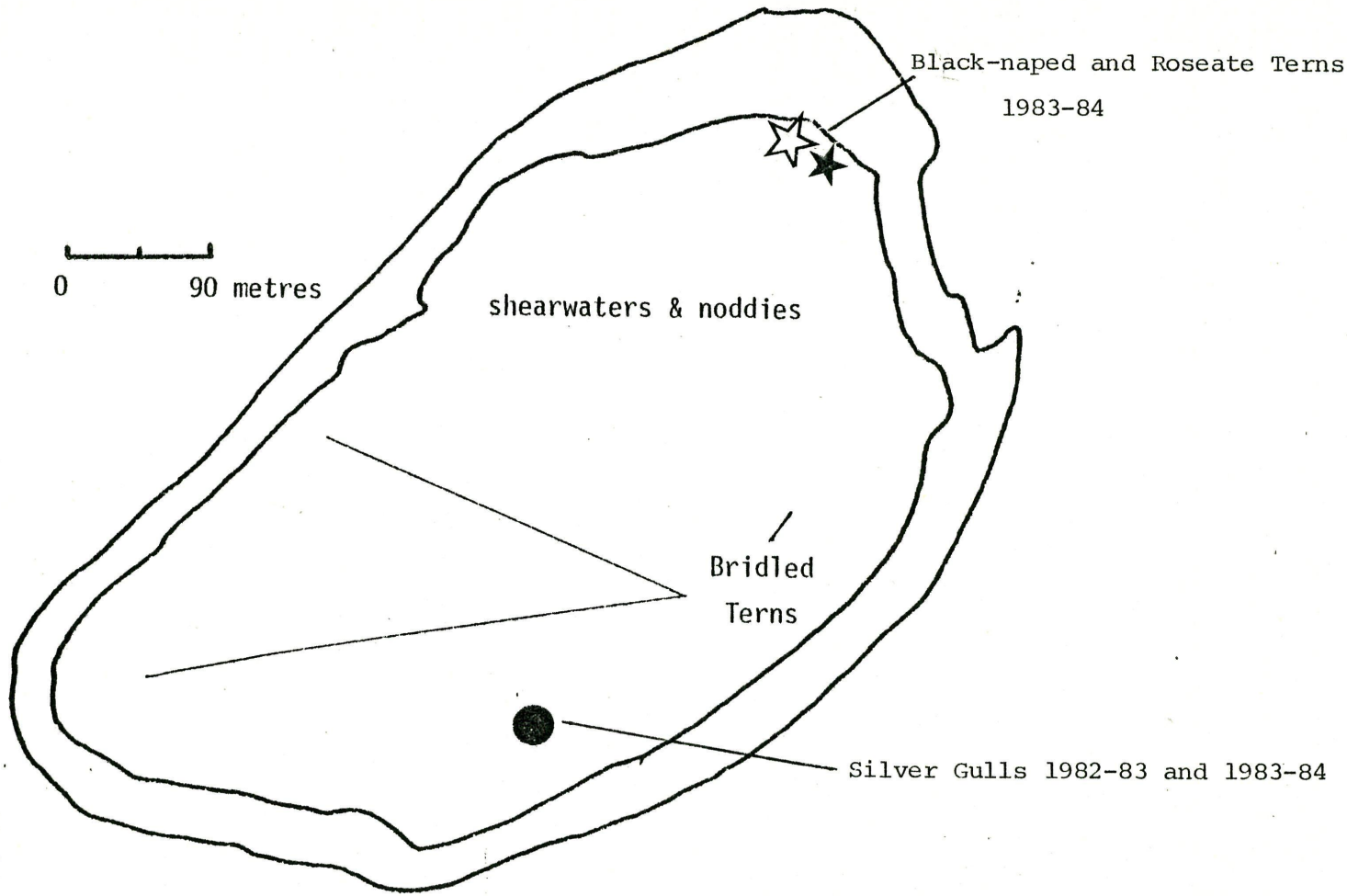


FIGURE 17. Roosting and nesting areas of birds at Lady Musgrave Island.

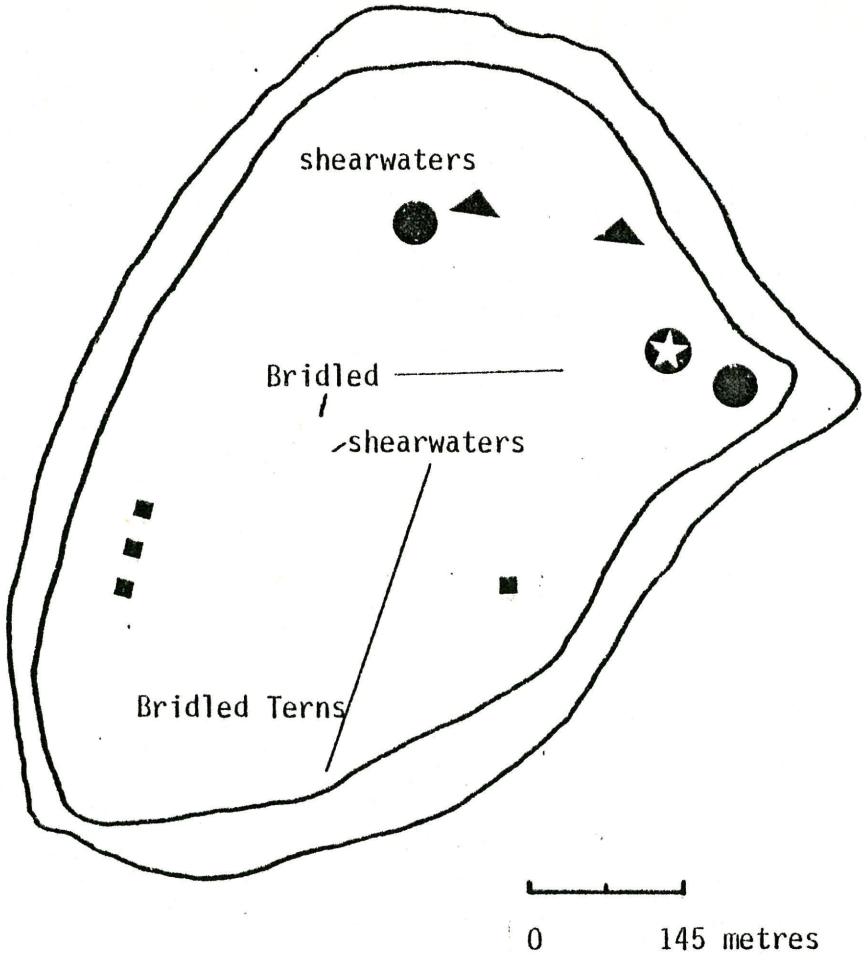


FIGURE 18. Roosting and nesting areas of birds at Lady Elliot Island.

Hoskyn Island

East Cay

Brown Boobies nested on this cay.

West Cay

Noddies nested in the Pisonia trees. Bridleds nested under the Melanthera and other shrubs toward the western half of the island (Fig. 15).

Roseates nested on the eastern end of the island (Fig. 15).

Fairfax Island

Brown Boobies nested on both cays but the majority were on the east cay (Fig. 16).

