South Pacific Regional Environment Programme

RESOURCE SURVEY OF NGERUKEWID ISLANDS WILDLIFE PRESERVE REPUBLIC OF PALAU

April 1989

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A Report to the Government of Palau, the South Pacific Regional Environment Programme, World Wildlife Fund, and the International Union for the Conservation of Nature

edited by

Charles Birkeland
and
Harley Manner

University of Guam

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EXECUTIVE SUMMARY

The Ngerukewid Islands Wildlife Preserve is one of the more pristine areas in Palau. Except for the strand, the natural vegetation has not been greatly affected. There has been virtually no habitat modification and relatively few species have been introduced to these islands. This may result partly from its relative isolation and from its traditional protection as a preserve. Pigeons and fruit bats are relatively common, which may indicate that hunting pressure has not been as great as in most areas of Palau. Likewise, fishing pressure appears to have been minimal. The relatively pristine condition of the area makes it valuable as a representative of natural conditions for comparison with other areas around Palau which are undergoing rapid development.

There are sizable populations in the Preserve of species that are rare or in the decline or hunted elsewhere in Palau: Micronesian megapode, Micronesian pigeon, Nicobar pigeon, Palau fruit-dove, and Micronesian fruit bat. The megapode is designated as an endangered species by the U.S. Fish and Wildlife Service and the Nicobar pigeon is being considered for such designation. A number of species endemic to Palau are found in the Preserve: Palau fantail, Palau fruit-dove, morningbird, mangrove flycatcher, and dusky white-eye. The Preserve is valuable as a refuge for the future of these vulnerable species.

The Preserve is the only place known to date where every species of giant clam in the world (7 species) can be found living in close proximity. However, the general diversity of the marine biota and terrestrial fauna is not outstanding. About 163 of the approximately 1200 species of fishes known from Palau were found in the Preserve. Likewise 14 of 32 reptiles and 28 of 146 birds were found in the Preserve. This is probably because of the small size of the islands in the Preserve and the absence of a number of habitats, e.g., exposed open-coast reef margins and slopes, extensive intertidal reef flats, mudflats, freshwater wetlands, and others. Mangroves and seagrass communities are very small and isolated. Limestone forests composed mainly of indigenous species dominate terrestrial habitats and lagoonal Acropora thickets dominated the reefs.

Although hunting appears to be less intense in the Preserve than in the rest of Palau, the collection of turtle eggs and coconut crabs is still a problem and should be prohibited. The sulfur-crested cockatoos in the Preserve are an introduced species and can potentially have an impact on the natural vegetation. The destruction of the endemic palm (Gulubia palauensis) is attributed to these birds. They should be removed from the Preserve, and future intrusions by cockatoos and other introduced species such as the eclectic parrot and rats should be dealt with also.

The populations in the Preserve should be monitored for changes over time. Particular attention should be given to the

larger species which are potentially hunted, such as the giant clams and fruit bats, the nests of endangered species such as megapodes and sea turtles, and the endemic palm species. Permanent quadrats and transects were established in representative terrestrial and marine habitats respectively. Attention should also be given to potential invasions by species such as cockatoos and rats.

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ACKNOWLEDGEMENTS

This project was initiated by the Government of the Republic of Belau, organized by the South Pacific Regional Environment Programme, and funded by the International Union for the Conservation of Nature and her Resources. Logistic support was provided by the Micronesian Mariculture Demonstration Center and the Division of Marine Resources. We are most grateful to Toshiro Paulis and Noah Idechong of the Division of Marine Resources and to Gerald Heslinga for making logistic and accommodation arrangements. The expertise and field work of David Ikip (Micronesian Mariculture Demonstration Center), Gerdence Meyar (Department of Agriculture, Republic of Belau), Mary Spencer and Alex Kerr (University of Guam), and Agnes Reinhart (Department of Education, Government of Guam) were of great benefit to the terrestrial studies. The help of Paul D. Gates (Western Pacific Regional Fisheries Management Council) was essential for the success of the marine studies. Demei O. Otobed, Chief Conservationist for the Division of Conservation and Entomology of the Republic of Belau, gave us useful comments on an earlier draft of the manuscript and provided important information from an obscure source in the literature. Ronald I. Crombie, of the National Museum of Natural History, identified species of lizards and gave useful information on the herpetofauna of Belau. John Engbring supplied background information on the birds of the Ngerukewid Islands. Joseph A. Beatty, University of Southern Illinois, identified arachnids.

Chapter 1

INTRODUCTION

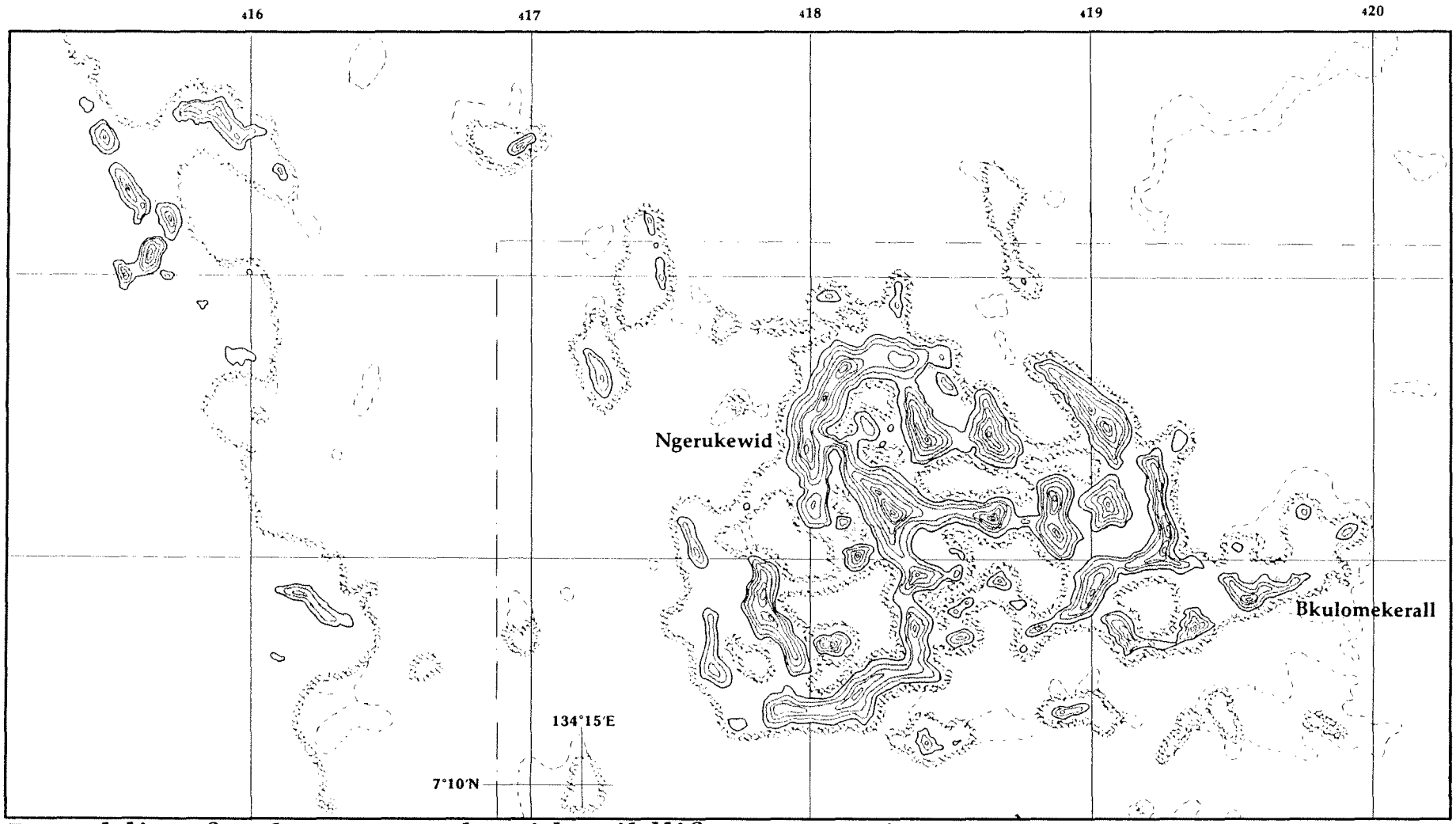
The Republic of Palau (also called Belau) is a fairly isolated oceanic chain of islands, with closest affinities to the continental-shelf land masses of New Guinea and the Philippines, about 820 km south and west, respectively (Fig. 1.1). Palau is made up of a geologically diverse chain of islands, with atolls at the northern end, with volcanic islands in the rest of the northern half of the chain, and with various limestone formations (high limestone islands, platform patch reefs, motus) in the southern half. Although the vast majority of the islands are the small limestone pinnacles in the south, the main volcanic island of Babelthuap makes up over 80% of the total land area. The islands of Palau extend in a north to southwest chain acróss 160 km.

Palau was formed during the period between the Miocene and the Pleistocene (Military Geology of Palau Islands, Caroline Islands, 1956). This makes it of intermediate age, less than half as old as Guam, but considerably older than the Hawaiian or Society Islands. The limestone islands are formed in shallow water from the remains of animals and plants that secrete calcareous skeletons or basal plates. The limestone islands of southern Palau have distinctive undercut notches at sea level, with overhangs commonly of 2 m, and as great as 6 m in some places. These notches and other modifications of the shapes of the limestone pinnacles were brought about by dissolution and bioerosion during periods of emersion from the seawater (Military Geology of Palau Islands Caroline Islands 1956).

The Ngerukewid Islands, or "Seventy Islands" as they are also known locally, are relatively distinct and isolated group of about 37 limestone islands in Palau, totalling approximately 87.3 hectares in land area, or about 0.2% of the land of Palau (Table 1.1). They lie 7.5 km west of Mechercher Island and 5 km northeast of the Ngemelis Islands and are considered a part of the larger "Rock Islands" area (Fig. 1.2). The Ngerukewid Islands are surrounded by a shallow lagoon protected by a barrier reef (over 2 km wide) to the west. The islands are limestone pinnacles up to 30 m tall, with overhangs or notches at sea level. The small size, the isolation, and the difficulty of access have protected this small group of islands from continuous habitation. Although traces of prior visitation exists on some of the islands, these factors have favored the traditional protection of Ngerukewid by taboos against exploitation and have helped to maintain its relatively pristine state. The Ngerukewid Islands Wildlife Preserve was officially established by the Government of Palau in 1956. At present, it is the only area in the Caroline Islands that is officially designated as protected for the conservation of nature.

Table 1.1. Areas of the 49 islands found in or adjacent to the Ngerukewid Islands Wildlife Preserve. Values in parentheses are subtotals for the three sections of Island 24 discussed in Chapter 3. They are not included in the total size figure. Islands initially numbered as individuals, but later found to be joined, are lumped.

Islands inside the Ngerukewid Preserve				Islands outside	
Island No.	Area (ha)	Island No.	Area (ha)	Island No.	Area (ha)
1	0.2	23	0.2	44	0.5
2	<0.2	20+24=(24N)	(20.3)	45	0.2
3	0.4	35+32=(24C)	(18.6)	46	2.7
4	1.2	9=(24S)	(9.6)	47	0.2
5	1.0	24(total)	48.5	48	1.0
6	5.0	25	0.2	49	2.5
7	1.7	26	1.0	50	2.0
8	1.0	27+29	0.4	51	<0.2
10	0.6	28	0.5	52	<0.2
11	0.5	30	0.2	53	0.5
12	3.0	31	0.5	54	2.0
13	2.5	33+34	<0.2	55	<0.2
14	0.4	36	<0.2		
15	0.2	37	<0.2	Total no. of islands	11.9
16	7.9	38	<0.2	12	
17	2.5	39	0.4		
18	0.4	40	<0.2		
19	5.2	41	<0.2		
21	0.4	42	<0.2		
22	0.4	43	<0.2		
		Total no. of islands 37	87.3		



Republic of Palau: Ngerukewid Wildlife Reservation Area: Sheet 1

Universal Transverse Mercator Projection, Zone 53

Datum Mean Sea Level

1:21,575

GN angle 0°6′W

Magnetic Variation 1 ½°E

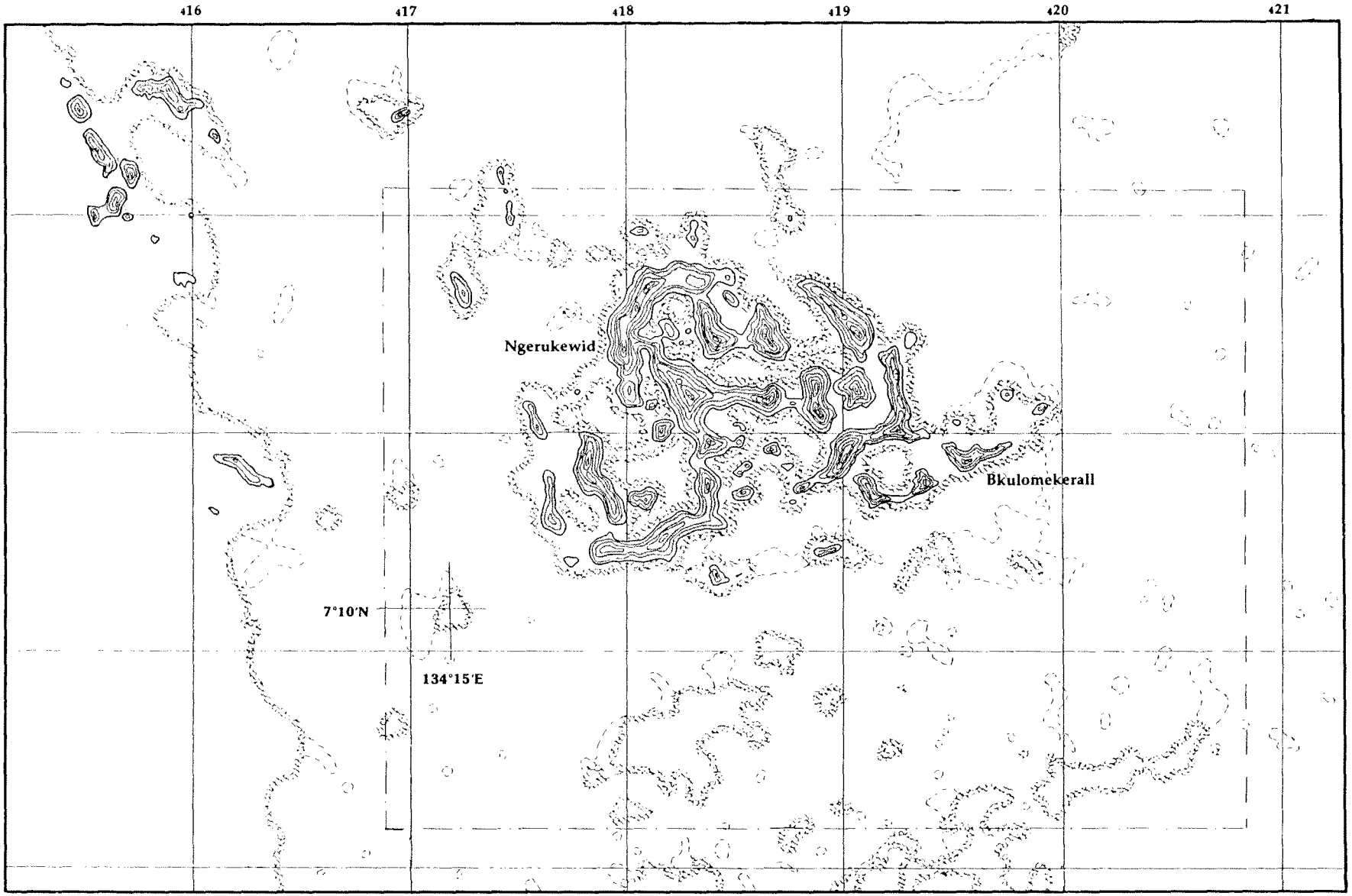
0 100 500 1000 2000
meters

0 ¼ ½ 1 2
miles

Contour Interval 10 meters

Deeper Reef
Shallow Reef
Shoreline
Sand Beach
10m Contour
Approximate Reservation Boundary

Compiled in 1988 from a USGS Topographic Map of 1984 and Aerial Photographs of 1969



Republic of Palau: Ngerukewid Wildlife Reservation Area: Sheet 2

GN angle 0°6′W

Magnetic Variation 1 ½°E

Universal Transverse Mercator Projection, Zone 53

1:26,890

0 100 500 1000 2000 meters

0 ¼ ½ 1 2 miles

Datum Mean Sea Level

Deeper Reef
Shallow Reef
Shoreline
Sand Beach
10m Contour
Approximate Reservation Boundary

Contour Interval 10 meters

Compiled in 1988 from a USGS Topographic Map of 1984 and Aerial Photographs of 1969

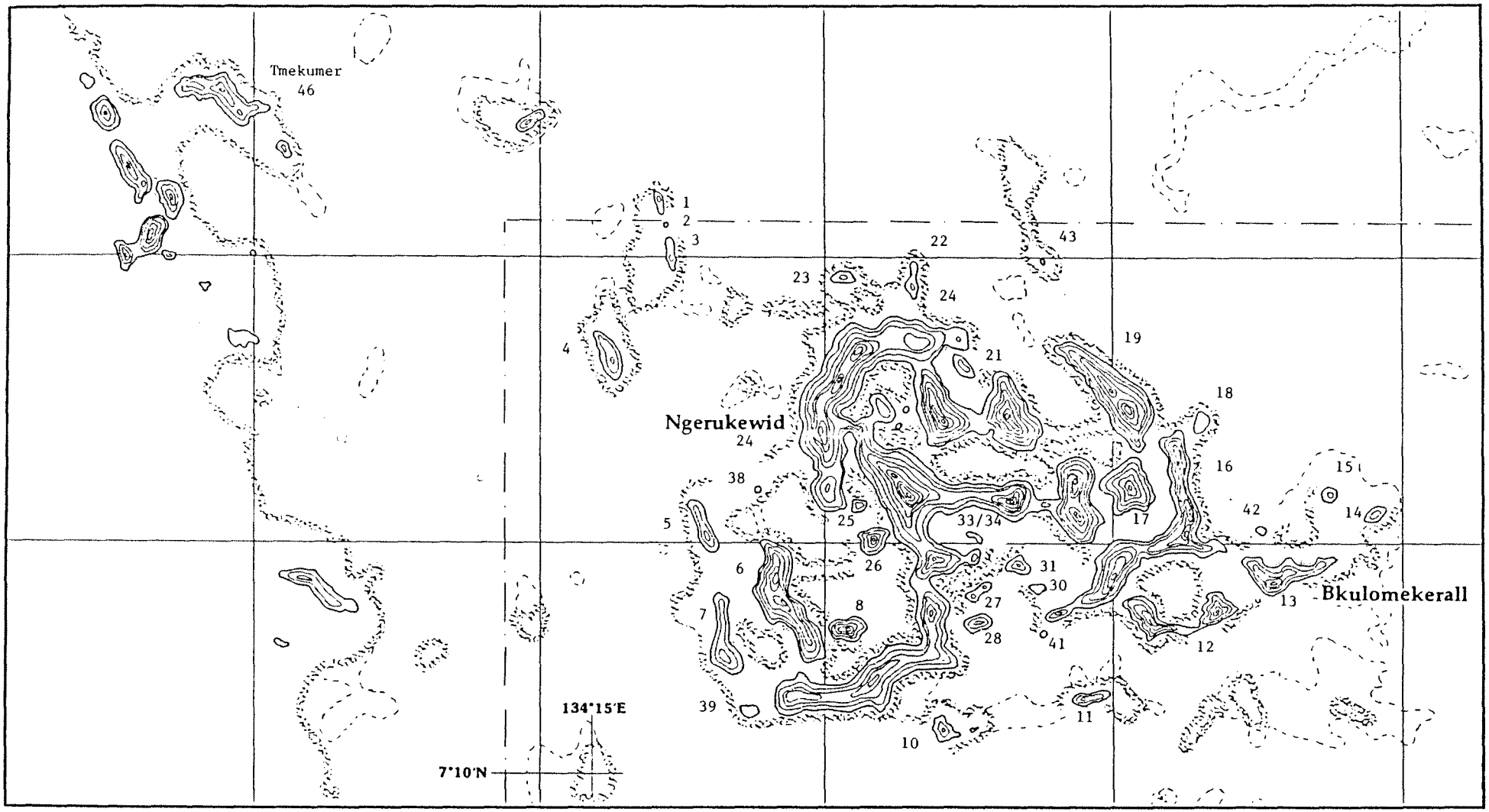


Figure 1.3. Identification of islands listed by number in this study..

Although the Ngerukewid Preserve is an officially-declared protected area, there has been little provision for a truly effective management program. At the Third South Pacific National Parks and Reserves Conference (Western Samoa, July 1985), the Government of Palau requested the International Union for the Conservation of Nature (IUCN) to assist in reviewing the status of the Ngerukewid Preserve and formulating a management plan. Subsequently, IUCN, in collaboration with the South Pacific Regional Environment Programme (SPREP) and the World Wildlife Fund (WWF), developed a two phase project for this purpose.

The first phase involved the gathering of information on the resources of the Preserve as there was little information available. With the close cooperation of the University of Guam (UOG) and the Government of Palau, an expert team brought together by the University undertook the first phase survey from 5-13 January 1988. The field team consisted of scientists from UOG, Guam Division of Aquatic and Wildlife Resources, the Government of Palau and SPREP (Appendix 1). The objectives of the survey were:

1. to conduct an inventory of the flora and fauna of the terrestrial and marine habitats of Ngerukewid Preserve and nearby areas,

2. to identify rare or endangered species,

3. to identify valuable, representative, and critical habitats within the Preserve,

4. to identify threats to the Preserve ecosystem,

5. to establish baseline transects for future monitoring,

6. to assemble the above information in a form that guides follow-up management planning.

This report presents the findings of the survey and in keeping with the above objectives, makes various proposals for the future management of the Preserve. The report is a collection the individual reports prepared by each survey team member or group of members working a specific field of study. It is hoped that the report will prove useful in guiding the future effective management of this important preserve and as a base for the future scientific study of the natural resources of the reserve and the Republic of Palau.

The 1984 United States Geological Survey Topographic Map - Chelbacheb, Republic of Palau (1:25,000 scale) - served as the initial base map of the Ngerukewid area, and each of the Ngerukewid Islands was given a number since only 2 islands of the group were named on the map. The field survey revealed a number of additional islands, and some land areas mapped as individual

islands were joined. Subsequent to the field survey, a new base map of the area was drafted which more accurately depicts the land and reef areas of Ngerukewid Preserve (Fig. 1.3). This map shows the 37 islands of the Ngerukewid group, but retains the full suite of numbers originally used during the field survey (Fig. 1.3). In addition, the group of islands immediately west of the Ngerukewid Islands were surveyed and numbers were also assigned to them for identification.

Chapter 2

FLORA AND VEGETATION OF THE NGERUKEWID ISLANDS WILDLIFE PRESERVE

HARLEY I. MANNER, Associate Professor of Geography, University of Guam, Mangilao, Guam 96923

LYNN RAULERSON, Professor of Biology, University of Guam, Mangilao, Guam 96923

INTRODUCTION

This chapter presents the results of studies conducted on the vegetation and flora of the Ngerukewid Islands, Wildlife Preserve, in accordance with the objectives of the survey described in Chapter 1. The complete identifications of all plant specimens were not available at the time of writing.

The methods used in this survey were described earlier. The results of this survey are described below and keyed to the survey objectives. Since only two of the 41+ islands in the Preserve are named, it was necessary to identify the islands by number (Figure 1.3). Selected characteristics for each of the islands are presented in Table 2.1.

INVENTORY OF FLORA AND IDENTIFICATION OF RARE AND ENDANGERED SPECIES

A search of the relevant literature indicates a lack of detailed information on the flora of the Ngerukewid Preserve. Between the 1930s and early 1940s, the eminent A. Hosokawa conducted extensive botanical expeditions in Micronesia. Although species were collected from many localities in Palau, Hosokawa did not list any specimen numbers for the Ngerukewid Islands. Only two species, Maytenus celebica and Cycas circinalis, are listed as collected from the Preserve (Fosberg, Sachet, and Oliver, 1979; 1982).

In order to inventory the flora of the Ngerukewid Preserve, observations and collections of plant species were made on each island visited. Voucher specimens of most plants observed were collected and sent for identification to (and deposition in) the National Herbarium in Washington, D.C., the Bishop Museum, and the University of Guam. It is possible that a few species were not collected because of site inaccessability. Each species was

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The other members of this team were: G. Meyer, A. Rinehart, and A. Kerr. Other contributions were made by M. Spencer, G. Wiles, and P. Conry (Appendix 1).

observed for abundance, viability, habitat preference, and potential susceptibility to extinction. Plant species, in particular Gulubia palauensis, were observed for damage. Fieldnotes from quadrat studies in representative habitats were also consulted in order to ascertain which species were rare or endangered.

For islands without landing sites, the plants were inventoried by boat reconnaissance. Collections of plant species from exposed cliff habitats near sea level and an assessment of rare and endangered species were also made from the boat.

The results of this inventory are presented in Table 2.2; they must be considered preliminary as identifications were not available at time of report submission. Some species were identified in the field by their Palauan names as listed in Otobed (1971) and Fosberg, et al. (1980).

More than 600 specimens representing at least 49 genera and 113 species were collected from the Ngerukewid Preserve. Except for Eugenia malaccensis and Serianthes kanehirae, which occurred in the strand, Artocarpus sp. and an araceas climber, all of which were most probably introduced by humans, all of the species are either endemic or indigenous to Palau and the Ngerukewid Preserve. Gulubia palauensis is a fairly common endemic species in the Preserve. Indigenous or native species are dominant and include some well-known pan-Pacific representatives such as Barringtonia asiatica, Polypodium scolopendria, Terminalia catappa, and Intsia bijuga. Only Serianthes kanehirae can be considered to be a weed as in all likelihood, it was accidently introduced to the Ngerukewid Islands. The paucity of weeds (adventitious plants) suggests that these islands are difficult (harsh) environments for the wide ranging pan-Pacific and pantropical weeds to become established in. The other alternative, that unauthorized visitors (who would intentionally or inadvertantly introduce weed and other species to the islands) are non-existent, is not substantiated by physical evidence. On Ngerukewid Island for example, there were trees slashed by a machete. The beaches on Bulomekerall and Ngerukewid Islands showed recent litter from picnickers and others.

Only one species, Gulubia palauensis, can be considered to be endangered. Although this species is commonly found throughout the Preserve, it is absent in some plant associations and on some islands. While it is unclear whether or not its absence is related to habitat constraints or the feeding preference of the cockatoo, there was sufficient evidence to suggest that the cockatoo may threaten the existence of this species on the islands. For example, a number of Gulubia palms on island 5 had freshly toppled crowns. Dead palm trunks were also seen on island 7, presumably the result of cockatoo feeding behavior. Furthermore, and by way of inference, islands near Koror to which the cockatoo escaped soon after arrival its in

Palau are almost completely devoid of Gulubia palauensis; the Ngerukewid Islands, which are both distant from Koror and isolated from other islands, now have cockatoos but still retain the palms.

Many other species, while locally rare (See quadrat data in Table 2.3), do not seem to be endangered. This conclusion must be considered tentative given the absence of previous information on their status, the brevity of the fieldwork period, and our relative unfamiliarity with a number of the species. These locally rare species include Garcinia rumiyo, Psychotria hombroniana var. canfieldeae, Alyxia palauensis, Taenophyllum sp., Peperomia sp. and Cyclosorus kingii. While these may be rare because of habitat preference, long-term monitoring and further study of these islands will be required before a definitive statement can be made.

IDENTIFICATION OF VALUABLE, REPRESENTATIVE AND CRITICAL HABITATS WITHIN THE PRESERVE

By habitat, we mean the place where an organism (animal or plant) normally lives, often characterized by a dominant plant, animal, or physical character. Habitats present a combination of environmental factors which determine the exact locality in which an individual plant or animal is to be found. Examples of habitats include a stream, forest, and a beach.

The above objective was primarily accomplished in two ways:

a. By boat reconnaissance around the islands. During the boat reconnaissance described above, major plant associations and terrestrial habitats were recorded for each island, and

b. By ground surveys and reconnaissance for the determination of habitats and plant associations.

As a result of these surveys, 4 habitats (or subtypes) are recognized: exposed strand, protected strand, cliff, and upraised limestone forest.

Exposed strand habitat. These habitats are the relatively permanent and narrow sandy beaches and backbeaches subject to moderate wave and current action. The vegetation of these strands consists of salt tolerant species, the seeds of which are usually dispersed by currents, and commonly-found, pan-Pacific species. The density and diversity of species is low at the water's edge and increases inland towards the backbeach. Strand species include Scaevola sericea, Hernandia sonora, Cocos nucifera, Pongamia pinnata, Tournefortia argentea, Calophyllum inophyllum, Barringtonia asiatica, Guettarda speciosa, Terminalia samoensis and Ficus. Back strand species include Eugenia malaccensis, Pandanus dubius, P. tectorius, and Polyscias grandiflora.

The data from Quadrats 1, 12, 19, and 20 (Table 2.3) are representative of the characteristics of vegetation of the strand. The diameter at breast height (DBH) of strand communities range between 186.6 and 356.9 cm, with a density of 0.04 to 0.20 individuals per square meter. Trees such as Intsia bijuga, Eugenia malaccensis, and Hernandia sonora reach heights of 28m. The ground cover is sparse near the water line but increases in coverage and abundance towards the back strand.

Casuarina equisetifolia, a common species throughout the Pacific is not found in the strand within the Preserve. It was found on the strands outside the Preserve. On island 3 however, Casuarina equisetifolia is common and occurred on upraised limestone in association with Dracaena multiflora, Pandanus tectorius and Eugenia reinwardtiana.

The soils of the strand range from extremely fine to coarse grained coral sands near the water's edge to the excessively drained Ngedebus soils which are located inland of the beach sands. The Ngedebus soils are derived from wave or wind deposited coral sands and are classified as carbonatic, isohyperthermic Typic Tropopsamments (Smith, 1983).

Protected strand habitat. Mangrove communities dominated by Rhizophora mucronata var. stylosa occurred in protected inlets and coves where minimal wave action and current flow allowed for the deposition of organic and mineral detritus. These mangrove communities are not common in the Preserve.

Cliff habitat (Halophytic-xerophytic scrub of Fosberg, 1960). These habitats are the nearly vertical to vertical limestone outcrops and slopes which are often exposed to salt spray. Soils are basically non-existent. The plant species found in this habitat are tolerant of xeric and halophytic conditions, and are represented by low and shrubby forms. Species diversity is relatively high in view of the exposure and the lack of soil development. Species found in this habitat include: Bikkia palauensis, Pemphis acidula, Phyllanthus rupi-insularis, Pouteria obovata, Capparis spp., Flagellaria indica, Gulubia palauensis, Scaevola sericea, and Dracaena multiflora.

Upraised limestone forest habitat. This habitat has less than vertical slopes, with some soil and organic matter accumulation in and around rock outcrops. This habitat is found between 3 and 60 m in elevation. While lower slopes are more exposed to salt spray and contain a greater number of salt tolerant species, moist forests occur at higher elevations. Fosberg (1960) considers these forests to be forests of hard limestone, a modified strand type. Through air photo interpretation, Cole, et al. (n.d.) state that the Rock Island forests are diverse in composition and variable from island to island.

The shallow soils of this habitat are classified as clayey-skeletal, oxidic, isohyperthermic Lithic Eutropepts of the Rock Outcrop - Peleliu series (Smith, 1983).

At low (less than 30 m) elevations, commonly found tree and shrub species include Intsia bijuga, Eugenia reinwardtiana, Cycas circinalis, Pouteria obovata, Dracaena multiflora, Glochidion spp., Aidia cochinchinensis, and Gulubia palauensis. Less common tree and shrub species are Garcinia rumiyo, Aglaia palauensis, and Trichospermum ledermanii.

On exposed outcrops and ridges, E. reinwardtiana, Gulubia palauensis and Intsia bijuga form almost monospecific communities. These communities are characterized by a large number of small, closely spaced individuals. For example, in Quadrat 4 on Bkulomekerall Island, there are 0.46 individuals per square m and a total DBH of 128.7 cm. Most trees have heights less than 4 m. There is little soil development and moisture in these sites.

On island 16, Gulubia palauensis occurred in an almost pure stand. Of the 20 trees with DBHs greater than 2.54 cm in Quadrat 7, 12 trees were Gulubia palauensis. The other 8 trees belonged to 3 other species. The total DBH of this site is 161.5 cm, and there were 0.55 trees per square meter. The ground is heavily littered with palm fronds, and Nepenthes mirabilis and young Gulubia palms are abundant.

At higher elevations, many trees attain heights of 20 to 30 m and there are fewer individuals per area. For example, in Quadrat 11 which was located at 40 m above sea level, 6 of 20 trees had heights greater than 20 m. Total DBH was 234.4 cm and there were 0.40 individuals per square meter. Ten species of trees were found in this quadrat. These communities are more moist and less halophytic. The ground is often covered by a heavier litter and root layer, and the ground cover often contains a wider diversity of ferns and other herbaceous species. Commonly found ground cover species include Tectaria sp., Pyrrosia sp., Polypodium scolopendria, and Flagellaria indica. The introduced species Eugenia malaccensis is not found at low or high elevations, but is restricted to the strand habitat.

Although Cole et al. (n.d.) state that commonly occurring species of the limestone forests, in addition to the species listed above, are Ptychosperma palauensis, Semecarpus venenosus, Premna obtusifolia, Psychotria spp., and Clerodendrum inerme, this survey found few Premna, Ptychosperma or Psychotria plants, and none of the other named species.

Summary of habitats. Except for the strand, the habitats described above are representative of the Ngerukewid Preserve. All of these habitats are dominated by indigenous or endemic species. In this sense, these habitats and their vegetation can

be considered to be valuable representatives of the natural vegetation of the Rock Islands. The exposed strand habitat also contains a number of species which, although native to Palau, have been introduced to the islands. This habitat may be considered to be less representative of the natural vegetation of these islands.

It is difficult to determine whether the habitats described for the Ngerukewid Preserve are "critical" because of the imprecise definition of critical. By critical, do we mean critical for the vegetation, or for a particular plant or animal species? For example, in contrast to the limestone islands outside the Preserve, the endemic palm Gulubia palauensis is widely found in the upraised limestone forests, and on the ridges of the Preserve. The presence of Gulubia here seems to be related not to the presence of appropriate habitats or niches, but to the abundance of the cockatoo. While these habitats may be critical for the survival of the endemic palm, the cockatoo seems to be a greater threat to their continued existence.

ESTABLISHMENT OF BASELINE TRANSECTS FOR FUTURE MONITORING

While one of the proposed objectives of this study was to establish baseline transects for future monitoring, attempts to gain meaningful data using transects through the difficult terrain of the islands were unproductive. Instead, variable circle area quadrats were established for longterm monitoring. In this method, a center point in a representative habitat or plant association was selected, and the nearest 20 trees and shrubs with DBHs greater than 2.54 cm were identified, measured for DBH and estimated for height. The distance to the 20th tree was then measured to give a value for the radius of the circle. The data of quadrat analyses are presented in Table 2.3. Details of quadrat location, the ground cover, density and other data are also presented for each quadrat and are mapped in Figure 2.1.

Permanent variable radius quadrats were established on 9 islands within the Preserve, and on 2 islands outside the Preserve boundary. While a conscious attempt was made to establish quadrats on as many islands as possible, this proved to be impractical because of the difficulties of access. Six quadrats were established on exposed strand habitats, while the other 23 quadrats were sited on the slopes and ridges of the upraised limestone forest habitat.

In terms of island size, 10 quadrats were established on the very large island of Ngerukewid (Island No. 24), while 3 quadrats were located Island No. 16, a large island. Ten quadrats were sited on medium sized islands (Island Nos. 5, 7, 13, and 39), and 3 quadrats were located on small islands (Nos. 3, 23, and 33/34). The other 3 quadrats were located on the small to medium sized islands outside of the Preserve boundary.

ASSEMBLE THE ABOVE INFORMATION IN A FORM THAT GUIDES FOLLOW-UP MANAGEMENT PLANNING

Because of their isolated geographic position and the rugged topography, the Ngerukewid Islands have not been greatly affected by human interference. These islands are dominated by steeply sloping limestone rock, and have little soil development or surface water resources. The vegetation is dominated by a relatively unaltered, halophytic and xerophytic vegetation composed of species native to the Preserve, Palau, and the tropical Pacific. There are few introduced plant species in the Preserve, and those are restricted mainly to the strand habitats. Even common and widespread pan-Pacific strand species such as Ipomoea pes-caprae and Vigna marina are not present in the Preserve islands. In contrast to the other islands of Palau, the palm species Gulubia palauensis is abundant in some habitats, although it is being threatened by the cockatoo.

While the islands of the Ngerukewid Preserve have been and are being exploited for marine and terrestrial fauna, the land resources have been little used, perhaps because of the lack of water and arable land. There is little evidence of permanent settlement, although campsites and campfires suggest prehistoric as well as present day occupation. Permanent settlement of these islands, while not probable, should be highly discouraged through legislation. However, as development and the pressures for exploitation of resources increase in Palau, these islands will become increasingly important as refugia and representatives of the natural vegetation of limestone islands in Palau. Specific recommendations resulting from this survey are detailed below.

Survey of the flora

This survey resulted in a reasonably complete inventory and collection of the plant species of the Ngerukewid Preserve. While every attempt was made to collect complete specimens (those with flowers and/or fruits) specimens for identification and deposition in herbaria, not all specimens had the flowers or fruits necessary for complete identification. Dr. F. R. Fosberg of the Smithsonian Institution and an authority on Pacific island flora provided the concurring identifications for this report. Even Dr. Fosberg had difficulty with sterile specimens, and noted that flowers and/or fruits were necessary for some identifications and desirable for all identifications. Therefore, **it is recommended that another survey be conducted, perhaps during June or July, in order to collect complete specimens.** This would be particularly important if Gulubia is at risk, because none was flowering or fruiting in January. Establishment of the species in a botanical garden may be an extremely important "next step", and seeds/fruits are required for such an undertaking.

The Ngerukewid Islands Wildlife Reserve as a closed area

Although the Preserve has been subjected to exploitation and visitation, the flora and vegetation has not been drastically altered. There are few if any plant species which are not native to Palau or the Rock Islands. Weeds and introduced plants are rare. **It is recommended that the Preserve as presently bounded, be maintained as a closed area.** Visits to the Preserve should be limited to authorized patrols and scientific surveys. This would help to ensure a nearly pristine environment, the vegetation, and the habitats necessary for the survival of the megapode and other marine and terrestrial organisms.

It has been strongly suggested that the cockatoo may be responsible for the death of the palm Gulubia palauensis. **It is recommended that a study be conducted on the impact of the cockatoo on the flora and vegetation of the Ngerukewid Preserve.** Such a study should recommend possible courses of action, i.e. eradication, control, the establishment of a seed bank of threatened species. If no study is undertaken, it is strongly suggested that the seeds of Gulubia palauensis be collected for storage or propagation in an accredited seedbank or arboretum. This would ensure that the species would be available for repropagation into the Rock Islands when appropriate.

Monitoring of permanent quadrats

Since quantitative information on the vegetation of the Ngerukewid Preserve was not available, twenty nine permanent variable area quadrats were established in the different habitats and plant communities for longterm monitoring. **It is recommended that these quadrats be reanalyzed every five years, and that further quadrats be established, particularly on those islands on which park visitation is intended.** These latter quadrats should document the impacts of visitation/management on the vegetation and flora of the Rock Islands.

Environmental education

Some of the problems in managing the Ngerukewid Preserve could be addressed by a program of environmental education. **It is recommended that the Government of Palau and the South Pacific Regional Environment Programme develop the necessary materials.**

Need for an archeological Survey

The Rock Islands were visited in prehistoric times for their plant and animal resources. Little is known, however, of the extent of exploitation or the archeology of the Ngerukewid Preserve. Pottery sherds of unknown age were found in the strands on Bkulomekerall and Ngerukewid islands. Therefore, **it is recommended that an archeological survey be conducted in the Ngerukewid Reserve.**

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Table 2.1. Selected Characteristics of Islands Within the Ngerukewid Islands Preserve

Island No.	Size	Gulubia Presence	Island Habitats and Coverage				Exposure	Quadrat Number	Island Height	Comments
			Strand	Forest	Scrub	Mangroves				
1	Small	None	----	Little	Most	----	Exposed on NNW	None	Low	Elongated NNW to SSE; xeric moisture regime; dominated by Casuarina; located on separate patch reef.
2	Small	None	----	----	All	----	"	None	Low	Extremely small island; xeric moisture regime; dominated by Casuarina; located on separate patch reef.
3	Small	None	----	Very little	All	----	"	16	Low	Elongated N to S; flat; xeric moisture regime; dominated by Casuarina; located on separate patch reef.
4	Small	Few	----	Some	Most	----	"	None	Medium	Trends NNW to SSE; xeric moisture regime; located on separate patch reef.
5	Medium	Common	----	1/3	2/3	----	West side of main islands	29	Medium	Domed; trends N to S; xeric to mesic moisture regime.
6	Large	Abundant	Some	Most	Very little	----	Sheltered	15	High (100m)	Elongated sine curve shaped, N to SW to S; mesic moisture regime; small strand exposed at low tide.
7	Medium	Common	Some	Most	Some	----	West edge of main island group	13, 25	Medium	Has been burned; abundance of Scaevola sericea; xeric - mesic moisture regime; well-developed strand forest.
8	Medium	Common	----	Little	Most	----	Sheltered, interior location	None	Medium (60 m)	Steep; xeric - mesic moisture regime; round island shape.
10	Small	Common	----	Little	Most	----	South edge of reef	None	Medium (60 m)	Minature of island 7; xeric moisture regime; steep; trends NW - SE.
11	Small	Common	----	Some	Most	----	South edge of reef	None	Medium (60 m)	Elongated E - W; steep N and S slopes; xeric moisture regime.

Island No.	Size	Gulubia Presence	Island Habitats and Coverage				Exposure	Quadrat Number	Island Height	Comments
			Strand	Forest	Scrub	Mangroves				
12	Large	Abundant	Some	Some	Most	----	South edge, inside patch reef, single island.	None	High (100+ m)	Flat topped; Elongated E - W; xeric moisture regime; minute strand on eastern edge of the island.
13	Medium	Few to Absent	Some	Some	Some	----	Fairly exposed to fairly protected	1, 2, 3, 4	High	Palauan name for this island Bkulomekerall; E - W orientation; xeric - mesic moisture regime; 2 well-developed strands equal amounts of scrub and forest.
14	Small	None	----	Some	Most	----	Eastern	None	Medium	Oval; trending E to W; xeric moisture regime; one Cycas circinalis present.
15	Small	None	----	Most	Some	----	Eastern and northern exposure	None	Low	Better vegetated than island 14; mesic moisture regime; more more Cycas circinalis present.
16	Large	Common - Seldom	Some	Most	Some	----	Interior location	5, 6, 7	High (100 m)	Sigmoid shaped island with small sinkhole with water; trends N - S; caves present; cockatoo damage to Gulubia palms; well-developed strand forest.
17	Medium	Common	Some	1/2	1/2	Very small patch	Mostly interior location	None	High (100 m)	Steep; rounded island with some extension N - S; at low tide, sand bar connects broadly with with island 16; equal amounts of forest and scrub.
18	Small	None	----	Some	Most	----	Exposed	None	Low	Elongated N - S; ENE (exposed side) is more xeric; WSW, more protected and mesic; domed shape.
19	Large	Some on ridges	Little	1/2-	1/2-	----	Exposed on NNE, main reef	None	High	Complex; 2 high hills; steep N and NE slopes; West slopes are heavily forested; xeric to mesic moisture regime.
21	Small	Common	----	Little	Most	----	Somewhat protected by island 24	None	Low	Trends NNW - SSE; steep sided, fairly oval flat topped-island.

Island No.	Size	Gulubia Presence	Island Habitats and Coverage				Exposure	Quadrat Number	Island Height	Comments
			Strand	Forest	Scrub	Mangroves				
22	Small	Seldom	----	Some, patchy	Most	----	Exposed on N part of main reef	None	Low	Middle section of island is lower in elevation than ends; N - S orientation; xeric moisture regime.
23	Small	Common	----	Some	Most	----	N side of main reef	14	Low	Steep; very weak limestone; E - W orientation; xeric moisture regime.
24	Very large	Yes	Some	Most	Much	Some	Exposed on W & S sides only	8 - 12 17 21 - 24	High	Known as Ngerukeuid Island or Orokuzui; Large and complex sigmoid-shaped island; contains all habitats & probably all plant species; mesic moisture regime; cockatoos present; 2 patches of strand.
25	Small	Common	----	Little	Most	----	Interior	None	Low	Domed; round island with xeric moisture regime; steep sided.
26	Medium	Common on ridge	----	1/2	1/2	----	Interior	None	High	Steeply sloping, oval to round island; much fallen rock; xeric to mesic moisture regime.
27	Small	Abundant	----	----	All	----	Interior	None	Low	Steep; trends ENE - W; 2 peaks; xeric moisture regime; much fallen rock.
28	Small	Common	----	Some	Most	----	Slight S exposure	None	Medium	Steep, flat topped oval island; E - W trend; xeric moisture regime.
30	Small	Common	----	Little - none	Almost all	----	Interior	None	Low	Xeric moisture regime; E to W orientation.
31	Medium	Common	----	Some	Most	----	Interior	None	Medium	Steep to S and to W; rocky surface; oval shaped; forest on upper slopes towards W.
34	Small	Abundant	----	----	All	----	Interior	18	Low	Xeric moisture regime; eyeglass shaped; trends NNW - SSE.
36	Small	Common	----	----	All	----	Interior	None	Low	Flat-topped; xeric moisture regime.
37	Small	Few	----	----	All	----	Interior	None	Medium	Relatively high for small size; xeric moisture regime.

Island Habitats and Coverage

Island No.	Size	Gulubia Presence	Strand	Forest	Scrub	Mangroves	Exposure	Quadrat Number	Island Height	Comments
38	Small	None	----	----	All	----	Exposed WNW	None	Low,	A rocky pinnacle; xeric moisture regime, less than 10 m high.
39	Medium	Few	----	Most	Some	----	SW edge of main reef	28	Medium	Dome-shaped; trends NNW to SSE; steep sided; 30 m high island.

Island No.	Size	Gulubia Presence	Strand	Forest	Scrub	Mangroves	Exposure	Quadrats	Island Height	Comments
40	Small	None	----	----	All	----	On spur reef to the S	None	Low	Narrow base; broad overhung mushroom-shaped island; axis NE - SW; xeric moisture regime.
41	Small	Common	----	----	All	----	South on main reef	None	Low	Flat-topped island; probably once part of # 16; mushroom-shaped; xeric moisture regime.
42	Small	None	----	----	All	----	N. side of of main reef	None	Low	Exposed to rough seas from N and NE; pedestalled and shoe-shaped; xeric moisture regime.
43	Small	None	----	----	All	----	Very exposed, on detached reef to the N	None	Low	A 20 m high pinnacle ("Lady with a flower basket").

Notes:
1. Islands are identified by numbers. See map reference (Map 3).
2. Island sizes are relative to each other.
3. Habitat coverage fractional or qualitative, based on observation.
4. Island heights were classified according to the following scale:
   Low - Height to 20 m
   Medium - Height 21 - 70 m
   High - Height more that 70 m

Table 2.2. Checklist of Plant Species
in the Ngerukewid Islands Wildlife Preserve

Polypodiaceae

Antrophyum plantagineum (Cav.) Kaulf.
Asplenium laserpitifolium Lam.
Asplenium nidus L. sl.
Asplenium polyodon Forst. f.
Belvisia spicata (L.f.) Mirb. ex Copel.
Cyclopeltis kingii (Hance) Hosok.
Davallia solida (Forst. f.) Sw.
Humata banksii Alst.
Nephrolepis saligna Carr.
Polypodium punctatum (L.) Sw.
Polypodium scolopendria Burm. f.
Pyrrosia lanceolata (L.) Farw.
Tectaria crenata Cav.
Tectaria grandifolia (Presl.) Copel. ?
Thelypteris cf gretheri rupi-insularis Fosb. ?
Vittaria incurvata Cav.

Psilotaceae

Psilotum nudum (L.) Beauv.

Schizaeaceae

Actinostachys spirophylla (Troll) Reed

Cycadaceae

Cycas circinalis L.

Monocotyledonae

Cyperaceae

Fimbristylis cymosa R. Br.

Dioscoreaceae

Dioscorea sp.

Flagellariaceae

Flagellaria indica L.

Gramineae

Lepturus repens (G. Forst.) R. Br.

Hydrocharitaceae

Halophila minor (Zoll.) den Hartog

Liliaceae

Dracaena multiflora Roxb.

Orchidaceae

Liparis sp.
Taeniophyllum sp.
Taeniophyllum sp.
Taeniophyllum sp.

Palmae

Cocos nucifera L.
Gulubia palauensis (Becc.) Moore & Fosb.

Pandanaceae

Pandanus cf dubius
Pandanus cf tectorius

Potamogetonaceae

Halodule uninervis (Forssk.) Achers. in Bossier
Syringodium sp.

Dicotyledonae

Acanthaceae

Hemigraphis reptans (Forst.) T. Anders.

Apocynaceae

Alyxia palauensis Maf.
Neisosperma oppositifolia (Lam.) Fosb. & Sachet

Araliaceae

*Meryta senfftiana Volk.
*Osmoxylon ? oliveri Fosb. & Sachet
Polyscias grandifolia Volk.
Schefflera odorata (Blanco) Merr. & Rolfe

Asclepiadaceae

Dischidia hahliana Volk.
Sarcolobus sulphureus (Volk.) Schltr.

Boraginaceae

Cordia subcordata Lam.
Tournefortia argentea L. f.

Burseraceae

Canarium sp.

Capparidaceae

Capparis carolinensis Kaneh.
Capparis cordifolia Lam.
Capparis quinifolia

Casuarinaceae

Casuarina equisetifolia L.

Celastraceae

Maytenus palauaica (Loesn.) Fosb.

Combretaceae

Terminalia catappa L.
Terminalia samoensis Rech.

Euphorbiaceae

Drypetes nitida Kaneh.
Glochidion sp.
Glochidion sp.
Macaranga carolinensis var. carolinensis Volk.
Phyllanthus rupi-insularis Hosok.

Goodeniaceae

Scaevola sericea Forst. f.

Guttiferae (Clusiaceae)

Calophyllum inophyllum L.
Garcinia rumiyo var. calcicola Fosb. (ined.)

Hernandiaceae

Hernandia sonora L.

Hippocrateceae

Loesneriella macrantha var. palauaica (Loesn.) Fosb.

