Extinction, Biogeography, and Human Exploitation of Birds on Tikopia and Anuta, Polynesian Outliers in the Solomon Islands[1]

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ABSTRACT

We analyzed bird bones from prehistoric archaeological sites on Tikopia and Anuta, two small, isolated islands at the eastern edge of the Santa Cruz group of the Solomon Islands. Among the 468 identifiable bird bones from Tikopia are those of six species unknown there in modern times: *Puffinus lherminieri* (Audubon's Shearwater), *Papasula abbotti* (Abbott's Booby), *Sula sula* (Red-footed Booby), *Sterna fuscata* (Sooty Tern), *Megapodius freycinet* ("Scrub Fowl" or Common Megapode), and *Gallirallus philippensis* (Banded Rail). Among the 299 identifiable bird bones from Anuta are those of four species not previously recorded there: *Puffinus pacificus* (Wedge-tailed Shearwater), *Puffinus lherminieri* (Audubon's Shearwater), *Sula sula* (Red-footed Booby), and *Sterna fuscata* (Sooty Tern). Most, if not all, of these avifaunal losses are probably due to predation and habitat alteration by humans and introduced rats, dogs, and pigs. Knowledge of these losses is important for biogeography and evolution because it fills in gaps in the natural distributions of species. These findings are important culturally because they provide evidence of prehistoric use and over-exploitation of avian resources. The samples of bones from Tikopia and Anuta are readily compared because they are fairly similar in size and represent approximately the same interval of time (the past 3,000 years). Most of the differences in species composition between these samples are probably due to (1) random sampling effects (samples of bird bones in the hundreds are too small to represent thoroughly the avifauna of an island even as small as Tikopia or Anuta) and (2) the very small size of Anuta, which, combined with its great isolation, either is below the limit that can support a diverse land bird fauna or is such that its extremely small populations of birds would be highly vulnerable to environmental disruptions, whether or not these disruptions are human in origin.

INTRODUCTION

Faunal remains from archaeological sites are usually analyzed from a cultural rather than biological standpoint. Typically, the primary interest of faunal remains lies in what they reveal about the food habits of past peoples rather than in what they say about the animals themselves.

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To learn more about the natural (i.e., pre-human) distribution of birds in Oceania, DWS has obtained collections of bird bones from early archaeological sites on many islands, especially those of eastern Polynesia. Study of these bird bones has shown that numerous populations and entire species of birds have been lost in Polynesia since the time of human arrival, necessitating a reevaluation of the natural biogeography of Pacific birds (Steadman 1989a). The discovery of extinct birds is important to the archaeologist as well as the biologist because the bones of extinct species or populations, which often outnumber those of surviving birds, represent food sources that were exhausted by prehistoric peoples.

This paper is an analysis of the bird bones from archaeological excavations on the small islands of Tikopia and Anuta in the eastern Solomon Islands. The archaeology of these islands is well known (Kirch & Yen 1982; Kirch 1982, 1986a, 1986b; Kirch & Rosendahl 1973, 1976). Mammal bones from the Tikopia sites were reported by Flannery et al. (1988). Although bird bones from Tikopia have been studied more thoroughly than those of most Polynesian archaeological sites (Kirch & Yen 1982:275–284), initial examination of these bones was not done by specialists in avian osteology and was accomplished with a very limited collection of modern comparative skeletons. Previous to our study, bird bones from Anuta had not been identified to any taxonomic level beyond "bird" (Kirch & Rosendahl 1973:92–93). Herein we identify all diagnostic bird bones from all sites on both Tikopia and Anuta. The resulting data permit meaningful comparisons of the prehistoric status and exploitation of birds on these two islands.

MATERIALS AND METHODS

The bones were identified by DWS and DSP. PVK was responsible for the archaeological content of this paper. Identifications were based upon comparisons with modern skeletons of birds from the National Museum of Natural History (USNM), the University of Washington Burke Museum (UWBM), and the New York State Museum (NYSM). The bones from Tikopia and Anuta are housed in the Department of Zoology, Bishop Museum (BPBM). Other abbreviations used: AMNH = American Museum of Natural History; WSSE = Whitney South Sea Expedition; MNI = minimum number of individuals; NISP = number of identified specimens. Although we provide data for both MNI and NISP in the species accounts, we agree with Grayson (1984:62,63,90–92) that MNI values usually can be predicted from NISP values, and that the latter may be better indicators of relative abundance of species. Thus we use only NISP in the tables. Archaeological sediments on Tikopia and Anuta were sieved through screens of 0.25 in. mesh. Screens of this mesh size recover most bones of sea birds and large land birds, but recover few bones of small and medium-sized land birds. The Tikopia names for birds in the species accounts (in parentheses following the English names) are from Kirch and Yen (1982:283–284) and Firth (1985). The Anuta names for birds are from Feinberg (1977). Unless stated otherwise, the modern distributions of birds outside of Tikopia and Anuta are from Mayr (1945), duPont (1976), Hadden (1981), and Pratt, Bruner and Berrett (1987). Osteological nomenclature usually follows Baumel et al. (1979).

THE ISLANDS

Anuta and Tikopia are among the more isolated islands of eastern Melanesia. Politically, both islands are part of the Solomon Islands, and thus are usually grouped with the Santa Cruz Islands as the easternmost province (Te Motu Province) of the Solomon Islands. Geographically, however, Anuta and Tikopia are almost equidistant from Vanikoro in the Santa Cruz Islands and Vanua Lava in the Banks Islands (Fig. 1). Tikopia and Anuta, 137 km apart, are closer to each other than to any other occupied island. A small, uninhabited volcanic spire, Fatutaka (also called Fataka or Mitre Island), lies 32 km southeast of Anuta and can be seen from the latter during clear weather. When the winds are favorable, Anutans voyage by

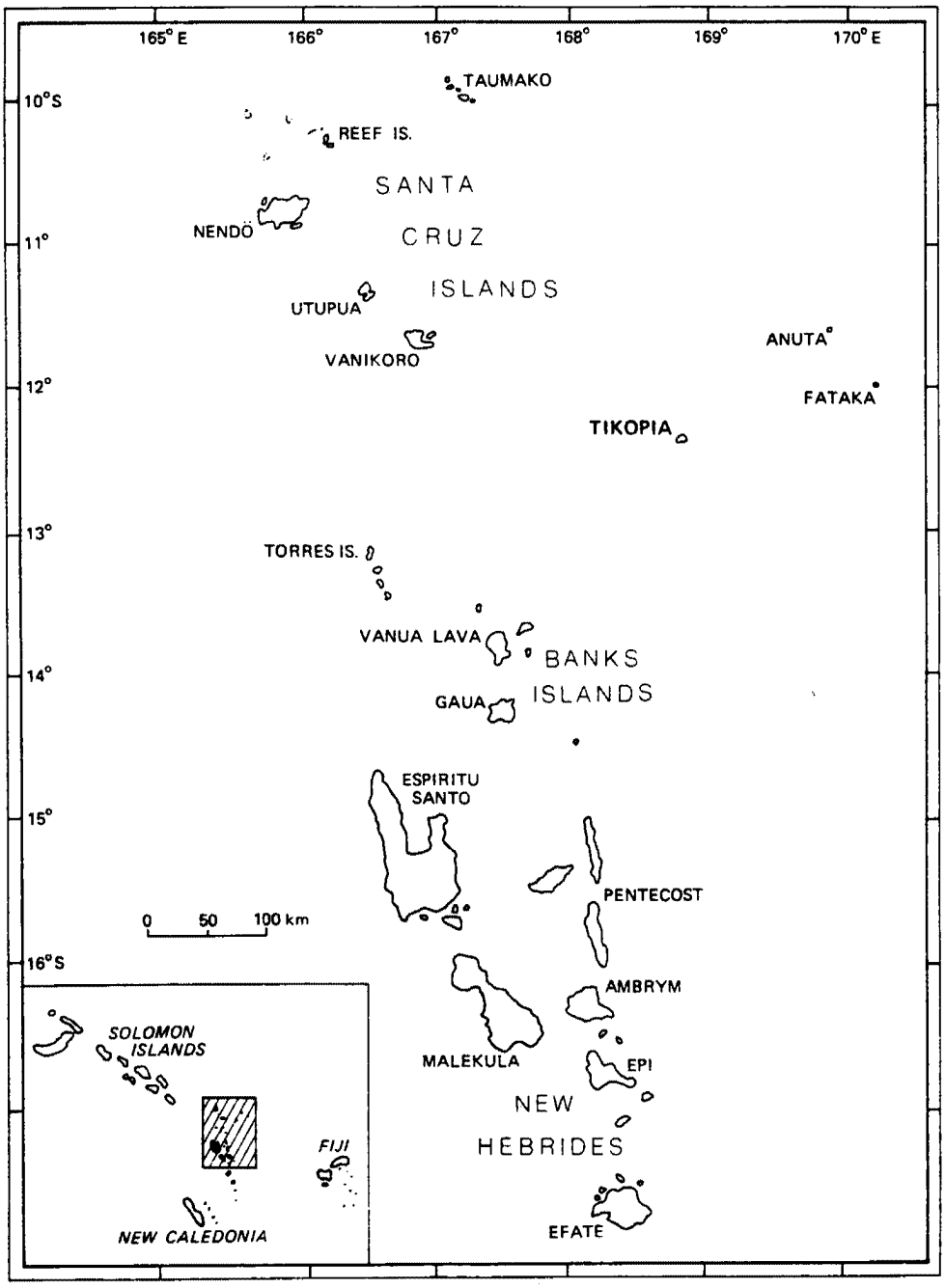

Fig. 1. Location of Tikopia and Anuta in relation to the Santa Cruz Islands and northern Vanuatu (= New Hebrides) (Kirch & Yen 1982:2).

outrigger to Fatutaka to gorge themselves on nesting sea birds and their eggs (Feinberg 1981:28,34). The birds of Fatutaka have never been surveyed, although Woodford (1916) mentioned that frigatebirds (*Fregata* sp.) nest there.

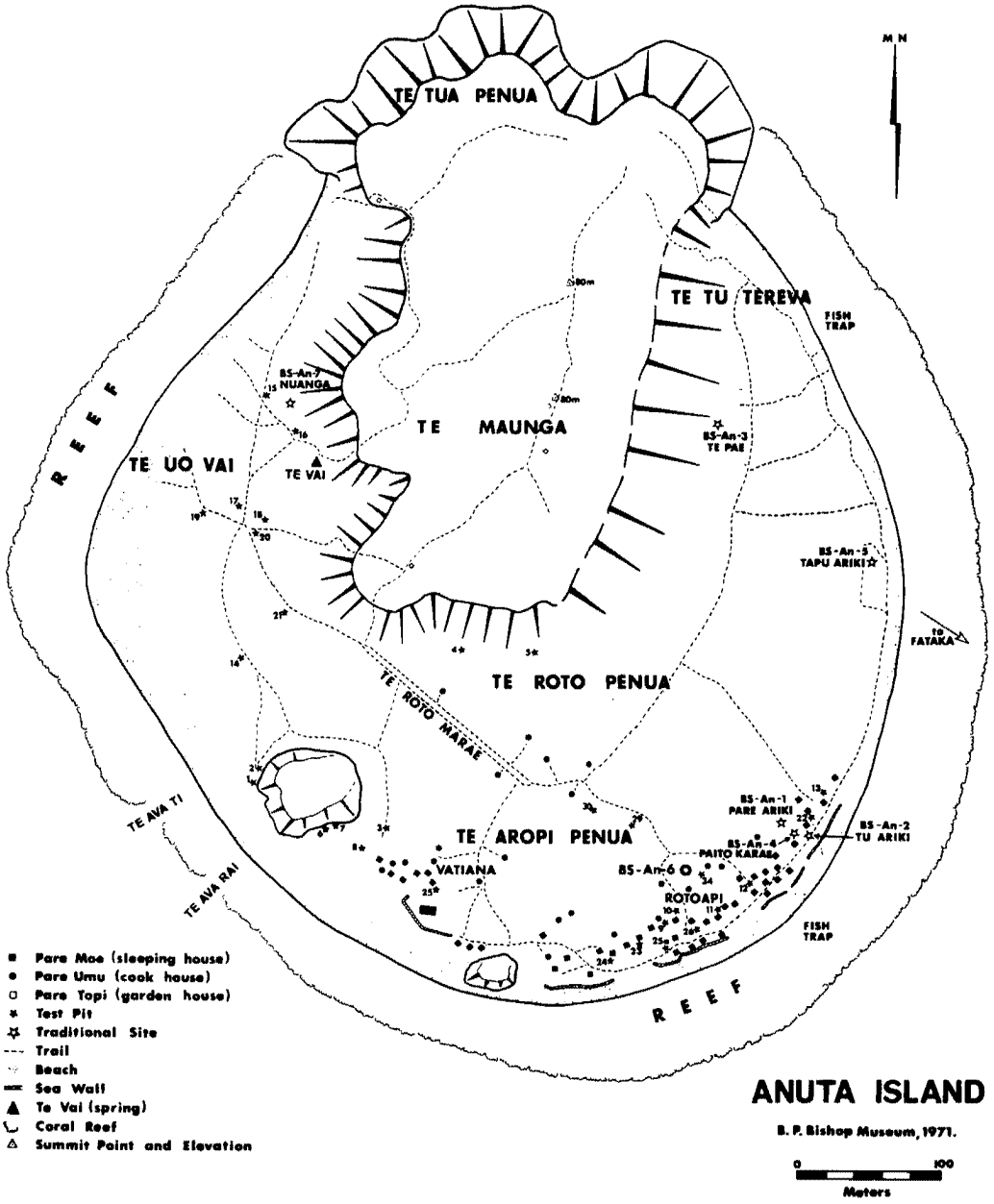

Fig. 2. Anuta Island, showing natural and cultural features, traditional sites, and excavation sites (Kirch & Rosendahl 1973:27).