Lady Musgrave Island

Shearwaters nested mainly under the Pisonia trees on the northern side of the island (Fig. 17). Noddies nested in the Pisonia Forest which is concentrated in the northern half of the island.

Bridled Terns nested under the bracken and in the strand vegetation, some eggs are laid in hallows on tree trunks.

Black-naped and Roseates nested on the grassed area on the northern part of the island near where people land on the island (Fig. 17).

Gulls nested in the open area surrounding the beacon (Fig. 17).

Lady Elliot Island

Shearwaters nested in the same areas as during the previous year. Bridleds nested either side of the airstrip. Crested nested in the same places as they had during 1982-83. Their chicks were near the water's edge near the north east point and inland (Fig. 18).

Effect of turtles on where seabirds nest

Turtles because of their size and digging activity affect where ground nesting seabirds nest. An obvious example of this is the distribution of

shearwater burrows on the perimeter of islands. Where the turtles dig, shearwaters invariably do not nest.

But, turtles may also affect where Bridleds, Roseates, Black-napeds, Cresteds, Lesser Cresteds and gulls nest. Species that nest on the perimeter of islands are especially susceptible to disturbance by nesting turtles. Hulsman (1983) suggested that Roseates and Black-napeds selected nesting areas that were protected from turtles. For example Black-napeds nested on beach rock well above the high water mark on Tryon Island. It is highly unlikely that a turtle could have climbed onto the rock from the beach but it is possible for a turtle to gain access from the Pisonia Forest side. However, a turtle would risk falling onto its back when crawling off the rock onto the beach where it would die so they would probably avoid the area.

Roseates nested behind the slabs of beach rock at Erskine Island during 1982-83 and 1983-84. It would be difficult for a turtle to crawl over the beach rock to the Roseate's nesting area.

At Wreck and Masthead Islands most nesting areas of the terns were in areas little used by turtles (Fig. 19). The large Black-naped colony on the spit at Wreck Island was in an area that usually has high turtle activity. But the number of turtles crossing the spit near the colony was low. Two turtles did approach the Black-napeds but veered away from the colony missing it by a few metres. Perhaps the noise from the colony dissuades turtles from going to close or it may be, terns strike turtles forcing them away from the nesting area.

In general, the areas of highest turtle activity are the ends of islands. This is illustrated in Fig. 19 and is typical of most elongated islands in the area.

FIGURE 19 Distribution and density of turtle diggings on the northern and southern beaches of WRECK ISLAND and Black-naped and Roseate nesting areas.

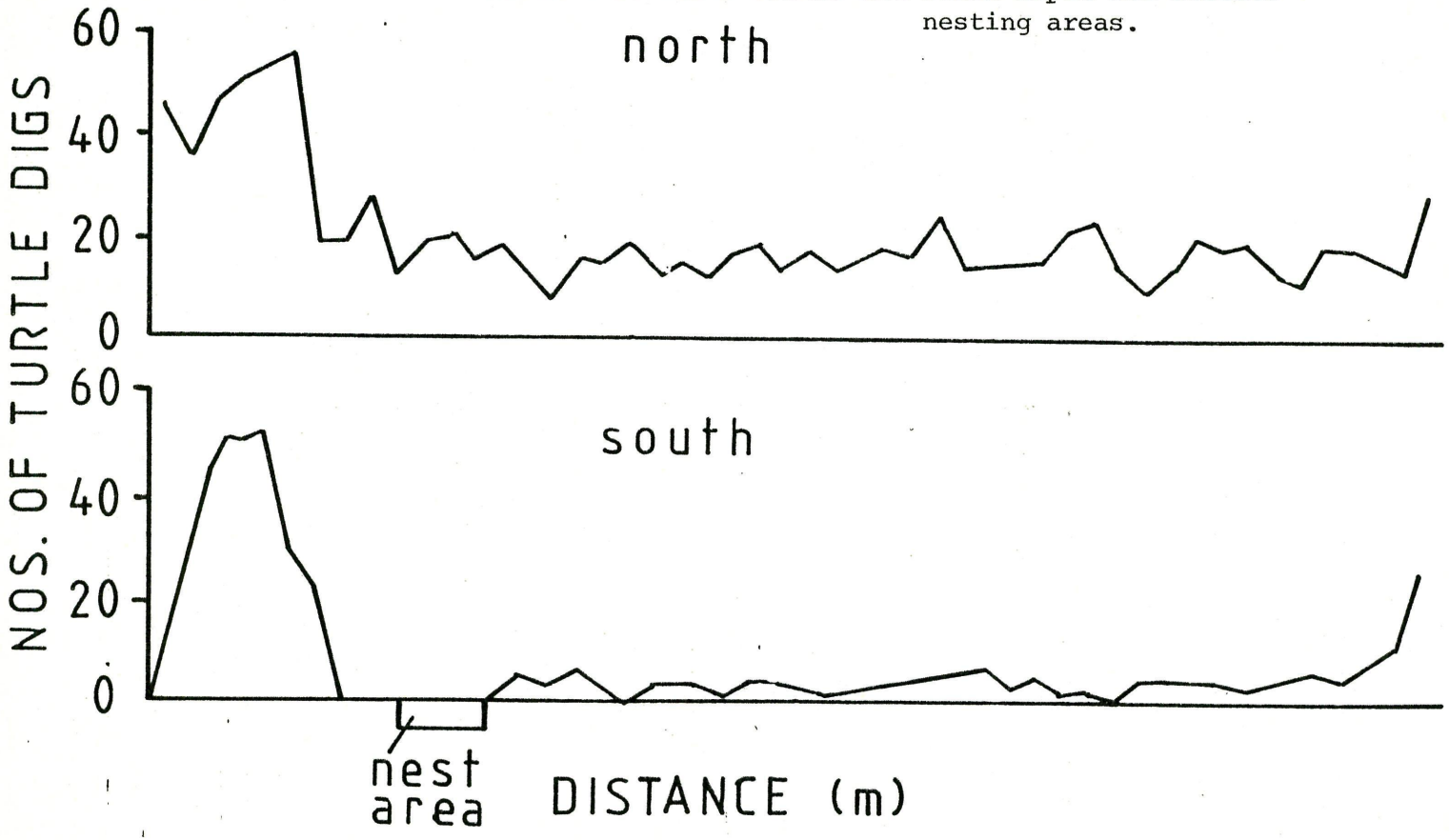


TABLE 9 Minimum number of breeding pairs of Black Noddy and number of fledglings produced at each colony.

Colony	# Pairs	Breeding success (%)	# Fledglings
North West	117199	50.9	59654
Masthead	85092	73.3	62372
Heron	43680	70.0	30576
One Tree	253	45.8	116+
Total	246224	62.0	152718

REPRODUCTIVE OUTPUT

Shearwater

The number of shearwater fledglings produced was not determined because the young, which hatch in late January and February, do not fledge until late April and May when I was not in the field.

Floyd and Swanson (1983) reported a mean breeding success of 43% for shearwaters at Muttonbird Island (33° 18'5, 153° 09'E) NSW. The breeding success varied from a low of 32% to a high of 54% over a three year period. Floyd and Swanson (1983) found that egg mortality (44.2%) was greater than chick mortality (23.2%). The result is consistent with findings of others for shearwaters (e.g. Harris 1966, Perrins et al 1973) and for terns (e.g. Hulsman 1977a).