Lecythidaceae

Barringtonia asiatica (L.) Kurz

Loganiaceae

Geniostoma sessile Kaneh.
Neubergia celebica (Koord.) Leenhouts

Lythraceae

Pemphis acidula Forst.

Leguminosae

Caesalpiniaceae

Intsia bijuga (Colebr.) O. Ktze

Fabaceae

Desmodium umbellatum (L.) DC.
Pongamia pinnata (L.) Merr.

Mimosaceae

Serianthes kanehirae Fosb. var. kanehirae

Malvaceae

Hibiscus tiliaceus L.

Meliaceae

Aglaia palauensis Kaneh.
Xylocarpus granatum Koen.

Moraceae

Artocarpus mariannensis Trec.
Ficus prolixa var. carolinensis (Warb.) Fosb.
Ficus senfftiana Warb.
Ficus tinctoria var. neo-ebudarum (Summerh.) Fosb.
Ficus sagittata Vahl.
Ficus microcarpa (Miq.) Corner var. microcarpa

Myristicaceae

Horsfeldia amklaal Kaneh.
Horsfeldia novo-guieensis Warb.
Horsfeldia palauensis Kaneh.
Myristica insularis Kaneh.

Myrsinaceae

Discocalyx palauensis Hosok.
?Discocalyx mezii Hosok.
Maesa palauensis Mez.

Myrtaceae

Decaspermum raymundii Diels
(Decaspermum fruticosum Forst)
Eugenia malaccensis L.
Eugenia cuminii (L.) Druce
Eugenia palauensis Kaneh.
ugenia reinwardtiana (Bl.) DC.
Eugenia suzukii Kaneh.
Eugenia javanica Lam.

Nepenthaceae

Nepenthes mirabilis (Lour.) Druce

Nyctaginaceae

Pisonia grandis R. Br.

Piperaceae

Peperomia kraemeri DC.
Peperomia palauensis G. DC. var. palauensis

Rhizophoraceae

Rhizophora mucronata var. stylosa (Griff.) Schimper

Rubiaceae

Aidia racemosa Cav.
Badusa palauensis
Bikkia palauensis Val.
Guettarda speciosa L.
Hedyotis sp.
Hedyotis stingulosa (Bartt. ex DC.) Fosb. (ined.)
Morinda citrifolia ?
Ophiorrhiza palauensis Val.
Psychotria sp.
Psychotria sp.

Sapindaceae

Allophylus timoriensis (DC.) Bl.
(Allophylus ternatus (Forst.) Radlk.)

Sterculiaceae

Sterculia palauensis Kaneh.

Symplocaceae

Symplocos racemosa var. palauensis (Koidz.) Nooteb.

Thymeleaceae

Wikstroemia elliptica Merr.

Tiliaceae

Trichospermum ledermannii Burret

Urticaceae

Elatostema calcareum Merr.
Pipturus argenteus (Forst. f) Wedd.

Verbenaceae

Callicarpa candicans var. intergrifolia (Lam.) Fosb. (ined.)
Callicarpa elegans Hayek.
Gmelina elliptica Sm.
Premna obtusifolia R. Br.

Table 2.3. Quadrat Data, Vegetation Survey
Ngerukewid Islands Wildlife Preserve

Quadrat Number 1
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: Black PVC pole set in cement.
Date of analysis: 1/5/88 and 1/6/88.

Quadrat Location: Eastern Beach. Quadrat center is located near the base of the escarpment, 1 to 2 m above the sandy beach, and approximately 4 m inland of the large Hernandia. By triangulation, the quadrat center can be located by compass bearings (uncorrected for magnetic declination) to the two islands offshore. Bearing to eastern island = 45 degrees, bearing to western island = 237 degrees.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Rinorea sp.	2.7	2
2.	Eugenia malaccensis	2.7	2
3.	Aidia cochinchinensis	2.8	3
4.	Meryta senfftiana	2.9	2
5.	Eugenia malaccensis	2.5	2
6.	Eugenia malaccensis	2.7	2
7.	Polyscias grandifolia	3.0	2.5
8.	Eugenia malaccensis	13.0	18
9.	Barringtonia asiatica	3.4	2.5
10.	Meryta senfftiana	3.6	3
11.	Neisosperma oppositifolia	12.3	12
12.	Neisosperma oppositifolia	3.0	2
13.	Barringtonia asiatica	3.8	2.5
14.	Hernandia sonora	130.8	25
15.	Meryta senfftiana	3.5	3
16.	Meryta senfftiana	12.5	6
17.	Aidia cochinchinensis	3.8	6
18.	Eugenia malaccensis	4.8	3
19.	Meryta senfftiana	3.6	2.5
20.	Pandanus dubius	6.8	2

Radius = 5.6 m, Area = 98.52 m sq
Density = 0.20 ind./m sq or 1 ind./4.93 m sq
Total DBH = 224.2 cm

Ground cover species and saplings with DBH less than 2.54 cm: Cycas circinalis (r), Dracaena multiflora (f), Tectaria crenata (c), Asplenium polyodon (c), Eugenia malaccensis (c), No. 16622 ? (c), Pandanus dubius (r), Peperomia sp. (r), Aidia cochinchinensis (c), Caesalpiniaceae (f).

Key: r = rare
a = abundant
f = frequent
c = common
e = epiphytic

Note: Collection numbers according to L. Raulerson, U. of Guam.

Table 2.3. (Continued)

Quadrat Number: 2
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: Black PVC pole set in cement.
Date of analysis: 1/5/88 and 1/6/88.

Quadrat Location: Eastern Beach. Quadrat 2 is located approximately 25 m upslope of Quadrat 1 and on the limestone outcrop, and in a Pandanus dubius grove. Bearing of Quadrat 2 to Quadrat 1 is 205 degrees (uncorrected for magnetic declination). Very steep site. Very little soil development, moderate leaf litter and organic soil.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Pandanus dubius (large leaf)	9.8	3
2.	Pandanus dubius	10.6	3
3.	Pandanus dubius	5.9	1.5
4.	Pandanus dubius	9.3	3
5.	Gmelina elliptica	14.6	12
6.	Rinorea sp.	4.1	3
7.	Rinorea sp.	19.3	15
8.	Dracaena multiflora (Orredak'l)	2.8	2
9.	Pandanus dubius	8.2	2
10.	Dracaena multiflora (Orredak'l)	4.3	2.5
11.	Rinorea sp.	12.9	3
12.	Guettarda speciosa (Blau)	26.3	20
13.	Eugenia reinwardtiana (Kesiil)	11.3	10
14.	Rinorea sp.	6.6	1.5
15.	Intsia bijuga (Dort)	23.2	25
16.	Pandanus dubius	6.2	2
17.	Rinorea sp.	38.4	25
18.	Guettarda speciosa (Blau)	20.0	20
19.	Aidia cochinchinensis	7.1	10
20.	Pandanus dubius	9.5	3

Radius = 5.0, Area = 78.54 m sq
Density = 0.25 ind./m sq or 1 ind./3.93 m sq
Total DBH = 250.4

Ground cover species and saplings with DBH less than 2.54 cm: Dracaena multiflora (a), Caesalpiniaceae (r), Loesneriella macrantha (r), Eugenia sp. (c), Schefflera sp. (r), Eugenia reinwardtiana (c), Pisonia grandis (r), Flagelleria indica (c), Intsia bijuga (c), Meryta ? (c), Rinorea sp. (c), Combretum ? (r), Asplenium nidus (r).

Table 2.3. (Continued)

Quadrat Number: 3
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: Black PVC pole set in cement.
Date of analysis: 1/6/88.

Quadrat Location: Western beach on northern side of Bkulomekerall. Quadrat is located just above the strand, on the lower part of the escarpment, towards the western side of the beach.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	12.8	5
2.	Eugenia reinwardtiana (Kesiil)	4.6	5.5
3.	Meryta senfftiana	7.5	5
4.	Sterculia palauensis	5.0	4
5.	Pongamia pinnata	40.0	20
6.	Eugenia reinwardtiana (kesiil)	7.0	3
7.	Meryta senfftiana	4.5	5
8.	Sterculia palauensis	27.0	30
9.	Sterculia palauensis	11.1	12
10.	Eugenia reinwardtiana (Kesiil)	9.2	5
11.	Sterculia palauensis	13.0	15
12.	Eugenia reinwardtiana (Kesiil)	2.5	3
13.	Sterculia palauensis	27.0	17
14.	Meryta senfftiana	3.2	3
15.	Eugenia reinwardtiana (Kesiil)	1.3	2
16.	Eugenia reinwardtiana (Kesiil)	2.0	4
17.	Eugenia reinwardtiana (Kesiil)	1.2	2
18.	Sterculia palauensis	12.4	20
19.	Combretum ?	4.0	
20	No. 16634	5.2	4

Radius = 5.14 m, Area = 82.99 cm
Density = 0.24 ind./m sq or 1 ind./4.15 m sq
Total DBH = 200.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Dracaena multiflora (a), Polypodium punctatum (e, c), Tectaria crenata (c) to 1 m high, Caesalpiniaceae (c, 0.3m), Asplenium polyodon (r, .3m), Cycas circinalis (r, .3m), Combretum ? - vine (r, 2m), Peperomia (r), Chrysophyllum sp. (r, 1m), Asplenium nidus (r, e), Dioscorea sp. (c).

Table 2.3. (Continued)

Quadrat Number: 4
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: A small cairn atop the pinnacle.
Date of analysis: 1/6/88.

Quadrat Location: Western beach on northern side of Bkulomekerall. Quadrat is located on a slightly exposed pinnacle ridge top, approximately 50-60 m upslope and to the southeast of Quadrat 3. Proceed upslope to saddle. With small (1.5 m high) thru-cave on right, proceed east upslope to exposed pinnacle.

	Species name (Palauan)	DBH cm	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	19.1	3,5
2.	Intsia bijuga (Dort)	5.5	3
3.	Intsia bijuga (Dort)	6.8	2.5
4.	Unidentified	1.0	1.5
5.	Eugenia reinwardtiana (Kesiil)	8.0	3
6.	Eugenia reinwardtiana (Kesiil)	4.2	2.5
7.	Unidentified. Same as #4	5.0	2.3
8.	Intsia bijuga (Dort)	1.0	3
9.	Eugenia reinwardtiana (Kesiil)	9.0	3
10.	Eugenia reinwardtiana (Kesiil)	2.0	2.5
11.	Dracaena multiflora (Orredak'l)	3.6	6
12.	Unidentified. Same as #4	1.0	2
13.	Sterculia palauensis?	3.3	3
14.	Intsia bijuga (Dort)	17.8	4
15.	Unidentified. Same as #4	4.2	2
16.	Bikkia ?	8.0	2
17.	Eugenia reinwardtiana (Kesiil)	1.6	3
18.	Eugenia reinwardtiana (Kesiil)	9.7	4
19.	Intsia bijuga (Dort)	5.2	2?
20	Eugenia reinwardtiana (Kesiil)	12.7	3.5

Radius = 3.7m, Area = 43.01 m sq
Density = 0.46 ind./m sq or 1 ind./2.15 m sq
Total DBH = 128.7 cm

Ground cover species and saplings with DBH less than 2.54 cm: Dendrobium sp. (c, e), Alyxia (c), Bulbophyllum profusum (c, e), Flagellaria indica (c), Eugenia reinwardtiana (c), Pyrrosia lanceolata (c, e), Asplenium polyodon (r), Dischidia hahliana (c), Caesalpiniaceae (r).

Table 2.3. (Continued)

Quadrat Number: 5
Island Number and/or Name: 16.
Quadrat center: Rock cairn dotted red.
Date of analysis: 1/7/88.

Quadrat Location: From the western end of the small beach on the north facing coast of the island, proceed from the very steep, only possible access point upslope to the immediate saddle, then eastward (with the sinkhole on the right), upslope 30 m to the ridge top knoll. Quadrat trees are painted red.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	6.5	3
2.	Intsia bijuga (Dort)	7.2	6
3.	Eugenia reinwardtiana (Kesiil)	11.5	7
4.	Intsia bijuga (Dort)	13.2	10
5.	Intsia bijuga (Dort)	9.4	10
6.	Rinorea sp. (16707)	4.4	3.5
7.	Rinorea sp. (16707)	6.5	5
8.	Intsia bijuga (Dort)	17.9	12
9.	Intsia bijuga (Dort)	9.8	8
10.	Intsia bijuga (Dort)	3.6	6
11.	Rinorea sp. (16707)	5.1	6
12.	Aidia cochinchinensis	9.5	12
13.	Wikstroemia elliptica (Tebudel)	3.2	4
14.	Like Guettarda (Beror)	12.6	12
15.	Intsia bijuga (Dort)	11.1	10
16.	Eugenia reinwardtiana (Kesiil)	6.1	7
17.	Eugenia reinwardtiana (Kesiil)	7.3	7
18.	Eugenia reinwardtiana (Kesiil)	4.2	4
19.	Intsia bijuga (Dort)	10.4	7
20.	Celtis sp. (No. 16708)	9.0	9.5

Radius = 2.9m, Area = 26.42 m sq
Density = 0.76 ind./ m sq or 1 ind./1.32 m sq
Total DBH = 168.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Dracaena multiflora (c, -.3m), Polypodium scolopendria (c), Intsia bijuga (c), Eugenia reinwardtiana (r, .3m), Caesalpiniaceae (No. 16587) (c), Asplenium polyodon (r).

Flagellaria indica and a Malaxis ground orchid were found outside quadrat. Ground cover was sparse.

Table 2.3. (Continued)

Quadrat Number: 6
Island Number and/or Name: 16.
Quadrat center: Rock cairn, with 30 cm red painted stone.
Date of analysis: 1/7/88.

Quadrat Location: From the western end of the beach on the north facing coast of the island, proceed upslope to the immediate saddle, and then turn westward with sinkhole on the left, and proceed further upslope. Go through small Pandanus grove and past 2 - 3 m high rock outcrop on left. Quadrat center is 10 m further, slightly downslope from rock outcrop. Tree with No. 10 painted on trunk is 5 m north of cairn. Quadrat 6 is located on a slope and a very weathered pinnacle opposite to Quadrat 5. Elevation is 30 to 40 m above sealevel. The area is flattish, but slopes away steeply.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	7.6	9
2.	Eugenia reinwardtiana (Kesiil)	6.3	10
3.	Large alt. leaf	3.4	5
4.	Like Guettarda (Beror)	10.2	10
5.	Aidia cochinchinensis	4.2	8
6.	Dracaena multiflora (Orredak'l)	8.3	9
7.	Eugenia reinwardtiana (Kesiil)	6.0	8
8.	Like Guettarda (Beror)	9.8	10
9.	Cycas circinalis	15.5	4
10.	Guettarda speciosa (Blau)	16.0	12
11.	Dracaena multiflora (Orredak'l)	13.8	8.5
12.	Dracaena multiflora (Orredak'l)	13.2	9
13.	Eugenia reinwardtiana (Kesiil)	3.8	5
14.	Eugenia reinwardtiana (Kesiil)	7.2	9
15.	Eugenia reinwardtiana (Kesiil)	11.2	10
16.	Eugenia reinwardtiana (Kesiil)	6.6	4
17.	Like Guettarda (Beror)	25.2	16
18.	Aidia cochinchinensis	14.6	14
19.	Dracaena multiflora (Orredak'l)	7.0	6
20.	Eugenia reinwardtiana (Kesiil)	7.6	5

Radius = 3.9 m, Area = 47.78 m sq
Density = 0.42 ind./m sq or 1 ind./2.39 m sq
Total DBH = 197.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Dracaena multiflora (c), Eugenia reinwardtiana (a, 1m), Pyrrosia lanceolata, Pandanus dubius (f, 1m), Alt. Leaf w/ prom. veins (f, 1.5m), Fern w/ leaflets not bilat. symm. (r), No. 16629 (r). Large Ficus microcarpa (15m) outside quadrat.

Table 2.3. (Continued)

Quadrat Number: 7
Island Number and/or Name: 16.
Quadrat center: Black PVC pole set in cement.
Date of analysis: 1/7/88.

Quadrat Location: On saddle area on south - southwestern end of island 16. Area is dominated by Gulubia palauensis (Esbuuch) palms. Quadrat center pole is at base of left flank of saddle (while facing SSE). See diagram. Ground is heavily littered with palm fronds. Thick organic mat over most of the quadrat. Site is relatively level and narrow.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Dracaena multiflora (Orredak'l)	2.6	3.5
2.	Gulubia palauensis (Esbuuch)	10.7	10
3.	Maesa sp.	4.1	4
4.	Maesa sp.	7.8	8
5.	Maesa sp.	6.6	5.5
6.	Maesa sp.	5.0	6
7.	Gulubia palauensis (Esbuuch)	12.6	9.5
8.	Gulubia palauensis (Esbuuch)	14.6	18
9.	Gulubia palauensis (Esbuuch)	5.8	3
10.	Gulubia palauensis (Esbuuch)	8.2	7
11.	Pouteria calcarea	11.6	11
12.	Pouteria calcarea	6.2	6
13.	Gulubia palauensis (Esbuuch)	10.1	10
14.	Gulubia palauensis (Esbuuch)	4.6	2
15.	Maesa sp.	5.4	4
16.	Gulubia palauensis (Esbuuch)	5.6	4
17.	Gulubia palauensis (Esbuuch)	10.6	7
18.	Gulubia palauensis (Esbuuch)	11.5	17
19.	Gulubia palauensis (Esbuuch)	11.2	8
20.	Gulubia palauensis (Esbuuch)	6.7	4

Radius = 3.4 m, Area = 36.32 m sq
Density = 0.55 ind./m sq or 1 ind/1.82 m sq
Total DBH = 161.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Nepenthes mirabilis (c), Gulubia palauensis (a), Pandanus tectorius (r, 1m), Flagellaria indica (c), Bulbophyllum profusum (c), Dendrobium (f, e), Dracaena multiflora (f, .5m), Garcinia rumiyo (f, 1m), Maesa sp. ? (r), Opp. leaf herb w round stem, perennial (f).

Table 2.3. (Continued)

Quadrat Number: 8
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock cairn dotted with red paint.
Date of analysis: 1/8/88.

Quadrat Location: Aspect is 228 degrees. Midslope location, gently sloping and less than 15 degrees, 30 m above sealevel. This is a well developed forest; litter is heavy; thick organic rooting mat. w, some mineral matter. Cover of species is about 80 %. There is evidence that people have visited this island as there are some slashed palms further down slope (near the landing).

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Pandanus dubius (Beku, Ongor)	8.6	6
2.	Sterculia palauensis	12.3	18
3.	Garcinia rumiyo (Tilol)	14.8	22
4.	Canarium sp.	11.5	15
5.	Like Guettarda (Beror)	6.3	8
6.	Aglaia palauensis	4.5	5
7.	Caesalpiniaceae	3.0	6
8.	Gulubia palauensis (Esbuuch)	16.2	20
9.	Aglaia palauensis	6.8	7
10.	Caesalpiniaceae	12.2	18
11.	Timonus subauritus	9.9	12
12.	Myristica sp.	14	8
13.	Timonius subauritus	10.5	15
14.	Intsia bijuga (Dort)	26.9	18
15.	Gulubia palauensis (Esbuuch)	9.0	5
16.	Aglaia palauensis	11.0	8
17.	Sterculia palauensis	4.3	5
18.	Pandanus dubius (Beku, Ongor)	12.5	10
19.	Pandanus dubius (Beku, Ongor)	3.5	6
20.	Pandanus dubius (Beku, Ongor)	3.3	-

Radius = 4.1 m, Area = 52.81 m sq
Density = 0.38 ind./m sq or 1 ind./2.64 m sq
Total DBH = 201.1 cm

Ground cover species and saplings with DBH less than 2.54 cm: Psilotum nudum (r), Pandanus dubius (c), Dracaena multiflora (c), Eugenia reinwardtiana (r), Garcinia rumiyo (c), Polypodium scolopendria (r), Asplenium polyodon (r), Vittaria incurvata (r), Flagellaria indica (r), Asplenium nidus (r), Combretum ? (c), Gulubia palauensis (c), Caesalpiniaceae (r).

Table 2.3. (Continued)

Quadrat Number: 9
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Cairn just west of windgap/erosion channel.
Date of analysis: 1/8/88.

Quadrat Location: Ridge top site, Aspect is 220 degrees. This site is located at about 45 m in elevation and to the east of Quadrat 8. There is a wind gap (erosion channel) to the east of the quadrat center. The windgap is dominated by Dracaena multiflora and Gulubia palauensis. Gently to steeply sloping site. Well developed mulch, and heavy litter. Site is an exposed pinnacle, above the Camp.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	8.0	10
2.	Eugenia reinwardtiana (Kesiil)	10.5	10
3.	Aidia cochinchinensis	6.5	5
4.	Eugenia reinwardtiana (Kesiil)	5.8	6
5.	Alt. compound leaf	10.2	10
6.	Timonius subauritus	3.5	5
7.	Timonius subauritus	5.7	5
8.	Meryta senfftiana	9.8	9
9.	Like Guettarda (Beror)	18.5	16
10.	Dracaena multiflora (Orredak'l)	5.2	5
11.	Aidia cochinchinensis	7.7	8
12.	Eugenia reinwardtiana (Kesiil)	5.8	7
13.	Eugenia reinwardtiana (Kesiil)	15.3	12
14.	Pouteria obovata (Elangel)	14.1	16
15.	Pandanus dubius (Beku, Ongor)	6.2	1
16.	Rinorea sp.	5.8	5
17.	Same as # 5	13.2	12
18.	Rinorea sp.	3.5	5
19.	Eugenia reinwardtiana (Kesiil)	4.2	4
20.	Intsia bijuga (Dort)	12.4	18

Radius = 3.7m, Area = 43.01 m sq
Density = 0.46 ind./m sq or 1 ind. /2.17 m sq
Total DBH = 171.9 cm

Ground cover species and saplings with DBH less than 2.54 cm: Davallia, Pandanus dubius, Dracaena multiflora, Psychotria hombroniana var. canfieldae (r), Dendrobium (f, e on Pouteria), Bulbophyllum profusum (e, on Pouteria), Rinorea sp. (a), Pyrrosia lanceolata (f, e), Gulubia palauensis (f), Polypodium scolopendria, Flagellaria indica, Loesneriella macrantha.

Table 2.3. (Continued)

Quadrat Number: 10
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Painted outcrop next to 2 large beror trees.
Date of analysis: 1/8/88.

Quadrat Location: Junction of three wind gaps, downslope and west of quadrat 9. Bearing from painted outcrop (quadrat center) is 186 degrees (uncorrected) to channel between two small islands.

Site has very heavy litter cover and is rather flat.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Unknown (sample)	3.6	5
2.	Like Guettarda (Beror)	33.6	35
3.	Like Guettarda (Beror)	33.1	35
4.	Rinorea sp.	6.1	7
5.	Rinorea sp.	6.4	4
6.	Like # 1	12.6	14
7.	Polyscias grandifolia	6.8	10
8.	Rinorea sp.	5.2	7
9.	Rinorea sp.	8.9	9
10	Rinorea sp.	4.4	5
11.	Rinorea sp.	6.7	4
12.	Horsfieldia or Myristica	4.5	8
13.	Myristica sp.	12.0	15
14.	Like # 1	16.0	20
15.	Rinorea sp.	6.2	5
16.	Rinorea sp.	5.0	5
17.	Slightly red. bark, sl. buttressed	25.0	30
18.	Same as # 1	5.2	8
19.	Rinorea sp.	4.5	5
20.	Horsefeldia or Myristica	22.5	13

Radius = 5.0, Area = 78.54 m sq
Density = 0.25 ind./m sq or 1 ind./ 3.93 m sq
Total DBH = 228.3 cm

Ground cover species and saplings with DBH less than 2.54 cm: Small pandanus (small leaved?), Tectaria crenata (f), Eugenia reinwardtiana (f), Vittaria incurvata (f, e), Gulubia palauensis (f), Caesalpiniaceae (r), Asplenium polyodon (f), Dracaena multiflora (f), Asplenium nidus (f), Many undet. seedlings.

Table 2.3. (Continued)

Quadrat Number: 11
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock cairn
Date of analysis: 1/8/88.

Quadrat Location: Left (west of gap) and about 20 m above overnight campsite. Slope of jumbled rock oriented W to SW and N to S.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Rinorea sp.	2.7	3
2.	Comp. alt. leaf, grey under	15.6	13
3.	Gulubia palauensis (Esbuuch)	14.0	22
4.	Celtis sp. ?	3.3	5
5.	Rinorea sp.	8.7	6
6.	Pongamia pinnata	4.5	7
7.	Trichospermum ledermanii (Elsau)	27.4	25
8.	Polyscias grandifolia	5.0	4
9.	Celtis sp. ?	9.5	15
10.	Guettarda-Dendrocnide	4.6	5
11.	Celtis sp. ?	21.8	18
12.	Gulubia palauensis (Esbuuch)	19.0	30
13.	Gulubia palauensis (Esbuuch)	16.0	20
14.	Short petiole, alt.	4.4	6
15.	Trichospermum ledermanii (Elsau)	20.7	20
16.	Dracaena multiflora (Orredak'l)	13.0	15
17.	Same as # 14	5.5	6.5
18.	Gulubia palauensis (Esbuuch)	18.0	25
19.	Rinorea sp.	8.6	4.5
20.	Same as # 14	12.1	12

Radius = 4 m, Area = 50.26 m sq
Density = 0.40 ind./m sq or 1 ind./2.51 m sq
Total DBH = 234.4 cm

Ground cover species and saplings with DBH less than 2.54 cm: Pyrrosia lanceolata, Flagellaria indica, Tectaria crenata, Pandanus tectorius, Dracaena multiflora, Rinorea sp., Celtis sp. All commonly found but not abundant.

Table 2.3. (Continued)

Quadrat Number: 12
Quadrat center: Tree in megapode mound.
Island Number and/or Name: 24, Ngerukewid.
Date of analysis: 1/8/88.

Quadrat Location: Back strand against limestone wall, aspect is SSW. Flat back strand; Wall slope is approximately 60 degrees. There is a large megapode mound in the quadrat.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Rinorea sp.	4.1	3
2.	Allophylus timoriensis ?	15.9	15
3.	Aidia cochinchinensis	6.1	7
4.	Polyscias grandifolia	3.3	3.5
5.	Itekill (liana)	5.2	Crown
6.	Eugenia reinwardtiana (Kesiil)	12.0	14
7.	Eugenia reinwardtiana (Kesiil)	14.5	6
8.	Flaky bark, see Quad 10	27.6	16.5
9.	Aidia cochinchinensis	7.8	6
10.	Chrysophyllum sp. ?	4.5	6
11.	Rinorea sp.	3.2	2
12.	Chrysophyllum sp. ?	3.9	3.5
13.	Alt. long leaf	23.9	11
14.	Same as # 13	13.6	12
15.	Guettarda speciosa (Blau)	33.0	28
16.	Terminalia catappa	45.0	25
17.	Calophyllum inophyllum	48.5	20
18.	Eugenia reinwardtiana (Kesiil)	13.5	12
19.	Neisosperma oppositifolia	5.6	5
20.	Calophyllum inophyllum	11.0	-

Radius = 7.2 m, Area = 162.86 m sq
Density = 0.12 ind./m sq or 1 ind./8.14 m sq
Total DBH = 302.2 cm

Ground cover species and saplings with DBH less than 2.54 cm: Guettarda speciosa (c), Calophyllum inophyllum (f), Asplenium nidus (f), A. polyodon (c), Cylcosorus kingii (r), Tectaria crenata (c), Cocos nucifera (r), Chrysophyllum sp., Pongamia pinnata (c), Rinorea sp. (c), Meryta sp. (r), Pandanus sp. (r), Aidia cochinchinensis, Unidentified vine.

Table 2.3. (Continued)

Quadrat Number: 13
Island Number and/or Name: 7
Quadrat center: Large Myristica tree marked with a red "X".
Date of analysis: 1/9/88.

Quadrat Location: Midslope location approximately 20 m above sea level and about 25 m north of the beach on island 7. Aspect of the quadrat is 110 degrees. Ridge crest rock above the quadrat has red arrow pointing downslope to center tree with "X". Area seems to have been flattened for a platform. Scaevola suggests very heavy disturbance.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Myristica/Horsefeldia	32.2	18
2.	Alt in whorl	5.4	4
3.	Pandanus dubius (Beku, Ongor)	11.2	4
4.	Dracaena multiflora (Orredak'l)	3.0	3
5.	Flaky bark, wood smells	26.6	20
6.	Rinorea sp.	9.4	7
7.	Eugenia reinwardtiana (Kesiil)	6.5	6
8.	Timonius subauritus	32.8*	12
9.	Gulubia palauensis (Esbuuch)	9.3	6
10.	Dracaena multiflora (Orredak'l)	3.0	3
11.	Intsia bijuga (Dort)	3.2	5
12.	Eugenia reinwardtiana (Kesiil)	3.7	4
13.	Dracaena multiflora (Orredak'l)	14.1	13
14.	Gulubia palauensis (Esbuuch)	13.3	21
15.	Pouteria obovata	7.6	12
16.	Aglaia palauensis	4.2	6
17.	Same as # 2	4.4	6
18.	Eugenia reinwardtiana (Kesiil)	14.4	13
19.	Alt. compound	18.0	13
20.	Rinorea sp.	5.5	6

Radius = 4.8 m Area = 72.38 m sq
Density = 0.28 ind./m sq or 1 ind./3.62 m sq
Total DBH = 227.8 cm

Ground cover species and saplings with DBH less than 2.54 cm: Bulbophyllum profusum on #1, Dracaena multiflora (f), Flagellaria indica (c), Pandanus dubius (f), Eugenia reinwardtiana (c), Gulubia palauensis (f).

Site is bounded by Scaevola sericea on lower slope; Macaranga on ridge, Pandanus tectorius and Asplenium polyodon. Psychotria hombroniana var. canfieldeae (r, 1.5m).

* Multiple trunks

Table 2.3. (Continued)

Quadrat Number: 14
Island Number and/or Name: 23.
Quadrat center: Pinnacle top near the western edge of the cliff.
Date of analysis: 1/9/88.

Quadrat Location: Crest position overlooking the northern and western sides of island. The quadrat center is approximately 10 m east of the western edge of the cliff. Site can be reached by climbing up the western cliff face. Very steep and dangerous site because of loose boulders and rocks.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Intsia bijuga (Dort)	13.4	7
2.	Intisa bijuga (Dort)	11.8	7
3.	Gulubia palauensis (Esbuuch)	6.3	5
4.	Intsia bijuga (Dort)	11.0	8
5.	Intsia bijuga (Dort)	9.7	10
6.	Gulubia palauensis (Esbuuch)	12.2	14
7.	Intsia bijuga (Dort)	6.2	3
8.	Garcinia rumiyo	6.4	3
9.	Pouteria obovata	15.2	12
10.	Pandanus tectorius (Ongor)	11.6	10
11.	Pandanus tectorius (Ongor)	13.3	10
12.	Intsia bijuga (Dort)	9.8	9
13.	Pandanus tectorius (Ongor)	4.2	5
14.	Garcinia rumiyo	3.9	3.5
15.	Aglaia palauensis	8.2	5
16.	Intsia bijuga (Dort)	15.4	10
17.	Eugenia reinwardtiana (Kesiil)	10.2	8
18.	Intsia bijuga (Dort)	13.4	8
19.	Gulubia palauensis (Esbuuch)	14.0	10
20.	Pandanus tectorius (Ongor)	6.0	1

Radius = 4.3 m Area = 58.09 m sq
Density = 0.34 ind./m sq or 1 ind./2.90 m sq
Total DBH = 202.2

Ground cover species and saplings with DBH less than 2.54 cm: Flagellaria indica (a), Polypodium scolopendria (f), Pandanus tectorius (a, seedlings), Pandanus dubius (outside the quadrat), Eugenia reinwardtiana (f), Asplenium nidus (outside), Gulubia palauensis (f), Alyxia palauensis (f), Dracaena multiflora (outside).

Table 2.3. (Continued)

Quadrat Number: 15
Island Number and/or Name: 7.
Quadrat center: Rock marked with red paint.
Date of analysis: 1/11/88.

Quadrat Location: Proceed inland from beach on eastern side of island. Quadrat center is 10 m above landing. Rocky slope between 45 and 60 degrees. Heavy leaf litter cover.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Dracaena multiflora (Orredak'l)	11.9	7
2.	Sterculia palauensis	4.0	3.5
3.	Meryta senfftiana	3.2	4
4.	Polyscias grandifolia	7.1	8
5.	Aglaia palauensis	4.9	6
6.	Chrysophyllum sp.	12.4	8.5
7.	Unidentified	16.2	9
8.	Rinorea sp.	5.1	5
9.	Horsfieldia palauensis	15.7	11
10.	Loesneriella macrantha	2.8	
11.	Horsfieldia	19.3	14
12.	Aglaia palauensis	4.9	8
13.	Rinorea sp.	4.3	5
14.	No. 16965 (Like Guettarda)	42.6*	7
15.	Horsfieldia	9.5	13
16.	Meryta senfftiana	8.4	13
17.	Intsia bijuga (Dort)	29.0	18
18.	Meryta senfftiana	3.4	5.5
19.	Guettarda speciosa	8.0	14
20.	Chrysophyllum sp.	37.8	30

Radius = 4.44 m Area = 61.93 m sq
Density = 0.32 ind./m sq or 1 ind./3.10 m sq
Total DBH = 250.5 cm

*Clump of 5 (10.1, 9.0, 11.2, 7.0, 53.0)

Ground cover species and saplings with DBH less than 2.54 cm: Horsfieldia (c), Aglaia palauensis, Rinorea sp., Caesalpiniaceae, Psychotria hombroniana var. canfieldeae (f), Eugenia, Cycas circinalis (r), Asplenium polyodon, Unidentified Vine, Asplenium nidus, Vittaria incurvata, Tectaria crenata, Flagellaria indica, Psilotum nudum sp., Combretum ?.

Table 2.3. (Continued)

Quadrat Number: 16
Island Number and/or Name: 3.
Quadrat center: Pinnacle facing 264 degrees.
Date of analysis: 1/11/88.

Quadrat Location: Quadrat center is a pinnacle facing west at 264 degrees, 10 m from cliff edge, and slightly north of the center of the island. There are no ferns in this quadrat. Ground is covered by a heavy Casuarina litter. Very rocky. Bat manure smell, quite nitrogenous, is noticeable.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	7.1	.5
2.	Dracaena multiflora (Orredak'l)	5.0	4
3.	No. 16929 Unknown (alt. whorl)	14.8	7
4.	Eugenia reinwardtiana (Kesiil)	5.0	6
5.	Pandanus tectorius (Ongor)	7.6	2
6.	Dracaena multiflora (Orredak'l)	3.0	2
7.	Dracaena multiflora (Orredak'l)	5.5	4
8.	Eugenia reinwardtiana (Kesiil)	3.0	3
9.	Dracaena multiflora (Orredak'l)	9.4	7
10.	Pandanus tectorius (Ongor)	6.0	3
11.	Dracaena multiflora (Orredak'l)	6.5	5
12.	Casuarina equisetifolia	28.3	18
13.	No. 16932 (white bark) Maesa ?	7.5	15
14.	Pandanus tectorius (Ongor)	8.5	4
15.	Dracaena multiflora (Orredak'l)	7.7	5
16.	Dracaena multiflora (Orredak'l)	4.2	3
17.	Casuarina equisetifolia	26.6	20
18.	Pandanus tectorius (Ongor)	7.6	5
19.	Pandanus tectorius (Ongor)	9.2	10
20.	No. 16929	13.0	8

Radius = 3.25 Area = 33.18 m sq
Density = 0.60 ind./m sq or 1 ind./1.66m sq
Total DBH = 185.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Pandanus tectorius (c), Eugenia reinwardtiana (f), Maesa ? (r), Unknown sapling, Celtis sp.

Table 2.3. (Continued)

Quadrat Number: 17
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Red paint spot on cliff face above the water, just above top lip of notch.
Date of analysis: 1/11/88.

Quadrat Location: Quadrat center is a mark on rock face located between the two mangrove sections, closer to the right end of the larger (left hand) mangrove section (facing west towards the island). See diagram. The site is flat towards the water, and slopes gentle to vertical towards the right and left.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Intsia bijuga (Dort)	8.5	8
2.	Ficus prolixa (?)	18.2	broken
3.	Rhizophora mucronata var. stylosa	12.0	10
4.	Rhizophora mucronata var. stylosa	11.2	7
5.	Rhizophora mucronata var. stylosa	9.5	7
6.	Pouteria obovata	3.4	4.5
7.	Dracaena multiflora (Orredak'l)	9.1	9
8.	Like Guettarda (split trunk)	9.3	14
9.	Eugenia reinwardtiana (?)	4.2	8
10.	Pandanus dubius (Beku, Ongor)	9.5	2.5
11.	Intsia bijuga (Dort)	28.5	9
12.	Glochidion (?)	5.5	4.5
13.	Sterculia palauensis	25.0	13
14.	Ficus prolixa	48.7*	15
15.	Opp. non-descript white petiole	13.3*	8
16.	Intsia bijuga (Dort)	9.2	10
17.	Same as # 15	11.3*	6
18.	Same as # 15	7.0	9.5
19.	Guettarda speciosa (Blau)	17.0	15
20.	Guettarda speciosa (Blau)	32.5	20

Radius = 7.0 m, Area = 153.93 m sq
Density = 0.13 ind./m sq or 1 ind./7.70 m sq
Total DBH = 282.9 cm

* = Multiple trunks

Ground cover species and saplings with DBH less than 2.54 cm: Cyclosorus kingii on cliff face, Polyscias grandifolia, Rhizophora mucronata var. stylosa (a), Tectaria crenata, Flagellaria indica (c), Cycas circinalis (f), Cocos nucifera (r), Eugenia reinwardtiana (f), Pandanus -thick succulent like, Gulubia palauensis (r), Asplenium polyodon, Psychotria hombroniana var. canfieldaea, Polypodium scolopendria. Cycas (34.0 DBH, 6.5 m).

Table 2.3. (Continued)

Quadrat Number: 18
Island Number and/or Name: 33 & 34.
Quadrat center: Black PVC pole stuck in rocks.
Date of analysis: 1/11/88.

Quadrat Location: Quadrat is located on the WSW portion of island 33 & 34 (the portion originally mapped as separate island number 33). Quadrat center is located is a pinnacle on SE side of island (or furtherest side from mangroves on island 24. Can be found midway to pinnacle top on the northern face of the pinnacle.

This is a small low island (less than 10 m in height) with a very jagged surface. The island is sheltered from winds. Very rocky surface; vegetation is low and scrubby.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Pandanus dubius (Beku, Ongor)	5.3	2
2.	Intsia bijuga (Dort)	4.9	7
3.	Dracaena multiflora (Orredak'l)	10.7	7
4.	Rinorea sp.	2.7	2
5.	Rinorea sp.	2.9	3
6.	Pandanus dubius (Beku, Ongor)	9.7	6
7.	Timonius subauritus	6.6	4
8.	Timonius subauritus	5.9	4
9.	Pandanus dubius (Beku, Ongor)	7.3	3
10.	Pandanus dubius (Beku, Ongor)	9.8	5
11.	Rinorea sp.	3.8	1.5
12.	Gulubia palauensis (Esbuuch)	8.6	6
13.	Pandanus dubius (Beku, Ongor)	9.5	4
14.	Timonius subauritus	3.7	5
15.	Pandanus tectorius (narrow leaf)	3.1	2
16.	Rinorea sp.	2.7	1
17.	Rinorea sp.	3.5	2.5
18.	Rinorea sp.	3.2	4
19.	Gulubia palauensis (Esbuuch)	7.1	8
20.	Timonius subauritus	5.3	5

Radius = 3.6m, Area = 40.77 m sq
Density = 0.49 ind./m sq or 1 ind./2.03 m sq
Total DBH = 116.3 cm

Ground cover species and saplings with DBH less than 2.54 cm: Flagellaria indica (a), Dendrobium sp. (f, e), Eugenia reinwardtiana (c), Rinorea sp. (c), Alyxia (f), Nepenthes mirabilis (f), Gulubia palauensis (f), Dracaena multiflora (f), Meryta senfftiana (r), Wikstroemia elliptica (f), Pandanus dubius and P. tectorius (c), Garcinia rumiyo (f).

Table 2.3. (Continued)

Quadrat Number: 19
Island Number and/or Name: 46, Kmekumer Island.
Quadrat center: Eugenia malaccensis, tree No. 1 in quadrat.
Date of analysis: 1/11/88.

Quadrat Location: Quadrat center is the Eugenia malaccensis located on the back strand which faces east. The strand area is greatly altered by human activity.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia malaccensis	65.3	24
2.	Polyscias grandifolia	2.5	4
3.	Polyscias grandifolia	3.5	5
4.	Serianthes kanehirae	6.3	8.5
5.	Aglaia palauensis	4.3	4.5
6.	Eugenia malaccensis (top cut off)	2.8	2
7.	Eugenia malaccensis	7.2	5.5
8.	Intsia bijuga (Dort)	43.0	30
9.	Hernandia sonora	52.5	23
10.	Eugenia malaccensis	2.6	2.5
11.	Neisosperma oppositifolia	3.0	2.5
12.	Ficus microcarpa (horizontal)	31.3	8
13.	Meryta senfftiana	4.5	3
14.	Eugenia malaccensis	3.0	3
15.	Ficus prolixa	44.0	12
16.	Long punctate leaves	4.3	7.5
17.	Eugenia malaccensis	9.4	8.5
18.	Eugenia malaccensis	46.7	15
19.	Eugenia malaccensis	11.5	14
20.	Sterculia palauensis	9.2	8.5

Radius = 8.4m , Area = 221.67 m sq
Density = 0.04 ind./m sq or 1 ind./11.08 m sq
Total DBH = 356.9 cm

Ground cover species and saplings with DBH less than 2.54 cm: Aglaia palauensis (c), Pandanus (c), Polyscias grandifolia (c), Eugenia (c), Dracaena multiflora, Loesneriella macrantha, Serianthes kanehirae (a), Caesalpiniaceae (a), Tectaria crenata (a).

Table 2.3. (Continued)

Quadrat Number: 20
Island Number and/or Name: 46, Tmekumer Island.
Quadrat center: Eugenia malaccensis tree, No. 1 in quadrat.
Date of analysis: 1/11/88.

Quadrat Location: Quadrat center is a large Eugenia malaccensis located on the strand approximately 15 m from the water's edge. This site is west of quadrat 19.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia malaccensis	18.1	15
2.	Eugenia malaccensis	2.8	4
3.	Meryta senfftiana	4.0	4.5
4.	Meryta senfftiana	2.8	2.5
5.	Intsia bijuga (Dort)	3.2	5.5
6.	Intsia bijuga (Dort)	17.6	24
7.	Eugenia malaccensis	3.3	4
8.	Eugenia malaccensis	2.8	1.5
9.	Eugenia malaccensis	6.9	7
10.	Guettarda speciosa (Blau)	2.8	4
11.	Intsia bijuga (Dort)	53.6	28
12.	Eugenia malaccensis	10.2	10
13.	Sideroxylon calcareum (No. 16980)	2.6	5
14.	Dracaena multiflora (Orredak'l)	3.0	2
15.	Eugenia malaccensis	10.0	7
16.	Eugenia malaccensis	9.6	7
17.	Eugenia malaccensis	3.2	1.4
18.	Eugenia malaccensis	4.4	3
19.	Eugenia malaccensis	17.2	13
20.	Eugenia malaccensis	8.5	7

Radius = 9.2 m Area = 265.90 m sq
Density = 0.08 ind./m sq or 1 ind./13.29 m sq
Total DBH = 186.6 cm

Ground cover species and saplings with DBH less than 2.54 cm: Aglaia palauensis (r), Polyscias grandifolia (f), Intsia bijuga (a), Eugenia malaccensis (a), No. 16713 (Kemaduangel) (c), Nephrolepsis saligna (a), Intsia bijuga (cut down).

Outside the quadrat and towards the beach is Asplenium nidus, Serianthes kanehirae, Polypodium scolopendria and Cocos nucifera (r).

Table 2.3. (Continued)

Quadrat Number: 21
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock cairn with red paint.
Date of analysis: 1/12/88.

Quadrat Location: Quadrat center is located above the mangrove community, with the saddle below. Tree marked No. 20 is 4 - 5 m SE of the cairn. A pandanus knoll is located on the left as you look towards the mangrove. The area is rocky with some leaf litter. Cockatoos may be heard here.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Rinorea sp.	5.5	7
2.	Rinorea sp.	11.3	11
3.	Rinorea sp.	4.8	7
4.	Eugenia reinwardtiana (Kesiil)	3.7	4
5.	Eugenia reinwardtiana (Kesiil)	9.4	10
6.	Rinorea sp.	6.4	7
7.	Rinorea sp.	13.1	11
8.	Rinorea sp.	8.1	8
9.	Rinorea sp.	5.6	7
10.	Rinorea sp.	11.0	7.5
11.	Sterculia palauensis	19.0	20
12.	Missed out		
13.	Horsfieldia palauensis	24.1	18
14.	Chrysophyllum	14.7	14
15.	Chrysophyllum	12.9	20
16.	Pandanus dubius (Beku, Ongor)	10.7*	14
17.	Guettarda speciosa (Blau)	60.9	23
18.	Aglaia palauensis	8.0	11
19.	Gulubia palauensis (Esbuuch)	12.3	22
20.	Eugenia reinwardtiana (Kesiil)	19.1	23

Radius = 3.95 m, Area = 49.02 m sq
(Note: #12 is missing.)
Density = 0.39 ind./m sq or 1 ind./2.58 m sq
Total DBH = 260.6 cm

Ground cover species and saplings with DBH less than 2.54 cm: Psilotum nudum, Flagellaria indica, Eugenia reinwardtiana (c), Pandanus dubius, Asplenium polyodon, Rinorea sp. (a), Asplenium nidus, Polypodium scolopendria.

Table 2.3. (Continued)

Quadrat Number: 22
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Red painted boulder.
Date of analysis: 1/12/88.

Quadrat Location: Quadrat center is located 25 m to the west of the mangrove landing area and within 2 m of the crest at approximately 50 m in elevation. Aspect of slope is 16 degrees. Very thick humus mat about 25 cm in depth in places. A large tree has been cut down probably for surveying. A Japanese marker capped by an Army Corp of Engineers spot elevation marker, dated 1947, is approximately 5 m south of the painted boulder.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Psychotria hombroniana var. canfieldeae	2.7	5
2.	Pouteria obovata	9.3	10
3.	Like Guettarda (Beror)	17.0	12
4.	Dracaena multiflora (Orredak'l)	8.2	7
5.	Intsia bijuga (Dort)	15.5	12
6.	Aidia cochinchinensis	4.5	8
7.	Eugenia reinwardtiana (Kesiil)	4.9	5
8.	Wikstroemia elliptica (Tebudel)	4.2	6
9.	Eugenia reinwardtiana (Kesiil)	4.9	4
10.	Eugenia reinwardtiana (Kesiil)	5.7	6
11.	Meryta senfftiana	4.0	5
12.	Unknown tree	5.1	7
13.	Aidia cochinchinensis	3.6	5
14.	Aidia cochinchinensis	3.5	6
15.	Gulubia palauensis (Esbuuch)	13.5	12
16.	Meryta senfftiana	4.1	5
17.	Polyscias grandifolia	8.8	6
18.	Eugenia reinwardtiana (Kesiil)	7.1	6
19.	Wikestroemia elliptica (Tebudel)	5.8	7
20.	Intsia bijuga (Dort)	8.8	10

Radius = 3.45 m, Area = 37.39 m sq
Density = 0.53 ind./m sq or 1 ind./1.87 m sq
Total DBH = 141.2 cm

Ground cover species and saplings with DBH less than 2.54 cm: Polypodium scolopendria (f), Eugenia reinwardtiana (a), Flagellaria indica (f), Asplenium polyodon (f), Dracaena multiflora (f).

Table 2.3. (Continued)

Quadrat Number: 23
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Painted red circle on a rock.
Date of analysis: 1/12/88.

Quadrat Location: Quadrat located above the mangrove community and to the west of quadrat 22. This quadrat is located at approximately 50 m in elevation. and overlooks a steep slope (approx. 60 degrees). Sharp pinnacles nearby.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Polyscias grandifolia	5.3	8.5
2.	Eugenia reinwardtiana (Kesiil)	9.0	8
3.	Rinorea sp.	6.9	7
4.	Eugenia reinwardtiana (Kesiil)	9.3	8
5.	Sterculia palauensis	16.4*	14
6.	Rinorea sp.	9.0	9
7.	Eugenia reinwardtiana (Kesiil)	10.2	8.5
8.	Like cottonwood	12.0	14
9.	Like cottonwood	14.0	15
10.	Eugenia reinwardtiana (Kesiil)	4.6	3.5
11.	Sterculia palauensis	21.0	17
12.	Same as 11?	5.8	13
13.	Rinorea sp.	19.5	17
14.	Pouteria calcarea	16.1	20
15.	Polyscias like	6.1	12
16.	Rinorea sp.	4.0	5
17.	Rinorea sp.	2.5	5
18.	Rinorea sp.	6.6*	6.0
19.	Eugenia reinwardtiana (Kesiil)	5.5	9
20.	Like Guettarda, no bracts, rough alt.	72.0	20

Radius = 3.6 m, Area = 40.72 m sq
Density = 0.49 ind./m sq or 1 ind./2.03 m sq
Total DBH = 255.8 cm

Ground cover species and saplings with DBH less than 2.54 cm: Taeniophyllum (large specimen), Asplenium polyodon, A. nidus, Vittaria incurvata, Rinorea sp., Polypodium scolopendria, Eugenia reinwardtiana, Dracaena multiflora, Davallia solida, Unidentified Araceae.

Table 2.3. (Continued)

Quadrat Number: 24
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Dome shaped rock 1.5 m high sprayed with paint.
Date of analysis: 1/12/88.

Quadrat Location: Quadrat center is a located 15 m west of quadrat 22 and at an elevation of 40 m. Aspect = 10 degrees.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	3.2	5
2.	No. 16992	3.2	8
3.	Chrysophyllum sp. (No. 16988)	4.9	12
4.	Eugenia reinwardtiana (Kesiil)	4.7	.6
5.	Intsia bijuga (Dort)(dying)	14.4	18
6.	Intsia bijuga (Dort)	12.6	15
7.	Guettarda speciosa (Blau)	12.1	20
8.	Meryta senfftiana	8.3	8
9.	Rinorea sp.	7.7	10
10.	Like Guettarda (Beror)	3.3	6
11.	Pouteria obovata	3.7	8
12.	Chyrsophyllum sp.	13.9	12
13.	Meryta senfftiana	5.2	8
14.	Pouteria calcarea ?	34.3	22
15.	Eugenia reinwardtiana (Kesiil)	5.6	5
16.	Intsia bijuga (Dort)	16.6	15
17.	Rinorea sp.	3.2	4.5
18.	Rinorea sp.	4.0	5
19.	Like Guettarda (Beror)	18.0	24
20.	No. 16992	21.8	15

Radius = 3.2 m, Area = 32.17 m sq
Density = 0.62 ind./m sq or 1 ind./1.61 m sq
Total DBH = 200.7 cm

Ground cover species and saplings with DBH less than 2.54 cm: Tectaria crenata (f), Eugenia reinwardtiana (f), Garcinia rumiyo (f), Chrysophyllum sp. (f), Pandanus tectorius (f), Asplenium polyodon, Dracaena multiflora (r), Caesalpiniaceae (r), Asplenium nidus (r), Polypodium scolopendria (c), Nephrolepis saligna.