Anuta (Fig. 2) is a diminutive "high" island with a total land area of only 40 ha (0.4 km^2) and a maximum elevation of 80 m above sea level. The island consists of the eroded remnant of an oceanic-type volcano. A fringing reef nearly encircles Anuta, except on the north where there are steep sea cliffs. The archaeological sites are located on the broad calcareous sand flat that accreted on the reef platform, especially on the south and west (Kirch & Rosendahl 1973: Fig. 1).

As might be expected on such a small island where the human population density is 432/km^2, the vegetation of Anuta is almost wholly anthropogenic. Yen (1973:122) described this managed vegetation in some detail and observed that "one conspicuous feature of the Anutan landscape is the lack of truly natural vegetation on any part of the island except the steep seaward cliffs of the mountain and the two southern promontories." Common Fairy-Terns (*Gygis alba*) and Brown Noddies (*Anous stolidus*) nest primarily on the crowns of large fruit trees (*Artocarpus*, *Burckella*) on the sandy flat and mountain slopes.

Tikopia (Fig. 3), with a land area of 4.6 km^2, is 11 times larger than Anuta although it too has a high population density (242 persons/km^2) and a largely anthropogenic landscape. The island consists of a remnant single-cone volcano (360 m above sea level) of late Pleistocene age. Faulting removed the southern rim of the volcano, exposing the central crater to the sea. Subsequently, the formation of a calcareous sand spit or tombolo separated this marine embayment from the sea, forming the island's present brackish water lake, which is frequented by Gray Ducks (*Anas superciliosa*). At the southwestern end of Tikopia a sandy flat has prograded across the fringing reef platform. This lowland calcareous plain contains extensive archaeological deposits, including the deep stratigraphic sequence of Sites TK-1, -35, and -36. Kirch and Yen (1982:79–85,346–349) described in detail these extensive geomorphological changes in the Tikopian landscape during the past 3,000 years.

The vegetation of Tikopia is thoroughly managed by the island's human population, with most of the land surface covered in a mosaic of orchard gardens and shifting cultivations (Kirch & Yen 1982:25–63). The dominance of arboriculture, rather than open field cropping, provides much habitat for birds such as the Rainbow Lorikeet (*Trichoglossus haematodus*), noisy flocks of which are commonly sighted in the crowns of sago palms (*Metroxylon salomonense*). Primary rainforest vegetation survives on the western coastal cliffs and on the steep cliffs rimming the inner slope of the crater lake. Difficult to climb by humans, these cliffs provide nesting habitats for boobies and noddies. Nonetheless, as Kirch and Yen (1982) extensively documented, most of the Tikopian landscape has been thoroughly modified through 3,000 years of human occupation.

The contemporary inhabitants of both islands are Polynesians, whose oral traditions indicate that their ancestors came from islands to the east, including 'Uvea, Futuna, Samoa, and Tonga. Culturally and linguistically, the people of Anuta and Tikopia are closely related and maintain regular inter-island contact through canoe-voyaging. Their languages are mutually intelligible, though distinct (Pawley 1967; Green 1971). The ethnography of Tikopia is meticulously described by Firth (1936, 1939, and other works) and that of Anuta by Firth (1954) and Feinberg (1981).

PREVIOUS ORNITHOLOGICAL STUDIES ON TIKOPIA AND ANUTA

There has never been a long-term study of the modern avifauna of Tikopia and Anuta. Our comparisons of the prehistoric and modern avifaunas would benefit greatly from a few weeks or months of intense ornithological survey on each island. A summary of modern records of birds on Tikopia and Anuta (Table 1) is based upon the references described below.

Members of the Whitney South Sea Expedition visited Anuta (which they called "Cherry Island" or "Anuda") on 8 February 1927 and Tikopia (called "Tucopia") on 11 and 12 February 1927 (Beck 1927:218–222; also see various WSSE publications in the Literature Cited). In spite of their great efforts, which yielded the only collection of birds ever made on Tikopia and the largest ever made on Anuta, the WSSE never compiled complete lists of species for either island. The specimens and field notes of the WSSE are housed in the Department of Ornithology, AMNH.

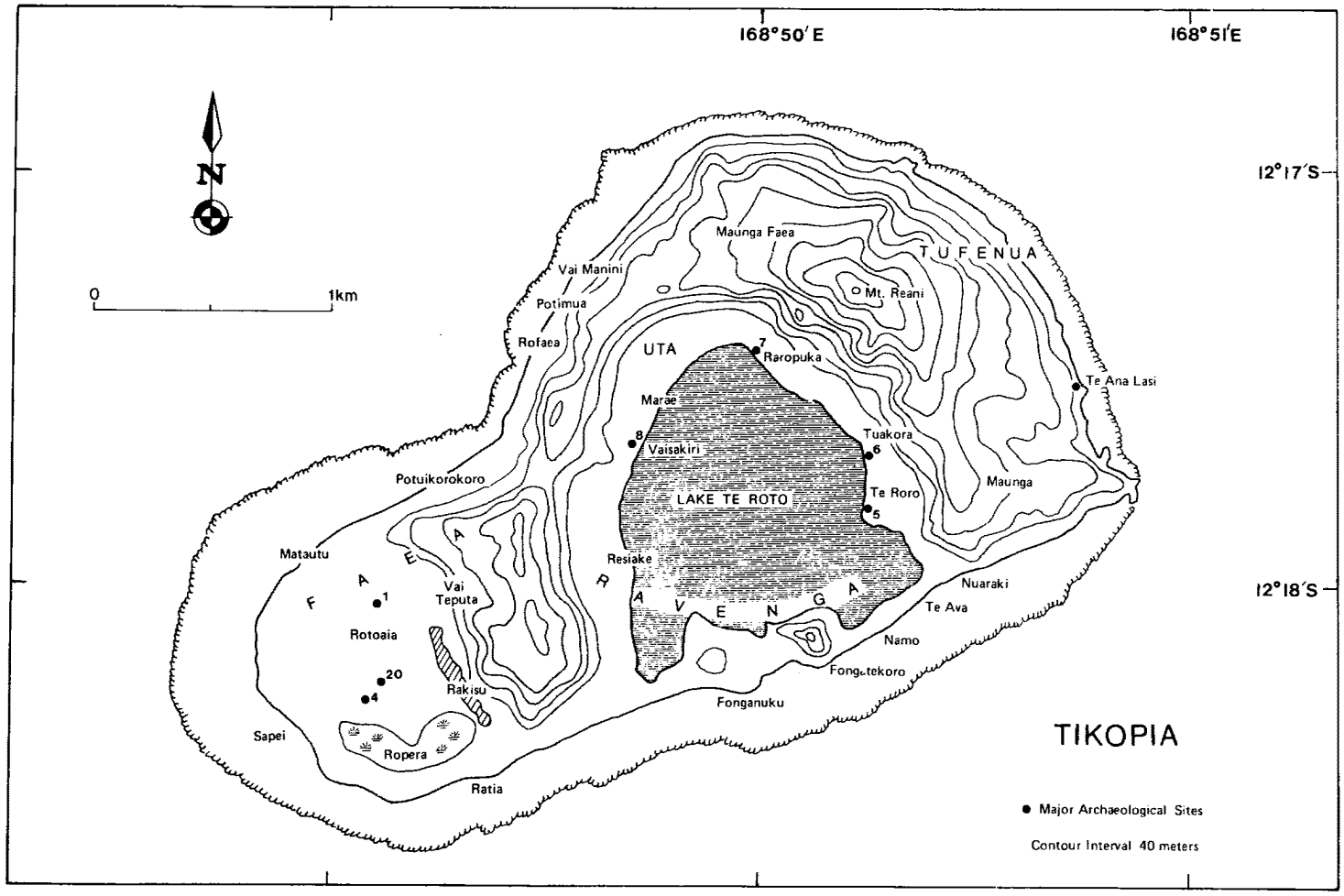

Fig. 3. Tikopia Island, showing natural and cultural features, traditional sites, and excavation sites (Kirch & Yen 1982:12).

Table 1. The birds of Tikopia and Anuta, Solomon Islands.

	Tikopia		Anuta	
	Modern record	Archaeological record	Modern record	Archaeological record
Sea birds				
Pterodroma rostrata (Tahiti Petrel)	X	X	–	–
* *Puffinus pacificus* (Wedge-tailed Shearwater)	?	X	–	X
Puffinus lherminieri (Audubon's Shearwater)	–	X	–	X
* *Phaethon rubricauda* (Red-tailed Tropicbird)	X	X	–	–
* *Phaethon lepturus* (White-tailed Tropicbird)	X	X	X	X
Papasula abbotti (Abbott's Booby)	–	X	–	–
Sula dactylatra (Masked Booby)	X	X	–	–
Sula leucogaster (Brown Booby)	X	X	X	X
Sula sula (Red-footed Booby)	–	X	–	X
Phalacrocorax melanoleucos (Little Pied Cormorant)	X	–	–	–
Fregata minor (Great Frigatebird)	?	X	X	X
Fregata ariel (Lesser Frigatebird)	?	X	–	X
Sterna fuscata (Sooty Tern)	–	X	–	X
Sterna lunata (M?) (Gray-backed Tern)	X	–	–	–
* *Anous stolidus* (Brown Noddy)	X	X	X	X
Anous minutus (Black Noddy)	X	X	X	X
* *Gygis alba* (Common Fairy-Tern)	X	–	X	–
Land birds				
Egretta sacra (Pacific Reef-Heron)	X	–	–	–
* *Anas superciliosa* (Gray Duck)	X	X	–	–
* *Pluvialis dominica* (M) (Pacific Golden Plover)	X	X	X	X
* *Charadrius mongolus* (M) (Mongolian Plover)	X	–	–	–
Heteroscelus incanus (M) (Wandering Tattler)	X	X	–	–
Numenius phaeopus (M) (Whimbrel)	?	–	–	–
Numenius tahitiensis (M) (Bristle-thighed Curlew)	X	X	–	–
Limosa lapponica (M) (Bar-tailed Godwit)	X	–	–	–

The Templeton Crocker Expedition of the California Academy of Sciences visited Anuta ("Anuda") on 15 July 1933, collecting two specimens of Black Noddy (*Anous minutus*) (Davidson 1934).

Sir Harry Luke visited Tikopia on 6 May 1941, making these observations of birds (Luke 1945:190,191): "Bosun birds [either *Phaethon lepturus* or *Phaethon rubricauda*] were flying about the cliffs . . . near the Christian village of Faea. . . . On the lake we saw some wild ducks [*Anas superciliosa*] . . . . Overhead flew pigeon [*Ducula pacifica*] and red and green parakeets [*Trichoglossus haematodus*]."

Kirch and Yen (1982:282–284) summarized the modern and prehistoric avifaunas of Tikopia. Their data on modern birds were based upon observations of R. Firth in 1928–29, 1952, and 1966, and their own observations in 1977 and 1978. The data of Kirch and Yen (1982, Table 41), combined with those of WSSE, yield a fairly complete picture of the modern avifauna of Tikopia, although uncertainties still exist. Information on the modern birds of Anuta remains less complete.

Table 1 continued

	Tikopia		Anuta	
	Modern record	Archaeological record	Modern record	Archaeological record
Arenaria interpres (M) (Ruddy Turnstone)	X	—	X	X
* *Megapodius freycinet* (Common Megapode)	—	X	—	—
* *Gallus gallus* (I) (Chicken)	X	X	X	X
Gallirallus philippensis (Banded Rail)	—	X	—	—
* *Porphyrio porphyrio* (Purple Swamphen)	X	X	—	—
* *Ducula pacifica* (Pacific Pigeon)	X	X	X	—
Trichoglossus haematodus (Rainbow Lorikeet)	X	—	—	—
Eudynamis taitensis (M) (Long-tailed Cuckoo)	X	X	X	X
Collocalia vanikorensis (Vanikoro Swiftlet)	X	—	—	—
Halycon chloris (Collared Kingfisher)	X	—	—	—
Aplonis tabuensis (Polynesian Starling)	X	X	—	—
Myzomela cardinalis (Cardinal Honeyeater)	X	—	—	—
Totals				
All species	27–31	25	11	14
All resident species	17–21	20	7	10
Resident sea birds	10–14	14	6	10
Resident land birds	7	6	1	0
Combined totals				
All species	36–37		16	
All resident species	26–27		12	
Resident sea birds	16–17		11	
Resident land birds	11		1	

* = species reported from archaeological sites on Tikopia by Kirch and Yen (1982); I = introduced by man; M = migrant.