Chick mortality is probably higher than egg mortality at North West Island because of the large number killed by cats. During mid February 1984. J. Rosier (pers. comm.) found large numbers of decapitated chicks on North West. However at the other colonies chick mortality is probably less than egg mortality because predation on chicks is virtually non existent.

Assuming a breeding success of 32% for shearwaters in the Capricornia Section about 142 200 fledglings would be produced.

Brown Booby

The 3700 fledglings produced in 1983-84 was far greater than the 1053 produced in 1982-83. But there were far more pairs breeding during 1983-84 than 1982-83.

Black Noddy

The breeding success of noddies was much higher during 1983-84 than that during 1982-84 (Table 9). As with other species, noddies produced a larger number of fledglings (152 718) during 1983-84 than during 1982-83 (73 311). The increased output resulted from two factors, higher breeding success and increase in the size of the breeding population.

Bridled Tern

The breeding success of Bridleds is usually high. At One Tree Island construction of a building when Bridleds were nesting resulted in breeding success of 24% far lower than in previous years ranging from 77 to 90%.

Roseate Tern

Roseates produced more than 200 fledglings during 1983-84, more than they produced during 198-83. Roseates had higher breeding success at Masthead Island than at Wreck Island (Table 10).

Black-naped Tern

A greater number of pairs nested and greater number of fledglings produced during 1983-84 (Table 11) than during 1982-83. As with the Roseate Terns, Black-naped Terns enjoyed a much higher breeding success at Masthead than at Wreck Island. A minimum of 27 fledglings were produced at One Tree Island. Not all the eggs had hatched by 25th January 1984 the time of my second visit to the island.

Crested Tern

Cresteds produced more fledglings in 1983-84 than in 1982-83 (Table 12). There was an increase in the number of young produced at all colonies except One Tree Island.

Lesser Crested Tern

This species did not nest in the region during 1982-83. Although Lesser Cresteds nested and reared young successfully during 1983-84, I do not know how many were produced. Come December when I arrived in the area there were only four fledglings or juveniles present. The others had presumably left with their parents. The pattern followed by Lesser Cresteds seems similar to that followed in 1973-74 (see Hulsman 1977b).

TABLE 10 Minimum number of breeding pairs of Roseate Tern and the number of fledglings produced at each colony.

Colony	Min # pairs	# eggs	# fledglings	Breeding success (%)
North Reef	14	20	12	61.2
Wreck	81	113	22	19.4
Masthead	107	150	85	56.7
Erskine	92	129	67+	52.0+
One Tree	3	4	1	25.0
Hoskyn	48	67	30	44.6
Lady Musgrave	14	20		-
$\bar{x}$ clutch size = 1.4	359	374	217	58.0

TABLE 11 Minimum number of breeding pairs of Black-naped Tern plus the number of fledglings produced at each colony.

Colony	Min # pairs	# eggs	# fledglings	Breeding success (%)
North Reef	18	18	6+	
Tryon	14	21	14	-
Wilson	20	20+	0	0
Wreck	152	228	43	28.3
Masthead	56	84	48	55
One Tree	81	121	27+	33.3
Hoskyn West	8	12	4+	
Lady Musgrave	21	30		-
$\bar{x}$ clutch size = 1.5	370	534	142	26.6%

TABLE 12 Minimum number of breeding pairs of Crested Tern and number of fledglings produced at each colony during 1983-84.

Colony	Min # pairs	# eggs	# fledglings
North Reef	755	755	600
Masthead	199	199	199
One Tree	43	43	43
Lady Elliot	3000	3000	3000
TOTAL	3997	3997	3842

Silver Gull

The number of fledglings produced by gulls was hard to measure. Their nesting was asynchronous and not all chicks were found because they hide in the vegetation.

FACTORS AFFECTING REPRODUCTIVE OUTPUT

Shearwater

The reproductive output of shearwaters is affected by

1. the frequency of burrows collapsing burying the occupants
2. the presence of mammalian predators e.g. cats and/or rats
3. human activity such as buildings, compaction of substrate
4. disturbance when eggs hatcing (Serventy et al 1971).

The frequency with which burrows collapse killing the occupants depends on a number of factors

1. the amount of moisture in the soil; dry soil collapses more readily than soil with some moisture in it; on the other hand very wet substrate also readily collapses;
2. the amount of structual support given to burrows by roots, branches and foundations of buildings;
3. the frequency that people walk through nesting areas and not on tracks.

Rats on islands such as Wreck and Fairfax probably eat eggs rather than chicks. It is possible that the increase in the rat population on Wreck Island caused the decline in the numbers of shearwaters, but the numbers of pairs on all islands except North West had decreased.

Brown Booby

Gulls prey on eggs of the booby whenever an opportunity arises. For example, gulls prey on eggs when boobies are frightened from their nests by humans walking too close to them.

Frigatebirds and gulls steal food from boobies possibly reducing the quantity of food fed to chicks. Under certain conditions such as wet

weather and strong winds, kleptoparasitism could lead to the death of some chicks.

Rats on East and West Fairfax may be responsible for predation on eggs. However, the frequency of mortality caused by the abovementioned factors has not been determined.

Black Noddy

The major causes of mortality of noddy eggs are predation by gulls and herons, and strong winds blowing eggs from nests. The major causes of chick mortality are predation by gulls and herons, Pisonia seeds sticking to plumage and chicks blown or fallen from nests, starving to death.

During 1983-84 predation seemed to be the major cause of mortality, some chicks had fallen out of their nests but few, if any, were incapacitated by Pisonia seeds.

There seemed to be a good food supply because chicks grew strongly and fledged within 43 days (B. Congdon pers. comm.). In 1979-80 chicks at One Tree Island had taken 53 days to fledge at a lower weight; this implies that food was not readily available to the adults. A number of gales and cyclones occurred during 1979-80. The combination of strong winds and rain chilled chicks as well as hindered the foraging of adults, preventing them from providing sufficient food to chicks to meet their increased energy needs.

Bridled Tern

Cyclonic weather is known to decrease the breeding success of this species (Hulsman 1977b) but it can tolerate if far better than other species such as Cresteds (See Langham 1983).

Rails apparently prey on eggs of Bridleds but generally the breeding success of Bridleds is high.

On islands where people live permanently or temporarily (camping) disturbances during sensitive stages of the breeding cycle, such as selection of nest-sites and early stages of incubation , can greatly reduce

breeding success. Areas close to where people camp or have permanent dwellings, the density of nesting Bridleds is low. This will be discussed more fully under the effects of disturbance in nesting birds.

Roseate and Black-naped Terns

I will deal with these two species simultaneously because they often nest together or at least next to one another. Their breeding success was greater at Masthead than at Wreck Island even though Masthead is open to the public and Wreck is not. The people at Masthead whom I spoke to during December when Roseates, Black-napeds and Cresteds were incubating eggs were very conscious of not disturbing nesting birds. Some had walked around the island but they had concentrated their activities around the camping area on the north western part of the island and on the reef itself. Masthead is a big island (44 ha) enabling people reasonable freedom of activity because they are far from the colonies and do not disturb the nesting birds.