Table 2.3. (Continued)

Quadrat Number: 25
Island Number and/or Name: 7.
Quadrat center: Tree marked with a red "O".
Date of analysis: 1/12/88.

Quadrat Location: Quadrat center is a marked tree with painted "O" located on the south side of old grass covered megapode mound. Sparse ground cover.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Pongamia pinnata	31.5	20
2.	Pongamia pinnata	9.2	12
3.	Ficus microcarpa	5.5	5
4.	Cocos nucifera	33.5	10
5.	Calophyllum inophyllum	77.5	25
6.	Meryta senfftiana	7.5	5
7.	Eugenia suzukii	8.5	8
8.	Eugenia reinwardtiana (Kesiil)	10.0	4
9.	Pandanus dubius (Beku, Ongor)	9.5	2
10.	Glochidion sp.	5.0	4
11.	Terminalia samoensis	11.0*	3
12.	Cocos nucifera	2.6	8
13.	Pongamia pinnata (cut)	6.0	1
14.	Pongamia pinnata (leaning)	22.2	7.5
15.	Pongamia pinnata	21.5	9
16.	Pongamia pinnata	11.5	7
17.	Cocos nucifera	31.0	18
18.	Meryta senfftiana	13.0*	4
19.	Cocos nucifera	29.5	4
20.	Terminalia samoensis	7.5	3

Radius = 9.0 m, Area = 254.47 m sq
Density = 0.08 ind./m sq or 1 ind./12.72 m sq
Total DBH = 353.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Meryta senfftiana, Dracaena multiflora, Lepturus repens, Terminalia samoensis, Pongamia pinnata, Hernandia sonora, Cyclosorus kingii (on wall), Maesa palauensis (on wall), Polypodium scolopendria (on wall), Eugenia (f), Pandanus dubius, Asplenium nidus (on wall), Geniostoma sessile (on wall), Flagellaria indica (on wall). Polypodium scolopendria, Ficus microcarpa, Barringtonia asiatica, Cocos nucifera, Calophyllum inophyllum.

Table 2.3. (Continued)

Quadrat Number: 26
Island Number and/or Name: 5.
Quadrat center: Pinnacle rocks painted red.
Date of analysis: 1/13/88.

Quadrat Location: About 5 m from cliff edge overlooking island 7. The bearing from the quadrat center to island 7 is 176 degrees (uncorrected). Aspect is 145 degrees; slope = 35 degrees. Esbuuch and Dracaena located outside quadrat. Very rocky site with moderate amount of litter on the surface.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Rinorea sp.	5.5	3
2.	Rinorea sp.	9.6	3
3.	Unknown	8.4	5
4.	Rinorea sp.	7.1	5
5.	Pouteria obovata	16.6	5
6.	Rinorea sp.	8.6	4
7.	Rinorea sp.	8.3	3
8.	Wikstroemia elliptica (Tebudel)	7.8	5
9.	Rinorea sp.	15.0	5
10.	Rinorea sp.	10.6	4
11.	Meryta senfftiana	11.3	6
12.	Eugenia reinwardtiana (Kesiil)	5.5	5
13.	Same as # 3	11.8	4.5
14.	Eugenia reinwardtiana (Kesiil)	16.9	5
15.	Same as # 3	9.8	6
16.	Rinorea sp.	12.6	4.5
17.	Rinorea sp.	11.4	5
18.	Pouteria obovata	13.1	4.5
19.	Pouteria obovata	7.1	3.5
20.	Pouteria obovata	9.5	4

Radius = 1.9 m Area = 11.34 m sq
Density = 1.76 ind./m sq or 1 ind./0.57 m sq
Total DBH = 206.5 cm

Ground cover species and saplings with DBH less than 2.54 cm: Rinorea sp. (c), Eugenia reinwardtiana (c), Asplenium polyodon (r), A. nidus (c), Flagellaria indica (c), Dracaena multiflora (c), #3 seedling (c), Aglaia palauensis (f).

Table 2.3. (Continued)

Quadrat Number: 27
Island Number and/or Name: Outside island, not labelled on survey maps.
Quadrat center: Rock sprayed with red paint.
Date of analysis: 1/13/88.

Quadrat Location: Outcrop on ocean side (windward) of gap, halfway up and facing Koror. Slope is steep.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Leaves whorled, losing lus.	8.0	15
2.	No. 17019	5.4	9
3.	Rinorea sp.	6.2	3.5
4.	Dracaena multiflora (Orredak'l)	8.9	12
5.	Dracaena multiflora (Orredak'l)	20.5	15
6.	Intsia bijuga (Dort)	5.9	14
7.	Meryta senfftiana	3.2	3.5
8.	Dracaena multiflora (Orredak'l)	4.1	7
9.	Intsia bijuga (Dort)	7.8	10
10.	Dracaena multiflora (Orredak'l)	5.5	10
11.	Aglaia palauensis	5.0	3
12.	Intsia bijuga (Dort)	7.4	9
13.	Ficus sp.	14.8*	5
14.	Meryta senfftiana	3.8	3.5
15.	Polyscias grandifolia	3.4	4
16.	Intsia bijuga (Dort)	9.3	11
17.	Aglaia palauensis	9.4	10
18.	Like # 1	10.8	13
19.	Compound leaf	2.9	3.5
20.	Intsia bijuga (Dort)	30.3*	12

Radius = 3.9 m, Area = 47.78 m sq
Density = 0.42 ind./m sq or 1 ind./2.39 m sq
Total DBH = 172.6 cm

Ground cover species and saplings with DBH less than 2.54 cm: Flagellaria indica, Eugenia reinwardtiana, cordate base in whorl, like cottonwood, Aglaia palauensis, Compound leaf, Pouteria obovata, Polypodium scolopendria (c), Peperomia sp. (c), Nepenthes mirabilis, Asplenium nidus, A. polyodon (c), Psychotria hormbroniana var. canfieldeae, Psilotum nudum, Malaxis sp.

Table 2.3. (Continued)

Quadrat Number: 28
Island Number and/or Name: 39.
Quadrat center: Outcrop painted red.
Date of analysis: 1/12/88.

Quadrat Location: Quadrat is located on a pinnacle about 5 m from the water's edge. The slope faces SW at 204 degrees.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Rinorea sp.	5.0	4.5
2.	Intsia bijuga (Dort)	13.6	9
3.	Eugenia reinwardtiana (Kesiil)	5.9	9
4.	Dracaena multiflora (Orredak'l)	3.0	4
5.	Aglaia palauensis	5.0	8
6.	Eugenia reinwardtiana (Kesiil)	13.0	11
7.	Dracaena multiflora (Orredak'l)	2.6	3
8.	Rinorea sp.	3.2	3
9.	Rinorea sp.	3.9	4
10.	Rinorea sp.	3.5	6
11.	Rinorea sp.	3.6	3
12.	Dracaena multiflora (Orredak'l)	3.6	3.5
13.	Rinorea sp.	5.2	3.5
14.	Aglaia palauensis	6.5	3
15.	Pouteria obovata	21.4*	8
16.	Unknown (No. 16981?)	5.3	2
17.	Rinorea sp.	7.1	5
18.	Meryta senfftiana	6.3	3
19.	Rinorea sp.	3.5	4
20.	Pongamia pinnata (Kisaks)	14.8	13

Radius = 2.2 m, Area = 15.20 m sq
Density = 1.32 ind./m sq or 1 ind./0.76 m sq
Total DBH = 136.0 cm

Ground cover species and saplings with DBH less than 2.54 cm: Rinorea sp., Aglaia palauensis, Alyxia palauensis, Eugenia reinwardtiana (c), Dracaena multiflora (a), Flagellaria indica (f). Pandanus dubius and Pouteria obovata.

Table 2.3. (Continued)

Quadrat Number: 29
Island Number and/or Name: 5.
Quadrat center: Pinnacle on slope with bearing of 229 degrees.
Date of analysis: 1/13/88.

Quadrat Location: Quadrat is located on a pinnacle with an aspect of 229 degrees (uncorrected), and on the edge of a pandan grove. It is approximately 10 - 20 m west of Quadrat No. 26. Very steep slope 60 degrees.

	Species name (Palauan)	DBH (cm)	Ht (m)
1.	Eugenia reinwardtiana (Kesiil)	3.7	3.5
2.	Rinorea sp.	3.8	,3
3.	Eugenia reinwardtiana (Kesiil)	3.2	3
4.	Same as # 3, quad 26	5.0	4
5.	Pouteria obovata	5.8	4.5
6.	Rinorea sp.	3.6	4
7.	Pouteria obovata	7.4	5
8.	Rinorea sp.	3.6	4.5
9.	Eugenia reinwardtiana (Kesiil)	8.4	4
10.	Rinorea sp.	3.4	5
11.	Dracaena multiflora (Orredak'l)	11.4	5.5
12.	Rinorea sp.	3.2	3
13.	Gulubia palauensis (Esbuuch)	10.8	10
14.	Rinorea sp.	4.4	4
15.	Pouteria obovata	5.8	3
16.	Dracaena multiflora (Orredak'l)	5.4	6
17.	Rinorea sp.	9.0	4
18.	Pandanus dubius	8.8	6
19.	No. 17023 (Discocalyx ?)	6.4	2
20.	Intsia bijuga (Dort)	11.0	6

Radius = 2.4m, Area = 18.10 m sq
Density = 1.10 ind./m sq or 1 ind./0.90 m sq
Total DBH = 124.1 cm

Ground cover species and saplings with DBH less than 2.54 cm: Dracaena multiflora (f), Flagellaria indica (c), Pandanus dubius (c), Pandanus tectorius (f), Eugenia reinwardtiana (c), Alyxia palauensis (r), Meryta senfftiana (r), Nepenthes mirabilis (f), Rinorea sp. (f), Combretum ? (c).

CHAPTER 3

TERRESTRIAL VERTEBRATES OF THE NGERUKEWID ISLANDS WILDLIFE PRESERVE

GARY J. WILES, Division of Aquatic and Wildlife Resources, Department of Agriculture, P.O. Box 2950, Agana, Guam 96910

PAUL J. CONRY, Division of Aquatic and Wildlife Resources, Department of Agriculture, P.O. Box 2950, Agana, Guam 96910

INTRODUCTION

Detailed information on the terrestrial fauna of the Ngerukewid Islands Wildlife Preserve has never been gathered. Previous work in the Preserve apparently includes only a small number of station counts for censusing birds made in 1979 (J. Engbring, unpubl. data). In general, Palau's wildlife has been poorly studied, particularly its reptiles and mammals. Even the distribution of many species is poorly documented within the archipelago. Background information on the resident birds of Palau is available in several published accounts (Marshall, 1949; Baker, 1951; Pratt et al., 1980, 1987; Engbring and Pratt, 1985; Engbring, 1988). None of these publications discuss birdlife in the Ngerukewid Islands.

The purposes of this study were to 1) determine the presence and relative abundance of terrestrial wildlife in the Preserve, 2) identify known or possible threats to the Preserve's fauna, and 3) offer recommendations for managing the Preserve in the future. Special importance was given to assessing the status of animal species that are rare or declining in Palau. At present, eight species from Palau are listed as threatened or endangered, or are proposed for listing by the U.S. Fish and Wildlife Service. In addition, the small islands located west of the Preserve and collectively known as the Kmekumer Island Group were briefly visited as part of this study to determine the suitability of including them as part of the Preserve.

METHODS

The relative abundance of birds and bats in the Ngerukewid Preserve was measured by conducting surveys (station counts) at various locations from a boat or on land. Survey locations were chosen to give wide geographic coverage within the Preserve (Figure 3.1) and to cover a range of different sized islands. Surveys from the boat provided wide views of the outer forest canopy, the Preserve's lagoon, and surrounding waters, and thus most animals were recorded visually. Boat surveys were useful in counting sea birds, fruit bats, forest birds that used the outer canopy, birds flying between islands, and birds with loud calls. Land surveys were conducted in the forest and primarily sampled forest birds. Most of the birds detected during land surveys were heard calling rather than seen.

During the surveys, all birds and bats seen or heard for a period of 10 minutes (8 minutes at evening boat stations) were recorded. The methodology used here is similar in design to the variable circular plot method of Reynolds et al. (1980) except that the distances to detected birds were not measured and densities were not estimated. Our methodology is designed to quantify relative abundance of birds and bats and will allow the results to be compared with other studies that report findings as an average number of birds

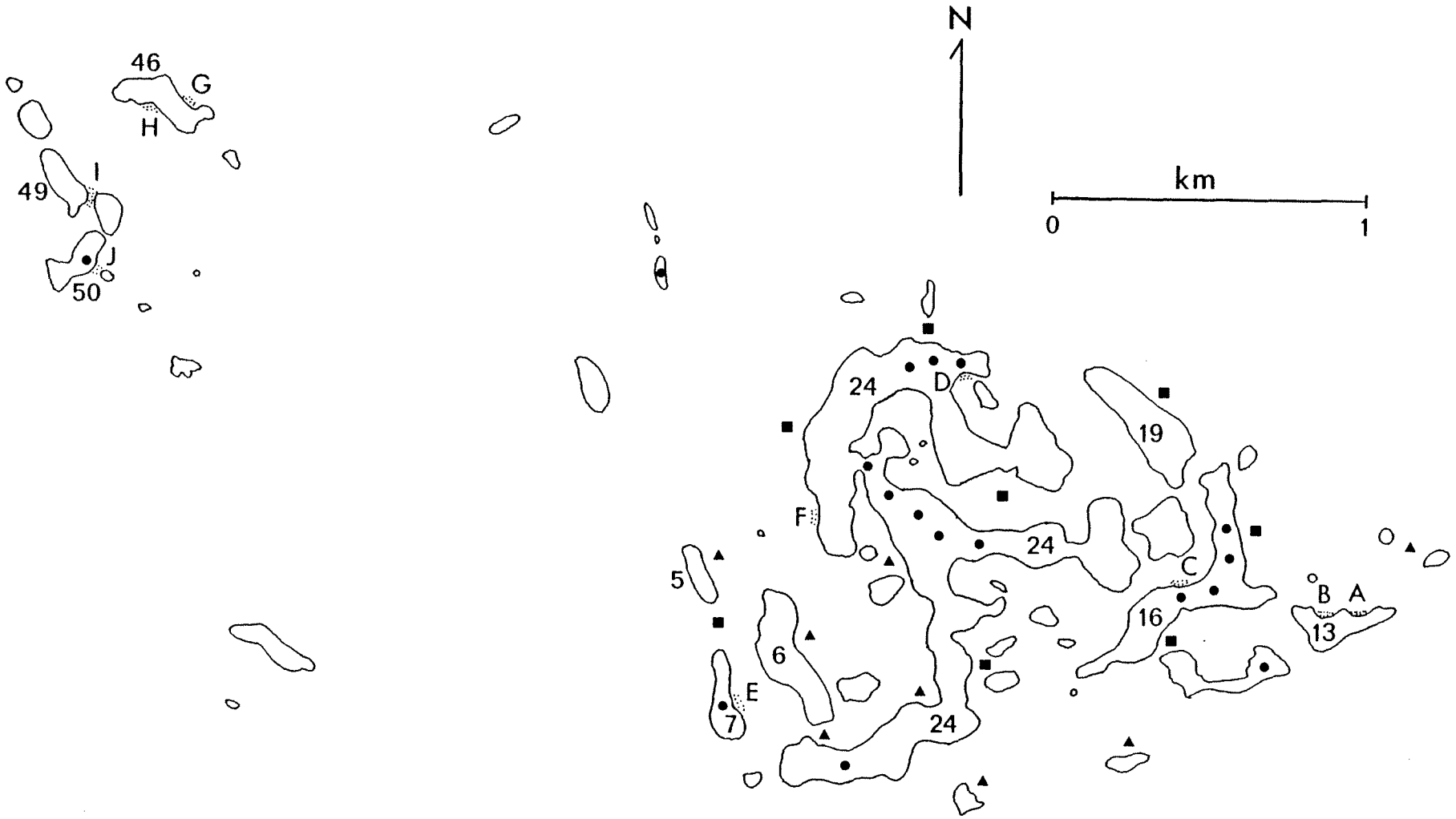

Figure 3.1. Locations of survey stations for birds and bats. Surveys were conducted on land (closed circles), from a boat in the evening (closed squares), and from a boat in the morning (closed triangles) in the Ngerukewid Islands, Palau, in January 1988. Beaches are represented by dotted areas and identified by letters.

and bats detected per station. A full listing of birds and bats observed per transect is presented in Table 3.1.

A total of 41 station counts were conducted with 17 stations located on land and 24 stations made from a boat parked close to shore. Station counts on land were conducted in the morning from 0700-1000 hrs on six islands. Single stations on small islands and multiple stations on larger islands were grouped and analyzed as 9 transects. Transects contained 1 to 4 stations. Counts made from the boat were conducted as follows. A series of 8 stations in a single transect was surveyed on two evenings from 1600-1800 hrs for a total of 16 stations. An additional 2 transects of 4 stations each were completed from a boat in the morning from 0700-1000 hrs. Results are reported as frequency of occurrence, number, and aggregate average number of birds observed per forest station, boat station, and for all stations combined. The aggregate average statistic differs from the more typically used average in that the latter is calculated by dividing the total number of individuals of a species recorded during all station counts by the total number of stations visited. The former is the mean of all transect averages and is calculated by first determining the average for each transect (i.e., the number of individuals of a species recorded during a given transect divided by the number of stations on that transect) and averaging these figures over all transects (i.e., sum of the transect averages for a given species divided by the number of transects).

Lizards and snakes were surveyed by walking slowly through a site and counting the number of animals seen on the ground, on tree trunks and branches, under the flaking bark of dead trees, in the crowns of *Pandanus* trees, and on rock outcrops. Observations frequently took place during other activities such as walking between station counts and the setting of traps. Most observations were made during the day when skinks were active, however, searches were also conducted at night between 1900 and 2300 hr to look for geckos. Animals were collected whenever possible to obtain positive identifications. Skinks were caught by shooting them with a heavy rubber band while geckos were captured by hand. Specimens were sent to the National Museum of Natural History, Washington, D.C. for identification and deposit.

The presence and distribution of Palau frogs and Palau owls was determined by listening for the calls of each species during four nights spent in the Preserve. Both animals have easily recognizable vocalizations. Because Palau owls readily respond to tape-recorded calls, we played calls several times each night to incite responses from nearby birds. On one evening from 1930-2130, a survey for owls and frogs was conducted by boat around Island 24 and neighboring islands. The survey consisted of 10 stations spread 200-300 m apart (Figure 3.2). Tape-recorded owl calls were played for 2 min at each station and were followed by a silent period of 8 min to listen for responses. This survey also provided an opportunity to record and map the singing of Palau frogs.

Trapping for small mammals and reptiles was conducted at three locations. These were on the northern end of Island 24 near Beach D, in the center of Island 24 north of the tallest hill, and on Island 16 near Beach C (Figure 3.2). Twelve stations spread about 20 m apart were established along a transect at each location. Each station had one rat trap, one mouse trap, one sticky trap (Trapper Glueboards, Bell Laboratories, Inc., Madison, Wisconsin) set on the ground, and a second sticky trap placed in an elevated position on a tree trunk, among the leaves of a *Pandanus* tree, or on a rock outcrop. Sticky traps were 10 x 23 cm is size and were used because of their efficiency at catching lizards and rodents that are exceptionally wary and otherwise difficult to capture. Traps were set at 1500 hr and were visited the next day at 1100 hr, a schedule that allowed both nocturnal and diurnal animals to be sampled.

Additional information about wildlife in the Ngerukewid Islands was gathered during incidental observations made outside of structured censuses.

Table 3.1. Numbers of birds and bats observed per transect, Ngerukewid Islands Wildlife Preserve. The average number of individuals observed per station can be calculated by dividing the number of individuals observed per land and boat transect by the number of stations counted on that transect.

	Land transects										Boat transects				
Species	1	2	3	4	5	6	7	8	9	Total	1	2	3	4	Total
No. stations/transcet	1	3	4	1	1	1	1	4	1	17	8	4	8	4	24
Location-island No.	12	24N	16	24S	3	24C	50	24C	7						
Birds															
Black noddy	0	5	3	1	1	0	0	0	0	10	40	4	15	4	63
Black-naped tern	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Brown noddy	0	3	3	0	0	3	0	4	0	13	33	7	15	1	56
Bridled tern	0	0	0	0	0	0	0	0	0	0	21	0	17	0	38
Caroline Islands white-eye	0	0	3	0	0	0	0	0	0	3	10	5	15	0	30
Collared kingfisher	2	4	1	0	0	1	0	4	0	12	9	6	2	1	18
Dusky white-eye	0	0	0	0	0	0	0	0	0	0	6	2	3	0	11
Island swiftlet	0	0	0	0	0	0	0	0	0	0	29	10	22	0	61
Mangrove flycatcher	0	8	7	1	0	1	1	5	2	25	7	8	7	2	24
Micronesian honeyeater	2	8	7	2	2	0	0	3	1	25	7	8	8	1	24
Micronesian megapode	0	1	0	0	0	0	1	5	0	7	0	0	3	2	5
Micronesian pigeon	0	1	0	2	0	3	0	5	0	11	6	2	5	1	14
Micronesian starling	3	2	14	1	2	4	2	10	3	41	16	10	24	3	53
Morningbird	1	2	0	0	0	0	0	0	0	3	1	0	0	1	2
Nicobar pigeon	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Palau fantail	0	0	0	2	0	1	0	0	0	3	0	0	0	0	0
Palau fruit-dove	1	5	4	3	0	3	0	15	0	31	6	8	14	1	29
Pacific reef-heron	0	0	0	0	0	0	0	0	0	0	2	0	1	0	3
Common fairy-tern	0	1	0	0	0	0	0	0	0	1	10	8	3	4	25
White-tailed tropicbird	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1
Noddy spp.	0	0	0	0	0	0	0	0	0	0	69	0	17	0	86
White-eye spp.	0	1	0	0	0	0	0	0	2	3	3	0	5	0	8
Tattler spp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Total birds	9	42	42	12	5	16	4	51	8	189	275	78	181	22	556
Bats															
Micronesian fruit bat	0	0	0	0	0	0	0	0	0	0	55	14	47	3	119
Pacific sheath-tailed bat	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
Total bats	0	0	0	0	0	0	0	0	0	0	55	14	52	3	124

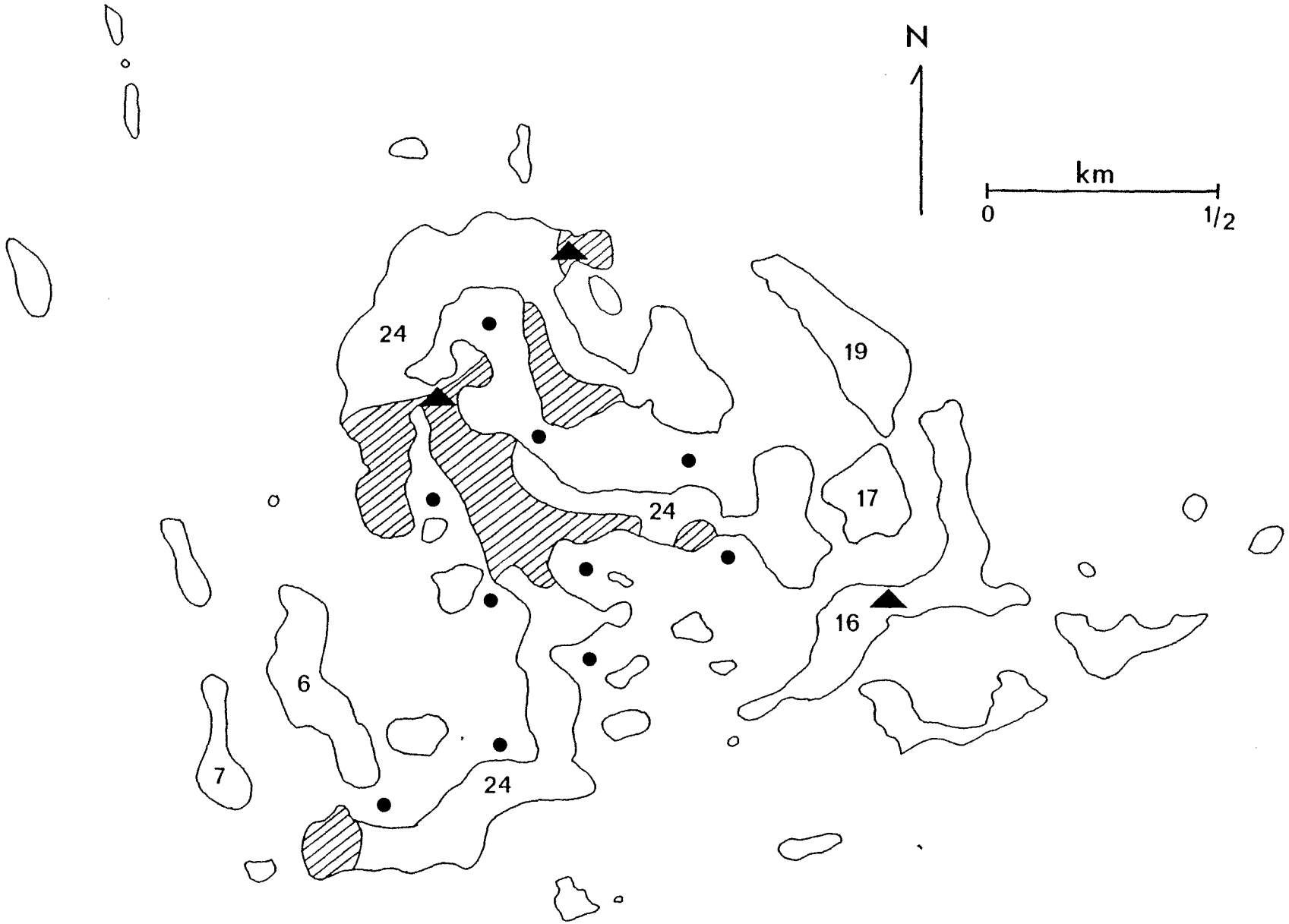

Figure 3.2. Locations of Palau frogs, survey stations for frogs and Palau owls, and trapping sites. Distribution of frogs (cross-hatched area), locations of survey stations made from a boat for frogs and owls (closed circles), and locations of trapping sites (closed triangles) in the Ngerukewid Islands Wildlife Preserve, Palau, in January 1988 are indicated.

SPECIES ACCOUNTS

The results of this survey are presented in the form of species accounts which summarize what was learned about each species in the Preserve. Species accounts are listed in taxonomic order with English, scientific, and Palauan names provided. Scientific names follow those used by R.I. Crombie (pers. comm.) for amphibians and reptiles, and by Pratt et al. (1987) for the birds. No authoritative account is currently available on Palau's mammals. Palauan names are taken from Owen (1977), who listed most, but not all, of the local names for Palau's wildlife.

The relative abundance of birds and bats were evaluated by station counts and incidental sightings. In order to quantify results, our terminology for status is based on the relative abundance and frequency of occurrence of individuals in those surveys. A species was considered abundant if it occurred in greater than 50% of the station counts and at numbers greater than an aggregate average of 1.0 birds/station. Those that were recorded on 20-50% of the stations counted and at an aggregate average of 0.2-1.0 birds/stations were regarded as common. Those considered uncommon occurred on 5-20% of stations counted and at an aggregate average of 0.1-0.2 birds/station. A species was classified as rare if it was detected on less than 5% of the station counts and at an aggregate average of less than 0.1 birds/station. The number of incidental sightings and other subjective appraisals of abundance were also used at times because not all species were equally detectable on station counts. The silent Nicobar pigeon and highly vocal Palau fruit-dove are examples of two species with greatly different detectability. Overall, we believe that the quantitative approach is more precise and useful for comparing results between studies than subjective classifications such as those used by earlier workers (Engbring, 1988; Pratt et al., 1987).

A similar classification system was used in determining the relative abundance of frogs and reptiles. Species were called common when found at rates of greater than one individual per hour searched per habitat at day or night. Those that were observed at rates of 0.10-1.00 individuals/hour were considered to be uncommon. Species that were rare were found at rates of less than 0.10 animals/hour.

The use of "N", "C", and "S" in association with Island 24 in the text refers to the northern, central, and southern portions of that island, respectively.

Palau Frog, *Platymantis pelewensis,* Dechedech

This species is endemic to Palau and is widespread and common throughout most of the archipelago (Owen, 1977). Surveys of Palau frogs singing at night detected animals only in limestone forest on Island 24N,C,S; frogs appear to be absent from other islands in the Preserve. Their distribution on Island 24 was uneven (Figure 3.2) with calling not heard on large portions of the island. Within their range, densities of singing frogs varied greatly with only a few animals vocalizing at some sites and large numbers doing so at other locations.

Calling began at nightfall and continued at least until midnight . In Koror, frogs were heard singing prior to dawn, thus calling probably lasts through the entire night. In the Preserve, calling was heard only in limestone forest at sites on the ground and in low vegetation such as in *Pandanus*. The cryptic dark brown coloration of frogs makes them difficult to find even though singing is loud and sometimes performed from exposed locations.

Metamorphosis in *P. pelewensis* has been described and illustrated by Atoda (1950). Larva develop entirely within their eggs, which are laid on the ground (Atoda, 1950), and

do not experience a free-swimming tadpole stage in their development cycle. This adaptation explains the ability of Palau frogs to colonize limestone islands, where sources of standing freshwater are absent except perhaps for those held in tree cavities or among the leaf nodes of *Pandanus*.

Hawksbill Sea Turtle, *Eretmochelys imbricata*, Ngasech, and Green Sea Turtle, *Chelonia mydas*, Melob

Hawksbill sea turtles are apparently more common in the Palau lagoon than green sea turtles, which occur primarily outside the lagoon's fringing reef (Pritchard, 1981; Owen, 1977). A substantial amount of turtle hunting and egg collecting occurs in Palau and is undoubtedly the cause of a gradual decline in hawksbill numbers from 1949 to the late 1970s (R.P. Owen, in Pritchard, 1981). Current trends in sea turtle populations in Palau are not known.

During the survey of the Ngerukewid Islands, five sets of tracks of sea turtles were found on four (Beaches E, F, G, and I) of 10 beaches (Figure 3.1). Each of the nests or nesting attempts showed signs of having been visited by people whose intent was to collect eggs. At each site, holes were made in the sand by probing with a stick to detect the presence of eggs or were dug by hand to remove the eggs. We did not identify the species of turtle making these tracks but suspect that they were made by hawksbill turtles. The Ngerukewid Islands are reported to be a favored nesting area of hawksbills (Johannes, 1981; T. Remokt, pers. comm.) and the species is known to nest widely on small beaches on limestone islands in the Palau Lagoon (Pritchard, 1981).

Each of the 10 beaches in the Ngerukewid Islands is probably used by turtles for nesting. The lengths of these beaches at high tide levels ranged from 30-115 m (mean = 62.7 m). The four beaches with nesting activity were among the smallest in the area, averaging 43.0 m in length.

Nesting has been recorded in all months of the year for hawksbill turtles in Palau although peak activity occurs in July and August (Pritchard, 1981). Hawksbills are reported to come ashore to nest most often around new and full moons (Johannes, 1981). The five visits to beaches in this study occurred approximately between 6 and 13 January, a period that was 3-10 days after the full moon.

Sea turtles were not observed on any of the 12 study transects made in the marine survey. However, incidental sightings of turtles occurred twice during other routine activities. A large turtle, probably a green sea turtle (*Chelonia mydas*), was observed on the south side of the Preserve near Island 28 (C. Birkeland, pers. comm.), and a medium-sized unidentified turtle was seen in shallow water along the west shore of Island 24N.

Salt Water Crocodile, *Crocodylus porosus*, Ius

This species of crocodile is reportedly common in mangroves and estuaries in Palau (Owen, 1977). The Ngerukewid Preserve does not support a resident population of salt water crocodiles and sightings of these animals are apparently extremely rare. A single large crocodile reportedly lived in the Preserve for an unknown length of time in the 1960s or early 1970s (Beki Madrasau, pers. comm. to J. Engbring), but aside from this, records from recent years are lacking. Two small clumps of mangroves exist in the Ngerukewid Preserve but are too small to support crocodiles permanently.

Snake-eyed Skink, *Cryptoblepharus poecilopleurus*

The status of snake-eyed skinks in Palau is not known. In the Ngerukewid Islands, this small skink was recorded only at Beach H, Island 46, where it was common in beach strand forest (Table 3.2). These lizards were conspicuous on tree trunks and logs, and frequently sought shelter under leaf litter when pursued. The high numbers of *C. poecilopleurus* at this location contrasted greatly with the low densities of other lizards residing in the Preserve. This species is generally restricted to shoreline habitats on other Pacific islands (McKeown, 1978; Schwaner, 1980; Wiles, pers. observ.). Thorough searches for other populations of *C. poecilopleurus* were conducted at Beaches A-G, I, and J, but none were discovered. Thus, it is unlikely that snake-eyed skinks occur within the present boundaries of the Preserve.

Green Tree Skink, *Lamprolepis smaragdina*, Chemaidechedui

These distinctive bright green and black skinks are common throughout Palau (Owen, 1977), but were found to be uncommon in the Preserve. This species had the widest distribution of any lizard noted in the study, being recorded on Islands 12, 16, 24, 46, and 50 (Table 3.3). *L. smaragdina* is primarily arboreal and was almost always found on the trunks and branches of large trees in both limestone and beach strand forest. The species appears to be more common in strand forest where observation rates were slightly higher than in limestone forest (Table 3.2). It was particularly abundant at Beach C, Island16, and Beach H, Island 46. Green tree skinks are somewhat gregarious with several animals found foraging within a meter of each other in the same tree.

Skink, *Eugongylus* sp.

The status and distribution of *Eugongylus* sp. in Palau are poorly known. This is the largest species of skink in the island chain. One individual captured in the Ngerukewid Preserve had a snout-vent length of 151 mm and weighed 70 gr. The upperparts of this lizard are brown and devoid of markings although the dorsal surface of the head and shoulders is often slightly brighter in color. The Palau population of this species has been incorrectly referred to as *E. mentovarius* by other authors (Dryden and Taylor, 1969; Owen, 1977) but additional taxonomic study is needed to establish this skink's correct identity (R.I. Crombie, pers. comm.).

These skinks were noted only in limestone forest on Islands 16, 24, and 46. Rates of observations and captures in sticky traps (Tables 2 and 4) suggest that *Eugongylus* sp. is uncommon in the Preserve. Skinks may have been attracted to sticky traps to feed on large wingless crickets (*Stonychophora* sp. nov.) that were often caught during the night. These lizards foraged inconspicuously in leaf litter during the day. Typically, animals were rarely seen until they were flushed by the close approach of an observer, whereupon they fled hastily to the nearest limestone crevice or hole.

Unidentified Skinks

The Preserve contains at least two other species of small skinks that escaped capture for identification. Sightings of these animals occurred in limestone forest (Table 3.2). Two blackish skinks (referred to as unidentified skink #1 in Tables 2 and 3) were observed on the forest floor on Island 24N while another was found under dead palm fronds lying on the ground on Island 12. A fourth small skink (referred to as unidentified skink #2 in Tables 2 and 3), this one having a golden back and brown flanks, was discovered in the crown of a *Pandanus* tree on Island 4. These few sightings indicate that both species are rare in the Preserve.

Table 3.2. Reptile and Palau frog observations. Numbers observed and observation rates (number/hour) of reptiles and frogs in limestone forest and strand forest on islands in or adjacent to the Ngerukewid Islands Wildlife Preserve.

Time period	Habitat	Total searching effort (hrs)	*Platymantis pelewensis*		*Cryptoblepharus poecilopleurus*		*Lamprolepis smaragdina*		*Eugongylus* sp.		unidentified skink #1		unidentified skink #2	
			no.	no./hr	no.	no./hr	no.	no./hr	no.	no./hr	no.	no./hr	no.	no./hr
day	limestone forest	55	0	0	0	0	5	0.09	12	0.22	3	0.05	1	0.02
day	strand forest	8	0	0	20	2.50	7	0.88	0	0	0	0	0	0
night	limestone forest	9	12	1.30	0	0	0	0	0	0	0	0	0	0
night	strand forest	1	0	0	0	0	0	0	0	0	0	0	0	0
Total		73	12		20		12		12		3		1	

Table 3.2. continued.

Time period	Habitat	*Gekko* sp.		*Lepidodactylus* sp. #1		*Lepidodactylus* sp. #2		Unidentified *Lepidodactylus*		*Candoia carinata*		*Dendrelaphis lineolatus*		Islands visited
		no.	no./hr	no.	no./hr	no.	no./hr	no.	no./hr	no.	no./hr	no.	no./hr	
day	limestone forest	0	0	4	0.07	0	0	2	0.04	0	0	2	0.04	3, 4, 12,13, 16, 24, 34
day	strand forest	2	0.25	0	0	1	0.13	0	0	0	0	0	0	7, 13, 16, 46, 49,50
night	limestone forest	2	0.22	0	0	0	0	0	0	0	0	0	0	7, 16, 24
night	strand forest	0	0	0	0	0	0	0	0	0	0	0	0	7, 16, 24
Total		4		4		1		2		0		2		

Gecko, *Gekko* sp.

The status of *Gekko* sp. in Palau is not known. A large conspicuous gecko, it was recorded at only two locations and appears to be rare in the Ngerukewid Preserve (Table 3.2). Two animals were found on the prop roots and leaves of *Pandanus dubius* in limestone forest on Island 24N. Two others were captured together during the daytime under the peeling bark of a large dead tree in strand forest at Beach H, Island 46. Previous authors (Dryden and Taylor, 1969; Owen, 1977) have referred to this species as *Gekko vittatus*, but a more recent examination by R.I. Crombie (pers. comm.) indicates that it should be distinguished as a separate species that is as yet undescribed.

Lepidodactylus spp.

Two similar species of small geckos of the genus *Lepidodactylus* were recorded in the survey, with both appearing to represent previously undescribed species (R.I. Crombie, pers. comm.). These are referred to here as *Lepidodactylus* sp. #1 and *Lepidodactylus* sp. #2. Four individuals of *Lepidodactylus* sp. #1 were found in *Pandanus* crowns and under flaking tree bark in limestone forest on Islands 4, 16, and 34. A single individual of *Lepidodactylus* sp. #2 was caught under the loose bark of a large tree in strand forest on Island 46. Two other geckos of this genus were seen in *Pandanus* crowns in limestone forest on Islands 24C and 50 but escaped capture. Surprisingly, none of the geckos were seen at night; all were discovered in their daytime hiding spots (Table 3.2).

Pacific Island Boa, *Candoia carinata*, Bersoech

This snake is common throughout Palau (Owen, 1977). Only one *C. carinata* was recorded during the survey, an indication that the species is rare in the Ngerukewid Islands. A single reddish brown boa was observed in a *Hernandia* tree at Beach B, Island 13 by M. Kataro and A. Rinehart. In the Solomon Islands, individuals of this species exhibit great variation in appearance with colors ranging from a striking pale gray with darker patterning along the back to dark brown with faint markings (McCoy, 1980). This degree of variation has also been noted in specimens from Palau.

Palau Tree Snake, *Dendrelaphis lineolatus*, Nguis

D. lineolatus is common in the Palau archipelago (Owen, 1977), but appears to be rare in the Preserve (Table 3.2). It was recorded only in limestone forest on the slopes of the tallest hill in the center of Island 24 where two sightings were made and one shed skin was found. Both sightings and the finding of the skin occurred on the ground. This small slender snake is widely recognized in Palau as being fast and agile in its movements. Owen (1977) noted that they are often found climbing in shrubs and low trees.

Banded Sea Snake, *Laticauda colubrina*, Mengerenger

Sea snakes are common residents in Palau's waters (Owen, 1977), but appeared to be uncommon in the Preserve with none sighted along any of the marine survey transects. However, sea snakes were found three times on shore sleeping in well-shaded resting spots located just above the high tide mark. In the first case, two snakes (one was large and the other was small) lay coiled together in a sandy-bottomed crevice below a limestone outcrop at the edge of Beach D, Island 24N. The largest animal remained at the site for at least 24 hours while the second snake departed during the night. One week later at 1030

hr, the same apparent two snakes were again present at this location, an indication that *L. colubrina* may return repeatedly to favored sleeping sites. On the third occasion, a single sea snake was discovered sleeping at 1600 hr in a limestone cavity in an undercut on Island 13. *L. colubrina* is both diurnal and nocturnal and normally forages on shallow reef flats near rocky shorelines (McCoy, 1980). *Laticauda* is the only genus of sea snake that comes ashore to lay eggs.

Audubon's Shearwater, *Puffinus lherminieri* , Ochaieu

Audubon's shearwaters occur commonly in Palau's limestone islands, where they roost at night and nest (Pratt et al., 1980). During the day, they feed on the open ocean outside the central lagoon and are rarely seen from land. This species was not recorded in our survey of the Ngerukewid Preserve. During four nights spent in the Preserve, we failed to observe these birds or hear their distinctive calls at dusk and during the night. Shearwaters were not noted on station counts made from the boat on two evenings when the boat was parked at several locations on the west side of the Preserve. These locations seemingly provided good viewing points to watch for birds returning to the Preserve from the direction of the barrier reef to the west.

White-tailed Tropicbird, *Phaethon lepturus*, Dudek

White-tailed tropicbirds are common in most of Palau and are frequently seen flying over islands singly or in small loose groups (Engbring, 1988). Tropicbirds were uncommon in the Ngerukewid Preserve with an estimated 8-10 birds present during the study. This species was recorded at 5% of all stations, with single individuals observed at one forest station and one boat station (Table 3.5). The largest number of birds seen at once was a group of 4 birds soaring over Island 24 and the adjacent lagoon. One active nest with a large fledgling(s) was discovered in limestone forest on Island 24C. The nest was 8 m high in the cavity of a large hollow tree on a hillside. An adult departed when the tree was approached, leaving the fledgling behind with its bill protruding from the nest hole.

Pacific Reef-Heron, *Egretta sacra*, Sechou

Reef-herons are common and found throughout Palau (Engbring, 1988). They were widespread but uncommon in the Ngerukewid Preserve. Reef-herons were primarily observed from the boat, and were recorded at 12% of the boat stations (7% of all stations) at an aggregate average of 0.09 birds/station (0.03 birds/station overall) (Table 3.5). None were observed at forest stations. A total of 19 observations was made (Table 3.6) and represented an estimated population of 6-8 birds. Birds occurred solitarily or in groups of two or three. Gray and white color phases were noted in about equal numbers. Birds preferred to forage in shallow water, particularly on beaches and sand flats exposed at low tides, rather than along the steep limestone undercuts of most islands. Although not determined, it is likely that the species breeds in the Preserve or on nearby islands.

Rufous Night-Heron, *Nycticorax caledonicus*, Melebaob or Sechou

This species is a common resident in much of Palau (Engbring, 1988). Its preferred feeding areas include mangroves and tidal flats, with mangroves also serving as favorite daytime roosting sites (Pratt et al., 1987). In the Ngerukewid Preserve, rufous night-herons were rare, with a single bird observed on three occasions near the small patch of mangroves on Island 24C. The bird roosted in the mangroves during the middle of the day. Another night-heron seen on Island 24S was probably the same individual bird.

Table 3.3. Occurrence of Palau frogs and reptiles in the Ngerukewid Islands Wildlife Preserve. Occurrence (x) is based on sightings and collected specimens made during the survey.

	Island									
Species	4	7	12	13	16	24	34	46	49	50
Platymantis pelewensis						x				
Sea turtles		x				x			x	x
Cryptoblepharus poecilopleurus								x		
Lamprolepis smaragdina			x		x	x		x		x
Eugongylus sp.					x	x		x		
unidentified skink #1			x			x				
unidentified skink #2	x									
Gekko sp.						x		x		
Lepidodactylus sp. #1	x				x		x			
Lepidodactylus sp. #2								x		
unidentified *Lepidodactylus*						x				x
Candoia carinata				x						
Dendrelaphis lineolatus						x				
Laticauda colubrina				x		x				

Table 3.4. Capture rates of small mammals and reptiles, Ngerukewid Islands Wildlife Preserve.

	Rat trap	Mouse trap	Sticky traps	
			Ground	Elevated
No. of trap nights	36	36	36	36
No. of animals captured	0	0	3[a]	0
No. of captures/trap night	0.00	0.00	0.08	0.00

[a] Three *Eugongylus* sp. were captured.

Table 3.5. Results of bird and bat surveys, Ngerukewid Islands Wildlife Preserve. Results as expressed as percent frequency of occurrence, total number of individuals observed, and aggregate average number of individuals observed per station. Species are listed in order of abundance as determined by the aggregate average number observed per station.

Species	% frequency of occurrence			Total number observed[a]			Aggregate average		
	Land	Boat	All	Land	Boat	All	Land	Boat	All
Birds									
Micronesian starling	94.1	75.0	82.9	41	53	94	2.41	2.06	2.30
Palau fruit-dove	64.7	58.3	61.0	31	29	60	1.49	1.19	1.40
Micronesian honeyeater	76.5	54.2	63.4	25	24	49	1.35	1.03	1.25
Mangrove flycatcher	82.4	54.2	65.9	25	24	49	1.19	1.06	1.15
Brown noddy	41.2	70.8	58.5	13	56	69	0.64	2.00	1.06
Black noddy	47.1	87.5	70.7	10	63	73	0.49	2.22	1.02
Island swiftlet	0.0	58.3	34.1	0	61	61	0.00	2.22	0.68
Micronesian pigeon	41.2	41.7	41.5	11	14	25	0.73	0.53	0.67
Collared kingfisher	47.1	50.0	48.8	12	18	30	0.62	0.78	0.67
Caroline Islands white-eye	5.9	25.0	17.1	3	30	33	0.08	1.09	0.39
Common fairy-tern	5.9	45.8	29.3	1	25	26	0.04	1.16	0.38
Bridled tern	0.0	45.8	26.8	0	38	38	0.00	1.19	0.37
Micronesian megapode	29.4	16.7	22.0	7	5	12	0.29	0.22	0.27
Palau fantail	11.8	0.0	4.9	3	0	3	0.33	0.00	0.23
Morningbird	11.8	8.3	9.8	3	2	5	0.19	0.09	0.16
Dusky white-eye	0.0	16.7	9.8	0	11	11	0.00	0.41	0.13
White-tailed tropicbird	5.9	4.2	4.9	1	1	2	0.04	0.03	0.04
Pacific reef-heron	0.0	12.5	7.3	0	3	3	0.00	0.09	0.03
Black-naped tern	0.0	4.2	2.4	0	2	2	0.00	0.06	0.02
Nicobar pigeon	0.0	4.2	2.4	0	1	1	0.00	0.03	0.01
Noddy spp.	0.0	37.5	22.0	0	86	86	0.00	2.69	0.83
White-eye spp.	11.8	8.3	9.8	3	8	11	0.26	0.25	0.26
Tattler spp.	0.0	8.3	4.9	0	2	2	0.00	0.09	0.03
Bats									
Micronesian fruit bat	0.0	91.7	53.7	0	119	119	0.00	4.25	1.31
Pacific sheath-tailed bat	0.0	8.3	4.9	0	5	5	0.00	0.16	0.05

[a] The average number of individuals observed per station can be calculated by dividing the total number observed per survey type by the number of stations conducted per survey type: land surveys-17 stations, boat surveys-24 stations, all surveys-41 stations.

Table 3.6. Total observations of birds, nests, and bats, Ngerukewid Islands Wildlife Preserve, by island. Numbers include survey data plus incidental sightings.

Bird, nest or bat	Island														
	1	2	3	4	5	6	7	10	11	12	13	14	15	16	17
Micronesian starling			6			1	6	1		11	13	1	1	59	4
Palau fruit-dove					2	6				3	6			27	1
Micronesian honeyeater	1		4	1	5	8	6	1		5	2			30	4
Island swiftlet					2	9	3			1	4			33	
Brown noddy				4		2		1			10			13	
Mangrove flycatcher					1	3	4		2	1				21	
Black noddy	3		4						1	10	5		3	8	1
Caroline Islands white-eye						5					12			33	
Micronesian pigeon					1	1	1				3			8	
Collared kingfisher				1	2	4				5				11	1
Micronesian megapode						3	1				6			8	
Bridled tern	1	2	2		5					2	6				
Common fairy-tern					5	6	3	2	2					2	
Dusky white-eye											7			11	1
Morningbird					1		1			2	6	1	1	2	
Pacific reef-heron						1								5	
Black-naped tern			2		10										
Nicobar pigeon										1				1	
Gr. sulphur-crested cockatoo															
Palau fantail															
White-tailed tropicbird	1													1	
Micronesian kingfisher											1			1	
Rufous night-heron															
Cicadabird											1				
Pacific golden plover			1												
Common sandpiper							1								
White-eye spp.					3		4				10			3	
Tattler spp.												1			
Nest w-t. tropicbird															
Nest brown noddy															
Nest collared kingfisher															
Megapode nest mound							2				1			1	
Total birds by island	6	2	19	6	37	49	30	5	5	41	92	3	5	277	12
Total nests by island	0	0	0	0	0	0	2	0	0	0	1	0	0	1	0
Micronesian fruit bat	2		2	3		8	2	2		4	2	4		61	4
Pacific sheath-tailed bat							4				12			6	
Total bats by island	2	0	2	3	0	8	6	2	0	4	14	4	0	67	4

Table 3.6. Continued.

