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ATOLLS AS SETTLEMENT LANDSCAPES: UJAE, MARSHALL ISLANDS

BY

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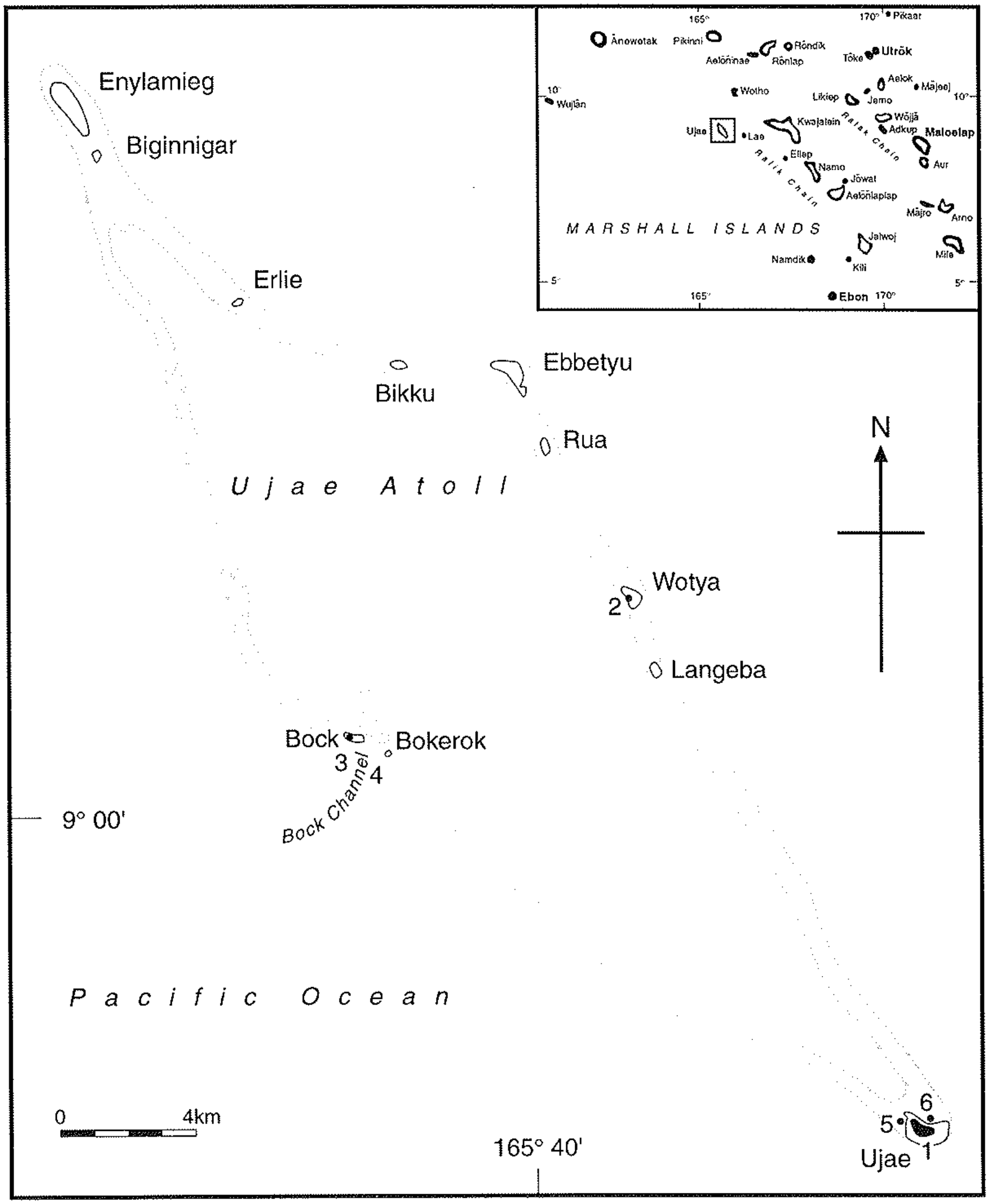

FIGURE 1. Ujae Atoll and archaeological sites with map of the Marshall Islands showing location of Ujae. Atolls in bold (Utrōk, Maloelap and Ebon), situated along the continuum of rainfall from the dry north to the wet south, are part of the long-term archaeological study of the Marshall Islands.

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ABSTRACT

Williamson and Sabath (1982) have demonstrated a significant relationship between modern population size and environment by examining atoll area and rainfall in the Marshall Islands. The present work seeks to extend that argument into prehistory by examining the relationship of ancient habitation sites and size of aroid pit agricultural systems to atoll land area and rainfall regime along the 1,500-3,500 mm precipitation gradient in the Marshall Islands. Four atolls were selected for study: Ebon at the wettest extent in the extreme south; Ujae and Maloelap near the center of the archipelago; and Utrõk at the dry north. The first phase of this long-term archaeological program is reported. During the survey of Ujae Atoll (9° 05' N, 165° 40' E), three habitation sites, an aroid pit agricultural zone, one early historic burial, and seven fish traps, weirs, and enclosures were recorded. Along with excavations at two habitation sites (8 m^2 total area), 35 traditional artifacts were recovered (shell adzes, ornaments, and manufacturing tools). Seven radiocarbon age determinations document land use beginning as early as the third century A.D. A beachrock sample dated to 2450 ± 70 BP relates to atoll development. Some 4,748 bones of fish, birds, turtles, Pacific rats, lizards, humans, and possible cetaceans, along with nearly 13 kg of shellfish, provide the basis for understanding prehistoric subsistence, human adaptations to the atoll setting, and land use patterns.

INTRODUCTION

Pacific coral atolls are unquestionably the most precarious landscapes for settlement, yet many of them evidence continuous human occupation for 2,000 years. Unlike the high volcanic islands of the Pacific plate and the non-oceanic or continental land masses west of the Andesite Line, coral atolls are unique in their small size, low elevation, limited diversity of terrestrial flora and fauna, poorly developed soils, and an absence of surface potable water—all characteristics that would limit a sustained human presence. How did small human founding groups survive and, in a sense, flourish on these most challenging of Pacific landscapes? In 1993, a long-term interdisciplinary study of the archaeology and pre-

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history of the Marshall Islands was initiated. Located about 4,000 km southwest of Hawai'i, the Marshalls are situated mostly between 4° - 12° north latitude and consist of 29 low coral atolls and five small islands oriented in two roughly parallel lines trending southeast-northwest for about 1,100 km. Selection of four atolls for intensive archaeological survey and excavations was based on the marked rainfall gradient beginning in the wet south, with about 3,500 mm of annual precipitation, to 1,500 mm in the dry north (Fig. 1). On Pacific atolls, rainfall is the most significant determinant of species diversity (Fosberg 1984; Stoddart 1992) and is mirrored in the prehistoric settlement patterns by varying densities of surface artifacts, area of prehistoric habitations, and size of agricultural systems. Williams and Sabath (1982), in their modern population studies, have demonstrated the close correspondence between human carrying capacity, island size, and climate. Consequently, Marshall Islands atolls were selected for study at opposite ends of the rainfall gradient beginning with the most southern one of Ebon (4° N latitude), Maloelap (8° 50') and Ujae (9°) near the center of the archipelago, and Utrōk (11° 15'), one of the farthest north, permanently inhabited atolls.

Beginning about 2000 BP, human colonists of the Marshalls targeted the pristine stocks of fish, sea birds, turtles, and coconut crabs (*Birgus latro*), yet permanent settlers would ultimately depend on terrestrial production for the bulk of their subsistence. Aroid pit cultivation for Giant swamp taro (*Cyrtosperma chamissonis*)—uniquely adapted to the harsh conditions of atolls (Thompson 1982; Weisler in press)—is the foundation of Marshall Islands culture. Pandanus, with numerous varieties cultivated throughout the Marshalls (Stone 1960), was the fundamental tree crop for the dry northern atolls, while breadfruit increased in importance towards the south. Arrowroot (*Tacca leontopetaloides*) was grown on all the atolls and supplemented the carbohydrate intake.

After a brief review of previous archaeological research in the Marshalls, results from the first archaeological survey and excavations from this long-term project are reported.

PREVIOUS ARCHAEOLOGICAL STUDIES

Archaeological research in the Marshall Islands began with the Kelton-Bishop Museum Expedition in 1977, and continued with phases in 1979 and 1980. The first effort was a brief reconnaissance-level survey of 12 atolls and recording of 42 sites with the goal of determining if these atolls had sufficient, intact prehistoric cultural deposits warranting detailed study (Rosendahl 1987). More than 4,000 portable artifacts were collected and included shell adzes, fishing gear, scrapers, ornaments, and manufacturing tools such as shell hammerstones and pumice and coral abraders. Although not from dated contexts, this is an important archaeological collection of Marshall Islands artifacts. Eight habitation sites on four atolls were test excavated and one radiocarbon age determination established occupation by 1260 ± 80 BP (Rosendahl 1987:161).

While Rosendahl's survey was extensive, Riley, in 1979, focussed on a single atoll, completing an intensive survey and transect excavations of a major prehistoric village site. He recorded 122 sites on Majuro Atoll which he classified into midden areas (sites with surface food remains), house platforms, coral-faced structures (some of which were historic burials, e.g., Riley [1987:fig. 2.4]), fishtraps, wells, and a *Cyrtosperma* pit zone. Following the observations made by the botanist Hatheway (1953), Riley suggested that the oldest portions of habitation sites should be in the middle of the islet. The greatest density of recorded sites was at Laura village, on the largest islet, and excavation conducted there produced a radiocarbon age determination of 1970 ± 110 BP—one of the oldest habitation dates for the Marshalls.

The last phase of the Kelton-Bishop Expedition was a detailed survey of Arno Atoll with systematic transect excavations undertaken to locate buried prehistoric sites that may not have surface indications (Dye 1987). Some 133 islets were surveyed and 164 sites recorded, mostly habitations. The earliest human occupation was dated to about 1000 BP, while dates for the reef platform were 2,500-3,000 years old.

In the northern Marshalls, Streck surveyed and conducted test excavations on five atolls (1990). Brief excavations on Bikini Atoll yielded 35 radiocarbon age determinations, 15 percent of which were older than 2000 BP. Most were "grab" samples from eroded exposures of cultural layers and the stratigraphic details have not been published. Few archaeologists accept the oldest dates because old drift logs may have been used for fuel (Kirch and Weisler 1994:292). That is, dating drift wood from trees with a long life span can add hundreds of years to radiocarbon age determinations. Consequently, the date when the log was used for fuel is increased by the age of the tree.

In conjunction with expansion of the airport on Kwajalein Atoll, Shun and Athens (1990; see also Beardsley 1994) reported a buried gray layer on Kwajalein islet dated to about 2000 BP. Located near the center of the islet, the layer may represent a natural swamp or constructed aroid pit. Also on Kwajalein, Weisler *et al.* (in press) recovered a single human burial during construction of utility lines. Found with 151 grave goods, the bones probably are those of an individual of relatively high status who may have shared communication or trade links with groups on nearby Polynesian islands. Ancestral ties with the Marianas are suggested by a comparison of ancient mtDNA.

Widdicombe recently completed a technological study of Marshallese shell adzes from Ebon, Maloelap, and Ujae atolls (1997). Adzes were manufactured from large and small taxa of *Tridacna*, helmet shells (Cassidae), conches (*Lambis* sp.), and less frequently from cones (Conidae) and augers (*Terebra* sp.). No significant differences were noted in terms of assemblage composition between Maloelap and Ebon yet, today, residents of the largest islet of Kaven, Maloelap Atoll, say that *T. gigas* does not grow there—perhaps because of the deep offshore lagoon waters. Consequently, *T. gigas* adzes may have been imported. Somerville-Ryan (1998) has reported on a taphonomic investigation of archaeological shellfish assemblages from Ebon Atoll. During prehistory, shellfish were brought to sites as food, as raw material for tool and ornament manufacture, and in water-rolled coral gravel used for pavement. His study suggests that only a few taxa reliably reflect food use, and archaeologists should be aware of this when selecting specimens for radiocarbon dating.

The past two decades produced at least brief archaeological surveys on nearly half of the Marshall Islands, and a range of prehistoric artifacts and habitation sites have been documented. Detailed excavations are, as yet, rare, but widely accepted radiocarbon dates establish human occupation by about 2000 BP.

ARCHAEOLOGICAL SURVEY OF UJAE ATOLL

Introduction and Objectives

The main focus of the archaeological study was the survey of Ujae islet and subsequent transect excavations for defining the site boundaries—at least the ocean to lagoon extent. This was done for three reasons: (1) the most substantial and oldest village is normally located on the largest islet of an atoll; (2) the entire population of the atoll now lives on Ujae islet, which facilitated the work and made best use of the limited time; and (3) the archaeological study was also undertaken as part of a historic preservation training program and, by conducting most work in the village, it was easier to interact with school children and other members of the community who visited the on-going excavations. In my former capacity as Chief Archaeologist for the Republic of the Marshall Islands, I found that it is much easier to teach historic preservation by involving residents directly in archaeological survey and excavations, than by lecturing about abstract concepts in the village schoolhouse.

Located near the center of the archipelago in the Ralik chain of the Marshalls, Ujae Atoll (9° 05' N, 165° 40' E)—ranks 22 in land area amongst the group—consists of 12 larger islets (with a total land area of 1.8 km^2) which surround a 180 km^2 lagoon (Bryan 1971). The largest islet, named for the atoll, contains the entire population of 488 people (Office of Planning and Statistics 1988). Some 81% of households are involved in copra production and credit is issued for kerosene, rice, flour, sugar, and cooking oil. It is a subsistence lifestyle with nearly all of the people engaged in growing food and fishing. In 1988, firewood was the dominant source of cooking fuel, but less so in 1994 after several years of U. S. Federal food assistance.

Only one diesel boat was operating at the time of our visit and it was rented for $US25/ day including two operators. The archaeological survey began after we left Ujae islet mid-morning on 4 July 1994 traveling within the lagoon up the windward side stopping at Langeba, Wotya, bypassing Rua, and spending the night at Ebbetyu (Fig. 1). Leaving Ebbetyu the following morning, we bypassed the small islets of Bikku and Erlie and had to wait several hours for high tide before approaching Enylamieg. We only spent a short time there to enable us to reach Bokerok with sufficient time to set up camp before dark. Bokerok supports a dense colony of nesting noddies and I saw it as a good opportunity to record how the Ujae Marshallese capture, butcher, and cook birds, and to document the fracture and burning characteristics these activities have on the bones (see Weisler and Gargett 1993) as well as the spatial patterns resulting from discard. This ethnoarchaeological study was of value for interpreting bird bones recovered from the excavations on Ujae and elsewhere. We spent two nights on Bokerok before going to Bock where we stayed an additional two nights while excavating a midden site. We returned to Ujae by mid-day on the 9th. The results of the survey are presented below by islet, beginning with Ujae and following counter-clockwise around the lagoon.