"Resident" totals exclude I, M. Combined totals = modern + archaeological.

ARCHAEOLOGICAL BACKGROUND

The archaeological investigation of Anuta was carried out by PVK and Paul Rosendahl in November-December 1971, as part of the first phase of the Southeast Solomon Islands Culture History Program of the Bishop Museum (Kirch & Rosendahl 1973, 1976; Green & Cresswell 1976). Prior to that study nothing was known of the island's archaeology or prehistory, and indeed, very little was on record of its ethnography (Firth 1954). A series of test excavations in the lowland calcareous flat revealed a large, stratified occupation site (AN-6), which was the focus of several larger excavations (Areas A to D). Site AN-6 yielded plainware Lapitoid ceramics and a large array of *Turbo*-shell fishhooks from the earliest occupation levels (Kirch & Rosendahl 1976). Radiocarbon dating suggested initial settlement of Anuta about 950 B.C. All of the bird bones analyzed herein are from Site AN-6.

Because the work on Anuta in 1971 had been limited essentially to test excavation, expanded excavations at AN-6 were planned as part of the 1977–78 phase of the Southeast Solomon

Islands Culture History Program. Two efforts by PVK to reach Anuta during this period were thwarted by heavy seas and shipping breakdowns, and no further archaeological study has been conducted. However, a reanalysis of the 1971 field data prompted Kirch (1982) to revise the stratigraphic sequence of Site AN-6, grouping the occupation strata into a series of chrono-stratigraphic zones. Zone E represents initial occupation of the island at ca. 950 B.C. Zone D represents continued occupation of Anuta by a pottery-making population during the first millennium B.C. Zone C is a massive deposit of largely sterile calcareous sand, which probably resulted from a major high-energy storm such as one of the cyclones that periodically lash the southeastern Solomon Islands. Anuta was evidently abandoned at about this time, perhaps as a result of the devastation of the island's fragile terrestrial ecosystem. Reoccupation of Anuta is indicated by Zone B deposits, with an earth oven dating to A.D. 580. Zone A is the extensive midden capping the AN-6 site, which is continuing to be deposited within the presently occupied village area. Until further excavations can be conducted on Anuta, this sequence appears to be the best interpretation of the 1971 test excavation results.

Tikopian archaeology was investigated by PVK in 1977 and 1978 as part of the second phase of the Southeast Solomon Islands Culture History Program (Kirch & Yen 1982; Kirch 1986a). Archaeological field strategy included a large series of test and transect excavations throughout the island, as well as intensive excavations at several key site localities. A total excavated area of 204 m^2 yielded a rich archaeological record with more than 5,000 artifacts and more than 35,000 vertebrate faunal remains. The faunal materials, dominated by fish bones, were analyzed by Kirch and Yen (1982:274–310), although identification of the avifaunal component was hampered by inadequate reference collections.

Tikopian prehistory can be subdivided into four cultural phases based on analysis of both artifactual and faunal materials (Kirch & Yen 1982:311–334). The Kiki phase (900–100 B.C.) began with initial colonization of the island by makers of a largely plainware, Lapitoid pottery. The Sinapupu phase (100 B.C.–1200 A.D.) is marked by the cessation of local pottery manufacture and by the importation of small quantities of exotic ceramics from Vanuatu to the south. The Tuakamali phase (1200–1800 A.D.) marks the arrival of immigrant populations of Polynesian speakers from the east. The Historic phase (post 1800 A.D.) marks the period of slight European influence. In some of the archaeological strata, it is difficult or impossible to distinguish between late Tuakamali and early Historic.

Most of the bird bones from Tikopia are from three localities (Tables 3, 4, 9). Virtually the entire prehistory of Tikopia is encapsulated within a deep stratigraphic sequence at the Sinapupu locality, including the arbitrary site designations TK-1, -35, and -36 (Kirch & Yen 1982:89–111). Individual strata in these excavations were combined into chrono-stratigraphic zones that can be correlated with the prehistoric cultural phases described above. The Kiki Site (TK-4) appears to represent the island's initial settlement locality, although its disturbed (gardened) upper Layer I also incorporates a very late prehistoric occupation component. The undisturbed Layer II of TK-4 contains materials dating exclusively to the early Kiki phase. Bird bones were also recovered from Sites TK-7, -8, -9, and -20 (Tables 5–8). TK-7 and -8 are midden deposits along the inner shore of the brackish water lake. TK-9 is a large rock shelter situated on the island's eastern coast. TK-20 is a major site of stone alignments in the Rotoaia area of western Tikopia. Sites TK-7, -8, -9, and -20 were occupied primarily or solely during the Tuakamali phase. Full details of all excavated sites are presented in Kirch and Yen (1982).

SPECIES ACCOUNTS

ORDER PROCELLARIIFORMES

FAMILY PROCELLARIIDAE

Pterodroma rostrata (Peale). Tahiti Petrel.

Material examined. TIKOPIA: NISP = 3, MNI = 2. Coracoid, BPBM 166358; humerus, BPBM 166068; ulna, BPBM 166286.

Remarks. This large petrel nests in the Marquesas, Society Islands, Solomon Islands, and New Caledonia (Murphy & Pennoyer 1952:20). The modern distribution is very localized within these island groups, although bones from archaeological sites in the Marquesas and Society Islands show that *Pterodroma rostrata* was previously more widespread. This is the first record from Tikopia. There are no records from Anuta. Kirch and Yen (1982:284) reported an unknown sea bird known to the Tikopia as *makatapa*. Firth (1985:230) listed the Tikopia *manu sina* as "?giant petrel." Perhaps one of these two names refers to *P. rostrata*.

The WSSE sighted individuals of Stejneger's Petrel, *P. longirostris* (Stejneger) and White-naped Petrel, *P. cervicalis* (Salvin), at sea 30 mi WSW of Tikopia on 13 February 1927 (Beck 1927:222). Neither of these species is known to nest in truly tropical waters. Because of the poor reliability of sight records of *Pterodroma*, we cannot be certain that these birds were identified accurately.

Pterodroma, species unknown. Indeterminate petrels.

Material examined. TIKOPIA: NISP = 2. Humerus, BPBM 166196; tarsometatarsus, BPBM 166118.

Remarks. These two specimens represent a large species of *Pterodroma*, but are too fragmentary for species-level identification. Because they may represent *P. rostrata*, these specimens yield no MNI and are not regarded as a distinct taxon in Table 1.

Puffinus pacificus (Gmelin). Wedge-tailed Shearwater (Tikopia *manu uri*).

Material examined. TIKOPIA: NISP = 1, MNI = 1. Humerus, BPBM 166240. ANUTA: NISP = 1, MNI = 1. Femur, BPBM 165699.

Remarks. The humerus from Tikopia is only tentatively referred to *Puffinus pacificus*, clearly being a species of *Puffinus* (rather than *Pterodroma*) in the size range of *Puffinus pacificus*. The distinctive femur from Anuta is confidently referred to *P. pacificus* because it is larger than the femur of *P. lherminieri* or *P. nativitatis* Streets. Moreover, the shaft of the femur is more curved than in any species of *Pterodroma*. The breeding distribution of *P. pacificus* includes virtually all island groups of the tropical Pacific (Murphy 1951: Fig. 1), although usually there are few nesting islands within any given island group. The only modern record of *P. pacificus* from the region is an unknown number seen 30 mi WSW of Tikopia on 13 February 1927 (Beck 1927:222). *Puffinus pacificus* is not known to nest on Tikopia today, although the Tikopia have a name (*manu uri*) for this species (Kirch & Yen 1982:283; Firth 1985:230), perhaps based upon birds seen at sea. The femur is the first record for Anuta.

Puffinus lherminieri Lesson. Audubon's Shearwater.

Material examined. TIKOPIA: NISP = 1, MNI = 1. Tibiotarsus, BPBM 181540. ANUTA: NISP = 35 (nearly all major skeletal elements represented), MNI = 14. BPBM 165778–165780, 165782–165792, 165797, 165815, 165821, 165822, 165826, 165828–165830, 165860–165862, 165915, 165916, 165935, 165947, 165952, 165955, 165958, 165963, 165966, 165979.

indicate that nesting populations [illegible] of the species (Steadman 1989a).

Sula, species unknown. Indeterminate boobies.

Material examined. TIKOPIA: NISP = 27 (nearly all major skeletal elements represented), MNI = 7. BPBM 166287, 166293, 166399, 166414, 181523, 181542, 181558, 181563, 181564, 181566, 181567, 181580–181584, 181587, 181589–181591, 181595, 181600–181602, 181641, 181642, 181648. ANUTA:

Remarks. These are the first records of *Puffinus lherminieri* on Tikopia and Anuta. The nearest modern record for *P. lherminieri* is a sighting at sea 30 mi WSW of Tikopia on 13 February 1927 (Beck 1927:222). This small shearwater is very widespread in the tropical Pacific, although, like *P. pacificus*, the distribution within individual island groups is very discontinuous. Its bones are found commonly in Polynesian archaeological sites in the Marquesas, Society Islands, Cook Islands, and Tonga (Steadman 1989a).

Procellariidae, genus (?genera) and species unknown. Indeterminate petrels and/or shearwaters.

Material examined. TIKOPIA: NISP = 15, MNI = 0. Sternum, BPBM 166134; 2 scapula, BPBM 166082, 166237; humerus, BPBM 166083; 6 ulnae, BPBM 166128, 166165, 166259, 166324, 166325, 166377; carpometacarpus, BPBM 166084; femur, BPBM 166175; 3 tibiotarsi, BPBM 166136, 166185, 166186.

Remarks. These fragmentary specimens represent medium to large-sized species of *Pterodroma* and/or *Puffinus*.

Order Pelecaniformes

Family Phaethontidae

Phaethon rubricauda Boddaert. Red-tailed Tropicbird.

Material examined. TIKOPIA: NISP = 4, MNI = 2. Humerus, BPBM 166124; 3 carpometacarpi, BPBM 166075, 166210/166211, 166219.

Remarks. Kirch and Yen (1982:283) recorded *Phaethon rubricauda* for modern Tikopia, although a local name for it was not obtained. There are no records for Anuta. This large tropicbird is very widespread in the tropical Pacific and Indian oceans. Bones of *P. rubricauda* occur in Polynesian archaeological sites on Henderson Island (Schubel & Steadman 1989) and Mangaia (Steadman 1985).

Phaethon lepturus Daudin. White-tailed Tropicbird (Tikopia, Anuta *tavake*).

Material examined. TIKOPIA: NISP = 15, MNI = 6. Mandible, BPBM 166314; 3 coracoids, BPBM 166116, 181537, 181538; 4 humeri, BPBM 166177, 166203, 166326, 166376; 3 ulnae, BPBM 166168, 166357, 181491; carpometacarpus, BPBM 166197; 2 manus digit II phalanx 1, BPBM 166163, 166342; pelvis, BPBM 166248. ANUTA: NISP = 1, MNI = 1. Scapula, BPBM 165978.

Remarks. This small tropicbird, a symbol of the Kafika deities (Firth 1985:516), still occurs on Tikopia (Beck 1927:221; Kirch & Yen 1982:283) and Anuta (Beck 1927:218). It was nesting on Tikopia on 11 February 1927 (Beck 1927:221). *Phaethon lepturus* is very widespread in the tropical Pacific, Indian, and Atlantic oceans. Bones of *P. lepturus* occur in Polynesian archaeological sites on Henderson Island, the Marquesas, Huahine, Mangaia, and 'Eua (Steadman 1989a).

Family Sulidae

Papasula abbotti (Ridgway). Abbott's Booby.

Material examined. TIKOPIA: NISP = 2, MNI = 1. Coracoid, BPBM 166283; tarsometatarsus, BPBM 166234.

Remarks. The osteological, systematic, and biogeographical details of these specimens are discussed in Steadman, Schubel, and Pahlavan (1988). Tikopia is 6,400 km east of the only locality where *Papasula a. abbotti* survives (Christmas Island in the Indian Ocean). Bones of a distinctive, extinct subspecies of Abbott's Booby, *P. a. costelloi*, have been recovered from

archaeological sites in the Marquesas (Steadman, Schubel & Pahlavan 1988), extending the former range of this endangered species an additional 4,800 km eastward into the Pacific. The Tikopian bones of *P. a. abbotti* are found only in the Kiki phase of Site TK-4, suggesting that this tree-nesting booby was extirpated very shortly (within a few decades to a few centuries) after the human colonization of Tikopia. There are no records of this species from Anuta.

Sula dactylatra Lesson. Masked Booby (Tikopia *mauakena*).

Material examined. TIKOPIA: NISP = 3, MNI = 2. Pterygoid, BPBM 181605; coracoid, BPBM 181599; humerus, BPBM 181598.

Remarks. *Sula dactylatra* still occurs on Tikopia today (Kirch & Yen 1982:283), although its nesting status is unknown. None of the sulid bones from Anuta was large enough to be of this species. There are no modern records of this species from Anuta. *Sula dactylatra* is widespread in the tropical Pacific and Indian oceans, although nesting islands are relatively few.

Sula leucogaster (Boddaert). Brown Booby (Tikopia *katoko*).