Bird, nest or bat	Island													Total No.
	19	22	23	24N	24C	24S	26	28	34	39	46	48	50	
Micronesian starling	3	1		20	36	11	3	4			5		5	191
Palau fruit-dove		1		22	46	12					1			127
Micronesian honeyeater	1			26	7	16		1	1		5			124
Island swiftlet	6	1	1	36	2	4				3	8			113
Brown noddy	5	2	1	35	19	4							3	99
Mangrove flycatcher	2	1		19	21	9	1	1			6		4	96
Black noddy	5		3	34	4	4							3	88
Caroline Islands white-eye				10	7	9					3			79
Micronesian pigeon	1			11	25	9					2			62
Collared kingfisher	1			14	11	2	1				2		1	56
Micronesian megapode				7	17	4					1		2	49
Bridled tern	1	1	1	21				3						45
Common fairy-tern				6		9	1	1						37
Dusky white-eye				3	2	2					7			33
Morningbird				6	4	3								27
Pacific reef-heron				3	9					1				19
Black-naped tern		2		2		2								18
Nicobar pigeon				6	2	3				1				14
Gr. sulphur-crested cockatoo					6	4					2	2		14
Palau fantail					5	4								9
White-tailed tropicbird				2	4									8
Micronesian kingfisher				3										5
Rufous night-heron					1	1								2
Cicadabird														1
Pacific golden plover														1
Common sandpiper														1
White-eye spp.		3		6	20	16								65
Tattler spp.	1	1			1	1								5
Nest w-t. tropicbird					1									1
Nest brown noddy					1									1
Nest collared kingfisher					1	1								2
Megapode nest mound				1	1						3		1	10
Total birds by island	26	13	6	292	249	129	6	10	1	5	42	2	18	1388
Total nests by island	0	0	0	1	4	1	0	0	0	0	3	0	1	14
Micronesian fruit bat	7	1		66	8	15					3		1	195
Pacific sheath-tailed bat				5										27
Total bats by Island	7	1	0	71	8	15	0	0	0	0	3	0	1	222

Osprey, *Pandion haliaetus*, Chesucherubuokel

This species is a rare visitor to Palau and Micronesia (Engbring, 1988; Pratt et al., 1987). Ospreys have been previously recorded in the Ngerukewid Preserve, with a single bird observed by J. Engbring (pers. comm.) in August 1985. None were seen during this survey of the Preserve.

Micronesian Megapode, *Megapodius laperouse*, Bekai

Micronesian megapodes are common on the coralline islands south of Koror but are much rarer on the inhabited islands of Koror, Arakabesan, and Babelthuap (Pratt et al., 1980). Megapodes were found to be common in the Ngerukewid Preserve. They were recorded on 22% of all stations (29% of forest stations) at an aggregate average of 0.27 birds/station (0.29 birds/station in forests) (Table 3.5). Megapodes were noted on nine islands, each of which was larger than 2 ha in size (Table 3.6). Birds were encountered as individuals or pairs foraging on the ground. In addition to individuals calling, we frequently heard pairs dueting. In a number of instances, an individual's call triggered a duet response by a neighboring pair of birds.

A rough estimate of the number of Micronesian megapodes in the Ngerukewid Islands was determined from densities of birds recorded on two islands in the Preserve. Three pairs of birds were noted on Island 16 (density of 0.76 birds/ha), and four birds were detected on Island 13 (density of 1.60 birds/ha). These density figures may be somewhat conservative as additional birds may have gone undetected on both islands. Data from other islands were inconclusive but were generally similar. An extrapolation of density estimates for the eight islands in the Preserve that were larger that 2 ha gives a population estimate of 57-121 birds, with an additional 7-15 birds on the four largest islands west of the Preserve. These figures total 64-136 megapodes for the entire island group. We believe that an estimate of 60-90 birds, or 69-103 birds/km^2, is reasonable for the Ngerukewid Islands as a whole, with 50-80 birds present in the Preserve.

Ten nest mounds of megapodes were discovered in the Ngerukewid Islands, but only six appeared to be active. Nine mounds (five active and four inactive) occurred in strand forest behind sandy beaches. These were typically constructed of sand with small amounts of organic matter mixed in. A single active mound was also found in limestone forest on a hillside on Island 24C at an elevation of about 50 m. It was built entirely of leaf litter and detritus. It is possible that other mounds of this second type exist in the Preserve, although their occurrence is apparently rare in the rest of Palau (Pratt et al., 1980). The presence of at least six active nest mounds indictes that there is an average of one mound per 10-15 birds in the island group, or that each mound is used by approximately 5-8 females.

Megapodes have been observed to fly several km between islands elsewhere in Palau (Pratt and Bruner, 1978). Birds in the Ngerukewid Preserve probably show little aversion about flying to neighboring islands to reach nest mounds. We observed birds visiting mounds on three occasions. In all three instances, individual birds rather than pairs were seen at or in the vicinity of mounds. In one case, a bird appeared to fly in from an adjacent island to reach Beach E, Island 7.

Lesser Golden-Plover, *Pluvialis dominica*, Derariik

Lesser golden-plovers are common migrants to Palau (Engbring, 1988), but only one bird was recorded in this survey of the Ngerukewid Preserve. It was seen on Island 4 in a

small opening below a grove of *Casuarina litorea*. Plovers favor open fields and tidal flats, two types of habitat that are almost entirely lacking in the Preserve.

Common Sandpiper, *Actitis hypoleucos*, Bengobaingukl

This species is a common migrant in Palau and uses a wide variety of habitats near water (Engbring, 1988). One common sandpiper was recorded in the survey, this being an individual observed on Beach E, Island 7.

Tattlers, *Heteroscelus* sp.

Two species of tattler, the Siberian tattler (*H. brevipes*) and wandering tattler (*H. incanus*), occur as migrants in Palau. Both have similar winter plumages and are difficult to distinguish in the field. The Siberian tattler is the more common of the two species in Palau (Engbring, 1988). Five sightings of unidentified tattlers were made in the Ngerukewid Preserve (Table 3.6). Several of the observations occurred on the north side of the Preserve and probably represented one bird. Two individuals were sighted on boat surveys (8% of boat stations) at an aggrgate average of 0.09 birds/station (Table 3.5). Overall, just 2-3 birds may have been in the Preserve at the time of the survey. All birds were seen feeding at the water's edge under the rocky undercuts of islands. They were easily detected when flushed by boats passing nearby.

Black-naped Tern, *Sterna sumatrana*, Kerkirs

This species is a widespread resident of the Palau archipelago, being most common from southern Babelthuap to Peleliu (Engbring, 1988). In the Ngerukewid Preserve, black-naped terns were uncommon with an estimated 6-8 pairs of birds present. This species was observed only on one boat station and was not recorded on any forest counts (Table 3.5). Birds were always observed in pairs and breeding is suspected to occur in the Preserve. Pairs were generally solitary and typically roosted 3-10 m high on vertical rock faces above the water. Engbring (1988) reported that black-naped terns roost and nest on sheer rock cliffs, and only seldom venture out of the main lagoon to feed.

Bridled Tern, *Sterna anaethetus*

Bridled terns are common residents in Palau's high limestone islands from Koror to Mecherchar (Engbring, 1988). This seabird was common in the Ngerukewid Preserve, but numbered far fewer than black noddies or brown noddies. Bridled terns were recorded only at boat stations; they were seen at 46% of those stations and occurred at an aggregate average of 1.19 birds/station (Table 3.5). Birds were noted throughout the Preserve (Table 3.6). This species normally roosts and nests in small colonies on cliffs (Engbring, 1988). In the Ngerukewid Preserve, bridled terns were seen in small groups of 6-10 birds sitting on rock faces over water. Birds were noted in the Preserve during the day and returning at dusk from the direction of the western barrier reef, beyond which they had presumably been feeding.

Brown Noddy, *Anous stolidus*, Mechadelbedaob

This species is abundant in Palau and occurs widely from Kayangel to Peleliu (Engbring, 1988). Brown noddies were found to be abundant in the Ngerukewid Preserve and were observed at 59% of all stations (71% of all boat stations and 41% of all forest stations) (Table 3.5). They were recorded at an overall aggregate average of 1.06

birds/station (2.00 birds/station at boat stations and 0.64 birds/station at forest stations). Noddies were often noted flying among the islands of the Preserve throughout the day. Larger numbers of these seabirds arrived in the Preserve at dusk, flying in from the direction of the outer edge of the lagoon, returning from feeding trips at sea. These terns are pelagic feeders, foraging mainly outside Palau's barrier reef (Engbring, 1988; Pratt el al., 1987).

Brown noddies reportedly nest year-round in Palau (Engbring, 1988). During the survey, two active noddy nests were found on hillsides in limestone forest on Island 24S, C. One nest was 9 m high in a tree and was constructed of dead leaves. It was hidden in thick foliage and held a single egg. The second nest was 10 m high in the cup of an aerial *Asplenium nidus* fern and contained a fully feathered nestling that was fed twice by a parent during 10 minutes of observation. In addition, a number of birds were observed to pick floating twigs off the surface of calm waters between islands, presumably to use as nesting material.

Black Noddy, *Anous minutus*, Bedaoch

The black noddy is found throughout Palau and is considered to be the most abundant tern in the archipelago (Engbring, 1988). This species was also the most abundant seabird on station counts made in the Preserve. It occurred on 71% of all counts (87% of boat counts and 47% of forest counts) and was recorded at an aggregate average of 1.02 birds/station overall (2.22 birds/station at boat stations and 0.49 birds/station at forest stations) (Table 3.5). We observed flocks of 20-30 birds feeding in the shallow reef flats immediately adjacent to the islands of the Preserve, with concentrations of hundreds of birds further out in the lagoon.

This species breeds throughout the year and commonly nests in vegetation overhanging water (Pratt et al., 1980). In this survey, a pair of active nests were found in *Bikkia* shrubs leaning out over water on Island 13. Adults sat on each nest but we were unable to determine whether eggs or young were present.

Common Fairy-Tern, *Gygis alba*, Sechosech

This species is common on most islands in the Palau archipelago (Engbring, 1988). Fairy-terns were also common in the Ngerukewid Preserve and were recorded on 29% of all station counts (46% of all boat counts and 6% of all forest counts) at an aggregate average of 0.38 birds/station overall (1.16 birds/station at boat stations and 0.04 birds/station at forest stations) (Table 3.5). They were almost always seen flying alone or in small groups among the islands of the Preserve, but little additional information was obtained for this species. Engbring (1988) reported that these birds are commonly associated with inland and coastal forests on islands, where they roost and nest.

Nicobar Pigeon, *Caloenas nicobarica*, Laib

In Palau, Nicobar pigeons range from Babelthuap to Peleliu, where they vary from being uncommon to rare (Pratt et al., 1980; Engbring, 1988). This species was uncommon in the Preserve. It was recorded only once on station counts (Table 3.5), but 2-3 birds per day were encountered during other field activities. Most sightings were of foraging pigeons flushed from the ground in limestone forest or of birds flying high overhead between the islands of the Preserve. This species was recorded on five widespread islands, most of which were large (Table 3.6). Pratt et al. (1980) suggested that Nicobar pigeons may be more common than believed and are probably overlooked because of their secretive habits and quiet behavior. We had similar observations and concluded that the

species may be more common in the Ngerukewid Preserve than indicated by our survey data.

Palau Ground-Dove, *Gallicolumba canifrons*, Omekrengukl

This species is a rare forest dweller throughout Palau, but is considered to be somewhat more common on small limestone islands (Engbring, 1988). Ground-doves were not recorded during this survey and appear to be absent from the Ngerukewid Preserve. These doves typically feed on the ground and are not considered to be especially secretive (Engbring, 1988), thus we believe that they would have been encountered during the survey had they been present.

Palau Fruit-Dove, *Ptilinopus pelewensis*, Biib

Palau fruit-doves are abundant and widely distributed in Palau (Pratt et al., 1980; Engbring, 1988). They were the second most abundant bird in the Ngerukewid Preserve as determined by count data, and were recorded on 61% of all stations at an aggregate average of 1.40 birds per station (Table 3.5). Fruit-doves were noted more frequently on station counts made on larger islands with greater forest development and appeared to avoid small islands with scrubby forests (Tables 5 and 6). This dove's predominantly green plumage and its use of the upper canopy made it difficult to see and consequently, most records were of calling birds. One instance of a fruit-dove feeding on the flowers of *Intsia bijuga* in beach strand forest was noted.

Micronesian Pigeon, *Ducula oceanica*, Belochel

These large pigeons occur from Babelthuap to Peleliu with densities varying widely among islands (Pratt el al., 1980). Micronesian pigeons were widespread and common throughout the Ngerukewid Preserve and occurred on 41% of all station counts at an aggregate average of 0.67 birds/station (Tables 5 and 6). They were recorded in greater numbers on forest stations (aggregate average of 0.73 birds/station) than from the boat (aggregate average of 0.53 birds/station). As with the other fruit-eating doves, this species was noted more frequently on larger islands with taller forest and greater numbers of fruit-producing trees. Birds foraged in the upper canopy and called from perches hidden in foliage.

Greater Sulphur-crested Cockatoo, *Cacatua galerita*, Iakkotsiang

Cockatoos were introduced to Palau in the 1940s and have established populations in the limestone islands (Engbring, 1988). Cockatoos are rare in the Ngerukewid Islands with two pairs of birds recorded during the survey. None were observed during station counts. One pair was seen and heard repeatedly on Island 24C,S, particularly in the vicinity of the largest hill in the center of the island. A second pair of cockatoos was seen flying between Islands 46 and 48, and probably made use of Islands 49 and 50 as well. We are certain these few birds represented the entire population in the Ngerukewid Islands. This species is easily detected because of its loud calls and habit of flying above the forest canopy.

Elsewhere in Palau, cockatoos feed on the hearts of two species of endemic palms and are responsible for killing large stands of these trees (Engbring, 1988). The palm *Gulubia palauensis* is common in the Preserve, indicating perhaps that populations of cockatoos have never been large in the Ngerukewid Islands. This species nests in tree cavities.

Nestlings are often captured by local residents, who are able to sell the birds for lucrative prices in the pet trade.

Palau Owl, *Pyrrhoglaux podargina*, Chesuch

The Palau owl is a common forest resident on Palau's major islands as well as on many smaller limestone islands (Engbring, 1988). Owl populations have apparently recovered from low post-World War II levels (Engbring and Pratt, 1985), causing the removal of this bird from the U.S. Endangered Species List in 1985. Surprisingly, owls were not detected during the survey and appear to be absent from the Ngerukewid Preserve. Birds did not respond to tape-recorded calls during the night-time survey of Island 24 and surrounding islands, nor were they heard calling from any other island during four nights spent in the Preserve.

Island Swiftlet, *Aerodramus vanikorensis*, Chesisekiaid

This species is abundant on most of Palau's islands (Pratt et al., 1980; Engbring, 1988). In the Ngerukewid Preserve, swiftlets occurred in moderate numbers and was considered to be common to abundant. These birds were recorded only at boat stations, occurring at 58% of these counts with an aggreagte average of 2.22 birds/station (Table 3.5). While foraging, birds typically flew silently over the forest canopy, thus none were recorded on counts made on land. Overall, swiftlets were found on 34% of all station counts with an aggregate average of 0.68 birds/station (Table 3.5). Birds were widely distributed in the Preserve (Table 3.6).

A small active colony of swiftlets was found on Island 24N in a cave that was also used as a roost by about 200 Pacific sheath-tailed bats. (A description of this and other caves visited in the survey is included in the species account for sheath-tailed bats.) The cave contained 13 swiftlet nests, many of which were visited by birds in our presence, perhaps indicating that eggs or young were present. Ten of the nests occurred in a faintly lit room that was next to the entrance and was also used by the bats. The remaining nests were located deeper in the cave in nearly complete darkness.

A second large cave on Island 16 and several small caves elsewhere in the Preserve did not contain swiftlets or guano. On several islands, birds were regularly seen flying near rock overhangs above the water. Closer examination revealed that none of these sites had nests. Because swiftlets were observed foraging until dark, the Preserve's entire population of these birds is believed to be resident rather than commuting to caves on other distant islands. One or more undiscovered caves must still exist in the Preserve and probably holds the bulk of the swiftlet population.

Collared Kingfisher, *Halcyon chloris*, Tengadidik

The collared kingfisher is the larger of Palau's two kingfishers and is common throughout the island chain (Pratt et al., 1980; Engbring, 1988). It is most abundant in coastal areas but also occurs in savanna and forested uplands on a few islands (Pratt et al., 1980). This species was common in the Ngerukewid Preserve and exhibited a strong association with areas next to water. It was recorded on 49% of all stations with an aggregate average of 0.67 birds/station (Table 3.5). A number of birds were seen flying between islands or perched on exposed branches over water. Sightings of this species were distributed throughout the Preserve (Table 3.6).

Two inactive nests belonging to collared kingfishers were found on Island 24C. Both were located near the water's edge in termite mounds attached to tree trunks or roots. The nests were 1-2 m above the ground at 5-15 m elevation.

Micronesian Kingfisher, *Halcyon cinnamomina*, Cherosech

In Palau, *H. cinnamomina* ranges from Babelthuap to Peleliu with its abundance varying from common to uncommon (Engbring, 1988; Pratt et al., 1987). During this survey, kingfisher calls that differed slightly from those of *H. chloris* were heard on five occasions, all incidental to station counts. These were probably given by Micronesian kingfishers although the identities of the birds involved were never confirmed visually. The calls were heard on Islands 24N,C, 16, and 13. All occurred in tall upland limestone forest inland from the shoreline.

Palau's two species of kingfishers typically segregate themselves by habitat with *H. chloris* avoiding the deep forests that are preferred by *H. cinnamomina* (Pratt et al., 1980). We believe that a small population of Micronesian kingfishers lives in the Preserve and that the species can be considered as uncommon. Because these birds are somewhat retiring in their habits, their numbers may have been slightly underestimated. The species probably occurs on most of the larger elevated islands with well-developed forest.

Cicadabird, *Coracina tenurostris*

Cicadabirds are widespread but uncommon in the rest of Palau (Pratt et al., 1980). This species was rare in the Preserve with only one bird recorded during the survey. A female was seen on Island 13 as it moved slowly through the forest canopy above Beach B. No other birds were recorded on station counts. It is possible that a small breeding population of cicadabirds exists in the Preserve and that other individuals were overlooked. Typically, these birds are difficult to detect because of their characteristic retiring and inconspicuous behavior, and their preference for foraging in treetops (Engbring, 1988; Pratt et al., 1987).

Morningbird, *Colluricincla tenebrosa*, Tutau

Morningbirds occur commonly from Babelthuap to Peleliu (Pratt et al., 1980; Engbring, 1988). Survey data suggested that this species was uncommon in the Ngerukewid Preserve. It occurred on only 10% of the stations counts (12% of forest stations and 8% of boat stations) at an aggregate average of 0.16 birds/station (0.19 birds/station in forests and 0.09 birds/station at boat stations) (Table 3.5). Morningbirds were rarely heard to call during the survey, and thus birds that were nearby but out of direct visual contact may have gone unrecorded on counts. We encountered birds more often while hiking through the Preserve and suspect that this species is slightly more common than indicated here. It probably occurs at moderate densities on most islands in the Ngerukewid Preserve. Pratt et al. (1980) indicated that morningbirds are most vocal before dawn and often follow an observer silently.

This species is a solitary skulker that feeds slowly and deliberately in the forest understory (Pratt et al., 1980). In the Ngerukewid Preserve, individuals or pairs were commonly seen foraging on the ground or less than a meter high in understory vegetation. On a number of occasions, we witnessed a possible courtship display in pairs of adults that consisted of one bird rapidly fluttering its wings in front of its companion in a manner similar to that performed by begging juveniles of many other bird species.

Mangrove Flycatcher, *Myiagra erythrops*, Chermelachull

The mangrove flycatcher ranges from Babelthuap to Peleliu and is common in all types of forest, especially mangroves (Pratt et al., 1980; Engbring, 1988). We considered the flycatcher to be abundant and well distributed in the Preserve. It was found on 66% of all station counts (82% of the counts in the forest) at an aggregate average of 1.15 birds/station (1.19 birds/station on forest counts) (Table 3.5). This species occurred primarily in higher quality limestone forest but was also observed in strand forest and on small islands with scrubby limestone forest. Birds foraged at a variety of heights, ranging from the understory to the upper canopy.

Palau Fantail, *Rhipidura lepida*, Melimdelebteb

Fantails are widespread and common in a variety of forest types in Palau (Engbring, 1988; Pratt et al., 1987). Numbers have apparently increased since World War II (Pratt et al., 1980), resulting in the removal of the species from the U.S. Endangered Species List in 1985. This species was rare in the Ngerukewid Preserve. It was found only in limestone forest on Island 24C,S, where a total of two pairs and a solitary bird were noted. Three of these individuals were detected on two (12%) of the forest station counts for an aggregate average of 0.33 birds/station (Table 3.5). None were observed from the boat. The conspicuous behavior of these birds makes it doubtful that many were overlooked during the survey. The presence of paired birds indicates that breeding probably occurs in the Preserve.

Micronesian Starling, *Aplonis opaca*, Kiuid

Micronesian starlings are widely distributed in Palau and are considered to be the most abundant forest bird in the archipelago (Baker, 1951; Pratt et al., 1980). Counts made in this survey indicated that starlings were also the most common bird in the Ngerukewid Preserve, being present on 83% of all station counts with an aggregate average of 2.30 birds per station (Table 3.5). The species was more common on station counts made in forests, where it occurred on 94% of the stations at an aggregate average of 2.41 birds per station (Table 3.5). Starlings occurred throughout the Preserve in limestone and strand forests and were one of the only species found on the smallest islands with poor forest development (Table 3.6). Birds were frequently seen flying in small flocks between islands. Individuals were noted to feed repeatedly on the fruit of a *Ficus* tree on Island 16.

Micronesian Honeyeater, *Myzomela rubrata*, Chesisebangiau

The Micronesian honeyeater occurs throughout Palau and is common and conspicuous near forest edges and openings, and in other disturbed habitats (Pratt et al., 1980; Engbring, 1988). This species was abundant in the Ngerukewid Preserve, occurring on 63% of all stations at an aggregate average of 1.25 birds/station (Table 3.5). In contrast to the observations of Pratt et al. (1980), we commonly found honeyeaters in the Preserve's tall undisturbed forest and recorded them more frequently inside the forest (on 76.5% of forest stations and at an aggregate average of 1.35 birds/staion) than from boat stations (Table 3.5). Honeyeaters also made frequent use of strand forest and were one of the few forest birds that occurred regularly on smaller islands with poorer limestone forest . Birds were often noted chasing each other at high speeds through the canopy and even between islands. One bird was seen feeding on flowers of *Gulubia palauensis*.

Caroline Islands White-eye, *Zosterops semperi*, Chetitalial

This species is common on most islands from Babelthuap to Peleliu (Pratt et al., 1980; Engbring, 1988). Caroline Islands white-eyes can be classified as common in the Ngerukewid Preserve even though they were recorded on only 17% of all stations at an aggregate average of 0.39 birds/station (Table 3.5). The species was detected more frequently during boat counts (25% of all stations at an aggregate average of 1.09 birds/stations) than at forest stations (6% of all stations at an aggregate average of 0.1 birds/station) (Table 3.5). Unidentified white-eyes, some of which may have been *Z. finschii*, occurred at an additional 10% of all stations (12% of forest stations and 8% of boat stations) at an aggregate average of 0.26 birds/station (Table 3.5). *Z. semperi* was seen only on islands that were larger than 2.5 ha in size (Table 3.6), indicating this species has a preference for taller forest with a closed canopy.

These white-eyes are gregarious and associated in groups of 5-15 birds. Birds foraged in the upper canopy and were constantly in motion, making individuals in flocks difficult to observe and identify as they flew overhead. Birds were seen feeding avidly on the flowers of *Aidia racemosa.*

Dusky White-eye, *Zosterops finschii*

Dusky white-eyes are common to abundant throughout most of Palau and frequent most habitats (Pratt et al., 1980). They were uncommon in the Ngerukewid Preserve and were identified on only 10% of all stations with an aggregate average of 0.13 birds/station (Table 3.5). During standardized counts, dusky white-eyes were only observed at boat stations, occurring on 17% of station counts at an aggregate average of 0.41 birds/station (Table 3.5). Dusky white-eyes were occasionally observed in mixed flocks with *Z. semperi*. Both species share the same habits of foraging in the upper canopy layer and being constantly active. As with *Z. semperi*, dusky white-eyes were noted only on larger islands (Table 3.6).

Micronesian Fruit Bat, *Pteropus mariannus pelewensis*, Olik

Although fruit bats in Palau have been heavily hunted over the past 15 years for use as an exported food item, this species is apparently still common is much of the archipelago (Wiles and Payne, 1986). Fruit bats were abundant and widely distributed in the Ngerukewid Preserve, being found on most islands visited in the survey (Table 3.6). Bats were observed flying between many of the islands in the Preserve. Despite this abundance, fruit bats were recorded only on boat counts and never noted on morning forest counts. They were seen on 92% of the boat counts at an aggreagate average of 4.25 bats per station (Table 3.5). The results reflect that fruit bats are more easily counted from boats anchored near islands where hillsides can be viewed rather than from stations located inside the forest. Bats also appeared to be more active in the afternoon, with moderate to large numbers of animals seen feeding from 1600 to darkness (at about 1830).

A rough estimate of the number of Micronesian fruit bats in the Ngerukewid Preserve was determined from the number of bats seen on the two sets of evening counts made from the boat. Approximately 32.7% of the Preserve was surveyed on this transect, with 43 and 55 bats observed on the two nights, respectively. An extrapolation of this data for the whole Preserve produces an estimated population of 131-168 fruit bats, or a density of 150-192 bats/km^2. The accuracy of station counts in estimating the sizes of bat populations has never been verified. Count results may be questionable because some individuals may be tallied more than once as they fly about, while others may not be counted at all if they do not fly and are not seen. These factors may cancel each other out to some extent. Our estimate of 130-170 bats in the Preserve is tentative although it seems

like a reasonable amount considering the frequency with which bats were sighted. We gathered little information on fruit bat abundance on the islands west of the Preserve, but bat densities there are probably similar to those in the reseve.

Little has been published on the natural history of Palau's fruit bats. In contrast to other populations of *P. mariannus* in Micronesia, *P.m. pelewensis* is not known to aggregate in colonies during the daytime. All bats seen in this survey and by Perez (1968) roosted solitarily or in small groups of 2-4 animals. Elsewhere, colonies of *Pteropus* are typically noisy and readily visible, which aids in their detection (Wiles 1987). The terrain of the Ngerukewid Preserve, which is characterized by steep hillsides with few hidden valleys or plateaus, is conducive to locating bat roosts. After 10 days of field work in the Preserve, we are confident that no colonies of fruit bat were present.

Ten to 12 female fruit bats were observed in flight with attached young during the survey. Young of this size probably ranged in age from a few days to perhaps 4-6 weeks old, indicating that births occurred sometime between late November and early January. Perez (1968) suggested that peak breeding activity in *P. m. pelewensis* does not occur during the late autumn and winter months but admitted that his conclusion was based on little data.

Most species of *Pteropus* have diverse diets that include fruit, nectar, pollen, and sometimes leaves (Marshall, 1985). In the Ngerukewid Preserve, fruit bats were noted to feed on the fruits of *Ficus* sp., *Pandanus tectorius*, and *Cycas circinalis*, the flowers of *Intsia bijuga* and *Gulubia palauensis*, and the leaf stems of *Artocarpus mariannensis*. *Intsia bijuga* was heavily in bloom during the survey and large numbers of fruit bats were attracted to its flowers. Up to five bats were commonly seen foraging in single trees at once. Several observations of bats visiting the flowers of *Gulubia palauensis* indicate that it is also a favored food. Elsewhere in southern Palau on the islands of Peleliu and Ngercheu, we noted that *P. m. pelewensis* fed on the fruit of *Eugenia malaccensis*, *Terminalia catappa*, and *Neisosperma oppositifolia*. On Koror, fruit bats are reported to eat the fruit of *Mangifera indica* (D. Hopper, pers. comm.).

Palau Fruit Bat, *Pteropus pilosis*

This species of fruit bat is endemic to Palau and is much larger than *P. m. pelewensis*. Nothing is known of its distribution in Palau or of its natural history. Only two specimens have ever been collected, both prior to 1874 (K.F. Koopman, pers. comm.), and the species may now be extinct. No noticeably large fruit bats were noted in the Ngerukewid Preserve during this survey. All of the fruit bats observed were moderate in size and were believed to be *P. m. pelewensis*.

Pacific Sheath-tailed Bat, *Emballonura semicaudata*, Chesisualik

This small insectivorous bat is considered to be abundant throughout Palau (Owen, 1977). Data gathered in this study indicate that sheath-tailed bats are uncommon in the Ngerukewid Preserve. Bats were seen flying at dusk on only two of the four nights spent in the Preserve and were never recorded in large numbers (usually 4-5 animals per location) at twilight. They were recorded at two (8%) of the 24 boat stations and occurred at an aggregate average of 0.16 bats per station (Table 3.5). Bats began to emerge from roosts near sunset with times of first sightings occurring at 1810 hr on one evening and at 1726 hr on a second, more cloudy evening. Future efforts to sample sheath-tailed bats at night with mist nets or harp traps may reveal that these animals are more common than indicated here by these few sightings at dusk. Bats were seen on Islands 7, 13, 16, and 24, an indication that the species forages widely throughout the Preserve.

Two fairly large caves were inspected for sheath-tailed bats during the survey. One cave with a colony of about 200 *E. semicaudata* was discovered on Island 24. It had two chambers, each estimated to be 25-30 m long, 5-15 m wide, and 3-10 m tall. Both chambers had entrances. The bats resided only in one small dimly lit room that was located just inside one of the entrances. This room was approximately 5 m long, 3 m wide, and 5-6 m tall. The bats were spread over most of the ceiling, with animals roosting 10 cm or more from neighboring bats. All bats appeared to hang from the open ceiling rather than inside crevices. The room was shared with a small number of island swiftlets which had built about 10 nests that were distributed across the ceiling among the bats. Nearly all bats took flight immediately when an observer entered the room. Most seemed to mill around inside the cave after being disturbed but some may have departed entirely. The cave did not have large accumulations of fresh guano. However, deposits of extremely soft soil were found in some places on the cave's floor and had probably formed from decomposed guano. The cave showed no signs of having been visited by people.

A second large cave, which was located on Island 16, did not contain sheath-tailed bats or guano. It had a main room that was about 75 m wide and 30 m long with several smaller chambers branching off and appeared to be of appropriate size for bats. Small caves that were a few meters long were found on several other islands but never contained bats.

Other caves probably exist in the Preserve. A tight flock of 12 bats suddenly appeared over Island 13 and fed briefly one afternoon at 1500 hr. Their roost, which was never discovered, was possibly inadvertantly disturbed by other members of the survey party working near the hill top.

Small Mammals, Beab

Small mammals that have been introduced to Palau include the musk shrew (*Suncus murinus*), house mouse (*Mus musculus*), and four species of rats (*Rattus* spp.) (Owen, 1977). Most of these animals are commensal with man but two species have established populations in forested areas. These are the Polynesian rat (*R. exulans*), which is common throughout Palau, and the roof rat (*R. rattus*), which is present to a lesser extent in forest (Owen, 1977).

Rodents and shrews appear to be absent from the Ngerukewid Islands with no evidence of their presence detected in the survey. Trapping was conducted on Islands 16 and 24N, C. No animals were captured during a combined total of 144 trap nights using rat, mouse, and sticky traps (Table 3.4, Figure 3.2). This effort was not extensive enough to prove conclusively that small mammals are absent from the Preserve and adjacent islands. However, the lack of any small mammal sightings by members of the terrestrial survey team during the entire 10-day study period supports this conclusion. As an interesting contrast to this, rats were so numerous on Ulong and Euidelchol, two other limestone islands in southern Palau, that several animals could be seen within minutes of going ashore on each island.

Dugong, *Dugong dugon*, Mesekiu

Aerial surveys of Palau's lagoon in 1977-1978 and 1983 estimated that only a small population of perhaps 50 dugongs remains in Palau (Brownell et al., 1981; Rathbun et al., 1988), although this figure is regarded as too low by some Palauans. Heavy dugong poaching was reported in both studies, causing Brownell et al. (1981) to predict that Palau's dugong population would become extinct by the year 2000 if illegal hunting was not reduced.

Dugongs were not observed in this study. Sightings of dugongs in or near the Preserve are not documented, although several animals were seen in the general vicinity of the Ngerukewid Islands during the surveys of Brownell et al. (1981) and Rathbun et al. (1988). Seagrass beds are rare in the Ngerukewid Islands, thus dugongs may rarely enter the Preserve. However, this species makes use of loafing areas during the day that are near reefs, patch reefs, or shipwrecks, and are remote from extensive seagrass beds (Brownell et al., 1981). Thus, the lack of seagrass in an area may not be a reliable indicator of dugong absence.

DISCUSSION

Although limited in scope, we believe that our bird, mammal, and reptile surveys were adequate to determine the presence and relative abundance of the terrestrial fauna found in the Ngerukewid Preserve. This study found that the Preserve supports a variety of wildlife that inhabit Palau's other limestone islands and fullfils one of the primary missions of a preserve, which is to protect a representative fauna of an area. In this regard, the Preserve is an excellent choice for a protected area and should be looked upon as a valuable asset for the people of Palau.

Excluding introduced species, the fauna of the Palau Islands is comprised of one species of amphibian, approximately 32 species of reptiles, 146 species of birds with 43 of these breeding in the archipelago, and four species of mammals (Owen, 1977; Pyle and Engbring, 1985; R. Crombie, pers. comm.). Based on the results of this study, the Ngerukewid Islands are known to contain one amphibian, approximately 14 species of reptiles, 28 species of birds, with all but five of these probably breeding in the Preserve, and three species of mammals.

Birds and Bats

The Preserve contains sizable populations of several species that are rare, declining, or hunted elsewhere in Palau, such as the Micronesian megapode, Micronesian pigeon, Nicobar pigeon, Palau fruit-dove, and Micronesian fruit bat (Engbring, 1988). The Preserve should provide safe and secure habitat for these vulnerable species in the future. The Preserve also supports populations of several bird species endemic to the Palau Islands, such as the Palau fantail, Palau fruit-dove, morningbird, mangrove flycatcher, and dusky white-eye. Their presence in the Preserve will help to insure their continued survival in the future. Sea birds are also well represented, with several species (i.e., the black noddy, brown noddy, and bridled tern) being particularly common, further adding to the value of the Preserve.

Although observations of breeding were lacking for most species, the isolation of the area, population sizes, presence of paired individuals, and observations of breeding behavior for some species suggests that nearly all of the forest birds, sea birds, and bats occur as breeding populations in the Preserve. Exceptions to this may be the rufous night-heron, for which only a single individual was found, and several species of migratory shorebirds. Although no large breeding colonies of sea birds are present, such as those reported for the black noddy on the remote Fanna and Helen Islands southwest of Palau (Engbring, 1988), the isolated and uninhabited nature of the Preserve makes it a highly suitable location for sea birds to breed in moderate numbers.

Most birds and bats were distributed throughout the Preserve. Although survey design and time limitations did not allow a critical appraisal of habitat associations, we noted a general trend of greater species diversity on larger islands that had high quality forest. This was particularly true for some species such as the doves, white-eyes,

Micronesian kingfisher, and Micronesian megapode, which seemingly preferred tall forest with an unbroken overstory.

A number of species that occur elsewhere in Palau's heavily forested limestone islands were not detected in the Ngerukewid Preserve. These included the Audubon's shearwater, yellow bittern (*Ixobrychus sinensis*), banded crake (*Rallina eurizonoides*), Palau ground-dove, Palau owl, jungle nightjar (*Caprimulgus indicus*), Palau bush-warbler (*Cettia annae*), giant white-eye (*Megazosterops palauensis*), and blue-faced parrotfinch (*Erythrura trichroa*). The rufous night-heron, cicadabird, and Palau fantail were present but rare in the Preserve. Bitterns, night-herons, and rails appear to be limited by lack of habitat, but the absence of even small numbers of the other species is puzzling. Biogeographical factors, such as the Preserve's small land mass and distances from neighboring islands, may play a role in the occurrence of these species. The lack of fresh water wetlands, mudflats, or large expanses of exposed tidal reef flats greatly limits the value of the Preserve for migrant shorebirds and waterbirds.

Herpetofauna

The small variety of reptiles in the Ngerukewid Islands is possibly related to several factors including the relative isolation of the Ngerukewid Islands from large neighboring islands, the small total land area of the island group, and the predominance of a single habitat on the islands. Limestone forest comprises about 99% of the land area on these islands, with strand forest being the only other terrestrial habitat. However, because faunal surveys of Palau's other limestone islands are lacking, it may be premature to conclude that the reptile fauna of the Ngerukewid Islands is relatively depauperate in comparison with other islands in southern Palau.

Densities of lizards and snakes were generally low throughout the Preserve and adjacent islands. In limestone forest, observation rates for each lizard species were less than one animal seen per hour for day and night searches (Table 3.2). Low capture rates of lizards on sticky traps corresponded with the low rates of observations (Table 3.4). The abundance of lizards in the Ngerukewid Islands appears to be much lower than on other islands in Micronesia, such as Rota and Tinian in the Marianas and Ulithi Atoll near Yap (Wiles, pers. observ.).

As with some birds, the distributions of reptiles and frogs did not appear to be uniform in the Preserve. Larger islands generally had greater numbers of species present than did smaller islands (Table 3.3). Many of the islands in the Preserve are less than a hectare in size and do not offer well-developed forest to sustain diverse lizard populations. Forests on larger islands tend to have greater plant diversity and size variation, plus beach strand forest is present on some of these islands. Further studies will undoubtedly expand the known distributions of many reptiles in the Preserve and will clarify their biogeographical relationships.

Rates of lizard observations were slightly higher in beach strand forest, but this is somewhat biased by the inclusion of data from Beach H, Island 46, where lizard densities were noticeably higher. Other strand areas had small lizard populations. The greater lizard diversity of Beach H may have been related to its large size. It was the largest beach strand area in the Ngerukewid Islands, being approximately 3,500 m^2 in size, whereas nine other beaches averaged 620 m^2 (maximum area = 1,100 m^2). At several larger beach strands visited outside the study area on the islands of Euidelchol and Ngercheu, skink populations were noticeably high, further indicating that larger beaches may typically have greater populations of lizards.

Current Levels of Hunting in the Preserve

Collecting of turtle eggs and the catching of coconut crabs (*Birgus latro*) appear to be the only major forms of hunting that presently occur in the Preserve. The amount of hunting of birds and fruit bats with pellet guns was difficult to determine. This type of gun is the only weapon that can be legally used for hunting in Palau at present. No recent evidence of hunting of fruit bats or birds with shotguns, which are illegal but probably still widely used (Wiles and Payne, 1986), was found. Only two shotgun shells, both badly rusted and probably at least 10 years old, were discovered in the survey. Hunting parties were not encountered during the survey, which is possible evidence that few hunters visit the Preserve. The relatively large populations of pigeons and fruit bats in the Preserve also indicate that extensive hunting for these animals does not occur. These species appear to be more numerous in the Preserve than on many of Palau's other islands (J. Engbring, pers. comm.). Some collecting of megapode eggs may occur in the Preserve, as it does elsewhere in archipelago (Owen, 1977; Pratt et al., 1977), but no direct evidence of this was found.

In the rest of Palau, hunting of wildlife is a common and widespread activity. The most sought after species include sea turtles, fruit bats, Micronesian pigeons, Nicobar pigeons, saltwater crocodiles, dugongs, and various types of land crabs (Brownell et al., 1981; Pratt et al., 1980; Pritchard, 1981; Johannes, 1981; Engbring and Pratt, 1985; Wiles and Payne, 1986). The eggs of sea turtles and Micronesian megapodes are also commonly collected. Although few data exist, overhunting has been implicated in reducing the populations of many of these species (Owen, 1977; Pratt et al., 1980; Pritchard, 1981; Brownell et al., 1981; Engbring and Pratt, 1985; Wiles and Payne, 1986). Most animals are taken for local use by residents, however, a thriving business in exporting fruit bats to Guam and Saipan exists (Wiles and Payne, 1986). In 1987 alone, approximately 7,000 fruit bats were shipped to Guam (Wiles, 1987). Products made from hawksbill turtle shells are also widely available in Koror for purchase by tourists.

Under current Palau legislation, most forms of wildlife are protected from hunting. Protected species include the dugong and most birds, with the exception of the collared kingfisher, both introduced species of parrots, red junglefowl (*Gallus gallus*), and the Micronesian pigeon which can be legally taken. Sea turtles can be legally harvested from February to May and September to November provided that shell lengths exceed 27 inches for hawksbills and 34 inches for green sea turtles. The collecting of turtle eggs is prohibited year-round.

Rare and Endangered Species in the Ngerukewid Preserve

The Ngerukewid Preserve contains several species of wildlife that are rare in Palau and have received legal protection from the U.S. Fish and Wildlife Service (USFWS) or the government of the Trust Territory of the Pacific Islands (TTPI). Two of these species, the Micronesian megapode and Nicobar pigeon, reside in the Preserve in appreciable numbers. The megapode is listed as endangered by the USFWS and the TTPI, while the pigeon has been proposed for endangered status by the USFWS. A third species of bird, the Palau fantail, is a rare and suspected breeder in the Preserve. It was removed from the U.S. Endangered Species List in 1985 but is still considered endangered under TTPI law. Two kinds of sea turtles are believed to occur in the Preserve with hawksbill turtles nesting on some beaches. The USFWS listed it and the green turtle as threatened but an exemption in the law allows citzens of the TTPI to harvest turtles on a subsistence basis. Two other species, the saltwater crocodile and dugong, are reported to visit the Preserve very rarely and neither are known to breed there. Both species are considered endangered by the USFWS, and the dugong is additionally listed as endangered by the TTPI.

Palau has several other species of wildlife that are rare or legally listed as endangered (Engbring and Pratt, 1985), but none of these occur in the Ngerukewid Preserve. They include the gray duck (*Anas superciliosa*) (endangered under TTPI law), purple swamphen (*Porphyrio porphyrio*) (rare, Engbring and Pratt, 1985), Palau ground-dove (endangered, TTPI), Palau owl (endangered, TTPI), jungle nightjar (probably rare, Engbring and Pratt, 1985), white-breasted woodswallow (*Artamus leuocorhynchus*) and blue-faced parrotfinch (both species are endangered, TTPI, and candidate endangered species, USFWS), and the Palau fruit bat (rare or possibly extinct).

The population staus of Palau's terrestrial reptiles is poorly known. None can be considered rare or in need of legal protection until further studies are completed to assess their abundance in the remainder of the archipelago.

MANAGEMENT RECOMMENDATIONS

The ecology of most islands in Micronesia has been altered to varying extents through habitat modification and the introduction of numerous animal species. Neither of these factors have occurred to a significant degree in the Ngerukewid Preserve, making it probably one of the least disturbed terrestrial ecosystems remaining in Micronesia. Because of this, the Preserve is highly deserving of its protected status and provides a valuable control site with which to evaluate other island faunas modified by introduced species. Efforts to manage the Preserve should strive to protect and preserve the area's present natural conditions.

1) All types of hunting should be prohibited in the Ngerukewid Preserve so that the Preserve's fauna is maintained under the most natural of conditions. A top priority should be to reduce and eventually halt the collecting of eggs from sea turtle nests, which is a common practice at present. The collecting of coconut crabs is the only other form of hunting that is currently common in the Preserve.

The protection of wildlife in the Preserve is dependant on adequate enforcement. Increased patrolling will be necessary to dissuade hunters from operating in the Preserve. This may require the hiring of additional staff who would work mainly to enforce the Preserve's non-hunting regulations. In addition to patroling for poachers, these workers could perform other useful duties. These might include the erasing of sea turtle tracks leading to new nests, performing wildlife surveys, and maintaining structures or nature trails built in the Preserve.

2) The Preserve's boundaries should be extended to include the 12 small islands found west of the Preserve. This action has been previously proposed by R.P. Owen (Johnson, 1972) and would increase the Preserve's land size from 87.3 ha to 99.2 ha. These islands are similar to those of the Preserve and are valuable for several reasons. They contain four beaches (Beaches G, H, I, and J), each of which probably provides nesting sites for sea turtles. Beach H has two active and one inactive megapode nest mounds and is perhaps the major nesting location for this species in the Ngerukewid Islands. Several of the beaches would also serve as good visitor sites.

3) Some restrictions should be placed on the number of people allowed to visit beaches with active megapode nest mounds. Present visitor levels appear to pose little or no threat to megapode nesting activity. However, as the Preserve becomes better publicized, increased numbers of tourists and local residents can be expected to visit the area. The Preserve's beaches offer attractive locations for scuba divers to stop for several hours in between dives (usually at lunch), or for campers who wish to spend one or more nights in the islands for recreational purposes. In addition, beaches generally offer the only convenient locations for landing boats and going ashore in the islands, and therefore are expected to receive more use than other areas of the Preserve.

Because beach strand areas are small and nest mounds are conspicuous features, some precautions should be be taken to keep visitors away from mounds. Without restrictions, people can be expected to walk inadvertently across nest mounds, perhaps causing soil compaction or the collapse of tunnels in mounds, and rendering them unsuitable for further use by megapodes. Also, increased human presence on beaches may frighten birds and prevent them from approaching mounds to lay eggs or perform routine maintenance activities on the mounds.

The most strict provision for preventing disturbances to megapodes and their nest mounds would be to allow visitors to go ashore only on Beaches A, B, D, F, G, I, and J, which do not have active mounds (Figure 3.2). Pratt et al. (1980) reported that megapodes are somewhat tolerant to picnicers, although they failed to state the exact amount of visitor use involved. Therefore, several alternative solutions may be practical without seriously threatening the birds. Use of beaches with nest mounds (Beaches C, E, and H) could be limited to several hours per day (e.g., at midday) at times when megapodes are less likely to attend mounds. Another solution might be to erect simple wooden fences around mounds to demarcate them for visitors. If properly designed and set back several meters or more from the mounds, such fences would probably not impede the birds. Multilingual signs in Palauan, English, and Japanese could be placed on fences asking people not to walk on the mounds or disturb megapodes seen nearby. Once a method of protection has been chosen, Preserve managers must work closely with tour operators, who bring many people to the islands, to gain their cooperation in following restrictions.

Records of mound activity should be maintained by the Preserve's staff to determine whether increased visitor use results in the abandonment of any nest mounds.

4) In order to protect the large number of native palms in the Preserve, all greater sulfur-crested cockatoos, which total four birds at present, should be removed from the Preserve and the adjacent western islands. Shooting the birds would probably be the easiest form of removal, although live capture would be acceptable if the birds could be successfully trapped. Eclectus parrots (*Eclectus roratus*), a second species of introduced parrot in Palau, and additional cockatoos that recolonize the Preserve in the future should be removed as soon as they are detected.

5) A strict effort should be made to keep other species of exotic wildlife, such as rodents and feral ungulates, out of the Preserve. This will help to ensure that the Preserve's native wildlife and flora remain under the present relatively pristine conditions. Accidental introductions of rats are especially worrisome and could easily occur with increased boat traffic to the Preserve. Deliberate introductions should certainly be prohibited. As an example, we were told by the governor of Peleliu that a visiting Philipino businessman wanted to release monkeys into the Preserve several years ago for eventual cropping as pets. Fortunately, his idea was discouraged by local authorities and the release never took place.

6) Caves in the Preserve should be protected from disturbances. Pacific sheath-tailed bats and island swiftlets roost and nest only in caves and are extremely sensitive to disruptions caused by people. The locations of caves should not be publicized for public use and visitors should not be allowed to enter caves.

7) Periodic surveys should be conducted to monitor the well-being of the Preserve's resident wildlife. Permanent transects should be established on all islands larger than 5 ha and on a representative sample of the smaller islands. Surveys should be conducted annually to provide data on changes in the status of resident species and to detect introductions of exotics on a timely basis. Methodology similar to that used in this study should be adequate to monitor populations and would provide data for comparison with the results reported here.

8) A survey of the Preserve's terrestrial invertebrate wildlife, including insects, spiders, land snails, and land crabs, should be conducted. Because of the general lack of introduced animals and changes in habitat caused by people, it is likely that the Ngerukewid Preserve still contains a largely intact native invertebrate fauna. This is a situation that may be fairly unique among Palau's limestone islands, where rats have apparently become widely distributed. A species of wingless cricket (*Stonychophora* sp. nov., Family Rhaphidophoridae, Order Orthoptera) that was collected incidently during this survey was a previously undescribed species (D. Nafus, pers. comm.). It is possible that the Ngerukewid Preserve harbors relict populations of other invertebrates that are absent from neighboring islands.

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Chapter 4

CORAL COMMUNITIES AT NGERUKEWID PRESERVE

CHARLES BIRKELAND, Marine Laboratory, University of Guam
Mangilao, Guam 96923

PAUL HOLTHUS, Project Officer (Scientist), South Pacific Regional Environment Programme (SPREP), B.P. D5,
Noumea, New Caledonia

INTRODUCTION

The life-forms of the hard-subtratum marine communities in the Ngerukewid Islands Wildlife Preserve are determined by the corals and other sessile benthic organisms. A change in the species composition or health of the coral community will have substantial affects on the characteristics of the fish and invertebrate communities (Sano et al., 1984; 1987; Williams et al., 1984; Wass, 1987; Birkeland and Amesbury, 1988). Therefore, a quantitative documentation of the coral community is a priority for a baseline survey.

Coral communities are sensitive to subtle changes in the physical environment, i.e., changes in factors such as sedimentation and water temperature. For example, there was a "bleaching" (expelling of zooxanthellae) by coral throughout the tropical western Atlantic; this is thought by some to be a strikingly visible indicator of a hard-to-detect rise in seawater temperature across an extensive area. The coral community is probably a sensitive monitor of the physical environment.

Likewise, the coral community is also possibly the best monitoring instrument for detecting illegal fishing using dynamite or liquid bleach. When fishes, soft invertebrates, and plankters are killed, they decompose and disappear within a few days. When dynamite detonates near the substratum, the characteristic circular pattern of coral rubble remains for months.

Furthermore, when baseline data are carefully obtained, the degree of impact of legal recreational activities (such as walking on a reef-flat, snorkeling around arborescent corals, anchoring) can be quantitatively assessed (Tilmant, 1987).

In addition to being a sensitive indicator of changes in the environment and human activities, the nature of the benthic community indicates the nature of the trophic ecology of the system (Birkeland, 1989). Some of these conclusions from our findings from the survey of the benthic communities at Ngerukewid will be given in the Discussion. The variations in the nature of the trophic structure of the coral-reef community has important implications for differences in appropriate resource management policies (Birkeland, 1987). The establishment of baseline

information and a set of permanent transects to allow a quantification of any changes with time in the coral communities in the Preserve are important for the above reasons.

It is remarkable that despite the renown of the corals of Palau in the public press (Faulkner, 1974; Faulkner and Chesher, 1979; O'Neill, 1978; and many others), there have been to our knowledge only three small areas surveyed by scientists, all in the immediate vicinity of Koror: Iwayama Bay (Abe, 1937; Abe et al., 1937), Malakal Island (Birkeland et al., 1976), and Arakabesan Island (Randall et al., 1978).

