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MARSHALL ISLANDS, MAY 1986

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ABSTRACT

Field work conducted by the senior author at Bikini Atoll, Marshall Islands, in May 1986 yielded twenty-three species of birds; six of these were documented as nesting and an additional four species almost certainly nest as well. Six species were previously unrecorded for Bikini Atoll, and one of these, the Laughing Gull (Larus atricilla) was new to Micronesia. The recorded avifauna for Bikini Atoll now stands at twenty-six species. Major seabird colonies were located on Aomoen (and other northern islets), Nam, and Oroken/Jalete/Lukoj (and other southeastern islets). Scaevola and Tournefortia scrub and Pisonia grandis forests are the most frequently used habitats for nesting seabirds. Numerically, the most abundant breeding birds were the terns Anous minutus, A. stolidus and Gygis alba and the boobies Sula leucogaster and S. sula. Environmental rehabilitation options which minimize habitat alteration on the important nesting islets are recommended. Close monitoring and protection of seabird populations after Marshallese resettlement will guard against excessive disturbance and exploitation.

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INTRODUCTION

Bikini Atoll is located in the northwestern Marshall Islands in eastern Micronesia (latitude $11^{\circ} 20'$ to $11^{\circ} 44'N$; longitude $165^{\circ} 10'$ to $165^{\circ} 44'E$). It is a large coral atoll consisting of some twenty-two islets, the two largest of which are Bikini Islet (560 acres) and Eneu Islet (304 acres). These low islets (less than 4m maximum elevation) are partly to extensively wooded, although the vegetation of all islets has been disturbed through human agency. Soil and vegetation characteristics and plant species lists are given in Fosberg (1986). The breeding avifauna of Bikini Atoll consists of up to ten species of seabirds, most of which are widespread through the tropical Pacific Ocean, and one species of heron. Several additional non-breeding species, mostly shorebirds, are recorded.

Reviews of the avifauna of Micronesia (e.g. Baker 1951, Owen 1977, Pyle and Engbring 1985, Pratt et al 1987) have been general in scope or have concentrated on the higher, ecologically more diverse islands in the western part of the region. Considerably less attention has been paid to the lower atolls which make up the easternmost portion of Micronesia. The avifauna of the Marshall Islands was summarized by Amerson (1969); in that work seventeen species were listed for Bikini Atoll, five of which were proven to nest there. Published references to Bikini Atoll's avifauna, apart from the above-mentioned works, are few, but include Anderson (1981) and Fosberg (1966).

In this paper we discuss the results of field work conducted by the first author on Bikini Atoll in May 1986; during this visit seabird population sizes, nesting status, and habitat requirements were evaluated, and avifaunal lists were developed for most of the atoll's islets. We interpret the results in light of previous studies of Bikini Atoll and other coral atolls in the region. In particular, we (1) summarize what is currently known of the avifauna of Bikini Atoll, (2) discuss the probable impacts of three periods of human influence on Bikini Atoll (Marshallese settlement, United States atomic weapon testing, and environmental rehabilitation activities), and (3) suggest probable effects and possible mitigating measures related to proposed Marshallese resettlement on Bikini Atoll.

METHODS AND MATERIALS

Field work was conducted on Bikini Atoll 14-28 May 1986 by K. L. Garrett; additional observations were made at sea between Bikini Atoll and Kwajalein Atoll aboard the research vessel Egabrag II by K. L. Garrett on 28-29 May 1986. During field work on Bikini Atoll, visits were made to thirteen of the islets, representing all parts of the atoll. In Table 1 we list the dates each islet was visited, and in Figure 1 show their location.

Table 1. Field effort by islet or islet-group

<u>ISLET</u>	<u>DATES OF COVERAGE</u> [MAY 1986]															
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
Eneu	X		X													X
Bikini		X	X	X	X	X	X	X	X		X	X				
Odrik/Lomilik							X									
Bokantuak								X	X		X					
Iomelan									X							
Aerokoj/Aerokojlol										X						
Enidrik										X						
Lukoj										X						
Jalete										X						
Aomoen											X		X			
Nam																X
Oroken																X

An attempt was made to cover all habitat types on each islet visited, although more thorough coverage was possible along the periphery of the islets and in more open habitats in islet interiors. Denser vegetation associations, such as low thickets of *Scaevola*, were penetrated where possible. For each islet, estimates were made of the number of adult birds present and all visible nests, egg sets and dependent young were counted. Population estimates were derived from direct counts of adult birds on most of the smaller islets. On certain islets, such as Nam, where coverage of interior habitats was impossible, population estimates were extrapolations of direct counts with available habitat area taken into account. It should be noted that most islets covered were of such small size that complete surveying was possible in a single visit.

At-sea transects from aboard the Egabrag II were conducted in the manner described by Ainley and Boekelheide (1983). The observer (Garrett) was stationed on the ship's bow, with observer eye level about 6m above the water surface. All birds within 300 m of the ship in a 90 degree quadrant bounded by lines extended straight

ahead from the bow and straight abeam of the side providing the most advantageous lighting were recorded. As the ship's speed was a constant 8.5 knots, each fifteen minute transect covered an area of approximately 118 hectares. Densities were calculated as individuals per 100 ha by multiplying the number of individuals recorded during each transect by a factor of 0.85. In the region surveyed, adjustments for ship-following or ship-avoiding birds did not appear to be necessary.

A collection of twenty-seven specimens, housed in the Natural History Museum of Los Angeles County, provided voucher specimens and allowed for some analysis of molt, stomach contents, parasite infestations and breeding condition. Appendix A lists these specimens and associated pertinent data.

RESULTS

Twenty-three species of birds were found on Bikini Atoll and adjacent marine waters. In Table 2. we list these species and their general status in the region. Three additional species are listed for Bikini Atoll by Amerson (1969) and Anderson (1981), bringing the known list for the atoll to a minimum of twenty-six species. Of the twenty-three species observed during the present study, nesting was proven for six species, and strong evidence of nesting was obtained for an additional four species. Two additional observed species (Wedge-tailed Shearwater and Great Frigatebird) nest in the Marshall Islands and might possibly nest on Bikini, though no evidence was obtained during current field work. Of the remaining species, three were migrant shearwaters which nest in the Australasian region and spend the austral winter in the North Pacific Ocean, seven were arctic nesting shorebirds which occur in Micronesia as wintering birds or transients, and one was a North American gull of purely accidental occurrence.

Table 2. Bird species observed at Bikini Atoll, May 1986

Annotations: N = nesting observed
 N? = nesting suspected
 nb = non-breeder; species nests in Micronesia
 m = migrant; species does not nest in Micronesia
 * = previously unrecorded at Bikini Atoll
 ** = previously unrecorded in the Marshall Islands

- Family Procellariidae
1. Puffinus pacificus nb
Wedge-tailed Shearwater
 2. Puffinus bulleri m*
Buller's (New Zealand) Shearwater
 3. Puffinus griseus m*
Sooty Shearwater
 4. Puffinus tenuirostris m*
Short-tailed Shearwater
- Family Phaethontidae
5. Phaethon rubricauda melanorhynchos N?
Red-tailed Tropicbird
- Family Fregatidae
6. Fregata minor palmerstoni nb
Great Frigatebird
- Family Sulidae
7. Sula sula rubripes N
Red-footed Booby
 8. Sula leucogaster plotus N
Brown Booby
- Family Ardeidae
9. Egretta sacra sacra N?
Eastern Reef Heron
- Family Charadriidae
10. Pluvialis dominica fulva m
Lesser Golden-Plover
- Family Scolopacidae
11. Heteroscelus incanus m
Wandering Tattler
 12. Heteroscelus brevipes m*
Gray-tailed Tattler
 13. Numenius phaeopus variegatus m
Whimbrel
 14. Numenius tahitiensis m
Bristle-thighed Curlew
 15. Arenaria interpres interpres m
Ruddy Turnstone
 16. Calidris alba m*
Sanderling
- Family Laridae
17. Larus atricilla m**
Laughing Gull
 18. Sterna bergii cristatus N?
Crested Tern
 19. Sterna sumatrana sumatrana N
Black-naped Tern
 20. Sterna fuscata oahuensis N?
Sooty Tern
 21. Anous stolidus pileatus N
Brown Noddy
 22. Anous minutus marcusii N
Black Noddy
 23. Gygis alba candida N
White (Fairy) Tern

In Appendix B we list all species recorded and the islets on which they were observed. In the following text we present information about these species in two formats. First, we discuss each islet or islet-group, its habitats, and its bird populations. Second, we provide detailed accounts for each species, in phylogenetic order; included are accounts for species published as having occurred on Bikini Atoll, but not encountered during the present field work.

ISLET ACCOUNTS

The accounts for the islets or islet groups contain first a descriptive statement of habitats, disturbance factors and other factors which influence their avifauna. These descriptions are brief, and the reader is referred to Fosberg (1986) for a detailed discussion of habitats on each of the islets. A discussion of bird population sizes, nesting activity, foraging activity, and other aspects of avian biology follows. Islets are treated in a sequence beginning at Eneu Islet, in the southeastern part of the atoll, and continuing counter-clockwise through the eastern, northern, and southwestern islets.

A. ENEU

Eneu is the second largest islet of Bikini Atoll, with an area of approximately 304 acres. It is located on the east side of the main pass of the atoll, and is oriented approximately north-south. The dominant features of the islet are a grid of planted coconut palms (Cocos nucifera) and the airstrip. Eneu is the only islet other than Bikini Islet which presently has continuous human presence (one or two residents in the house and occasional activity at the storage/ machine building, airstrip and landing dock). Rats (Rattus, sp.) are reported to occur commonly on Eneu Islet.

Bird habitats on Eneu can be characterized as follows: (1) beaches, including sandy beaches, coral flats and beach rock; (2) sparse, short grass and herbs associated with cleared areas (e.g. the airstrip); (3) scrub, dominated by Tournefortia and Scaevola; (4) coconut plantations; and (5) Cordia and/or Pisonia forest. The last habitat type is poorly represented on Eneu.

No evidence of nesting seabirds was encountered during visits to Eneu, although small nesting populations of the White Tern in Tournefortia shrubbery or Pisonia trees might have been overlooked. The lack of breeding seabirds is most likely explained by continuous human presence, and by the presence of rats and cats.

The open habitats along the air strip were occupied by foraging Lesser Golden-Plovers and Ruddy Turnstones, with high counts of 18 and 10, respectively. Along the beaches and coral reef flats, the following species were encountered, with maximum counts given in parentheses: Eastern Reef Heron (4), Lesser Golden-Plover (8), Wandering Tattler (4), Ruddy Turnstone (4), Black-naped Tern (2), Crested Tern (6 on sandspit at north tip), and Black Noddy (4). Additional species flying low over the islet were: Great Frigatebird (5), Brown Booby (1), Sooty Tern (5), Brown Noddy (7), and White Tern (5).

Perhaps because the seaward fringing reef is quite narrow near the southern tip of Eneu Islet, deep-water foraging flocks of seabirds were noted relatively close to shore there. These flocks contained 500+ noddies (not identified to species), at least three Brown Boobies, and several shearwaters, apparently Wedge-tailed.

B. BOKANTUAK and IOMELAN

A series of five small islets lie between the major islets of Eneu and Bikini. The northernmost two of these, Bokantuak and Iomelan, may be reached on foot at low tide from the southeastern tip of Bikini Islet. The central islet is bare of vegetation. Observation from a small boat suggests that the avifauna of the southernmost two islets, Rojkora and Bokonjebi, is quite similar to that of Bokantuak and Iomelan.

Bokantuak and Iomelan are dominated by Scaevola thickets with scattered Tournefortia (the latter is most frequent along the lagoon side). The ocean side is fringed by a broad reef; above high tide line there is a broad stretch of crushed coral and beach rock. Open gravelly areas extend inward from the ocean side toward the center of each islet. Scattered Guettarda grows on Iomelan but was not noted on Bokantuak.

Bokantuak and Iomelan, and presumably the other two vegetated islets in this chain, have small nesting colonies of Brown Noddies and White Terns, along with scattered nesting pairs of Black-naped Terns. Two nesting pairs of Black-naped Terns were found on Bokantuak Islet, the "nests" being shallow scrapes in the crushed coral two to three meters from the nearest Scaevola thickets; each scrape contained a single egg. Two White Tern eggs and two additional chicks were located on Bokantuak; all were in Tournefortia trees near the lagoon side. Only one Brown Noddy nest was located; it was in a Scaevola shrub and contained a single egg. Aggressive behavior by all three species of terns suggests that many additional nesting pairs were present. Combined estimates for Bokantuak and Iomelan

breeding populations were: Black-naped Tern, 15 pairs; Brown Noddy, 30 pairs; White Tern, 200 pairs. Inclusion of the southern two islets in this chain would probably at least double these numbers.

Other birds noted on Bokantuak and Iomelan Islets were: Eastern Reef Heron (2-3), Lesser Golden-Plover (2), Gray-tailed Tattler (1), Bristle-thighed Curlew (2), Whimbrel (1), Ruddy Turnstone (5), Crested Tern (4), and Laughing Gull (1). Black Noddies and one Brown Booby were noted on the adjacent coral flats and heads at low tide.

C. BIKINI

Because work on the atoll was headquartered on Bikini Islet, that islet received the most thorough coverage. The entire lagoon and seaward shores were covered several times, as was the interior. Avian habitats on Bikini Islet could be characterized as for Eneu Islet: (1) beaches, including sandy beaches, coral flats and beach rock; (2) open areas dominated by grasses, as along roadsides; (3) scrub, dominated by Scaevola and Tournefortia, but locally also by Leucaena or Suriana; (4) coconut plantations, which dominate the interior of the islet; and (5) patches of woodland dominated by Cordia, Dodonea or other small trees.

No seabirds were found nesting on Bikini Islet, a not unexpected result considering the human activity there and the presence of cats and rats throughout the islet. The continuous presence of one or two mildly aggressive pairs of White Terns in Tournefortia and Suriana scrub near the southeastern tip of the islet does suggest that this adaptable species might in fact nest on the islet.

Seventeen species of birds were recorded on or over Bikini Islet. This was the highest species list for any islet on the atoll, the result, no doubt, of saturated coverage. Notes on each of the species follow:

Red-tailed Tropicbird. One flying low over the northwest tip of the islet on 15 May.

Red-footed Booby. Occasionally seen over the lagoon just off the islet.

Brown Booby. Adults regularly seen over the lagoon and ocean waters just offshore, and perched on taller coral heads on the ocean reef.

Great Frigatebird. Small numbers occasionally seen high over the islet, with flocks of up to six birds.