Material examined. TIKOPIA: NISP = 2, MNI = 2. Radius, BPBM 166241; tibiotarsus, BPBM 166182. ANUTA: NISP = 5, MNI = 2. Quadrate, BPBM 165971; sternum, BPBM 165874; coracoid, BPBM 165846; ulnare, BPBM 165909; tibiotarsus, BPBM 165720.

Remarks. The only modern record of *Sula leucogaster* from Tikopia is that of Kirch and Yen (1982:283). There is a sight record from Anuta on 8 February 1927 (Beck 1927:218). *Sula leucogaster* occurs in many localities scattered through the tropical Pacific, Indian, and Atlantic oceans.

Sula sula (Linnaeus). Red-footed Booby.

Material examined. TIKOPIA: NISP = 44 (nearly all major skeletal elements represented), MNI = 13. BPBM 166073, 166120, 166139, 166188, 166214, 166216–166218, 166233, 166239, 166242, 166243, 166249, 166250, 166262, 166273, 166284, 166294, 166328, 166352–166354, 166382, 166386–166398, 166415, 166416, 181547, 181559, 181585, 181588, 181592, 181593. ANUTA: NISP = 85 (nearly all major skeletal elements represented), MNI = 7. BPBM 165703, 165706, 165707, 165709–165712, 165718, 165743–165759, 165762, 165764–165774, 165793, 165845, 165848, 165850–165854, 165856–165858, 165872, 165873, 165879, 165880, 165887, 165891, 165892, 165895, 165898–165901, 165903, 165904, 165906, 165908, 165910–165912, 165923–165927, 165930, 165931, 165973, 165975, 165982, 165985, 165987, 165988, 165990–165992, 165994, 165996.

Remarks. There are no modern records of *Sula sula* from Tikopia or Anuta. This is the most common species of bird from the archaeological site on Anuta, and the second most common species from the Tikopian sites. Although *S. sula* is widespread in tropical oceans today, bones from archaeological sites on Henderson Island, the Marquesas, and Society Islands indicate that nesting populations have been removed from many islands within the Pacific range of the species (Steadman 1989a).

Sula, species unknown. Indeterminate boobies.

Material examined. TIKOPIA: NISP = 27 (nearly all major skeletal elements represented), MNI = 7. BPBM 166287, 166293, 166399, 166414, 181523, 181542, 181558, 181563, 181564, 181566, 181567, 181580–181584, 181587, 181589–181591, 181595, 181600–181602, 181641, 181642, 181648. ANUTA: NISP = 51 (nearly all major skeletal elements represented), MNI = 0. BPBM 165695, 165702, 165708, 165713–165717, 165719, 165727, 165760, 165761, 165763, 165775, 165794, 165816, 165847, 165849, 165855, 165868, 165875–165878, 165881–165886, 165888–165890, 165893, 165894, 165896, 165897, 165902, 165905, 165907, 165928, 165929, 165949–165951, 165972, 165974, 165993, 165995, 165997, 165998.

Remarks. These fragmentary specimens cannot be distinguished from the bones of *Sula sula* or *S. leucogaster.* They are too small to represent *S. dactylatra.*

FAMILY PHALACROCORACIDAE

Phalacrocorax melanoleucos (Vieillot). Little Pied Cormorant (Tikopia *manu fiti*).

Material examined. None.

Remarks. The WSSE collected two specimens of *Phalacrocorax melanoleucos* on Tikopia on 11–12 February 1927 (Amadon 1942) and saw about 10 other individuals (Beck 1927:219). This species is also listed for Tikopia by Kirch and Yen (1982:283) and Firth (1985:230). There are no records of this species from Anuta. Tikopia is the easternmost locality in the modern range of *P. melanoleucos,* which extends discontinuously through the Solomon Islands and New Caledonia to Australia, New Guinea, Indonesia, and Palau (Amadon 1942). The absence of its bones from archaeological sites might suggest that this small cormorant colonized Tikopia since the arrival of humans. This suggestion is supported by the apparent lack of differentiation between the Tikopia population and other populations except those on Rennell and New Zealand (Amadon 1942).

FAMILY FREGATIDAE

Fregata minor (Gmelin). Great Frigatebird (Tikopia *rofa*).

Material examined. TIKOPIA: NISP = 9, MNI = 3. Sternum, BPBM 166198; coracoid, BPBM 166220; scapula, BPBM 166298; 4 humeri, BPBM 166160, 166315, 181503, 181504; radius, BPBM 166316; manus digit II phalanx 1, BPBM 166069. ANUTA: NISP = 12, MNI = 5. 3 coracoids, BPBM 165698, 165731, 165732; scapula, BPBM 165831; 2 humeri, BPBM 165728, 165832; 2 ulnae, BPBM 165736, 165738; 3 radii, BPBM 165741, 165870, 165871; tibiotarsus, BPBM 165865.

Remarks. These specimens are larger than the bones of *Fregata ariel.* The WSSE collected one specimen of *F. minor* on Anuta on 8 February 1927 (Beck 1927:218). *Fregata minor* occurs in the South Atlantic and the tropical portions of the Pacific and Indian oceans.

Firth (1985:403) defined the Tikopia word *rofa* as *F. minor,* which "nests on Tikopia," thus providing the only record of *F. minor* for Tikopia. Firth (1985:203) defined *rofa kaute* as the "Wattled Frigate Bird (*F. aquila*)," which nests on Fatutaka. As *F. aquila* (Linnaeus) is usually regarded as a subspecific name for Atlantic populations of *F. minor,* we believe that Firth's *rofa kaute* is the male of *F. minor,* whose red throat patch would account for the name "Wattled Frigate Bird." Clark (1982) noted that the two Polynesian species of *Fregata* (*F. minor* and *F. ariel*) are not distinguished in any Polynesian language. We also have found this to be true on all Polynesian islands we have visited.

Fregata ariel (Gray). Lesser Frigatebird.

Material examined. TIKOPIA: NISP = 3, MNI = 1. Humerus, BPBM 166282; radius, BPBM 166115; carpometacarpus, BPBM 166080. ANUTA: NISP = 7, MNI = 2. Mandible, BPBM 165720; coracoid, BPBM 165730; scapula, BPBM 165733; 3 ulnae, BPBM 165737, 165739, 165740; carpometacarpus, BPBM 165986.

Remarks. These specimens are smaller than the bones of all individuals of *Fregata minor.* Although the bones listed above are the first records of *F. ariel* from either Tikopia or Anuta, modern sight records of *Fregata* have not been identified to species (Kirch & Yen 1982:283). Both species of *Fregata* wander far from roosting and nesting islands, especially during storms. Thus it is likely that both *F. ariel* and *F. minor* still visit (but probably do not nest on) both Tikopia and Anuta, which is why neither is counted among the extirpated species. *Fregata ariel* occurs locally through much of the tropical Pacific, Indian, and Atlantic oceans.

Fregata, species unknown. Indeterminate frigatebirds.

Material examined. ANUTA: NISP = 6. Mandible, BPBM 165735; 2 coracoids, BPBM 165961, 165970; scapula, BPBM 165936; 2 ulnae, BPBM 165734, 165735.

Remarks. These specimens fall into the range of size overlap between the bones of *Fregata minor* and *F. ariel*. The bones of female *F. minor* are consistently larger than any bones of *F. ariel*, while the bones of male *F. ariel* are always smaller than any bones of *F. minor*. The bones of male *F. minor* and female *F. ariel* are often impossible to distinguish.

Family Laridae

Subfamily Sterninae

Sterna fuscata Linnaeus. Sooty Tern.

Material examined. TIKOPIA: NISP = 2, MNI = 1. Humerus, BPBM 166344; ulna, BPBM 166174. ANUTA: NISP = 4, MNI = 2. Maxilla, BPBM 165705; quadrate, BPBM 165932; scapula, BPBM 165934; ulna, BPBM 165818.

Remarks. We refer these specimens to *Sterna fuscata* rather than the similarly sized *Anous stolidus* because of these characters: quadrate—broader processus orbitalis quadrati, with a large basal foramen; rostrum—narrower and straighter; scapula—more dorso-ventrally compressed proximal portion of the blade; humerus—sharper apex of crista pectoralis, less pneumatic proximal end, larger fossae pneumotricipitalis, deeper fossa musculo brachialis, sharper caudal surface of proximal portion of shaft; ulna—larger overall, smaller cotyla dorsalis, larger papillae remigiales caudales, more elongate tuberculum carpale.

This is the first record from either Tikopia or Anuta for *Sterna fuscata*, which occurs locally throughout tropical oceans. Kirch and Yen (1982:283) and Clark (1982) listed the Tikopia name *tara* for *Sterna* sp., which could refer to either *S. fuscata* or *S. lunata*. Kirch and Yen (1982:283) also listed the name *rakia* for an unknown bird thought to be a tern. Clark (1982) identifies the Tikopia *rakia* as *Anous tenuirostris* (Temminck) (= *A. minutus*; see below). Firth (1985:230) listed the Tikopia *manu riki* as a general term for terns and *manu tai* as the Common Tern (*Sterna hirundo* Linnaeus), a migratory species not otherwise recorded for Tikopia.

Sterna lunata Peale. Gray-backed Tern.

Material examined. None.

Remarks. A single individual of *Sterna lunata* was collected just offshore of Tikopia on 11 February 1927 (Beck 1927:221). There is no evidence that *S. lunata* nests on Tikopia. There are no records of this species from Anuta. *Sterna lunata* occurs through much of the tropical Pacific.

Anous stolidus (Linnaeus). Brown Noddy (Tikopia *ngongo*).

Material examined. TIKOPIA: NISP = 135 (nearly all major skeletal elements represented), MNI = 38. BPBM 166070, 166079, 166086–166089, 166091–166093, 166095, 166098–166100, 166102, 166104–166108, 166110, 166111, 166113, 166117, 166121, 166122, 166133, 166135, 166137, 166138, 166141–166144, 166152–166156, 166158, 166164, 166167, 166169, 166170, 166172, 166173, 166176, 166178, 166179, 166189, 166191–166193, 166204, 166224, 166226, 166245–166247, 166252, 166256, 166257, 166271, 166272, 166279, 166280, 166289, 166292, 166296, 166308, 166309, 166321–166323, 166329, 166330, 166337, 166339, 166340, 166343, 166347–166351, 166361–166366, 166371, 166378–166380, 166385, 166400, 166402–166406, 166412, 166420–166422, 181493, 181497, 181507, 181530, 181532, 181541, 181543, 181565, 181568–181570, 181572, 181573, 181575, 181576, 181594, 181596, 181597, 181604, 181606, 181608, 181611, 181618, 181619, 181621, 181622, 181625, 181626, 181644, 181645. ANUTA: NISP = 44 (nearly all major skeletal elements represented), MNI = 12. BPBM 165697, 165700, 165704, 165722, 165724, 165776, 165777, 165781, 165795, 165796, 165798, 165799,

165800, 165801, 165803, 165804, 165809, 165819, 165820, 165833–165835, 165838, 165840, 165841, 165859, 165863, 165913, 165914, 165933, 165939, 165941–165944, 165953, 165954, 165956, 165959, 165960, 165967–165969, 165980.

Remarks. *Anous stolidus* is the best represented species in the archaeological record of Tikopia and the second most common archaeological species on Anuta. While species of *Anous* are rare in non-anthropogenic fossil sites on oceanic islands (Olson 1975, 1977; Olson & James 1982), bones of *Anous* spp. are common in Polynesian archaeological sites. As on Tikopia and Anuta, the pantropical *A. stolidus* usually outnumbers *A. minutus* in these situations. *Anous stolidus* was nesting on Tikopia on 11 February 1927 (Beck 1927:221) and was listed for Tikopia by Kirch and Yen (1982:283). This species is still eaten by the Tikopia and is sometimes kept as a pet. "A few" specimens of *A. stolidus* were collected on Anuta on 8 February 1927 (Beck 1927:218). The nesting requirements of *A. stolidus* are very versatile, which probably explains its high survivability on inhabited islands.

Anous minutus Boie. Black Noddy (Tikopia *rakia*).

Material examined. TIKOPIA: NISP = 35 (nearly all major skeletal elements represented), MNI = 15. BPBM 166078, 166085, 166090, 166094, 166096, 166097, 166157, 166171, 166202, 166346, 166381, 166408–166410, 166413, 166417, 166418, 166495, 181520, 181548, 181571, 181574, 181607, 181609, 181612–181617, 181620, 181624, 181631, 181637, 181639. ANUTA: NISP = 10, MNI = 4. Sternum, BPBM 165805; coracoid, BPBM 165701; 4 humeri, BPBM 165723, 165810, 165836, 165837; 4 ulnae, BPBM 165817, 165823, 165918, 165957.

Remarks. *Anous minutus* was nesting on Tikopia on 11 February 1927 (Beck 1927:221). "A few" specimens of *A. minutus* were taken on Anuta on 8 February 1927 (Beck 1927:218). Two others were collected on Anuta on 15 July 1933 by the Templeton Crocker Expedition (Davidson 1934). The bones reported here include most of those reported as *Gygis alba* by Kirch and Yen (1982:283). *Anous minutus* is widespread in the tropical Pacific and Indian oceans.

Gygis alba (Sparrman). Common Fairy-Tern (Tikopia *akiaki*).