Islet Survey

Ujae Islet (0.47 km^2). This is the largest islet of the atoll and the one suspected of having the biggest and oldest village. The center of the islet has numerous elongate and sinuous *Cyrtosperma* pits which today are mostly abandoned. Breadfruit, banana, papaya, and

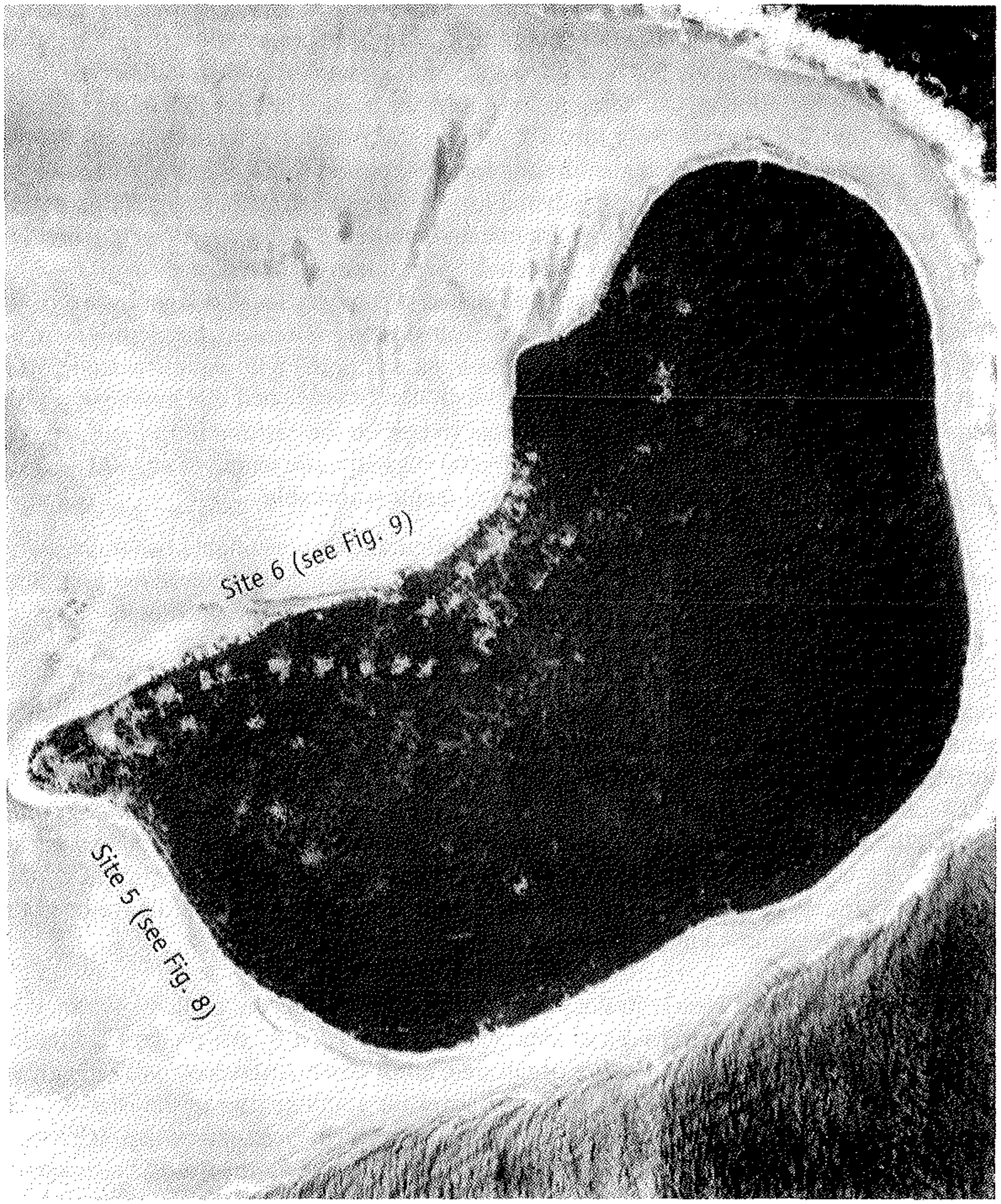

FIGURE 2. Aerial view of Ujae taken 17 February 1944 before construction of the landing strip now located along the southern half of the islet. The modern village paths are clearly visible just inland of the lagoon shore. Note the extensive reef flats that cover most of this frame. (Courtesy of Bernice P. Bishop Museum, negative No. CP 117,087, composite of #116 and #117, AP28A-VD3.)

Pandanus trees are maintained in the modern village which is located within the northern third of the islet. In Figure 2, an aerial photograph taken 17 February 1944, the main village paths form an obtuse triangle just inland from the lagoon shore near the middle of the coast, with one leg of the polygon extending to the northwest point. The first step in the archaeological survey of Ujae islet was to walk around the modern village and observe the stratigraphy in trash pits and foundations dug for new houses. This was an expedient way of gaining a general indication of the depth and location of prehistoric deposits. In gardening areas with clear ground visibility, large, fragmented shellfish (such as *Tridacna* and *Lambis*) were observed and a few shell adzes collected. Several transects walked through the interior established that the ancient village (designated site 1) was located lagoonward of the *Cyrtosperma* pits. Seven 1 m^2 units were excavated along a transect beginning near the center of the islet to just above the lagoon shore; an additional unit was excavated 250 m east of the main transect. The lagoon-ocean side transect established that the site was 420 m wide (north-south) and a conservative estimate (based on the distribution of surface artifacts and cultural layers seen in modern trash pits) suggest a site length of ca. 600 m along the lagoon shore axis. A site area of 25 hectares seems reasonable.

On the reef flat off the west coast, six stone configurations, presumably fish traps, weirs, and enclosures, were located. No Ujae residents knew anything about these features since they probably went out of use decades before; these features are described below.

Langeba Islet (0.06 km²). This is the first islet north of Ujae along the east or windward margin of the atoll. No archaeological sites were located on this islet as it is small with numerous wind-fallen trees, and wave-deposited rubbish—evidence of wash-overs. There are less than 100 coconut trees on the islet, with typical coastal vegetation such as *Tournefortia* and *Scaevola*. Coconut crabs were collected from the bases of a few large *Pisonia grandis* trees in the interior of the islet. A large exposure of beachrock was noted along southeast coast. The gravelly interior and small islet size does not support a fresh water lens. Coconut crabs found today, in addition to nesting seabirds in previous times, would have been the dominant food resources and the main reasons for visiting the islet.

Wotya Islet (0.16 km²). Nearly in the center of the east coast of the atoll, Wotya may be large enough to support a fresh water lens which is suggested by the modern habitation area. Turtle nests were observed on the ocean side, north shore. Arrowroot was seen growing in the interior and large *Pisonia* trees that cover the south quarter of the islet support nesting noddies (*Anous* spp.). The presence of the small tree, *Neisosperma* sp. (*Ochrosia* sp.), in the islet interior, suggested to Fosberg (1955:21) that storm waves occasionally reached inland areas, dispersing seeds of this plant, which otherwise should not have been found growing away from the shoreline. A prehistoric midden (site 2) was located along the lagoon side west shore immediately above an area of beachrock. The shoreline is eroded here, forming a wave-cut bank ca. 1.25 m high exposing a dark midden layer ca. 0.5 m thick consisting of *Tridacna* and *Lambis* shellfish, coral oven stones, and one earth oven, the base of which was 1.10 m below surface. The site runs about 75 m along the shoreline, while its inland extent can only be determined by excavation. However, it is probably less than 0.5 hectare. Numerous *Tridacna* valves inland of the exposure may be from the modern settlement.

Rua Islet (0.08 km^2). We sailed slowly past this islet and due to its small size, low elevation, and sparse vegetation, its was unlikely to have prehistoric cultural deposits.

Ebbetyu Islet (0.22 km^2). We arrived at this islet after 5 pm and could only spend a short time surveying before dark. Turtle tracks were noted on the northwest point on the ocean side. Two modern, abandoned houses were located just inland of the south shore on the lagoon side. The most southeast house had three large breadfruit trees and a well about 50 m inland from a coral pavement. The islet size suggests a prehistoric site should be present, but excavation would be necessary to locate buried deposits. Compounding the problem of identifying prehistoric cultural material on the ground surface is the presence of large shellfish that may only be refuse from the modern occupants; this is especially true of historically-discarded shellfish that have been bleaching in the sun for many decades and, consequently, can be confused with prehistoric midden. Fosberg noted, in February 1952, a layer of pumice pebbles covering a few square yards of Anuij, the islet south and connected to Ebbetyu (Fosberg 1955:20). Pumice is used occasionally today to sharpen tools and would have been an important resource in prehistory.

Bikku Islet (0.09 km^2). We did not have time to stop at this islet but, as we sailed by, it was clear from its small size, rocky topography, and sparse vegetation that no prehistoric cultural deposits would be present.

Erlie Islet (0.06 km^2). One of the smallest of the islets, time limits did not permit stopping at this locale but, similar to the environmental constraints observed on Bikku, no prehistoric cultural deposits could be expected. Fosberg reported a pure *Cordia* forest which he considered a rare occurrence in the Marshalls (1955:22). He mentioned an "enormous number of hermit crabs" which, today, are the preferred bait for bottom fishing for the lethrinid *Monotaxis grandoculis* (personal observation on Utrõk Atoll, 1996-7).

Biginnigar Islet (0.07 km^2). This small shoal could not have supported prehistoric cultural deposits. Residents mentioned that Golden cowries (*Cypraea aurantium*) are occasionally collected on the adjacent reef flats.

Enylamieg Islet (0.44 km^2). This islet must be approached at high tide to affect a landing. Unfortunately, we arrived at low tide and wasted precious time walking across the broad reef flat. Arriving at the southern tip of the islet, we walked inland about one-half of the way, noting a village (abandoned perhaps a few generations ago) marked by beachrock slab-lined paths near the west coast. Because this islet is no longer used for habitation, it is densely overgrown and ground visibility was negligible. No prehistoric sites or features were observed, but islet size and presence of the historic village suggests that an ancient site must surely exist.

Bock Islet (0.09 km^2). On the leeward side of Ujae Atoll, just north of the main channel to the lagoon, Bock islet has a dense, black, prehistoric midden located just above a beachrock formation on the lagoon shore. Fosberg and colleagues established an astronomical station on Bock for several days in early 1952. On the south end of the islet, large *Pisonia* trees reached heights of 30 m—a fact remarked by Fosberg in 1952 (1955:19). He also recorded large individuals of *Intsia*, at least 25 m in height, which, in Hawai'i, is normally a "small to medium-sized tree" (Neal 1965:418). The economically important *Morinda citrifolia* (*nen*) was recorded in several places along an elevation transect. The temporary encampment, noted by Fosberg some 30 years before, was still in use in 1994; and the Marshallese are still coming to Bock to capture the plentiful noddies. A partially submerged beachrock "island" is the best marker for the prehistoric site, where, beginning just above the beach and immediately west of the site, a trail leads inland to a modern sleeping house, cook shed, and well. The inland extent of the midden is clearly delimited by a wet swale less than 10 m distant from a low mound, while the site measures 135 m east along the lagoon shore (see Figs 1 and 3). Assuming a width of ca. 15 m, the site is about 2,025 m^2 (or 1/5th hectare). Unlike the largest islets of most atolls, this smaller landmass does not have a central depression where *Cyrtosperma* pits are usually found. On Bock, the islet rises gradually from the lagoon shore before descending to the cobble ridge and beachrock on the ocean side (Fig. 3). We stayed on the islet a day and a half completing an elevation transect and a 1 m^2 excavation unit, described below.

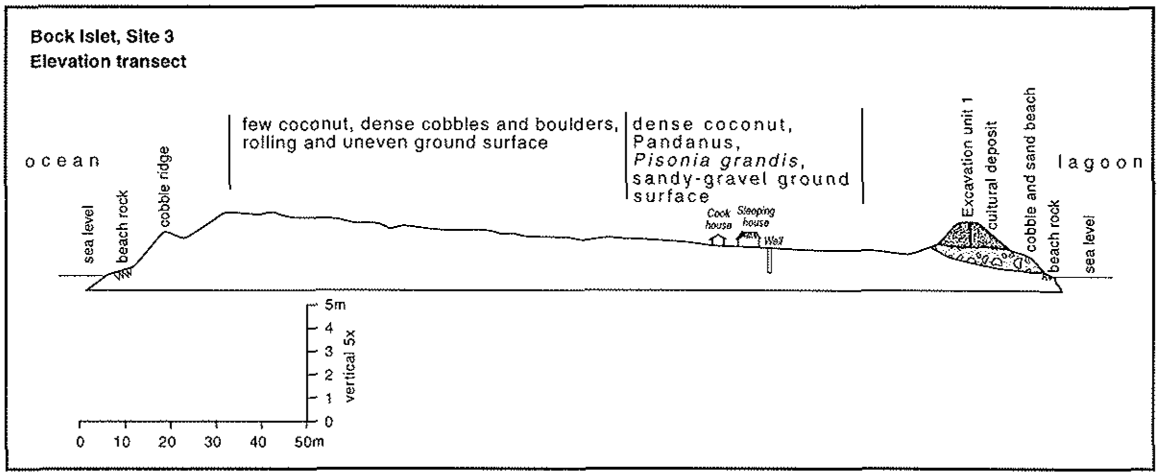

FIGURE 3. Transect through site 3, Bock Island.

Bokerok Islet (<0.05 km²). This small islet does not have prehistoric cultural deposits but, at least today, is a significant nesting area for noddies. On the lagoon side there is a small camp used for a few days at a time while capturing noddies. The site lies about 4 m inland of the vegetation line and consists of a level area (9 m^2) used for sleeping as well as processing and roasting birds. A fire pit, used for roasting and not baking birds, is situated near the level area and about 1 m away is a dense concentration of wing bones where these non-edible portions of birds were routinely discarded. Elements containing high meat portions were tossed around the perimeter of the sleeping area after roasting and consumption (Fig. 4). Two historic burials were found inland, one was mapped and consisted of a rectangular perimeter of beachrock slabs, only two remaining in the original upright position (Fig. 5). These are typical historic burials as described by Finsch during his visit to the Marshalls in the 1870's (Finsch 1893).

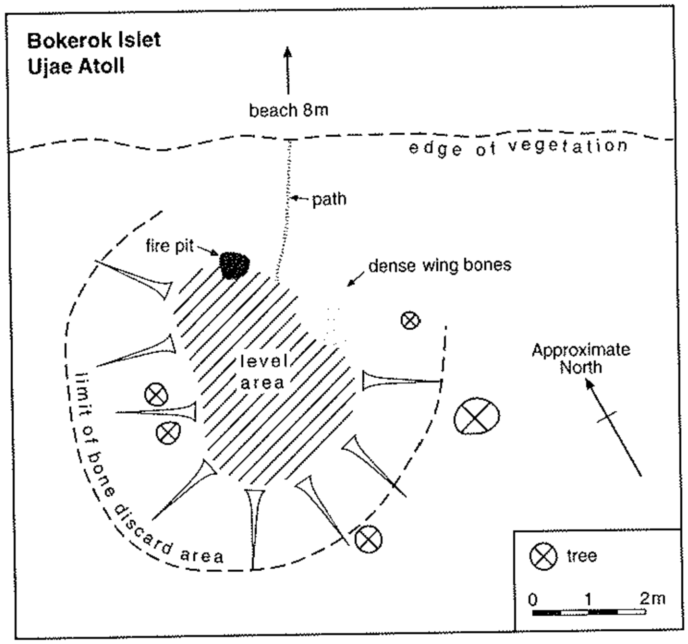

FIGURE 4. Modern bird processing camp, Bokerok islet.

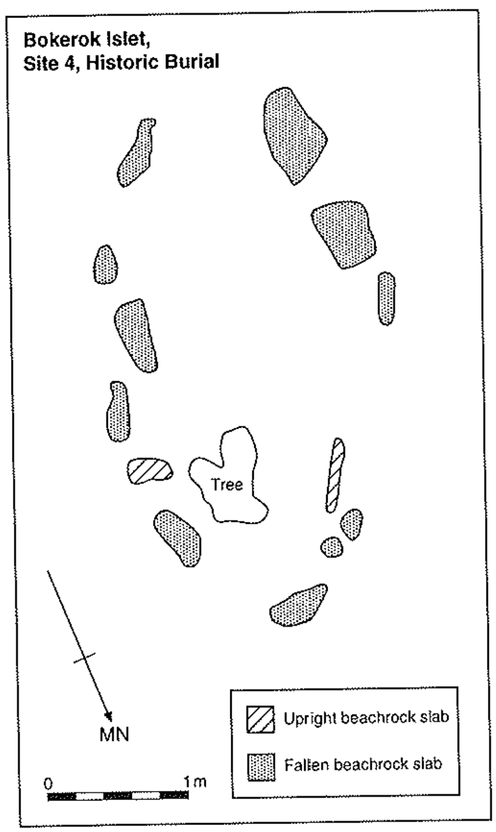

FIGURE 5. Historic burial, site 4, Bock islet.