Eastern Reef Heron. Up to half a dozen birds seen almost daily, primarily along shorelines and on reefs, but occasionally in cleared areas and

- roadsides in the interior. Possibly nests on the islet; other observers have commented on the tendency of this species to nest in concrete bunkers (such bunkers exist in Bikini Islet).
- Lesser Golden-Plover. Up to 12 per day found along beaches and other open areas (e.g. roadsides).
- Bristle-thighed Curlew. Occasionally seen along beaches and sandspits, especially at the southeastern tip of the islet. Maximum daily count: four.
- Whimbrel. Occasionally seen along beaches or in grassy areas in the interior of the islet. Maximum daily count: six.
- Wandering Tattler. Small numbers regularly seen along beaches, especially coral flats on the seaward shore. Maximum daily count: eight.
- Ruddy Turnstone. Small numbers occasionally seen along beaches. Maximum daily count: seven.
- Sanderling. One seen along seaward beach on 15 May.
- Black-naped Tern. Small numbers regularly seen along the shorelines, especially on sandspits at the southeastern and northwestern tips of the islet; regularly seen foraging over the lagoon just off the islet. Both adults and juveniles noted, but no signs of nesting found.
- Sooty Tern. Small numbers of adults occasionally seen over the islet or adjacent waters.
- Crested Tern. Up to ten per day regularly seen along beaches and, especially, sandspits. Foraging noted in shallow lagoon waters and, especially, over the seaward reef. Both adults and juveniles noted, but no signs of nesting.
- Brown Noddy. Small flocks regularly seen in flight over the islet and adjacent waters; not seen perched.
- Black Noddy. Small flocks frequently seen in flight over the islet and adjacent waters; also regularly found on beaches, but not seen perching in trees. Foraging flocks frequently seen over lagoon and ocean waters; small numbers also foraged along the seaward shore of the islet.
- White Tern. Small numbers regularly observed over beaches and adjacent waters, and with foraging flocks of noddies over the lagoon. Aggressive birds perching in shrubs at the southeast tip of the islet suggested the possibility that one or two pairs may nest.

D. AOMOEN

Aomoen is the easternmost of a chain of narrow, scrubby islets interconnected by sandbars along the

northern section of the atoll. The vegetation is simple, with Scaevola and Tournefortia being the dominant shrubs; shrub growth is densest around the slightly raised perimeter of the islet. There are extensive low flats of grasses and sparse shrubs throughout the interior of the islet. Habitats on the islet may thus be characterized as: (1) beaches, including sandy beaches, coral flats and beach rock; (2) open grassy areas with sparse shrub growth, dominating the islet's interior; and (3) mixed Scaevola and Tournefortia scrub, found through much of the islet, but especially around the raised perimeter.

The most striking ornithological feature of Aomoen Islet is the nesting colony of Brown Noddies. A minimum of 500 nesting pairs were estimated to be present; nest sites ranged from simple scrapes among the sparse grasses in the open interior portion of the islet to more elaborate stick and leaf lined structures located from one to three meters high in Scaevola (primarily) or Tournefortia shrubs. Eggs, downy young, and nearly-fledged juveniles were all commonly encountered, indicating an extended nesting season. The greatest concentration of nests was found on the ground in the central portions of the islet.

White Terns were also found nesting commonly on the islet. Over 250 pairs were estimated to be present, with eggs and downy young found exclusively on Tournefortia branches, especially around the perimeter of the islet.

Black-naped Terns were assumed to be nesting, based on repeated aggressive swoops by adult birds along the sandy or crushed coral seaward shore. It is likely, based on this behavior, that up to five pairs were nesting.

Other species of birds noted on Aomoen Islet were:
Brown Booby. Up to four birds present over seaward reef.

Great Frigatebird. One adult female seen on each visit.

Lesser Golden-Plover. Up to six seen on seaward beach.

Wandering Tattler. Two seen on seaward beach.

Bristle-thighed Curlew. Three seen on seaward beach.

Ruddy Turnstone. Ten seen on beaches.

Crested Tern. Six birds noted just offshore; flying juveniles noted, but no definite signs of nesting.

Sooty Tern. Up to fifteen adults noted over the islet, but no signs of nesting.

E. ODRIK/LOMILIK

These islets are joined by a vegetated sandbar and are, in fact, joined by sandbars to Aomoen Islet on the east and Bwikor Islet on the west. Field work was limited to the Lomilik (eastern) side of the Odrik/Lomilik chain. Bird habitats were generally similar to those described for Aomoen Islet, consisting of: (1) beaches; (2) open grassy areas with sparse Scaevola and Tournefortia growth; and (3) dense Scaevola and Tournefortia scrub. In addition, a small shallow pond constructed for milkfish production and bordered by Suriana growth is located in the center of the islet. Such ponds are utilized by shorebirds, and apparently are visited occasionally by migratory waterfowl in late fall and winter (none recorded during present field work). The western islet of Bwikor was not visited, but probably does not differ substantially from Odrik/Lomilik in its birdlife.

Nesting of both Brown Noddies and White Terns was observed. The Brown Noddy population on Odrik/Lomilik was estimated at 100+ pairs. At least ten nests were observed on inner branches of Tournefortia in one small section of the islet, and several downy young and feathered juveniles were noted on the ground. In addition, two dense flocks of Brown Noddies on the seaward beach totaling some 150 birds may have been composed largely of fledged juveniles (which are similar in outward appearance to adults). The Brown Noddy nesting population on Odrik/Lomilik appeared to be lower than that on Aomoen, perhaps because of the very restricted area of grass and sparse scrub compared to the latter islet.

White Terns nested on Tournefortia branches, as on other islets. Up to 100 pairs were probably present, and adults would hover low overhead and call, as if being vigilant around eggs or young, wherever Tournefortia growth was prevalent. No systematic counts of White Tern or Brown Noddy eggs and young were made since the islet was visited during mid-day when prolonged disturbance might have affected nesting success.

Sooty Terns are presumed to nest on the Bwikor/Odrik/Lomilik/Aomoen chain of islets, although no evidence was obtained during the present visit. Visitors working on Bikini Atoll in November 1985 described the presence of large numbers of terns from these islets which fit the description of Sooty Terns (BARC consultants, pers. comm.) . During our field study at least fifty adults were observed flying over Odrik/Lomilik, along with at least five juveniles. As juveniles are rarely seen around land other than natal

islets, it is assumed that these young birds represented the end of a winter through early spring nesting season; nesting cycles of this species in the tropical Pacific Ocean are complex (see, for example, Ashmole 1965).

Other bird species noted at Odrik/Lomilik Islet were: Red-tailed Tropicbird. One adult flying low over the islet; possibly nests under Scaevola scrub.

Brown Booby. At least five adults flying low over the islet and just offshore; no signs of nesting.

Great Frigatebird. One adult female overhead.

Eastern Reef Heron. Two birds along the seaward beach.

Lesser Golden-Plover. Six birds on the beaches.

Ruddy Turnstone. At least ten birds, on beaches and on the shore of the milkfish pond.

Crested Tern. At least eight over the islet and adjacent waters. No signs of nesting.

Black Noddy. Small flocks well offshore, but not seen in the immediate vicinity of the islets.

E. NAM

Nam is one of the larger islets on Bikini Atoll, located in the northwestern portion. Its western end was truncated by the Bravo test blast. Habitats include (1) beaches, primarily finely crushed coral on the lagoon side and a combination of this and raised coral and shelf-like beach rock on the seaward reef side; (2) dense Scaevola scrub with intermixed Tournefortia, Guettarda and other shrubs, covering most of the islet; and (3) limited Pisonia growth, such as at the western tip of the islet. There is very little area covered by grass and sparse scrub.

Brown Boobies were found nesting at the eastern tip of Nam Islet. At least twenty adults were flying around the eastern tip, or sitting at the edge of scrub. Five downy chicks were found at the edge of the Scaevola/Tournefortia scrub, and it is likely that more chicks were present a few meters back into the scrub. Ten to twenty nesting pairs were likely present.

Brown Noddies were nesting abundantly throughout the scrub areas of the islet. The number of nesting pairs was estimated to be at least 500, and young of all ages were observed. Nesting was observed in both Scaevola and Tournefortia, with no ground nesting noted.

Black Noddies were found nesting in a colony of about twenty-five pairs in Pisonia trees and taller

Tournefortia near the western tip of the islet. Up to fifty additional individuals were seen around the perimeter of the islet, and it is likely that many more pairs were nesting in taller vegetation in the interior of the islet.

White Terns were abundant throughout the islet, and both eggs and young were noted. Up to 350 nesting pairs were estimated to be present, based on the hovering behavior of adults around the Tournefortia shrubs.

Black-naped Terns were concentrated along the lagoon shore and, especially, the eastern tip of the islet. Several juveniles, capable of flight, were noted. Based on aggressive behavior by adults, it was estimated that at least ten pairs were nesting on Nam Islet. A concentration of twenty-five adult birds near the eastern tip of the islet suggests that the nesting population might well exceed this number, although these birds were perhaps packed too densely to represent breeding birds (which appear to be well-spaced in a linear edge habitat rather than clumped together).

Other bird species noted at Nam Islet were:

Buller's Shearwater. Six birds flying over the Bravo crater just west of the tip of the islet.

Red-tailed Tropicbird. One or two adults were flying low over the seaward shore of the islet; nesting under the Scaevola scrub here is likely.

Great Frigatebird. Some twenty-five birds were resting on vegetation near the eastern tip of the islet, including three or four adult males, at least fifteen adult females, and at least six juveniles. No nests or young were observed, and it is not known whether this species currently nests on the islet.

Eastern Reef Heron. Two birds noted on the seaward reef.

Lesser Golden-Plover. About thirty-five birds noted, primarily on the seaward shore.

Wandering Tattler. Eight birds noted around the shoreline.

Bristle-thighed Curlew. Two birds noted along the shoreline.

Whimbrel. One bird noted on the seaward shore.

Ruddy Turnstone. Thirty birds noted along the shoreline, primarily along the seaward shore; at least one flushed out of a Scaevola thicket.

Crested Tern. Twenty birds around the shoreline, including at least five flying juveniles; no definite signs of nesting here.

Sooty Tern. Five birds flying overhead; no signs of nesting here.

F. OROKEN

Oroken is part of a series of small islets in the southwestern portion of Bikini Atoll. From northwest to southeast, lie the islets of Bokdrolul, Bokaetoktok, Oroken, and Adrikan, each separated by a fairly deep pass through the fringing reef. Two islets located farther southeast, Jalete and Lukoj, are treated separately below. Bokdrolul and Bokaetoktok viewed from the lagoon, but only Oroken was covered on foot; Adrikan was observed only from a distance. These four islets are all similar in general vegetation structure, and the notes given below for Oroken likely apply to each of the islets. These islets, along with Nam, lie the greatest distance from the inhabited islets of Eneu and Bikini (more than fifteen miles), and might therefore be expected to suffer the least frequent disturbance by humans. Significant avian habitats on Oroken are: (1) beaches, primarily sandy; (2) Tournefortia and Scaevola scrub, dominated by the former; and (3) Pisonia grandis forest. As is typical of the last habitat, the forest is dense but lacks undergrowth.

The most prominent features of the birdlife of Oroken Islet are the presence of large numbers of nesting boobies of two species, and the presence of a very large nesting colony of Black Noddies in the Pisonia forest. Smaller numbers of White Terns also nest.

Brown Boobies nested abundantly around the perimeter of the islet; an estimated 200 chicks were seen, along with a few eggs. Extrapolating to include the portions of the islet's perimeter that were not covered, an estimated 300 pairs of Brown Boobies nest on Oroken. Nearly all chicks were found at the edge of the Tournefortia scrub, or in the first ten to twenty meters in toward the center of the islet from the scrub edge. A small number of chicks and sitting adults were noted well into the interior of the islet. The young varied in age from naked, newly hatched birds to fully feathered birds just capable of flight. As for many bird species in the region, this suggests a rather prolonged nesting period. Small numbers of Brown Boobies were also observed from a distance on Bokdrolul and Bokaetoktok Islets, and the species is assumed to be nesting there as well.

Red-footed Booby nests were confined to the taller shrubs and trees, as is typical of this species. Nests were located in Pisonia and, especially, Tournefortia. Nesting pairs were concentrated toward the perimeter of the wooded part of the islet. About forty chicks were seen, along with some 300 flying birds (mostly adults, but some juveniles). A minimum of 100 nesting pairs is

assumed, and the figure is possibly twice that. Even from some distance, some thirty Red-footed Boobies were noted on Bokdrolul Islet, and the species is assumed to be nesting there and perhaps also on Bokaetoktok.

Black Noddies were easily the most abundant birds on Oroken Islet, with nests located in virtually every Pisonia tree checked. Highly colonial, these terns were encountered in densities of ten to twenty nests per Pisonia tree, even in the very center of the islet. Nests were located from four meters to treetop height. Most nests observed had an attending adult, but no large chicks were observed; several small chicks were seen. A conservative estimate of 2000 pairs was made. Only small numbers of Black Noddies were noted from a distance at Bokdrolul and Bokaetoktok Islets, and it is not known whether the species nests in Pisonia forests there.

White Terns had eggs in both Tournefortia and Pisonia, and adults hovering over presumed nests sites were found throughout the islet (though concentrated around Tournefortia growth around the islet's perimeter). A conservative estimate of 200 nesting pairs was made for the islet. Several dozen White Terns were noted over Bokdrolul and Bokaetoktok, and it is almost certain that the species nests on those islets as well.

Other species noted on Oroken Islet were:

Great Frigatebird. Fifty birds, representing a fairly even mix of adult males, adult females and juveniles, were perched along the outer edges of the wooded areas. No signs of nesting observed.

Lesser Golden-Plover. Three observed along the shoreline.

Bristle-thighed Curlew. One observed along the lagoon shore.

Ruddy Turnstone. Ten observed, primarily along the seaward shore; one flushed from the ground under the Pisonia forest.

Crested Tern. Two noted just off the northwest tip.

Sooty Tern. Eight noted in flight overhead; no signs of nesting.

The only bird species noted in this area of the atoll but not on Oroken Islet was a single Red-tailed Tropicbird over Bokaetoktok; this species may nest under scrub at the perimeter of these islets.

G. JALETE

This small islet is covered with scrub, dominated by Scaevola and Tournefortia; it lacks Pisonia forest. A

few coconut palms are found in the center of the islet, and the islet has a good population of coconut crabs.

Brown Boobies were nesting along the southern and eastern shores of the islet, at and just inward from the edge of the scrub. At least thirty downy young and two weakly flying juveniles were noted, and a minimum estimate of fifty nesting pairs was made.

Brown Noddies were found nesting commonly throughout the islet, and young of all ages were observed. An estimated minimum of 200 nesting pairs were present. Nests were observed on the ground and, especially, in Scaevola and Tournefortia shrubs.

At least six pairs of Black-naped Terns were assumed to be nesting along the periphery of the scrub. Two downy young (siblings?) were found under a Tournefortia shrub just inward from the high tide line. The minimum population estimate was based on defensive behavior and calling by adults. An additional three flying juveniles were observed.

Other birds observed were:

Lesser Golden-Plover. Five along the shoreline.
 Bristle-thighed Curlew. Four along the shoreline.
 Ruddy Turnstone. Six along the shoreline.
 Sooty Tern. One adult flying overhead.
 Crested Tern. Four observed along the shoreline.
 Black Noddy. At least fifty birds were perched in Tournefortia shrubs near the periphery of the islet, but no signs of nesting were observed.

No Red-tailed Tropicbirds were observed around Jalete Islet, although the species is said to nest under shrubs around the periphery of the islet. Somewhat surprisingly, no White Terns were noted at Jalete Islet.