Material examined. None.

Remarks. All of the bones reported by Kirch and Yen (1982:283) as *Gygis alba* are from indeterminate terns or *Anous minutus*. *Gygis alba* was nesting on Tikopia on 11 February 1927 (Beck 1927:221) and was listed for Tikopia by Kirch and Yen (1982:283). A few individuals of *G. alba* were seen on Anuta on 8 February 1927 (Beck 1927:218). *Gygis alba* is very widespread in tropical oceans. The lack of bones of *G. alba* from Tikopia and Anuta is puzzling. This small tern is found regularly in archaeological sites elsewhere in Polynesia. Like *Anous stolidus*, the plastic breeding requirements of *G. alba* probably explain its relatively high compatibility with human occupation.

Sterninae, genus (?genera) and species unknown. Indeterminate terns.

Material examined. TIKOPIA: NISP = 20, MNI = 2. 4 coracoids, BPBM 166109, 166221, 166260, 181521; 2 scapulae, BPBM 166103, 166401; furcula, BPBM 166411; 3 humeri, BPBM 166190, 166206, 166334; 6 ulnae, BPBM 166101, 166114, 166288, 166306, 166307, 166332; radius, BPBM 166407; carpometacarpus, BPBM 166129; manus digit II phalanx 1, BPBM 166341; tibiotarsus, BPBM 166130. ANUTA: NISP = 14, MNI = 0. 3 coracoids, BPBM 165802, 165938, 165962; 4 humeri, BPBM 165839, 165917, 165940, 165981; 2 radii, BPBM 165827, 165948; 2 carpometacarpi, BPBM 165825, 165983; manus digit II phalanx 1, BPBM 165984; 2 synsacra, BPBM 165725, 165842.

Remarks. Although much of this material probably represents *Anous stolidus* or *A. minutus*, the specimens are too fragmentary to identify even to genus.

Order Ciconiiformes

Family Ardeidae

Egretta sacra (Gmelin). Pacific Reef-Heron (Tikopia *keo*).

Material examined. None.

Remarks. The WSSE collected a male and female of *Egretta sacra* on Tikopia in February 1927 (Mayr & Amadon 1941). Kirch and Yen (1982:283) listed *E. sacra* for Tikopia. Firth (1985:182) stated that the Tikopia recognize the light (*keo kena*) and dark (*keo uri*) phases of this heron. *Egretta sacra* is found nearly throughout the tropical Pacific and may occur on Anuta, although there are no records. Clark (1982) noted *motuku* as another Tikopia name for *E. sacra*. *Motuku* is the widespread Polynesian cognate for *E. sacra*. *Keo* is cognate with *kao*, a widespread name for the Striated Heron, *Butorides* (*Ardeola*) *striata* (Linnaeus), a much smaller and more localized species unrecorded on Tikopia and Anuta. The scarcity or lack of bones of *Egretta sacra* in most Polynesian archaeological sites is because these "fishy" tasting birds were seldom eaten.

Order Anseriformes

Family Anatidae

Anas superciliosa Gmelin. Gray Duck (Tikopia *toroa*).

Material examined. TIKOPIA: NISP: 2, MNI = 1. Coracoid, BPBM 181519; scapula, BPBM 181518.

Remarks. The WSSE collected 13 specimens of *Anas superciliosa* on Tikopia on 11–12 February 1927 (Amadon 1943). At that time, the ducks were plentiful and had several broods of small young (Beck 1927:219). Luke (1945:191) also noted ducks on Te Roto ("the lake"), Tikopia in May 1941, as did Kirch and Yen (1982:283–284) in 1977–1978. There are no records from Anuta. The bones of *A. superciliosa* were from two test pits of the Tuakamali phase. Thus it may be that *A. superciliosa* colonized Tikopia only after the accretion of calcareous sands closed Te Roto from the sea. *Anas superciliosa* occurs in various fresh, brackish, and (rarely) salt water habitats from Indonesia, Australia, and New Guinea through much of Polynesia. The lack of differentiation of the oceanic populations and the lack of dated, early archaeological records from anywhere in Polynesia suggest that *A. superciliosa* is a recent colonizer of many islands, including Tikopia.

Order Charadriiformes

Family Charadriidae

Pluvialis dominica (P.L.S. Müller). Lesser Golden-Plover (Tikopia, Anuta *turi*).

Material examined. TIKOPIA: NISP = 4, MNI = 4. Coracoid, BPBM 166254; 2 humeri, BPBM 166184, 166301; tarsometatarsus, BPBM 166251. ANUTA: NISP = 3, MNI = 1. 2 humeri, BPBM 165812, 165814; ulna, BPBM 165824.

Remarks. This migratory shorebird is common throughout Oceania. "Quite a lot" of *Pluvialis dominica* were seen on Tikopia on 11 February 1927 (Beck 1927:219). Kirch and Yen (1982:283) listed *P. dominica* for Tikopia, noting that modern Tikopia regard the bird as sacred. A single individual of *P. dominica* was seen on Anuta on 8 February 1927 (Beck 1927:218). We use the word *turi* for *P. dominica* somewhat cautiously because both Clark (1982) and Firth (1985:558) listed the Tikopia *turi* as a general term for migratory shorebirds.

Charadrius mongolus Pallas. Mongolian Plover.

Material examined. None.

Remarks. A "ring plover of some sort" was collected by the WSSE on the beach at Tikopia on 12 February 1927 in the company of one *Pluvialis dominica* and several *Arenaria interpres* (Beck 1927:283). Kirch and Yen (1982:283) listed "*Charadrius* sp. Plover *kiu*" as occurring today and in an archaeological context from Tikopia. We found no bones referable to *Charadrius*. The "ring plover" collected by the WSSE is a winter-plumage female of *C. mongolus* (AMNH 215556, examined by DWS in July 1988). This species breeds in northeastern Asia and winters in Micronesia and much of Melanesia. Tikopia is probably near the eastern limit of its regular winter range.

FAMILY SCOLOPACIDAE

Heteroscelus incanus (Gmelin). Wandering Tattler (Tikopia *turi vare*).

Material examined. TIKOPIA: NISP = 4, MNI = 4. 3 humeri, BPBM 166205, 166423, 181654; carpometacarpus, BPBM 166345.

Remarks. *Heteroscelus incanus* is very common and widespread in Oceania and undoubtedly occurs regularly today on Tikopia and Anuta. Nevertheless, the four bones from Tikopia are the only certain records for either island other than the definition of *turi vare* as the Tikopia word for *H. incanus* in Firth (1985:558).

Numenius phaeopus (Linnaeus). Whimbrel.

Material examined. None.

Remarks. An unknown number of probable *Numenius phaeopus* ("Hudsonian? Curlew") was seen on Tikopia on 11 February 1927 (Beck 1927:219). There are no specimens of *N. phaeopus* from Tikopia in AMNH. There are no records from Anuta. This large shorebird breeds at high northern latitudes, then migrates and winters through much of the tropical western Pacific, straying as far east as Tuvalu, Fiji, and Samoa.

Numenius tahitiensis (Gmelin). Bristle-thighed Curlew (Tikopia *kiu*).

Material examined. TIKOPIA: NISP = 2, MNI = 1. Cervical vertebra, BPBM 166331; humerus, BPBM 166302.

Remarks. These two specimens are larger than in *Numenius minutus* Gould and smaller than in *N. madagascariensis* (Linnaeus). They agree in size and other features with the cervical vertebra and humerus of *N. tahitiensis* but cannot be distinguished unequivocally from the similarly sized *N. phaeopus* (Linnaeus). The WSSE collected three females of *N. tahitiensis* on Tikopia on 11 and 12 February 1927 (Stickney 1943). Although there are no records of it from Anuta, *N. tahitiensis* is a widespread migrant and winter visitor in Polynesia and Melanesia, and probably visits Anuta at least occasionally. Kirch and Yen (1982:283) correlated the Tikopia name *kolili* with *Numenius* sp., which could be either *N. phaeopus* or *N. tahitiensis*. Firth (1985:191) identified *kolili* as the Common Sandpiper, *Actitis hypoleucos* (Linnaeus), a Eurasian migrant for which no other records exist from Tikopia or Anuta and which might be confused with *Heteroscelus incanus*.

Limosa lapponica (Linnaeus). Bar-tailed Godwit.

Material examined. None.

Remarks. The only record on Tikopia of *Limosa lapponica* is a female collected on 11 February 1927 by the WSSE (Stickney 1943). This migrant shorebird, relatively rare in the region covered here but more common to the west, has not been recorded from Anuta.

Arenaria interpres (Linnaeus). Ruddy Turnstone (Tikopia *turi fakataumako*).

Material examined. ANUTA: NISP = 1, MNI = 1. Coracoid, BPBM 165937.

Remarks. An unknown number of *Arenaria interpres* was seen on Tikopia on 11 February 1927; three others were seen on Anuta on 8 February 1927 (Beck 1927:218, 221). There are no specimens in AMNH. This distinctive shorebird, which breeds at high northern latitudes, migrates and winters through much of the tropical Pacific.

Order Galliformes
Family Megapodiidae

Megapodius freycinet Gaimard. "Scrub Fowl" or Common Megapode.

Material examined. TIKOPIA: NISP = 10, MNI = 4. Coracoid, BPBM 166317; radius, BPBM 166074; tibiotarsus, BPBM 166207; 3 tarsometatarsi, BPBM 166183, 166291, 166373; hallux, BPBM 181555; 2 pedal phalanges, BPBM 166126, 166338; claw, BPBM 166119.

Remarks. This is the first record of *Megapodius freycinet* for Tikopia. There are no records of it for Anuta. Green (1976:256) reported bones of megapodes (not identified to species) from Lapita sites in the Reef Islands, north of Santa Cruz (Nendo) Island. *Megapodius freycinet* has an extremely broad range (Amadon 1942), scattered from Indonesia, New Guinea, and northern Australia eastward to islands near Tikopia (Ureparapara, Gaua, and Valua in the Banks Islands and numerous islands in Vanuatu). *Megapodius freycinet* is widespread as well in the main group of the Solomon Islands. Considering the extinction/extirpation of various megapodes in Melanesia and Polynesia (see below), it is somewhat surprising that *M. freycinet* still survives on the Solomon Islands outlying atolls of Ontong Java and Sikaiana (Bayliss-Smith 1972), which have land areas of 9.5 km^2 and 1.3 km^2, respectively, roughly comparable to the areas of Tikopia and Anuta.

The only other extant species of *Megapodius* in Oceania are *M. pritchardi* G. R. Gray, a much smaller species confined to Niuafo'ou (Tonga) and *M. laperouse* Gaimard of Palau and the Marianas. Two extinct species of *Megapodius*, both larger than *M. freycinet*, are known from archaeological bones from Lifuka, Tonga (Steadman 1989a, b) and late Holocene fossils from New Caledonia (Balouet & Olson 1989). Also known from the late Holocene of New Caledonia is the extinct *Sylviornis neocaledoniae* Poplin, a truly giant megapode much larger than any species of *Megapodius* (Poplin, Mourer-Chauviré & Evin 1983, Poplin & Mourer-Chauviré 1985). Numerous 19th century records of megapodes (based upon eggs or sightings; mostly not determined to species) exist for Fiji, Tonga, and Samoa (Steadman 1989a, b). These records have generally been overlooked by modern authors because they were not included in the systematic review papers on megapodes by Mayr (1938) and Amadon (1942), which were based mainly on WSSE specimens.

Eight of the 10 bones of *M. freycinet* from Tikopia are from Layer II of Site TK-4, which Kirch and Yen (1982:326) regarded as the earliest human occupation of Tikopia. The ninth megapode bone is from lower strata of the Sinapupu phase of the Sinapupu locality, while the tenth is from Zone A_2 of Site TK-36, which includes a mixture of Kiki and Tuakamali phase sediments (Table 3). Thus, it is reasonable to suggest that *M. freycinet* became rare on Tikopia soon after the first arrival of people.

Family Phasianidae

Gallus gallus Linnaeus. Chicken (Tikopia, Anuta *kio*).

Material examined. TIKOPIA: NISP = 75 (nearly all major skeletal elements represented), MNI = 26. BPBM 166081, 166123, 166125, 166132, 166140, 166145–166151, 166159, 166166, 166187, 166194,

166195, 166199, 166201, 166208, 166209, 166212, 166213, 166215, 166235, 166258, 166267, 166269, 166270, 166274, 166277, 166290, 166299, 166300, 166304, 166311–166313, 166318–166320, 166355, 166356, 166359, 166360, 166367–166370, 166372, 166375, 166383, 166384, 181492, 181498, 181500, 181501, 181505, 181507, 181517, 181527, 181533, 181554, 181577, 181578, 181636, 181640, 181643, 181646, 181647, 181651–181653, 181655, 181656. ANUTA: NISP = 19 (most major skeletal elements represented), MNI = 6. BPBM 165696, 165721, 165726, 165742, 165806–165808, 165843, 165844, 165864, 165866, 165921, 165922, 165945, 165946, 165964, 165965, 165976, 165977.