Wreck Island presents a different set of problems to those met at Masthead Island. For example, there is a large population of gulls (>200) breeding on the island, rats are present and large numbers of turtles come ashore and nest. Turtle researchers on the island kept away from nesting areas of Roseates and Black-napeds and so kept disturbance to a minimum. The effects of turtles on where seabirds nest and reproductive output, will be discussed later in the report.

I do not know what caused the complete failure of 20 pairs of Black-napeds to rear young at Wilson Island. They nested on the western side of the island (P. Ogilvie pers. comm.) near where people land. It is possible that the birds were disturbed by people and so deserted, but there is no firm evidence to confirm the suggestion.

Predation by gulls on eggs and chicks of Roseates and Black-napeds is potentially a major cause of egg and chick mortality; it has been in previous seasons (Hulsman 1977a).

FEEDING AREAS OF EACH SPECIES

Shearwaters

No large concentrations of shearwaters were found foraging during 1983-84 as were during 1982-83. About 50% of shearwaters were found feeding within 9km of their nearest colony (Fig. 20). Only 8.9% of shearwaters were found 16 to 20km from their colonies in 1983-84 whereas in 1982-83 >90% were found that distance from colonies.

However since less than 0.03% of the total population shearwaters breeding in the region were observed foraging in the areas visited, it seems reasonable to surmise that most hunt further than 33km from their colonies.

Black Noddy

The majority of noddies were found foraging within 6km of their colonies (Fig. 21). Large aggregations of noddies were often seen near North West Reef. Flocks containing 1000-2000 noddies were often observed close to North West Island.

As in 1982-83 noddies tended to forage in the vicinity of coral reefs.

Bridled Tern

The distribution of foraging Bridled terns in 1983-84 differed from that in 1982-83. In 1982-83 about 36% of Bridleds were found between 2.4km from their colonies whereas 14.8% were found there in 1983-84. Some 31.8% of Bridleds were found foraging 4.6km from their colonies in 1983-84. Also in 1982-83 about 36% of Bridleds were found foraging between 10-14km from their colonies whereas merely 5.5% were found there in 1983-84 (See Fig. 22).

FIGURE 20. Distribution of shearwaters foraging in relation to distance from their nearest colony.

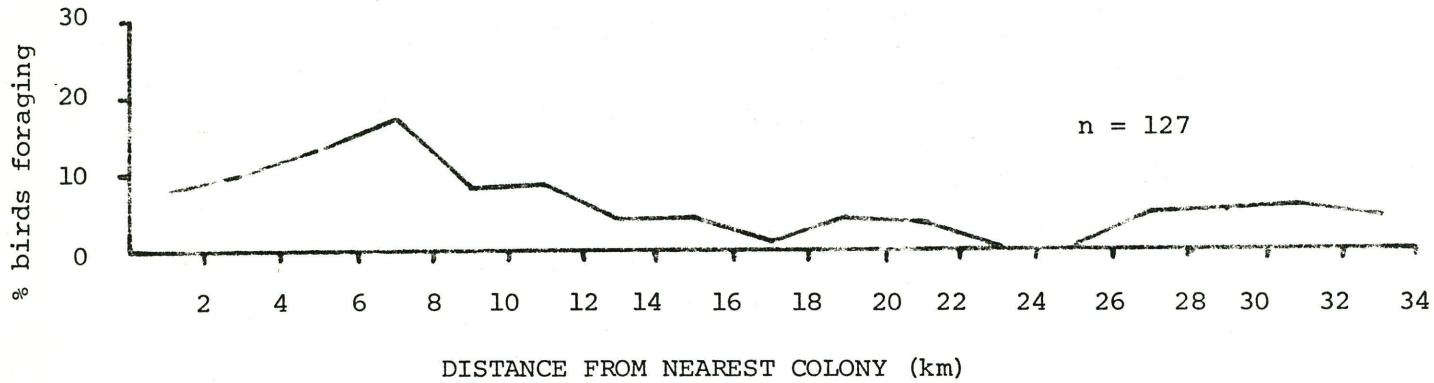


FIGURE.21. Distribution of noddies foraging along transects between Heron Island and Gladstone 1983-84