H. LUKOJ

This small islet is located just southeast of Jalete Islet, and generally resembles that islet except for a fairly well-developed forest of Pisonia in the interior and, especially, at the western end of the islet. Otherwise the islet consists of well-developed Tournefortia and Scaevola scrub, with an admixture of Guettarda, Pemphis and other shrubs.

Red-footed Boobies were numerous around Lukoj Islet, especially in roosts at the eastern end of the islet, where an estimated 30 adults and 20 flying juveniles were seen. One downy chick was seen in a nest in Pisonia at the western tip of the islet, and it is likely that many

more nests were present. Nevertheless, the breeding population for this islet must be conservatively estimated at less than twenty pairs.

Black Noddies were nesting commonly in the Pisonia forest, with over three hundred nests counted near the western tip of the island, all high in Pisonia branches. Based on this density of nests, the extent of the Pisonia forest on Lukoj, and the number of adults noted flying around the islet, an estimate of 500 nesting pairs of Black Noddies was made. Several flying adults had small Pisonia twigs adhering to the plumage, caused by the dense hooks on the small Pisonia burrs. At least one adult was found unable to fly because of dense Pisonia burrs stuck to the wings and other parts of the plumage (LACM specimen # 103109).

The presence of several sitting Great Frigatebirds near the eastern tip of the islet suggests the possibility of nesting. Three adult males, ten adult females and twenty white-headed immatures were counted, but no signs of active nesting were observed.

Black-naped Terns were certainly nesting around the perimeter of the islet, based on aggressive diving behavior of adults and the presence on the beach of at least three flying juveniles. Fifteen adult birds were counted, and it is likely that the nesting population for Lukoj was at least six pairs.

No definite evidence of nesting was obtained for the Brown Noddy, although adults were commonly seen over the scrub around the perimeter of the islet, and nesting seems likely in the Pemphis, Tournefortia, or Scaevola growth. About fifty adults were noted.

White Terns were found over the entire islet, with a minimum of 100 adults estimated. Hovering and calling behavior around the edge of the scrub suggested that the species was nesting, but no eggs or young were found. It would appear likely that at least fifty pairs were nesting on Lukoj.

Other bird species noted were:

Lesser Golden-Plover. Eight along beaches.

Wandering Tattler. Two on beach rock of ocean shore.

Bristle-thighed Curlew. Three along beaches.

Ruddy Turnstone. Six along beaches.

Crested Tern. Five adults just offshore; no signs of nesting here.

Sooty Terns. Five adults overhead.

I. ENIDRIK

Enidrik was visited only briefly in the late morning of 23 May, so few conclusions could be drawn about the breeding avifauna of the islet. Only the western portion of the islet was visited, although the entire lagoon side was viewed from the small boat. Most of Enidrik consists of typical Tournefortia and Scaevola scrub, with a considerable admixture of tall Pemphis, Guettarda, and Cordia; Suriana grows commonly along the perimeter berms. High waves generated by Typhoon Lola the week prior to the visit had flattened some of the scrub on the western end of the islet.

Bird species observed at Enidrik Islet were:
 Brown Booby. Two adults just offshore; no signs of nesting of this species or Red-footed Booby.
 Eastern Reef Heron. Two birds seen along the shoreline.
 Lesser Golden-Plover. Twelve observed along the shorelines.
 Wandering Tattler. One observed along the ocean shoreline.
 Bristle-thighed Curlew. One observed along the ocean shoreline.
 Ruddy Turnstone. Four observed along the shoreline.
 Black-naped Tern. Six adults observed, including a noisy and aggressive pair that undoubtedly had a nearby nest. Extrapolating to the entire perimeter of Enidrik, it is likely that at least ten pairs of Black-naped Terns nest on the islet.
 Crested Tern. Eight adults observed; no signs of nesting.
 Brown Noddy. At least ten adults observed, and at least three old nests seen in scrub.
 Black Noddy. Twenty birds seen well offshore; no evidence of nesting on Enidrik Islet.
 White Tern. At least thirty adults flying over Tournefortia and Pemphis scrub; undoubtedly nesting based on calling and hovering behavior. Assuming rather even densities around the islet's scrub perimeter, it is likely that at least fifty pairs of White Terns nest.

J. AEROKOJ/AEROKOJLOL

These two islets are broadly connected by a vegetated sandspit and thus simply appear as one islet. In turn they are connected on the west to three smaller islets (Bikdrin, Lele, Eneman) by a very shallow reef (and remnants of an old causeway, now appearing as a series of rusted metal pilings). An old air strip on

Aerokoj/ Aerokojlol is overgrown, but recognizable by the scattered distribution of the tall Tournefortia scrub and the even gravelly substrate. A few coconut palms grow toward the eastern end of the islet. Otherwise the islet is dominated by typical Scaevola and Tournefortia scrub, perhaps attaining a somewhat taller stature here than on many other islets. Scattered other shrubs occur, but no Pisonia is present.

Over one hundred adult Brown Noddies were observed, and at least five nests were found in Tournefortia shrubs. It is likely that the nesting population was between fifty and one hundred pairs.

White Terns were numerous, with over two hundred birds seen. No eggs or young were noted, but hovering and calling behavior of adults suggested that the species was nesting, with a population probably in excess of one hundred pairs.

Black-naped Terns were suspected to be nesting along the shoreline on the ocean side, with six adults observed and one especially aggressive pair strongly indicating active nesting.

Other bird species observed at Aerokoj/Aerokojlol were:

Brown Booby. Twenty-five adults perched along the eastern shore, but no signs of nesting observed.

Eastern Reef Heron. Three observed along the shoreline.

Lesser Golden-Plover. Thirty observed along the shoreline and shallow reefs.

Wandering Tattler. Two observed on the shallow reefs.

Bristle-thighed Curlew. One observed along the shoreline.

Ruddy Turnstone. Twenty-five observed along the shoreline and shallow reefs.

Crested Tern. Ten seen around the shorelines and just offshore; no signs of nesting noted.

Black Noddy. About fifty birds around the islets; while a few were perched in trees, there were no signs of nesting.

SPECIES ACCOUNTS: AN ANNOTATED LIST OF THE BIRDS OF BIKINI ATOLL

The following accounts treat each of the species recorded from Bikini Atoll, including three species not recorded during present field work. Information summarized in these accounts includes: (a) general world distribution and status, including conservation status

(data from Harrison 1983 and Hayman et al 1986); (b) status and distribution on Bikini Atoll; (c) estimated population size on Bikini Atoll; (d) nest-site requirements (where applicable); (e) foraging habits and requirements (where known); (f) notes on additional aspects of behavior and ecology.

Figures 2 through 8 show the distribution of nesting colonies of the six species confirmed as breeders on Bikini Atoll, as well as roost sites (possibly also used for nesting) of the Great Frigatebird.

1. Puffinus pacificus WEDGE-TAILED SHEARWATER

This tropical and sub-tropical shearwater of the Pacific and Indian Oceans nests over a broad longitudinal range which includes some of the Marshall Islands. It is closely related to the Buller's Shearwater, the latter breeding only in the cooler southwest Pacific Ocean. Most recent authors (e.g. Mayr and Cottrell 1979) consider pacificus to be monotypic.

Amerson (1969) considered this species to be a possible breeder on Bikini Atoll, but firm nesting evidence was lacking. No nesting evidence was obtained during present field work; the species is probably best considered a regular visitor to offshore waters and, occasionally, the lagoon, throughout the year. Two birds were flying north through the wide pass between Eneu and Aerokoj Islets on 23 May. One bird was seen about 6 nautical miles south of Eneu Islet on 28 May, and eleven additional birds were seen on 29 May off the west side of Kwajalein Atoll. Wedge-tailed Shearwaters nest in burrows within vegetated portions of atoll islets; no certain nest burrows were noted during present field work. They feed well at sea, often joining mixed foraging flocks of terns and boobies (as observed on 29 May from the Egabrag II).

All Wedge-tailed Shearwaters noted during present field work were of the dark color morph; both dark and light color morphs are known from Micronesian populations; light morphs are said to predominate at breeding colonies (Amerson 1969).

2. Puffinus bulleri BULLER'S SHEARWATER

Buller's Shearwaters nest on islets off North Island, New Zealand, then migrate northward across the western and central Pacific Ocean as far as Alaska; the species is strictly a migrant through Micronesia. The species was not recorded at Bikini Atoll prior to this study.

Six Buller's Shearwaters were observed flying across Bikini Lagoon at Bravo Crater just west of Nam Islet on 27 May. A single bird was seen the same day in the pass east of Aerokoj. Four birds were seen from six to fifteen nautical miles south of Eneu Islet on 28 May, and six additional birds were seen north and just west of Kwajalein Atoll on 29 May.

3. Puffinus griseus SOOTY SHEARWATER
4. Puffinus tenuirostris SHORT-TAILED SHEARWATER

These two monotypic species are considered together, as their seasonal roles in the Marshall Islands are roughly similar. Both breed on islands in the Australasian region, migrating broadly across the Pacific ocean as far as the Aleutian Islands (with Short-taileds even reaching the Bering Strait); both species are strictly migrants through Micronesia. Previous publications list neither of these species for Bikini Atoll, although migrants are frequently recorded in Marshall Islands waters.

Two Sooty Shearwaters were seen in Bikini Lagoon, northwest of Eneu Islet, on 16 May. Two Short-tailed Shearwaters were just off the ocean side of Aerokoj/Aerokojlol on 23 May. Several additional dark shearwaters seen in the lagoon or just offshore were not identified to species. An additional Short-tailed Shearwater was seen from the Egabrag II approximately 25 nautical miles SSE of Eneu Islet on 28 May. Large numbers of both of these species are to be occasionally expected in waters around Bikini Atoll, especially during their northward migration (roughly March through May).

5. Phaethon rubricauda RED-TAILED TROPICBIRD

The subspecies melanorhynchus nests widely over the tropical central, south, and west Pacific Ocean, primarily on low atolls. The smaller White-tailed Tropicbird, Phaethon lepturus, also occurs through these regions, nesting mainly on higher islands; it has not been recorded from Bikini Atoll.

Although Amerson (1969) did not specifically record Red-tailed Tropicbirds from Bikini Atoll, their presence at Bikini as recorded during the present study is hardly surprising. Single birds were noted at Bikini Islet, Odrik/Lomilik Islet, Nam Islet, and Bokaetoktok Islet. This species is said to nest on the northern islets and on Jalete Islet, but no evidence was obtained during the present study. Red-tailed Tropicbirds nest on the ground, usually under Scaevola or other growth (Clark et

al 1983). It is likely that their nesting season at Bikini does not include late spring; if the species was in fact nesting during late spring, population size was certainly quite low.

6. Fregata minor GREAT FRIGATEBIRD

This species breeds widely through the world's tropical oceans, and is the most abundant and widespread frigatebird in the tropical Pacific Ocean. The subspecies palmerstoni is the form found in the Marshall Islands (and widely through the Pacific).

Amerson (1969) considered this species a possible breeder at Bikini Atoll. No confirmation of breeding was obtained during the present study, but the species is not uncommon around the atoll and utilizes several islets for roosting. Small numbers were occasionally noted over Bikini and Eneu Islets, and single adult females were seen over Aomen and Odrik/Lomilik Islets. Roosts or post-breeding aggregations of Great Frigatebirds were found on three islets: Nam (25), Oroken (50), and Lukoj (33) (Fig. 2). About 40% of these birds were white-headed juveniles. If frigatebirds were nesting, juveniles would be expected to be rather evenly spaced, on or near nests. Instead, flocks were rather tightly clumped and no nest structures were noted. Frigatebird nests are usually placed on the tops of low shrubs, and active nests should have been visible. We conclude that Great Frigatebirds probably do not nest on Bikini Atoll, although more study is needed.

7. Sula dactylatra MASKED (BLUE-FACED) BOOBY

Masked Boobies of the subspecies personata nest widely through the central, south and west Pacific Ocean; they have been recorded as nesting at Taongi and Bikar in the northern Marshalls.

A single individual recorded off the atoll by Anderson (1981) is the only record of this species for Bikini. The species was not found during present field work.

8. Sula sula RED-FOOTED BOOBY

Like the other boobies occurring at Bikini Atoll, Red-foots are widespread through the world's tropical oceans. The subspecies rubripes nests abundantly over much of the tropical Pacific and Indian Oceans.

On Bikini Atoll Red-footed Boobies were found nesting only on the southwestern islets (Fig. 3). An estimated twenty pairs were nesting on Lukoj Islet, 100

(to 200) pairs on Oroken Islet, and perhaps thirty pairs on Bokdrolul Islet. Series of specimens collected on Oroken and Bokdrolul Islets in April-July 1946 (Amerson 1969) suggest that these islets were important nesting colonies then as well. Small numbers of Red-footed Boobies were occasionally noted over the lagoon in other sections of the atoll. A minimum nesting population for the atoll of 150 pairs is suggested, although more thorough coverage of the southwestern islets would very likely reveal a total population of at least 300 pairs.

Red-footed Boobies build stick nests in tall shrubs and low trees, and breeding was restricted to islets containing Pisonia forest (although nests were not necessarily placed in Pisonia). Both downy young and flying juveniles were noted during the present study. Red-footed Boobies feed on fish and squid both well at sea and just offshore; they are frequently associated with large foraging flocks of noddies. Prey is obtained by shallow plunge-diving or by aerial pursuit just above the surface of the water (Schreiber and Clapp 1987). Fifteen birds were part of a feeding flock also containing Black and Brown Noddies off the ocean side of Aerokoj on 23 May. Large feeding flocks were also noted between Bikini and Kwajalein Atolls on 29 May.

Red-footed Boobies occur in a variety of color morphs. The predominant morph at Bikini Atoll was white bodied and white tailed, with dark remiges; a large number of these birds had some brown on the upper wing coverts, and many were completely brown mantled. A small percentage of birds were brown bodied and white tailed. No dark tailed adults were noted.

9. Sula leucogaster BROWN BOOBY

Brown Boobies are widespread through the world's tropical and subtropical oceans. The subspecies plotus nests through much of the tropical central, south and west Pacific and the Indian Ocean, and is the nesting subspecies on Bikini Atoll. This species is probably numerically less abundant than the Red-footed and Masked Boobies in the tropical Pacific Ocean.

Amerson (1969) considered this species a possible breeder at Bikini Atoll. During the present field work breeding colonies were found on Nam Islet and some of the southwestern islets (Fig. 4). Ten to twenty pairs were estimated from Nam, at least 300 pairs from Oroken, and fifty pairs from Jalete. It is quite possible that nesting also occurred on Bokdrolul and Bokaetoktok Islets. With more thorough coverage of the southwestern islets, it is likely that May 1986 breeding population of Brown Boobies at Bikini Atoll would have been found to

exceed 400 pairs. All stages from eggs to flying juveniles were observed during the present field work. As in many Bikini Atoll seabird species, this suggests a prolonged, asynchronous breeding season; such asynchrony implies that population counts derived from a single visit are likely to be low. Brown Boobies nest strictly on the ground, under the cover of Tournefortia and other shrubs, and, on Oroken, under Pisonia trees.

Brown Boobies forage over the lagoon and well at sea (Red-footed Boobies, by contrast, forage well at sea but only infrequently over the lagoon).