Remarks. This well-known domesticate, which originated in Southeast Asia, accompanied prehistoric peoples nearly everywhere in Oceania. The bones from Tikopia and Anuta suggest that *Gallus gallus* was present on these islands since the time of initial Polynesian colonization. Kirch and Yen (1982:283) recorded G. *gallus* from Tikopia today; it exists on Anuta as well.

Galliformes, genus (?genera) and species unknown. Indeterminate galliform.

Material examined. TIKOPIA: NISP = 4. 3 humeri, BPBM 166200, 166297, 166303; pedal phalanx, BPBM 166222.

Remarks. These fragmentary specimens cannot be distinguished from the bones of *Megapodius* or *Gallus*.

Order Gruiformes

Family Rallidae

Gallirallus philippensis (Linnaeus). Banded Rail.

Material examined. TIKOPIA: NISP = 5, MNI = 3. Humerus, BPBM 166327; 2 femora, BPBM 166131, 166310; 2 tibiotarsi, BPBM 166076, 166305.

Remarks. Among these bones are three that Kirch and Yen (1982:276,283) reported as "*Rallus*? or *Porzana*? Medium-sized Rail." The two fragmentary femora are only tentatively referred to *Gallirallus philippensis*. This rail is widespread in the southwest Pacific from New Guinea, Australia, and New Zealand east to Tonga, Samoa, and Niue. Because of its remarkable ability to colonize islands, which may result in multiple colonizations of a single island, the intraspecific variation of modern populations is complicated, with few discernible patterns (Schodde & de Naurois 1982). There are no modern records of G. *philippensis* from Tikopia or Anuta.

Porphyrio porphyrio (Linnaeus). Purple Swamphen (Tikopia *karae*).

Material examined. TIKOPIA: NISP = 31 (most major skeletal elements represented), MNI = 16. BPBM 166071, 166077, 166181, 166223, 166225, 166227, 166228, 166229, 166231, 166232, 166236, 166263, 166265, 166266, 166268, 166275, 166281, 166285, 166295, 166419, 181499, 181510, 181511, 181514, 181524, 181526, 181529, 181531, 181534, 181535, 181557.

Remarks. These specimens, although variable in size, agree with bones of *Porphyrio porphyrio* rather than those of the smaller, extinct *P. paepae* Steadman (currently known only from the Marquesas [Steadman 1988]), which is the only other Polynesian species of this genus outside of flightless forms from New Caledonia (Balouet & Olson 1989) and New Zealand. *Porphyrio porphyrio* was common on Tikopia on 11 February 1927 (Beck 1927:219) when the WSSE collected two males and two females (AMNH 216881-216884; examined by DWS in July 1988). Kirch and Yen (1982:283) also reported *P. porphyrio* from Tikopia today and in archaeological records. There are no certain records from Anuta, although Feinberg (1977) listed *karae* for Anuta, the word perhaps being borrowed from Tikopia. *Porphyrio porphyrio* occurs through warmer parts of Africa and Asia through Indonesia, New Guinea, Australia, and New Zealand, then east through the Pacific islands to Tonga, Samoa, and Niue.

Order Columbiformes

Family Columbidae

Ducula pacifica (Gmelin). Pacific Pigeon (Tikopia, Anuta *rupe*).

Material examined. TIKOPIA: NISP = 5, MNI = 5. Coracoid, BPBM 166261; humerus, BPBM 181649; manus digit II phalanx 1, BPBM 181528; carpometacarpus, BPBM 166253; tarsometatarsus, BPBM 181627.

Remarks. *Ducula pacifica* is the only columbid recorded from Tikopia or Anuta. The WSSE collected *D. pacifica* on both islands in February 1927 (Amadon 1942). Luke (1945:191) recorded *D. pacifica* on Tikopia in May 1941, as did Kirch and Yen (1982:283) in 1977–1978. The *rupe* is traditionally regarded as an incarnation of the *Atua i Taumako*, an ancestral deity of the Taumako clan (Firth 1985:413).

The distribution of *D. pacifica* extends locally from the Bismarcks, Solomon Islands, and New Caledonia east to the Cook Islands. It is the only resident land bird known from Anuta, whether modern or prehistoric. With its remarkable ability to colonize small, remote islands, *D. pacifica* is an excellent example of a "supertramp" species (Diamond 1974, 1982). In Vanuatu, Diamond and Marshall (1977:727) listed *D. pacifica* among species "observed flying over open water between islands, or appearing as vagrants on islands where they did not maintain permanent populations." The lack of bones of *D. pacifica* from Anuta and the Kiki phase of Tikopia is compatible with the theory that this species of minimal geographic variation may be a relatively recent colonizer of these islands.

Mayr (1945:203) stated that the Green-winged Pigeon, *Chalcophaps indica* (Linnaeus), occurs "on all the [Santa Cruz] islands," although we cannot find any literature or specimens to verify this statement for either Tikopia or Anuta. Among the WSSE specimens of *C. indica* in AMNH, the localities nearest to Tikopia or Anuta are the islands of Utupua, Santa Cruz, Tinakula, and Fenualoa.

Order Psittaciformes

Family Psittacidae

Trichoglossus haematodus (Linnaeus). Rainbow Lorikeet (Tikopia *sivi*).

Material examined. None.

Remarks. *Trichoglossus haematodus* was sighted but not collected on Tikopia in February 1927 (Beck 1927:219), May 1941 (Luke 1945:191), and 1977–78 (Kirch & Yen 1982:283). There are no records of this species from Anuta. This small, colorful parrot occurs from Indonesia to Vanuatu, reaching the eastern limit of its range on Tikopia. Clark (1982) listed the Tikopia *sivi* as *T. haematodus* and the Tikopia *lenga* for *Vini* (*Charmosyna*) *palmarum* (Gmelin), the latter not found on Tikopia. The Tikopia may know *V. palmarum* from their visits to Vanikoro, where this species does occur.

The nectarivorous Rainbow Lorikeet adapts well to arboriculture, which includes non-native flowering trees. This adaptability probably explains the survival of *T. haematodus* on Tikopia. Other nectarivorous, frugivorous, or insectivorous birds that tolerate arboriculture are *Ducula pacifica*, *Halcyon chloris*, *Aplonis tabuensis*, and *Myzomela cardinalis*.

Order Cuculiformes

Family Cuculidae

Eudynamis taitensis (Sparrman). Long-tailed Cuckoo (Tikopia *kareva*, *kaareva*).

Material examined. TIKOPIA: NISP = 1, MNI = 1. Humerus, BPBM 181496. ANUTA: NISP = 1, MNI = 1. Humerus, BPBM 165867.

Remarks. The only modern record of *Eudynamis taitensis* for Tikopia is that of Kirch and Yen (1982:283). A specimen of *E. taitensis* was taken by WSSE on Anuta on 8 February 1927 (Bogert 1937). This cuckoo breeds only in New Zealand, then migrates and winters through most of Melanesia, Micronesia, and Polynesia. Many Tikopia, however, regard *E. taitensis* as indigenous to their island, where it is thought to be the embodiment of *Atua i te Uruao*, the God of the Woods (Firth 1985:167).

Order Apodiformes

Family Apodidae

Collocalia vanikorensis (Quoy and Gaimard). Vanikoro Swiftlet (Tikopia *pakalili*).

Material examined. None.

Remarks. *Collocalia vanikorensis* occurs locally from Sulawesi to Vanuatu (Salomonsen 1983:88). The only record of *C. vanikorensis* on Tikopia is from Firth (1985:327), who stated that it nests in cliffs and is eaten by the Tikopia. There are no records from Anuta. This small swiftlet has been recorded from the nearby islands of Lomlom, Disappointment (Netepa), and Vanikoro (Mayr 1945:205), so its occurrence on Tikopia is plausible. There are no records of this species from Anuta. Because of the extreme difficulty in species-level systematics of *Collocalia* (Salomonsen 1983), specimens are needed to be certain that the species of *Collocalia* on Tikopia is not *C. spodiopygia* (Peale) or *C. esculenta* (Linnaeus), which also occur in the region.

Kirch and Yen (1982:284) listed the Pacific Swallow, *Hirundo tahitica* Gmelin, as occurring on Tikopia under the name *pakalili*. Because they did not list any species of *Collocalia*, we assume that the bird in question was in fact the superficially similar *C. vanikorensis*. Clark (1982) noted that the Polynesian names for *Hirundo tahitica* are always the same as those for *Collocalia*. Because *H. tahitica* has been recorded from nearby Lomlom, Santa Cruz Island, and Utupua (Mayr 1945:207), its occurrence on Tikopia is plausible and should be investigated further.

Order Coraciiformes

Family Alcedinidae

Halcyon chloris (Boddaert). Collared Kingfisher (Tikopia *sikotara*).

Material examined. None.

Remarks. The WSSE collected four specimens of *Halcyon chloris* on Tikopia on 11 and 12 February 1927, the plumage of which was too worn to determine to subspecies (Mayr 1931). Kirch and Yen (1982:283) included *H. chloris* among the modern birds of Tikopia. Kingfishers have not been reported from Anuta. The range of *H. chloris* extends from coastal Africa and Asia to Australia, New Zealand, and western Pacific islands east to Samoa and Tonga. Diamond, Gilpin and Mayr (1976) listed *H. chloris* as one of the long-distance "great speciators" of the Solomon Islands. Thus, its colonization of Tikopia is not extraordinary nor would it be surprising if the Tikopia form should prove to be an endemic subspecies.

Order Passeriformes

Family Sturnidae

Aplonis tabuensis (Gmelin). Polynesian Starling (Tikopia *miti*).

Material examined. TIKOPIA: NISP = 2, MNI = 2. 2 humeri, BPBM 166264, 181539.

Remarks. These specimens agree in size and qualitative features with the smallest humeri in a series of fossils and skeletons of *Aplonis tabuensis* from 'Eua, Tonga. *Aplonis tabuensis* is near the western limit of its range on Tikopia, where it occurs as the endemic subspecies *A. tabuensis tucopiae* Mayr, collected on 11–12 February 1927 by WSSE (Mayr 1942). Kirch and Yen (1982:284) listed *A. tabuensis* among the modern birds of Tikopia. It is not known from Anuta. The distribution of *A. tabuensis* extends from the Santa Cruz group east to Fiji, Wallis and Futuna, Samoa, Tonga, and Niue. The occurrence of an endemic subspecies of *A. tabuensis* on Tikopia is interesting in light of the young geological age of the island, which has been dated as only ca. 80,000 years (Fryer 1974). Elsewhere, bones of *A. tabuensis* have been identified in Tonga from an archaeological site on Lifuka and a late Holocene paleontological site on 'Eua (Steadman 1989a,b).

Family Meliphagidae

Myzomela cardinalis (Gmelin). Cardinal Honeyeater (Tikopia *lenga, malingi*).

Material examined. None.

Remarks. The WSSE collected a single specimen of *Myzomela cardinalis* on Tikopia on 11 February 1927, this being the holotype of an endemic subspecies *M. c. tucopiae* Mayr (Mayr 1932, 1937; Koopman 1957). Kirch and Yen (1982:284) listed *M. cardinalis* among both the modern and prehistoric birds of Tikopia. We found no bones of *M. cardinalis* or any other very small passerines in any of the archaeological material. The curious range of *M. cardinalis* consists of the Solomon Islands, Santa Cruz group, Vanuatu, and Samoa. It is not known from Anuta.

Kirch and Yen (1982:284) also reported bones of an unknown honeyeater, *Myzomela* sp. (local name *malingi*) from strata of the Kiki and Sinapupu phases on Tikopia. This unknown species was regarded by them as distinct from *M. cardinalis*, for which they recorded the name *lenga*. The name *malingi* probably refers to the female of *M. cardinalis*, which is mostly dark grayish olive above and yellowish olive below, whereas the male is entirely bright black and red (Pratt, Bruner & Berrett 1987, Plate 32). Perhaps *lenga* refers only to the male. Alternatively, Firth (1985:205) identified *lenga* as the Tikopia name for *Charmosyna margarethae* (= *Trichoglossus haematodus*). This should be investigated further, for the name *lenga* is a cognate with other western Polynesian names for small species of parrots (Clark 1982).

Table 2. Bird bones from Tikopia, arranged by cultural phase, designated by Kirch and Yen (1982).