Site Classes

Habitation Sites. The common habitation site was a midden recognized on the surface by scattered and fragmented large shellfish (such as *Tridacna* and *Lambis*), coral and beachrock oven stones, and shell adzes. Earth ovens are commonly used on the outer atolls (not Majuro or Kwajalein) and shellfish are still eaten today. Consequently, it is not always possible to differentiate old, bleached, and weathered food shells that are, say 100 years old, from prehistoric specimens. Therefore, the presence of shell adzes was the best criterion to identify a prehistoric habitation site, especially in reference to topographic setting and proximity to aroid pits. Buried prehistoric cultural deposits were recognized by dark, sandy sediment, earth ovens, and dispersed charcoal, oven stones, shell artifacts, shellfish, and bone midden. Cultural deposits were found exposed at the lagoon shoreline near beachrock (e.g., site 2) or seen in the walls of trash pits and other recent excavations. There has been a tendency by some archaeologists to designate a new site for each seemingly isolated surface scatter of artifacts and shellfish found on an islet as Rosendahl did for portions of Ebon islet, Ebon Atoll (1987:26, 84). However, even on large islets, excavation has demonstrated that there is one main prehistoric village site associated with inland aroid pits.

Predictably, the major habitation site was located on the largest islet of Ujae associated with aroid pits for the cultivation of Giant swamp taro. Estimated to be at least 25 hectares, it is larger than all the other habitation sites on the atoll combined. Site 2 on Wotya, and site 3 on Bock are, together, less than a hectare and are not associated with aroid pits.

Agricultural Sites. Aroid pits are typically, but not exclusively, located near the interior of the largest islets where the Ghyben-Herzberg fresh water lens is the thickest and most reliable during periods of drought (Weisler 1999). Extensive aroid pits were observed in the interior of Ujae islet, but similar features should be present on Enylamieg as well. The Ujae pits were mostly long and sinuous forms, meandering for 100 m or more. Three pits ranged in width from 28 to 35 m, and nearly 2 m deep as measured from the rims. Only one small pit (20 by 34 m) was planted with *Cyrtosperma* (see Fig. 6), while a portion of a much larger pit was currently being weeded and planted. Because most of the pits are no longer used and, consequently, overgrown with dense, high vegetation, the time-consuming task of clearing these features to make accurate size assessments was not undertaken. These features were not recorded in detail as the main emphasis of the archaeological study and training program was on habitation sites. However, an elevation transect on Ujae islet established the location of the aroid pit zone relative to the ancient village site and shorelines (Fig. 7).

Fish Traps. Situated close to the lagoon shore on the reef flat are various stacked stone configurations, some of which are clearly fish traps, but other features may have had different functions such as enclosures for holding fish or turtles. These devices show signs of disrepair and probably have not been used for decades. Riley (1987:187) provided a classification of fish traps from Majuro Atoll but, unfortunately, did not provide illustrations of his types. I adapt his scheme (using his type descriptions) in the presentation of the Ujae features. Riley's type 1 is most common on Majuro and Ujae as well. It consists of a V-shaped configuration that funnels fish to a circular trap (Fig. 8A). Most Ujae examples are situated open to the ocean side and two of the traps (site 5B and C) take advantage of the

FIGURE 6. Small *Cyrtosperma* pit with a few arrowroot plants in foreground and to right.

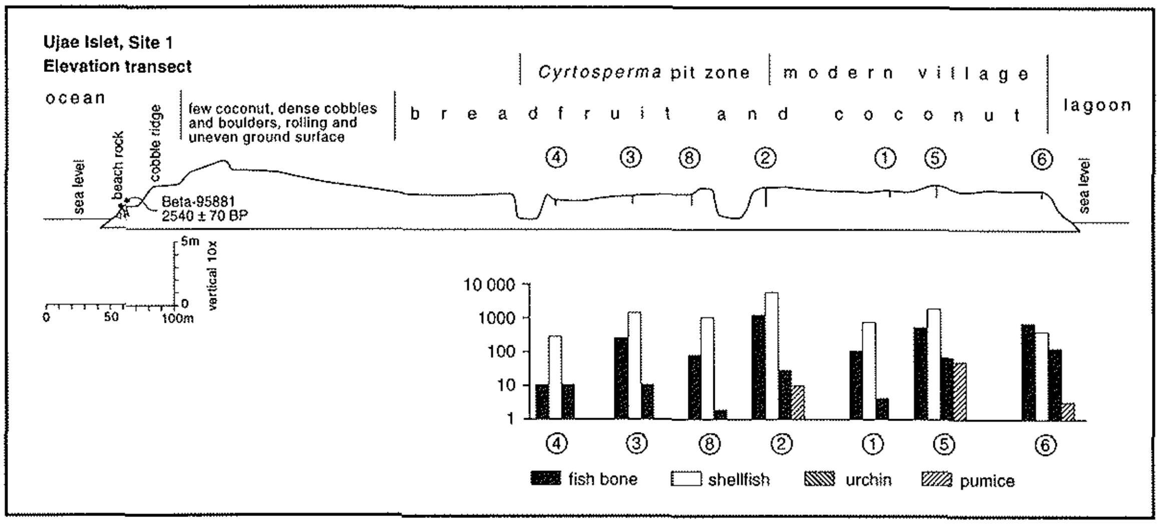

FIGURE 7. Elevation transect through site 1, Ujae islet. Fish bone (counts) and shellfish, urchins, and pumice weights for excavated units.

shoreline which acts as an extension of the landward leg of trap site 5C (Fig. 8). Site 6 is an adaptation of type 1 traps that takes advantage of the lagoonal topography, such as natural alignments of coral, rubble, and depressions, as well as the coastline for extending the

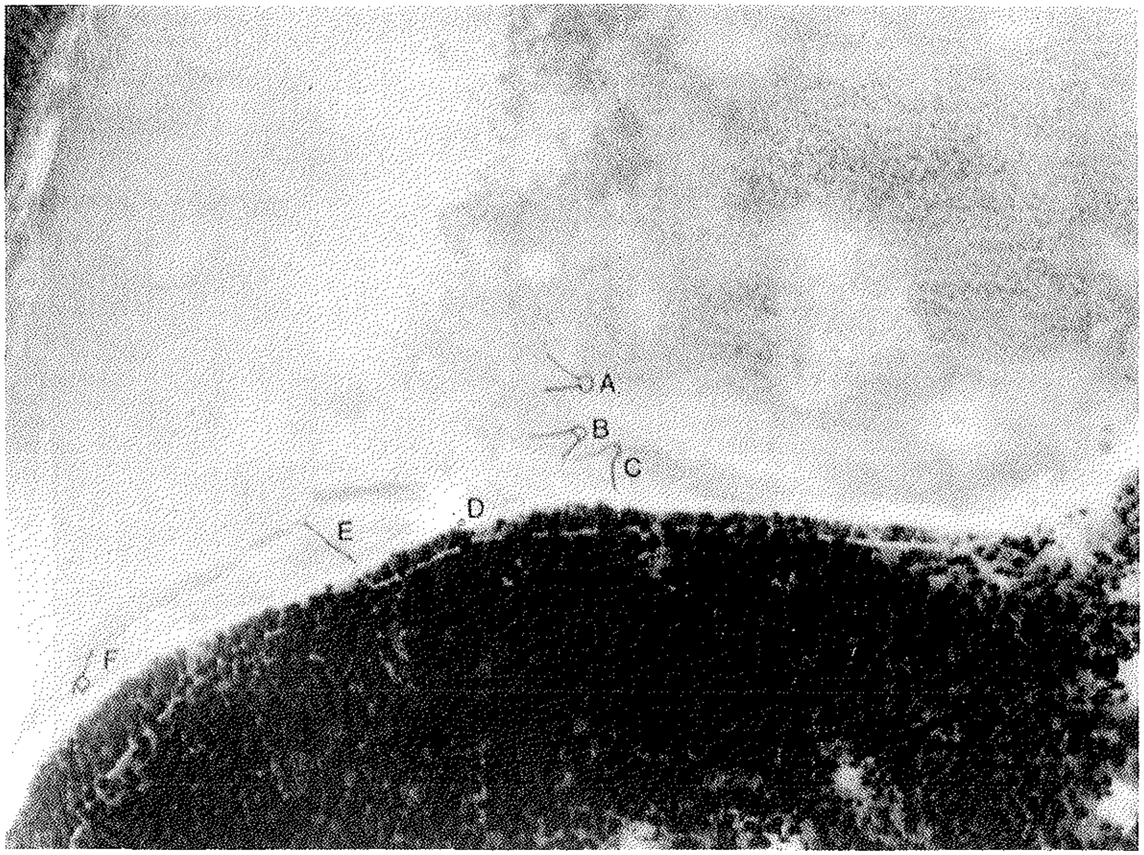

FIGURE 8. Aerial photo of Ujae islet, site 5 fish traps features A-C, possible turtle enclosure feature D, wall feature E, and enclosure feature F. Photo taken 7 February 1944. (Bernice P. Bishop Museum negative number CP 117,081.)

length of the catchment (Fig. 9). This trap is four times as long and three times as wide as the west coast features of similar form. On Majuro, large schools of the Bigeye scad (*Selar crumenopthalmus*) are caught in similar traps (personal communication, Laura, Majuro resident, 1994). The Yellowstripe goatfish (*Mulloides flavolineatus* and *M. vanicolensis*), which congregates in large schools over sand flats, may also be a species commonly caught in stone traps.

Site 5E uses the local topography to aid in directing fish—a similar situation to the type 1 traps. Extending from the shoreline, a low wall was built perpendicular to a ridge on the reef flat, thus forming a three-sided square open to the ocean side (Figs 8 and 10, middle). There is no circular trap as in the type 1 features, while this square configuration may have been used in conjunction with a seine net that closed the fourth side of the trap.

The two legs extending from site 5F may have acted to help channel fish to the square enclosure, but the exact function of this feature is uncertain (Fig. 10, lower). It is somewhat similar to the description of Riley's type 3 traps (1987:187). Site 5D is a circular enclosure measuring about 3 m in diameter (Fig. 10, upper). This may have been a turtle pen as similar, but larger, structures have been noted elsewhere in the Pacific on islands with shal-

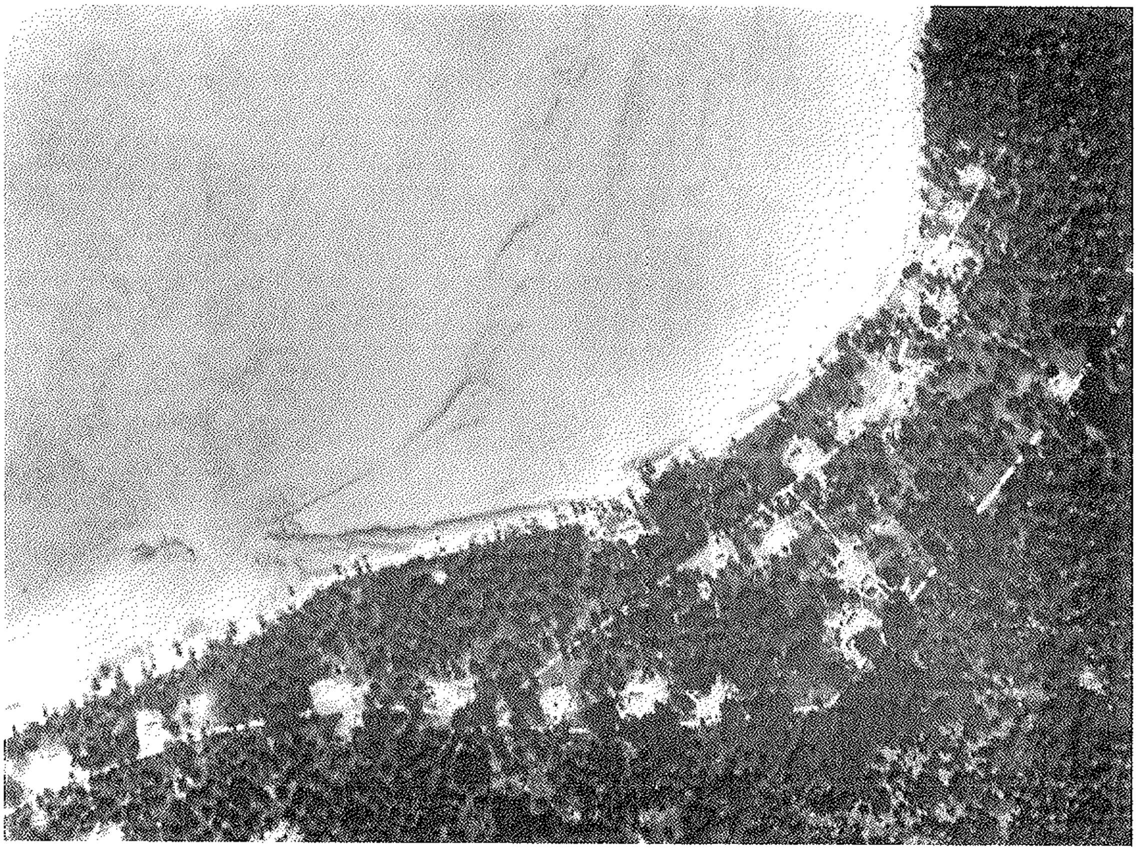

FIGURE 9. Aerial photo of Ujae islet, site 6 fish trap. Photo taken 17 February 1944. (Bernice P. Bishop Museum negative number CP 117,086.)

low offshore topography (Emory 1939:17). Riley's type 2, a semicircle that joins at the beach, was not seen on Ujae Atoll.

In summary, Ujae fish traps were built to take advantage of the local offshore topography and were situated in reference to prevailing currents. Both topography and currents acted to enhance the efficiency of the traps, which could be checked after each incoming tide. Although a range of fish species were undoubtedly trapped, Bigeye scad and goatfish may have accounted for significant catches. I have observed seine net catches of hundreds of rabbitfishes (Siganidae) on Utrõk Atoll, and it is reasonable to suspect that species of this family may have been caught in traps as well. The variability of forms in Ujae fish traps and enclosures warrants a more inclusive classificatory scheme for the Marshall Islands features that should be adapted from Riley's initial attempt at describing the Majuro sites. It is worth noting that traps were only associated with Ujae islet probably reflecting the relatively larger village there. These devices may be a form of intensification of the marine subsistence regime, built during late prehistory. It is unlikely that traps would have been constructed as part of the colonization phase of settlement when marine stocks were at their highest levels and capturing fish required less effort.

FIGURE 10. Site 5 possible turtle enclosure feature D (top), wall feature E (middle) built perpendicular to natural reef alignment, and enclosure feature F (bottom).

TEST EXCAVATIONS

Excavations were conducted primarily on Ujae islet, where 8 m^2 were completed at the major habitation (site 1), with an additional 1 m^2 dug at site 3 on Bock islet. The objectives were to: (1) determine the depth and nature of the prehistoric cultural deposits; (2) obtain samples for radiocarbon dating; (3) collect shellfish and faunal material to address subsistence issues; (4) acquire artifacts from secure stratigraphic contexts; and, in the case of site 1, (5) determine the lagoon to ocean side site boundaries. Experience has shown that it is simply not possible to accurately determine habitation site boundaries on atolls without excavation.

Unit excavations proceeded by arbitrary 10 cm levels or spits within, but never crossing, stratigraphic boundaries. All sediments were passed through 1/4" (6.4 mm) sieves, then material sorted into one of several classes which normally included: artifacts, bone, shell, urchins, crustacea, and charcoal. Separating cultural material into these classes reduced the amount of breakage during shipment and facilitated lab work. The stratigraphic profile of at least one side of each excavation unit was drawn, recording such layer characteristics as boundary, Munsell color, texture, consistency, structure, etc. Elevation transects were made through the excavation units from the lagoon shore to the ocean side showing the topographic features and vegetation of the islet.