10. Egretta sacra EASTERN REEF HERON

This medium-sized heron is resident from the coasts of southeast Asia east through much of the tropical southwest Pacific Ocean, including, for example, the Marshall, Gilbert, Phoenix and Line Islands, and French Polynesia (Hancock and Elliott 1978). The nominate subspecies occurs through most of this region, including the Marshall Islands.

Amerson (1969) considered the Eastern Reef Heron a possible breeder on Bikini Atoll. BARC consultants visiting Bikini Atoll have mentioned the tendency of this species to nest in bunkers. Hancock and Elliott (1978) note that this species may nest on the ground, in shrubs or small trees, on ledges, or in crevices. No evidence of nesting was found during present field work, but this relatively sedentary species was encountered frequently and almost certainly nests at Bikini Atoll. From two to six birds were encountered on most islets visited, except the small southwestern islets, where no reef herons were seen. The total population for the atoll is estimated at fifteen to twenty-five pairs. Birds were generally encountered along seaward reefs, but also along lagoon shorelines and, on Bikini and Eneu Islets, in clearings and along roads well into the interior of the islets. While Eastern Reef Herons probably feed primarily on crabs and fish at Bikini Atoll, their frequent presence in the interior of the larger islets suggests that their diet may also include prey such as lizards and grasshoppers; if this is the case, the reef heron is the only resident bird species on Bikini Atoll which derives some of its food from the terrestrial ecosystem.

As Eastern Reef Herons are polymorphic, various observers in Micronesia have commented on the relative frequency of dark, mottled and white plumage morphs. For example, Anderson (1981) found 18 dark, 14 mottled and 13 white morphs on atolls he visited, while Fosberg (1966) considered dark and white morphs about equally frequent and mottled birds relatively infrequent.

During present field work, morphs were encountered as follows: six dark, two mottled, and eleven white.

11. Poliolimnas cinereus WHITE-BROWED RAIL

A single individual of the Micronesian race micronesiae was collected on Bikini Islet on 3 January 1933 (Amerson 1969). This is the only record of a rail from the Marshall Islands.

12. Pluvialis dominica LESSER GOLDEN-PLOVER

Lesser Golden-Plovers occurring in the Marshall Islands belong to the race fulva (often referred to as the Pacific Golden-Plover). Fulva breeds in tundra regions from northern Siberia east to western Alaska and winters widely through the central, south, and southwest Pacific. It is a winter visitor and migrant in the Marshall Islands, although small numbers of non-breeding birds remain through the summer.

Lesser Golden-Plovers were recorded on all islets visited, with a conservative minimum total of 150. Flocks of up to twenty birds were seen, and the species was encountered in roughly equal abundance on large and small islets. It is likely that during migration peaks the Bikini Atoll population is considerably higher than 150 birds. Numbers would be expected to be lowest from late May through late July. Foraging birds were encountered on beaches, reefs (at low tide), and open terrestrial habitats (such as the Eneu airstrip and Bikini roadsides). Occasionally birds were even encountered in small clearings in wooded areas.

13. Heteroscelus incanus WANDERING TATTLER

As with the Lesser Golden-Plover and all other shorebirds recorded on Bikini Atoll, the Wandering Tattler nests in arctic regions and occurs in the Marshall Islands in a strictly non-breeding role. Specifically, Wandering Tattlers breed above tree line in Alaska and extreme eastern Siberia, and winter along the western coasts of the Americas and through all but the westernmost Pacific islands.

Wandering Tattlers were found on nearly all of the islets visited, with a maximum counts of ten on Bikini Islet and eight on Nam Islet. A total of about thirty birds was noted during field work, but this number would be expected to be higher during winter and, especially, peak spring and fall migration periods. Birds were encountered on shorelines and, especially, reefs.

14. Heteroscelus brevipes GRAY-TAILED TATTLER

The Gray-tailed Tattler is closely related and very similar in appearance to the Wandering Tattler. It breeds locally in eastern Siberia and winters in the southwestern Pacific and Australasian regions.

Amerson (1969) considered this species an uncommon migrant through the Marshall Islands, but listed records only for Eniwetok and Kwajalein Atolls. One bird was observed during present field work: at low tide on the reef adjacent to the northern end of Bokantuak Islet on 21 May; this apparently represents the first sighting for Bikini Atoll. This species must be distinguished carefully from the Wandering Tattler; Gray-tailed Tattlers are paler in all plumages, and their most frequent call note (an upslurred "chu-weet?") is very different from the calls of Wanderings. This species may occasionally be more numerous on Bikini Atoll, as suggested by the senior author's sighting of 20 birds at Majuro, Majuro Atoll, on 13 May 1986.

15. Numenius phaeopus WHIMBREL

Whimbrels breed across the Arctic tundra regions and winter widely through the temperate and tropical latitudes of the northern and southern hemispheres. The subspecies occurring on the Marshall Islands is variegatus, which breeds in eastern Siberia and winters in southeast Asia, the Australasian region, and islands of the southwest Pacific.

Amerson (1969) considers the Whimbrel a common migrant and winter visitor to the Marshall Islands, but does not list the species from Bikini Atoll. Anderson (1981) did not list Whimbrel from Bikini. During present field work the Whimbrel was recorded only on Bikini Islet (at least six birds), Bokantuak Islet (one), and Nam Islet (one). All could be clearly assigned to variegatus based on the barred whitish lower back and rump. Only on Bikini Islet did the Whimbrel outnumber the Bristle-thighed Curlew. Whimbrels were primarily seen along sandy shorelines.

16. Numenius tahitiensis BRISTLE-THIGHED CURLEW

This close relative of the Whimbrel breeds very locally in extreme western Alaska and, presumably, in eastern Siberia (few nests have ever been located). It winters on islands in the central and south Pacific; although widespread in winter in this region, it is nowhere abundant.

Amerson (1969) considered this species a common migrant and winter visitor in the Marshall Islands, and listed four March and April specimens taken on Bikini Atoll. During present field work Bristle-thighed Curlews were recorded in small numbers on nearly every islet visited; a conservative total for the atoll was twenty-five birds. Birds were found on reefs, beach rock, and sandy shorelines. Peak numbers occurring during winter and migration would likely considerably exceed the present estimate of twenty-five birds. Crabs and other intertidal invertebrates probably constitute the major portion of the diet of this species.

17. Arenaria interpes RUDDY TURNSTONE

This species breeds widely across the far northern latitudes and winters through most of the world's temperate and tropical coasts. Subspecies are poorly defined, but Micronesian birds are almost certainly of the nominate race.

The Ruddy Turnstone is considered a common migrant and winter visitor in the Marshall Islands by Amerson (1969), who lists five February, March and August specimens from Bikini Atoll. The species was found on all islets visited during present field work, in numbers ranging from four to thirty-one per islet. A conservative total estimate for the atoll is 130 birds, making this species second in numerical abundance to the Lesser Golden-Plover among Bikini Atoll shorebirds. All types of beaches and reefs were utilized, as well as open areas in the interior of the larger islets.

18. Calidris alba SANDERLING

This small sandpiper nests across the high arctic and winters over a very broad latitudinal range along most of the world's coasts.

While Amerson (1969) considers this species a common migrant and (presumably) winter visitor in the Marshall Islands, neither he nor Anderson (1981) list any records for Bikini Atoll. During present field work a single bird was seen on 15 May foraging along the southeast shore of Bikini Islet.

19. Larus atricilla LAUGHING GULL

Gulls are generally absent from oceanic islands of the tropical Pacific Ocean; the few records pertain to long distance wanderers. Prior to the present field work, the only gull recorded from the Marshall Islands was a single Franklin's Gull (Larus pipixcan) photographed at Majuro Atoll (Anderson 1981).

A single adult Laughing Gull in alternate plumage was observed on Bokantuak Islet, just south of Bikini Islet, on 21 May. On 22 May the same individual was seen and photographed on the next islet to the south, Iomelan. The Laughing Gull breeds on the Atlantic coast of the United States, along the Gulf of Mexico, and locally through the Caribbean Sea. Non-breeding birds are found more widely along the coasts of North, Middle and northern South America, and the species has been recorded with some regularity on the Hawaiian Islands. The present record is the first for Micronesia (Garrett, in press).

20. Sterna bergii CRESTED TERN

The Crested Tern breeds from the islands of the central, south and western tropical Pacific Ocean to the coasts of Australasia, southeast Asia and south Africa. The subspecies cristata is the form breeding from eastern Australasia east into the Pacific.

Amerson (1969) listed the Crested Tern as a breeding species on Bikini, citing a series of nestlings taken as specimens in August. During the present field work these terns were noted on every islet visited on Bikini Atoll, but positive evidence of nesting was not obtained. The number of flying juvenile birds, combined with the sedentary nature of this species, suggest that the species does currently nest at Bikini. A minimum of 85 birds was found on the various islets visited, of which about 25% were juveniles. It is likely that at least thirty to fifty pairs of Crested Terns nest at Bikini Atoll. The largest number of adult birds was found on Bikini and Nam Islets. Crested Terns nest in open sand or gravel areas on islets, sometimes loosely associated with Sooty Tern colonies. Nestlings are recorded for May on some atolls in the Marshall Islands (Amerson 1969), so breeding schedules for the region are probably complex. Many flying immature birds were judged to be relatively recently fledged, and a few were begging food from nearby adults; this behavior may occur well away from breeding grounds for up to four months, however (Feare 1975). No courtship activity was noted during the present field work, although such activities as preliminary to a summer nesting season might have been expected. Crested Terns are very rarely seen at sea, and the degree to which they disperse between atolls is unknown but likely to be small. Foraging Crested Terns were noted along beaches on both the lagoon and seaward sides of the islets, but particularly favored was the outer edge of the fringing reef at low tide.

21. Sterna sumatrana BLACK-NAPED TERN

The Black-naped Tern is less widespread through the tropical Pacific Ocean than the other seabird species which nest at Bikini Atoll. It breeds on islands in the Indian Ocean, the coasts of southeast Asia and northern Australia, east into the Pacific to the Phoenix Islands. The nominate race occurs on Bikini Atoll.

Black-naped Terns were listed by Amerson (1969) as possible breeders at Bikini Atoll. We obtained definite nesting evidence during present field work with the discovery of eggs on Bokantuak Islet and downy chicks on Jalete Islet; aggressive behavior and fish-carrying by adults on most of the islets visited suggest that nesting was actually widespread (Fig. 5). We conservatively estimate fifty-five nesting pairs for the atoll, but the number is possibly considerably higher. These terns were found to nest on open gravelly substrate from one to three meters away from the edge of the Scaevola/Tournefortia scrub zone. Such nests were sometimes just above the high tide line, but on Bokantuak Islet, at least two pairs were nesting well into the interior of the tiny islet where broad gravelly pans extended inland. Nesting pairs were generally separated by at least twenty meters. Downy young were found under the shade of the outermost shrubs. Most foraging appeared to take place over the lagoon; Black-naped Terns often mixed with small flocks of noddies, but frequently foraged alone as well.

Measurements of two eggs from separate nests on Bokantuak Islet were: 38.1 X 27.7 mm (15.0g) and 38.7 X 27.9 mm (13.5g).

22. Sterna fuscata SOOTY TERN

The Sooty Tern is one of the most abundant and widespread nesting birds of the world's tropical oceans. The subspecies oahuensis nests through most of the tropical Pacific Ocean and is the form occurring at Bikini Atoll. The overall population of this subspecies is perhaps in the tens of millions (three to four million pairs nested at Christmas Island, Republic of Kiribati, Line Islands, during peak years).

Amerson (1969) considers the Sooty Tern a possible breeder on Bikini Atoll. While the species was not recorded actually breeding during current field work, we believe that colonies did exist in late 1985/early 1986 on some of the northern islets. On the Odrik/Lomilik section of northern islets at least fifty adults were observed, along with at least five flying juveniles. As noted under the account for those islets, juveniles are

rarely seen around land other than at their natal colonies. We thus believe these juveniles represented offspring from a recent nesting effort. Some adults on Odrik/ Lomilik were swooping low over areas of sparse shrubs and extensive grass cover (typical nest sites), but no eggs or young chicks were discovered. Small numbers of adult Sooty Terns were noted in flight over most of the other islets visited, again with no evidence of nesting. If Sooty Terns do nest on the atoll, their population size is probably quite low.

Sooty Terns usually nest in densely packed colonies in open grassy areas with sparse shrubs; such conditions do occur on several of the northern islets, from Bwikor east to Aomen. These terns feed well at sea, and are highly pelagic while not nesting.

23. Anous stolidus BROWN NODDY

The two species of noddies are common and widespread in the world's tropical and subtropical oceans, the Brown Noddy being the slightly more widespread of the two. Brown Noddies of the subspecies pileatus nest through much of the central, south, and western Pacific Ocean, as well as the Indian Ocean; this is the nesting form at Bikini Atoll.

Amerson (1969) listed egg and nestling specimens taken at Jalete Islet in March 1946, thus documenting breeding of this species. During the present field work the species nested commonly on several islets, with the largest colonies noted at Aomoen (500 pairs minimum), Odrik/Lomilik (100 pairs), Nam (500 pairs), Jalete (200 pairs), and Aerokoj/Aerokojlol (50 pairs minimum); see Fig. 6. On most of these islets eggs, downy chicks, and nearly fledged young were all observed. The total nesting population for the atoll is difficult to estimate, since the breeding season appears to be prolonged, but our conservative minimum estimate is 1500 pairs (the true figure likely well exceeds that number). Data from Anderson (1981) and Fosberg (1966) suggest this species breeds virtually throughout the year in the Marshall Islands.

Brown Noddies nest in moderately dense colonies; nests are located on the ground (among grasses in areas of sparse shrubs or at the edge of dense shrubbery) or in Scaevola, Tournefortia, or Pemphis shrubs (where the nests of dead leaves and sticks are often conspicuous). Even within a small area in a single colony this mixture of nest sites was evident.

In Table 3 we present mass and dimensions of five Brown Noddy eggs from Bokantuak and Aomoen Islets.

Larval chigger mites found on several nestling Brown Noddies were identified as Eutrombicula wichmanni, a widespread species in the Pacific region. These mite larvae infestations appeared as red patches, two to five mm in diameter, scattered through the apteria.

TABLE 3. Dimensions and mass of eggs of Brown Noddies from Bokantuak and Aomoen Islets.

<u>Length</u> (mm)	<u>Width</u> (mm)	<u>Mass</u> (gm)
52.6	35.3	36.0
52.8	36.2	38.0
49.6	36.4	37.2
55.6	33.9	36.0
51.8	36.0	37.2

Both noddy species forage by picking prey (usually small fish or squid) from the water surface; foraging flocks are often dense, containing up to several hundred individuals. The two noddy species will mix within foraging flocks, or form pure flocks. Both species were noted foraging over the lagoon and over the open ocean, with the Brown Noddy numerically less abundant in both areas.

24. Anous minutus BLACK NODDY

Like its congener, the Black Noddy is widespread and geographically variable. The subspecies nesting at Bikini Atoll appears to be marcusi, which nests in the tropical western Pacific north of the Australasian region.