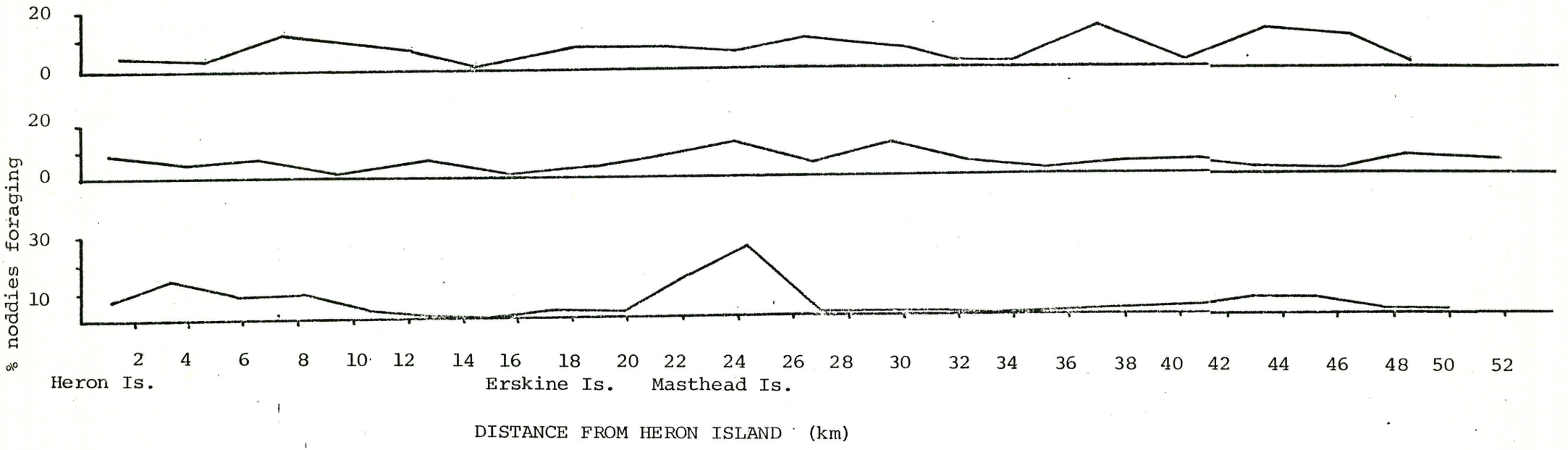
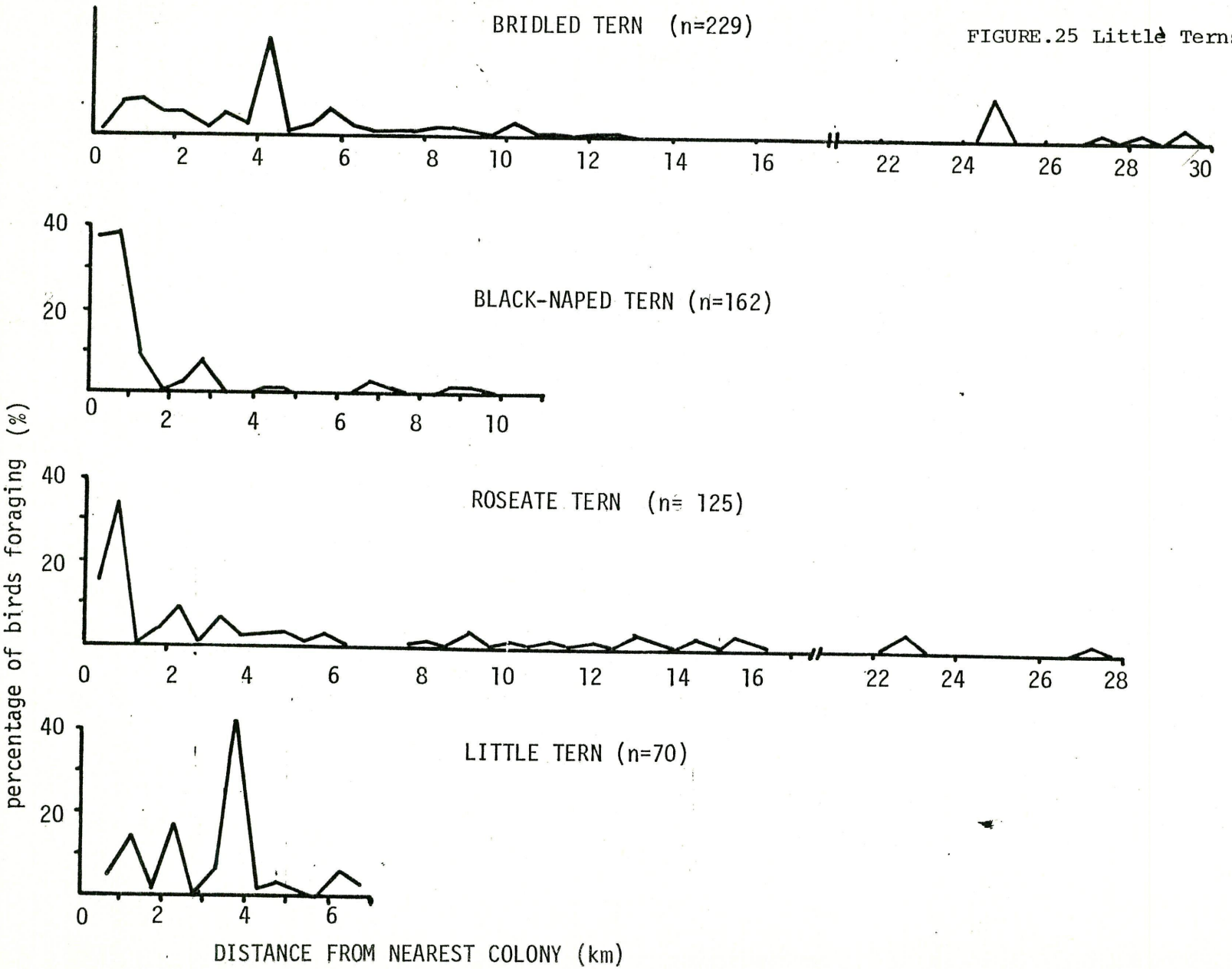


FIGURE.22. Distribution of Bridled Terns foraging, FIGURE 23. Roseate Terns, FIGURE. 24. Black-naped Terns, FIGURE.25 Little Terns.



Roseate Tern

The distribution of foraging Roseates differed from that of Black-napeds in 1983-84. About 60% of Roseates were found foraging within 3km of their colony (Fig. 23). As in 1982-83 Roseates were found often hunting where fast moving water occurred over follows or close to the reef crest. The largest concentrations of Roseates were found at Wreck Reef and Erskine Reef.

Black-naped Tern

About 83.4% of Black-napeds were found foraging within 3km of their colony (Fig. 24). Like the Roseates, Black-naped foraged where fast moving water occurred over shallows or close to the reef crest. They foraged with Roseates at Wreck and Erskine Reefs.

These results support earlier findings of Hulsman (1977b) that Black-napeds forage close to their nesting areas.

Crested Tern

Few Cresteds were seen foraging on transects between islands. They tend to hunt over reef flats and short distances out to sea, but in a specific direction. For example, Cresteds often hunt several kilometres to the south or south-east of One Tree Reef. At Masthead, Cresteds headed due north from the island to their foraging grounds which I did not locate.

Lesser Crested Tern

This species hunts very close to its colonies. Lesser Cresteds usually hunt in the surf and reef flats.

Little Tern

Little Terns are often found hunting close to the seaward side of the reef crest. However, they may be close to the island or off the crest further from the island. Occassionally this species foraged between reefs. Most (85.7%) Littles foraged within 4km of an island (Fig. 25).

DISCUSSION

Sources of error in estimates

My estimates of numbers of shearwaters and noddies on Masthead Island for 1982-83 are incorrect because:

1. I used 68ha as the island's area when the actual area is 44ha (see Hulsman 1981); and
2. where transects were in relation to the distribution of shearwaters and noddies.

I have tried a number of methods to calculate the area of Masthead Island: a dot grid method (Hulsman 1981); approximate the area with an elipse or a rectangle. The dot grid method yielded an area of 43.8ha. The area of an elipse with principal axes 1400m by 400m is 44ha. A rectangle 1400m by 400m is a very poor approximation of Masthead's shape and would greatly overestimate the area of the island. But the 56ha answer from the rectangle is less than the 64.8ha given by the Qld Lands Department.

The position of the transects in 1982-83 and 1983-84 in relation to the distributions of shearwater burrows (Fig. 7a) and noddy nests (Fig. 8a) on Masthead Island show the reason for the bias in the estimates of population sizes.

In 1982-83 transects 1, 2, 3 and 4 were censused. This would lead to an overestimate in the number of shearwaters and an underestimate of the number of noddies.

In 1983-84 transects 5, 6, 7 and 8 were censused. This would lead to an underestimate in the number of shearwaters and an overestimate in the numbers of noddies.

I have calculated the degree of overestimation or underestimation from using transects 1 to 4 or 5 to 8 and have adjusted my estimates accordingly.

DISTRIBUTION AND ABUNDANCE

Shearwater, Brown Booby, Noddy, Bridleds, Cresteds and Silver Gulls distributions do not change from year to year as do those of other species of seabirds studied. They tend to breed on the same islands year after year. However the actual abundance of each of these species can fluctuate quite markedly e.g. Noddies and Cresteds (Tables 5 and 6).

The number of noddies in the Capricornia Section increased quite dramatically between 1982-83 and 1983-84. Possible reasons for this increase are (1) that recruitment to the breeding population had increased. Cohorts from previous successful breeding efforts returned and started breeding in the region; (2) that the breeding population changes in size because adults do not return to their colonies and breed each year.

I suspect that the second reason is the most likely. However there remains the problem where do the new recruits or adults go during the years they are not in the Capricornia Section?