Site MLUj-1, Ujae Islet

At the major habitation site of Ujae Atoll, seven one meter square units were excavated along a north-south transect running due south (180°) for 420 m from the middle of the lagoon shore (Fig. 7). As time permitted, an eighth unit was placed 250 m east of unit 2 to determine the limits of the site boundary along that axis. Stratigraphic profiles are presented in Figures 11 and 12 and detailed layer descriptions provided in Appendix 1. The cultural layer was thickest and oldest on the lagoon side, just north of the aroid pits, and generally thinned north and south of this point. In general, the upper 20 cm of each excavation unit contained dense coconut roots in a gravelly sand matrix. In the midst of the modern village, unit 5 had a surface layer of water-rolled coral pebbles—a typical pavement found throughout villages today. Except in units 2 and 5, all cultural material was contained in the top 25 cm in a gravelly sand to coarse sand, black to dark gray matrix. Portions of combustion features were encountered and included earth ovens (see Fig. 11, unit 5, S profile) and other smaller and thinner features that may have been ovens, or charcoal and oven stone concentrations may have served for roasting food. The culturally sterile subsoil was encountered near 75 cm below surface and, in unit 2, below one meter. Cultural content is described below.

Site MLUj-3, Bock Islet

This small midden site, located just inland of a beachrock formation, runs parallel to the lagoon shore. The site does not extend inland very far, yet is quite long, suggesting that inhabitants preferred to be close to the water, away from the rocky interior. One 1 m^2 unit was excavated at the highest point of the site to get a complete sample of the stratigraphy. Five layers were defined primarily on the basis of color, texture, and artifact content (see Fig. 13 and Appendix 1). Dense gravel was encountered to one meter below surface sug-

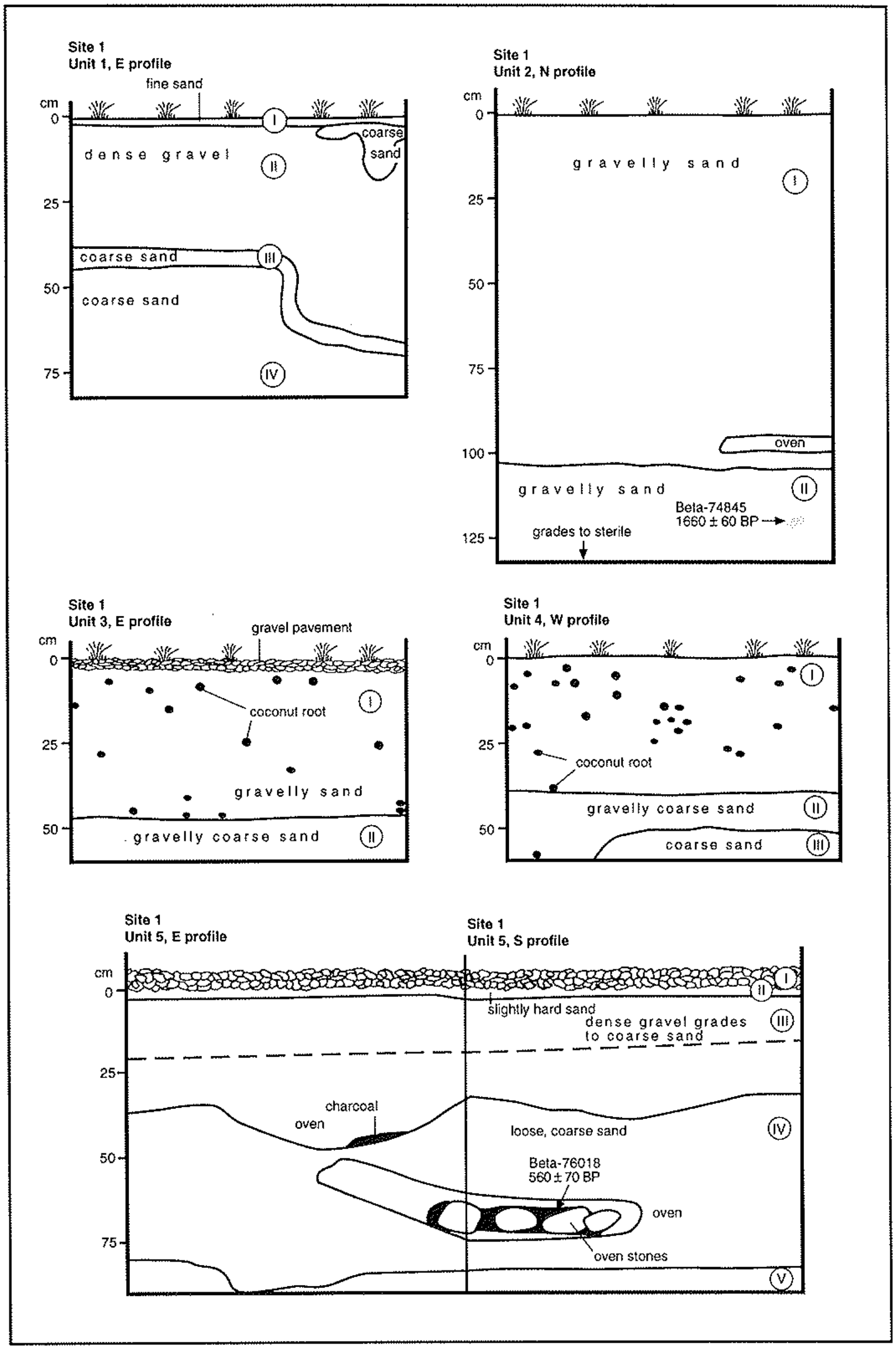

FIGURE 11. Profiles of units 1-5, site 1, Ujae islet.

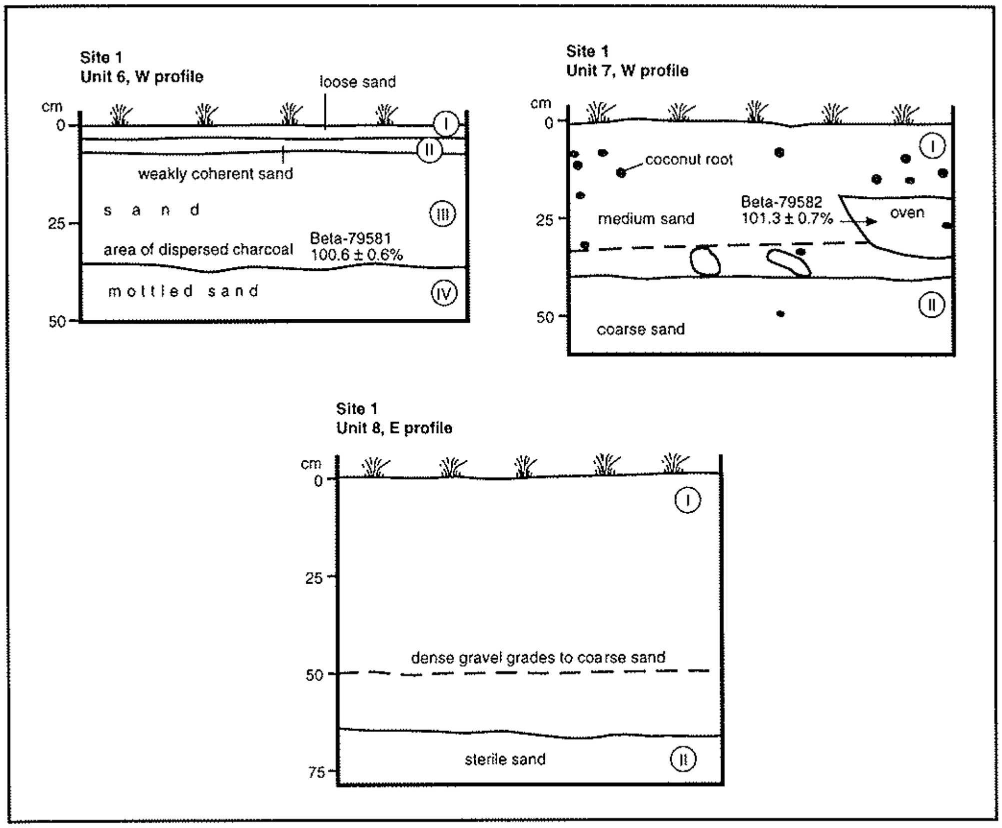

FIGURE 12. Profiles of units 6-8, site 1, Ujae islet.

gesting a frequent repaving of the ground surface. The lack of aroid pit cultivation and rocky nature of the landscape indicates that the islet was probably occupied by small groups for short periods of time, perhaps as a staging area in which to exploit the outer reefs and troll for pelagic species. A basal radiocarbon date suggests late prehistoric occupation.

DATING

The selection of samples for radiocarbon dating was constrained by the limited number of excavation units. However, the objectives for securing chronometric dates were to: (1) obtain a set of dates for the basal cultural layer which would establish initial occupation in the location of the units, but not necessarily of the site itself; (2) determine the relatively oldest portion of the site along a transect that would suggest the direction of site expansion over time and how this may correlate to islet formation; (3) contrast the basal habitation dates between the largest islet and at least one site on a small islet; and (4) date a sample of beachrock in reference to an elevation transect for establishing a chronometric benchmark for this topographic feature that may have implications for human colonization of the islet.

Seven radiocarbon samples were selected from clear stratigraphic contexts: four from the largest habitation on Ujae Atoll, site 1; two from the small habitation site on Bock islet; and a beachrock sample from the ocean side transect on Ujae islet. All samples were proc-

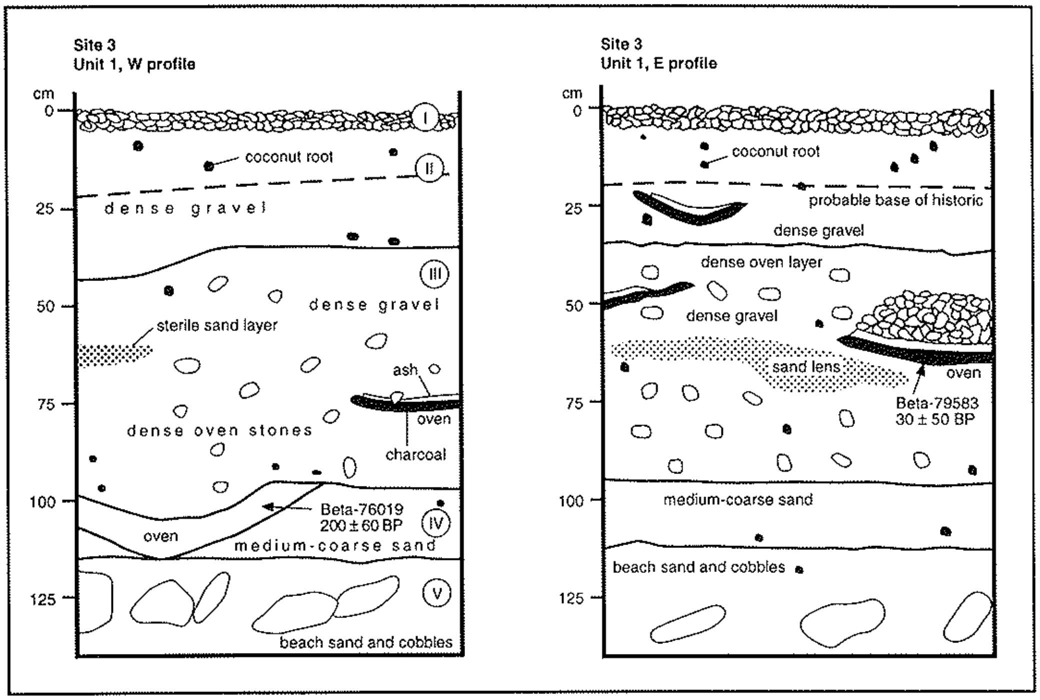

FIGURE 13. Profiles of unit 1, site 3, Bock islet.

essed by Beta Analytic Inc. Pretreatment of the carbonized material consisted of mechanical cleaning with gentle crushing, followed by washings in de-ionized water and removal of any rootlets. Acid washes were used to remove carbonates—a potential problem with samples recovered from calcareous sands on atolls—and alkali washes removed secondary organic acids. The beachrock sample was processed in a similar manner. All procedures went normally.

Table 1 presents the details for each dated radiocarbon sample. When possible, discrete combustion features were selected for dating of known material such as coconut shell or husk and *Pandanus* keys (or drupes). Unidentified wood charcoal was part of two samples and the sole material for one sample. Ideally, it is best to get wood charcoal identified prior to dating to eliminate the possibility of "old" wood that can produce dates not related to the target event (Dean 1978). A thumb-sized piece of wood charcoal was submitted from an oven (Beta-79582) to Gail Murakami of International Archaeological Research Institute, Inc. for identification. The sample could not be identified due to a lack of adequate reference material. It is prudent that atoll reference plants be collected to facilitate wood charcoal identifications which would not only furnish better control for radiocarbon dating, but provide insights into plant use and, perhaps, environmental change during prehistory (Hastorf and Popper 1988; Weisler and Murakami 1991).

The oldest date for the site 1 transect was at unit 2 (AD 256-542), just lagoonward of the *Cyrtosperma* pit concentration. This area, and similar settings on other atolls, has been shown to produce the earliest habitation dates. It is likely that upon discovering Ujae, the colonists explored the atoll and located the largest islet. It is near the center of Ujae islet that the Ghyben-Herzberg lens would be the largest and thickest and the prime locale for

Table 1. Ujae Atoll radiocarbon age determinations.

Beta No.	Provenience	^{14}C	$^{13}C/^{12}C$	Conventional	Material	Weight	Context	Calibrated 2 σ Range(a)
74845	1-2/II (119 cmbs)	1680 ± 60	-26.2	1660 ± 60	1	31.3	in situ	AD 256 - 542
76018	1-5/IV (65-75 cmbs)	610 ± 70	-28.0	560 ± 70	1, 4	23.4(b)	oven	AD 1289 - 1449
79581	1-6/III (30-40 cmbs)	100.4 ± 00.6%	-25.8	100.6 ± 00.6%	2, 3	12.1	dispersed	modern
79582	1-7/I (20-30 cmbs)	101.0 ± 00.7%	-26.8	101.3 ± 00.7%	3, 4	74.6	oven	modern
79583	3-1/III (62-74 cmbs)	70 ± 50	-27.4	30 ± 50	1	62.3	oven	AD 1694 - 1955
76019	3-1/III (112-124 cmbs)	260 ± 60	-28.3	200 ± 60	4	54.4(b)	oven	AD 1531 - 1955
95881	Ujae Is. 1 m above reef platform	2100 ± 60	-1.7	2540 ± 70	beachrock	596.0	oceanside	BC 315 - AD 130

All samples analyzed by radiometric dating technique; 1 = coconut husk; 2 = coconut shell; 3 = *Pandanus* key; 4 = unidentified wood charcoal.
(a) Calibrated after Stuiver and Reimer (1993). (b) Samples given extended counting time.

aroid pit cultivation. North of unit 2, units 5 (AD 1289-1449) and 6 (modern) produced progressively later dates documenting a clear chronological trend from near the center of the islet to the lagoon. While later habitation dates may reflect differential site use and population expansion, islets do build lagoonward (Wiens 1959) and over a period of several hundred years, new land was undoubtedly forming thus providing additional space for settlement.

In the context of islet formation, dating the ocean side beachrock formation establishes when this topographic feature existed (BC 315- AD 130). Admittedly, the sample is not reckoned precisely to modern sea level, but the date may establish a *terminus a quo*, or starting point, in which to determine when the islet could have supported human colonists. It is unlikely that people colonized Ujae prior to the beginning of the first millennium AD. This is in agreement with the earliest dates for Ebon, Kwajalein (Shun and Athens 1990), Majuro (Riley 1987), Maloelap, and Utrõk atolls. Few, if any, archaeologists accept the 3000+ BP dates reported by Streck (1990) for Bikini Atoll, where he has yet to provide the cultural context and complete stratigraphic details of the samples.