Amerson (1969) cited a nestling of this species taken at Oroken Islet in July, and Fosberg (1986) refers to nesting colonies in the Pisonia forests of certain southwestern islets of the atoll. During present field work nesting colonies were found on Nam (twenty-five pairs minimum), Oroken (2000 pairs), and Lukoj (500 pairs) (Fig. 7). Nesting was also suspected on several other southwestern islets which were not visited (e.g. Bokdrolul and Bokaetoktok), although the species was not nesting on Jalete Islet (which lacks Pisonia forest). Because of the difficulty of estimating the number of nesting pairs in a forested habitat and the likelihood that the breeding season is prolonged in this species, the estimates above may be very conservative. Anderson (1981) suggested an October through April nesting season for this species at Ujelang Atoll, but implied that some nesting took place throughout the year.

Certainly at least 3000 pairs of Black Noddies must nest at Bikini Atoll, making it numerically the most abundant bird species on the atoll.

Black Noddy nests were found exclusively in Pisonia trees, although other tall woody species may also be utilized. Colonies were rather dense, with ten to twenty nests noted in some trees. Nests were located inside the canopy, usually more than 5m above the ground. As Fosberg (1986) has noted, this species, perhaps along with other tern species and Sula, is an important agent in the formation of atoll phosphate rock. Stages of this process are evident on the southwestern islets of Bokaetoktok, Oroken and Lukoj. Because of the affinity of nesting Black Noddies for Pisonia trees, many individual birds are noted with small burrs of Pisonia adhering to their plumage. Occasionally entire fruit bearing twigs stick to the birds' feathers; when such burr clusters entwine the flight feathers, birds are sometimes rendered flightless. We do not know if this is a significant mortality factor in Black Noddies.

25. Gygis alba WHITE TERN

The White, or "Fairy", Tern is a widespread nester around the world's tropical oceans. The taxonomy of the Pacific Ocean forms of this species is complex and is best reviewed by Baker (1951). The form breeding in the Marshall Islands is candida, which also breeds north to the Bonin and Marianas Islands and east to the Line, Phoenix and Hawaiian Islands.

White Terns are among the most conspicuous birds of the Marshall Islands. Amerson (1969) lists the species as a resident breeder on Bikini Atoll, citing a nestling specimen taken in March. During the present field work White Terns were found on every islet visited except Jalete (Fig. 8). Significant populations occurred on most of these islets except Eneu (where only five birds were seen and no evidence of nesting was found) and Bikini (where the species was seen regularly in small numbers but nesting was probably limited to one or two pairs at the southeastern tip of the islet). The largest colonies were on the Bokantuak/Iomelan Islet chain (200 pairs minimum), Aomoen (250 pairs), Nam (350 pairs), and Oroken (200 pairs). We conservatively estimate a total of 1300 pairs. It appears (e.g. Baker 1951) that nesting of White Terns occurs through much of the year, so the total annual nesting population at Bikini probably far exceeds this number.

White Terns lay their single eggs on the larger branches of woody shrubs and trees, especially favoring Tournefortia on most islets. They utilized Pisonia as

well as Tournefortia on Oroken. As no nest is constructed, counts of nesting pairs must often be based on the behavior of adult birds. On most islets nesting was concentrated in shrubs toward the islet perimeter, although some pairs nested nearer to the islet centers. Nesting colonies of White Terns and Brown Noddies were often in the same areas, although breeding White Terns were generally more sparsely distributed.

In Table 4 we present mass and dimension data for seven White Tern eggs. Larval chigger mites collected from downy White Terns were identified as Eutrombicula wichmanni.

TABLE 4. Dimensions and mass of seven eggs of White Terns from Bokantuak, Aomoen, and Odrik/Lomilik Islets.

<u>Length</u> (mm)	<u>Width</u> (mm)	<u>Mass</u> (gm)
41.2	28.6	17.5
41.9	30.0	21.5
41.7	30.8	21.2
40.6	30.0	20.0
39.9	30.5	21.0
41.0	29.7	20.5
38.0	30.0	18.5

White Terns forage over lagoon and ocean waters, frequently associating with large groups of noddies. Their diet consists of small fish and squid.

26. Eudynamis taitensis LONG-TAILED CUCKOO.

This species breeds in New Zealand and adjacent islands and spends the austral winter (roughly March through October) in the islands of the tropical Pacific (principally in Polynesia, but also in parts of Micronesia and Melanesia).

Amerson (1969) cites two specimens from Bikini Atoll: one from Oroken 1 May 1946 and one from Nam 6 August 1947. No cuckoos were observed during the present field work. This is the only bird species recorded from Bikini Atoll which is limited to terrestrial habitats.

AT-SEA TRANSECTS

In addition to the surveys of Bikini Atoll islets described above, Garrett conducted a series of transects

on 28-29 May from aboard the Egabrag II. As the foraging range at sea of nesting species on Bikini Atoll is not documented, it is by no means asserted that all birds recorded during these transects were from Bikini populations. In fact, the ship's course brought it close to Wotho Atoll and close to the lee of Kwajalein Atoll for a considerable distance. Transect results are presented here to extend the limited knowledge of at-sea distribution and abundance of Marshall Islands birds. Transects were conducted on a straight-line course between Eneu Islet, Bikini Atoll, and the major pass on the southwest side of Kwajalein Atoll.

A total of thirteen transects were conducted, eleven of them on 29 May (Table 5). In addition, observations were made between transects; the total time of active observation was 10.5 hr. The lack of proportionality between transect densities and total counts is due to the random sampling nature of the transects (e.g. several large flocks of noddies and boobies were seen but did not fall within the transect time periods and/or the transect distance limits).

Table 5. Results of at-sea transects

SPECIES	DENSITY*	TOTAL**
Wedge-tailed Shearwater	0.07	13
Buller's Shearwater	0.07	10
Sooty Shearwater	0.13	2
Short-tailed Shearwater	0.20	3
dark shearwater, species?	-	3
Red-tailed Tropicbird	-	1
Brown Booby	0.39	41
Red-footed Booby	1.50	152
Pomarine Jaeger	-	1
Brown Noddy	18.00	723
Black Noddy	36.30	1847
noddy, species?	-	310
TOTAL	<u>56.66</u>	<u>3106</u>

*DENSITY = number of individuals per 100 hectares; limited to those birds recorded during official transect periods (15 min./hr)

**TOTAL = total number of individuals observed during cruise (total observation time = 10.5 hr.)

DISCUSSION

Our data indicate that avifaunal diversity and abundance at Bikini Atoll is typical of low coral atolls in the region, with significant nesting populations of several species of seabirds. We recorded twenty-three species at Bikini, compared to seventeen species compiled from a variety of sources by Amerson (1969). The increase can be explained simply by more thorough coverage during the present field work; the species we added were, for the most part, migratory shearwaters and shorebirds present in low densities. Historical details of Bikini Atoll bird populations are lacking. We infer that current populations equal or exceed those known during field work in 1946 and 1947 (Amerson 1969). Data prior to the 1946 removal of the Marshallese people from Bikini are insufficient to draw a comparison of "inhabited" and "uninhabited" periods.

Data do not appear to be available to allow an analysis of the effects of atomic testing on Bikini Atoll seabird populations. It cannot be documented that any species have disappeared from the atoll due to bomb testing, although pre-testing surveys were few. It is likely that most or all current populations of Bikini Atoll seabirds represent recolonizations occurring after the conclusion of atomic bomb testing, but even this statement requires substantiating data not available to us. Mutations of rats from Enewetak Atoll after nuclear testing have been documented (Temme 1987), but no such studies of seabirds exist.

Analyses of the effects of proposed environmental rehabilitation scenarios and resettlement of Bikini Atoll by the Marshallese must be made within the framework of known factors which threaten seabird populations. A discussion of such factors is presented by the ICBP Seabird Specialist Group (Croxall, Evans and Schreiber, eds., 1984). Recurrent threats to seabird populations include alien species (such as cats and rats), habitat modification and destruction, and disturbance and exploitation by humans. Recommendations contained in the ICBP publication include: (1) surveys for, and censuses of, seabird colonies; (2) elimination of alien species; (3) establishment of, and improvements to, reserves; (4) prevention or reduction of habitat disturbance and destruction; (5) protection from exploitation; (6) education and publicity; (7) legal protection; and (8) research.

The alternative plans for the rehabilitation of Bikini Atoll fall into three major categories (BARC 1984): (1) delay of resettlement for about eighty years to allow the decay of radionuclides to acceptable levels;

(2) treatment of soil to reduce the uptake of cesium-137 by plants; and (3) removal of contaminated soil. These alternatives apply only to Bikini Islet, and Marshallese resettlement will be restricted to Bikini and Eneu Islets. Under alternative (3) contaminated soil would be disposed either in the lagoon (Bravo crater), on an unoccupied islet, on the seaward side of Bikini Islet, or between Bikini and Eneu Islets to help form a causeway. The probable effects of these various alternatives are discussed below. Additionally, we discuss the potential impacts of the return of Marshallese residency on Bikini Atoll.

Delay Of Resettlement

A delay of resettlement has the primary advantage of avoiding any adverse impacts necessitated by the implementation of soil treatment and (especially) soil removal alternatives. Potential harm to bird colonies through disturbance and exploitation by the Marshallese would continue to be a concern with this option, because the islet of Eneu would be inhabited even with a delay of the resettlement of Bikini Islet.

Treatment Of Soil

Various methods have been proposed for reducing harmful effects of cesium-137 without removing existing topsoil on Bikini Islet. These include leaching of the soil with sea water, cropping of vegetation, adding a layer of "clean", fertile soil over the contaminated soil, or the use of potassium fertilizer to block cesium uptake. The application of each of these methods would be necessary only on Bikini Islet. The soil treatment alternatives have the advantage, like the delay of resettlement, of avoiding the potential harmful impacts of soil removal and disposal. While Bikini Islet is the largest in the atoll, it is currently the least important (along with Eneu) for nesting seabirds. This is undoubtedly due to a history of intensive human occupation, continued disturbance through maintenance and rehabilitation work, and the introduction of cats and rats. Therefore, while soil treatment operations may have a temporary impact on the distribution and behavioral patterns of the shorebirds and non-breeding seabirds which visit Bikini islet, the impacts on nesting seabirds are expected to be negligible. Sea turtles nesting on the seaward shore of Bikini Islet should receive little harmful impact from soil treatment operations, as they are physically well removed from agricultural sites.

Soil Removal

The clearing of vegetation and removal of topsoil has been advanced as an effective method of diminishing soil contamination. A further version of this alternative entails the replacement of removed soil with sediment dredged from the lagoon. Soil removal and replacement manipulations would have a major temporary effect on the habitats of the treated islets, although vegetation would ultimately return or agricultural crops would be planted. Such manipulations on Bikini Islet would have little impact on nesting seabirds because of the islet's relatively unimportant status for breeding seabirds.

Potentially harmful effects of soil removal fall into two main categories. First, the removal of soil and vegetation from islets other than Eneu and Bikini would disrupt any seabird nesting that is underway and would temporarily create a habitat without significant tall vegetation growth (and therefore unsuitable for most Bikini Atoll seabird species). Several small islets identified as requiring excavation in order to meet cesium-137 standards for agriculture are very important for nesting seabirds (e.g. Aomoen, Lukoj, and Jalete). Removal of taller Scaevola, Tournefortia, and Pisonia (Lukoj) from these islets would impact the nesting of noddies, White Terns and Red-footed Boobies for a considerable period. Secondly, the various plans for the disposal of removed topsoil have potential negative impacts on wildlife. Disposal of spoil on any of the islets with important breeding colonies will have at least short-term effects on nesting success (through direct disturbance and through habitat alteration). Negative effects on seabirds would be essentially permanent if spoil disposed on islets were to be capped with concrete. Disposal of soil on the seaward side of Bikini Islet to extend the islet would have little effect on Bikini Atoll seabird populations, but could impact sea turtle nesting (although human disturbance factors on this islet would likely reduce or eliminate sea turtle nesting on Bikini whether soil disposal takes place there or not). Creation of a causeway between Eneu and Bikini using spoil would probably eliminate nesting populations of Brown Noddies, White Terns and Black-naped Terns on the small islets between Eneu and Bikini. Again, however, a large human population on Eneu and Bikini would probably impact tern colonies on these islets whether or not a causeway is built, since the reef between these islets can be walked at low tide.

Effects Of Marshallese Resettlement

As noted above, among the most insidious effects of humans on populations of seabirds are the exploitation of colonies for food (or other resources) and the introduction of predators (such as cats and rats). Both of these concerns must be addressed if and when the Marshallese resettle Bikini Atoll.

The direct impacts of Marshallese resettlement of Eneu and Bikini Islets are expected to be minimal, since neither islet contains seabird nesting colonies. Of greater concern is the potential for disturbance to and exploitation of seabird nesting colonies on outlying islets. Disturbance can be direct, through visitation of colonies, or indirect through habitat modification and the introduction of predators. Exploitation can likewise be direct, through harvesting of eggs, nestlings and adults at breeding colonies, or indirect through exploitation of critical marine food resources upon which seabirds depend.

While human/seabird coexistence on atolls is by no means impossible, there appears to be a general negative correlation between seabird populations and human populations on the atolls of the Marshall Islands. In Figure 9 we show the relationship between the number of confirmed breeding native bird species and the 1964 human population estimates for all of the Marshall Islands for which sufficient data exist (taken from Amerson 1969). A negative trend is evident from the graph. While this gives only a first order approximation of the relationship between human and bird populations, it suggests that resettlement of Bikini Atoll will likely result in a downward adjustment in the number of breeding bird species. It is important to point out that local extinctions of both seabirds and landbirds have probably occurred on oceanic islands such as the Marshalls since the earliest settlement by humans (Olson and James 1982). Thus, while no breeding landbirds are known historically from Bikini Atoll, there may well have been populations of species such as the Micronesian Pigeon, Ducula oceanica, in the distant past.

Cultural Or Subsistence Value of Bikini Seabirds

Birds have been of direct importance to the Marshallese as a food source. Seabird colonies are frequently exploited for eggs, nestlings and adults. The Micronesian Pigeon is another bird species which has been used for food by the Marshallese, but it does not occur on Bikini Atoll or neighboring atolls.

Indirectly, seabirds are valuable to Marshallese fishing operations; through much of the tropical Pacific Ocean fishermen have learned to locate concentrations of food fish by looking for foraging flocks of noddies, White Terns, boobies and other seabirds. Serious depletion of Bikini Atoll seabird populations would probably reduce seabird foraging in the waters immediately surrounding the atoll, perhaps affecting the efficiency of fishing operations.

Cultural and aesthetic values derived by the Marshallese from birds are difficult to estimate, but are certain to suffer in proportion to the loss of bird populations.

RECOMMENDATIONS

Recommendations derived from field and literature studies of Bikini Atoll's avifauna are presented below as follows: first, islets and islet groups are prioritized in terms of their importance as seabird nesting habitat; habitats within these islets are also prioritized. Second, the various options for rehabilitation and resettlement are ranked in terms of their potential impacts on birds. Finally, some recommendations for further study are offered.