As stated in Hulsman (1983:75) I thought that there were fewer noddies at Heron Island during 1982-83 than 1979-80. However I do not know if the 1983-84 population was the same, less or greater than the 1979-80 population. It is possible for the noddy population at Heron to increase but it is nearing saturation point.

The apparent decrease in numbers of noddies at Masthead Island was a result where transects were in relation to the distribution of noddies. The population at Masthead has remained relatively constant: 160 000 in 1972 and 169 000 in 1984.

The numbers of Roseates and Black-napeds were greater during 1983-84 than during 1982-83. The results of this survey confirm that the numbers of these two species fluctuate greatly from year to year. I still believe that geographical area in which Roseates and Black-napeds that breed in the Capricornia Section in some years is greater than the area of the Capricornia Section. But where they breed is not yet known only that it is likely to be north of the Capricornia Section.

Lesser Cresteds bred at One Tree during 1983-84. As usual they nested in September early in the breeding season. Where these birds nest in other

years is not yet known but like the Roseates and Black-napeds it will be north of the Capricornia Section.

The number of Silver Gulls was less in 1983-84 than in 1982-83 (Tables 5 and 6). That does not support my impression (Hulsman 1983:75) that their numbers were increasing rather than remaining constant. The number of gulls on North West, Masthead, Fairfax and Lady Elliot in 1983-84 was less than that in 1982-83. The gull population is extremely mobile and frequently redistributes itself among the islands. (Table 13).

MOVEMENT OF SEABIRDS

At this stage it is too early to have returns from birds that were banded during 1982-83 and 1983-84. However it is possible to make some preliminary remarks about the movements of seabirds between breeding seasons in the basis of data collected during the period 1982-84. Marine Parks Officers have censused all species of seabird except shearwaters and noddies during the year. Changes in the numbers of each species on various islands may indicate the degree of movement but not necessarily from where the birds came from.

Seabirds and waders are extremely mobile. To illustrate the point I have selected three species of seabird Roseate, Black-naped and Silver Gull. some of the fluctuations in the numbers may result from not obtaining a good count of the number of the species concerned because birds were away foraging. However this is unlikely because the counts were done during high tide when the birds were forced to the islands to roost.

The fluctuations in the numbers of gulls at Tryon, Heron and Lady Musgrave Islands are large. For example, the number of gulls at Tryon changed by 55 gulls over 20 days, and at Heron changed by 76 gulls over one day (Table 13).

Similar types of trends are found in the numbers of Roseates (Table 14) and Black-napeds (Table 15). But the changes in the numbers of these two species may be related to post-fledgling dispersal of young with their parents. For example, the numbers of black-napeds and their fledglings at Tryon changed greatly after mid January 1984 (when campers had left the

TABLE 13 Changes in the numbers of Silver Gulls on islands of the Capricornia Section during the period of the census.

Gulls

Date	North Reef	Tyron	North West	Wilson	Wreck	Masthead	Erskine	Heron	One Tree	Hoskyn	Fairfax	Lady Musgrave	Lady Elliot
21.12.83													
23.12.83						121	13						
24.12.83													
25.12.83									26				
28.12.83													
31.12.83		64										50	
1.1.84	24												
2.1.84			33										
4.1.84				70				203					
5.1.84													
7.1.84													
8.1.84	12						18						
15.1.84								287					
16.1.84								259					
17.1.84								219					
18.1.84								295					
19.1.84		119											
21.1.84			29										
22.1.84					221				10				
23.1.84									19				
25.1.84													
27.1.84													
31.1.84												100	
1.2.84			21										
5.2.84		65											
7.2.84													
8.2.84		91											
9.2.84				62									
18.2.84											40		

TABLE 14 Changes in the numbers of Roseate Terns on islands of the Capricornia Section during the period of the census.

Roseate

Date	North Reef	Tyron	North West	Wilson	Wreck	Masthead	Erskine	Heron	One Tree	Hoskyn	Fairfax	Lady Musgrave	Lady Elliot
19.12.83						88							
23.12.83							88						
24.12.83					162								
25.12.83					160								
28.12.83				47									
31.12.83		3				214				60			
1.1.84	14												
4.1.84	22			252									
5.1.84										96			
7.1.84						460							
20.1.84		41							12				
23.1.84									9				
25.1.84						169							
27.1.84						173							
31.1.84												28	
5.2.84		66											
7.2.84				312									
8.2.84		182											
9.2.84				36 (+f)									

TABLE 15 Changes in the numbers of Black-naped Terns on islands of the Capricornia Section during the period of the census.

Black-naped

Date	North Reef	Tyron	North West	Wilson	Wreck	Masthead	Erskine	Heron	One Tree	Hoskyn	Fairfax	Lady Musgrave	Lady Elliot
19.12.83						121							
21.12.83						104							
23.12.83							14						
25.12.83													
26.12.83					304				164				
29.12.83	41			31									
31.12.83	23		0							15			
4.1.84	30	40						16					
5.1.84										28			
7.1.84	20					230							
8.1.84							25						
10.1.84		38											
19.1.84		153						10					
20.1.84		173											
22.1.84			0										
23.1.84						96			97				
28.1.84													
31.1.84											80	200	
5.2.84		196											
7.2.84				50									
9.2.84				92									

island). Also their numbers increased at Wilson Island which is near Wreck Island, site of a large colony. Also there is some good fishing at both Wilson and Erskine Reefs for Black-napeds and Roseates close to shore. A situation advantageous to adults feeding young. These changes may reflect a northward dispersal by this species from its colonies in the Capricornia Section of the Marine Park. Dispersal is likely to be northward because of

1. the nutrient rich waters around coral reefs attract prey of seabirds and therefore attract seabirds

2. the area is the southern end of the distribution of Black-napeds, Roseates, Bridleds and Lesser Cresteds (see Slater 1971, Blakers, Davies and Reilly, 1984).

3. other species whom range extend to southern Australian waters e.g. Silver Gull and Crested Tern also disperse northward along the eastern seaboard (see Purchase 1973).

MANAGEMENT STRATEGIES

The management proposals that I am putting forward are consistent with the objective of the Great Barrier Reef Marine Park, that is, conserve the Great Barrier Reef and yet allow people to have reasonable access and use of it.

If this objective is to be met it is necessary to increase the public's awareness of the requirements of seabirds for successful breeding. By my discussing this matter with campers on Tryon, North West and Masthead, I am convinced that the concerted effort to educate the public who use the Great Barrier Reef is a feasible and worthwhile exercise.

There are basically four types of people who visit coral cays:

1. Natural historians who are aware of the impacts of most of their activities on the flora and fauna of cays and reefs and are keen to learn more.

2. People who are interested in nature and are aware of the impact of some of their activites on the flora and fauna of cays and reefs and are keen to learn more.

3. People who are ignorant about nature and the impact of their activities but are keen to learn more.

4. People who are ignorant about nature and the impact of their activities and are not interested in learning about nature and how to minimise our adverse impacts on it.

Most people fall into categories 2 or 3. As I pointed out in my previous report (Hulsman 1983:97) "people tend to disturb breeding seabirds through ignorance", this also applies to their disturbing nesting turtles. If one explains to people what to do near seabird colonies or nesting turtles and explains the reasons why, then one usually gets a positive response from them. I have found this to be so from my dealings with people at Michaelmas Cay, Tryon, North West, Masthead, Heron and One Tree Islands.