If the earliest habitation dates are on the largest islet of each atoll, the smaller islets should have later dates of use. While I am not suggesting that people did not use all the islets from initial colonization, the routine, and more permanent use of these locales, was probably after a period of settlement build-up on Ujae islet. As seen today, residents of the main village venture farther afield for bottom fishing in the lagoon, only after stocks are reduced close by. Diminutive islets, especially without a fresh water lens, could only be used for short periods of time and, consequently, may have only supported small groups while capturing birds, collecting shellfish, and fishing the adjacent shores.

In summary, Ujae Atoll may have been sufficiently above sea level about 2000 BP and, having a large enough land mass and resulting Ghyben-Herzberg fresh water lens, could only then support a permanent human population. The earliest habitation date of AD 256-542 establishes that people settled sometime after the first few centuries AD and used the smaller islets more intensively in later prehistory. The earliest habitation date does not document initial colonization, but suggests that the earliest cultural deposits on Ujae have not been located.

ARTIFACTS

It is on low coral atolls that shell resources are the primary raw material for tool manufacture. With an absence of local volcanic or continental rocks, the fashioning of shell into a wide range of functional and ornamental artifacts was taken to extreme. For example, in the Marshall Islands, adzes were made from at least seven shell taxa: *Tridacna maxima*, *T. gigas*, *Cypraecassis rufa*, *Cassis cornuta*, *Lambis lambis*, *Conus* sp., and *Terebra maculata*. Vegetable peelers and scrapers—modern examples still in use today—were made most frequently from the gastropod *Cypraea tigris* and probably *C. mauritiana* and *C. maculifera*, as well as bivalves including *Anadara* sp., *Asaphis* sp., and *Pinctada margaritifera*. A shell weaving tool was fashioned from *Tridacna*. The large, flat pearlshell bivalve, *Pinctada margaritifera*, provided ample raw material for making a range of single-piece fishhooks and trolling lures; *Turbo* was also used, but to a much lesser extent. The widest spiral near the apex of large cone shells (*Conus leopardus* and *C. literatus*) was shaped into rings that were displayed on arms and hung within greatly distended ear lobes. The raw material for other ornaments, including beads and pendants, was supplied by red-colored *Spondylus* valves, *Conus*, and possibly *Strombus luhuanus*. Abrading tools were made from coral and pumice.

The archaeological assemblage of Ujae artifacts included 35 tools and ornaments of indigenous manufacture (excluding manuports). Most of the specimens are relatively large surface artifacts collected during the survey; however, a few artifacts were subsurface finds (Table 2). I describe the collections under broad functional classes.

Shell Adzes

Adzes made from the shells of Tridacnidae—the largest bivalve known—have a wide distribution in the western and northern Pacific and are the most common shaped artifacts found in Marshall Islands habitation sites. The 23 specimens reported here are surface finds

Table 2. Artifacts from sites 1 and 3, Ujae Atoll, Marshall Islands.

Type/Class	Site 1	Site 3	Total
Historic			
Button	2	0	2
Ceramic	3	0	3
Glass	68	2	70
Metal	154	2	156
Nail	17	0	17
Plastic	4	0	4
Subtotal	248	4	252
Indigenous			
Abraders			
Coral	1	0	1
Pumice	5	0	5
Adzes			
Cypraecassis	7	0	7
Tridacna gigas	4	0	4
Tridacna maxima	11	0	11
Tridacna sp.	1	0	1
Needle			
Bone	1	0	1
Ornaments			
Conus ring	3	0	3
Tectus ring	1	0	1
Manuports			
Non-oceanic rock	3	0	3
Oceanic rock	1	0	1
Pumice	187	1	188
Worked Shell			0
Pinctada sp.	1	0	1
Subtotal	226	1	227
Total	722	9	731

from site 1 on Ujae islet. Because of the relatively small sample size, I followed the classification system devised by Kirch and Yen (1982:208-232) for their analysis of 234 Tikopian shell adzes. Three taxa were identified in the Ujae collection: *Tridacna maxima*, *T. gigas*, and *Cyraecassis rufa*, and the adzes are described under each taxon.

Tridacna maxima is the most commonly-used adze material found in the Marshall Islands and while present throughout the entire sequence, it is more often associated with late prehistory. Fifty percent of the Ujae adzes identified to species are *T. maxima* (Fig. 14a). Adzes were commonly shaped from the valve's dorsal region where the long axis of the adze blade was perpendicular to the radial flutes (see Kirch and Yen 1982:fig.84). This is the region of the valve where the longest adze could be obtained. Also within the dorsal region, 9 of 11 (82%) of the adzes incorporated the area demarcated by the retractor muscle scars undoubtedly because this surface is more parallel to the valve's exterior than any other portion of the shell. Consequently, less grinding would be necessary to derive the final adze shape. It may also be that the shell material is denser and more durable at the retractor muscle scars and, consequently, may have produced stronger adze blades. Of the three adzes where valve side could be determined, all blades were made from the ventral valve (Fig. 14b and c) and measured up to 88.63 mm long. All *T. maxima* adzes that could be assigned a type were type 3 (Kirch and Yen 1982) which is a more specific classification of Rosendahl's (1987) TRI-EXT (exterior region of the *Tridacna* valve, literally, *Tridacna* exterior). The Ujae adzes typically have 50% or more grinding on all surfaces, are quadrangular in cross-section with rounded or blunt-shaped butts, and most frequently have slightly curved cutting edges (in plan) that are flat (see Tables 3 and 4).

Four *T. gigas* adzes (and possibly a fifth, Fig. 15a) display the widest range of variability in size and shape. This is predictable since *T. gigas* reach more than 1.0 m in posterior-anterior length and 10 cm thick, supplying a virtual "blank slate" for adze design. From comparisons with modern reference specimens of *T. maxima* and *T. gigas*, it is readily apparent based on adze size (Fig. 15c) and thickness (Fig. 15b) that these four adzes can only have been fashioned from *T. gigas*. The width of SA 17 (Fig. 15c) exceeds that of average *T. gigas* flutes and was therefore made from the hinge portion of the valve. SA 2 (Fig. 15b) could have been made from the hinge or flute region of thick individual valves. As a class, these adzes typically exhibit 100% grinding and are the longest in the assemblage at 134.22 mm. Cross-sections are plano-convex and quadrangular with blunt or pointed butts, slightly curved or straight cutting edges with concave or flat bevels; these adzes are similar to Kirch and Yen's (1982) type 6 and 8 made from *T. maxima*. *T. gigas* adzes are generally the oldest forms of shell tools in culture-historical sequences from the western and northern Pacific. It is interesting to note that SA 17 (Fig. 15c) may have a residue on the proximal region of the back that may be the result of hafting.

The second most numerous group of Ujae adzes were manufactured from the lip or whorl of the Bullmouth Helmet shell *Cyraecassis rufa*. A number of authors have confused this taxon with the Horned Helmet shell (*Cassis cornuta*) when referring to some adzes made from the lip or whorl (e.g., Beardsley 1994:photo 15; Kirch and Yen 1982:fig.91g; Shun and Athens 1990:fig.3 specimen 2). Although adzes, chisels, and gouges were made from the lip of *Cassis cornuta* and *Cypraecassis rufa*, only whorls of the latter taxon where fashioned into adzes. I have seen no adzes made from the whorl of *Cassis cornuta* either in

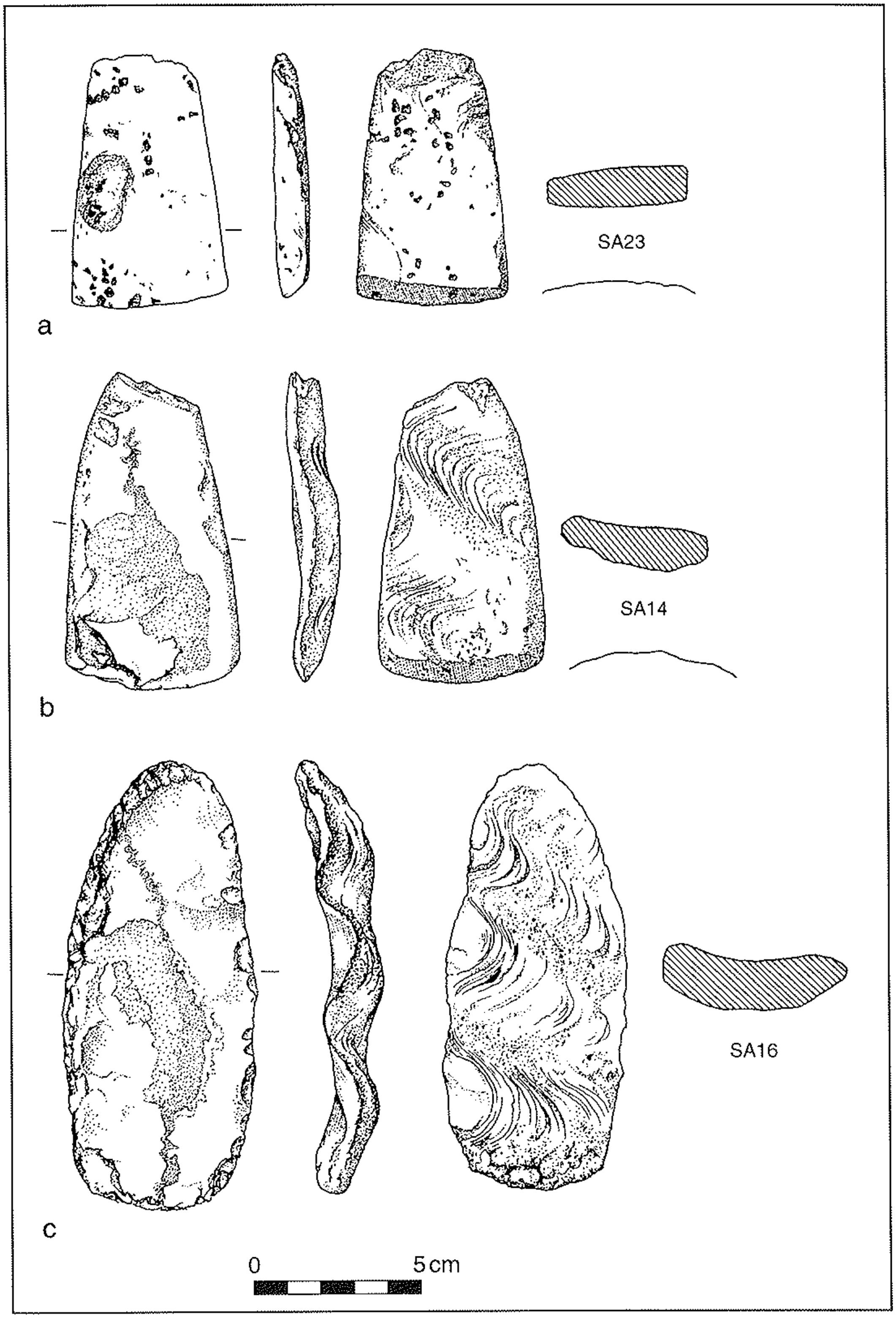

FIGURE 14. *Tridacna maxima* shell adzes. All specimens made from the dorsal region of the valve, perpendicular to the radial flutes. a and b = finished forms; c = adze preform flaked to rough shape, ready for grinding. Artifacts b and c made from the ventral valve.

Table 3. Discrete attributes of Ujae shell adzes*.

Taxon	Catalog No.	Stage	Portion	Cross-section	Butt Shape	Shell Region	Grinding Location	Grinding %	Cutting Edge In Plan	Bevel	Kirch &Yen (1982) Classification
Tridacna maxima	SA 1	finished	midsection	quadrangular	—	dr	f, b, s	50-100	—	—	—
Tridacna maxima	SA 4	finished	butt+mid	quadrangular	rounded	dr	f, b, s	50-100	—	—	3
Tridacna maxima	SA 7	finished	whole	quadrangular	rounded	dr	f, b, s	50-100	straight	flat	3
Tridacna maxima	SA 9	finished	mid+edge	quadrangular	—	dr?	f, b, s	50-100	curved	flat	3?
Tridacna maxima	SA 11	finished	butt+mid	quadrangular	blunt	dr?	f, b, s	50-100	—	—	3
Tridacna maxima	SA 12	finished	mid+edge	quadrangular	—	v, dr	f, b, s	50-100	slightly curved	flat	—
Tridacna maxima	SA 13	finished	mid+edge	quagrangular	—	dr	f, b, s	50-100	straight	flat	—
Tridacna maxima	SA 14	finished	whole	quadrangular	rounded	v, dr	f, b, s	50-100	slightly curved	flat	3
Tridacna maxima	SA 16	preform	whole	quadrangular	rounded	v, dr	—	0	—	—	3?
Tridacna maxima	SA 23	finished	whole	quadrangular	blunt	dr	f, b, s	50-100	slightly curved	flat	3
Tridacna maxima	SA 25	finished	butt+mid	quadrangular	rounded	dr	f, b, s	50-100	—	—	3
Tridacna sp.	SA 18	finished	mid+edge	quadrangular	—	?	f, b, s	100	curved	flat	8
Tridacna gigas	SA 2	finished	whole	plano-convex	blunt	?	f, b, s	100	slightly curved	concave	6
Tridacna gigas	SA 10	finished	butt+mid	plano-convex	rounded	?	f, b, s	100	—	—	6
Tridacna gigas	SA 17	finished	whole	quadrangular	pointed	?	f, b, s	100	straight	flat	8
Tridacna gigas	SA 21	finished	butt	?	rounded	?	f, b, s	100	—	—	8?
Cypraecassis rufa	SA 3	finished	mid+edge	concave-convex	—	whorl	b, s	0-50	curved	flat	10
Cypraecassis rufa	SA 5	finished	whole	plano-convex	round	lip	f, b, s	100	curved	flat	9
Cypraecassis rufa	SA 15	finished	whole	concave-convex	pointed	whorl	b, s	0-50	slightly curved	flat	10
Cypraecassis rufa	SA 19	finished	whole	concave-convex	pointed	whorl	b,s	0-50	slightly curved	flat	10
Cypraecassis rufa	SA 20	finished	mid+edge	concave-convex	—	whorl	b, s	0-50	curved	flat	10
Cypraecassis rufa	SA 24	finished	whole	plano-convex	pointed	lip	f, b, s	0-50	curved	concave	9
Cypraecassis rufa	SA 26	finished	mid+edge	concave-convex	—	whorl	b, s	0-50	curved	flat	10

* abbreviations. Shell Region: dr = dorsal region, v = ventral. Grinding Locations: f = front, b = back, s = side.

Kirch and Yen (1982) types 6 and 8 refer to *Tridacna maxima*, although the Ujae *T. gigas* adzes appear to be similar in form.

Table 4. Continuous attributes of Ujae shell adzes*.