Habitat Recommendations

Maintenance of the current diversity of Bikini Atoll seabirds will require the preservation of some or all of the islets on the northern and southwestern portions of the atoll. Islets dominated by relatively low growth of Scaevola, Tournefortia and other shrubs harbor large colonies of Brown Noddies and White Terns. The small southwestern islets which have well-developed Pisonia forests constitute the only important breeding sites of Black Noddies and Red-footed Boobies on the atoll. The most important Pisonia islets are Oroken, Lukoj and (presumably) Bokdrolul and Bokaetoktok. Islets dominated by lower shrubs which have large breeding colonies of noddies, White Terns, and Brown Boobies are Nam, Odrik/Lomilik/Aomoen (apparently lacking Brown Boobies) and Jalete (apparently lacking White Terns). Preservation and protection of all of the islets mentioned above should be a major priority if maintenance of Bikini Atoll seabird abundance and diversity is desired.

Islets of lesser preservation priority, but still documented as harboring significant seabird populations, are: the Bokantuak/Iomelan chain between Bikini and Eneu Islets, Aerokoj/ Aerokojlol Islets, and Enidrik Islet.

Fosberg (1986) documents the ecological and historical significance of phosphate rock formation which occurs in connection with dense seabird colonies in Pisonia forests. We concur with Fosberg that preservation of Pisonia forests and protection of their seabird faunas should be a major conservation priority at Bikini Atoll.

Resettlement Recommendations

For the maintenance of maximum seabird diversity and abundance, the ideal alternative for Bikini Atoll would clearly be a permanent ban on Marshallese resettlement. We recognize, however, that this option is not realistic and not desirable to the Bikinians.

Environmental cleanup options which minimize habitat destruction on islets demonstrated as important to breeding seabirds are desirable. For this reason, soil removal and disposal options are recommended against if they involve removal of soil/vegetation or dumping of spoil on islets given high preservation priority in the section above.

Soil treatment options which are limited to Bikini Islet would have no harmful impact on seabird populations.

The construction of a causeway between Eneu and Bikini Islets would slightly diminish atoll populations of Brown Noddies, White Terns and Black-naped Terns, but would not have a major overall impact.

It is recommended that Bikinian access to the important nesting islets on the north and southwest portions of the atoll be restricted. As some nesting appears to take place through the entire year, restrictions should be year-round. Excessive disturbance is known to cause abandonment of nests of many seabird species, to subject eggs and young to physiological stress, and to expose eggs and young to increased predation pressures. Consumptive exploitation of seabird eggs, young, and breeding adults can also have significant negative impacts on seabird populations. An ideal option would be the ban on visits to all islets extending counter-clockwise from Aomen through Lukoj. If such a ban is not practical, then close monitoring of visits and of bird population sizes and breeding success is certainly called for.

It is further recommended that a program to monitor the health and productivity of Bikini Atoll seabird populations be established in conjunction with Marshallese resettlement.

Recommendations For Further Study

Additional basic information on Bikini Atoll seabird populations is desirable. Specifically, population studies should be conducted in fall and early winter in order to gain a more complete understanding of seasonal variation in population sizes and annual nesting cycles. Such information might confirm nesting for several species currently only suspected of breeding at Bikini Atoll (e.g. Sooty Tern, Crested Tern, Red-tailed Tropicbird, Great Frigatebird, and Wedge-tailed Shearwater) and yield a better understanding of total annual population sizes.

Literature and field studies of other atolls in the Marshall Islands would be helpful in determining the factors which prevent or promote coexistence between human populations and seabird populations. Studies should compare atolls with large human populations (e.g. Kwajalein) and those which are uninhabited or nearly so.

Long-term population studies of terns and other seabirds in the Marshall Islands could help determine whether the harvesting of eggs and young for food might be managed in order to provide the Marshallese with a renewal food resource.

SUMMARY

The avifauna of Bikini Atoll consists of at least twenty-six species. During field work in May 1986 twenty-three species were recorded; six of these were documented as nesting, and an additional four species almost certainly nest as well. Major seabird colonies were located on Aomoen (and the other northern islets), Nam, and Oroken/Jalete/Lukoj (and the other southeastern islets). Scaevola and Tournefortia scrub and Pisonia grandis forests are the most frequently used habitats for nesting seabirds. Environmental rehabilitation options which minimize habitat alteration on the above islets are recommended. Close monitoring and protection of seabird populations after Marshallese resettlement will guard against excessive disturbance and exploitation.

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Appendix A. Specimens collected at Bikini Atoll, May 1986.

Format:

Species name/ LACM Catalog Number/ Age/ Sex/ Gonads/ Weight
Date/ locality of collection.
Additional Notes/ [Nature of Specimen]

All specimens are housed at the Natural History Museum of Los Angeles County.

Sula leucogaster plotus #103104 Nestling/ male 7X2
15 May 1986 southwestern islets
Captured alive by Marshallese 4 May 1986 [study skin]

Sula sula rubripes #103129 adult/ male/ 898g
27 May 1986 Oroken Islet
Stomach contained about 40 squid beaks [flat skin and skeleton]

Sula sula rubripes #103130 Juvenile/ male/449g
27 May 1986 Oroken Islet
Found freshly dead [flat skin and skeleton]

Numenius tahitiensis #103118 adult/ female/ 10x6/ 465g
25 May 1986 Bikini Islet
Tail molt; largest ovum = 1mm [flat skin and skeleton]

Sterna bergii cristata #103119 adult/ female/ 275g
25 May 1986 Bikini Islet
Largest ovum = 3mm [study skin and partial skeleton]

Sterna bergii cristata #103120 adult/ male/ 11x6/ 79g
23 May 1986 Jalete Islet
Stomach contents = two fish, each 4cm [study skin]

Anous stolidus pileatus #103105 juvenile/ male/ 5x3/ 202g
20 May 1986 Odrik/Lomilik Islet
Heavy body, tail, wing molt [study skin]

Anous stolidus pileatus #103110 nestling/ sex?/ 175g
23 May 1986 Jalete Islet
All flight feathers in sheath [study skin]

Anous stolidus pileatus #103114 adult/ female/ 10x8/ 175g
24 May 1986 Aomoen Islet
Largest ovum = 4mm; stomach contents = fish remains
[study skin and partial skeleton]

Anous stolidus pileatus #103125 nestling/ sex?/ 37.5g
26 May 1986 Aomoen Islet
Egg tooth prominent [alcoholic]

Anous stolidus pileatus #103126 nestling/ sex?/ 92g
26 May 1986 Aomoen Islet

[study skin]

Anous stolidus pileatus #103127 nestling/ sex?/ 109g
26 May 1986 Aomoen Islet
Stomach contents = 2 squid beaks, fish remains [study skin]

Anous minutus marculsi #103109 adult/ female/ 97g
23 May 1986 Lukoj Islet
Covered with Pisonia burrs; largest ovum = 3mm [flat
skin and skeleton]

Anous minutus marculsi #103113 adult/ sex?
23 May 1986 Jalete Islet
mummified [skeleton]

Anous minutus marculsi #103115 adult/ female/ 8x5/ 88.5g
25 May 1986 Bikini Islet
Largest ovum = 1.5mm; no brood patch [study skin and
partial skeleton]

Anous minutus marculsi #103116 adult/ male/ 2x1/ 108g
25 May 1986 Bikini Islet
Inner primary molt [flat skin and skeleton]

Anous minutus marculsi #103117 adult/ male/ 3x2/ 102g
25 May 1986 Bikini Islet
Inner primary molt [study skin and partial skeleton]

Gygis alba candida #103106 adult/ male/ 8x4/ 114g
21 May 1986 Bokantuak Islet
Brood patch bare [study skin]

Gygis alba candida #103107 adult/ female/ 10x5/ 100g
22 May 1986 Iomelan Islet
Largest ovum = 3mm [study skin and partial skeleton]

Gygis alba candida #103108 adult/ male/ 3.5x1.5/ 103g
22 May 1986 Iomelan Islet
[flat skin and skeleton]

Gygis alba candida #103121 adult/ female/ 10x5/ 87g
26 May 1986 Aomoen Islet
Largest ovum = 2.5mm [study skin and partial skeleton]

Gygis alba candida #130122 adult/ male/ 8x4/ 110g
26 May 1986 Aomoen Islet
[flat skin and skeleton]

Gygis alba candida #103123 nestling/ sex?/ 23g
26 May 1986 Aomoen Islet
parasitic mites collected [alcoholic]

Gygis alba candida #103124 nestling/ female/ 3x2/ 86g
26 May 1986 Aomoen Islet
[study skin]

Gygis alba candida #103128 adult/ sex?/ 108g
 27 May 1986 Nam Islet
 Brood patch unfeathered [alcoholic]

Appendix B. Complete species list for each islet visited, Bikini Atoll, May 1986.

+ = species present

n = breeding probable

N = breeding confirmed (eggs and/or young found)

	Eneu	Bokonjebi	Rojkora	Iomelan	Bokantuak	Bikini	Aomoen	Lomilik	Odrrik	Nam	Bokdrolul	Bokaetoktok	Oroken	Adrikan	Jalete	Lukoj	Enidrik	Eneman	Lele	Bikdrin	Aerokojlol	Aerokoj	
<u>Phaethon rubricauda</u>						+	+			n	+												
<u>Sula sula</u>						+	+				+	+	N			N							
<u>Sula leucogaster</u>	+					+	+	+	+	N	+	+	N		N		+	+	+		+	+	
<u>Fregata minor</u>	+					+	+	+		+	+	+	+			+							
<u>Egretta sacra</u>	+					+	+	+	+	+							+				+	+	
<u>Pluvialis dominica</u>	+					+	+	+	+	+			+		+	+	+				+	+	
<u>Numenius phaeopus</u>						+	+			+													
<u>Numenius tahitiensis</u>	+					+	+	+		+			+		+	+	+					+	
<u>Heteroscelus incanus</u>	+					+	+	+		+						+	+				+	+	
<u>Heteroscelus brevipes</u>						+																	
<u>Arenaria interpres</u>	+					+	+	+	+	+			+		+	+	+				+	+	
<u>Calidris alba</u>						+																	
<u>Larus atricilla</u>						+	+																
<u>Sterna bergii</u>	+					+	+	+	+	+			+		+	+	+	+	+	+	+	+	
<u>Sterna sumatrana</u>	+					n	N	+	N	n					N	N	n						
<u>Sterna fuscata</u>	+					+	+	+	+	+			+		+	+	+	+					
<u>Anous stolidus</u>	+					n	N	+	N	N	n	N			N	n	n	+	+	+	+	N	N
<u>Anous minutus</u>	+					+	+			N	+	+	N		+	N	+	+	+	+	+	+	
<u>Gygis alba</u>	+	+	+	N	N	n	N	N	n	N	+	+	N	+	+	n	+	+	+	+	n	n	

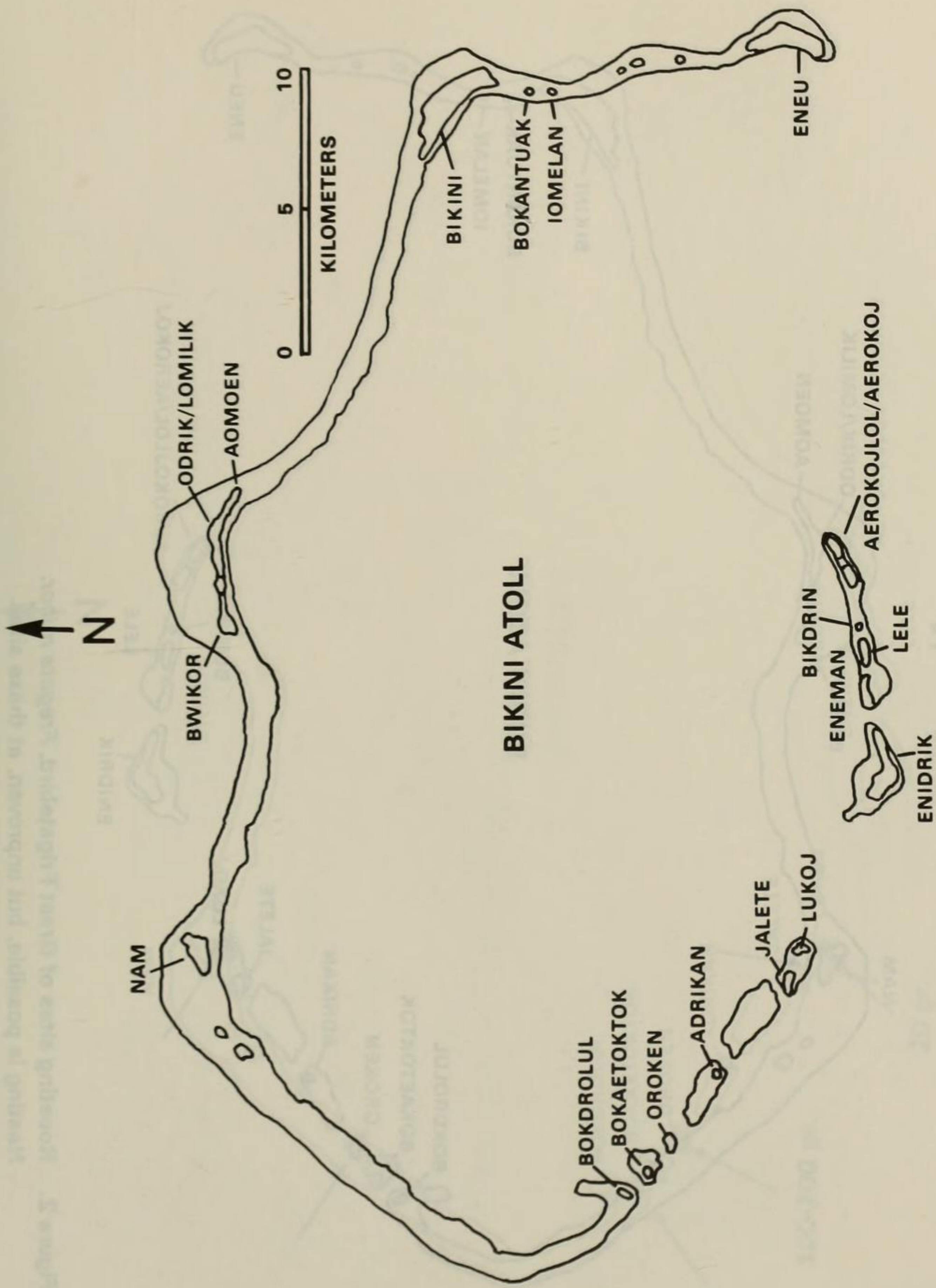


Figure 1. Location of islets of Bikini Atoll, Marshall Islands.