In general, guests at the Heron Island Resort are not as well informed about nature as campers on the other islands. However, there are exceptions e.g. some very experienced ornithologists from overseas as well as Australia spend some time at the resort not during the "Bird Week".

Public education

A several pronged approach to increase the public's awareness so as to minimise impacts on flora and fauna of cays and reefs could involve dissemination of information in

1. Publications such as "Coral Reef Handbook". Professor Kikkawa and I have revised the section on birds in the Coral Reef Handbook. In it we deal with the major seabird species found in the Capricornia Section, information about the biology of shearwaters, noddies and silver gulls, and how to behave near seabird colonies to reduce the amount of disturbance to colonies. However the Coral Reef Handbook has a restricted audience. According to one of the shop assistants at Heron Island, few resort guests buy the book, it is mostly bought by visitors to the research station.

2. Publications by government agencies e.g. "Reeflections", and brochures. Marine Parks personnel have been giving the brochure (produced by the Bird Observers' Club) to campers. However campers whom I spoke to said

that although the brochure was interesting they thought one dealing specifically with the Great Barrier Reef would be more appropriate.

3. Photocopied typed sheets containing more appropriate detailed information than what is in brochures. Essentially providing information about the biology of the main species nesting in the region. That is the same type of information given about shearwaters and noddies in the "Coral Reef Handbook", but include Brown Boobies, Roseate, Black-naped, Bridled and Crested Terns etc.

4. Information about how to behave near seabird colonies and nesting turtles to be sent to all people who receive permits to camp on islands.
   (a) People should be aware of the general rule that if birds fly up and remain in the vicinity, retire as quickly as possible, to enable them to return to their eggs and chicks.
   (b) Campers should be asked to set up their camps in such a way so that it does not interfere with shearwaters leaving in the mornings. So rather than set up one's tent across a runway, set it up alongside a runway.
   (c) Noisy generators should not be permitted on islands. Not only do they disturb the birds but also annoy people, particularly at night when sound travels well. At this stage I do not know what noise level is annoying but it can easily be measured. There are some new generators which are very quiet and people should be encouraged to decrease the noise level emitted from their generators. If a person does not want to buy a quieter generator then he/she can buy or construct a cover to reduce the noise to an acceptable level.

5. Posters displayed at the office of the Marine Park Section's Office at Heron Island.

6. Conduct guided tours of small groups of people under the strict supervision of NPWS/GBRMPA Officers who have the necessary skills to conduct tours and communicate information effectively to people.

7. TV and radio programmes e.g. "Earthwatch" on ABC TV, documentaries on the GBR etc.

Role of Rangers

It is most important for Marine Parks personnel to speak to campers. The chats between park rangers and users are very useful and certainly impart the message in a friendly atmosphere to care for the flora and fauna of islands. This procedure is beneficial to the campers, Marine Park Section's prestige and protection of the flora and fauna of the islands and reefs.

In some cases rangers were unable to speak to campers because they were away from the island when the rangers were there. In at least one case at Tryon Island a group of people who had come in a trawler were camped near the nesting area of the Black-napeds. Rangers had left messages for this group on at least two occasions about the need to keep clear of the nesting area of Black-napeds. The group had a two year old child who frequently went into the nesting area and disturbed the adults and chicks. Also on two occasions when I was on the island, the child's grandmother took he and his sister to look at the Black-napeds and stood at the edge of the nesting area. In fact the children were picking up chicks and patting them etc. These frequent disturbances primarily from this particular group of campers made the Black-naped adults very nervous and they flew up whenever anyone ventured onto the beach within 80m of the nesting area. Usually one can approach to within 50m of a nesting area before eliciting such a response from adults.

I explained several times to the children and the adults in the group the reasons why they should not disturb the Black-napeds. However they did not seem to get the message to leave the Black-napeds alone. It was a situation that required a ranger to speak to the people about how to behave near a colony. The authority of a ranger may have convinced the people that what they were doing was not in the best interests of the birds.

Most of the people whom we spoke to had talked to rangers and had heeded their advice and kept away from the nesting birds. People seem to respond very positively to the "soft sell" approach used by Marine Parks personnel to communicate information to them.

This practice of rangers telling to campers should be supplemented by information sent to people requesting camping permits. Information about

the natural history of the island and reef as well as how to behave in seabird colonies and near nesting turtles.

In my previous report (Hulsman 1983:99) I outlined the sequence of behaviours that terns perform when an intruder approaches a colony. Unfortuately this sequence occurs very quickly in less than 2m travelling by the intruder, therefore we cannot effectively make use of it to advise people when to move away from the colony without disturbing the nesting birds. Instead we will have to rely on a person noticing that the birds are nesting before they are disturbed or birds flying up calling and remaining near the area (see Hulsman 1983:99).

The type of information about seabirds that should be conveyed to the general public is given in my earlier report (Hulsman 1983:97-99).

Guided Tours

Initially the education programme should be directed at the campers, day visitors to islands and visitors to resorts and research stations. An education programme run by GBRMPA/NPWS in co-operation with Heron Island Pty Ltd, directed at resort guests could add another enjoyable dimension to their trip to the GBR. It would have to be an extremely professionally run exercise akin to that run by Col Limpus and Phil King at Heron Island. People respond very well to both of these NPWS officers because of their knowledge of the subject (turtles) and ability to communicate their knowledge and enthusiasm to them.

One could tackle this problem at several levels

1. the island as an ecosystem substrate, vegetation, fauna and their inter-relationships with one another
2. substrate and vegetation
3. vegetation
4. vegetation and avifauna; or
5. avifauna.

A programme to increase the public's awareness about minimising our impact on the GBR, helps in the management of resources and people's access to, and use of the region. It also has obvious public relations benefits for the agencies responsible for managing the Marine Park.

I would like to give an example of the type of information that could be conveyed by Marine Parks personnel to visitors (resort and research) to Heron Island during guided tours of the island.

Vegetation and Avifauna

There is an excellent story in explaining the reasons for the distribution of various vegetation types on the island and the distribution of shearwater burrows and noddy nests.

The island's vegetation can be grouped into five easily recognised habitats, 1. Strand Forest, 2. Low Pisonia Forest, 3. Low-medium Pisonia Forest 4. Medium Pisonia Forest and 5. Tall Pisonia Forest (see Table 22 Hulsman 1983:82, Dale et al 1984 for definitions).

The Strand Forest contains Casuarina, Argusia, Scaevola, Pandanus and Cordia trees or shrubs. This habitat occurs on the periphery of the island it is narrow on the windward (or southern) side of the island and wider on the leeward (or northern) side of the island. The Casuarina dominated Forest is on the leeward side of the island. On the windward side the Strand Forest is dominated by Argusia.

Argusia tends to occur on the edge of the island because its seeds are dispersed by water. Seeds are washed up on a beach or island edge where they may germinate and successfully grow. Poor nutrient content of the substrate at the edge of the island and wind shearing may contribute to stunting Argusia's growth. It can grow to at least 8m tall when it occurs in more favourable sites, such as inland.