Catalog No.	Length	Width Cutting Edge	Width Midpoint	Width Poll	Thickness Midpoint	Thickness Butt	Weight	Cutting Edge Angle	Ratio WT	Ratio WL	Ratio TL	Taper
SA 1	—	—	35.58	—	4.80	—	—	—	7.41	—	—	—
SA 2	78.76	21.85	22.89	16.08	24.25	18.78	68.1	50	0.94	0.29	0.31	1.42
SA 3	—	—	29.25	—	4.50	—	—	40	6.50	—	—	—
SA 4	—	—	45.04	22.63	8.41	7.91	—	—	5.36	—	—	1.99
SA 5	66.46	19.70	17.35	6.43	10.05	5.31	21.2	40	1.73	0.26	0.15	2.70
SA 7	73.56	33.13	32.23	13.70	11.94	6.24	45.6	40	2.70	0.44	0.16	2.35
SA 9	—	34.33	33.49	—	7.14	—	—	30	4.69	—	—	—
SA 10	—	—	—	39.08	—	28.59	—	—	—	—	—	—
SA 11	—	—	33.21	17.38	6.02	6.04	—	—	5.52	—	—	1.91
SA 12	—	40.02	43.98	—	6.04	—	—	45	7.28	—	—	—
SA 13	—	37.10	34.20	—	5.06	—	—	50	6.76	—	—	—
SA 14	88.63	49.52	41.97	28.24	10.27	9.31	73.4	50	4.09	0.47	0.12	1.49
SA 15	78.81	41.08	33.06	8.83	8.13	7.35	39.7	40	4.07	0.42	0.10	3.74
SA 16	126.18	39.81	53.72	19.37	12.21	6.99	143.6	—	4.40	0.43	0.10	2.77
SA 17	134.22	72.08	62.87	22.56	20.22	15.88	295.9	45	3.11	0.47	0.15	2.79
SA 18	—	25.73	24.97	—	6.87	—	—	40	3.63	—	—	—
SA 19	81.25	31.30	29.65	9.13	7.22	8.14	32.1	55	4.11	0.36	0.09	3.25
SA 20	—	44.00	41.46	—	3.65	—	—	45	11.36	—	—	—
SA 21	—	—	—	51.64	—	—	—	—	—	—	—	—
SA 23	75.89	45.85	39.78	28.10	11.79	7.30	69.1	60	3.37	0.52	0.16	1.42
SA 24	83.22	20.53	23.39	7.87	22.55	16.33	66.8	45	1.04	0.28	0.27	2.97
SA 25	—	—	35.12	15.05	5.89	5.43	—	—	5.96	—	—	2.33
SA 26	—	—	—	—	5.18	—	—	40	—	—	—	—

* abbreviations. Ratio WL = ratio of midpoint width/midpoint thickness; Ratio WL = ratio of midpoint width/length; Ratio TL = ratio of midpoint thickness/length; Taper = ratio of midpoint width/poll width.

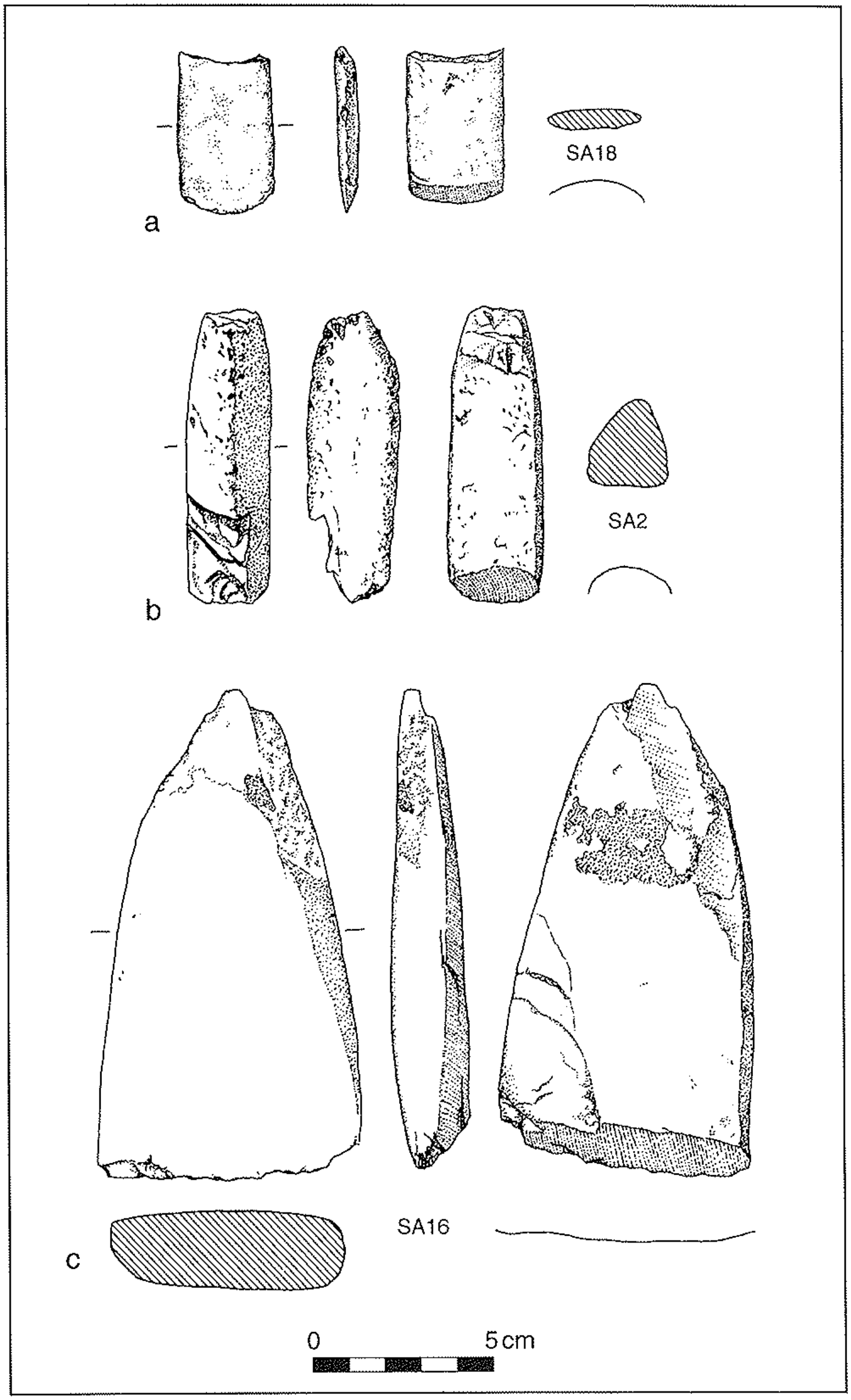

FIGURE 15. Shell adzes of *Tridacna gigas* typically display a wide range of cross-section form.

publications or in the Alele Museum (National Museum of the Marshall Islands) collections. Inspection of whole and fragmentary reference shells shows clearly that the whorls of *Cassis cornuta* are much thinner with an uneven surface. Five of seven (71%) specimens were made from the whorl of *Cyraecassis rufa* shells at least 138 mm long (Fig. 16c and d). Grinding is minimal on the back and sides and is not required on the front surface. All specimens are concave-convex in cross-section with curved to slightly curved, flat cutting edges at an angle of 40-55° (see Tables 2 and 3). These specimens are type 10 of Kirch and Yen (1982). Two adzes made from the lip region are both plano-convex in cross-section and are classified as type 9. Grinding is minimal (Fig. 16a) to 100% (Fig. 16b) The cutting edges are curved and flat or concave.

Abraders

These artifacts were used for shaping and smoothing relatively soft material—such as thin shells (e.g., *Conus* sp. and *Pinctada* sp.), wood, and bone—into tools and ornaments. A single *Acropora* sp. branch coral abrader has a rounded and smooth surface that would be ideal for shaping the interior bend of pearlshell fishhooks. It measures 71.22 mm long and

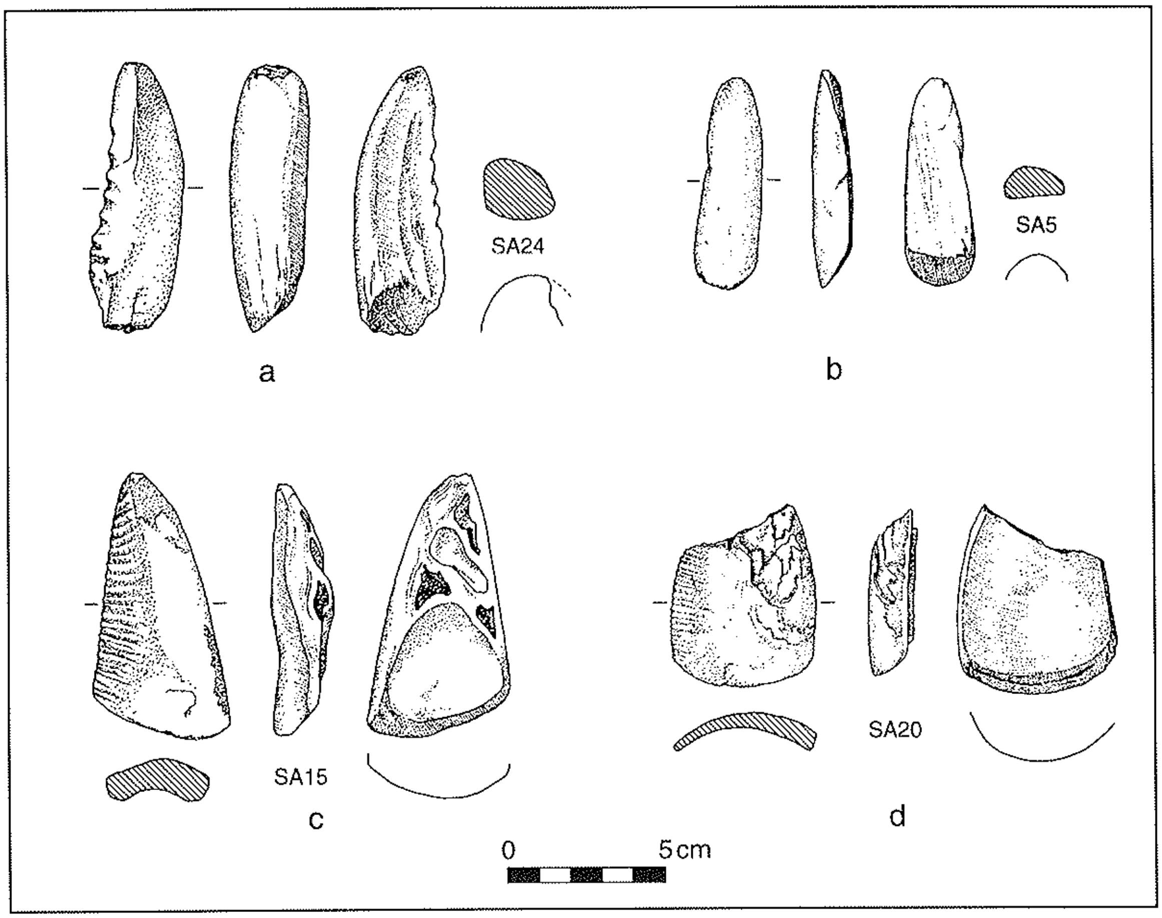

FIGURE 16. Adzes made from the lip region (a and b) and body whorl (c and d) of *Cypraecassis rufa*.

weighs 6.0 gms (Fig. 17f). According to Rosendahl, who made extensive surface collections throughout the Marshalls, and my examination of the artifact collections in the Alele Museum, *Acropora* sp. branch coral abraders are much less common than the *Porites* sp. forms that are angular and blocky (cf. Rosendahl 1987:fig.1.67, a, c, and h with Fig. 17f). Four pumice abraders (mean length = 40.92 mm; mean weight = 4.28 gms) each have multiple worn facets that were used to shape flat and convex surfaces (Fig. 17g, h, and i). Fosberg (unpublished, cited in Sachet 1955:12) reported that a large black, coarse-grained, hard pumice was seen in use as a whetstone for machetes on Bock islet, Ujae and a similar piece was found inland in the northeast region of Ujae islet. It is plano-convex with use-wear on the flat surface and measures 106.20 mm long and weighs 158.6 gms.

Worked Pearlshell

Only one piece of clearly worked shell was recovered. A 28.10 mm long specimen (16.08 wide and 4.72 mm thick) of *Pinctada* sp. may be the by-product of fishhook manufacture (Fig. 17c). It is slightly ground on a portion of the interior surface.

Ornaments

Shell rings are the most ubiquitous ornaments found in the Marshall Islands and have been referred to as arm bands, bangles, or circular units, to name just a few (cf. Kirch 1988). The rings were variously worn on lower and upper arms as well as within greatly stretched ear lobs. The rings were most commonly made from the largest cone shell (*C. leopardus* or *C. litteratus*), although *Tectus* and probably *Trochus* were also used. Portions of four rings were recovered from Ujae, displaying three styles made from *Conus* and *Tectus*. The largest ring fragments—with projected diameters of 60 and 80 mm—display up to four neatly-incised parallel grooves (Fig. 17a) and are similar, but not identical, to a ring reported from Ebon Atoll (Rosendahl 1987:fig.1.76l). The illustrated Ujae ring measures 16.69 mm wide and 3.00 mm thick, while the second one measures 5.29 mm thick with an incomplete width. Another *Conus* ring has raised parallel margins and an estimated whole diameter of 50 mm, a width of 13.91 mm, and 2.26 mm in thickness in the center (Fig. 17b). Despite being only 18.41 mm long, a shell ring fragment of *Tectus* has a reconstructed diameter of 60 mm; it has no design.

A small *Terebra* cf. *dimidiata* shell (length = 83.18 mm) has a hole chipped near the aperture to facilitate suspension as a pendant (Fig. 17e). No other *Terebra* shell pendants have been reported from archaeological contexts in the Marshalls.

Bone Tool

Possibly made from a mammal long bone, this elongate, flat, pointed artifact measures 76.57 mm in length and, at the center, is 7.72 mm wide and 2.65 mm thick; it weighs 1.6 gms. The proximal portion is biconically drilled, while the pointed end is worn and blunted probably from use as a thatching tool or needle (Fig. 17d). It is covered with scratches oblique to its long axis and has a polished appearance overall. This is the only known example of this artifact type from the Marshalls.

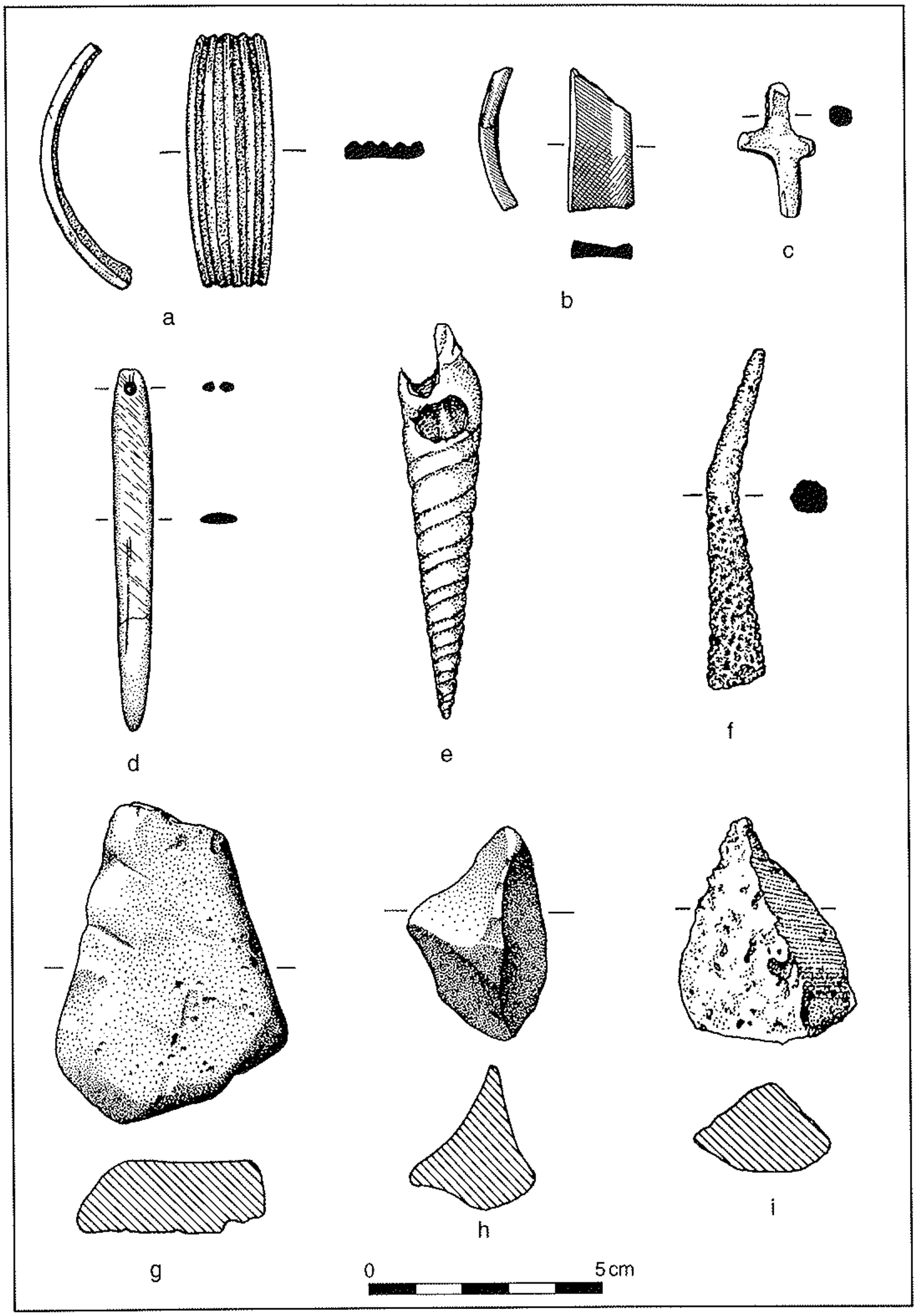

FIGURE 17. Assorted artifacts from Ujae excavations a = *Conus* shell ring fragment with four neatly incised grooves; b = *Conus* shell ring fragment with slightly raised edges; c = worked pearl shell (*Pinctada margaritifera*); d = possible thatching needle made from mammal (?) bone; e = *Terebra* pendant; f = *Acropora* sp. file or abrader; g - i = pumice abraders with flat and rounded used surfaces.