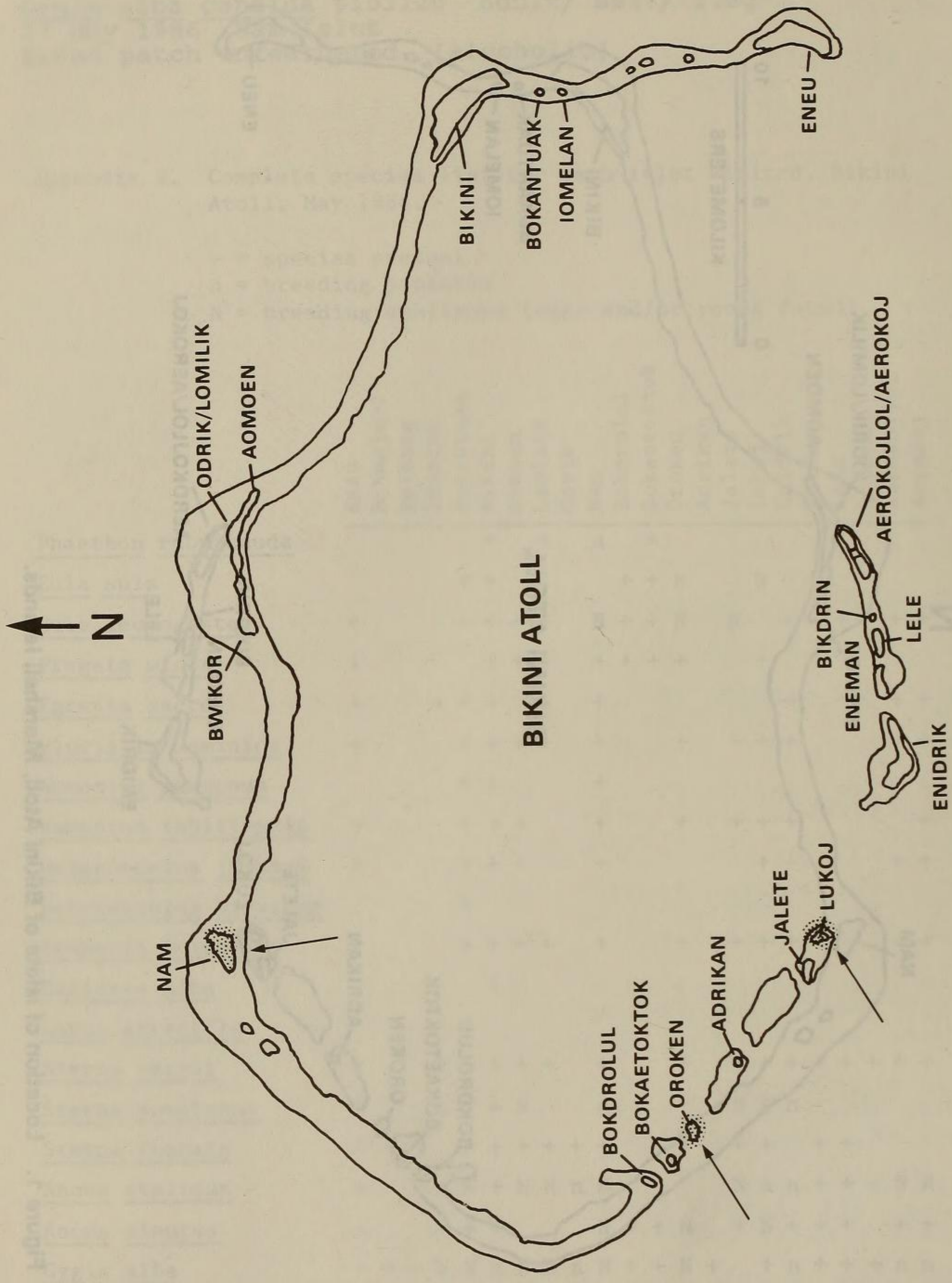


Figure 2. Roosting sites of Great Frigatebird, *Fregata minor*. Nesting is possible, but unproven, at these sites.

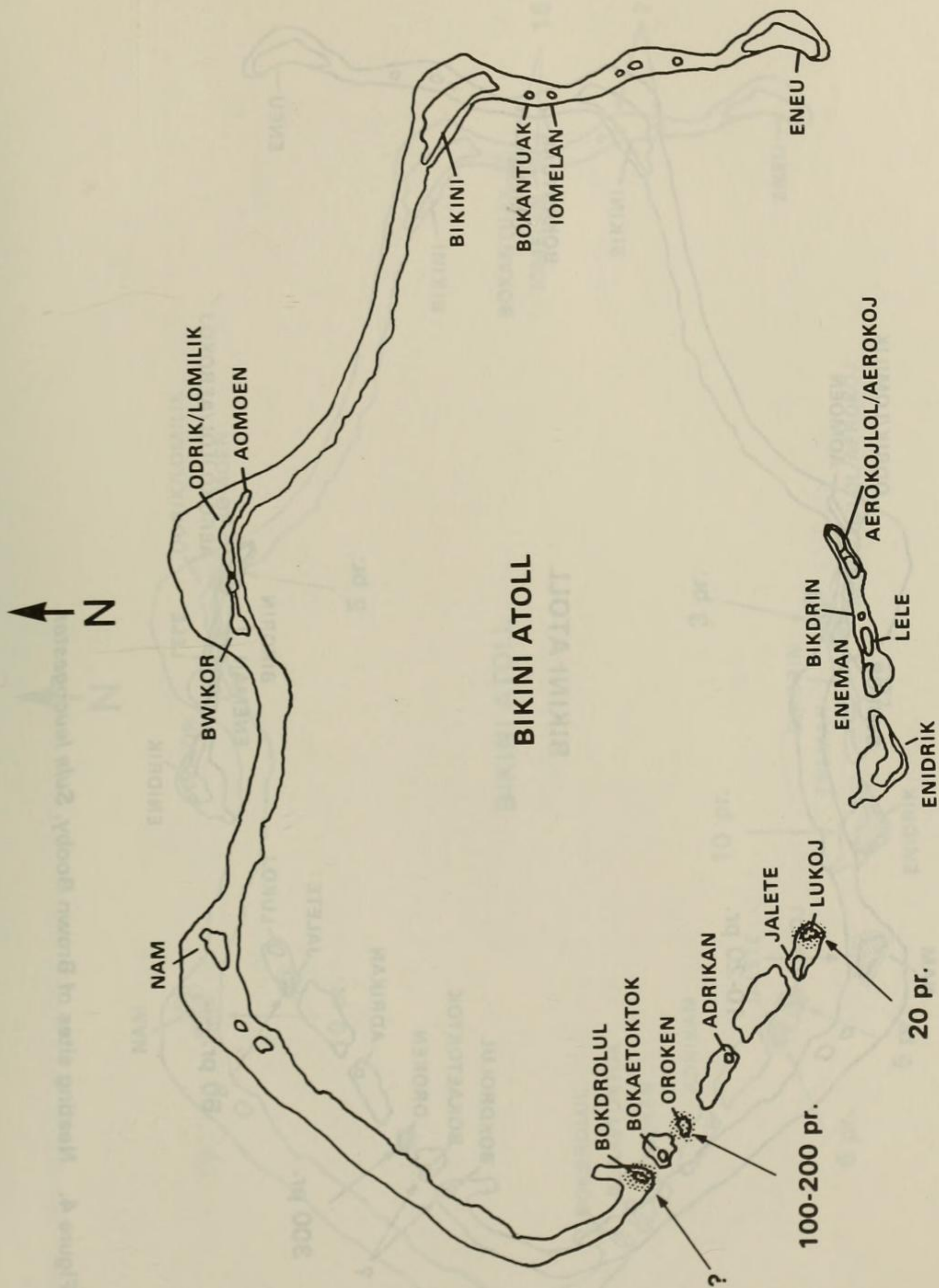


Figure 3. Nesting sites of Red-footed Booby, *Sula sula*.

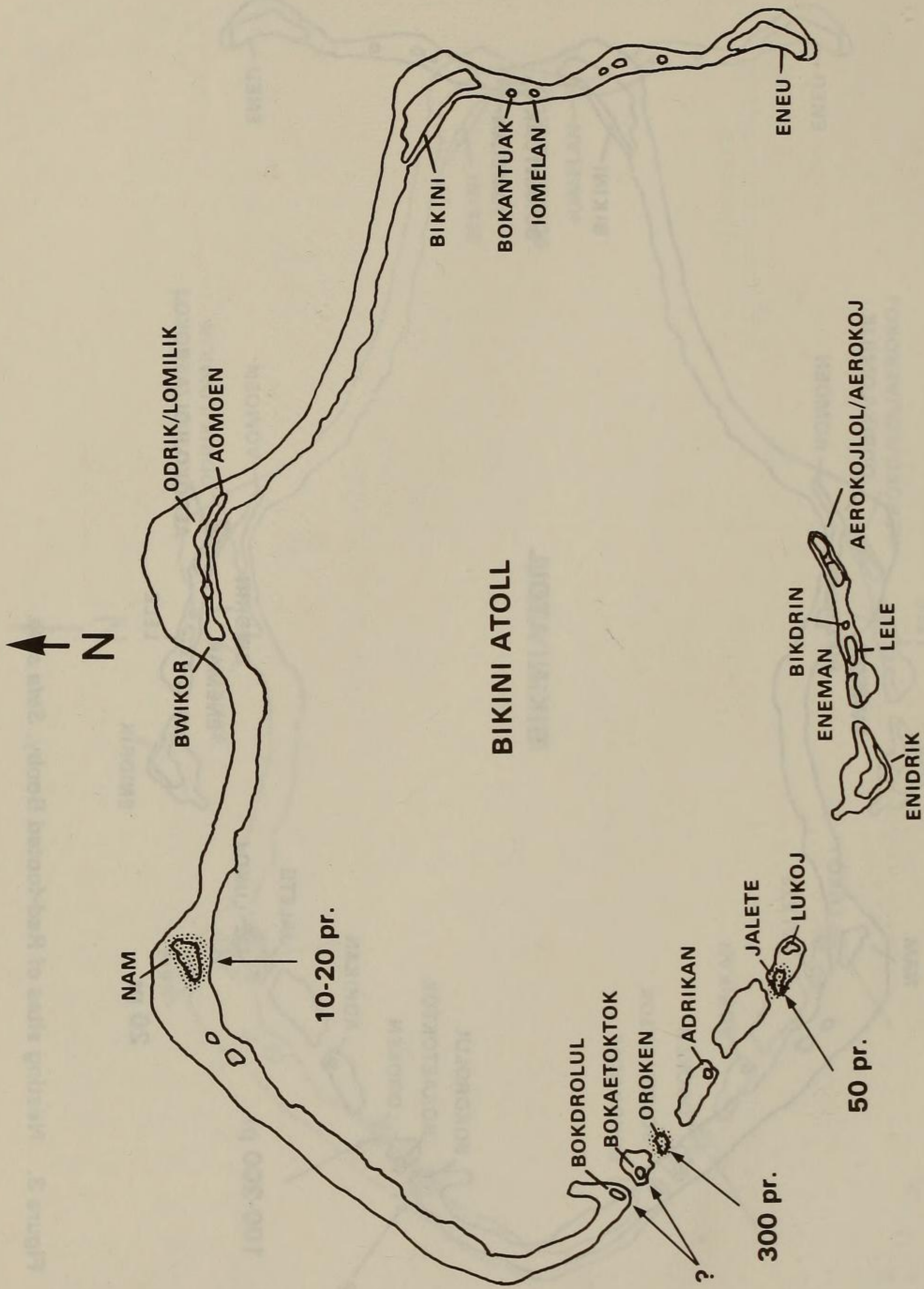


Figure 4. Nesting sites of Brown Booby, *Sula leucogaster*.

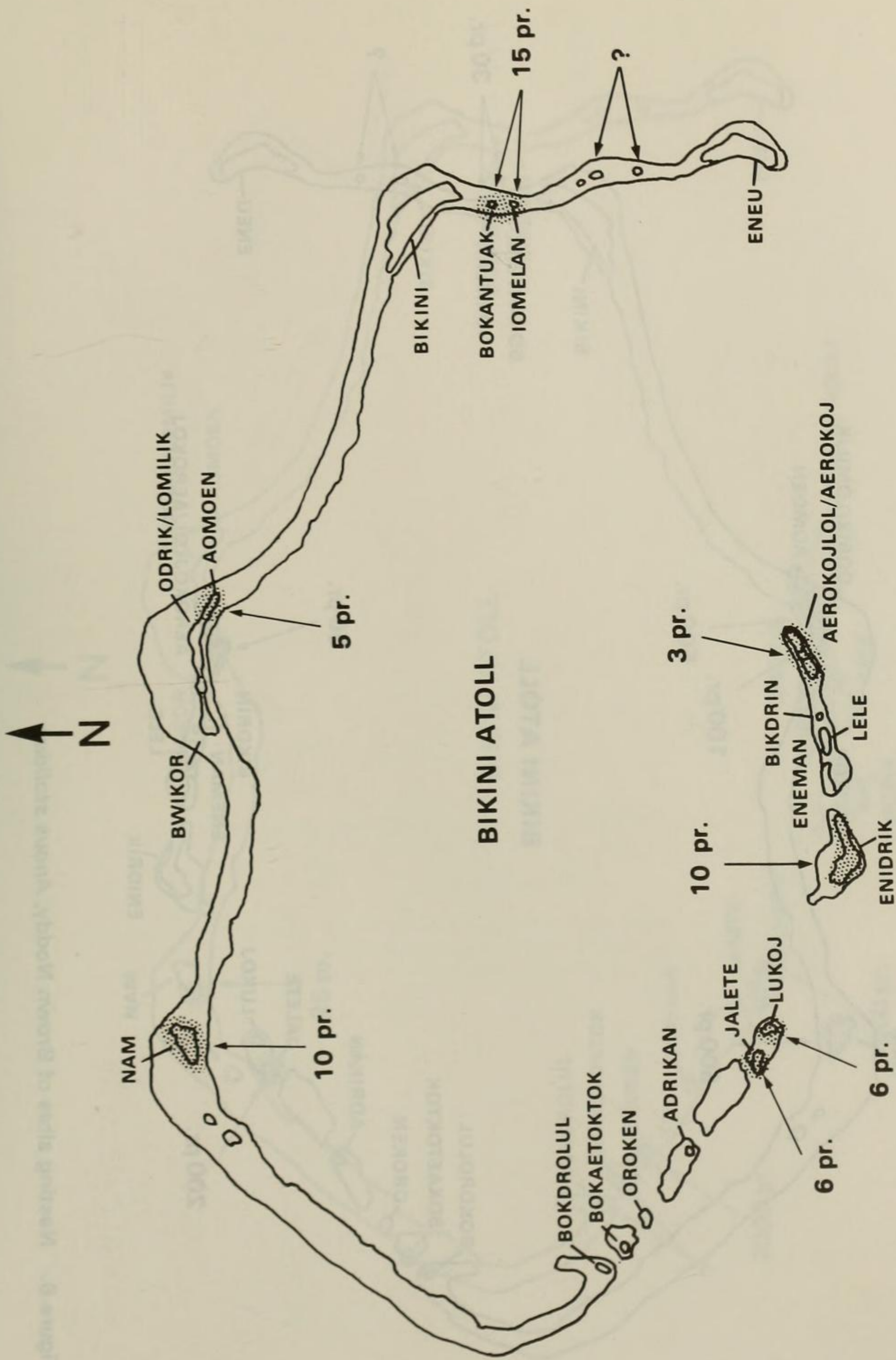


Figure 5. Nesting sites of Black-naped Tern, *Sterna sumatrana*.