METHODS

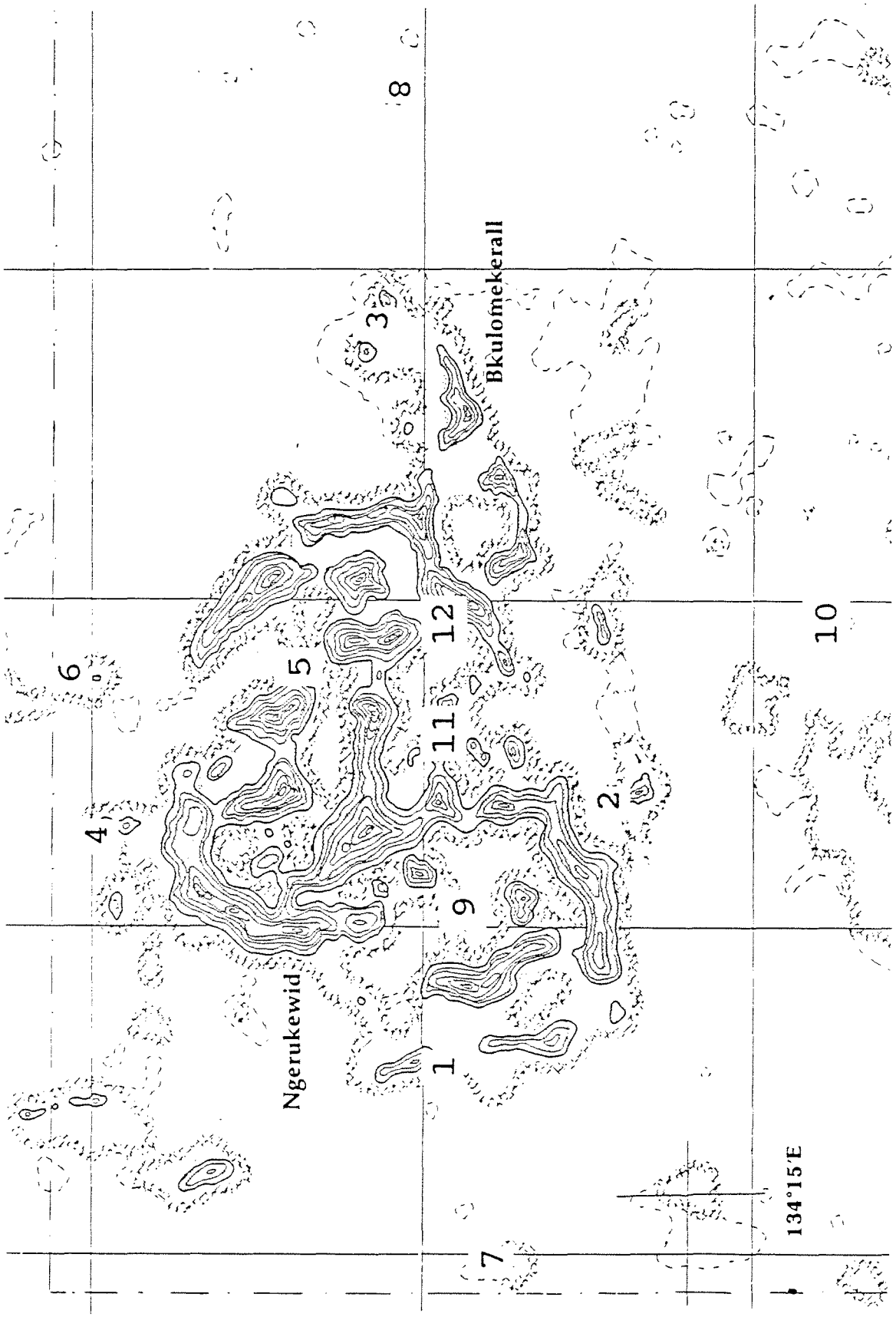
Our goal was to set up permanent transects and to obtain baseline data that could be compared with information obtained from the same transects in the future. To be as representative as possible, we established four transects in each of three regions: on reefs in the channels within the islands (interior), on fringing reefs around the perimeter of the island group (perimeter), and on patch reefs outside the Ngerukewid Island group, but within the boundaries of the Preserve (outer). As far as possible, we placed the transects of each group around the four sides of the Preserve as an attempt to include as many factors as possible for each group and to reduce bias. The locations of the transects are indicated in Figure 4.1.

The beginning, usually nearshore, end of most of the permanent transects was marked with a large spike driven into the reef-rock. To reset the transect for future surveys, the surveyor should find the stake and run the 50-m transect line straight out in the appropriate direction. To assist the surveyor in setting out future transects, the details of the location of each transect marker and the appropriate direction to lay out each transect are given in Appendix 3. It will be necessary to bring a copy of these instructions, a hand-bearing compass, and a 50-m transect line to undertake future replicate transects.

The line-intercept technique was the survey method used for assessing the benthic sessile communities. The coral community around Ngerukewid is dominated by extensive areas of branching acroporids. It is difficult to distinguish the boundaries between neighboring branching acroporid colonies. Furthermore, the boundaries of these patches can extend across long distances. Therefore, the point-quarter and quadrat methods of surveying coral communities are difficult to apply and inappropriate to the Ngerukewid situation. The percent cover by speces is a more appropriate measure than is the point-quarter or quadrat methods for assessing community structure in cases where it is difficult to distinguish individuals.

To perform the line-intercept technique, the 50-m transect line is laid out in the appropriate place. Then the surveyor measures two dimensions of each macroscopic sessile animal that is

Fig. 4.1 - General location of marine survey transects. Details of stake location, transect bearings, and landmarks are given for each transect in Appendix 3.



crossed over by the transect line. One dimension is the length of the segment of line that actually crosses over the particular animal. The second dimension is the maximum diameter of the particular animal that is perpendicular to the transect line. For each individual animal occurring under the transect line, the surveyor records the species name and these two dimensions.

From the line-intercept survey, one can then summarize the data for each species into the following values:

a. total number of individuals encountered (n),

b. total of intercept lengths (ΣL),

c. number of transects in which the species appeared (T), and

d. total of reciprocals of maximum diameters perpendicular to the transect lines (Σ[1/D]).

With these values, several aspects of the community structure of the corals, or of the macroscopic sessile benthic animals, can be calculated.

density = (Σ[1/D]) ([unit area]/[50-m])

relative density

= (density for a species)/(total density all spp.)

surface cover

= (total L for a species)/(50-m)

relative predominance (relative surface cover)

= (total L for a species)/(total L for all species)

total coverage by living corals

= ([50-m] - total noncoral L)/[50-m]

Many of the corals occurring at a particular transect site did not fall under the transect line. For this reason, coral communities in the area around each transect were surveyed. The relative abundance of each coral genus or species encountered was recorded when identifiable. These surveys included the relatively shallow reef flat coral communities where the transects were laid, as well as any adjacent reef slope areas, down to depths of approximately 15 m. In addition, general descriptive information on reef geomorphology and substrate type was recorded. An overall description of coral reef environments is available from a synthesis of this information.

CORAL REEF COMMUNITIES

The coral reef areas of the Ngerukewid Preserve area can be separated into three major groups based on their location, coral community, and reef morphology. These are: 1) interior reef areas (communities of limited coral development within the main Ngerukewid Islands reef platform); 2) the fringing reef perimeter (the outer reef flat and slope of the Ngerukewid Islands reef platform); and 3) outer patch reefs (separate reefs within the Preserve area). A list of the corals occurring in these areas, and their relative abundances around each transect site, is presented in Table 4.1.

Interior Reef Areas (Transect sites 5, 9, 11, 12)

The bulk of the main reef platform upon which the Ngerukewid Islands are situated consists of sand-dominated reef flats and basins with limited coral community development. The reef flats are generally covered with water to depths of 0.5 to 1.5 m. The sandy sites of the intervening basins slope down to sand bottoms at depths of 5 to 10 m. Despite the dominance of sediment substrata, scattered coral development is found along the somewhat shallower reef flat areas connecting the islands, along the fringes of the islands, and in isolated clusters of reef mounds. Data from transects support this general pattern (Table 4.2).

Coral coverage is highly variable in these areas, reflecting the patchy nature of coral community development in the interior of the Ngerukewid platform. Bare sand, or sand and rubble, is interspersed with thickets of Acropora and areas of mixed 5-25% live coral coverage. Moderate to large Porites mounds and microatolls are common and conspicuous, often serving as landmarks to identify the site's transect line.

In addition to the visually dominant thickets of the branching Acropora formosa and A. aspera, clumps of bottlebrush A. echinata, bushy A. tenuis, and club-like A. palifera are commonly scattered throughout these coral assemblages. Along with the massive Porites lutea and P. lobata colonies, clumps of branching P. cylindrica also can be common. Other abundant or relatively common coral in the interior reef include: Stylophora pistillata, Lobophyllia, Fungia, Goniastrea, Favia, Favites, Symphyllia, and Seriatopora hystrix. Data provide a quantification of corals encountered in the transect (Table 4.2).

Fringing Reef Perimeter (Transect sites 1, 2, 3, 4)

The outer portions of the main reef platform on which the Ngerukewid Islands are situated are characterized by a mostly submerged reef flat with increasing coral cover and diversity towards the reef edge.

From the edge, the reef slopes down relatively steeply, with high coral cover and diversity, to the sandy lagoon floor at

Table 4.1. Distribution and relative abundance of corals, Negerukewid Islands Wildlife Preserve. Symbols indicate relative abundance in the region of each site: D=dominant, A=abundant, C=common, R=rare. Parentheses "()" indicate the likely species identification. Grouping of species with close parenthesis ")" indicates species which were lumped together in field identification.

Corals	Reef area:	Interior				Perimeter				Outer			
	Transect site:	5	9	11	12	1	2	3	4	6	7	8	10
Class ANTHOZOA													
Order SCLERACTINIA													
ASTROCOENIIDAE													
Stylocoeniella			R					R	R				
POCILLOPORIDAE													
Stylophora pistillata		A	C	O	C	A	A	A	A	C	A	O	C
Seriatopora hystrix		C			O	C	C	C	C	O	C	C	C
Pocillopora damicornis		O	O		R	C		C	O	O	O	O	O
Palauastrea ramosa		R											
ACROPORIDAE													
Acropora palifera		C	R		O	O	O	A	O	O	O		O
A. formosa		O	D	D	O	D	D	D	D	D	D	D	D
A. aspera		D	D	D	D	D	C	C	D	D	D	D	O
A. echinata)		D	P	A	R	D	D	D	D	D	D	D	A
A. carduus)													
A. humilis		O		R	R		O	O		O	O	O	O
A. (florida)		C	O	O						O		O	

Table 4.1. Continued.

Corals	Reef area:	Interior				Perimeter				Outer			
	Transect site:	5	9	11	12	1	2	3	4	6	7	8	10
A. tenuis)			C	C	C	O	R	R	A	C			
A. samoensis)													
A. nasuta)			R						O	O			O
A. (hyacinthus)							O			R	O	O	R
A. (valenciennesi)												R	
Astreopora		O				O	O	O	O	O		O	O
Montipora		O	O		R	R	O	O	C	O	C	O	O
M. verrucosa							O		O			R	R
PORITIDAE													
Gonipora						O			C		O	R	O
Porites cylindrica			R	C	D	A	A		A	C	C	O	A
P. lutea)		O	C	D	D	A	O	C	A	C	C	C	A
P. lobata)													
P. australiensis)													
P. (Synaraea) rus			R					R					R
SIDERASTREIDAE													
Psammocora contigua		O								R		O	
P. digitata		O						O	O	O	O	O	O
Coscinaraea (columna)			R						R	R		R	

Table 4.1. Continued.

Corals	Reef area:	Interior				Perimeter				Outer			
	Transect site:	5	9	11	12	1	2	3	4	6	7	8	10
AGARICIIDAE													
Pavona decussata)										O	O	O	O
P. cactus)													
P. varians)						O			O			R	
P. venosa)													
Leptoseris (mycetoseroides)												R	
Pachyseris speciosa						R		O	O		O	O	
FUNGIIDAE													
Fungia (V.) concinna		O	C	O		A	C	C	C	C	C	C	C
F. (C.) echinata			C	C		C	C	C	A	O	C	O	
F. (F.) fungites		O	C	C		O	O	O	C	C	O	O	O
Herpolitha limax						O	O			R			C
Sandolitha robusta							O	O	O	O		O	
Polyphyllia talpina												R	
Heliofungia actiniformis			O									R	R
FAVIIDAE													
Favia		C	C	C	C	C	A		A		C	O	A
Favia stelligera		O	O					O	C	O			O

Table 4.1. Continued.

Corals	Reef area:	Interior				Perimeter				Outer			
	Transect site:	5	9	11	12	1	2	3	4	6	7	8	10
F. pallida)								C	O				
F. speciosa)												O	
Favites			R	C	O	O		C	C	O	C	C	A
Barabattoia amicorum						R		R					
Caulastrea furcata									O	R	R	O	R
Goniastrea retiformis)		C	O	C	O	O	C	C		O	C	O	C
G. edwardsi)													
G. aspera)													
Platygyra (daedalea)		O			O	R		O	O	R			R
Leptoria phrygia							R	R					
Diploastrea heliopora						O	R		O			R	O
Leptastrea purpurea		O			R	O	O	O	R	O		R	
Cyphastrea seralia)		O		O	O	C	O	C	O	C	O	O	O
C. chalcidicum)													
C. microphthalma)													
Echinopora lamellosa		O	O			O			O	O	A	A	C
E. mammiformis										O	O	O	O
Oulophyllia crispa					R				R	R		O	O
(Plesiastrea)						R							

Table 4.1. Continued.

Corals	Reef area:	Interior				Perimeter				Outer			
	Transect site:	5	9	11	12	1	2	3	4	6	7	8	10
OCULINIDAE													
Acrhelia horrescens									R	R	R	R	
PECTINIIDAE													
Echinophyllia aspera)						O	O		C			O	R
Oxypora lacera)													
Pectinia paeonia)						O	O		O	O		O	O
P. alcicornis)													
MUSSIDAE													
Lobophyllia corymbosa)			O	C	A		C	C	C	C		C	A
L. hemprichii)													
Symphyllia (recta)		C	O		O	C	C	C	C	O	C	O	C
MERULINIDAE													
Merulina ampliata		O				R			O	O	R	O	O
Hydnophora rigida						O			O	O	O	O	
H. microconos								O					

Table 4.1. Continued.

Corals	Reef area:	Interior				Perimeter				Outer			
	Transect site:	5	9	11	12	1	2	3	4	6	7	8	10
CARYOPHYLLIIDAE													
Euphyllia ancora												R	
E. glabrescens				R	R								
Plerogyra sinuosa										R			
Physogyra lichtensteini				O		R			R			R	O
DENDROPHYLLIIDAE													
Turbinaria (stellatula)						O		O	R	O	O	R	
Order COENOTHECALIA													
HELIOPORIDAE													
Heliopora coerulea			(recorded)										
Class HYDROZOA													
Order MILLEPORINA													
Millepora tenera								R			O		
M. platyphylla										R		R	

Table 4.2. Percent surface cover by major categories of benthos. Cover is estimated from results of line-intercept transects.

Reef Area:	Interior				Perimeter				Outer			
Transect Site:	5	9	11	12	1	2	3	4	6	7	8	10
branching acroporids	9.2	43.5	38.0	0.7	29.1	30.1	47.9	61.9	18.1	49.5	44.8	24.6
other corals	10.4	7.3	3.5	2.4	2.0	5.1	16.4	13.7	14.5	12.7	22.8	4.4
octocorals*	0.9	0.7	2.0		0.7				0.08		0.1	0.6
ascidians	0.1	0.1	0.06	1.3	1.0	7.0	0.8	0.4	2.3	0.8	0.4	5.1
sponges	3.4	3.5	0.9	6.4	0.5	2.9	0.4	0.05	0.8	0.2	0.3	0.7
dead branching acroporids	11.4				5.5	18.0						
rubble, algal turf or sand	64.6	44.9	55.5	89.2	61.2	36.8	34.5	24.0	64.2	36.8	31.6	64.6

*All were alcyonaceans except for the individual at Site 8 which was a gorgonacean.

depths of 15-18 m. A completed list of the corals encountered in these areas is given in Table 4.1.

The shallow perimeter reef flat areas immediately adjacent to most of the islands (e.g., Site 1) often have zones of low (0-20%) coral cover. This usually consists of Porites microatolls and clumps of low branching Acropora aspera on the sand substratum. On the north and northeast facing portions of the perimeter reef (e.g., Sites 3 and 4), the reef flat is exposed to wind waves generated across the open lagoon. In these areas, the shallow exterior reef consists of a more topographically varied and diverse coral community with 10-50% live coral cover. In addition to those corals mentioned above, abundant and common corals include: Stylophora pistillata, Acropora formosa, A. echinata, A. palifera, Goniastrea, Favia, Favites, Porites lobata, P. lutea, Fungia, Symphyllia, Seriatopora hystrix, Lobophyllia and Pocillopora damicornis. The percent coverage by major categories of benthos and dominant coral genera encountered in the transect is provided (Table 4.2, 4.3).

Towards the reef edge, a zone of algal-encrusted branched reef rubble often occurs, with very little (5-25%) live coral cover. As the reef surface begins to dip towards the lagoon, extensive thickets of short branching Acropora aspera dominate with 40-80% coverage in places. At depths of 2-5 m, these mix with, and are replaced by, extensive stands of the longer branched Acropora formosa, forming complete coral coverage of dense tangled thickets. In some areas (e.g., Site 3), much of the Acropora is dead, standing, algal-encrusted colonies, possibly indicating predation by the corallivorous crown-of-thorns starfish (Acanthaster planci).

The slope of the fringing reef perimeter is an area of high coral diversity with live coral cover ranging from 20-80%. As depth increases, the Acropora formosa stands are punctuated with large massive Porites or, less commonly, with Diploastrea heliopora colonies. Attached to portions of these mounds, or other solid substrata interspersed among the thickets and massive colonies, are a variety corals. The most common corals include: Stylophora pistillata, Lobophyllia, Fungia, Montipora, Favia, Favites, Echinopora, and Symphyllia. Acropora echinata and Porites cylindrica are abundantly dispersed in the community, especially at lower depths.

Portions of the perimeter reef slope with reduced coral cover are usually dominated by patches or channels of sand and rubble. Below 12-15 m, the sediment accumulates and coral cover becomes reduced. The sand-dominated lagoon floor is encountered at depths of 15-18 m.

Along the northeast sector of the perimeter reef (off Site 3), the reef slope drops down to a broad terrace which gradually slopes from depths of 5-10 m. The terrace supports large massive Porites mounds and associated corals, similar to the more typical

Table 4.3. Relative percent cover of predominant coral genera, Main life-forms* of acroporid and poritids are listed separetely within Acropora and Porites. To calculate percent cover for the entire substratum, multiply the appropriate percentages in this table times the appropriate percentages in Table 4.2.

Reef Area:	Interior				Perimeter					Outer		
Transect Site:	5	9	11	12	1	2	3	4	6	7	8	10
Class ANTHOZOA												
Order SCLERACTINIA												
ASTROCOENIIDAE												
Stylocoeniella		0.3										
POCILLOPORIDAE												
Stylophora pistillata	38.7	4.3		3.9	1.2	7.2	7.6	6.1	11.5	2.8	2.1	9.7
Seriatopora histrix	4.7			7.8	1.2	4.0	2.2	2.5	1.5	6.5		0.9
Pocillopora damicornis		0.4		2.6			0.1		0.5		0.9	
ACROPORIDAE												
Acropora palifera		0.5			1.0	2.3	3.2	2.3	1.2	0.2		6.8
A. (formosa)		79.8	91.6	7.8		25.6	62.2	46.8	36.9	78.8	65.8	70.5
A. (aspera)	46.7			8.5	73.2	47.8	1.1		7.6	0.5	0.4	6.3
A. (echinata)		3.8		7.2	19.4	9.3	8.0	31.9	5.2			
A. (nasuta)		1.5				0.5		1.1	2.7			1.1
A. hyacinthus									2.1			
Astreopora									1.7		0.1	0.7
Montipora	1.3	1.0			1.6	0.5	2.3	3.1	3.4	0.2	2.7	0.3
M. verrucosa								0.1				

Table 4.3. Continued.

Reef Area:	Interior				Perimeter					Outer		
Transect Site:	5	9	11	12	1	2	3	4	6	7	8	10
PORITIDAE												
Porites (lutea)		3.5	2.9	55.7	0.5	0.3	6.6	0.9	12.0	6.8	5.7	2.6
P. cylindrica		0.1	2.0	6.5				0.2	3.2	1.3	6.0	
P. (Synaraea) rus												0.2
SIDERASTREIDAE												
Psammocora							0.2					
Coscinaraea		0.4						0.2				
AGARICIIDAE												
Pavona									0.4			
FUNGIIDAE												
Fungia		0.7				0.3	1.8	0.1		1.3	0.6	
Heliofungia		0.3										
Herpolitha limax									1.5			
PECTINIDAE												
Pectinia											0.1	
MUSSIDAE												
Lobophyllia									1.6		0.6	
Symphillia	3.8						0.9	0.3	1.4	0.1	2.1	

Table 4.3. Continued.

Reef Area:	Interior			Perimeter					Outer		
Transect Site:	5	9	11	12	1	2	3	4	6	7	8	10
MERULINIDAE												
Merculina									0.4	0.3	2.8	0.6
FAVIIDAE												
Favia		3.2	0.5			1.8	0.5	0.7		0.3	3.9	
Favia stelligera							1.7	0.8	1.5			
Favites			2.0	2.1	1.9		1.2	1.7	2.9		2.0	
Caulastera furcata											2.0	
Goniastrea		1.6		1.2							1.0	
Leptoria phrygia						0.4						
Leptastrea purpurea							0.4	1.2	0.8		0.4	
Echinopora											0.8	
Cyphastrea			0.2								0.6	0.3
DENOROPHYLLIIDAE												
Turbinaria										0.3		
Class HYDROZOA												
Order MILLEPORINA												
Millepora										0.6	1.2	

*The species in parentheses are representative of groups of species in morphological groupings, e.g., Porites (lutea) includes P. lobata and P. australiensis, Acropora formosa includes A. rubra, A. aspera includes A. nobilis, and A. nasuta includes A. tenuis.

reef slope described above. Between the mounds and patches of Acropora and other corals, sand and some rubble dominate the terrace, giving an overall level of reduced, but highly variable, coral cover. At about 10 m depth, coral cover and diversity increase, and the slope drops sharply down with a coral community typical for the perimeter reef slope at those depths. The sandy lagoon floor is encountered 15 m.

Along portions of the south-facing perimeter reef (e.g., around Site 2), the reef slope occurs in relatively protected waters where there are also embayment-like indentations in the reef configuration. This results in a greater proportion of sand accumulation on the reef slope and a locally shallower lagoon floor at 8-10 m depths. The coral community in these areas is dominated by branching Acropora with occasional blocks of large coral colonies which have slumped down the unstable slope.

Outer Patch Reefs (Transect sites 6, 7, 8, 10)

The main Ngerukewid Islands reef platform is surrounded by numerous patch reefs of various sizes and configurations. The majority of these are found to the south and, to a lesser extent, to the east of the main reef platform. A few large patch reefs occur to the north and one, with additional island areas, occurs to the northeast. Coral communities on the outer patch reefs were generally similar to each other, with greater coral cover and diversity than the reef slope of the reef platform perimeter (Tables 4.2, 4.3).

The interior reef flat of most patch reefs is a mix of variable coral cover, sand and rubble. Portions of the substrata, especially towards the center of larger patch reefs, may be dominated by sand and rubble with little live coral. Elsewhere, mounds and microatolls of Porites, and occasionally Turbinaria and stunted thickets of Acropora aspera, provide topographic relief and localized high coral cover. Other common corals on the reef flat include: Seriatopora hystrix, Stylophora pistillata, Acropora palifera, A. echinata and A. tenuis. Close to the reef edge, a zone of branched coral rubble may occur, as on the outer edge of the main Ngerukewid Islands reef platform.

Also on the outer patch reefs, the reef slope similarly commences with a dense cover of Acropora aspera which is replaced by tangled thickets of A. formosa in the upper 2-5 m. Below these depths, large Porites and Diploastrea heliopora, massive coral colonies, and monospecific stands of some corals such as Echinopora lamellosa, stand out in the diverse coral assemblage. Coral cover ranges from 40-90% with a relative abundance of: Porites cylindrica, Stylophora pistillata, Fungia, Lobophyllia, Favia and Acropora echinata, as well as those corals mentioned above. In some areas, a large portion of Acropora formosa thickets are dead.

Other corals which are relatively common on the outside patch reef slopes include: Favites, Cyphastrea, Merulina, Pavona cactus, P. decussata, Goniastrea, Hydnophora rigida, Montipora and Herpolitha. Towards the lower slope, coral cover drops off to 30-60% as sediment accumulation becomes more prevalent. The sand lagoon floor is encountered at depths of 18-22 m around the outer patch reefs.

DISCUSSION

The preconceived organization of the survey into the three groups (within the islands, around the fringing reef perimeter, and on outer patch reefs within the Preserve) turned out to be satisfactory. The variation within habitats was small, despite the effort to make the within group variance as large as possible by placing the transects on the four sides of the island group. The four widely spaced transects within each group may be considered replicates.

The variance among groups is also not great. However, there is a definite trend for a greater number of coral species to be found outside the island group than within: outer > perimeter > within. The same trend was noted for acroporid corals in particular. Poritid corals are more predominant in coral communities among the islands than outside (Table 4.3). Nevertheless, in general, the coral communities do not vary as much as is usually found within an area of coral reef of comparable extent in most other areas.

Surface cover by scleractinian corals was greatest on outer reef sites and least on inner reef sites, with perimeter sites being intermediate in surface cover by corals. This trend was also found in octocorals (mostly alcyonaceans). Acroporid corals and ascidians were also considerably less abundant on inner reefs than on outer or perimeter reefs, but for these two groups, the perimeter reefs had greater surface coverage than did the outer reefs. It was particularly notable that sponges showed the opposite pattern to the other groups being discussed here. Sponges were far more dominant on inner reefs. The inverse relations in the prevalence of sponges and ascidians was striking.

The coral communities in the Preserve were considerably less diverse than were those at other sites studied in Palau: the south tip of Malakal (48 genera, 163 species - Birkeland et al. 1976) and the resort site on Arakabesan (40 genera, 117 species - Randall et al. 1978). As discussed with the fish fauna in this report, the coral communities are healthy, but there is not a variety of coral habitats. Most coral communities in the Preserve are lagoonal acroporid thickets. Exposed reef slopes, exposed reef margins, passes with strong currents through reefs, and other coral habitats are all absent. Nevertheless, the lagoonal coral communities in the Preserve are robust and pristine and constitute a good representation of a typical lagoonal reef of Palau.

A striking aspect of the benthic communities of Ngerukewid was the predominance of animal-plant phototrophic symbiotic relationships. Both plants and heterotrophic sessile benthic animals were relatively sparse, while animal-plant symbionts were predominant. All 7 species of tridacnids (giant clams) of the world were present. Ascidians with phototrophic symbionts were prevalent (Didemnum molle, Lissoclinum patellum, Lissoclinum voeltzkowi, Diplosoma virens, Diplosoma similis, Eudistoma viride). The sponges with phototrophic symbionts were also common (Dysidea sp., Phyllospongia foliascens).

The prevalence of animal-plant symbionts in the benthic community, and the sparsity of benthic plants and heterotrophs, indicates that there is probably very little nutrient input into the Ngerukewid Islands (Birkeland, 1987; 1989). This is actually not surprising because the islands are isolated across a wide, shallow-water, sand-bottom, lagoon. The Ngerukewid Islands are separated from the deep oceanic waters by a barrier reef over 2 km wide. There is strong evidence that materials in the water column are removed by the reef community when water flows across even much smaller reef flats (Glynn, 1973). Of course there are abundant nutrients in the waters in the lagoon around Pohnpei because of nutrient runoff from the island. However, there is almost certainly very little nutrient runoff from the porous limestone pinnacles of Ngerukewid because soil is very meager.

The prevalence of animal-plant symbionts and the paucity of benthic plants and heterotrophs suggests that the recycling of nutrients is strongly favored. With few nutrients in the water column, with little nutrient input, and with a rich coral-reef community established, much of the nutrients are probably bound in the biomass. If this is the case, the system could be relatively easy to overexploit. This may be a partial explanation for the paradox of coral reefs being very productive, but also especially vulnerable to over-exploitation. If this is the case, then systems such as the coral reefs at Ngerukewid should support only subsistence fisheries by resident (turnover of biomass) but not large-scale export of biomass.

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Chapter 5

FISHES OF THE NGERUKEWID ISLANDS WILDLIFE PRESERVE

STEVEN S. AMESBURY, Marine Laboratory, University of Guam, UOG Station, Mangilao, Guam 96923

INTRODUCTION

Among the major components of the marine biota of the Ngerukewid Islands Wildlife Preserve are the fishes. Fishes play important roles in the ecology of coral reef systems as well as being important economically. Their economic value makes them a potential target for poachers in the Preserve, and monitoring of fish stocks may be needed to determine whether protective measures are necessary to ensure the continued abundance and diversity of fish communities in the Preserve.

MATERIALS AND METHODS

Twelve permanent 50-m underwater transects were established within the Ngerukewid Preserve (Figure 4.1, Appendix 3). Four of the transects (6, 7, 8, and 10) were on outer patch reefs surrounding the emergent islands of the Preserve; four (1 through 4) were on the perimeter fringing reef of the islands; and four (5, 9, 11, and 12) were on interior reefs among the islands of the Preserve.

Fishes were enumerated by species along and within one meter of each side of each of the 50-m transects (each transect covering a total area of 100 m^2). A list of additional species observed in close proximity to each of the transect lines was also made subsequent to the enumeration.

RESULTS AND DISCUSSION

Approximately 150 fish species were seen on the Ngerukewid transects (as well as some additional fishes which were not identified to the species level) (Table 5.1). Species richness at individual transect stations ranged from 39 to 66. There were no obvious differences in fish species richness among the three habitat types surveyed.

Fish abundance on the transects varied from 94 to 580 fish per 100 m^2 (a large aggregation of apogonids encountered on transect 11 contributed to the unusually high fish density on that transect). There seemed to be no clear-cut distinction in fish abundance among the three habitat types.

A few other fish species were observed in the Ngerukewid Preserve area at locations other than the 12 transects (Table 5.2). Even including these species, the total species list for the Preserve amounts to considerably fewer than 200 (although more species of fish undoubtedly occur in the Preserve but were not observed during the survey).

The total reef ichthyofauna of Palau is estimated to be in the neighborhood of 1200 species (Myers, in press). Much of this diversity is contributed by the

habitat diversity within the Palau archipelago. Other surveys in Palau carried out by the University of Guam Marine Laboratory have listed 66 and 125 fish species within specific reef areas (Birkeland et al., 1976; Randall et al., 1978). Compared to those areas (the fringing reef at the southern end of Malakal Island and the fringing reef off the Palau Pacific Resort on Arakabesan Island), the Ngerukewid Preserve is relatively rich in fish species. The 1000 or so Palauan reef fish species which were not observed in the Ngerukewid Preserve probably fall into one or more of the following categories:

a) rare or uncommon species that were fortuitously not observed during the survey,
b) nocturnal or cryptic species that were overlooked during the survey, and
c) species that occur in habitats not represented within the Preserve.

The most significant kinds of reef fish habitats not represented within the Preserve are those habitats characteristic of outer reef margins and slopés. These are typically very speciose fish habitats on Pacific islands, containing many species not commonly found in habitats within the barrier reef (Amesbury, 1978; Amesbury et al., 1979).

Many of the species seen during the survey are fishes commonly havested for food: acanthurids, caesionids, carangids, haemulids, holocentrids, kyphosids, lethrinids, lutjanids, mullids, scarids, serranids, and siganids. Although unauthorized fishing undoubtedly does take place within the Preserve, it is not possible to say whether this has had a significant impact on the stocks of economically important species occurring there. Because the islands in the Preserve are uninhabited and because many alternative fishing spots are available, it is likely that fishing pressure has had only moderate impact on stocks of fishes within the Preserve.

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Table 5.1. Abundance (no. per 100 m^2) of fishes along marine community transects. Plus (+) symbol indicates presence of species in the vicinity of the transect line.

	TRANSECTS											
	interior				perimeter				outer			
	5	9	11	12	1	2	3	4	6	7	8	10
ACANTHURIDAE												
Acanthurus lineatus							1	+		+	+	
A. nigricans									+			
A. nigrofuscus						8		7				
A. triostegus					+							+
A. xanthopterus				+						+	1	1
juvenile Acanthurus										3		
Ctenochaetus striatus		1	3		1	1	2	15	8	15	3	2
Naso lituratus					+	+				+		
N. unicornis							+					
N. vlamingi									+			
juvenile Naso					+							
Zebrasoma veliferum	+	+	1			+	+	+	+		+	
APOGONIDAE												
Apogon leptacanthus			+									
Archamia fucata											+	
Cheilodipterus macrodon	10		3			+		1				
C. quinquelineatus	5		3	+				3			2	+
Sphaeramia nematopterus	13	+										
S. orbicularis				+								
unidentified apogonids		10	400									
ATHERINIDAE												
unidentified atherinids							+					
AULOSTOMIDAE												
Aulostomus chinensis									+			
BALISTIDAE												
Balistapus undulatus		+										
Balistoides viridescens				+							+	
Rhinecanthus aculeatus	+		+	+	1		+			1	1	
R. verrucosus					+							
Sufflamen chrysopterus								+		+	+	
BLENNIIDAE												
Meiacanthus grammistes	3	1	1			1	2	2	+	1	2	1
Salarias fasciatus						+	1					
unidentified blenniids				1								
CAESIONIDAE												
Caesio caerulaureus			8									
C. xanthonotus		+									+	
Pterocaesio chrysozonus	+	+	26									
CARANGIDAE												
Caranx melampygus		+										
CHAETODONTIDAE												
Chaetodon auriga	+			2	+	+	+	+	+	+	2	1
C. bennetti		1										
C. citrinellus								+			+	
C. ephippium	2	+	3	4		+	+	+	+	+	+	
C. kleini	+	+	+	1	+	+	+	+		+	+	+
C. lineolatus		+										
C. melannotus		+	2			+				+	+	+
C. octofasciatus		+										
C. ornatissimus	1											
C. rafflesi	+						+	1				
C. speculum	2	1										
C. trifasciatus		1					2	2		+	+	

Table 5.1. Continued

	TRANSECTS											
	interior				perimeter				outer			
	5	9	11	12	1	2	3	4	6	7	8	10
C. ulietensis		+										
C. vagabundus						+		1			2	
Megaprotodon trifascialis	1	2	2						+		1	
CHANIDAE												
Chanos chanos					+							
FISTULARIIDAE												
Fistularia commersonii		+								+		
GOBIIDAE												
Amblygobius albimaculatus	+		4	1	2			+	1			2
Gobiodon citrinus	9	8					2	12		1	6	
Ptereleotris evides	+		+	6			+		+			
unidentified gobiids			3									1
HAEMULIDAE												
Plectorhynchus orientalis	1	+										
HOLOCENTRIDAE												
Myripristis violaceus											+	
Neoniphon sammara		+										
Sargocentron diadema						+						
S. spinifer			1							+		
KYPHOSIDAE												
Kyphosus cinerascens		+		+								
LABRIDAE												
Anampses meleagrides											+	
Cheilinus celebicus									+			
C. fasciatus		1							+			
C.trilobatus							+	1				
C. undulatus		+			+	1	+	+	+	+		
Choerodon anchorago	+	1		1	+	+	+	+		+	+	+
Cirrhilabrus sp.									+			
Coris gaimard												+
Coris variegatus						+					1	+
Epibulus insidiator		2				2			4		1	
Gomphosus varius						+	+		+			
Halichoeres hoeveni	1		+		+	+	9	10	2	12	16	4
H. scapularis											1	
H. trimaculatus	3	+	2	4	13	1		1	+	5		24
Hemigymnus fasciatus									+			
H. melapterus		2			2	+	+			+		+
Labrichthys unilineata									+			
Labroides bicolor									+			
L. dimidiatus		3	1	+	1	3		2	5	+	+	
Macropharyngodon meleagris									+	+		
Pseudocheilinus hexataenia						1						
Stethojulis bandanensis	3				1	1	+		+	2		8
Thalassoma amblycephala												+
T. hardwicki					2	8	+	5	1	1	+	+
T. lunare						+						
T. lutescens		+							1			
T. quinquevittata								+				
juvenile labrids	2	2	1	11	5	4		12		8	3	4
unidentified labrids				1		1	+					4
LETHRINIDAE												
Gnathodentex aureolineatus		+										
Lethrinus variegatus					+							
Lethrinus sp.												+
Monotaxis grandoculis											+	

Table 5.1. Continued

	TRANSECTS											
	interior				perimeter				outer			
	5	9	11	12	1	2	3	4	6	7	8	10
LUTJANIDAE												
Lutjanus bohar		+										
L. fulvus			1	+	+	+						
L. gibbus				+								1
L. lutjanus	+		1									
MONACANTHIDAE												
Oxymonacanthus longirostris										+		
Paraluteres prionurus	+											
MULLIDAE												
Mulloides flavolineatus		+						+				
Parupeneus barberinus	1	+	2		+		+	+		+	+	+
P. trifasciatus				+	+	+	+	2	+	+	+	+
Upeneus tragula	+											
NEMIPTERIDAE												
Pentapodus macrurus											+	
Pentapodus sp.	+	+	+	+	+	+	+	2			+	
Scolopsis cancellatus	1			1	3	1	+	+			+	1
S. ciliatus	1	1	4	+	4							+
Scolopsis sp.	1	1					+	+		+	2	
POMACANTHIDAE												
Pomacanthus sexstriatus								+		+	+	
P. xanthometopon		+										
POMACENTRIDAE												
Abudefduf lorenzi	1											
A. saxatilis				+								
A. sexfasciatus					+	+	+	+		+		
A. sordidus					+							
Amblyglyphidodon aureus							1				+	
A. curacao	22	4			+	3	8	+	+	27	26	2
A. ternatensis	45	27	+	+				8	1	4	64	+
Amphiprion melanopus		+	1								+	
Chromis analis	4											
C. atripes		3					6	3	6		6	10
C. caerulea	45	100	54	80	+		+	+	+	90	85	+
Chrysiptera biocellata	1		2	4	2					1		+
C. cyanea								+	+			
Dascyllus aruanus	47	13	1	20	7	15	1	29	7	84	37	24
D. melanurus					7	20	3		2	2		
Dischistodus chrysopoecilus				5	6							+
D. melanotus	1				10	12	2	+	31	+		+
D. perspicillatus	18	+	9	12	5	7	+	8		20	4	24
Neopomacentrus nemurus											10	
Paraglyphidodon melas								1			1	
Plectroglyphidodon lacrymatus									1	2		
Pomacentrus burroughi												1
P. chrysurus	3											
P. coelestis										+		
P. gramminorhynchus	14	6	1			10	32	7	1	33	17	32
P. molluccensis						5		4	60	5	+	1
P. nigrimanus								+			77	
P. pavo	1	+	28	+							4	2
P. simsiang	2	9		+			4	12		5	13	
P. tripunctatus		3								10	1	1
Stegastes albifasciatus							1					
S. fasciolatus		1			5			19		1		
S. lividus	33	34	+	4	21	125	15	13	74	4		15
S. nigricans							1	1	7	1		1
juvenile pomacentrids				2								3
unidentified pomacentrids						5				4		

Table 5.1. Continued

	TRANSECTS											
	interior				perimeter				outer			
	5	9	11	12	1	2	3	4	6	7	8	10
PSEUDOCHROMIDAE												
Pseudochromis fuscus	4				1				1	2		
SCARIDAE												
Bolbometopon muricatum		+		+								
Cetoscarus bicolor		+			+			+	+		+	
Hipposcarus longiceps	+	2	+	+	+			1	+	+	+	+
Scarus ghobban				+			+			+		
Scarus oviceps		1			1	3	+	+	+	+	+	+
S. schlegeli		1				+			+		+	
S. sordidus		1			+	1	+	+	1	1	+	+
juvenile scarids		8	2	12	5	83	+	1	89	18		34
unidentified scarids								+			+	
SERRANIDAE												
Epinephelus caeruleopunctatus											+	
E. merra		+						+			+	+
Epinephelus sp.	+									+		
SIGANIDAE												
Siganus argenteus					+							+
S. doliatus	+						+		+			
S. lineatus		1		+								
S. puellus		+		+						+	+	
S. vulpinus									+			
juvenile siganids												+
unidentified siganids											+	
SPHYRAENIDAE												
Sphyraena sp.	+	+	10									
SYNGNATHIDAE												
Corythoichthys intestinalis				+								
ZANCLIDAE												
Zanclus cornutus	+	+		1	+	+	1	+	+		1	+
TOTAL SPECIES OBSERVED:	51	66	39	42	46	47	49	58	51	58	65	52
TOTAL ABUNDANCE ON TRANSECT (no. per 100 m^2):	301	252	580	173	105	322	94	186	303	363	390	204

Table 5.2. Additional fish species observed in the Ngerukewid Preserve.

APOGONIDAE	Archamia zosterophora
CHAETODONTIDAE	Heniochus chrysostomus
LABRIDAE	Halichoeres hortulanus
LUTJANIDAE	Lutjanus decussatus
POMACANTHIDAE	Pygoplites diacanthus
POMACENTRIDAE	Amblyglyphidodon leucogaster
SCARIDAE	Scarus flavipectoralis
TETRAODONTIDAE	Arothron nigropunctatus

CHAPTER 6

BENTHIC MARINE PLANTS OF THE NGERUKEWID ISLAND WILDLIFE PRESERVE, REPUBLIC OF PALAU

SUSANNE de C. WILKINS, Marine Laboratory, University of Guam,
P. O. Box UOG Station, Mangilao, Guam 96923

INTRODUCTION

Several papers and technical reports discuss the marine flora of some islands and atolls of Palau, however, no specific information is available for the area of Ngerukewid. Tsuda (1981) conducted a biological survey of the marine algae of Kayangel Atoll. He observed 51 species of marine benthic algae and 5 species of sea-grasses (Tsuda et al., 1977). During the same year an addendum to the bibliography of marine benthic algae of Micronesia (Tsuda and Wray, 1977) was published. A total of 53 species of marine benthic algae were identified during a study on Arakabesan Island (Rendall et al., 1977).

This paper reports on a total of 41 species of benthic marine algae and 3 species of sea-grasses.

METHODS

Marine plants and substrate coverage were quantified by a point-quadrat method along three sets of four 50-m transects within the Ngerukewid Preserve (Figure 4.1) at varying depth. Frequently areas covered by algal turf, crustose coralline algae, encrusting sponges, etc., are difficult to measure by dimensions, these organisms are therefore surveyed more appropriately by the point-quadrat method. This method consists of tallying organisms under the points of intersection of string tied across a 1/16-m2 (25 x 25 cm) quadrat. The quadrat frame consists of 25 squares with 16 internal crosspoints. Whatever algal species occurrs under each point is recorded. In the event that the point falls on two layers of algae, the base alga is recorded and the overlying alga is noted as present. When identification to species was impossible in the field, specimens were collected, pressed, labeled and identified in the laboratory. If no alga was found under the point, then whatever was present, e.g., sand, dead coral, or live coral, was recorded (Birkeland et al.; 1987).

The quadrat was tossed randomly at 5-m intervals along the length of the transect. Therefore, data was collected from a total of 11 quadrat tosses, or 176 points along each transect.

The three sets of four permanent transects 50-m long were located within the boundaries of the Ngerukewid Preserve. One set of transects was located along interior reefs of the Ngerukewid Island Group, the second set was located along the outer perimeter of the fringing reef around the islands and the final set was located on patch reefs surrounding the islands but within the Preserve (Figure 4.1). The

transects were numbered in the order they were established. Thus, the numbers of the transects for each set are not necessarily in consecutive order.

Percent cover of each transect was calculated by taking the number of points occupied by a particular category divided by the total number of points per transects. Frequency of occurrence was calculated by taking the number of quadrat tosses in which a benthic constituent occurred, divided by the number of tosses per transect. Both cover and frequency values were converted to percent by multiplying by 100. Other algal species also seen along the transects were recorded as observed.

In addition, the only seagrass bed within the boundaries of the Preserve was investigated, its size measured, and ten quadrat tosses made along the center of the sea-grass bed. At each toss the species and number of sea-grasses falling within 5 internal squares of the quadrat were recorded.

RESULTS AND DISCUSSION

Results of the quantitative survey of benthic marine plants in the Ngerukewid Preserve are presented in Tables 6.1, 6.2, and 6.3. A total of 22 algal species were recorded along the transects of the first set located within the interior portion of the Preserve. The overall percent coverage ranged between 7.0 and 17.4 percent. A somewhat higher species diversity (27 algal species) was recorded along the transects located around the perimeter of the island cluster. The average algal cover of the perimeter reef transects was 11.1 percent and was almost equal to that of the first set. A total of 22 algal species were recorded along the transects of the outer patch reefst with an average cover of 9.1 percent. A total of 44 species of benthic marine plants were identified throughout the entire study area. This represents approximately 35 percent of the the total recorded species for Palau and is somewhat lower than similar studies done in Palau (Tsuda, 1981; Randall et al., 1977).

A band of sea-grasses, composed of three different species, was located along the beach of island 7. The total area covered by sea-grasses was approximately 449 m2. The density of Syringodium isoetifolium, the most abundant of the three species, varied from 200 to 5,600 plants/m2. Cymodocea rotundata and Halophila ovalis varied from 0 to 1,200 and 0 to 800 plants/m2 respectively (Table 6.4).

Assuming primary production to be the primary role, the marine plant community of Ngerukewid Preserve may be described in terms of their secondary roles as functional groups in the marine ecosystem of the preserve (Tsuda, 1973). Fleshy macroalgae and marine plants were greatly reduced. Only a few members of this group such as Laurencia and Caulerpa were sparsely distributed, low growing, and were noted mostly near the base of branching corals or inbetween rubble. Lobophora variegata was also conspicuous in most areas. Sea-grasses were recorded only from one area. Corals, clams and tunicates capable of photosynthesis themselves were the dominant component throughout the

study sites and competed quite successfully with the marine plants of the area.

Algal turf was found only along a few transects and consisted mostly of Cladophoropsis sundanensis, Microcoleus lyngbyaceus, Gelidiopsis intricata, and Sphacelaria. Filamentous red algae, of the genus Polysiphonia, Herposiphonia, and Ceramium were commonly found on the branches of dead Acropora.

Carbonate producing algae such as Halimeda cylindracea were common in sandy areas, especially along the transects of the first set. Jania and Amphiroa were generally associated with rubble and were quite inconspicuous.

Seasonal occurrence of certain species of marine plants, the type of substrate available, competition for space, and grazing pressure are factors influencing species diversity. The substrate of the transects along the interior reefs and some on the outside patch reefs consisted predominantely of sand and loose coral rubble with relatively few conspicuous marine plants. Pronounced tidal fluctuations combined with solar heating may be an additional factor influencing algal diversity in some areas.

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Table 6.1. Frequency and percent coverage of benthic flora, interior reefs. Plain numbers indicate percent coverage, numbers in parenthesis indicate frequency of occurrence converted to percent (see Methods in the text). Algal species occurring epiphytically on algae, or other algal species observed in the vicinity of the transec are marked with an X.

	TRANSECTS			
Species	5	9	11	12
CYANOPHYTA (blue-green)				
Schizothrix calcicola (Ag.) Gomont	1.7 (18)	0.6 (9)	0.6 (9)	X
CHLOROPHYTA (green)				
Caulerpa brachypus Harv.		0.6 (9)		X
Caulerpa racemosa var. peltata (Forsk.) J. Ag.		1.1 (9)	0.6 (9)	
Caulerpa serrulata (Forsk.) J. Ag.				0.6 (9)
Caulerpa urvilliana Montagne	X	0.6 (9)		
Halimeda cylindracea Zone		X	4.0 (18)	2.8 (27)
Halimeda gigas Taylor		0.6 (9)		
Halimeda simulans Hove.				1.1 (9)
Neomeris annulata Dickie				0.6 (9)
Udotea geppi Yamada		X		X
PHAEOPHYTA (brown)				
Lobophora variegata (Lamx.) Womersley		0.6 (9)	0.6 (9)	
Spacelaria sp.	1.1 (9)	X	0.6 (9)	
RHODOPHYTA (red)				
Amphiroa foliacea Lamx.	X		0.6 (9)	
Centroceras sp		1.1 (18)		0.6 (9)
Gelidiopsis intricata (Ag.) Vickers		2.3 (27)	X	
Griffithia tenius C. Ag.		0.6 (9)		
Herposiphnia sp.		1.1 (9)		
Jania capillacea Harvey	2.3 (36)	2.8 (18)		X

Laurencia papillosa (Forsk.) Grev.	X	1.7 (27)		
Mesophyllum sp.		1.1 (9)		
Polysiphonia sp.	1.7 (18)	X	X	1.1 (18)
Porolithon onkodes (Heydrich) Foslie	1.1 (18)		X	
Scuzz		2.3 (9)		2.8 (9)
Live coral	10.6 (18)	13.1 (36)	2.8 (9)	1.1 (18)
Live branched coral	18.2 (27)	7.4 (18)	1.7 (9)	
Dead coral	5.1 (18)	23.9 (64)	7.4 (18)	13.1 (27)
Reef rock	10.2 (27)	14.2 (18)		
Rubble	15.3 (18)	9.1 (9)	9.1 (36)	16.5 (45)
Sand	25.0 (45)	9.7 (27)	69.3 (82)	51.7 (73)
Didemnid molle	1.1 (9)			
Lissoclinum patella				0.6 (9)
Red Ascidian	1.7 (9)			
Sponge	2.3 (27)	4.5 (45)		5.1 (36)
Tridacna sp.	0.6 (9)			
Bivalve	0.6 (9)	1.1 (18)		
Soft coral			2.3 (9)	
Cassiopea sp.				0.6 (9)
Leave			0.6 (9)	1.1 (9)
Number of plant genera/transect	5	11	6	6
Number of plant species/transect	5	4	6	7
Overall percent plant coverage	7.9	17.4	7.0	12.4
Total number of plant genera	17			
Total number of plant species	22			

Table 6.2. Frequency and percent cover of the benthic flora, fringing reef perimeter. Plain numbers indicate percent coverage, numbers in parenthesis idicate frequency of occurrence converted to percent (see Methods in the text). Algal species occurring epiphytically on algae, or other algal species observed in the vicinity of the transec are marked with an X.