Manuports

These artifacts include physically-unmodified items that are foreign to their place of cultural deposition. Included here are pieces of pumice that were probably collected along the lagoon edge or ocean shore and brought to the habitation site for shaping into abraders or simply crushed and added to garden plots to enrich the soil with iron and trace elements (Sachet 1955). Because pumice was found only in the cultural deposits, and not the sterile subsoil, it is assumed here that the material was humanly transported; it can, however, occur naturally in the interior of smaller islands. Some 187 unshaped pieces weighing 74.6 gms were recovered from site 1, while site 3 contained only one specimen weighing 0.2 gms; all material was from subsurface contexts and has identical fine texture and absence of large inclusions; Munsell color of unweathered interior surfaces was 2.5Y 7/3 (pale yellow). A piece of pumice collected by Fosberg on Ujae in 1952 had an iron content of 2.7% (Sachet 1955:21). A recent geochemical analysis of Ujae pumice is presented in Table 5.

Four additional manuports were found as surface artifacts and, unfortunately, cannot be placed chronologically. They are, however, important for documenting the availability of non-local rocks that, on other atolls, have been used for abrading tools, hammerstones, and oven stones. None of the Ujae non-pumice manuports exhibit evidence of physical modification. There are two specimens of metamorphosed quartz sandstone (65.7 and 238.6 gms), an altered rhyolite lava (261.5 gms), and a highly weathered volcanic rock (117.4 gms). X-ray fluorescence analysis and thin-section petrography were conducted to gain some insight as to the geological origins of these rocks (Tables 5 and 6). The sandstone and rhyolite specimens come from mainly mature island arcs or continental margins such as Japan, western United States, and New Guinea (John Sinton, personal communication, 1994). The weathered volcanic rock originated from an oceanic island, the nearest is Kosrae, some 540 km (290 nautical miles) southwest. Other oceanic rocks have been found in the Marshalls (e.g., Namu Atoll, Mason 1947:10; Spennemann and Ambrose 1997), yet the Ujae specimen is quite weathered and soft and not ideal for tool manufacture; there is no evidence suggesting use as an oven stone. It is unlikely these manuports were humanly transported from their place of geologic origin, as they may have arrived in the roots of drift logs. It is also possible that the metamorphosed quartz sandstone is discarded ship ballast from the German era (1857-1914) when vessels plied the Marshalls to acquire copra.

FAUNAL MATERIAL

Fish

Understanding prehistoric fishing strategies in the tropical Pacific and how practices may have evolved over time has been a subject of major inquiry for the past few decades. There have been numerous detailed studies of portable technology such as fishhooks (Emory *et al.* 1959; Sinoto 1959, 1962; Weisler and Walter 1999) as well as summaries of the impressive fish ponds and traps of Hawai'i (Kikuchi 1976; Summers 1964). How and why fishing strategies changed over time has been the subject of numerous papers from New Zealand (Anderson 1997; Leach and Anderson 1979; Leach and Boocock 1993), the Cook Islands (Allen 1992; Walter 1998), Hawai'i (Kirch 1979), the Marquesas (Rolett 1989; Leach *et al.* 1997); the Societies (Leach *et al.* 1984), a few areas of Micronesia (e.g., Leach *et al.* 1996), and Near Oceania or the western Pacific (Butler 1994). Ethnographic studies

Table 5. X-ray fluorescence analysis of oceanic and non-oceanic rocks from Ujae site 1.

	Artifact Number				
	S.A. 6	S.A. 8	S.A. 27	S.A. 28	Pumice
Normalized Results (wt%)					
SiO_2	71.77	75.57	45.02	69.27	67.27
Al_2O_3	12.99	13.30	14.28	16.09	15.43
TiO_2	0.766	0.163	+6.04	0.888	0.390
FeO*	4.88	1.44	11.53	5.47	3.88
MnO	0.089	0.016	0.207	0.048	0.119
CaO	1.62	0.33	12.02	0.63	5.31
MgO	2.33	0.09	5.58	2.06	1.17
K_2O	2.05	5.06	2.85	3.54	1.09
Na_2O	3.36	3.97	1.48	1.84	4.05
P_2O_5	0.153	0.068	+1.00	0.17	+1.129
Trace Elements (ppm)					
Ni	24	10	100	37	5
Cr	99	2	19	69	5
Sc	17	2	28	22	18
V	72	0	397	84	39
Ba	233	611	849	492	184
Rb	82	174	68	130	14
Sr	220	100	762	106	597
Zr	286	103	450	193	83
Y	27	38	38	33	19
Nb	12.6	15.9	+89	22.0	1.4
Ga	9	10	21	17	13
Cu	7	1	79	5	5
Zn	63	12	+130	42	70
Pb	10	11	0	6	3
La	14	52	53	18	0
Ce	66	101	119	72	15
Th	8	24	4	12	0

Major elements are normalized on a volatile-free basis. *Total Fe is expressed as FeO.
"+" denotes values >120% of the highest standard. For analytical procedures see Hooper *et al.* (1993).

(Dye 1983; Kirch and Dye 1979) have been especially useful in expanding knowledge gained solely from the analysis of artifacts, fish bones, and their spatial relationships. Of importance here is the excellent exposition on Belauan traditional marine lore by Johannes (1981). And I personally cannot argue strongly enough for participant observation which has been vital to my understanding of prehistoric fishing. For example, some would argue that parrotfish (Scaridae), with its robust mouth parts, is an important family when considering its contribution to prehistoric subsistence. However, having spent more than two years on more than half a dozen atolls in the Marshalls, it is obvious that this family is over-represented in the archaeological assemblage because its hard mouth parts—used for identification—preserve well and bear little resemblance to the rank-order abundance by family of what is caught today.

Table 6. Petrographic descriptions of oceanic and non-oceanic rocks from Ujae site 1.

Artifact No.	Description
S.A.6	Metamorphosed quartz sandstone, now a slightly foliated, partially recrystallized, quartzo-feldspathic schist. There are lots of strung-out quartz and feldspar clasts about 1-1.5mm long in a foliated matrix of either biotite or possibly stilpnomelane, quartz, feldspar and some zircon and apatite. This is a low grade (greenschist, about 350°C) metamorphic rock of an originally quartz-rich sediment. Such rocks come from mature arc or continental settings.
S.A.8	This is an altered rhyolite lava with lovely quartz and altered feldspar phenocrysts about 2 mm in size in a largely altered, very fine-grained groundmass. The feldspars are completely replaced by a cloudy, cryptocrystalline mica, probably mainly sericite. There are also some iron-rich olivines in this rock. Rocks like this come from arcs, mainly mature island arcs or continental margins, e.g. Japan, western US, New Guinea etc.
S.A.27	This rock also is a metamorphosed quartz-rich sediment but it has quite a different texture than S.A.6. There are subrounded clasts of quartz and feldspar about 0.3-0.5 mm in a matrix of pale brown biotite, a little muscovite, apatite, quartz and feldspar. The rock is not strongly foliated or schistose. The temperature of metamorphism is similar as for S.A.6, but the texture is quite different (different stress regime). Also from some mature arc or continent.
S.A.28	A volcanic rock without phenocrysts, there are microphenocrysts (~0.3 mm) of Ti-rich clinopyroxene in a vesicular groundmass of Ti-clinopyroxene, plagioclase and magnetite. Rocks like this come from oceanic islands.

I would like to illustrate the importance of local fishing knowledge when interpreting a fish faunal assemblage. On Utrõk Atoll, from late November to early February (1996-97), goatfish (Mullidae) and rabbitfish (Siganidae) made up more than half of the fish consumed in the village. It was quite common to capture schools numbering in the hundreds by seine nets positioned out from the shoreline. In fact, I ate Yellowstripe goatfish (*Mulloides flavolineatus* and *M. vanicolencis*) nearly every day and it wasn't even the peak season for its occurrence (Myers 1991:148). Both mullids and siganids have relatively fragile mouth parts and their limited occurrence in archaeological deposits is probably due more to taphonomic processes, than prehistoric subsistence practices.

On Airik islet, Maloelap Atoll, I witnessed in November (1993), a fishing technique that has virtually no archaeological visibility—both of the tools used for capture and the resulting fish bones that may become incorporated into cultural deposits. In the very early morning hours, when the water is calm, about a half dozen men position themselves along the lagoon shore, each spaced about 3-5 m apart, standing on the wet sand. Each person holds at opposite ends, a tightly braided, 2 m coconut leaf that is bent in a U-shape. Constantly watching the inshore waters, the men scan for predatory carangids that are chasing schools of juvenile mullids, herding them ever closer to the dry shoreline. Once the school is forced into water less than 20 cm deep, the young fish flee the predator by breaking the surface in unison thus alerting the men to their presence. Each man then swoops down with his braided coconut leaf forming a barrier around the school, open to the wet sand. The leaf is then dragged along the bottom, pulling slowly towards dry sand. A couple kilograms of fish can be trapped by each fisherman. The fish are then consumed whole. There is, of course, no visibility of this technique in the archaeological deposits.

The last example I will mention is that recorded on Ebon Atoll in 1995. The Marshallese word, *ajilowōd* refers to a "herd of bonitos that enters [the] lagoon and can't find its way out" (Abo *et al.* 1976:307). Etna Peter, longtime Ebon resident, described, by word and picture, how large schools of skipjack tuna (*Katsuwonus pelamis*) would enter the lagoon. Each family of the village then gathered coconut leaves which were woven to form a loose braid several meters long. The weave was loose enough that leaflets extended in all directions around the braid. By securing numerous sections of coconut leaf braids (one produced by each family), the length was extended to a couple hundred meters. The "rope" was then loaded onto several canoes with the goal of getting the school positioned between the lagoon shore (at the main village) and a half-circle line of canoes. The canoes moved slowly towards the shore, scaring the tuna to shallow water where they were speared by waiting villagers. As I have witnessed on numerous occasions, fish are hesitant to swim under thick ropes lying on the surface. Although this technique would not be visible archaeologically, the presence of scombrid bones in archaeological sites from the Marshall Islands, is not an automatic proxy for inferring the trolling fishing technique.

The archaeological fish bones from Ujae Atoll were identified to the lowest taxonomic level possible using an extensive reference collection derived in large part from the Marshall Islands and excellent illustrations of scarids in Bellwood (1994). For those families including Carangidae, Labridae, and Scaridae, sufficient reference material permits identification to genus. This is especially important since carangids inhabit a wide range of environments and can be captured by varied techniques. Scarid and labrid bones identified at the genus level can sometimes reveal their habitat preferences which may relate more precisely to the ecology of fishing strategies (Bellwood 1994; Bellwood and Choat 1990; Myers 1991; Randall 1996).

Some 4,473 fish bones were identified, 575 (12.7%) to family or below (Table 7). The five-paired mouth parts (maxillary, premaxillary, dentary, articular, and quadrate) along with other post-cranial bones were used for identification. These latter elements included dermal spines of diodontids, scutes and pterygiophores of carangids, scales of balistids, and caudal peduncle of scombrids. The assemblage was also separated into cranial bones, spines, and vertebrae to gain a better understanding of the assemblage structure. For example, there are more than twice as many vertebrae at site 1 than there are at site 3, and this difference may relate to variable processing techniques, consumption patterns or, perhaps, taphonomy. While I make no pretence that the fish bone assemblage is a random sample, it should broadly represent what is present in the archaeological deposits. Some 19 families were identified which is only about five families less than much larger samples from Ebon, Maloelap, and Utrõk atolls.

Since there was no fishing gear recovered from the excavations, it may be that seine net fishing from the ocean side, but mainly from the more protected lagoon shoreline, was a dominant strategy. With the exception of Belonidae, Cirrhitidae, Diodontidae, Lethrinidae, marine eel, and Scombridae, the majority of fish could be captured by net; this is 95% of all

Table 7. Number of identified specimens (NISP) for fish bone from sites 1 and 3, Ujae Atoll.

Taxon	1	3	Total
Acanthuridae	10	3	13
Balistidae	20		20
Belonidae	1	1	2
Bothidae	1	2	3
Carangidae			
Caranx	2	1	
Elagatis	1		
Selar	1	1	
Total Carangidae (all taxa)	31	20	51
Cirrhitidae		1	1
Diodontidae	14		14
Elasmobranchii	1		1
Exocoetidae	1		1
Holocentridae	6		6
Labridae			
Labridae (to family only)	2	4	
Bodianus	2		
Coris	1		
Thalassoma	2	1	
Total Labridae (all taxa)	7	5	12
Lethrinidae			
Lethrinus	1		
Monotaxis	2		2
Total Lethrinidae (all taxa)	3		3
Marine eel	1	1	2
Mullidae	2	2	4
Nemipteridae		1	1
Ostraciotidae	1	15	16
Scaridae			
Scaridae (to family only)	52	34	86
Calotomus	1	2	3
Scarinae	53	13	66
Scarinae (not *Scarus*)	6	4	10
Cetoscarus bicolor	9	2	11
Hipposcarus longiceps	17	16	33
Scarus/Hipposcarus	91	27	118
Scarus spp.	22	11	33
Scarus gibbus	4	4	8
Scarus oviceps	2		2
Total Scaridae (all taxa)	257	113	370
Scombridae		2	2
Serranidae	48	5	53
Total identified	404	171	575
Total unidentified	2672	1226	3898
Total cranial	1762	919	2681
Total spines	279	247	526
Total vertebrae	1035	231	1266
Total bones	3076	1397	4473
% identified	13.1	12.2	12.7

identified bones as quantified by number of identified specimens (NISP). It is often the case that one family can be captured by a number of techniques. For example, just about any fish can be speared under the right circumstances. Balistids, cirrhitids, lethrinids, and serranids are often caught by hooks dropped from a canoe off the reef slope. While bearing in mind taphonomic processes and the relatively small sample size—only Balistidae, Carangidae, Scaridae, and Serranidae are represented by more than 20 NISP each—there is every reason to suspect that the prehistoric residents of Ujae used a varied set of capture techniques as practiced by individuals, small groups, and, at times, by most of the village in a cooperative fashion (such as tuna fishing described above). Certain taxa do stand out as representing a certain capture technique more than others. Belonidae are almost exclusively taken by trolling as well as the carangid, *Elagatis*, which is taken inside the lagoon, while larger individuals are caught along the ocean side reef edge. Cirrhitidae and Lethrinidae are caught most frequently by baited hook lowered from canoes on the ocean side reef or deeper lagoon. Diodontidae are usually speared. Scarids are usually netted or speared, although one time in Hawai'i, I saw one caught by a hook baited with seaweed.