Of the Strand vegetation Argusia and Cordia are the most popular with noddies. Their branch structure and easy access to branches because of their sparse leaf cover may make them suitable for nesting in. [There are excellent examples of these on the leeward side of the island along the beach between the resort and Marine Parks buildings]. There are usually few shearwater burrows in the Strand vegetation despite the grass providing some structural support for burrows because turtles nest in the strand. Turtles digging or simply crossing an area would collapse burrows trapping the occupants inside leaving them to die. A strong selection pressure to avoid burrowing in the strand vegetation.

The distribution of the other four habitat types is very patchy. Generally the low Pisonia Forest tends to occur on the windward side of the island where wind shearing stunts the growth of the trees. Tall Pisonia forest tends to occur towards the centre of the island. The low-medium and medium Pisonia forests tend to occur between the low and the tall Pisonia Forests.

These four Pisonia Forests represent different seral stages in the succession from low to tall Pisonia. Tall Pisonia are easily blown over by strong winds because of their size and very shallow root system. When a tall Pisonia tree is blown over it creates a space in the canopy and species such as Figs, Celtis and Pipturus grow well there. These spaces will develop into low Pisonia because the branches of fallen Pisonia grow vertically and use the nutrients from the decaying trunk to establish themselves as trees in their own right. Thus the patchy distribution of these habitats is caused by strong winds and cyclones damaging the vegetation, reverting it to an earlier seral stage. Few noddies nest in low Pisonia forest because there are few suitable nest sites. The branches are narrow and usually access to sites is poor because of the dense leaf cover.

Low Pisonia will regenerate into low-medium Pisonia forest which noddies prefer to nest in. Noddies are colonial nesters, i.e. tend to nest near other noddies. Trees such as Figs and Celtis that are readily accessible for noddies and have suitable branches for nesting on are favoured by noddies. From these trees, nesting spreads or overflows to nearby Pisonia trees. It seems that when the Celtis or Fig tree is filled with nests, the nearest that other noddies can get to established nests is in adjacent trees. Thus, at points of overflow, nests in adjacent trees are at the same height above the ground. Once nesting is established in an adjacent tree, it may spread along the main branches. This gives rise to the arch patterns which can be clearly seen in Pisonia trees. [These patterns are clearly illustrated around the resort and research station.]

The low-medium Pisonia forest develops into medium Pisonia forest which is not as popular with noddies as is the earlier seral stage. Access to nests by birds tends not to be as good in medium Pisonia forest as in low-medium Pisonia forest. Fig and Celtis trees tend to be smaller in this seral

stage than in low-medium Pisonia forest and are not as preferred as taller ones are by noddies.

Tall Pisonia forest contains a large number of potential nest-sites with good access, but not all nest-sites are used. For instance, noddies rarely nest in the upper third of Pisonia trees > 10m tall, possibly because there is a great deal of movement (swaying etc) by the upper parts of the trees and since noddy nests are simply platforms which eggs and chicks can easily fall out of. Although some tall Pisonia trees have large numbers of nests, many have few nests in them. Tall trees that are avoided by noddies may be senile which increases the brittleness and hence the likelihood of branches breaking and thus that of nests and contents falling to the ground and increasing egg and chick mortality.

The distribution of shearwaters' burrows on the island is largely determined by suitable substrate in which to burrow. It cannot be too hard, otherwise it is too difficult for shearwaters to dig into, and it cannot be too soft because the burrow would readily collapse. So shearwaters burrow where the substrate is firm. The greatest densities of burrows occur in areas where vegetation provides structural support for the burrows. Roots of Pisonia trees, fallen Pisonia trees and branches, and Abutilon provide the kind of structural support required.

Shearwater play a constructive as well as a destructive role with respect to the vegetation. Their constructive role includes transferring nutrients from the sea to the island (defaecating on island). Their burrowing activities keep nutrients mixed throughout the profile of the substrate. Furthermore, fallen leaves are usually blown into burrows where they decompose, providing nutrients for the trees from which they came.

The destructive role of the shearwater is that it undermines the shallow-rooted Pisonia trees, increasing their susceptibility to being blown over by strong winds. It is perhaps ironic that fallen trees enable the shearwaters to obtain higher nesting densities because of the increased structural support in the area, as well as increasing access from the sky to their nesting area.

Management in Short-Term

Initially the public should be restricted to the large islands where their activities are less likely to disturb breeding seabirds simply because of the size of the island. On large islands such as North West and Masthead there is ample room for people to camp, walk etc. without disturbing the nesting birds. On the other hand, on small islands people are more likely to disturb nesting birds than on large islands, because their activities occur too close to the nesting areas.

The marked walking track on North West is good. People can walk across the island and see the variety of habitats and not fall into a burrow. The marking of tracks has to be maintained otherwise people can easily lose their way and then try to walk through areas with large densities of burrows risking injury to themselves as well as shearwaters.

It seems that Wilson Island is no longer suitable for successful breeding by Roseates and Black-napeds. There is too much people traffic on the island during the breeding season. This island (5ha) is too small to accommodate people and successful Roseate and Black-naped colonies. I am not suggesting that people have deliberately disturbed colonies. I am suggesting that even if people remain away from colonies their activities can disturb the birds because the island is too small.

Some islands should remain closed to the public during the breeding season of seabirds. For example, small islands where easily disturbed species such as Boobies, Roseates, Black-napeds or Cresteds nest i.e. North Reef, Erskine, Wreck, Hoskyn (East and West), Fairfax (East and West). Fairfax and Hoskyn would need to be closed for longer periods than would North Reef and Erskine Islands. The boobies start nesting in July and finish about April. Given the sensitivity of the Boobies and the importance of the colonies at Hoskyn and Fairfax these islands, except perhaps West Hoskyn, should be closed all year round.

This would require some changes to the current zoning plan of the Capricornia Section. I shall submit a more detailed proposal at a later date.

At Lady Musgrave Island, Roseate and Black-naped Tern nest near where boats land, the only safe place to land on the island from lagoon side. Therefore the nesting birds will be distrubed. One cannot prevent people from landing on the island unless there is a full time ranger there during the breeding season. I think that it would be better to protect colonies at Wreck, Masthead, Erskine, One Tree and Hoskyn leaving Lausgrave open to the public.

Management in Long-Term

As public awareness increases and people recognise and respect the requirements of birds etc. then it will be feasible to visit Fairfax and Hoskyn Islands. Initially it might be done under the supervision of GBRMPA/NPWS officers and later unsupervised visits, towards the end of the breeding season e.g. young fledging. However, I am speaking about a long term goal in terms of increasing the public's access to islands and assume here that Preservation Zones will remain closed to all members of the public irrespective of their level of awareness.

About 80% of Wedge-tailed Shearwaters on the eastern coast of Australia breed at North West Island. This is based on my census of colonies in Capricornia and the colony sizes in New South Wales given by Lakers et al (1984). The bulk of the Wedge-tailed Shearwater breeding population on one island. The island should not be developed in anyway but should be kept for camping by 100 to 150 people at any one time. Large numbers of day visitors to the island between October and June would not only be detrimental to the birds on the island but also could affect vegetation, substrate (erosion, compaction) and the enjoyment of the campers.

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