	TRANSECTS			
Species	1	2	3	4
CYANOPHYTA (blue-gree)				
Microcoleus lyngbyaceus (Kuetz.) Crouan	1.1 (9)	0.6 (9)		0.6 (9)
Schizothrix calcicola (Ag.) Gomont		0.6 (9)	0.6 (9)	0.6 (9)
CHLOROPHYTA (green)				
Acetabularia moebii Solms-Laubach				0.6 (9)
Boodlea composita (Harv.) Brand	X		1.7 (9)	
Caulerpa brachypus Harv.		X		
Caulerpa racemosa (Forsk.) J. Ag.		X		
Caulerpa serrulata (Forsk.) J. Ag.				0.6 (9)
Cladophoropsis sundanensis Reinbold			5.7 (9)	
Dictyosphaeria cavernosa (Forsk.) Boerg.	X		0.6 (9)	X
Halimeda cylindracea Zone			0.6 (9)	0.6 (9)
Halimed discoidea Decaisne		X	X	
Halimeda gigas Taylor		X		X
Halimeda opuntia (L.) Lamx.		1.1 (18)	X	
Microdictyon setchelianum Howe			1.1 (9)	
Neomeris annulata Dickie			X	
Udotea argentea Zanard.		1.1 (9)		
Valonia fastigiata Harv.	X			1.1 (18)

PHAEOPHYTA (brown)				
Lobophora variegata (Lamx.) Womersley	6.8 (45)	X		1.1 (9)
Sphanelaria sp.			X	0.6 (9)
RHODOPHYTA (red)				
Amphiroa foliacea Lamx.		0.6 (9)		
Ceramium mezatlenense Dawson		X		1.7 (27)
Gelidiopsis intricata (Ag.) Vickers	X			1.7 (18)
Gelidium pussilum (Stackh.) LeJolis			1.1 (18)	
Hydrolithon reinboldii (W. V. Bosse & Foslie) Foslie	1.7 (18)			
Hypoglossum attenuatum Gardner		X		
Jania capillacea Harvey	X		X	3.4 (36)
Polysiphonia sp.	1.1 (18)			2.3 (18)
Porlithon onkodes (Heydrich) Foslie		1.1 (18)	X	2.3 (18)
Live coral	7.8 (36)	17.6 (36)	5.1 (27)	8.0 (54)
Live branched coral	11.4 (45)	6.2 (18)	4.5 (36)	3.2 (27)
Dead coral	52.8 (82)	27.3 (64)	9.7 (27)	25.0 (36)
Reef rock	1.7 (18)	4.0 (18)	2.9 (9)	
Rubble		7.4 (18)	11.4 (36)	10.8 (27)
Sand	5.7 (18)	28.4 (64)	41.5 (73)	12.5 (27)
Didemnid molle	1.1 (18)	1.1 (18)	1.1 (18)	7.4 (36)
Diplosoma similis			1.7 (27)	2.3 (27)
Eudistoma sp.	0.6 (9)	2.8 (18)		4.5 (27)
Lissoclinum patella			1.7 (27)	2.3 (27)
Lissoclinum diplosoma				0.6 (9)
Sponge		0.6 (9)	3.4 (18)	7.4 (36)
Bivalve		1.1 (18)		
Foramanifera sp.			0.6 (9)	2.3 (18)
Snail			0.6 (9)	
Anemone			0.6 (9)	0.6 (9)
Number of plant genera/transect	4	6	8	12
Number of plant species/transect	4	6	8	12
Overall percent plant coverage	0. 7	5.1	12.0	16.6
Total number of plant genera	22			
Total number of plant species	27			

Table 6.3. Frequency and percent coverage of benthic flora, outer patch reefs. Plain numbers indicate percent coverage, numbers in parenthesis indicate frequency of occurrence converted to percent (see Methods in the text). Algal species occurring epiphytically on algae, or other algal species observed in the vicinity of the transec are marked with an X.

	TRANSECTS			
Species	6	7	8	10
CYANOPHYTA (blue-gree)				
Microcoleus lyngbyaceus (Kuetz) Crouan	X	1.7 (18)		1.1 (18)
Schizothrix calcicola (Ag.) Gomont	1.1 (18)	1.1 (18)	0.6 (9)	
CHLOROPHYTA (green)				
Caulerpa brachypus Harv.		0.6 (9)		
Caulerpa racemosa var. peltata		1.1 (9)		
Halimeda incrassata (Ellis) Lamx.				X
Halimeda opuntia (L.) Lamx.	1.1 (9)	X		X
PHAEOPHYTA				
Dictyota barayresii Lamx.	X		X	
Lobophora variegata Womersley	1.1 (9)	2.8 (27)	1.1 (18)	X
Sphacelaria sp.		2.3 (27)		2.3 (27)
Sphacelaria tribuloides Menegh.	1.7 (18)			
RHODOPHYTA (red)				
Amphiroa foliacea Lamx.		1.7 (18)	X	0.6 (9)
Gelidiopsis intricata (Ag.) Vickers	X		X	1.1 (18)
Gelidium pussilum (Stackh.) LeJolis			X	
Herposiphonia sp.	0.6 (9)	X		0.6 (9)
Hydrolithon reinboldii (W.v. Bosse & Foslie) Foslie				0.6 (9)

Jania capillacea Harvey	X	1.1 (9)	X	2.3 (27)
Jania tenella Kuetz			X	
Laurencia papillosa (Forsk.) Grev.	X	1.1 (18)		X
Lithophyllum kotschyanum (Unger) Foslie			X	
Peyssonelia rubra (Grev.) J. Ag.		2.3 (27)		
Polysiphonia sp.		2.3 (36)		1.7 (18)
Polisiphonia scopulorum Harv.	1.1 (18)			
Porolithon onkodes (Heydrich) Foslie	1.1 (18)	2.3 (18)		1.1 (9)
Live coral	14.8 (36)	11.9 (54)	1.1 (18)	5.1 (27)
Live branched coral	9.1 (27)	10.8 (45)	14.8 (45)	6.8 (45)
Dead coral	14.2 (36)	47.2 (91)	11.9 (36)	22.2 (64)
Reef rock	4.5 (9)			
Rubble	25.0 (36)		12.5 (36)	12.5 (27)
Sand	17.6 (36)	1.7 (9)	46.6 (36)	32.4 (82)
Didemnid molle	0.6 (9)	2.3 (9)	0.6 (9)	4.5 (45)
Lissoclinum patella			1.7 (27)	0.6 (9)
Eudistoma sp.		1.1 (9)	2.3 (36)	2.8 (36)
Diplosoma similis		0.6 (9)		
Lissoclinum diplosoma			3.4 (18)	
Beige Tunicate			2.3 (36)	
Sponge	0.6 (9)	1.7 (18)	1.1 (18)	0.6 (9)
Tridacna sp.	4.4 (18)			
Foramanifera sp	2.3 (36)	1.7 (18)		0.6 (9)
Anemone		0.6 (9)		
Tube worm			0.6 (9)	
Snail				0.6 (9)
Number of plant genera/transect	5	12	6	7
Number of plant species/transect	5	14	6	7
Overall percent plant coverage	7.9	17.1	1.7	9.6
Total number of plant genera	17			
Total number of plsnt species	22			

Table 6.4. Seagrass coverage, center of the seagrass bed at Island 7. Number of seagrasses falling within five internal squares of the quadrat were counted. Plain numbers indicate the total number of seagrasses per toss, the numbers in parenthesis indicate the average number (x100) of seagrasses per m2.

	NUMBER OF TOSSES									
species	1	2	3	4	5	6	7	8	9	10
Syringodium isoetifolium (Aschers.) Dandy	17 (14)	35 (28)	66 (52)	68 (56)	17 (12)	6 (8)	26 (20)	61 (48)	51 (40)	3 (2)
Cymodocea rotundata Ehrenb. & Hemor.	3 (2)	11 (9)	1 (1)	4 (3)	6 (5)					15 (12)
Halophila ovalis (R. Br.) Hook.				2 (2)		3 (4)	6 (8)			2 (2)
Total	20 (16)	46 (37)	67 (53)	74 (61)	23 (17)	9 (12)	32 (28)	61 (48)	51 (40)	20 (16)

Chapter 7

MARINE MACROINVERTEBRATES OF THE NGERUKEWID ISLANDS WILDLIFE PRESERVE

BARRY D. SMITH, Coastal Resources Extension Specialist, Marine Laboratory, University of Guam, Mangilao, Guam 96923

INTRODUCTION

Although no single, comprehensive account of the macroinvertebrate fauna of Palau has been published, several taxa have been studied extensively, including sponges (Bergquist, 1965), tridacnid clams (Rosewater, 1965), crinoids (Meyer and Macurda, 1980), asteroids (Marsh, 1977), and ascidians (Tokioka, 1967; Kott, 1982). The purpose of this chapter is to report a quantitative and qualitive assessment of the conspicuous marine macroinvertebrates occurring in the Ngerukewid Islands Wildlife Preserve.

METHODS

Populations of conspicuous epibenthic macroinvertebrates inhabiting the Ngerukewid Islands Wildlife Preserve were sampled along twelve 50-m transects established in three zones designated as outer patch reef stations, perimeter fringing reef stations, and interior reef area stations (see Fig. 4.1). Species of macrobenthos encountered within 1 m of the transect line were identified and enumerated by an observer swimming along the line. Data were recorded for 5-m segments of the line; thus, each transect consisted of ten 10-m^2 rectangular quadrats and covered a total area of 100 m^2.

Because of the difficulty involved in distinguishing individuals among the abundant colonially-associated organisms such as ascidians and sponges, aggregations of these organisms were treated as individuals for the purposes of this survey. The data generated, therefore, estimate the density of colonies present, but do not provide any indication of the numbers of individuals within the colonies.

The abundant didemnid ascidian Didemnum molle was sampled with a 25 X 25 cm quadrat tossed twice at 5-m intervals along the transect line. Thus, population density estimates are based on a total of twenty 0.0625-m^2 samples per transect.

Areas adjacent to the transects were also examined to record the presence of species inhabiting the reef but not occurring within the selected study sites. Remains of dead macroinvertebrates were noted when present, but they were not quantified.

RESULTS

The Ngerukewid Islands Wildlife Preserve supports a diverse fauna of epibenthic macroinvertebrates (Table 7.1), but with localized exceptions, species are not present in great abundance (Tables 7.2, 7.3, and 7.4). Although the species composition of the major invertebrate phyla exhibited some variation among the three

habitats surveyed, the numbers of species representing the phyla were similar in all habitats.

Interior Reef Areas (Stations 5, 9, 11, 12)

Sponges occurred in their greatest numbers in the protected waters of the interior coral areas. Found on three of the four stations, Phyllospongia foliascens reached the highest density of any macroinvertebrate species at Station 12, where it exceeded one colony per square meter. A sponge resembling the Clathria cervicornis reported by Bergquist (1965) and unidentified species also occurred on transects of the interior stations.

Although less diverse in the interior coral areas than in other zones, cnidarian macroinvertebrates were more abundant in this habitat. The large hydroid Aglaophenia cupresina and the soft corals Stereonephthya spp. and Litophyton spp. were the predominant species of this group in terms of highest densities recorded, but only Litophyton spp. occurred on more than one station in this zone.

Molluscs were the most diverse group of macrobenthos in the interior coral areas. Gastropods species seldom exceeded one individual per 100 m^2, and the money cowrie Cypraea moneta was the only species that was widely distributed in this zone. Bivalves attained their greatest overall abundance in this zone, with species that live embedded in coral colonies being the predominant forms. The mytilid Septifer bilocularis occurred on all four stations and attained the highest density of the bivalves present. The arcid clams Arca ventricosa and Barbatia amygdalumtostum were present in lower numbers, but they were found throughout the zone. Tridacna crocea, one of the smaller species of the giant clams, was clustered in high densities near intertidal areas at two stations.

Although the echinoderm species were diverse in the interior coral areas, they were not abundant. Only the sea urchins Parasalenia gratiosa and Echinometra mathaei exceeded one individual on any transect, and no echinoderms occurred at all on the transect at Station 12.

Ascidians were present on transects throughout this zone, but their densities were lower relative to the other zones examined. Lissoclinum patella and Eudistoma cf. viride occurred most commonly in the interior coral areas, but Didemnum molle attained the highest densities.

Fringing Reef Perimeter (Stations 1, 2, 3, 4)

Sponges were recorded throughout this zone, but only one species, cf. Clathria cervicornis, occurred in any abundance. In addition to Phyllospongia foliascens, a tetillid species resembling Cinachyra spp. occurred on transects of fringing reefs.

The predominant cnidarian macroinvertebrates on fringing reef stations exhibited clumped distributions. The large hydroid Aglaophenia cupresina occurred in a cluster of 41 individuals around a large rock on Station 4, but only two colonies were observed on the remainder of the area surveyed. All 6 of the colonies of Litophyton spp. were also associated with this rock. A similar distribution was found for Lobophytum spp. at Station 3, where 12 of the 13 colonies encountered on the transect occurred in one quadrat.

Molluscs were represented on the fringing reefs by a diverse assemblage of gastropods and bivalves. The sessile vermetid snail Dendropoma maxima and the horned cerith Cerithium nodulosum were the most abundant gastropods. Coral-associated bivalves were commonly encountered in this zone, and an as yet unidentified species of Electroma found on branching Acropora was the most widespread species. The hammer oyster Malleus regula was the most abundant of the suspension-feeding bivalve species, and Tridacna crocea was the most abundant of the four tridacnid clams present on transects. Although they were not encountered within the sampled area, Tridacna gigas, Tridacna derasa, and Hippopus porcellanus were observed in areas adjacent to transects on fringing reefs. Thus, all seven extant species of tridacnid clams inhabited the fringing reefs of the Ngerukewid Islands Wildlife Preserve.

Echinoderm density and diversity on the fringing reefs were similar to that found in the interior coral areas. Only three species were represented by more than single individuals.

Ascidians exhibited their greatest species diversity on the fringing reefs. Species diversity and abundance were greatest at Stations 1 and 2.

Outer Patch Reefs (Stations 6, 7, 8, 10)

The fan-shaped sponge Phyllospongia foliascens was the only conspicuous sponge species encountered on transects on outer patch reefs. The species was not abundant in this zone, and although no measurements were made, the colonies appeared to be smaller in size on patch reefs than in interior coral areas.

Aglaophenia cupresina was the most abundant cnidarian macroinvertebrate on outer patch reefs. Soft corals were represented solely by nephtheid species. An unidentified plexaurid gorgonian was encountered on one transect. An anemone believed to be a Heterodactyla sp. occurred as a substory or shade species beneath branching Acropora spp. Because of the cryptic nature of this habitat, density estimates for this anemone should be considered conservative.

The vermetid snail Dendropoma maxima was the most abundant gastropod mollusc on outer patch reefs. At Station 8, dense clusters of these suspension-feeding snails occurred embedded in Porites and Millepora coral colonies.

Bivalve diversity was greater on patch reef transects than in the other zones sampled. The hammer oyster Malleus regula, the mytilid Septifer bilocularis, and the Acropora-commensal Electroma were the most widely distributed species on patch reefs, with Septifer bilocularis occurring in the greatest abundance. Of the five species of giant clams encountered in the sampled area, Tridacna crocea was the most abundant and usually occurred in shallow reef flat areas.

Echinoderms attained their greatest diversity and greatest abundance on the outer patch reefs; no species, however, occurred on all transects in this zone. Two unidentified species of crinoids were encountered in the sampled area. A small synaptid holothurian, Synatula cf. media, was epizoic on a large red sponge at Station 8.

The ascidians present on transects of the outer patch reefs were the same species recorded in the other zones. As also found in the other zones, the predominant species were Didemnum molle and Eudistoma viride.

DISCUSSION

The results of this survey provide several interesting considerations. The high diversity of marine species that one would expect of this geographic location is readily apparent. Although the abundances of individuals within each species may appear to be low, the data of the present survey are similar to those reported in previous surveys within the archipelago (Birkeland et al., 1976; Randall et al., 1978).

The predominant epibenthic macroinvertebrate forms of Ngerukewid are suspension-feeders and invertebrates associated with algal symbionts. Each of the major phyla occurring on the transects is represented by one or more species of suspension-feeders. Suspension feeding is the primary means of acquiring nutrition for 40-50% of all the conspicuous macroinvertebrates surveyed at Ngerukewid.

Algal-bearing macroinvertebrates also represent a considerable proportion of the fauna at Ngerukewid. Heslinga and Fitt (1987) recently reviewed the clam-alga association of the Tridacnidae, and Kott (1982) discussed the evolution of didemnid ascidians and their prokaryotic algal symbionts. Lewin et al. (1983) found that the primary productivity of such phototrophic invertebrate-algal associations of coral reef systems may be comparable to those reported for kelp beds and seagrass communities.

Tridacnid clams have received considerable attention in recent literature because of their economic value in the Orient and the threat of overharvesting giant clam stocks (Hardy and Hardy, 1969; Bryan and McConnell, 1976; Yamaguchi, 1977; Fitt et al., 1984; Heslinga et al., 1984; Heslinga, 1985; Heslinga and Fitt, 1987). Despite the advances in mariculture technology for tridacnids and the potential to farm these clams or to enhance natural stocks, their restricted distributions (Rosewater, 1965; 1982) and economic value combine to make them candidates for overharvest and possibly even extinction. Species such as Tridacna gigas, Tridacna derasa, and Hippopus porcellanus occur in the Ngerukewid Islands Wildlife Preserve along with the four more widely distributed species, making this one of the few areas in the world where all seven species coexist.

The diversity of suspension-feeding and phototrophic species was not reflected in predatory species. This lack of diversity is strikingly apparent among the predatory gastropods. Whereas Taylor (1984) found 56 species of predatory gastropods on a fringing reef at Guam, only 9 occurred on similar substrates in the present survey. Sandy areas on the fringing reefs of Ngerukewid that would seemingly provide suitable habitat for various vermivorous species of Vexillum, Conus, and Terebra yielded only single species of each of these genera.

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Table 7.1. Species inventory of conspicuous marine macroinvertebrates observed in the Ngerukewid Islands Wildlife Preserve. The predominant habitat type is given for each species and station. Species observed within the boundary of the preserve but not at a sampling station are listed under Other. Habitat types are: Cr = Live Coral; It = Intertidal Limestone Bench; Mg = Mangrove Prop Roots; Pv = Limestone Pavement; Rb = Rubble; Rk = in, on, or under reef rocks; Sg = Seagrass Meadow; Sn = Sand; St = Silt; and Tf = Algal Turf/Sand Veneer Over Pavement. An asterisk (*) represents an observation of the dead remains of a species.

Stations	1	2	3	4	5	6	7	8	9	10	11	12	Other
PROTOZOA													
Marginopora vertebralis	Rb	Rb		Rb		Rb	Rb						
PORIFERA													
Phyllospongia foliascens (Pallas)			Rk	Rk	Rb	Rk		Rk		Rk	Rk	Rk	Rk
cf. *Clathria cervicornis* (Thiele)	Rk	Rb										Rk	
cf. *Cinachyra* sp.			Pv										
orange finger sponge											Rk		
CNIDARIA													
Cassiopea medusa Light	St										St	St	
Aglaophenia cupresina (Lamouroux)				Rk	Rk	Rk		Rk					
Lobophytum spp.			Rk										
Sinularia spp.			Rk					Rk					
Dendronephthya sp.				Rk				Rk					
Litophyton sp.		Rk		Rk	Rk	Rk		Rk			Rk		Rk
Stereonephthya sp.		Rk		Rk	Rk		Rk	Rk					Rk
plexaurid sp.								Rk					
Entacmaea quadricolor (Rueppell & Leuckart)								Rk	Rk		Rk		
cf. *Heterodactyla* spp.		Rb	Rb				Rb					Rk	Rb
Heteractis crispa (Ehrenberg)	Rk												Rk
Palythoa spp.			Rk									Rk	
ANNELIDA													
Sabellastarte sanctijosephi (Gravier)		Rk	Rk	Rk	Rk			Rk	Rk	Rk	Rk	Rk	Rk
Spirobranchus giganteus (Pallas)				Cr		Cr	Cr						Cr
MOLLUSCA													
Haliotis varia Linnaeus				*									*
Patelloida saccharina (Linnaeus)			It										It
Patelloida sp. cf. *profunda* complex			It										
Cellana cf. *eucosmia* Pilsbry			It										It
Patella flexuosa Quoy & Gaimard			It										It
Chrysostoma paradoxum (Born)		*											
Euchelus atratus (Gmelin)												Rk	
Monodonta labio (Linnaeus)													It
Trochus maculatus Linnaeus		Rk			Rk	Rk	Rk			Rk		Rk	
Trochus ochroleucus Gmelin													Rk
Tectus pyramis (Born)	*		Rk			Rk							

Table 7.1. Continued.

Stations	1	2	3	4	5	6	7	8	9	10	11	12	Other
Tectus triserialis (Lamarck)		*		Rk									
Stomatia phymotis Helbling												*	
Stomatia rubra (Lamarck)													Rk
Nerita albicilla Linnaeus			It										
Nerita maxima Gmelin													It
Nerita plicata Linnaeus			It										It
Nerita polita Linnaeus			It										
Nerita squamulata LeGuillou			It										It
Nerita undata Linnaeus			It									*	It
Littorina coccinea (Gmelin)			It										
Littorina scabra (Linnaeus)	It												It
Littorina undulata Gray			It										It
Nodilittorina millegrana (Philippi)			It										It
Dendropoma maxima Sowerby			Cr	Cr	Cr	Cr		Cr					
Cerithium alveolus (Hambron & Jacquinot)	Rb	Rb											Rb
Cerithium atromarginatum Deshayes													Sn
Cerithium columna Sowerby	Rb												Sn
Cerithium nodulosum Bruguiere	Rb												
Cerithium rostratum (Sowerby)	Pv												Sn
Cerithium salebrosum Sowerby		Sn											Sn
Cerithium suturale Philippi												*	
Cerithium tenuifilosum Sowerby	Sn	Sn											
Cerithium zonatum (Wood)				Rb					Sn		Sn		Rb
Cerithium sp. 1										Sn	Sn		
Cerithium sp. 2													St
Clypeomorus batillariaeformis Habe & Kosuge					*								St
Clypeomorus bifasciata (Sowerby)					St								
Pseudovertagus aluco (Linnaeus)										Sn		Sn	
Rhinoclavis aspera (Linnaeus)	Sn											Sn	Sn
Rhinoclavis fasciata (Bruguiere)		Sn											Sn
Rhinoclavis sinensis (Gmelin)													Sn
Rhinoclavis vertagus (Linnaeus)													Sn
Lambis lambis Linnaeus	Rb		Rb										
Strombus gibberulus gibbosus (Roeding)	Sn												Sn
Strombus lentiginosus Linnaeus													Rb
Strombus luhuanus Linnaeus	*												
Strombus mutablis Swainson	Sn	*										Sn	
Strombus urceus Linnaeus											*		
Hipponix foliaceus (Quoy & Gaimard)													*
Trivia oryza (Lamarck)			Rk										
Cypraea annulus Linnaeus		Rb		Rb									Rb
Cypraea arabica Linnaeus												Rk	
Cypraea asellus Linnaeus													*
Cypraea cylindrica Born													Rk
Cypraea erosa Linnaeus													Rk
Cypraea lynx Linnaeus		Rk								Rk		Rk	
Cypraea mappa Linnaeus										*			
Cypraea moneta Linnaeus	Rb	Rk							Rb	Rk	Rk	Rb	
Cypraea ovum Gmelin												Rk	

Table 7.1. Continued.

Stations	1	2	3	4	5	6	7	8	9	10	11	12	Other
Cypraea quadrimaculata Gray													Rb
Cypraea staphylaea Linnaeus		*											
Cypraea tigris Linnaeus	Rb		Rk		Rk					Pv			
Cypraea vitellus Linnaeus													Sn
Natica bougei Sowerby	Sn												Sn
Natica gualtieriana Recluz													Sn
Natica onca (Roeding)		*											
Natica orientalis Gmelin													*
Polinices melanostomus (Gmelin)												*	
Polinices tumidus (Swainson)													Sn
Cymatium gemmatum (Reeve)		Rb											
Cymatium muricinum (Roeding)												Rb	
Cymatium nicobaricum (Roeding)													Rb
Colubraria muricata (Lightfoot)													*
Chicoreus brunneus (Link)													Rk
Cronia margariticola (Broderip)	Rk				Rk						Rb	*	Rb
Drupa ricinus (Linnaeus)						Rk							
Drupa rubusidaeus Roeding										Rk			
Drupella ochrostoma (Blainville)			*										
Drupella elata (Blainville)													Pv
Morula anaxeres (Kiener)													It
Morula granulata (Duclos)	It												
Morula cf. marginatra (Blainville)			It										It
Morula nodicostata (Pease)			Rk										
Muricodrupa fenestrata (Blainville)													It
Naquetia trigonula (Lamarck)		*											*
Thais aculeata (Deshayes)			It										It
Thais cf. savignyi (Deshayes)			It										It
Quoyula monodonta (Blainville)					Cr								
Mitrella ligula (Duclos)	Sn	Sn	*										Sn
Pyrene flava (Bruguiere)													Rb
Pyrene ocellata (Link)	Pv												It
Pyrene testudinaria (Link)	Tf		Rk										Pv
Pyrene turturina (Lamarck)		Rb											
Pyrene varians (Sowerby)		Tf											
Cantharus fumosus (Dillwyn)		Rb	Rk				Rb					Rb	
Cantharus iostomus (Gray)													Rk
Cantharus undosus (Linnaeus)													
Engina alveolata (Kiener)	Tf		*										Rk
Hebra horrida (Dunker)	Sn			Sn									Sn
Nassarius albescens (Dunker)	Sn											*	Sn
Nassarius cf. bellulus (A. Adams)											*		
Nassarius coronatus (Bruguiere)													Sn
Nassarius distortus (A. Adams)													Sn
Latirus sp.	Sn												Sn
Vasum turbinellus (Linnaeus)	Sn	Sn			Rb				Rb			Rb	
Cancilla filaris (Linnaeus)	Sn												Sn
Imbricaria punctata (Swainson)													Sn
Mitra mitra Linnaeus													Sn

Table 7.1. Continued.

Stations	1	2	3	4	5	6	7	8	9	10	11	12	Other
Mitra (Strigatella) litterata (Lamarck)			It										
Mitra (Strigatella) paupercula (Linnaeus)			It										
Vexillum gruneri (Reeve)													Sn
Vexillum plicarium (Linnaeus)	*									Sn	Sn	*	Sn
Vexillum (Costellaria) deshayesii (Reeve)	Sn			Sn								*	Sn
Vexillum (Costellaria) granosum (Gmelin)		Sn											
Vexillum (Costellaria) sansuisugum (Linnaeus)													Sn
Vexillum (Costellaria) semifasciatum (Lamarck)													Sn
Vexillum (Costellaria) virgo (Linnaeus)													Sn
Vexillum (Pusia) luculentum (Reeve)			It										
Vexillum (Pusia) pisolinum (Lamarck)	It												It
Vexillum (Pusia) speciosum (Reeve)													*
Vexillum (Pusia) unifascialis (Lamarck)													Rb
Clavus canalicularis (Roeding)	Sn												
Clavus sp.													Sg
Eucithara funiculata (Reeve)													Sn
Eucithara sp.													Sg
Xenuroturris kingae Powell													*
Conus capitaneus Linnaeus										Pv			
Conus coronatus Gmelin	Sn											Rb	Pv
Conus ebraeus Linnaeus					Pv	Pv						Pv	Pv
Conus flavidus Lamarck	Tf												
Conus litteratus Linnaeus	Sn												Sn
Conus lividus Hwass	Tf	Rb											
Conus magus Linnaeus													Sn
Conus marmoreus Linnaeus													Sn
Conus miles Linnaeus							Pv						
Conus miliaris Hwass	Tf		Pv										
Conus moreleti Crosse													Pv
Conus pulicarius Hwass													Sn
Conus rattus Hwass						Rb							
Conus sponsalis Hwass	Tf												
Conus virgo Linnaeus		Sn											
Conus vitulinus Hwass		Rb											
Terebra affinis Gray	Sn	Sn											Sn
Terebra cingulifera Lamarck													Sn
Otopleura auriscati (Holten)													*
Otopleura mitralis (A. Adams)													Sn
Atys naucum (Linnaeus)										*,			
Nembrotha sp.						Rk							
Anadara antiquata (Linnaeus)													Sg
Arca cf. plicata (Dillwyn)		Rb	Rk	Rk								Rk	
Arca ventricosa (Lamarck)		Rk	Rk	Rk	Rk	Rk		Rk	Rk		Rk	Rk	Rk
Barbatia amygdalumtostum (Roeding)			Rk	Rk		Rk		Rk	Rk	Rk	Rk	Rk	Rk
Barbatia tenella (Reeve)		Rk											
Septifer bilocularis (Linnaeus)			Rk	Rk	Rk	Rk	Rk	Rk	Rk	Rk	Rk	Rk	Rk
Electroma sp.	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr		Cr
Pinctada margaritifera (Linnaeus)						*							Rb
Pteria penguin (Roeding)													Rk

Table 7.1. Continued.

Stations	1	2	3	4	5	6	7	8	9	10	11	12	Other
Malleus regula (Forsskal)		Rb	Rb	Rk	Rk	Rb	Rb	Rk	Rk	Rk	Rk	Rk	Rk
Pedum spondyloideum (Gmelin)	Cr	Cr	Cr	Cr		Cr		Rk				Cr	
Spondylus squamosus Schreibers		Rk											
Spondylus varius Sowerby													Rk
Spondylus zonalis Lamarck													Rk
Spondylus sp.		Rk		Rk	Rk	Rk		Rk	Rk			Rk	
Lima basilanica (Adams & Reeve)												Rk	
Lima lima vulgaris (Link)													Rk
Crassostrea sp.													Mg
Hyotissa hyotis (Linnaeus)							Rk		Rk				
Lopha cristagalli (Linnaeus)						Rk							Rk
ostreid sp.													Mg
Chama lazarus (Linnaeus)											Rk	Rk	
Chama iostoma Conrad									*			Rk	
Chama spp.									Rk	Rk	Rk	Rk	Rk
Anodontia edentula (Linnaeus)													*
Wallucina cf. gordoni (E.A. Smith)		*											
Frimbria fimbriata (Linnaeus)													Sn
Cardita variegata Bruguiere			Rk										
Corculum cardissa (Linnaeus)													Sn
Fragum fragum (Linnaeus)	Sn												
Fulvia tenuicostata (Lamarck)											*		
Trachycardium cf. alternatum (Sowerby)				*						Sn			
Trachycardium enode (Sowerby)									*				
Tridacna crocea Lamarck		Pv	Pv	Rk	Pv	Rk	Rk	Rk	Rk	Pv		Rk	Pv
Tridacna derasa	Rb	Rb		Rb		Rb	Rb	Rb		Rb			Rb
Tridacna gigas (Linnaeus)	Rb	*	*										
Tridacna maxima (Roeding)			Pv	Pv		Pv							Rk
Tridacna squamosa Lamarck		Rk	Rk	*		Rk	Rb	Rk	Pv	Pv			Rk
Hippopus hippopus (Linnaeus)	Pv	Rb	Pv	Rb		Pv			Pv	Pv			
Hippopus porcellanus Rosewater	Rb	Rb											
Atactodea striata (Gmelin)													Sn
Quadrans cf. gargadia (Linnaeus)		*											
Tellina perna Spengler		Sn											Sn
Tellina cf. remies Linnaeus									*				
Gari cf. squamosa (Lamarck)				Sn									Sn
Gari sp.		*											
Glycydonta marica (Linnaeus)		Sn											Sg
Lioconcha castrensis (Linnaeus)				Sn					*				
Lioconcha ornata (Lamarck)										Sn			
Pitar cf. citrinus (Lamarck)													*
Pitar sp.											*		
Nautilus sp.													*
ARTHROPODA													
Dardanus lagopodes (Forsskal)	Rb												
Dardanus megistos (Herbst)	Pv												
Trizopagurus strigatus (Herbst)													Rb

Table 7.1. Continued.

Stations	1	2	3	4	5	6	7	8	9	10	11	12	Other
grapsid sp.													Mg
Panulirus sp.						Rk							
ECHINODERMATA													
Comanthus cf. parvicirrus (J. Mueller)		Rb					Rk	Rk					
Acanthaster planci (Linnaeus)	Cr					Cr							
Choriaster granulatus Lutken													Rb
Culcita novaeguineae Muller & Troschel		Rb				Rb	Rb	Rb			Pv		
Fromia sp.					Rb								
Tamaria fusca (Gray)													Rk
Linckia laevigata (Linnaeus)	Pv	Rb	Pv	Rk		Pv		Rk		Pv			Pv
Linckia multifora (Lamarck)	Rb	Rk		Pv		Rb	Rb		Rb	Pv			Rb
Linckia sp.												Pv	
Nardoa novaecaledoniae (Perrier)				Rb	Rb						Rb	Rb	
Echinaster leuzonicus (Gray)				Rb									
Echinometra mathaei (de Blainville)		Rk		Rk	Rk	Pv	Rk			Rk			
Parasalenia gratiosa A. Agassiz					Rk	Rk							
Mespilia globulus (Linnaeus)			Rk										
Ophiarachnella gorgonia (Muller & Troschel)													Rb
Ophiomastix mixta Lutken													Rb
Ophiothrix cf. hybrida H. L. Clark													Rb
Actinopyga echinites (Jaeger)				Rk									
Actinopyga lecanora (Jaeger)				Pv									
Bohadschia argus Jaeger		Sn											
Bohadschia marmorata Jaeger								Sn			Sn		
Holothuria atra Jaeger	Sn	Sn	Sn			Rb	Rb	Rb		Sn	Sn		
Holothuria axiologa H. L. Clark													Sn
Holothuria edulis Lesson		Rb		Rb				Sn					
Holothuria impatiens (Forsskal)				Rb									
Stichopus chloronotus Brandt	Pv	Rb					Rb		Sn	Sn	Sn		
Stichopus variegatus Semper		Sn		Sn				Sn					
Synaptula cf. media Cherbonnier & Feral						Sp		Sp					Sp
CHORDATA													
Didemnum molle (Herdman)	Rb	Rb	Rb	Rb	Rb	Rb	Rb	Rb	Rb	Rb	Rb	Rb	Rb
Didemnum cf. moseleyi (Herdman)	Rk												
Diplosoma similis (Sluiter)	Rb	Rb		Rb		Rb	Rb	Rb	Rb		Rb		
Lissoclinum patella (Gottschaldt)	Rb	Rb			Rb		Rb	Rb	Rb	Rb	Rb	Rb	Rb
Lissoclinum voeltzkowi (Michaelson)	Rb	Rb					Rb				Rb	Rb	Rb
Eudistoma cf. viride Tokioka	Rb	Rb	Rb	Rb	Rb	Rk	Rb	Rb	Rb	Rb	Rb	Rb	Rk

Table 7.2. Distribution and abundance of conspicuous macroinvertebrates, interior reef transect stations 5, 9, 11, 12. Data are mean ± standard deviation in ten 10-m^2 quadrats for all species except *Didemnum molle*. Data for *Didemnum molle* are mean ± standard deviation in twenty 0.0625-m^2 quadrats. An asterisk (*) denotes the occurrence of a dead specimen on the transect.

	Station 5	Station 9	Station 11	Station 12
PORIFERA				
Phyllospongia foliascens (Pallas)	1.9 ± 1.4		0.2 ± 0.6	10.7 ± 13.1
cf. *Clathria cervicornis* (Thiele)				5.4 ± 10.0
orange finger sponge			0.4 ± 1.3	
CNIDARIA				
Cassiopea medusa Light			0.1 ± 0.3	0.1 ± 0.3
Aglaophenia cupresina (Lamouroux)	2.8 ± 5.7			
Litophyton sp.	2.0 ± 4.4		2.6 ± 7.9	
Stereonepthya sp.	3.7 ± 5.6			
Entacmaea quadricolor (Rueppell & Leuckart)		0.2 ± 0.6	0.2 ± 0.6	
cf. *Heterodactyla* spp.				0.1 ± 0.3
ANNELIDA				
Sabellastarte sanctijosephi (Gravier)	0.1 ± 0.3	0.2 ± 0.6	0.6 ± 1.3	
MOLLUSCA				
Trochus maculatus Linnaeus	0.2 ± 0.6			0.1 ± 0.3
Dendropoma maxima Sowerby	0.1 ± 0.3			
Cypraea lynx Linnaeus				0.1 ± 0.3
Cypraea moneta Linnaeus		0.3 ± 0.9	0.1 ± 0.3	0.1 ± 0.3
Cypraea tigris Linnaeus	0.1 ± 0.3			
Vasum turbinellus (Linnaeus)	0.1 ± 0.3	0.1 ± 0.3		
Conus ebraeus Linnaeus	0.1 ± 0.3			
Arca ventricosa (Lamarck)	0.5 ± 0.8	0.3 ± 0.7	1.0 ± 3.2	
Barbatia amygdalumtostum (Roeding)		0.5 ± 0.8	0.7 ± 2.2	0.7 ± 1.5
Septifer bilocularis (Linnaeus)	4.7 ± 5.0	4.6 ± 7.3	6.1 ± 16.6	4.2 ± 9.0
Electroma sp.	1.9 ± 1.7	1.4 ± 2.1	0.3 ± 0.7	
Malleus regula (Forsskal)	1.7 ± 2.6	1.4 ± 2.3	2.6 ± 6.2	1.3 ± 2.5
Pedum spondyloideum (Gmelin)				0.2 ± 0.6
Spondylus spp.	0.3 ± 0.7	0.2 ± 0.6		0.1 ± 0.3
Chama spp.			0.3 ± 0.7	0.3 ± 0.7
Tridacna crocea Lamarck	4.7 ± 9.5	1.3 ± 2.6		1.5 ± 2.3
Tridacna squamosa Lamarck		0.1 ± 0.3		
Hippopus hippopus (Linnaeus)		0.1 ± 0.3		

Table 7.2. Continued.

	Station 5	Station 9	Station 11	Station 12
ECHINODERMATA				
Culcita novaeguineae Muller & Troschel			0.1 ± 0.3	
Fromia sp.	0.1 ± 0.3			
Linckia multifora (Lamarck)		0.1 ± 0.3		
Nardoa novaecaledoniae (Perrier)	0.1 ± 0.3		0.1 ± 0.3	
Paraselenia gratiosa A. Agassiz	0.4 ± 1.0			
Echinometra mathaei (de Blainville)	0.2 ± 0.4			
Bohadschia marmorata Jaeger			0.1 ± 0.3	
Holothuria atra Jaeger			0.1 ± 0.3	
Stichopus chloronotus Brandt		0.1 ± 0.3		
CHORDATA				
Didemnum molle (Herdman)	0.2 ± 0.9		1.4 ± 5.8	1.5 ± 6.8
Diplosoma similis (Sluiter)		0.1 ± 0.3	0.1 ± 0.3	
Lissoclinum patella (Gottschaldt)	0.2 ± 0.6	0.2 ± 0.6	0.6 ± 1.1	7.9 ± 4.6
Lissoclinum voeltzkowi (Michaelsen)			0.1 ± 0.3	0.4 ± 0.7
Eudistoma cf. *viride* Tokioka	1.1 ± 1.7	0.8 ± 1.3	1.6 ± 3.5	0.6 ± 1.1

Table 7.3. Distribution and abundance of conspicuous macroinvertebrates, fringing reef perimeter transect stations 1-4. Data are mean ± standard deviation in ten 10-m^2 quadrats for all species except Didemnum molle. Data for Didemnum molle are mean ± standard deviation in twenty 0.0625-m^2 quadrats. An asterisk (*) denotes the occurrence of a dead specimen on the transect.

	Station 1	Station 2	Station 3	Station 4
PORIFERA				
Phyllospongia foliascens (Pallas)			0.1 ± 0.3	0.2 ± 0.4
cf. Clathria cervicornis (Thiele)	2.7 ± 5.1	5.7 ± 5.5		
cf. Cinachyra sp.			0.1 ± 0.3	
CNIDARIA				
Cassiopea medusa Light	0.1 ± 0.3			
Aglaophenia cupresina (Lamouroux)				4.3 ± 12.9
Lobophytum spp.			1.3 ± 3.8	
Sinularia spp.			0.3 ± 0.9	
Dendronephthya sp.				0.1 ± 0.3
Litophyton sp.				0.6 ± 1.9
Stereonepthya sp.				0.4 ± 1.0
cf. Heterodactyla spp.		0.4 ± 1.3	0.3 ± 0.7	
Heteractis crispa (Ehrenberg)	0.1 ± 0.3			
Palythoa spp.			0.4 ± 1.3	
ANNELIDA				
Sabellastarte sanctijosephi (Gravier)		0.2 ± 0.4		0.1 ± 0.3
MOLLUSCA				
Tectus pyramis (Born)			0.1 ± 0.3	
Dendropoma maxima Sowerby			2.9 ± 3.6	0.2 ± 0.4
Cerithium nodulosum Bruguiere	0.7 ± 1.9			
Lambis lambis Linnaeus			0.1 ± 0.3	
Cypraea annulus Linnaeus				0.1 ± 0.3
Cypraea moneta Linnaeus	0.2 ± 0.4	0.1 ± 0.3		
Cypraea tigris Linnaeus	0.1 ± 0.3		0.1 ± 0.3	
Drupella ochrostoma (Blainville)			*	
Vasum turbinellus (Linnaeus)	0.3 ± 0.7			
Conus flavidus Lamarck	0.1 ± 0.3			
Arca ventricosa (Lamarck)			0.1 ± 0.3	0.3 ± 0.7
Septifer bilocularis (Linnaeus)			0.2 ± 0.6	
Electroma sp.	0.5 ± 1.3	0.1 ± 0.3	0.9 ± 1.6	0.6 ± 1.0
Malleus regula (Forsskal)		1.0 ± 1.2	1.7 ± 2.7	1.0 ± 1.1
Pedum spondyloideum (Gmelin)	0.1 ± 0.3		0.6 ± 1.3	0.1 ± 0.3
Spondylus sp.				0.1 ± 0.3
Tridacna crocea Lamarck			3.9 ± 5.5	1.7 ± 2.1
Tridacna gigas (Linnaeus)		*	*	

Table 7.3. Continued.

	Station 1	Station 2	Station 3	Station 4
Tridacna maxima (Roeding)			0.1 ± 0.3	0.2 ± 0.4
Tridacna squamosa Lamarck		0.5 ± 0.5	0.1 ± 0.3	*
Hippopus hippopus (Linnaeus)	0.1 ± 0.3	0.4 ± 0.5	0.2 ± 0.4	
ARTHROPODA				
Dardanus megistos (Herbst)	0.1 ± 0.3			
ECHINODERMATA				
Culcita novaeguineae Muller & Troschel		0.1 ± 0.3		
Linckia laevigata (Linnaeus)	0.2 ± 0.6			0.1 ± 0.3
Linckia multifora (Lamarck)		0.1 ± 0.3		
Nardoa novaecaledoniae (Perrier)				0.1 ± 0.3
Echinometra mathaei (de Blainville)		0.1 ± 0.3		0.1 ± 0.3
Actinopyga echinites (Jaeger)				0.1 ± 0.3
Holothuria atra Jaeger			0.3 ± 0.5	
Holothuria edulis Lesson		0.1 ± 0.3		
Stichopus chloronotus Brandt		0.5 ± 1.0		
CHORDATA				
Didemnum molle (Herdman)	2.6 ± 3.9	10.9 ± 18.3	1.5 ± 4.3	0.7 ± 2.9
Didemnum cf. *moseleyi* (Herdman)	0.5 ± 1.3			
Diplosoma similis (Sluiter)	4.0 ± 8.0	12.0 ± 10.1		0.2 ± 0.6
Lissoclinum patella (Gottschaldt)	0.2 ± 0.6	16.0 ± 8.9		
Lissoclinum voeltzkowi (Michaelsen)	1.2 ± 2.0	11.0 ± 8.2		
Eudistoma cf. *viride* Tokioka	2.7 ± 3.0	14.8 ± 7.5	1.5 ± 2.3	1.1 ± 1.7

Table 7.4. Distribution and abundance of conspicuous macroinvertebrates, outer patch reef transect stations 6-8, 10. Data are mean ± standard deviation in ten 10-m^2 quadrats for all species except *Didemnum molle*. Data for *Didemnum molle* are mean ± standard deviation in twenty 0.0625-m^2 quadrats. An asterisk (*) denotes the occurrence of a dead specimen on the transect.

	Station 6	Station 7	Station 8	Station 10
PORIFERA				
Phyllospongia foliascens (Pallas)	0.5 ± 1.0		0.2 ± 0.4	0.2 ± 0.6
CNIDARIA				
Aglaophenia cupresina (Lamouroux)	0.1 ± 0.3		8.3 ± 7.7	
Dendronephthya sp.			0.1 ± 0.3	
Litophyton sp.	1.4 ± 3.1		0.5 ± 0.8	
Stereonepthya sp.		1.6 ± 4.0	0.1 ± 0.3	
plexaurid sp.			0.1 ± 0.3	
Entacmaea quadricolor (Reuppell & Leuckart)			0.4 ± 1.3	
cf. *Heterodactyla* spp.		1.7 ± 1.7		
ANNELIDA				
Sabellastarte sanctijosephi (Gravier)			0.8 ± 1.9	0.1 ± 0.3
Spirobranchus giganteus (Pallas)	0.1 ± 0.3	0.2 ± 0.4		
MOLLUSCA				
Trochus maculatus Linnaeus	0.2 ± 0.4	0.1 ± 0.3		0.1 ± 0.3
Tectus pyramis (Born)	*			
Dendropoma maxima Sowerby	2.7 ± 4.2		27.0 ± 59.2	
Cypraea moneta Linnaeus				0.6 ± 1.1
Drupa rubusidaeus Roeding				0.1 ± 0.3
Conus capitaneus Linnaeus				0.1 ± 0.3
Conus miles Linnaeus		0.2 ± 0.6		
Nembrotha sp.	0.1 ± 0.3			
Arca ventricosa (Lamarck)	1.0 ± 2.5		2.3 ± 5.9	
Barbatia amygdalumtostum (Roeding)	0.4 ± 1.0		0.8 ± 1.5	0.1 ± 0.3
Septifer bilocularis (Linnaeus)	2.2 ± 3.1	0.1 ± 0.3	10.8 ± 13.9	0.3 ± 0.9
Electroma sp.	0.2 ± 0.4	0.2 ± 0.4	0.1 ± 0.3	0.6 ± 1.3
Malleus regula (Forsskal)	1.2 ± 1.8	0.4 ± 0.7	4.5 ± 5.1	0.9 ± 1.9
Pedum spondyloideum (Gmelin)	1.9 ± 3.7		0.7 ± 1.3	
Spondylus spp.	0.1 ± 0.3		0.4 ± 0.7	
Chama sp.				0.1 ± 0.3
Tridacna crocea Lamarck	0.7 ± 1.3	0.8 ± 1.9	1.3 ± 1.9	0.1 ± 0.3
Tridacna derasa (Roeding)		0.2 ± 0.6	0.2 ± 0.4	
Tridacna maxima (Roeding)	0.1 ± 0.3			
Tridacna squamosa Lamarck	0.3 ± 0.7	0.1 ± 0.3	0.5 ± 0.7	0.1 ± 0.3
Hippopus hippopus (Linnaeus)	0.1 ± 0.3			0.3 ± 0.5

Table 7.4. Continued.

	Station 6	Station 7	Station 8	Station 10
ECHINODERMATA				
crinoid [PAL-24]		0.1 ± 0.3		
crinoid sp. 2			0.1 ± 0.3	
Culcita novaeguineae Muller & Troschel			0.2 ± 0.4	
Linckia laevigata (Linnaeus)	0.4 ± 0.5		0.1 ± 0.3	
Linckia multifora (Lamarck)	0.1 ± 0.3	0.4 ± 0.7		0.6 ± 0.7
Paraselenia gratiosa A. Agassiz	0.2 ± 0.6			
Echinometra mathaei (de Blainville)	0.1 ± 0.3	0.2 ± 0.4		0.1 ± 0.3
Holothuria atra Jaeger	0.1 ± 0.3	0.5 ± 1.0		0.8 ± 1.0
Holothuria edulis Lesson			0.2 ± 0.4	
Stichopus chloronotus Brandt		0.2 ± 0.4		0.2 ± 0.4
Synaptula cf. media Cherbonnier & Feral			1.7 ± 5.4	
CHORDATA				
Didemnum molle (Herdman)	6.5 ± 15.4	4.9 ± 12.0	1.2 ± 5.3	8.8 ± 11.7
Diplosoma similis (Sluiter)	0.2 ± 0.4	2.0 ± 3.0	1.2 ± 3.8	
Lissoclinum patella (Gottschaldt)		1.8 ± 2.8	7.3 ± 6.6	0.8 ± 1.7
Lissoclinum voeltzkowi (Michaelsen)		1.3 ± 3.4		
Eudistoma cf. viride Tokioka	5.1 ± 5.0	11.5 ± 7.7	14.2 ± 8.4	55.5 ± 20.5

CHAPTER 8

ARACHNIDS OF THE NGERUKEWID ISLANDS WILDLIFE PRESERVE

ALEXANDER M. KERR, Research Assistant, Department of Biology, University of Guam, Mangilao, Guam 96923

INTRODUCTION

Little work has been done on the arachnids of Micronesia. The taxonomy and distribution of most of the species are unknown, some areas have never been sampled (Samuelson and Nishida, 1987). Among these places is the Ngerukewid Islands Wildlife Preserve. In ten (10) days of collecting, twenty-five arachnids were taken there, comprising eleven different families including members of the orders Scorpiones and Amblypygi, the tailless whipscorpions. Some species have not been identified and possibly are undescribed, such as the unusual pisaurid collected on Island 16.

METHODS

Collection was done by hiking across the islands and coaxing all arachnids seen into a wide-mouth jar containing 70% ethanol. Strand, limestone forest and limestone shrub forest habitats were investigated. No collection was done at night; nocturnal species were found by looking under stones and leaf litter and in rock crevices and caves.

Later, the specimens were seperated and put into individual bottles with 70% ethanol, sexed, given tentative names or code numbers and labeled. The large whipscorpion was eviscerated, dried and mounted in a clear plastic case with cotton and a few p-dichlorobenzene crystals. The preserved arachnids were then sent to Dr. Joseph A. Beatty, University of Southern Illinois, for further identification.

RESULTS

Ctenizidae (trapdoor spiders): A mainly tropical family with a spiny rake on the jaw margin which is used for digging.

Conothele gressitti (Roewer)
Number collected: two (2) females
Location: Found in leaf litter in closed limestone forest behind strand on Ngerukewid Island (No. 24), 11 Jan. 88. No web.
Comments: Males of this species are unknown.

Uloboridae (Wooly-webbed spiders): The web of this spider, instead of being covered in sticky threads (as in Araneidae), has wooly hackled threads that entangle prey. A mostly tropical family.

Tangaroa beattyi (Opell)
Number collected: three (3) females
Location: All on horizontal webs 30 centimeters from the ground in tree seedlings of the limestone forest. One (1) from Bkulomekeral Island (No. 13), 8 Jan. 88; two (2) from Island 16, 7 Jan. 88.
Comments: Described from Yap, known also from Palau.

Scytodidae (Spitting spiders): This family squirts sticky threads at insects in order to capture them. A mostly tropical group.