Species	Phase					Total
	Kiki	Sinapupu	Tuakamali	Historic	Unknown*	
Sea birds						
Pterodroma rostrata (Tahiti Petrel)	1		1		1	3
Pterodroma sp. (unknown petrel)	1				1	2
Puffinus pacificus (Wedge-tailed Shearwater)	1					1
Puffinus lherminieri (Audubon's Shearwater)	1					1
Procellariidae sp. (unknown petrel/shearwater)	14				1	15
Phaethon rubricauda (Red-tailed Tropicbird)	4					4
Phaethon lepturus (White-tailed Tropicbird)	11	1	2		1	15
Papasula abbotti (Abbott's Booby)	2					2
Sula dactylatra (Masked Booby)				3		3
Sula leucogaster (Brown Booby)	1				1	2
Sula sula (Red-footed Booby)	11	3	25	4	1	44
Sula sp. (unknown booby)			11	16		27
Fregata minor (Great Frigatebird)	6			2	1	9
Fregata ariel (Lesser Frigatebird)	3					3
Sterna fuscata (Sooty Tern)	2					2
Anous stolidus (Brown Noddy)	88	4	13	23	7	135
Anous minutus (Black Noddy)	11	1	6	16	1	35
Sterninae sp. (unknown tern)	13		6	1		20
Land birds						
Anas superciliosa (Gray Duck)				2		2
Pluvialis dominica (Pacific Golden Plover)	2	1	1			4
Numenius tahitiensis (Bristle-thighed Curlew)	2					2
Heteroscelus incanus (Wandering Tattler)	3			1		4
Megapodius freycinet (Common Megapode)	8	1			1	10
Gallus gallus (Chicken)	36	4	7	15	13	75
Galliformes sp. (unknown galliform)	2		1		1	4
Gallirallus philippensis (Banded Rail)	4				1	5
Porphyrio porphyrio (Purple Swamphen)	8	8	12		3	31
Ducula pacifica (Pacific Pigeon)		2	1	2		5
Eudynamis taitensis (Long-tailed Cuckoo)	1					1
Aplonis tabuensis (Polynesian Starling)	1	1				2
Total bones	237	26	86	85	34	468
Minimum number of species	22	10	9	9	11	25

* Includes layer I of TK-4 (28 bones, mixed Kiki and Tuakamali) and layer I, zone A_2 of TK-36 (6 bones, mixed Tuakamali and Kiki).

Table 3. Bird bones from the Sinapupu locality, Tikopia (Sites TK-1, -35, -36; Test Pits 20, 47–49, 51, 52).

	Stratigraphic zone*							
	A_1	A_2	A_3	B_1	B_2	C_1	C_2	Total
Sea birds								
Pterodroma rostrata (Tahiti Petrel)		1						1
Puffinus pacificus (Wedge-tailed Shearwater)						1		1
Puffinus lherminieri (Audubon's Shearwater)						1		1
Procellariidae sp. (unknown petrel/shearwater)						1	2	3
Phaethon lepturus (White-tailed Tropicbird)		2		1		3	2	8
Sula leucogaster (Brown Booby)		1						1
Sula sula (Red-footed Booby)		4	4	2		1	2	13
Sula sp. (unknown booby)	1		8					9
Anous stolidus (Brown Noddy)		2	3	4		3	8	20
Anous minutus (Black Noddy)				1			2	3
Sterninae sp. (unknown tern)	1	2				1	1	5
Land birds								
Pluvialis dominica (Pacific Golden Plover)			1	1				2
Heteroscelus incanus (Wandering Tattler)							2	2
Megapodius freycinet (Common Megapode)		1			1			2
Gallus gallus (Chicken)	2	4	1	1	3	3	5	19
Galliformes sp. (unknown galliform)			1					1
Porphyrio porphyrio (Purple Swamphen)	1	4	7	5	2		6	25
Ducula pacifica (Pacific Pigeon)			1	1	1			3
Eudynamis taitensis (Long-tailed Cuckoo)							1	1
Aplonis tabuensis (Polynesian Starling)				1		1		2
Total bones	5	21	26	17	7	15	31	122
Minimum number of species	4	8	6	9	4	7	9	16

*Zones A_1 – A_3 = Tuakamali phase; zones B_1, B_2 = Sinapupu phase; zones C_1, C_2 = Kiki phase. A_2 contains some C_1–C_2 mixture in Site TK-36.

Table 4. Bird bones from Site TK–4, Tikopia.

	Layer*			
	I	II	II/III	Total
Sea birds				
Pterodroma rostrata (Tahiti Petrel)	1	1	—	2
Pterodroma sp. (unknown petrel)	1	1	—	2
Procellariidae sp. (unknown petrel/shearwater)	1	11	—	12
Phaethon rubricauda (Red-tailed Tropicbird)	—	4	—	4
Phaethon lepturus (White-tailed Tropicbird)	1	6	—	7
Papasula abbotti (Abbott's Booby)	—	2	—	2
Sula leucogaster (Brown Booby)	—	1	—	1
Sula sula (Red-footed Booby)	1	8	—	9
Fregata minor (Great Frigatebird)	1	6	—	7
Fregata ariel (Lesser Frigatebird)	—	3	—	3
Sterna fuscata (Sooty Tern)	—	2	—	2
Anous stolidus (Brown Noddy)	7	77	—	84
Anous minutus (Black Noddy)	1	9	—	10
Sterninae sp. (unknown tern)	—	11	—	11
Land birds				
Pluvialis dominica (Pacific Golden Plover)	—	2	—	2
Numenius tahitiensis (Bristle-thighed Curlew)	—	2	—	2
Heteroscelus incanus (Wandering Tattler)	—	1	—	1
Megapodius freycinet (Common Megapode)	—	8	—	8
Gallus gallus (Chicken)	11	27	1	39
Galliformes sp. (unknown galliform)	1	2	—	3
Gallirallus philippensis (Banded Rail)	1	4	—	5
Porphyrio porphyrio (Purple Swamphen)	1	2	—	3
Total bones	28	190	1	219
Minimum number of species	10	19	1	19

*Layer I = mixed Kiki and Tuakamali phases; layer II = Kiki phase; layer III = Kiki phase.

Table 5. Bird bones from Site TK–7, Tikopia.

	Layer*		
	II	III	Total
Sea birds			
Sula sula (Red-footed Booby)	17	1	18
Anous stolidus (Brown Noddy)	1	—	1
Total bones	18	1	19

*Layer II = Tuakamali phase; layer III = Sinapupu phase.

Table 6. Bird bones from Site TK–8, Tikopia.

	Layer*	
	I	Total
Sea birds		
Sula sp. (unknown booby)	1	1
Land birds		
Porphyrio porphyrio (Purple Swamphen)	1	1
Total bones	2	2

*Layer I = Tuakamali phase.

Table 7. Bird bones from Site TK–9, Tikopia.

	Layer*			
	I	I/II	III	Total
Sea birds				
Sula sp. (unknown booby)	—	1	—	1
Anous stolidus (Brown Noddy)	—	4	3	7
Anous minutus (Black Noddy)	4	2	—	6
Sterninae sp. (unknown tern)	—	2	1	3
Total bones	4	9	4	17

*All layers = Tuakamali phase.

Table 8. Bird bones from Site TK–20, Tikopia.

	Layer*	
	I	Total
Land birds		
Gallus gallus (Chicken)	2	2
Total bones	2	2

*Layer I = Tuakamali phase.

Table 9. Bird bones from the Ravenga coastal excavations, Tikopia.

	Test pit / Layer*														
	21	22		23	24	25	26	27	29	30	35		45		
	I	I	II	I	I	I	I	I	I	II	I	II	I&II		Total
Sea birds															
Sula dactylatra (Masked Booby)									1		2				3
Sula sula (Red-footed Booby)					4										4
Sula sp. (unknown booby)					9						5	1	1		16
Anous stolidus (Brown Noddy)					7				9		3	2	1		22
Anous minutus (Black Noddy)		1			2				11	2					16
Sterninae sp. (unknown tern)				1											1
Land birds															
Anas superciliosa (Gray Duck)			2												2
Heteroscelus incanus (Wandering Tattler)							1								1
Gallus gallus (Chicken)	1				3	3		2		2	1	2			14
Ducula pacifica (Pacific Pigeon)					1				1						2
Total bones	1	1	2	1	26	3	1	2	22	4	11	5	2		81
Minimum number of species	1	1	1	1	5	1	1	1	3	2	3	3	2		8

* All test pits and layers = Historic phase.

Table 10. Bird bones from the Faea coastal excavations, Tikopia.

	Test Pit / Layer*				
	3 I	6	16 VI	17 II	Total
Sea birds					
Fregata minor (Great Frigatebird)	2	—	—	—	2
Anous stolidus (Brown Noddy)	—	1	—	—	1
Land birds					
Porphyrio porphyrio (Purple Swamphen)	—	—	1	1	2
Gallus gallus (Chicken)	—	2	—	—	2
Total bones	2	3	1	1	7

*Test Pits 3, 6 = Historic phase; Test Pit 16, layer VI = Sinapupu phase; Test Pit 17, layer II = Tuakamali phase.

Table 11. Bird bones from Site AN–6, Anuta, Solomon Islands.

	Chrono-stratigraphic zone*						
	A	A/B	B/C	C/D	D	E	Total
Sea birds							
Puffinus pacificus (Wedge-tailed Shearwater)						1	1
Puffinus lherminieri (Audubon's Shearwater)		1	21	1		12	35
Phaethon lepturus (White-tailed Tropicbird)			1				1
Sula leucogaster (Brown Booby)	3		2				5
Sula sula (Red-footed Booby)	20	7	57			1	85
Sula sp. (unknown booby)	14	2	29		1	5	51
Fregata minor (Great Frigatebird)	3		8			1	12
Fregata ariel (Lesser Frigatebird)			7				7
Fregata sp. (unknown frigatebird)	1		4			1	6
Sterna fuscata (Sooty Tern)	1	2				1	4
Anous stolidus (Brown Noddy)	10	1	8		1	24	44
Anous minutus (Black Noddy)	3					7	10
Sterninae sp. (unknown tern)	4		4			6	14
Land birds							
Pluvialis dominica (Pacific Golden Plover)						3	3
Arenaria interpres (Ruddy Turnstone)						1	1
Gallus gallus (Chicken)	4		5	2	1	7	19
Eudynamis taitensis (Long-tailed Cuckoo)			1				1
Total bones	63	13	147	3	3	70	299
Minimum number of species	7	4	9	2	3	10	14

*A to E = youngest to oldest strata.

DISCUSSION

Bird Exploitation: Ethnographic Background

Ethnographic information on the exploitation of birds on Anuta and Tikopia is available from the works of Feinberg (1977, 1981), Firth (1936, 1939), Yen (1973), and from the field notes and observations by PVK on Anuta in 1971 and on Tikopia in 1977–78. On Anuta, hunting for birds is an occasional activity of men and boys. Such hunting is rather rare, and the contribution of avian flesh to the diet is limited. Over a 43-day period in 1971, the Notau family on Anuta caught nine birds with a total yield of 1.8 kg (Yen 1973:138). During the same period, approximately 34 kg of fish were obtained by the Notau household. Feinberg (1981:82) noted that only twice during his 11 months on Anuta were "enough birds captured for an island-wide distribution."

Birds are captured by the Anutans in two ways: (1) with a long-handled net (*te kupenga veu*) and (2) by hand (*tangotango*). The *kupenga veu* method can be practiced during the day in the vicinity of a nesting site but is most effective at dusk when birds return from foraging at sea. Yen (1973:117) remarked that such bird netting takes place on the slopes of the hill gardens, "for the seabirds also rest in the second growth of the gullies. The hunters usually take positions in the taro or manioc plots and entice the birds into the range of 3- to 4-meter-long poles with nets attached, by calling to them." A *kupenga veu* net observed by PVK had a diameter of 1.1 m, with a 5 cm mesh, and was attached to a bamboo pole 4.5 m long. The kinds of birds said to be caught with this net were *ngao* and *rakia*, names that probably refer to the Brown Noddy and Black Noddy, respectively.

The *tangotango* method is described by Feinberg (1981:34): the "procedure is to see a bird dozing in a tree, climb up behind it, grab it, and break its neck." A variation on the *tangotango* method is to use a noose on the end of a pole, which "is usually done with large species on the cliff face of the hill overlooking the sea."

Birds are exploited on Tikopia with very similar technology and levels of intensity as on Anuta. Firth (1939:60–61) wrote:

> Birds of a number of species exist, but again because of their religious affiliations [as lineage totems] very few of them are eaten. Even the pigeon, consumed by most Polynesians, is eaten only by members of a few kinship groups, and then rarely. The small swift (*Collocalia francica* [= *vanikorensis*]), a noddy, and a petrel are the only birds deliberately and periodically sought by netting. They are not regarded as the property of any individuals or groups, and the catch depends on personal skill and initiative. They are not an important element in the food supply.

On two or three occasions in 1977–78, PVK was served booby and Brown Noddy that had been netted from Tikopia's cliffs and baked in an earth oven. It was said that the small numbers of Gray Ducks found on the lake are the property of the chiefs of Ravenga district and may be taken only with their permission (Kirch & Yen 1982:21). In 1977–78, a teenage girl in Matautu Village kept a Brown Noddy as a pet. The bird had been taken as a fledgling and reared by the girl. It lived in a small, thatched birdhouse next to the girl's dwelling. The bird was free to fly about and usually went to sea during the day in search of food. It always returned to its house in the evening, however, no doubt enticed by the baked fish that the girl provided for it.

On both Anuta and Tikopia, the chicken is raised as a domestic species, living in and near the villages and fed primarily coconut gratings. These birds are normally consumed only for special feast occasions, while the eggs are not collected or eaten (except by resident archaeologists who found that two out of the three eggs they sampled were fertilized or rotten).

Aside from their use as food, frigatebirds provide large wing bones (humerus, ulna, radius) used to make traditional tattooing needles on both islands. The mid-shaft is beveled to form a chisel-like end that is finely serrated. The worked bone is then hafted onto a wooden shaft.