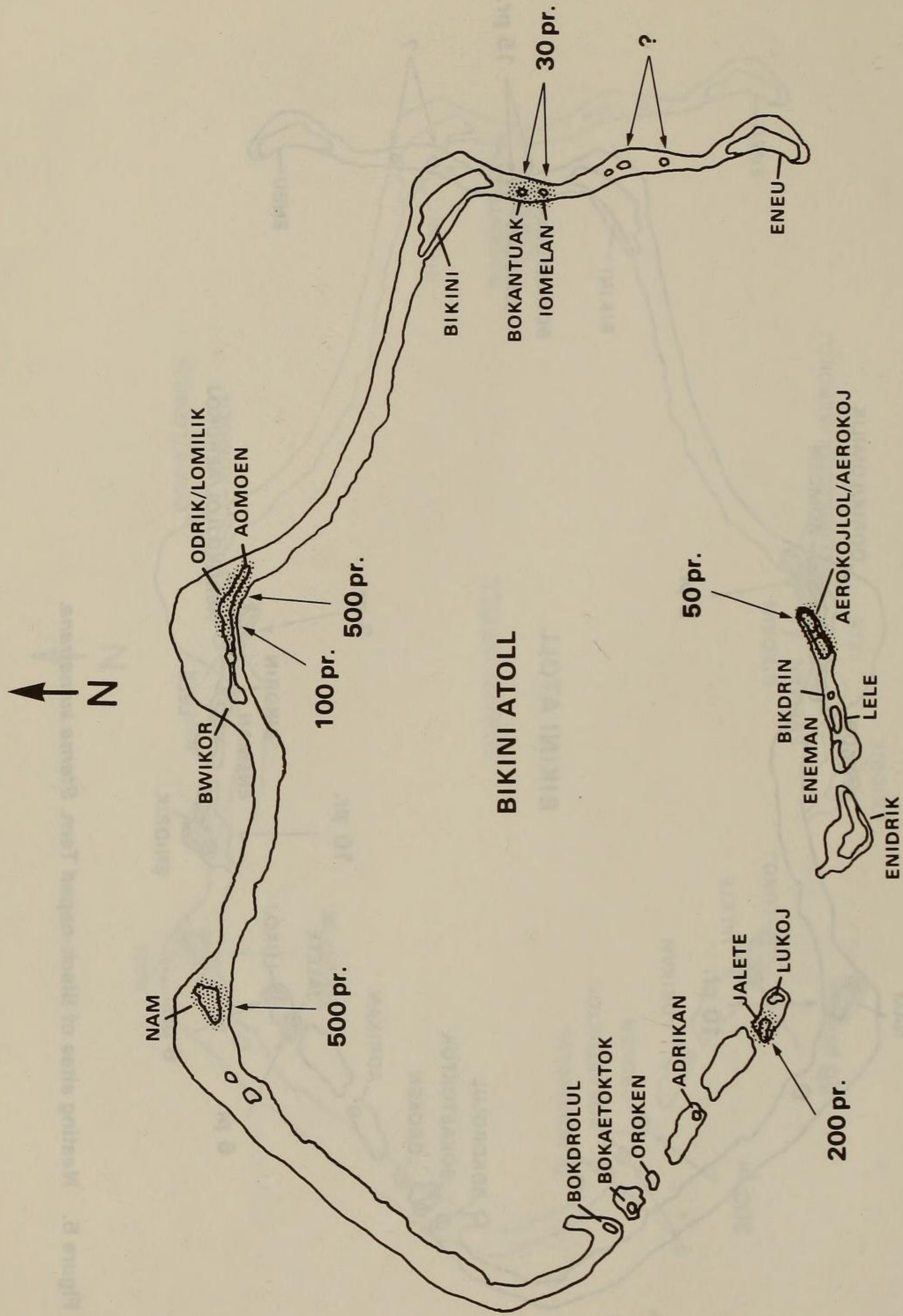


Figure 6. Nesting sites of Brown Noddy, *Anous stolidus*.

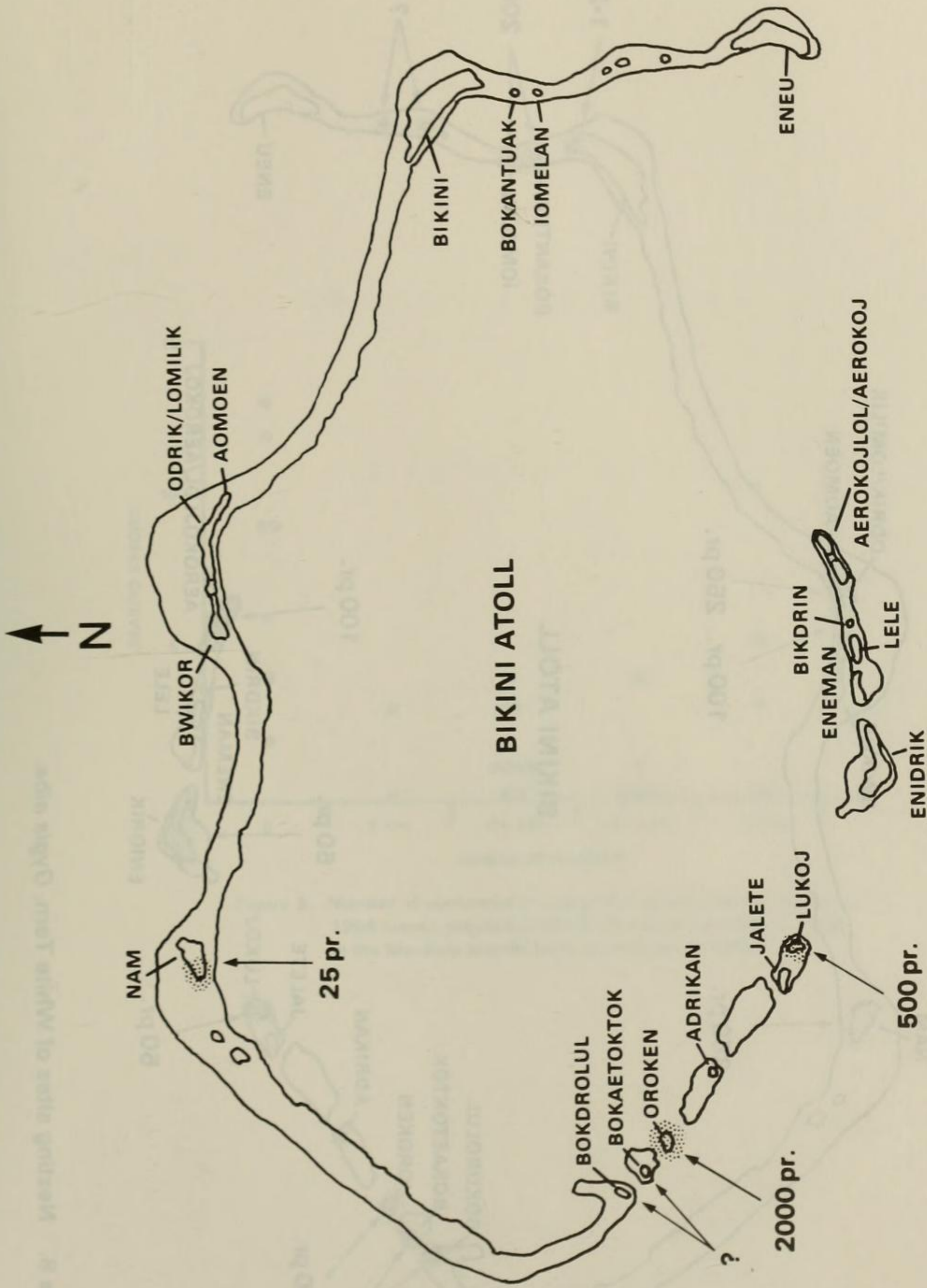


Figure 7. Nesting sites of Black Noddy, *Anous minutus*.

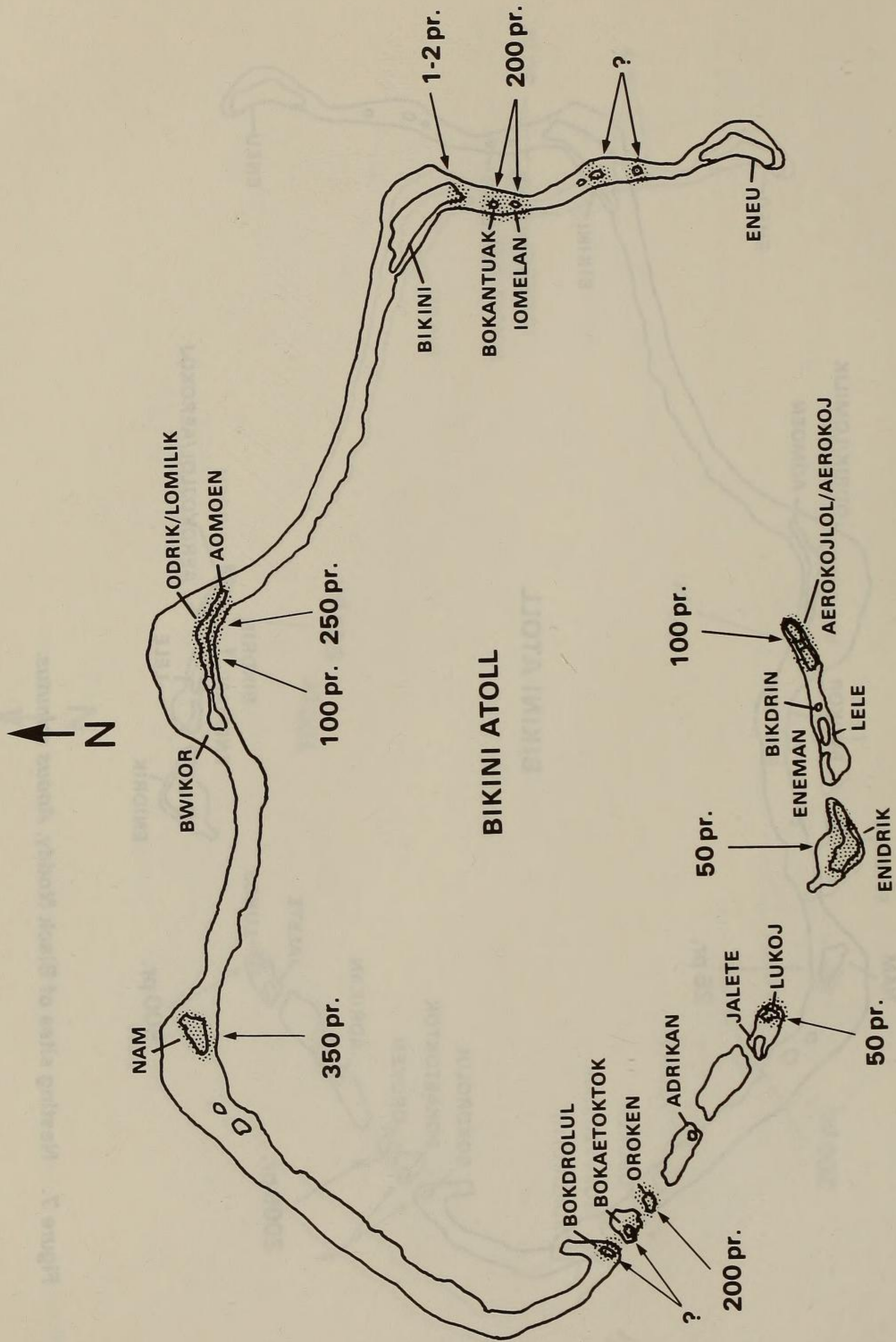


Figure 8. Nesting sites of White Tern, *Gygis alba*.

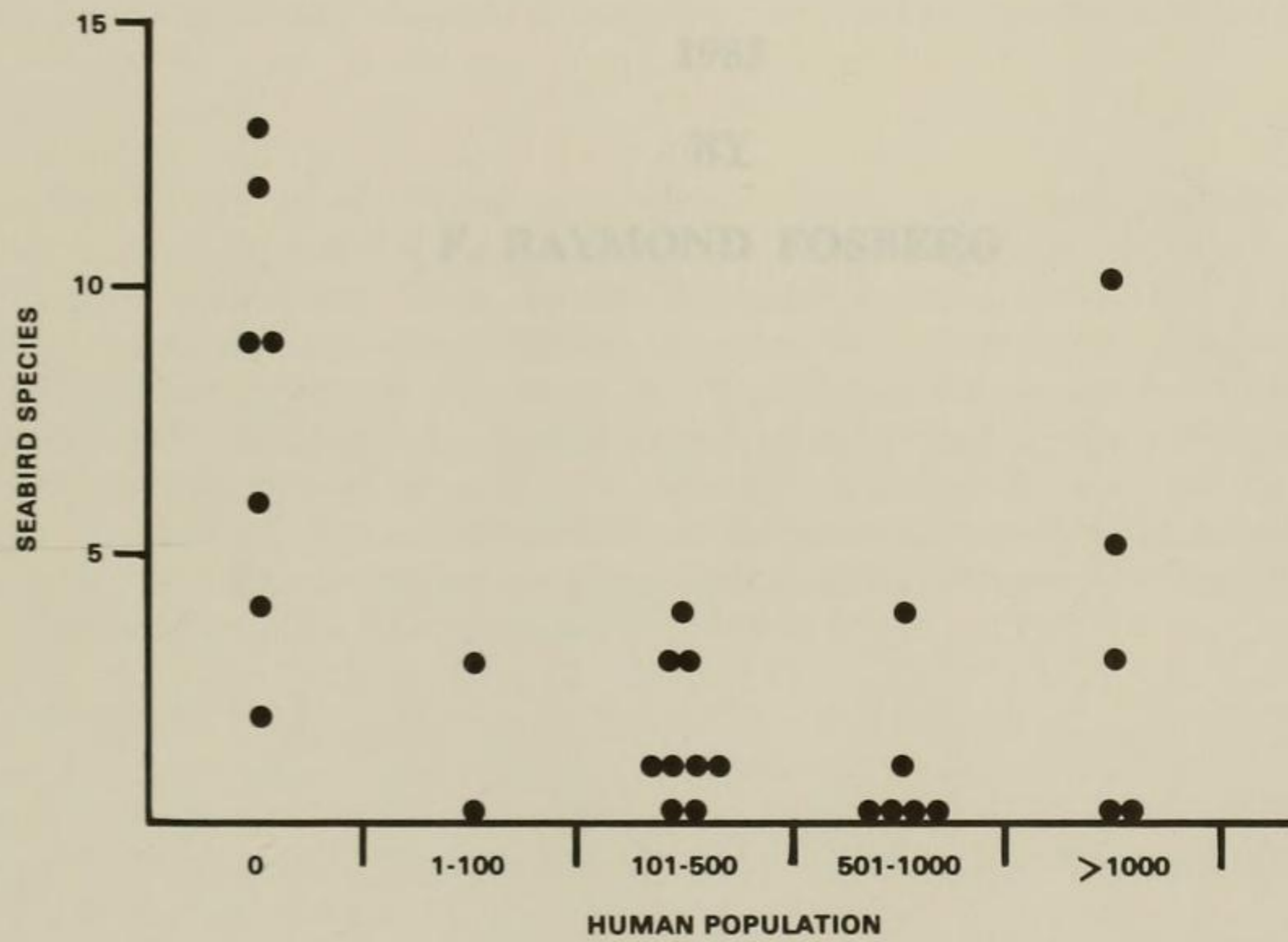


Figure 9. Number of confirmed breeding bird species plotted against 1964 human population size for twenty-nine different atolls in the Marshall Islands (data from Amerson 1969).