Scytodes striatipes (L.Koch)
Number collected: one (1) female
Location: In foliage of Eugenia cuminii in the limestone forest of Bkulomekerall Island (No. 13), 5 Jan. 88.
Comments: No web.

Pholcidae (Daddy-long-legs spiders): This family is sometimes confused with the Phalangiidae, the daddy-long-legs of temperate regions.

Smeringopus pallidus (Blackwell)
Number collected: one (1), sex undetermined.
Location: Upside-down in a loose, tangled web in a cave overlooking the east-facing beach on Ngerukewid Island (No. 24), 8 Jan. 88.
Comments: More often listed as S. elongatus (Vinson). If they are synonyms, S. pallidus is correct.

Araneidae (Orb-web weavers): The weavers of the typical orb-web. Concentric strands are sticky, the radial strands are not.

Leucauge sp.
Number collected: one (1) female; one (1) juvenile.
Location: in webs tilted away from the vertical in limestone forest. The female was found on Island 3, 9 Jan. 88.
Comments: All spiders of this genus angle their webs .

Nephila sp.
Number collected: one (1) juvenile.
Location: in shaded limestone forest in the Ngerukewid Islands Wildlife Preserve (Island number not recorded), 6 Jan. 88.

Comments: Presumably N. maculata, but the specimen is too young to determine.

Neoscona sp.
Number collected: two (2) juveniles.
Location: from vertical webs in limestone forest one (1) meter from the ground on Island 16, 7 Jan. 88.

Unknown araneid.
Number collected: three (3) females.
Location: All on vertical webs in shaded limestone forest on Island 16, 8 Jan. 88.
Comments: common.

Lycosidae (Wolf spiders): These spiders build no web, but live in leaf litter or in tunnels. They are among the most widespread spiders.

Arctosa sp.
Number collected: two (2) females, one (1) male.
Location: Large female in full sunlight among dried Padina sp. deposited by high tide on Tmekemer Island, 10 Jan. 88. The smaller female is from strand on island immediately southwest of Tmekemer, 12 Jan. 88.
Comments: Whether these will remain in this genus is uncertain. The epigynum, the small plate on the anterior ventral portion of the abdomen that covers the gonopore, is very different from the American Arctosa species.

Pisauridae (Nursery web spiders): These diurnal spiders live without a web. However, they construct a small one for the young by tying together leaves with silk.

Unknown pisaurid.
Number collected: one (1) female.
Location: on shaded beach in strand litter on Island 16, 7 Jan. 88.
Comments: the tarsi curled upon immersion in 70% ethanol.

Clubionidae (Sac-web spiders): All are hunting spiders, but construct a tubular sac under debris or in a rolled leaf in which they rest. Some species resemble ants, often living with the ants they mimic.

Chiracanthium sp.
Number collected: one (1) juvenile female.
Location: on Cordia foliage in the Ngerukewid Islands Wildlife Preserve (Island number unrecorded), 10 Jan. 88.
Comments: Many species of this genus are poisonous.

Salticidae (Jumping spiders): These spiders make no web and live by hunting. They have excellent binocular vision and most are very colorful.

Unknown salticid.
Number collected: one (1) male.
Location: from leaf litter under Scaevola sericea shrubs and Causurina trees behind strand on the island immediately southwest of Tmekemer, 12 Jan. 88.
Comments: Possibly Menemerus birittatus.

Unknown salticid.
Number collected: one (1) male, one (1) juvenile.
Location: Male found in beach litter on Ngerukewid Island (No. 24), 8 Jan. 88. The juvenile was found in beach litter on Island 3, 9 Jan. 88.
Comments: Possibly Mollica microphthalma

Scorpiones (Scorpions)

Hormurus australasiae
Number collected: two (2) of undetermined sex.
Location: under rotting Hernandia bark on Tmekemer Island, 10 Jan. 88.

Amblypygi (Tailless whipscorpions): A tropical order of about fifty species in one family, Tarantulidae. The first pair of legs is modified into long whip-like feelers.

Charon grayi (Gervais)
Number collected: one (1) of undetermined sex.
Location: on wall of cave on Island 16, 6 Jan. 88.
Comments: Known in Micronesia only from Palau.

DISCUSSION

Most of the arachnids found in this survey have been collected in other areas of Micronesia (Roewer, 1963; Sabath et al., 1974; and Takashima, 1950). At the time of the survey, many arachnids were immature and made identification difficult. In spite of this and the brief amount of time spent collecting, at least one (1) unusual find was made.

The most interesting spider found was an unknown pisaurid collected from Island 16. Members of the family Pisauridae are scarce in Micronesia. Only one small juvenile has been collected in Palau by Beatty and Berry (pers. comm). This specimen, however, is unique in having curled tarsi, a trait seen previously in only the New World genera. It would be desirable to

return and collect more specimens of this arachnid, especially males.

CONCLUSIONS

1. Ngerukewid Islands Wildlife Preserve contains unusual and previously uncollected arachnids.

2. Further investigation is warranted.

3. Continued protection of the area is recommended.

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APPENDIX 1

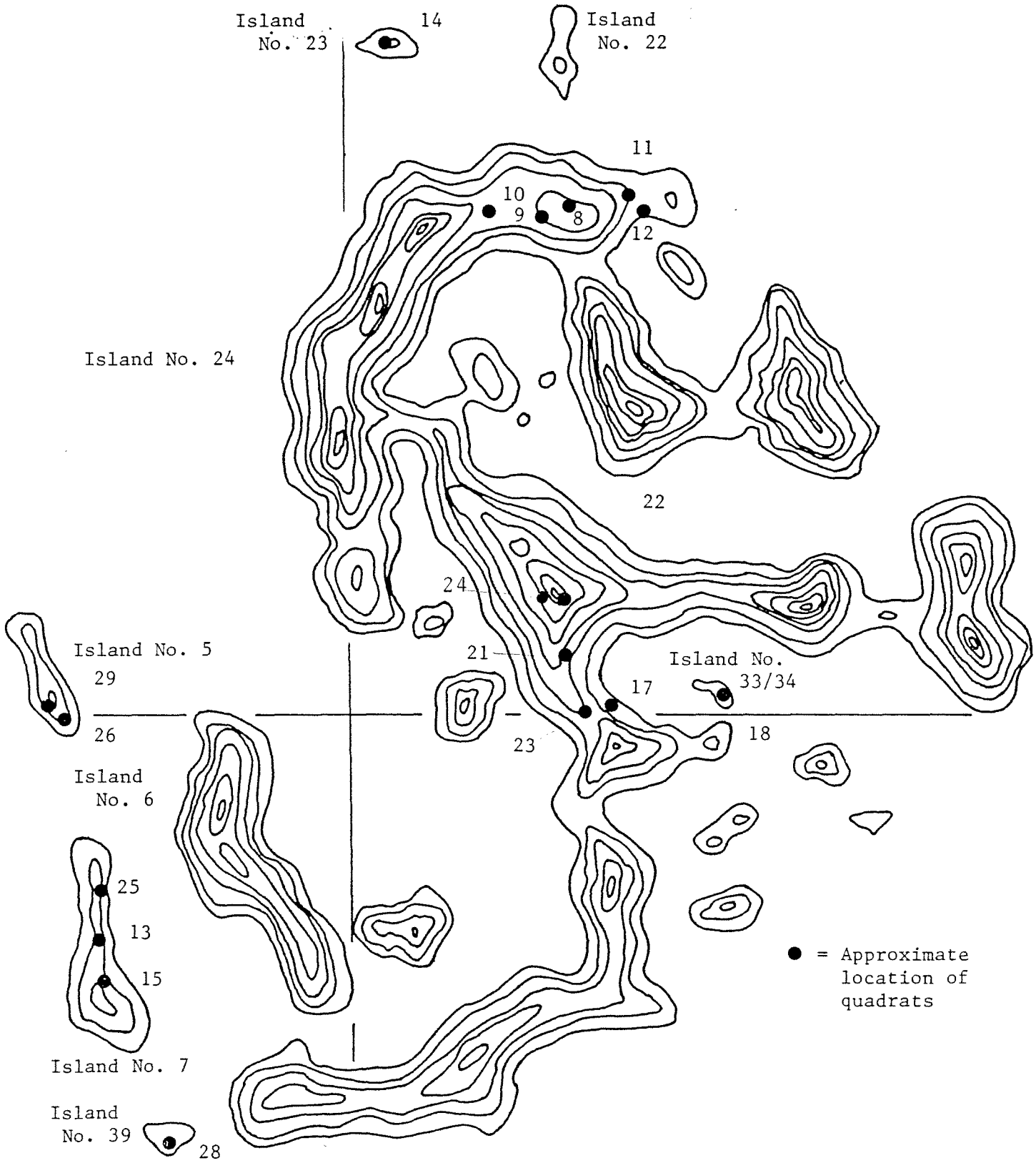
Names and Addresses of Participants

Participants

Amesbury, S.S.	Marine Laboratory, University of Guam, Mangilao, Guam 96923
Birkeland, C.	Marine Laboratory, University of Guam, Mangilao, Guam 96923
Conry, P.J.	Division of Aquatic and Wildlife Resources, Department of Agriculture, P.O. Box 2950, Agana, Guam 96910
Holthus, P.F.	South Pacific Regional Environment Programme, South Pacific Commission, P.B. D5, Noumea, New Caledonia
Kerr, A.M.	Department of Biology, University of Guam, Mangilao, Guam 96923
Manner, H.I.	Division of Social and Behavioral Sciences, University of Guam, Mangilao, Guam 96923
Raulerson, L.	Department of Biology, University of Guam, Mangilao, Guam 96923
Smith, B.D.	Marine Laboratory, University of Guam, Mangilao, Guam 96923
Wiles, G.J.	Division of Aquatic and Wildlife Resources, Department of Agriculture, P.O. Box 2950, Agana, Guam 96910
Wilkins, S. de C.	Marine Laboratory, University of Guam, Mangilao, Guam 96923

APPENDIX 2

Location Maps and Directions for Terrestrial Community Transects



Location of vegetation quadrats on islands in the Preserve. Locations are approximate.

Quadrat Number 1
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: Black PVC pole set in cement.

Quadrat Location: Eastern Beach. Quadrat center is located near the base of the escarpment, 1 to 2 m above the sandy beach, and approximately 4 m inland of the large Hernandia. By triangulation, the quadrat center can be located by compass bearings (uncorrected for magnetic declination) to the two islands offshore. Bearing to eastern island = 45 degrees, bearing to western island = 237 degrees. See location map on page 3.

Quadrat Number: 2
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: Black PVC pole set in cement.

Quadrat Location: Eastern Beach. Quadrat 2 is located approximately 25 m upslope of Quadrat 1 and on the limestone outcrop, and in a Pandanus dubius grove. Bearing of Quadrat 2 to Quadrat 1 is 205 degrees (uncorrected for magnetic declination). See location map on page 3.

Quadrat Number: 3
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: Black PVC pole set in cement.

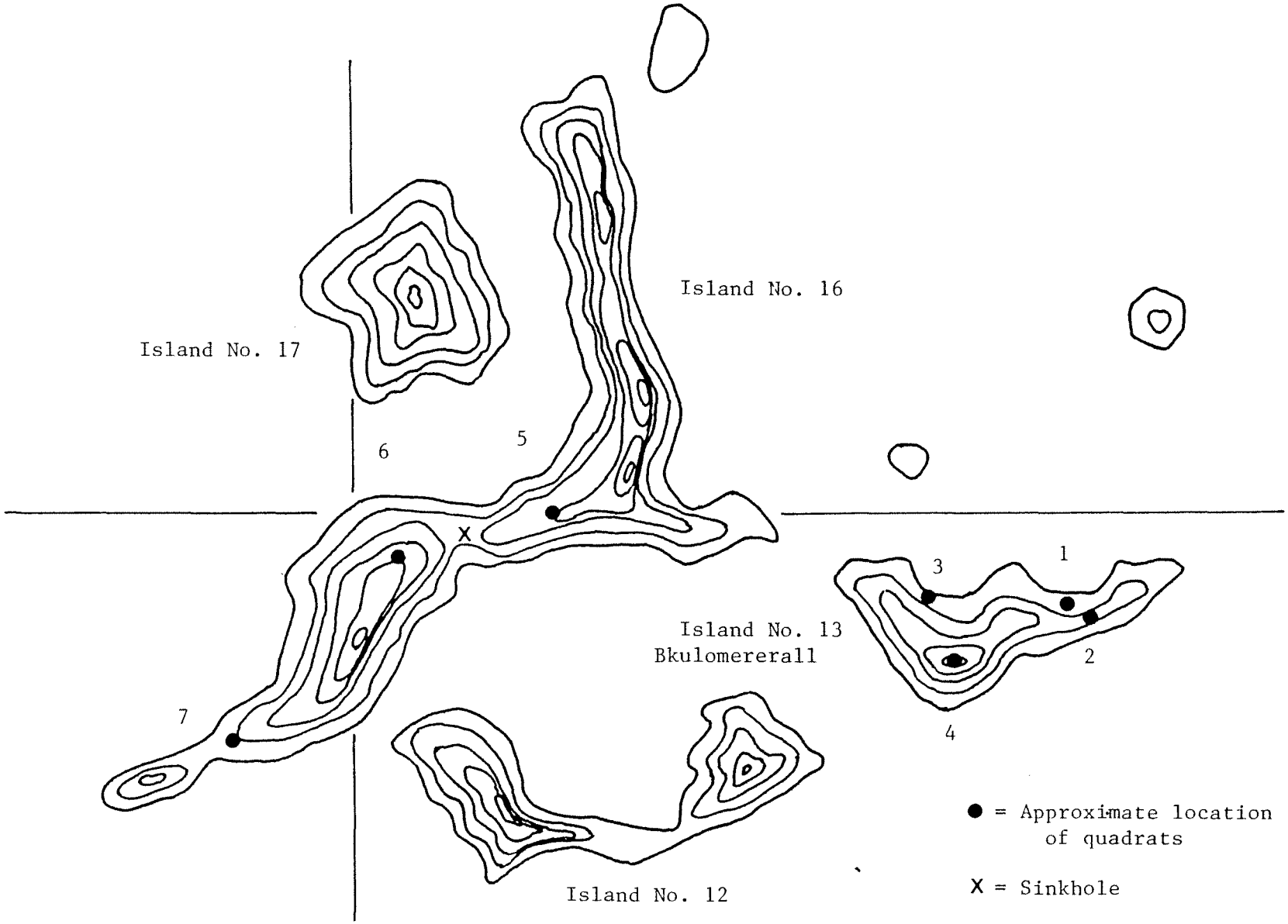
Quadrat Location: Western beach on northern side of Bkulomekerall. Quadrat is located just above the strand, on the lower part of the escarpment, towards the western side of the beach. See location map on page 3.

Quadrat Number: 4
Island Number and/or Name: 13, Bkulomekerall.
Quadrat center: A small cairn atop the pinnacle.

Quadrat Location: Western beach on northern side of Bkulomekerall. Quadrat is located on a slightly exposed pinnacle ridge top, approximately 50-60 m upslope and to the southeast of Quadrat 3. Proceed upslope to saddle. With small (1.5 m high) thru-cave on right, proceed east upslope to exposed pinnacle. See location map on page 3.

Quadrat Number: 5
Island Number and/or Name: 16.
Quadrat center: Rock cairn dotted red.

Quadrat Location: From the western end of the small beach on the north facing coast of the island, proceed from the very steep, only possible access point upslope to the immediate saddle, then eastward (with the sinkhole on the right), upslope 30 m to the



Location map of quadrats 1 - 7.

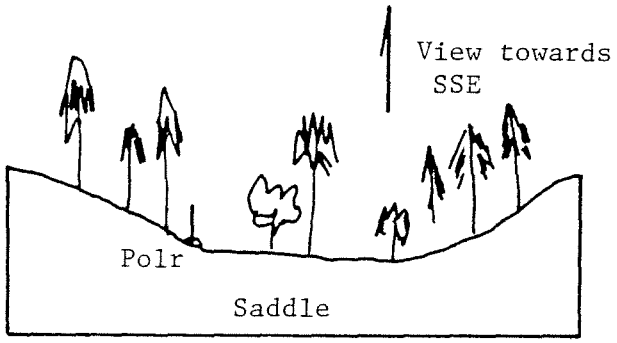
ridge top knoll. Quadrat trees are painted red. See location map on page 3.

Quadrat Number: 6
Island Number and/or Name: 16.
Quadrat center: Rock cairn, with 30 cm red painted stone.

Quadrat Location: From the western end of the beach on the north facing coast of the island, proceed upslope to the immediate saddle, and then turn westward with sinkhole on the left, and proceed further upslope. Go through small Pandanus grove and past 2 - 3 m high rock outcrop on left. Quadrat center is 10 m further, slightly downslope from rock outcrop. Tree with No. 10 painted on trunk is 5 m north of cairn. Quadrat 6 is located on a slope and a very weathered pinnacle opposite to Quadrat 5. Elevation is 30 to 40 m above sealevel. The area is flattish, but slopes away steeply. See location map on page 3.

Quadrat Number: 7
Island Number and/or Name: 16.
Quadrat center: Black PVC pole set in cement.

Quadrat Location: On saddle area on south - southwestern end of island 16. Area is dominated by Gulubia palauensis (Esbuuch) palms. Quadrat center pole is at base of left flank of saddle (while facing SSE). See diagram below and accompanying location map on page 3. Ground is heavily littered with palm fronds. Thick organic mat over most of the quadrat. Site is relatively level and narrow.



Sketch showing approximate location of center of quadrat 7 on Island No. 16.

Quadrat Number: 8
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock cairn dotted with red paint.

Quadrat Location: Aspect is 228 degrees. Midslope location, gently sloping and less than 15 degrees, 30 m above sealevel. There is evidence that people have visited this island as there are some slashed palms further down slope (near the landing). See diagram below and location map on page 6.

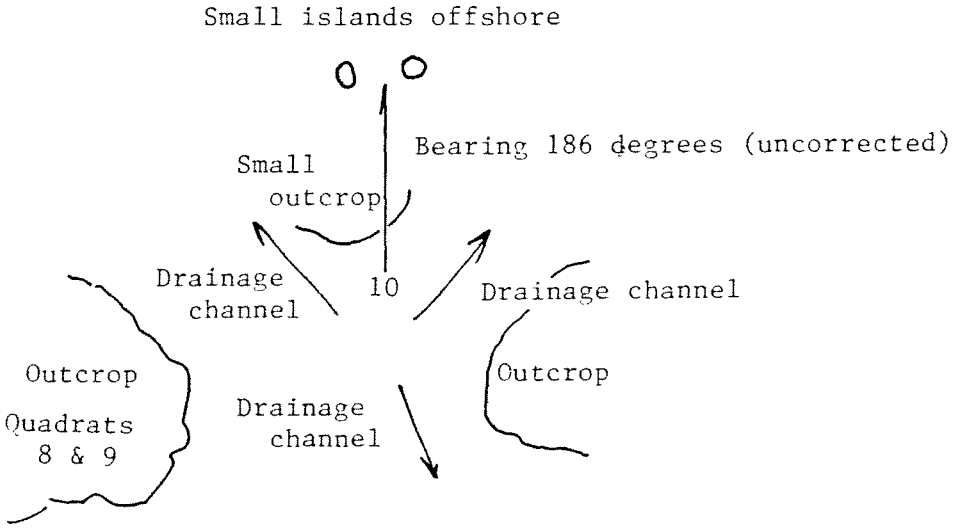
Quadrat Number: 9
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Just west of windgap/erosion channel.

Quadrat Location: Ridge top site, Aspect is 220 degrees. This site is located at about 45 m in elevation and to the east of Quadrat 8. There is a wind gap (erosion channel) to the east of the quadrat center. The windgap is dominated by Dracaena multiflora and Gulubia palauensis. Gently to steeply sloping site. Well developed mulch, and heavy litter. Site is an exposed pinnacle, above the Camp. See diagram below and location map on page 6.

Quadrat Number: 10
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Painted outcrop next to 2 large beror trees.

Quadrat Location: Junction of three wind gaps, downslope and west of quadrat 9. Bearing from outcrop to channel between two small islands is 186 degrees (uncorrected). Site has very heavy litter cover and is rather flat. See diagram below and location map on page 6.

Sketch map of quadrats 8, 9, and 10.



Quadrat Number: 11
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock cairn

Quadrat Location: Left (west of gap) and about 20 m above overnight campsite. Slope of jumbled rock oriented W to SW and N to S. See location map on page 6.

Quadrat Number: 12
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Tree (Rinorea sp.) in center of megapode mound.

Quadrat Location: Back strand against limestone wall, aspect is SSW. Flat back strand; Wall slope is approximately 60 degrees. There is a large megapode mound in the quadrat. See location map on page 6.

Quadrat Number: 13
Island Number and/or Name: 7
Quadrat center: Large Myristica tree marked with a red "X".

Quadrat Location: Midslope location approximately 20 m above sea level and about 25 m north of the beach on island 7. Aspect of the quadrat is 110 degrees. Ridge crest rock above the quadrat has red arrow pointing downslope to center tree with "X". Area seems to have been flattened for a platform. See location map on page 6.

Quadrat Number: 14
Island Number and/or Name: 23.
Quadrat center: Pinnacle top near the western edge of the cliff.

Quadrat Location: Crest position overlooking the northern and western sides of island. The quadrat center is approximately 10 m east of the western edge of the cliff. Site can be reached by climbing up the western cliff face. Very steep and dangerous site because of loose boulders and rocks. See location map on page 6.

Quadrat Number: 15
Island Number and/or Name: 7.
Quadrat center: Rock marked with red paint.

Quadrat Location: Proceed inland from beach on eastern side of island. Quadrat center is 10 m above landing. Rocky slope between 45 and 60 degrees. Heavy leaf litter cover. See location map on page 6.

Quadrat Number: 16
Island Number and/or Name: 3.
Quadrat center: Pinnacle facing 264 degrees.

Quadrat Location: Quadrat center is a pinnacle facing west at 264 degrees, 10 m from cliff edge, and slightly north of the center of the island. There are no ferns in this quadrat. Ground is covered by a heavy Casuarina litter. Very rocky. Bat manure smell, quite nitrogenous, is noticable. See location map on page 9.

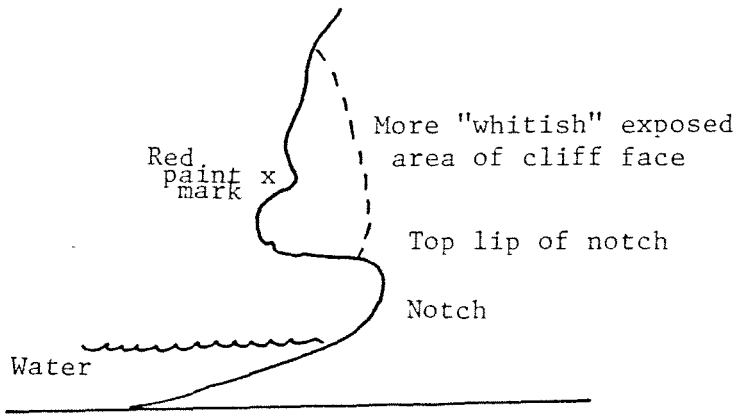
Quadrat Number: 17
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Red paint spot on cliff face above the water, just above top lip of notch.

Quadrat Location: Quadrat center is a mark on rock face located between the two mangrove sections, closer to the right end of the larger (left hand) mangrove section (facing west towards the island). See diagram below and location map on page 6. The site is flat towards the water, and slopes gentle to vertical towards the right and left.

Quadrat Number: 18
Island Number and/or Name: 33 & 34.
Quadrat center: Black PVC pole stuck in rocks.

Quadrat Location: Quadrat is located on the WSW portion of island 33 & 34. Quadrat center is located is a pinnacle on SE side of island (or furtherest side from mangroves on island 24. Can be found midway to pinnacle top on the northern face of the pinnacle. See location map on page 6.

Sketch showing the location of Quadrat 17 (x). The x is marked in red paint.



Quadrat Number: 19
Island Number and/or Name: 46, Tmekumer Island.
Quadrat center: Eugenia malaccensis, tree No. 7 in quadrat.

Quadrat Location: Quadrat center is the Eugenia malaccensis located on the back strand which faces east. The strand area is greatly altered. See location map on page 9.

Quadrat Number: 20
Island Number and/or Name: 46, Tmekumer Island.
Quadrat center: Eugenia malaccensis tree, No. 1 in quadrat.

Quadrat Location: Quadrat center is a large Eugenia malaccensis located on the strand approximately 15 m from the water's edge. This site is west of quadrat 19. See location map on page 9.

Quadrat Number: 21
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock cairn with red paint.

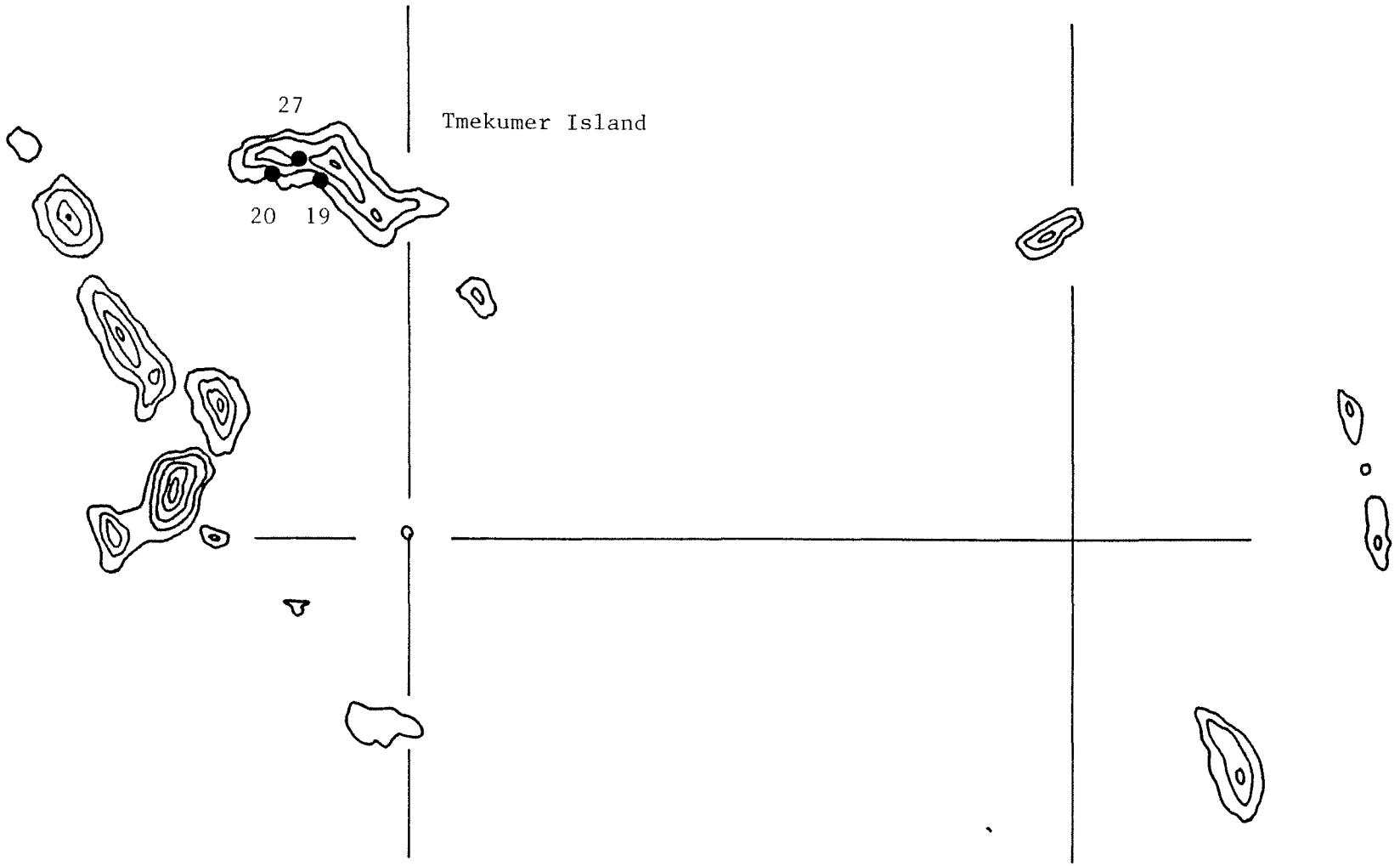
Quadrat Location: Quadrat center is located above the mangrove community, with the saddle below. Tree marked No. 20 is 4 - 5 m SE of the cairn. A pandanus knoll is located on the left as you look towards the mangrove. The area is rocky with some leaf litter. Cockatoos may be heard here. See location map on page 6 and diagram on page 11.

Quadrat Number: 22
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Red painted boulder.

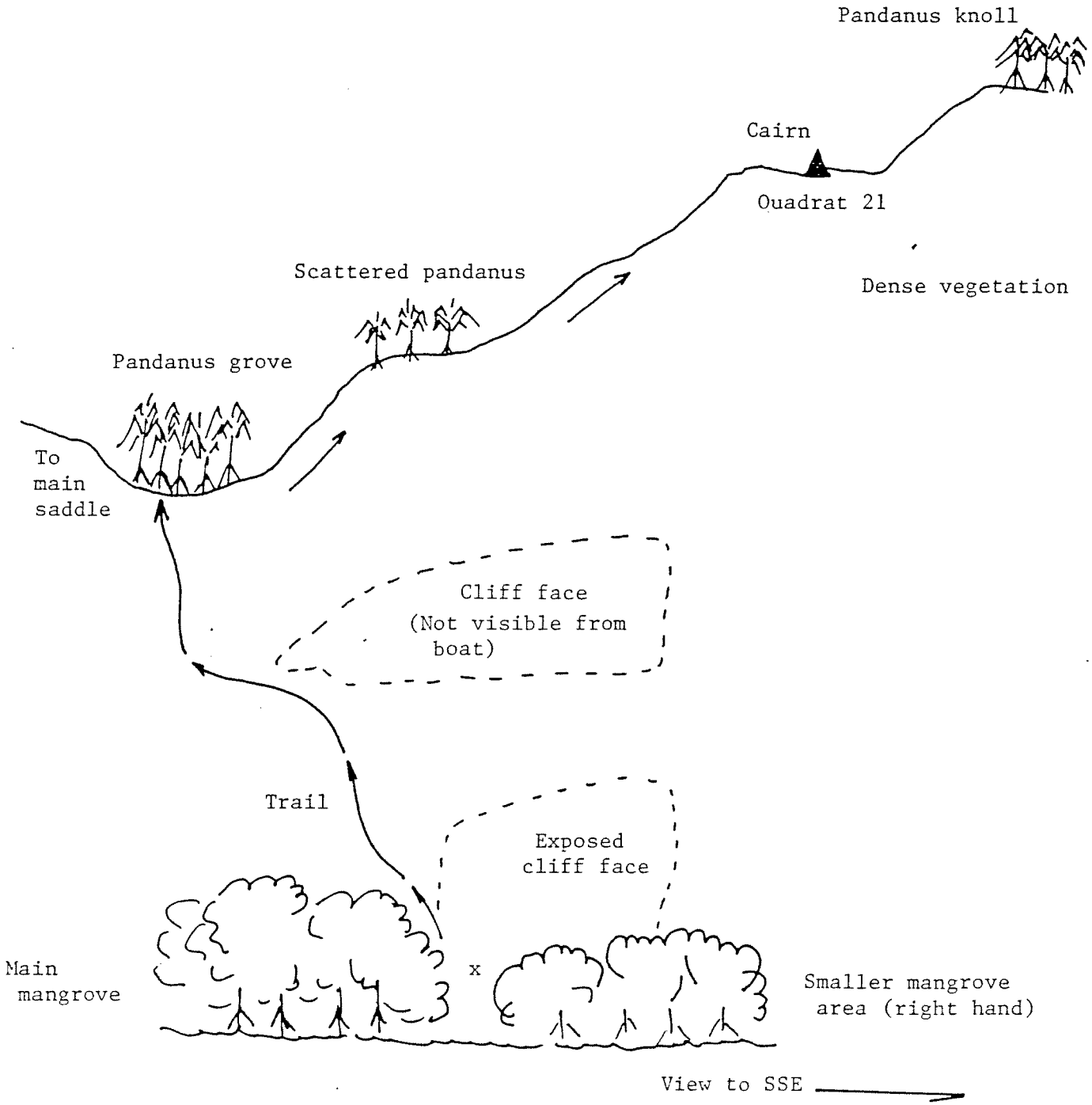
Quadrat Location: Quadrat center is located 25 m to the west of the mangrove landing area and within 2 m of the crest at approximately 50 m in elevation. Aspect of slope is 16 degrees. Very thick humus mat about 25 cm in depth in places. A large tree has been cut down probably for surveying. A Japanese marker capped by an Army Corp of Engineers spot elevation marker, dated 1947, is approximately 5 m south of the painted boulder. See location map on page 6.

Quadrat Number: 23
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Rock with a painted red circle.

Quadrat Location: Quadrat located above the mangrove community and to the west of quadrat 22. This quadrat is located at approximately 50 m in elevation. and overlooks a steep slope (approx. 60 degrees). Sharp pinnacles nearby. See location map on page 6.



Location of quadrats on Tmekumer Island.



Sketch showing location of center of quadrat 21 (cairn) on Island No. 24.
Note: x mark is not visible from water's edge of mangroves.

Quadrat Number: 24
Island Number and/or Name: 24, Ngerukewid.
Quadrat center: Dome shaped rock 1.5 m high, painted on top.

Quadrat Location: Quadrat center is a located 15 m west of quadrat 22 and at an elevation of 40 m. Aspect = 10 degrees. See location map on page 6.

Quadrat Number: 25
Island Number and/or Name: 7.
Quadrat center: Tree marked with a red "O".

Quadrat Location: Quadrat center is a marked tree with painted "O" located on the south side of old grass covered megapode mound. Sparse ground cover. See location map on page 6.

Quadrat Number: 26
Island Number and/or Name: 5.
Quadrat center: Pinnacle rocks painted red.

Quadrat Location: About 5 m from cliff edge overlooking island 7. The bearing from the quadrat center to island 7 is 176 degrees (uncorrected). Aspect is 145 degrees; slope = 35 degrees. Esbuuch and Dracaena located outside quadrat. Very rocky site. See location map on page 6.

Quadrat Number: 27
Island Number and/or Name: 46, Tmekumer Island.
Quadrat center: Rock sprayed with red paint.

Quadrat Location: Outcrop on ocean side (windward) of gap, halfway up and facing Koror. Slope is steep. See location map on page 9.

Quadrat Number: 28
Island Number and/or Name: 39.
Quadrat center: Outcrop painted red.

Quadrat Location: Quadrat is located on a pinnacle about 5 m from the water's edge. The slope faces SW at 204 degrees. See location map on page 6.

Quadrat Number: 29
Island Number and/or Name: 5.
Quadrat center: Pinnacle on slope with bearing of 229 degrees.

Quadrat Location: Quadrat is located on a pinnacle with an aspect of 229 degrees (uncorrected), and on the edge of a pandan

grove. It is approximately 10 - 20 m west of Quadrat No. 26. Very steep slope 60 degrees. See location map on page 6.

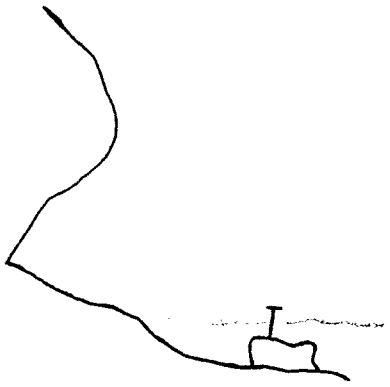
APPENDIX 3

Location Maps and Directions for Marine Community Transects

Transect 1

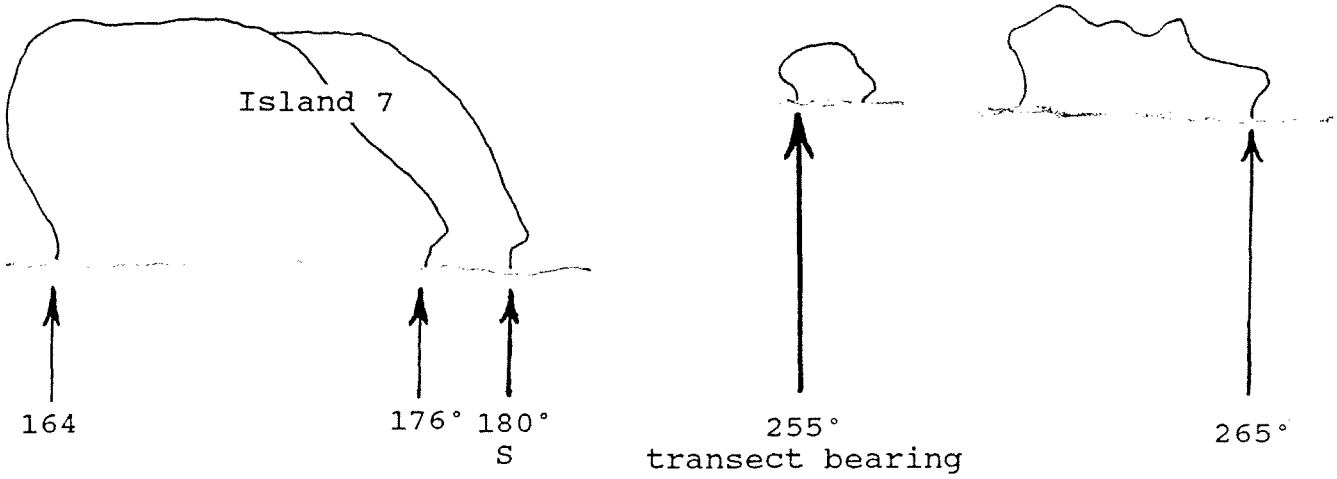
Location: Island 5, south end (see map)

Marker stake location: on a rock at 70 cm depth

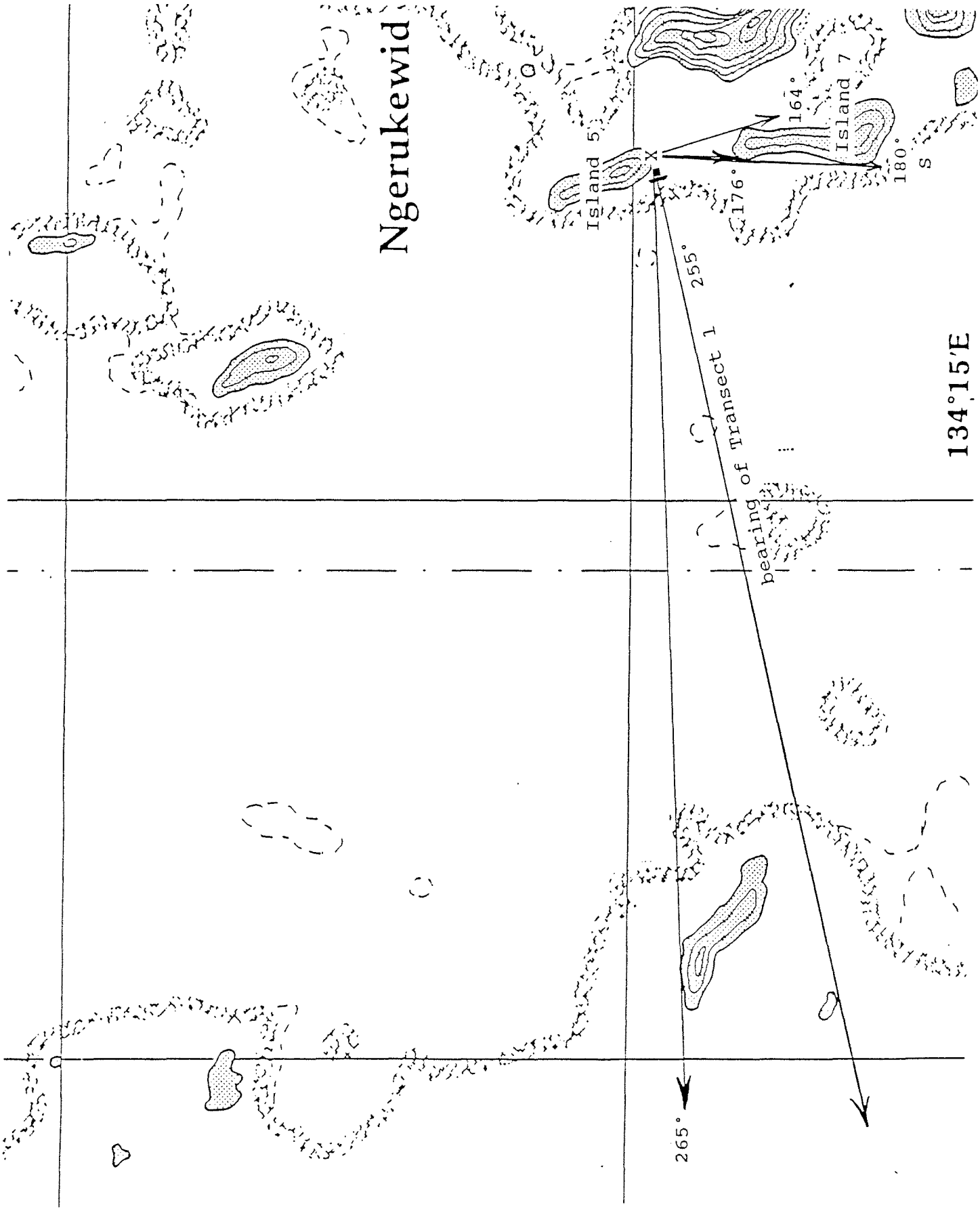


Transect bearing: 255°

Sketches of targets of compass bearings:



Transect 1 (map)

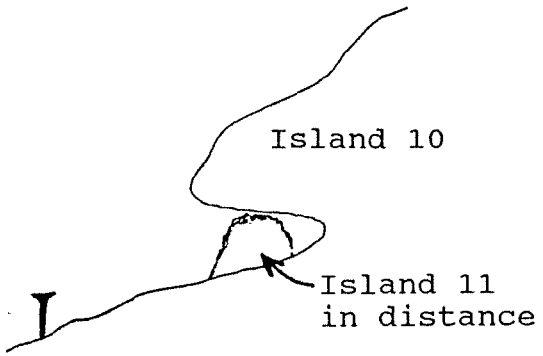


Transect 2

Location: Island 10, northwest side (see map); transect begins 33 m from the stake in the direction of the transect bearing (324°) and runs along the crest of the reef that connects Island 10 and Island 9

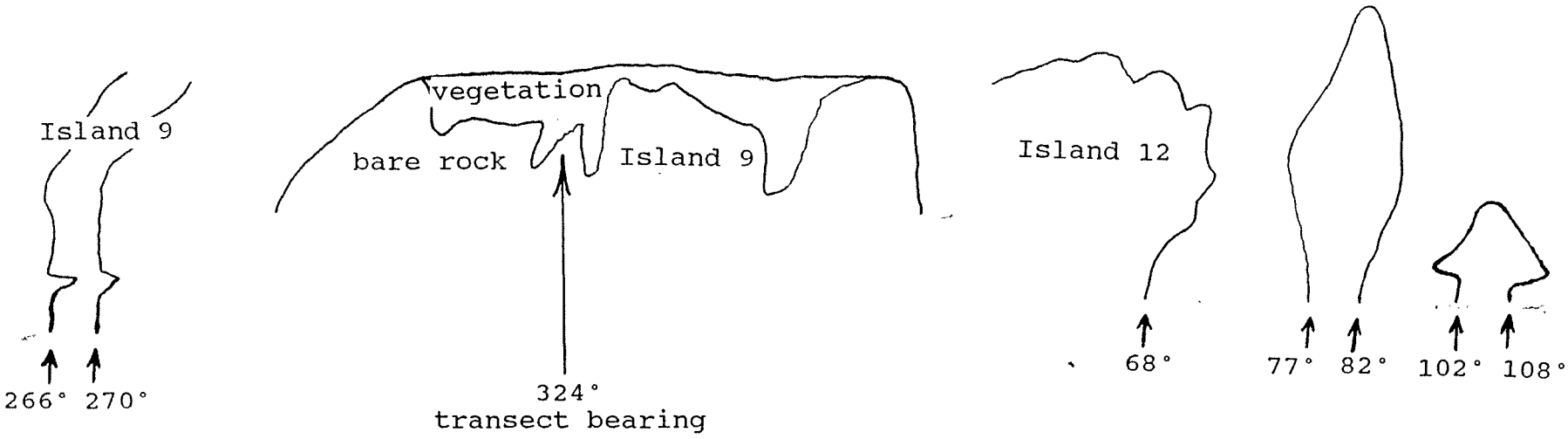
Marker stake location: on the supratidal, near notch in wall

side view looking E
to N end of Island 11

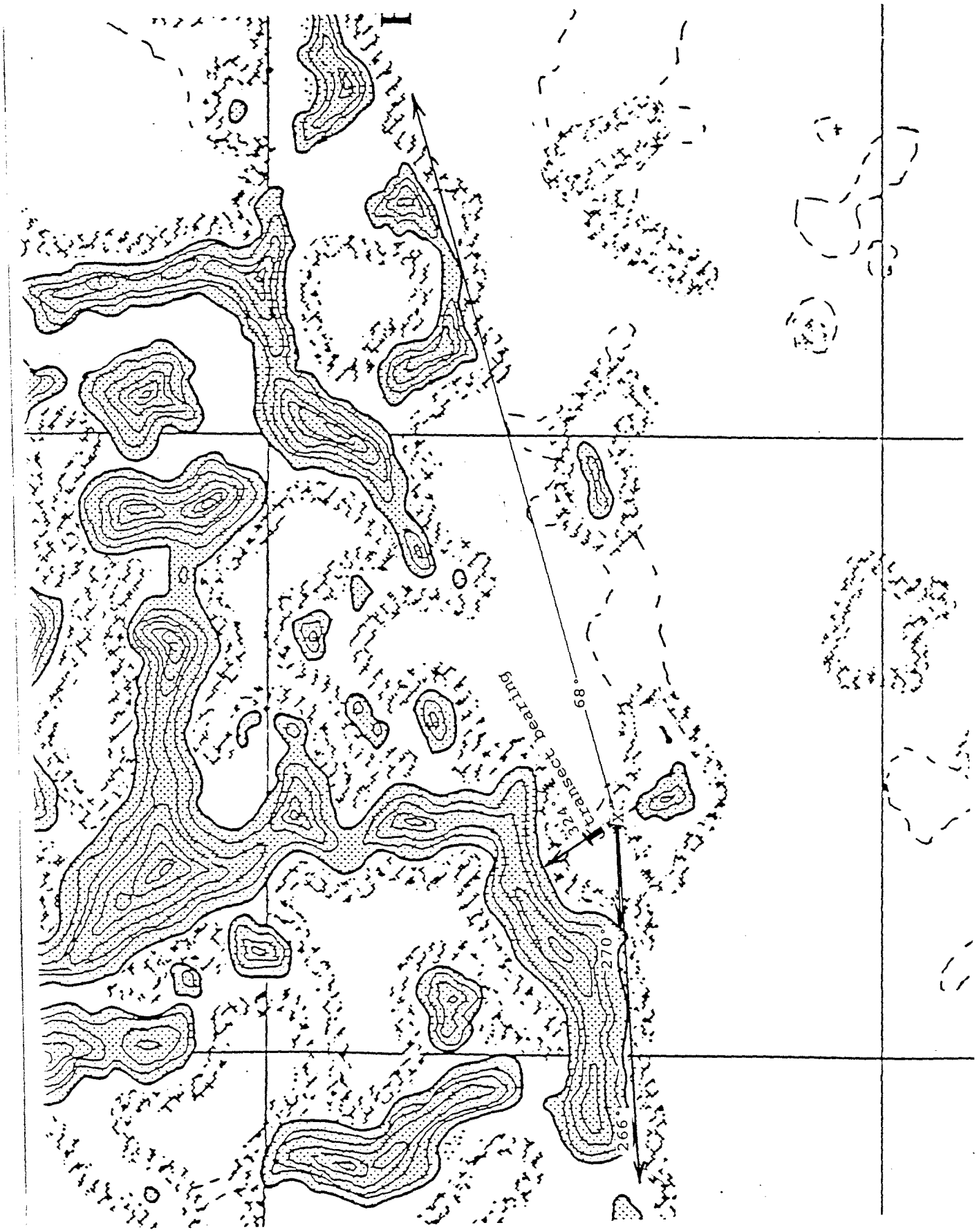


Transect bearing: 324°

Sketches of targets of compass bearings:



Transect 2 (map)

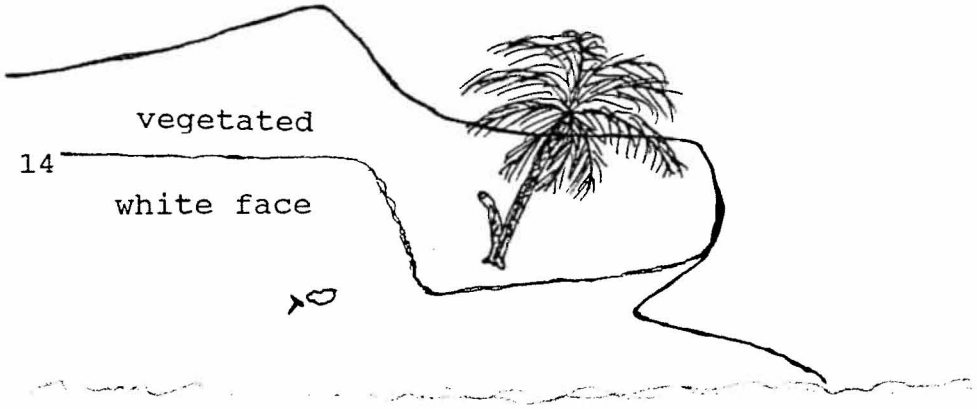


Transect 3

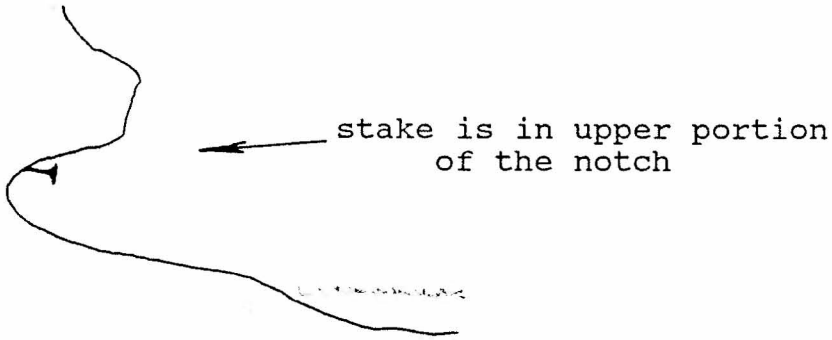
Location: Between Islands 14 and 15 (see map)