Extinction

The bones from Tikopia (Tables 3–10, summarized in Table 2) show that the following species have been lost since the arrival of people: Audubon's Shearwater, Abbott's Booby, Red-footed Booby, Sooty Tern, Common Megapode, and Banded Rail. From Anuta, the Wedge-tailed Shearwater, Audubon's Shearwater, Red-footed Booby, and Sooty Tern have been lost. We make no claim that these fossil records are complete; other species probably have been lost from these islands without the archaeological recovery of their bones. Based upon our studies elsewhere in Polynesia as well as continental zooarchaeological assemblages (Grayson 1984:132–151), samples of about 300 bones are not large enough to represent all species deposited at most archaeological sites.

We believe that human activities are responsible for the loss of birds on Tikopia and Anuta, although unequivocal proof of this is not possible. The clearing of forests for agriculture reduced the amount of indigenous habitat for native birds. Just as significant, each of the extirpated species is highly edible. Recovery of their bones from midden contexts strongly suggests that they were used for food. Rats and dogs also preyed on birds and must have been particularly harmful to ground-nesting species. Of the species lost from Tikopia and Anuta, all except Abbott's Booby and the Red-footed Booby nest on the ground. Today Abbott's Booby nests high in trees on its last remaining locality, Christmas Island in the Indian Ocean. The burning and felling of trees would have depleted its numbers in Tikopian forests. Eggs and nestlings of Abbott's Booby would have been easy prey for Tikopia who presumably, like other oceanic peoples, were excellent tree-climbers. Red-footed Boobies nest in low trees or bushes, usually from 1–3 m above the ground. Their loss can be attributed largely to predation from rats, dogs, and humans, with eggs and nestlings again being the most vulnerable.

The cultural sequence of Tikopia (Kirch & Yen 1982:311–334) consists of the Kiki phase (the first 800 years of occupation by pottery-makers), the Sinapupu phase, the Tuakamali phase, and the Historic phase. Strata of the Kiki phase greatly exceed those of the Sinapupu, Tuakamali, and Historic phases in total number of bird bones (237 versus 27, 86, and 86, respectively) and in species richness (27 versus 10, 9, and 9; Table 2). Even more than on Anuta (see below), the archaeological record on Tikopia suggests the loss of certain species soon after initial human colonization. The bones of three of the five extirpated species on Tikopia (Abbott's Booby, Sooty Tern, and Banded Rail) are confined to strata of the Kiki phase, which also yielded the only bones of seven of the nonextirpated species. Of the 10 bones of the Common Megapode, eight are from Kiki strata, one is from early Sinapupu strata of TK-35, and one is of unknown age. The Kiki phase was characterized by heavy predation on a great variety of birds, particularly petrel/shearwaters, tropicbirds, boobies, frigatebirds, shorebirds, terns, domestic chickens, megapodes, rails, and swamphens. Only for the Masked Booby, Red-footed Booby, Black Noddy, Gray Duck, Purple Swamphen, and Pacific Pigeon was predation during the later cultural phases as severe as during the Kiki.

On Tikopia, an avifauna fairly rich in species was quickly depleted by colonizing Polynesians. Elsewhere in Polynesia, this pattern of heavy predation on birds during first human contact has been documented also on Lifuka, Tonga (Steadman 1989b), much of eastern Polynesia (Steadman 1989a), Hawaii (James et al. 1987), and New Zealand (Anderson 1983, 1984; Cassells 1984). Bird losses of similar magnitude probably occurred on many other Pacific islands where no archaeological records of birds are currently available. Having evolved in the absence of predatory mammals, most island birds were probably very tame at first human

contact, and thus were easily obtained by skilled Polynesian hunters. Even if these hunters became aware of the scarcity of certain species after decades or centuries of exploitation, they could do little to prevent predation by rats and dogs, or possible avian pathogens introduced with chickens. Moreover, these people were unlikely to alter their agricultural practices for the sake of preserving forest habitats for birds. By the end of the Kiki phase on Tikopia, it is likely that most of the island was under some form of managed vegetation. Hunting of birds continued throughout the prehistoric occupation of the island at a reduced intensity, as it does today. The steady but relatively low level of post-Kiki predation probably has prevented some of the extirpated species from recolonizing Tikopia, thereby maintaining an avifauna unable to recover to its pre-human level of richness.

Some strong patterns emerge when the bird bones from Anuta (Table 11) are analyzed according to the revised Anuta sequence (Kirch 1982). Zone E represents initial human colonization of Anuta beginning about 950 B.C., while Zone D is the continued occupation by this early pottery-making population. The sterile sands of Zone C represent the hypothesized cyclone and abandonment of the island, while Zone B is the reoccupation of Anuta by humans at ca. 600 A.D. Zones E and B/C both show high species richness and large numbers of bones (Table 11), which is exactly what might be expected to accompany human colonization events. There was an initial burst of predation on the Anuta avifauna (Zone E), followed by recovery of the avifauna while the island was unoccupied by humans (the time between Zones C/D and B/C), and then a second burst of predation (Zone B/C).

There are differences, however, between the two periods of greatest human predation on the birds of Anuta. Zone E is dominated by terns (37 of 64 bones), which are much scarcer in Zone B/C (12 of 120 bones). Boobies and frigatebirds are rare in Zone E (3 of 64 bones) but very common in Zone B/C (81 of 120 bones). The scarcity of boobies and frigatebirds in Zone E is difficult to explain unless Brown Noddies, which are so common in Zone E, are able to compete with the much larger boobies and frigatebirds for nesting sites. All of these species are highly edible. Only one of the four species lost from Anuta (Wedge-tailed Shearwater) is confined to Zone E. Bones of the other three extirpated species (Audubon's Shearwater, Red-footed Booby, Sooty Tern) are scattered nearly throughout the sequence, although the data suggest that predation on Audubon's Shearwater during Zone B/C may have been sufficient to prevent this species from surviving into Zone A. Unlike on Tikopia, the Anutan record is highly variable in the amount of time between arrival of people and loss of a particular species. In fact, the archaeological data suggest that two of the extirpated species (Red-footed Booby and Sooty Tern) might either still exist on Anuta in very low numbers or have been lost only decades ago. The asynchrony of island extinctions/extirpations, in spite of a probable heavy burst of early losses, occurred as well in Hawaii (Olson & James 1984; James et al. 1987), New Zealand (Anderson 1983, 1984), and eastern Polynesia (Steadman 1989a).

Biogeography

Cain and Galbraith (1956:100) stated that "thanks largely to the Whitney Expedition [WSSE] . . . the distribution and geographic variation of almost all the birds of the Solomon Islands are well known." The tireless rigor of the WSSE collectors was remarkable indeed, and for many of the hundreds of Pacific islands they visited the resident avifauna was represented completely in their specimens and field notes. Our studies have shown, however, that the WSSE information for Tikopia and Anuta probably was not complete for two reasons.

First is the very short period of time that WSSE spent ashore on the two islands (one day on Anuta, two days on Tikopia). Even on such small islands, a day or two is not enough time to survey the resident avifauna. We have been able to extract much supplemental information on the modern birds of Tikopia and Anuta from other sources, namely social anthropologists

(Feinberg 1977, 1981; Firth 1936, 1939), archaeologists (Kirch & Yen 1982), linguists (Clark 1982, Firth 1985), and government officials (Luke 1945). Throughout Oceania, such "non-ornithological" works often provide important information on birds. Regardless, our knowledge of the modern birdlife of Tikopia and Anuta would benefit from a few weeks of intense ornithological survey.

The second reason is that the natural distribution of Pacific island birds cannot be learned by studying only the birds alive today. A major wave of avian extinction has accompanied the human colonization of Polynesian islands during the past few millennia (Steadman 1989a). So many populations of land birds have been lost that biogeographic analyses based only upon the living fauna are likely to be misleading. On Tikopia and Anuta, rich archaeological records of birds allow us to evaluate the modern avifauna with historical perspective. Without the archaeological record, we would have little idea to what extent the birds of Tikopia and Anuta have been affected by human activities.

As mentioned earlier, at least six species have been lost from Tikopia since the arrival of people. From Anuta, at least four species have been lost. The loss of land birds includes the megapode and rail from Tikopia and no species from Anuta. Other land birds may have existed on Tikopia and Anuta only to be wiped out so rapidly by the first humans that their bones were not incorporated into the archaeological record, as is suggested in the "blitzkreig" model of continental extinction (Martin 1984).

Although the actual number of land birds that existed on these islands in pre-human times may have been greater, the archaeological record shows that the minimum natural land bird fauna of Tikopia was 11 species while that of Anuta was only one species, the "supertramp" Pacific Pigeon (Table 1). These numbers should be regarded as minimum values given that bones of passerines and other small birds are often not recovered from archaeological sites. This substantial difference in species richness probably is related to the smaller land area of Anuta. The modern number of species of birds on individual islands within the Solomon Islands/Vanuatu region is correlated positively with the island's area (Diamond & Mayr 1976, Diamond & Marshall 1977) and negatively with the island's distance from a large island (Diamond, Gilpin & Mayr 1976). The former relationship is most pronounced among islands that are much larger and/or much less isolated than Tikopia or Anuta. Except for Tikopia and Anuta, none of the data on numbers of species for the Solomon Islands or Vanuatu has been calibrated by studies of Holocene bone deposits. Until such information becomes available, we do not know how much extinction/extirpation has occurred in these island groups since the arrival of people.

With 11 species of land birds and an area of 4.6 km^2, Tikopia most closely resembles Ontong Java (9 species, 9.5 km^2) and Sikaiana (6 species, 1.3 km^2), two outlying atolls of the Solomon Islands. These two atolls are about as isolated (170 and 240 km, respectively) as Tikopia and Anuta from large islands with diverse avifaunas, although the nearest large islands to Ontong Java and Sikaiana are much larger and have more species than the "large" islands nearest to Tikopia and Anuta, which are 228 and 280 km from Vanikoro and 210 and 350 km from the Banks Islands. The effect of isolation can be appreciated further by noting that the seven islands in the main Solomon or Vanuatu groups with land areas of 2.4–8.9 km^2 (i.e., roughly similar in area to Tikopia) have from 13 to 38 species of land birds (Diamond & Mayr 1976: Table 1; Diamond & Marshall 1977: Appendix 1), compared with 11 for Tikopia.

The data for Anuta (one species, 0.4 km^2) also provide interesting comparisons. Fourteen islands in the Solomon Islands with smaller land areas than Anuta have from six to 22 species of land birds (Diamond & Mayr 1976: Table 1). Each of these islands is less isolated than Anuta by at least an order of magnitude. Long-term, uninterrupted survival of land bird populations may be very tenuous on islands of such a small size. For example, the land area of Anuta simply

may be too small to sustain viable populations of many species. This makes sense intuitively because such a small island would be extremely vulnerable to environmental perturbations, whether natural or manmade. (Recall that strata of Zone C on Anuta are considered to represent a major storm that may have removed people as well as birds from the island.) Diamond (1983) reported the minimum land area needed to support various species of land birds in the New Guinea/Bismarck/Solomon Islands region. Although populations of certain birds (including species of *Halcyon* and *Aplonis*) exist regularly on islands even smaller than Anuta, Diamond (1983) was concerned with land-bridge islands close to rich source areas. Thus, his results are not especially applicable to Anuta or Tikopia, which never have been connected to another island and are relatively isolated. Although small islands near a major source area for new colonists may suffer prehistoric extinctions similar to those of isolated islands, the lost species are more likely to be replaced on nearby islands than on isolated islands such as Anuta or Tikopia.

To summarize, the large difference in number of land bird species between Tikopia (11 species) and Anuta (one species) suggests that the land area of Anuta may be so small that land bird populations are difficult to establish or maintain. If this is the case, then the effect of decreasing island area is very dramatic between the size of Tikopia (4.6 km^2) and Anuta (0.4 km^2), at least for relatively isolated islands in the western Pacific. However, we cannot rule out the possibility that at least some of the observed differences in species richness between Anuta and Tikopia are because bird bones from the earliest cultural levels are more representative of the actual pre-human species composition on Tikopia than on Anuta. On islands so small, the inclusion of a species in faunal remains may depend upon whether or not the first 50 years of cultural debris is deposited and recovered. For example, is the lack of flightless rails on both islands a true reflection of the natural absence of such species, or were flightless rails lost within the first decades of human occupation, leaving behind few or no bones? If the primary source of predation was rats rather than humans, then most of the bones of flightless rails and other ground-nesting birds would decompose on the humic forest floor rather than be preserved in the calcareous sands of cultural middens.

Alternatively, the young geological ages of Tikopia and Anuta (ca. 80,000 years) might suggest that endemic species of birds, including flightless rails, have never existed on these islands. Endemic subspecies of land birds do occur, however, on Tikopia (see species accounts of *Aplonis tabuensis* and *Myzomela cardinalis*). If the earliest excavated levels of the sites on Tikopia and Anuta truly represent the first decades of human occupation, if the bird bones from these strata truly represent all species present at first contact, and if the endemic species can be recognized osteologically, then the lack of flightless rails or other endemic species of birds on these islands is a natural phenomenon. This suggestion could be tested by screening (with sieves of 1/16 or 1/8 in. mesh) the oldest cultural strata on both islands, searching for the tiny bones that may tell us even more about the prehistoric birds of Tikopia and Anuta.

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