Marker stake location: above the water on Island 14 in upper portion of the notch. The transect runs 308° towards the north notch (inner edge) of Island 15. South edge of pinnacle on Reef W' intersects north notch of Island 15 on inner edge. (0 to 33.3 m along transect is rubble Acropora and live Acropora; 33.3 to 50 m is live and dead mixture of branching Acropora.)

facing the transect stake from on the transect

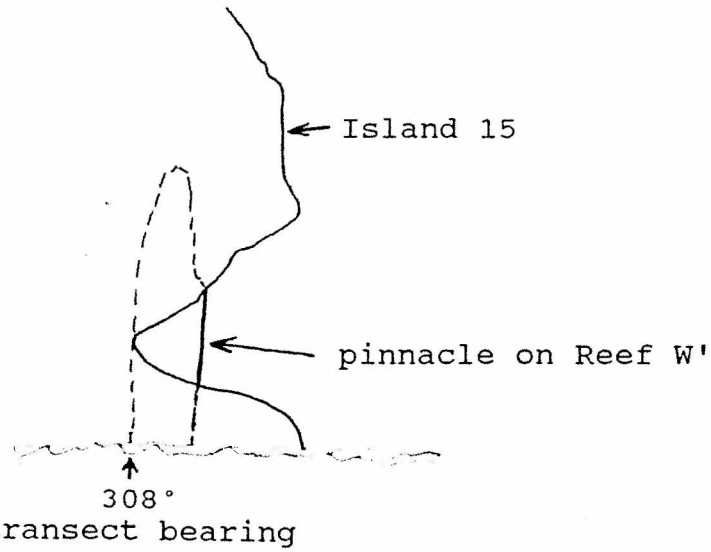


side view to S

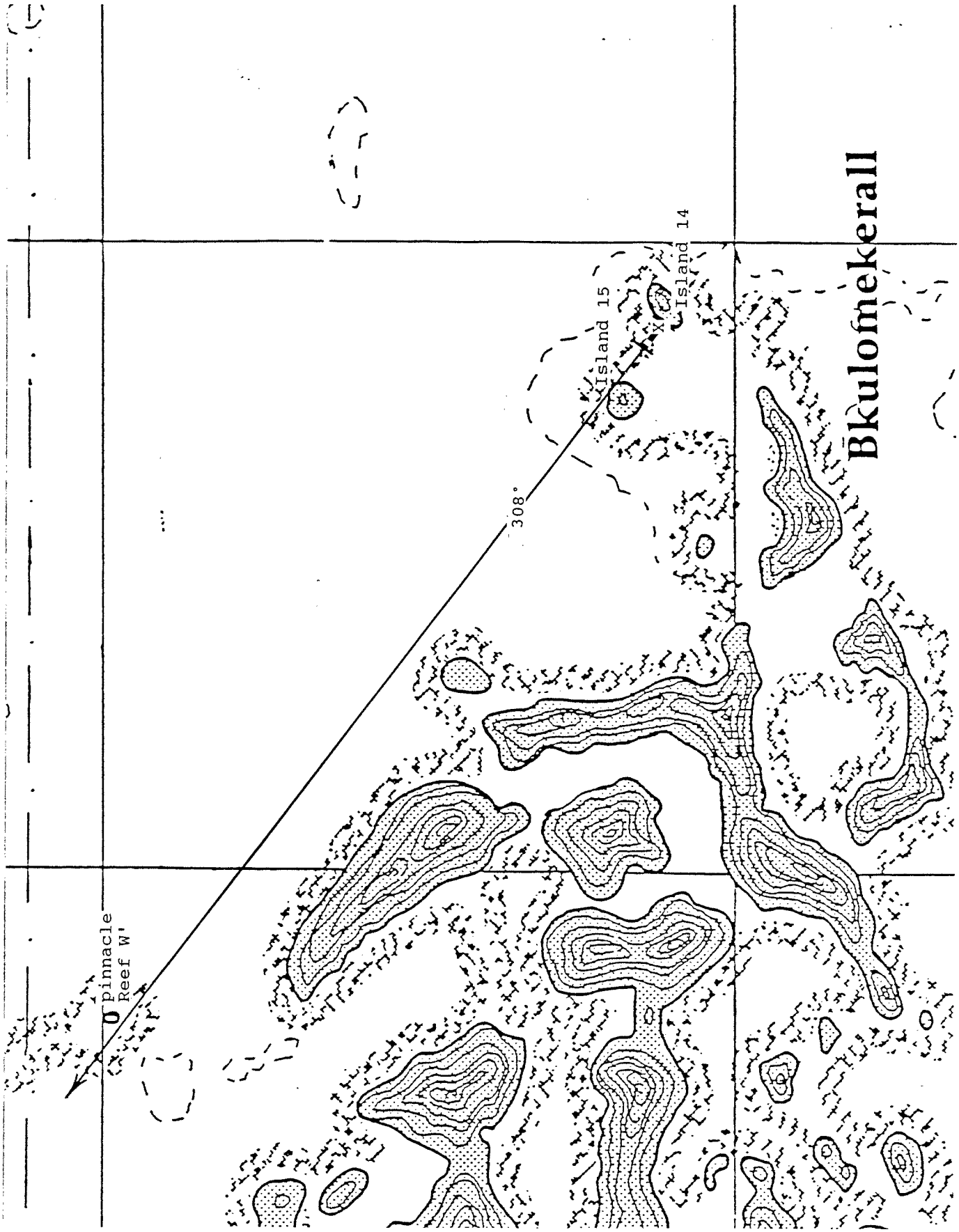


Transect bearing: 308°

Sketches of targets of compass bearings:



Transect 3 (map)



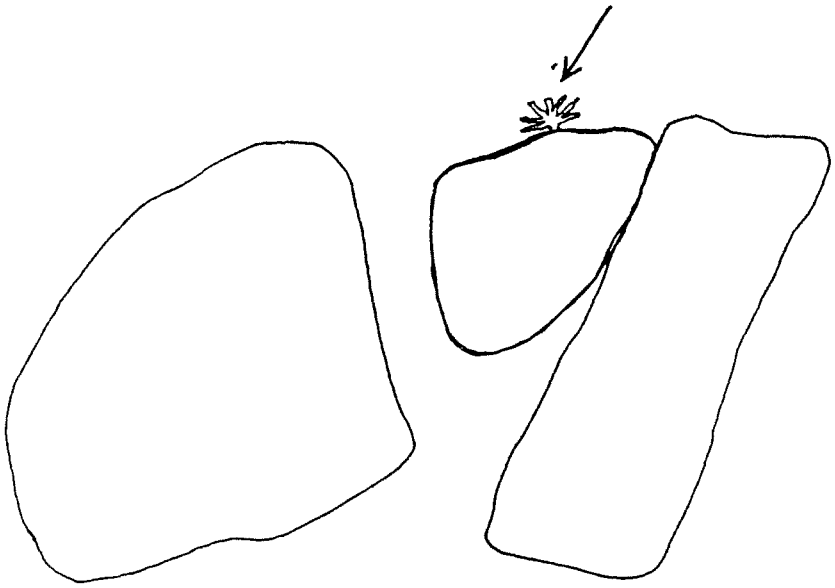
Transect 4

Location: Island 22, begins at the rocks at the N tip of Island 22 and extends along the subtidal patch reef towards the W tip of Island 24

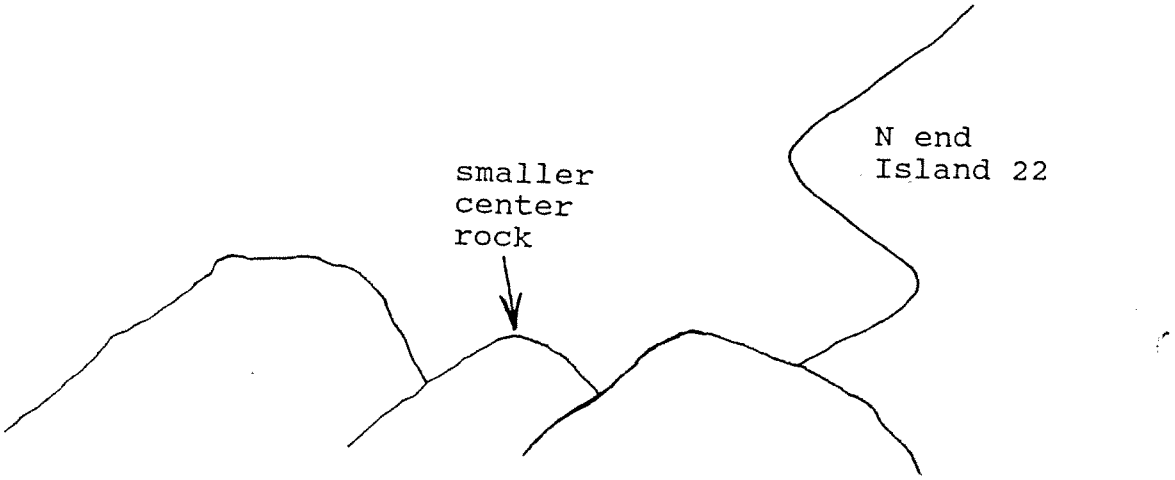
Marker stake location: no marker stake; the end of the transect begins looped over a small branching coral on the smaller central rock of the 3 rocks at the N tip of Island 22

Transect bearing: 229°

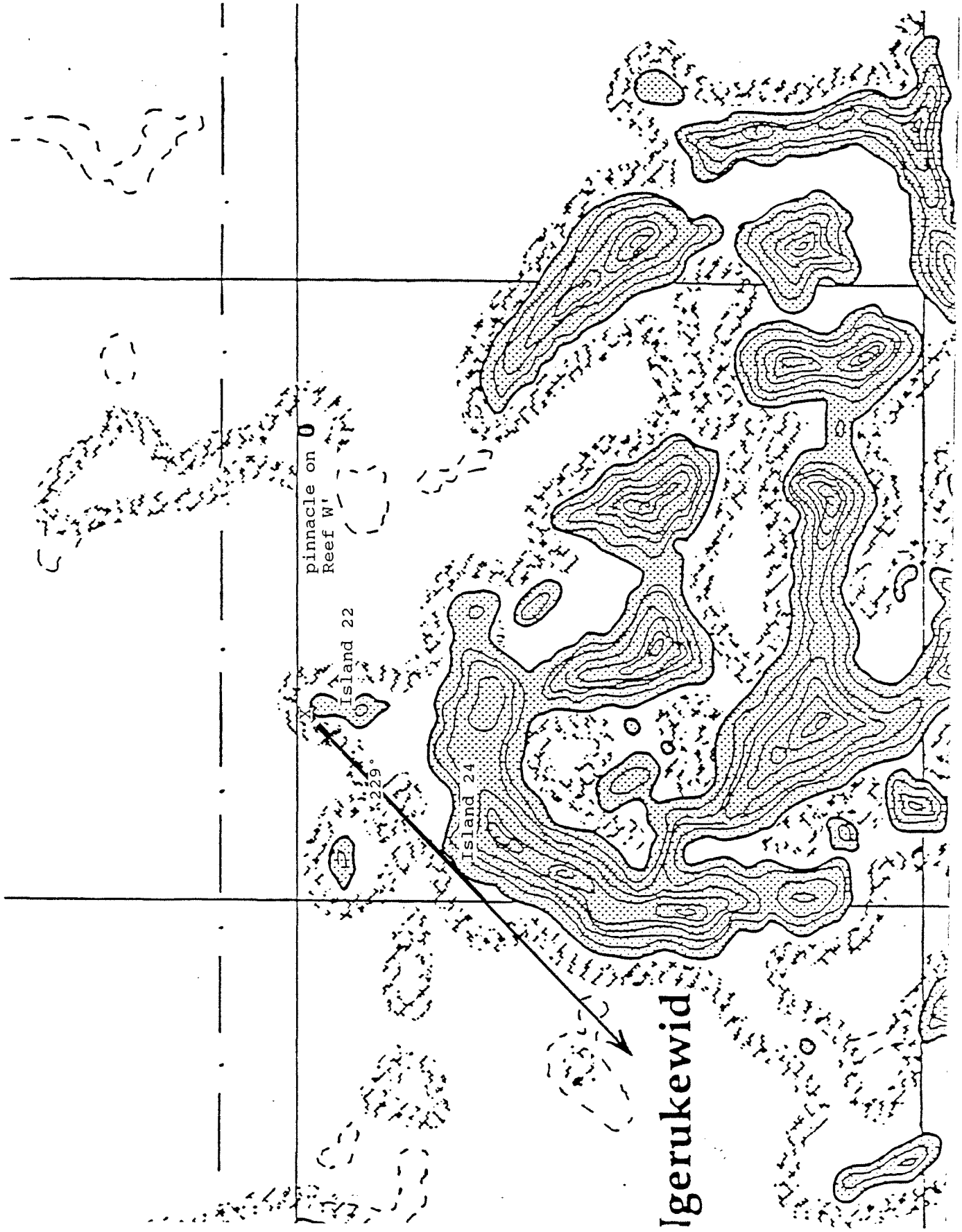
plan view of rocks and small coral at which transect line begins



side view towards NE



Transect 4 (map)

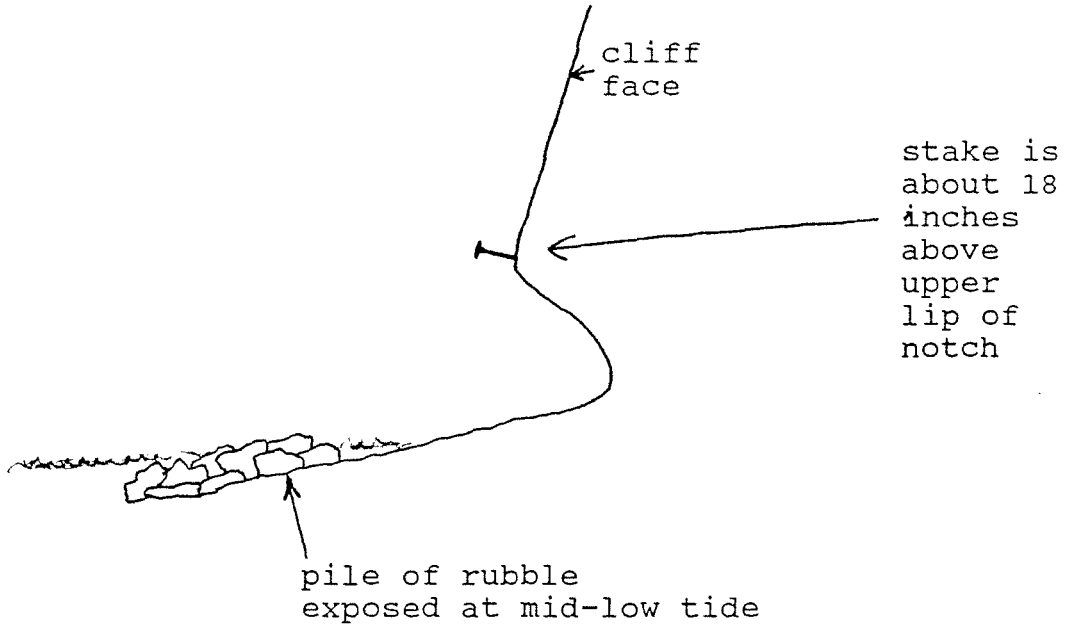


Transect 5

Location: southeast tip of Island 20 (= east end of northern half of Island 24); the transect runs from shore to a depth of 20 ft

Marker stake location: 18 inches above the upper lip of the notch, about 6 ft 2 inches above the water level

side view facing S



Transect bearing: 74°

Targets of compass bearings:

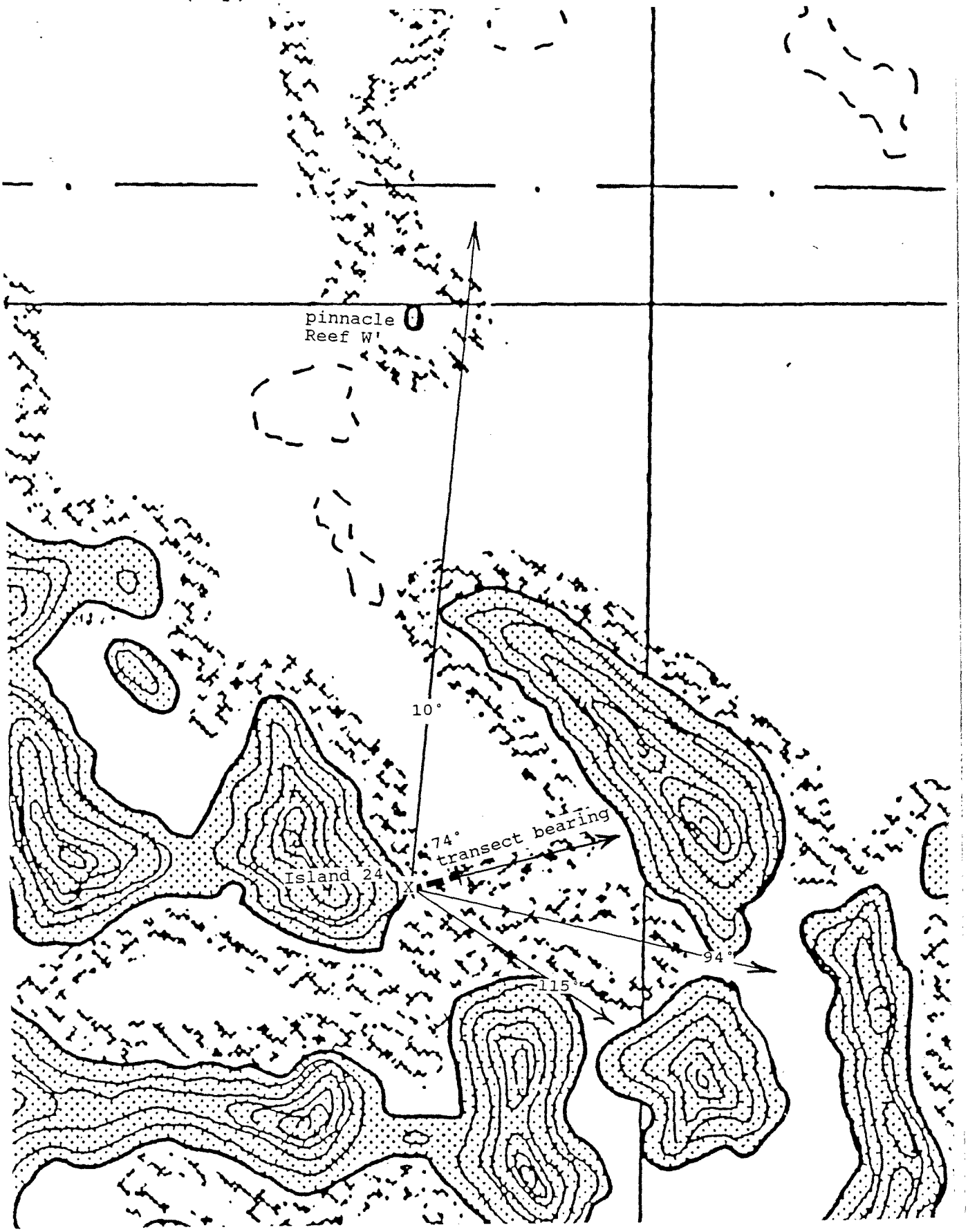
10° -- nip to the right of the pinnacle on Reef W'

74° -- direction of the transect towards a dip in the hills

94° -- right entrance to the inside waters

115° -- other lip of the mouth of the inlet

Transect 5 (map)

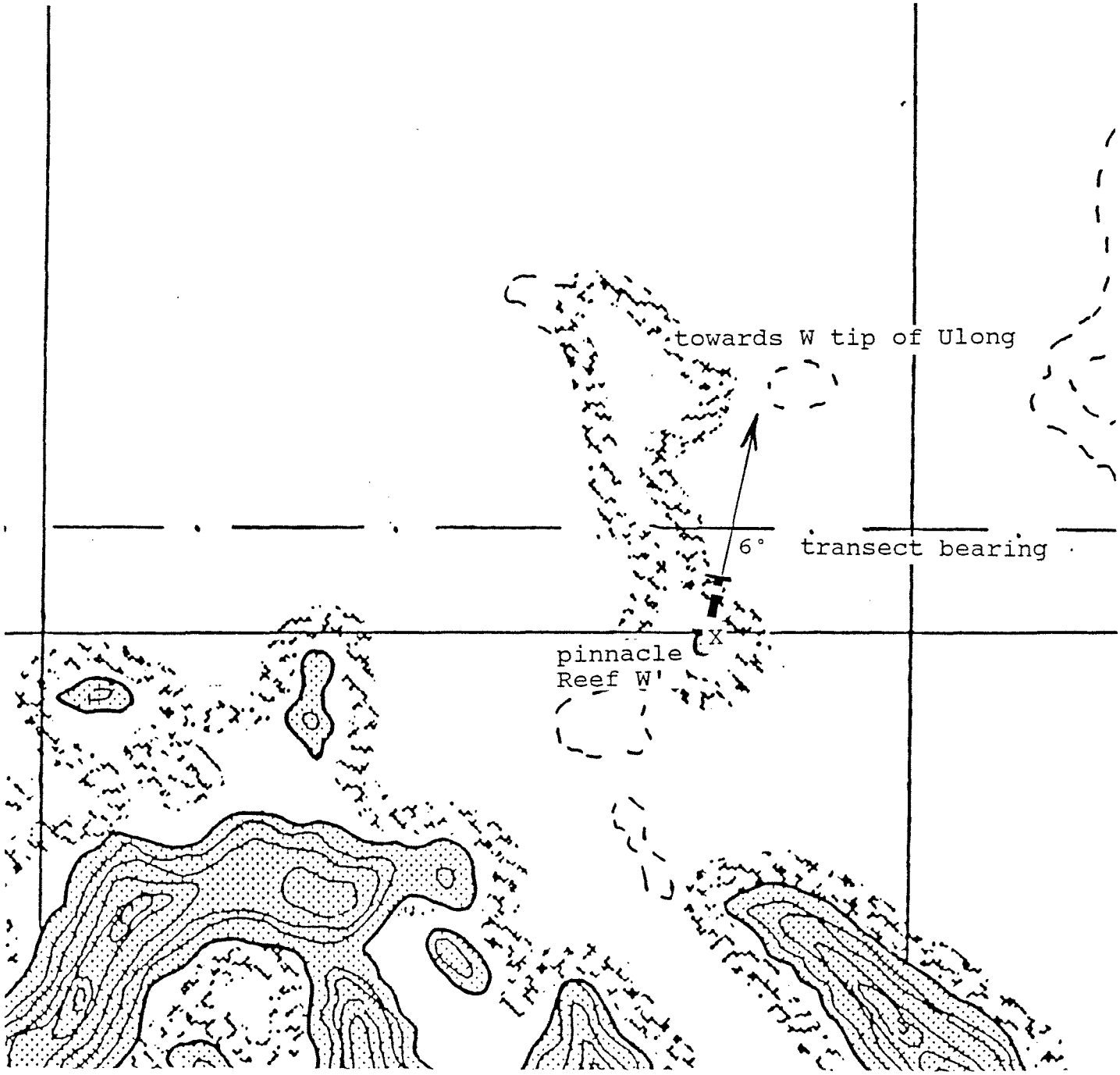


Transect 6

Location: North point of the pinnacle on Reef W'

Marker stake location: no marker stake; a conspicuous and distinctive point of rock sticks out of the base of the pinnacle just above the waterline. The transect began there and ran directly towards the W tip of Ulong Island to the N

Transect bearing: 6°

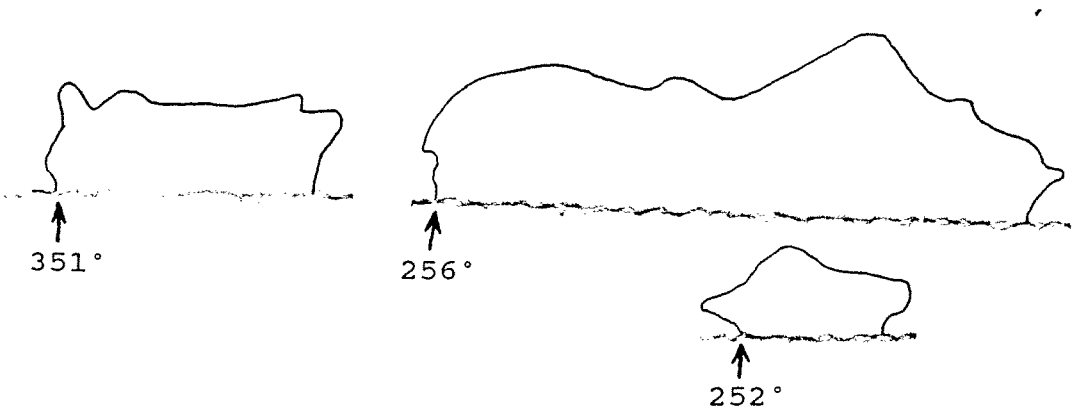


Transect 7

Location: on Reef B; near 2 large microatolls and yellow *Turbinaria* coral

Transect bearing: 129°; just a little to the right of Island 7

Sketches of targets of compass bearings:



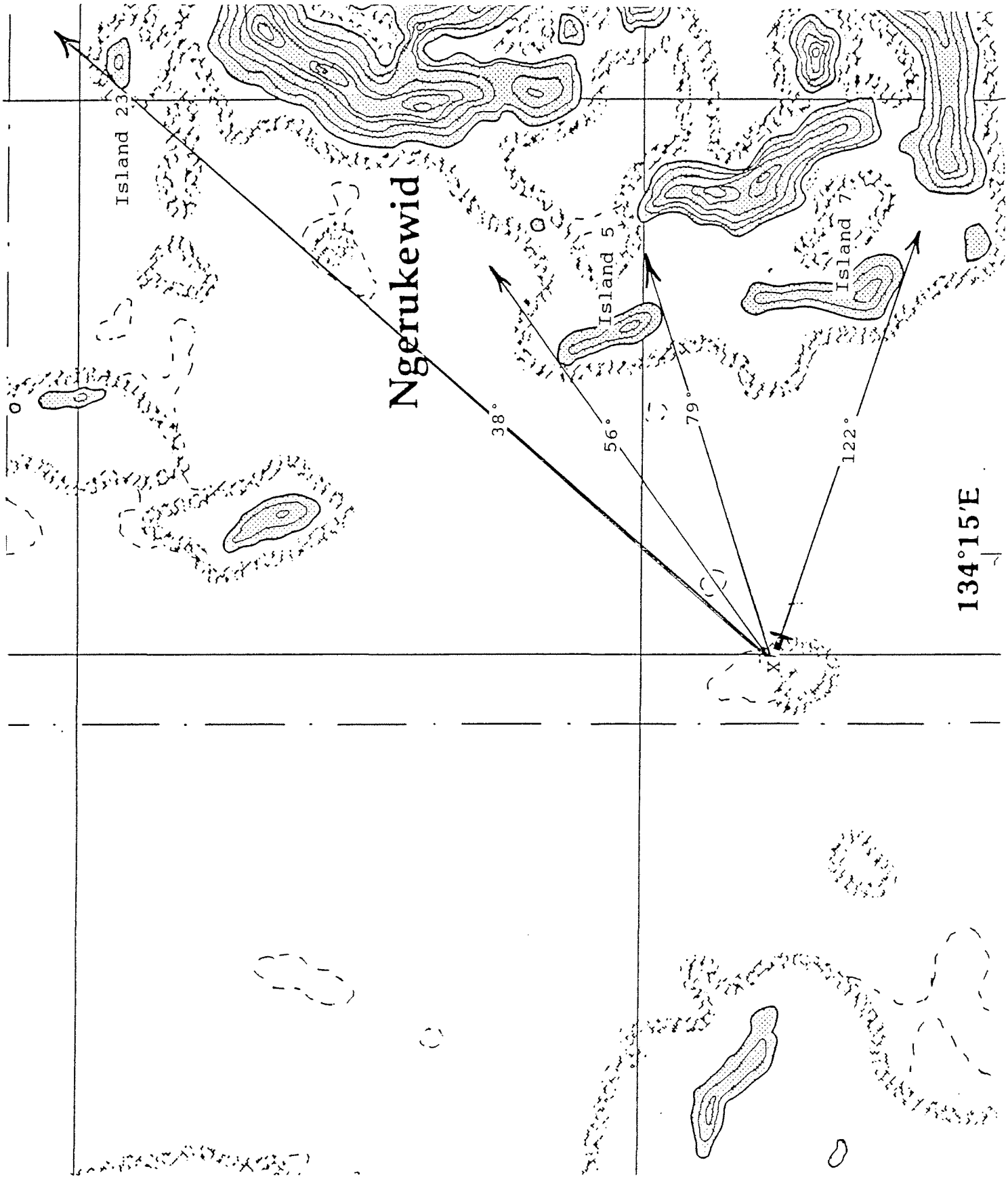
122° -- right tip of Island 7

79° -- right tip of Island 5

56° -- left tip of Island 5

38° -- left tip of Island 23

Transect 7 (map)

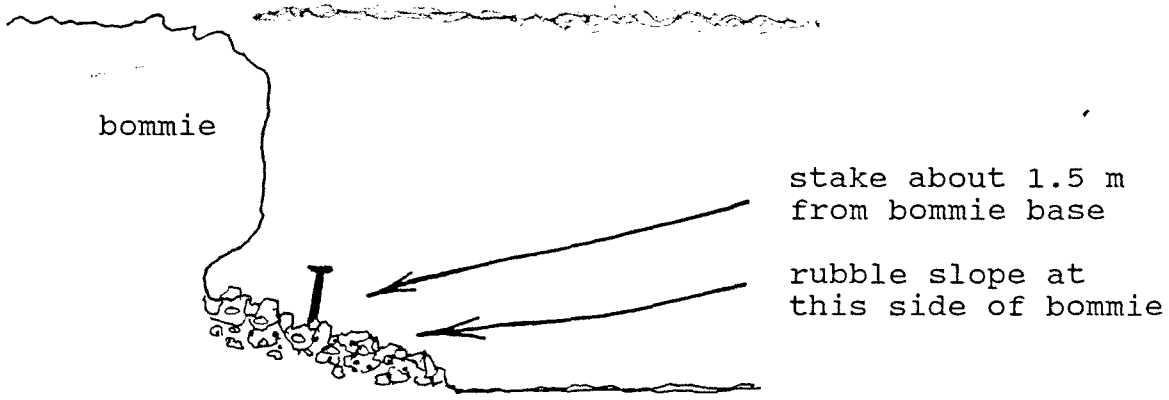


Transect 8

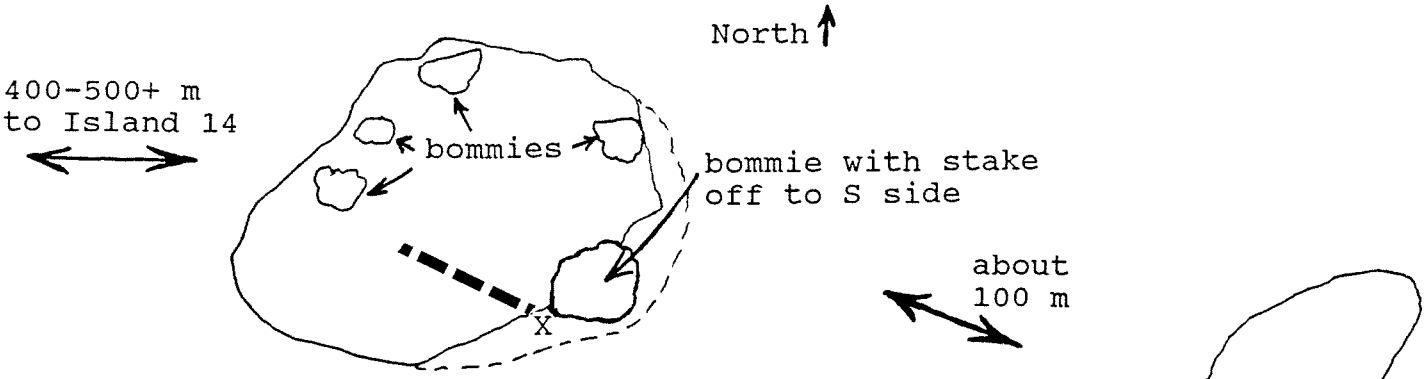
Location: On Reef O'

Marker stake location: on SSE side of largest bommie (3 - 4 m diameter, about 4 m high) on the reef, on a low ridge; bommie has several 30 - 50 cm diameter Acropora colonies on upper surface

side view, to ESE, of bommie



plan view of Reef O'



Targets of compass bearings:

297° -- pinnacle on Reef W'

292° -- northern edge of 70 Islands

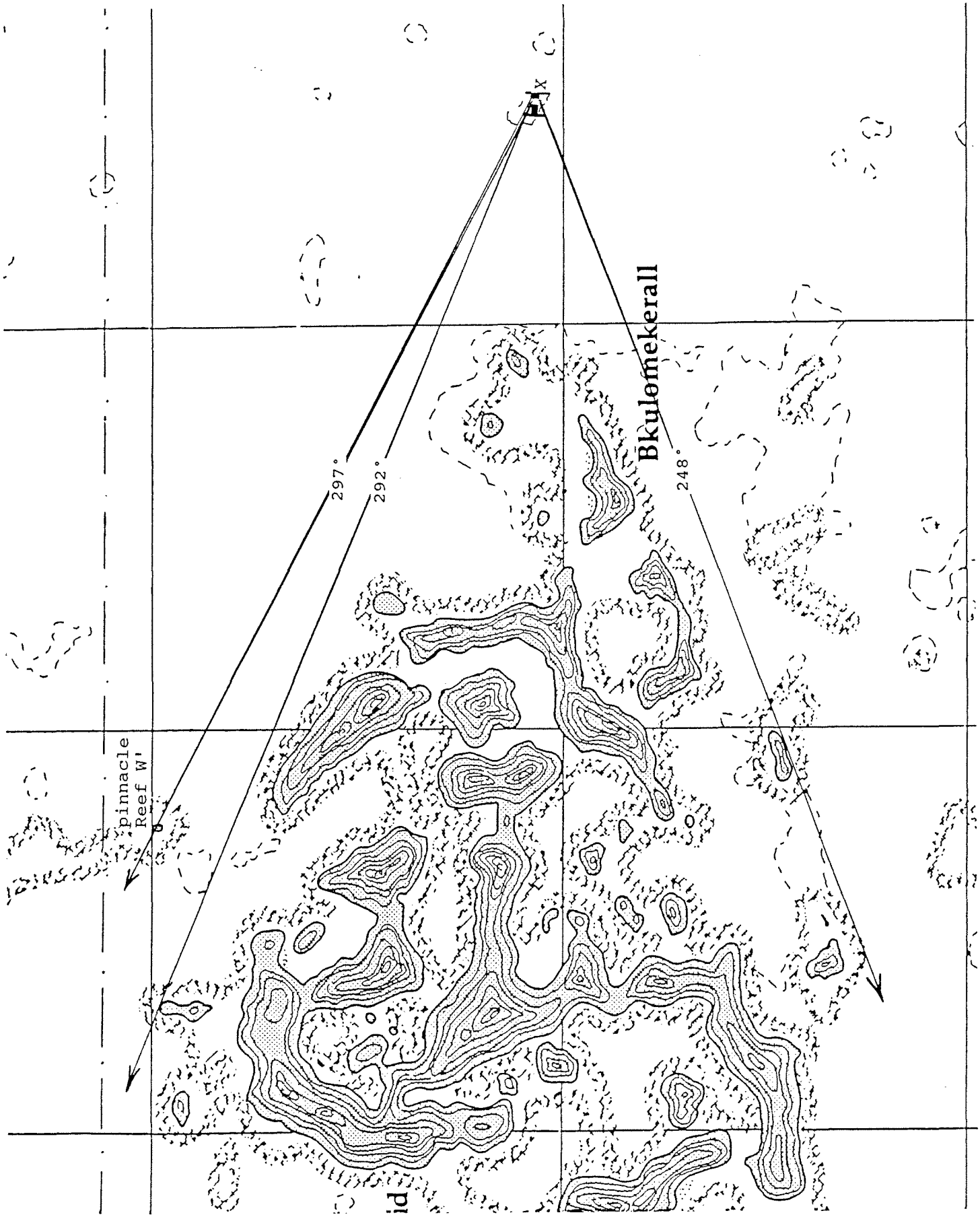
248° -- southern edge of 70 Islands

168° -- big and little islands

22° -- left tip of Ngebengel

356° -- left tip of Ulong

Transect 8 (map)



Transect 9

Location: On large bommie about 50 - 60 m SSW of Island 26; bommie is largest in immediate area, 3 - 4 m diameter and about 2 m tall, bommie is flat and dead on top

Marker stake location: on top of bommie described above

Transect bearing: 241°

Targets of compass bearings:

19° -- inner edge of left notch in Island 26

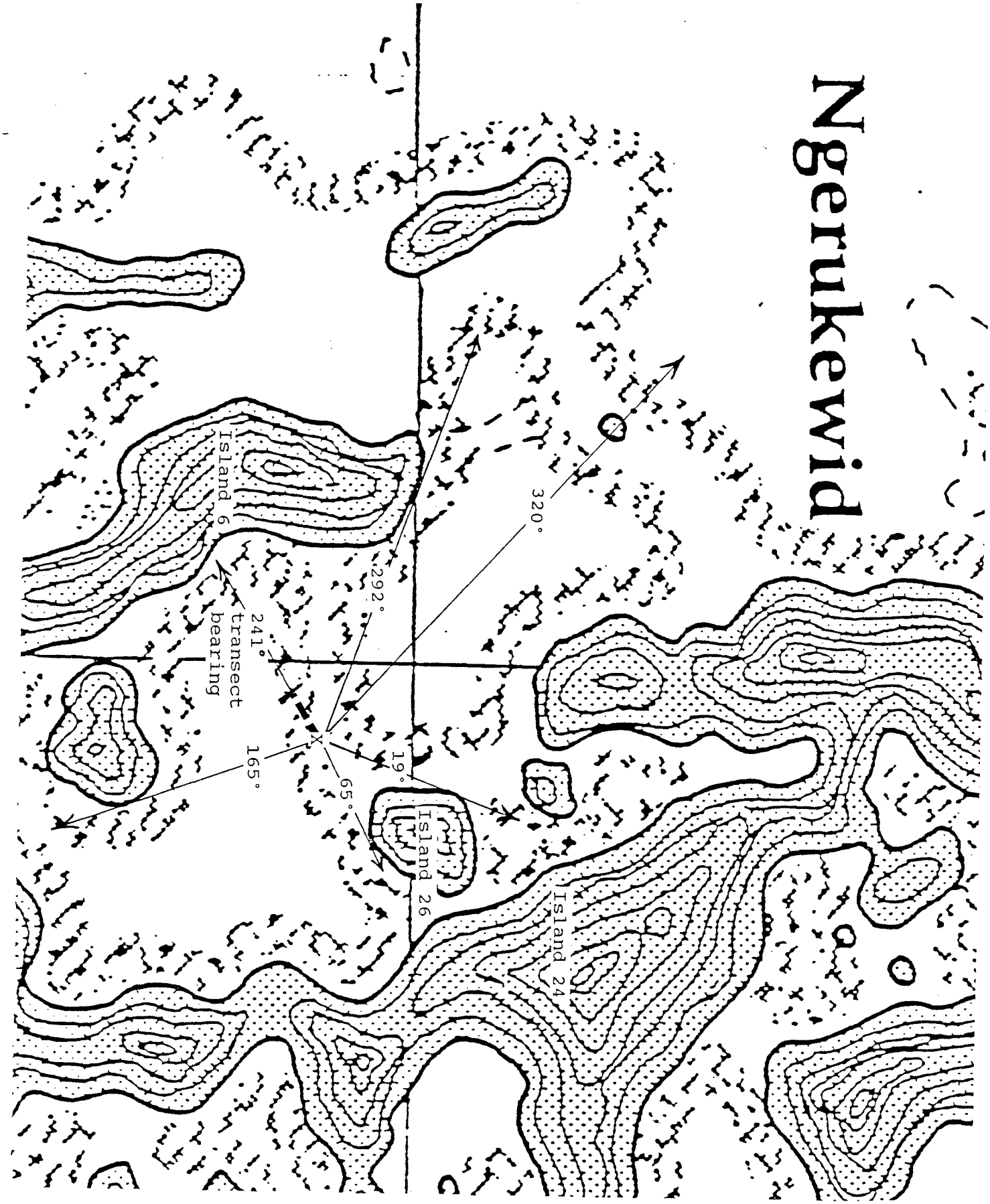
65° -- right side of Island 26

165° -- inner left notch of Island 8

292° -- notch in W opening to open waters

320° -- Rock 38

Transect 9 (map)

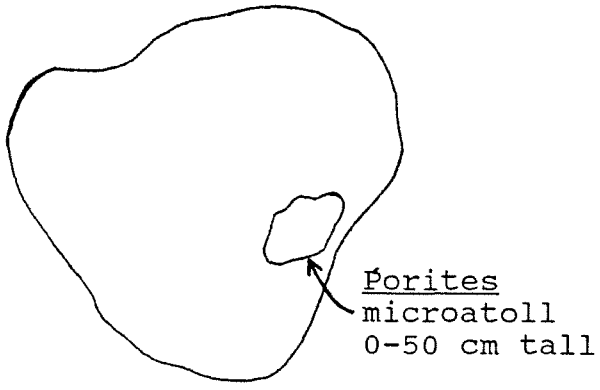


Transect 10

Location: Reef K

Marker stake location: stake is now missing, start transect at base of 1.5 m diameter microatoll (50 cm tall) on the side in the direction 285°

plan view of Reef K



Transect bearing: 285°

Targets of compass bearings:

35° -- right corner of 70 Islands (NE)

127° -- right edge of island with arch

165° -- left edge of Ngecheu

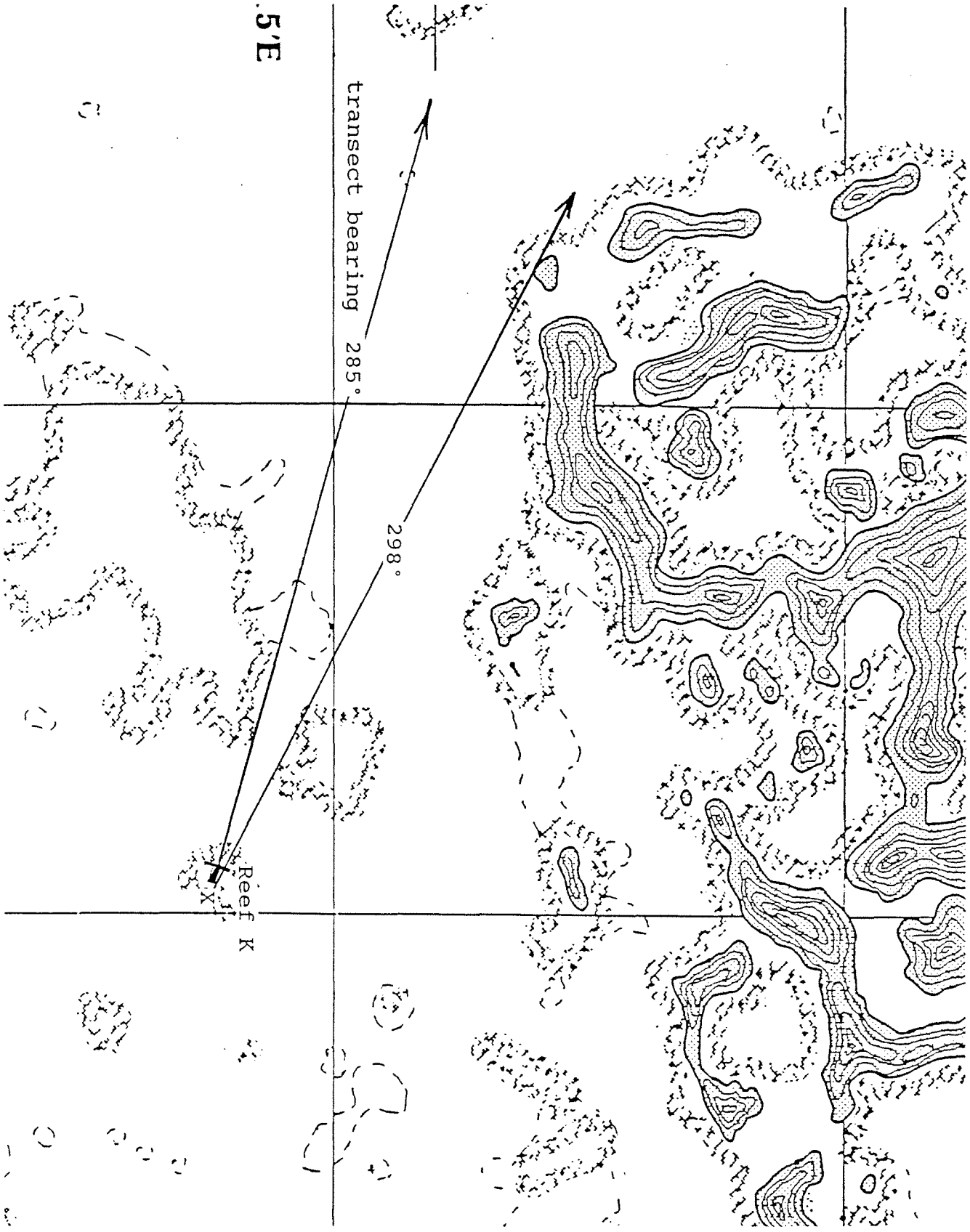
285° -- small mushroom rock to left of California Girl Rock (285°= direction of transect)

288° -- left edge of inner notch of California Girl Rock

295° -- left edge of inner notch of Island 39

298° -- left edge of solid band of 70 Islands (South edge of islands)

Transect 10 (map)

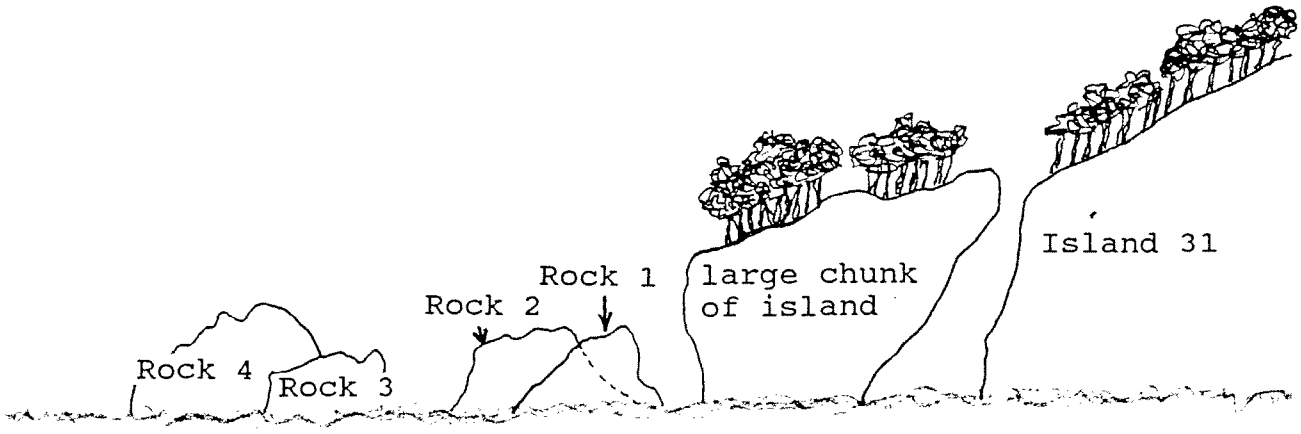


Transect 11

Location: SW end of Island 31; runs towards Island 27=29

Marker stake location: no marker stake; transect begins looped over Rock 2 in diagram below

side view of rocks at SW end of Island 31, looking NNE

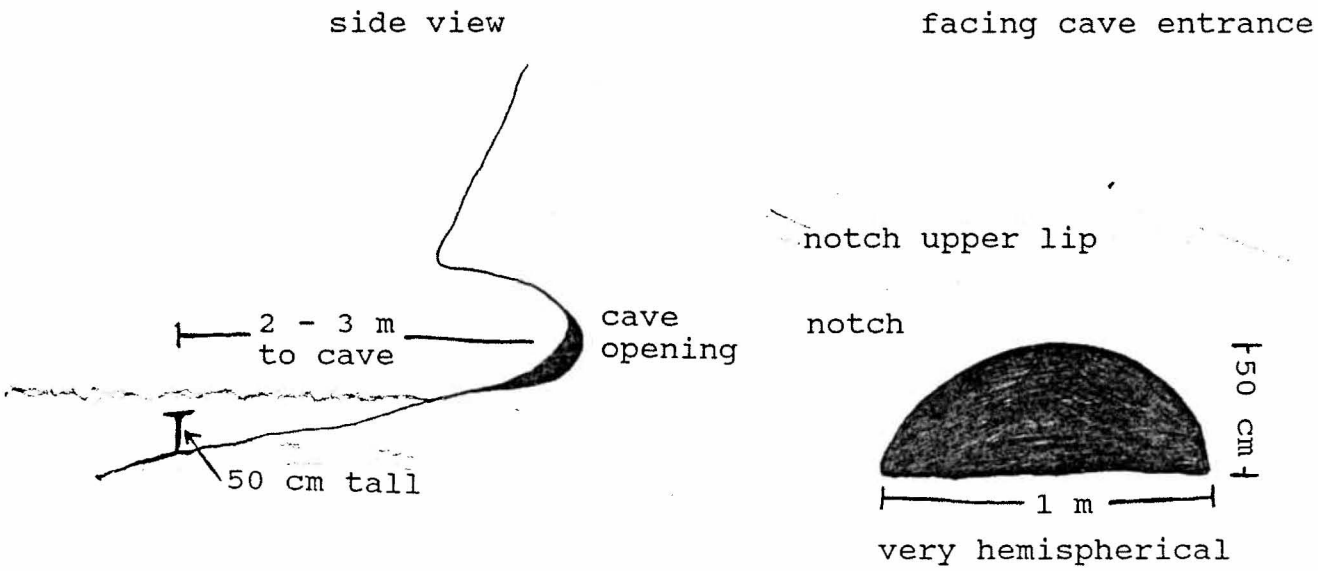


Transect bearing: approximately 236°; the band of living coral was so thin that it is best to run the line towards Island 27=29 along the band of living coral

Transect 12

Location: on the Island 16 side of the pass between Island 16 and Island 24

Marker stake location: stake is 2 - 3 m on the subtidal slope from the opening of a very hemispherical cave (1 m wide, 50 cm tall) near the water level below the notch



Transect bearing: 229.5°

Targets of compass bearings:

229.5° -- far left notch of Island 24=9
(bearing = direction of transect)

346.5° -- inside right notch of Island intersects with left point of Island 17

Transects 11 and 12 (map)