Birds

No other class of fauna has been more instrumental in understanding the role of humans in causing extinctions and faunal depletions on Pacific islands than birds. By some estimates, more than 2,000 species of land birds disappeared after human colonization of Oceania (Steadman 1995). While most attention has focussed on diachronic changes such as extinctions and the resulting description of new taxa (James and Olson 1991; Steadman 1989; Wragg and Weisler 1994), less effort has focussed on functional studies like the role of bird use in relation to the settlement landscape. What role did birds fill in the subsistence regime? How were they captured? Are there sites within the atoll settlement system that can be identified as bird procurement locales? Much has been written about prehistoric fishing through the analysis of artifacts, bones, and ethnohistoric records, but little about birds. This is understandable in terms of visibility—there are numerous artifacts associated with fishing, yet none identified exclusively for capturing birds.

The Ujae bird bone assemblage, totaling 87 specimens, was analysed to understand the role of avian predation within an atoll setting. The model, proposed here, is that each wooded islet within Ujae Atoll should have supported bird colonies prior to human colonization. Indeed, on many atolls, I have observed terns nesting on rubble cays and noddies breeding on even the smallest of islets with just a few trees. It is quite likely that the largest islets with forests of *Pisonia* would have supported sea bird colonies in the thousands. After human colonization of the largest islet of Ujae, bird populations would have been reduced rapidly—perhaps within a few human generations—and remnant colonies shifted to the offshore islets. These smaller offshore islets, that could not sustain permanent human populations due to a lack of fresh water, became resource locales where small human groups visited for several days at a time for capturing birds and exploiting the adjacent marine environments. How, then, would this be visible archaeologically?

The Ujae bird bones were first identified to lowest taxon by Alan Ziegler, then analyzed further by David Steadman. At the University of Otago, the bones were analyzed taphonomically by recording for each bone: species, element, portion, age, segment, length, presence of burning, burning color, cut marks, gnawing, weathering, midden staining, and other modifications. Unlike most fish remains, bird bones can be incorporated into archaeological sites by non-human means and it was important to remove any obvious elements that may have been incorporated into the prehistoric cultural deposits by natural deaths (Weisler and Gargett 1993).

Table 8 presents the identified bird taxa from Ujae sites 1 and 3. Due to the highly fragmented condition of the elements, 64% were identified only to small, medium, or large bird. The subsurface bone was generally well preserved, while most of the elements recovered in the first spit or within the coral pavement of the modern village were white and clearly of recent deposition; many of these bones were of historically introduced taxa such as domestic chicken (*Gallus gallus*) and turkey (*Meleagris galloparo*), but three elements of booby (*Sula* sp.) were also identified. Of the total assemblage, 55 specimens (63%) were from prehistoric contexts. These bones showed no signs of burning, cut marks, or gnawing. From recent observations of Marshallese capturing, butchering, cooking, and discarding noddies (*Anous* spp.) and boobies, it is likely that only the proximal end of the humeri will show direct evidence of butchering. On smaller birds, such as noddies and terns, the wings are simply twisted and pulled off and show characteristic spiral fractures. While the same can be done with much greater effort for larger birds, today, wings are usually severed by cutting with a knife.

The smaller, denser bones were disproportionately well-preserved and used for identification to family level. These elements included the phalanx, tarsometatarsus, carpometacarpus, tibiotarsus, coracoid, and portions of the humerus and radius. One of the more significant bone attributes was the age of the individual represented by adult or juvenile (i.e. pre-flighted) elements. Bones of young individuals can be identified by their rough surface texture, whereas adult elements are smooth. All juvenile bones were recovered from Bock islet and strongly points to capturing young birds from their nests.

Of the prehistoric bird bones identified to family, all save one, were identified to Laridae. This family includes noddies, terns, and gulls and, judging from the small size of the archaeological bones, the first two are most likely. In fact, since noddies nest in the thousands throughout the Marshall Islands, it seems probable that bones of these species would be most common in the middens. The other family identified was Scolopacidae which includes such shorebirds as sandpipers and curlews.

Human occupation of Ujae Atoll was at least by AD 256-542 which may be several hundred years after colonization. This seems to be reflected in the total absence of extinct bird taxa which are usually a signature of the earliest occupation layers. Considering that only 1 m^2 was excavated on Bock islet (representing only 11% of the total subsurface sample), 55% of the prehistoric bird bones were found there. This suggests the importance of bird collecting on Bock islet and may signal a similar subsistence focus on the other offshore islets. From determining the growth stage of the individual bones, many of the birds captured on Bock were juveniles without the capability of flight. Although identification was at the family level, a small bird, such as the noddy, was the likely target prey. The low frequency of bird bones in the major habitation site of Ujae islet and high occurrence on Bock, suggests that birds may have been scarce on the main islet and birds on the offshore islets were consumed immediately after capture; that is, they were not taken back to

Table 8. Summary of bone, shellfish, and other midden from sites 1 and 3.

Taxon	Site 1 count	Site 1 weight	Site 3 count	Site 3 weight	Total count	Total weight
Bone						
Bird						
Small/medium bird	—	—	5	—	5	—
Medium/large bird	36	—	7	—	43	—
Medium bird	7	—	—	—	7	—
Large bird	—	—	1	—	1	—
*Gallus gallus**	4	—	—	—	4	—
Laridae	1	—	19	—	20	—
*Meleagris galloparo**	3	—	—	—	3	—
Scolopacidae	—	—	1	—	1	—
Sula sp.*	—	—	3	—	3	—
Total bird	51	—	36	—	87	—
Fish	3076	—	1397	—	4473	—
*Canis familiaris**	1					
Homo sapiens	27	—	0	—	27	—
Lizard	2	—	0	—	2	—
Medium vertebrate	64	—	5	—	69	—
Rattus exulans	8	—	0	—	8	—
*Sus scrofa**	3					
Turtle (cf. *Chelonia mydas*)	2	—	0	—	2	—
Unidentified mammal	20	—	0	—	20	—
Total bone	3305		1474		4775	
Shellfish						
Gastropods	2722	6866.5	176	366.2	2898	7232.7
Bivalves	662	3857.2	196	1908.7	858	5765.9
Total shellfish	3384	10723.7	372	2274.9	3756	12998.6
Charcoal	209	84.6	458	77.9	667	162.5
Crustacea	19	6.1	5	1.2	24	7.3
Echinoderms	449	262.9	3	3.5	452	266.4
Pumice	187	74.6	1	0.2	188	74.8

* = Recovered from historic contexts.

the main islet. Those smaller islets without a fresh water source were incapable of sustaining permanent human groups and can be seen as resource locales within the wider atoll settlement pattern. These islets, although probably visited by the first human colonists, played a more vital role in later prehistory after bird colonies were depleted near major habitation sites.

Human Remains

A total of 27 bones were identified as human and were only recovered from site 1 at units 2 and 6. As with all faunal material, Alan Ziegler analyzed the bone first, identifying the elements to nearest taxon. Mike Green, a physical anthropologist then at the University of Otago, made further observations and comments. The bones were quite fragmentary, without any signs of chemical erosion. Post-depositional breakage was probably the result of physical actions such as mixing cultural deposits through excavation for combustion and other habitation features. Judging from the depositional contexts, a minimum number of five individuals are represented based on skeletal and dental fragments. From unit 2 the following were inventoried: one adolescent to small adult represented by a patella fragment; the left temporal (petrous) fragment of an infant; a left temporal fragment belonging to an older child or early adolescent; the permanent left maxillary tooth (M3) of someone between the ages of 17-25 years old; and from unit 6, a deciduous left mandibular (M1) tooth from a 1-2 year old child. The concentration of at least four individuals in the stratigraphic sequence of unit 2 suggests possible use of the area as a small cemetery. No grave goods could be unequivocally associated with the bones due to the mixed nature of the cultural deposits, although several shell ring fragments were found in the deposits.

Other Bone

Included in this category is lizard, turtle, *Rattus exulans*, dog (*Canis familiaris*), pig (*Sus scrofa*), medium vertebrate, and unidentified mammal (see Table 8). Only two turtle bones were recovered and this may reflect its early depletion in the first few hundred years after human colonization of the atoll. The tracks and nest sites of a few individuals noted during the survey of the smaller islets may indicate the remnants of a much larger population that has never regained its previous numbers. The situation appears to be similar to Henderson island, southeast Polynesia, where the archaeological occurrence of turtle bones is much greater in the early prehistoric period and modern sightings of the green sea turtle (*Chelonia mydas*) are quite limited (Brooke 1995).

Bones of the Pacific rat (*Rattus exulans*) were found in three units from site 1. Recovery of bones of this taxon is highly correlated to the use of small mesh sieves during excavation. Because 6.4 mm sieves were used, this faunal category is clearly under-represented. One phalange of a several month old dog and two teeth and an innominate fragment from pigs four to five and nine to ten months old were recovered from historic contexts. The categories of medium vertebrate and unidentified mammal may contain, amongst other taxa, a few bones of some type of smaller cetacean and those of humans, but positive identification is uncertain (Alan Ziegler, personal communication, 1995)

Shellfish

At least as practiced today on the outer atolls of the Marshall Islands, shellfish gathering is usually done by women and children during low tides to collect molluscs on the lagoon and ocean reef flats, and within the shallow grooves perpendicular to the ocean side reef edge during calm seas. Shellfish are collected for food as well as to incorporate into curios and certain individual shells are sold to foreign visitors (e.g., the Helmet shell, Golden cowrie, and Triton's trumpet). The most common food taxa are *Turbo*, *Lambis*, and occasionally Tridacnidae. There are several species of *Tridacna* and the smaller taxa, such as *T. maxima* and *T. crocea*, are collected by women, while bivalves of *T. gigas* can weigh dozens of kilograms and are collected by men usually with ropes dropped from canoes in deeper parts of the lagoon. Cowries (Cypraeidae) are rarely eaten, while the Money cowrie (*Cypraea moneta*) is the dominant shell used in curio production.

In reference to high volcanic islands, atoll shorelines—such as those found at Ujae—have a limited number of gross habitats yet a wide diversity of shell taxa are found within a short distance. The nerites are generally located on the ocean side in the splash zone, *Turbo* are most often found along the ocean side reef edge, *Lambis* inhabit rubble and sand lagoon bottoms, and smaller bivalves such as *Asaphis*, *Codakia*, and *Tellina* prefer sandy beaches. These habitats have remained relatively stable over the past 2,000 years of human occupation and changes in the diversity and richness of archaeological shellfish assemblages from the Marshalls may be related to other factors such as human predation. For example, where terrigenous runoff can prograde shorelines along high volcanic islands—burying healthy reefs that are transformed to mudflats—such radical alterations do not occur in the region. The environmental stability on Ujae Atoll permits examination of the long-term effects of humans on shellfish populations.

Measures for quantifying marine shellfish are by no means standardized in archaeology. This fact is reflected in current debates (e.g., Mason *et al.* 1998). Some prefer identifying the minimum number of individuals (MNI) by recourse to recurring attributes such as hinges on bivalves and apices on gastropods. This, however, eliminates most highly fragmented shells which may be a significant percentage of all shellfish by weight in an assemblage. Others prefer tabulation by weight, which may over-represent some taxa that have large individuals such as Tridacnidae. In addition to quantification issues, other factors can influence the interpretation of marine shellfish assemblages in the Marshall Islands, such as differentiating material deposited by people vs. those specimens that occur naturally in coastal sediments (see Carucci 1992 for Belau). First, there has been a long tradition of gathering coral gravel from the ocean side beaches to pave village surfaces. Along with coral, many kinds of whole and fragmented shellfish become incorporated into archaeological sites and these shells can be incorrectly interpreted as food remains. Many large shellfish, including *Conus*, *Tridacna*, and *Pinctada*, are the raw materials for ornament and tool production. Fragments of these taxa may represent industrial waste and not food shell. Especially with *Tridacna gigas*, one would expect the meat to be extracted and consumed before lugging the heavy shell to a habitation site to manufacture tools from the valves. One need only try lifting a 80 cm long individual that could weight more than 25 kg.

Nearly 13 kg of shellfish were recovered from excavations at sites 1 and 3 and the frequency, by weight, is listed in Table 9. Overall, 56% were gastropods (mostly, Cerithidae, Turbinellidae, Turbinidae, and Neritidae) and 44% bivalves (overwhelmingly, Tridacnidae). Figure 18 compares the counts (number of identified specimens or NISP) and weights for up to 32 families from each site. Although the sample is greater at site 1 with 82.5% of total shellfish weight—and this may affect diversity measures between the sites—the relationship of Tridacnidae to all other taxa merits discussion. The evenness, or class (family) relative abundance, is quite different between sites. Whereas Tridacnidae makes up nearly 85% of all shell weight at site 3, it is only 33% at site 1. If the offshore islets, such as Bock, were used by small groups for short stays while capturing sea birds, reef fish, coconut crabs, and turtles, it appears that only the largest shellfish were targeted at this time. In this way, maximum yields could be acquired by short visits. Conversely, the relative abundance of shellfish families is much more even at site 1 where a more generalist collection strategy was employed. The distribution may also reflect the depletion of large bivalves during the first few centuries after atoll colonization. Hence, the greater relative emphasis on Cerithidae and a few other gastropods and bivalves.

Table 9. Shellfish weight for sites 1 and 3.

Taxon	Site 1	Site 3
Gastropods		
Bullidae	5.8	
Cardiidae	3.6	
Cassis sp.	107.9	
Cerithium sp.	2849.9	23.7
Cerithium nodulosum	30.5	
Cheila equestris	1.9	
Conus sp. (large)	31	28.8
Conus sp. (small)	229.7	20.8
Cymatiidae	33.4	
Cymatium sp.	6	
Cypraea sp. (large)	23.4	
Cypraea sp. (small)	191.2	1.4
Cypraea annulus	1.4	
Cypraea caputserpentis	1.9	
Cypraea moneta	5.6	
Cypraeassis rufa	10.5	
Drupa sp.	80.5	1.9
Drupa grossularia	1.7	
Drupa morum	37.4	
Drupa ricinus	17.8	2.4
Drupella sp.	2.2	
Lambis sp.	970.3	
Muricidae	17.7	
Nerita sp.	3.2	
Nerita picea	1.5	
Nerita plicata	166.2	5.5
Nerita polita	380.7	58.1
Neritidae	4.3	1.1
Patellidae	5.9	
Sabia sp.	10.4	0.1
Strombus sp.	33.9	
Strombus mutabilis	7.9	
Tectus pyramus	157.2	0.1
Terbridae	2.3	
Terebra crenulata	29.1	
Thaididae	2.8	
Thais sp.	23.2	4.8
Trochidae	56.2	2.4
Trochus niloticus	27.1	
Turbo sp.	434.7	186.6
Vasum sp.	506.4	19.8
Vasum tubiferum	205.4	
Vermetidae	7.4	
Unidentified gastropod	139.4	8.7
Subtotal	6866.5	366.2
Bivalves		
Arca sp.	21.2	0.6
Asaphis sp.	78.5	7.9
Barnacle	3.6	0.1
Chama sp.	27.7	
Codakia sp.	3.1	
Codakia punctata	14.4	
Codakia tigerina	2.7	
Fragum sp.	11	0.2
Hippopus hippopus	65.4	605.6
Isognomon sp.	0.4	
Lucinidae	5.1	
Mytilidae		0.3
Periglypta sp.	2.9	
Pinctada sp.	4.8	
Pinnidae	4.5	
Spondylus sp.	27.1	
Tellina sp.	30.4	
Tellina palatum	45.1	2.2
Tellinidae	2.3	0.4
Tonnidae	0.8	
Tridacna sp.	1639	1290.5
Tridacna gigas	507.8	
Tridacna maxima	1238.1	
Tridacna squamosa	47.9	
Veneridae	0.6	
Unidentified bivalve	72.8	1.9
Subtotal	3857.2	1908.7
Total	10723.7	2274.9

UJAE ATOLL AS A SETTLEMENT LANDSCAPE

With more than a dozen islets (total land area, 1.8 km^2) surrounding a 180 km^2 lagoon, Ujae Atoll is one of the smaller atolls of the Marshall Islands. The majority of islets are situated along the windward coast, while the main entrance to the lagoon is through Bock Channel in the lee side. Atoll settlement patterns are predictable in a general sense, where the largest and oldest village—occupied as early as the third century—was located on the

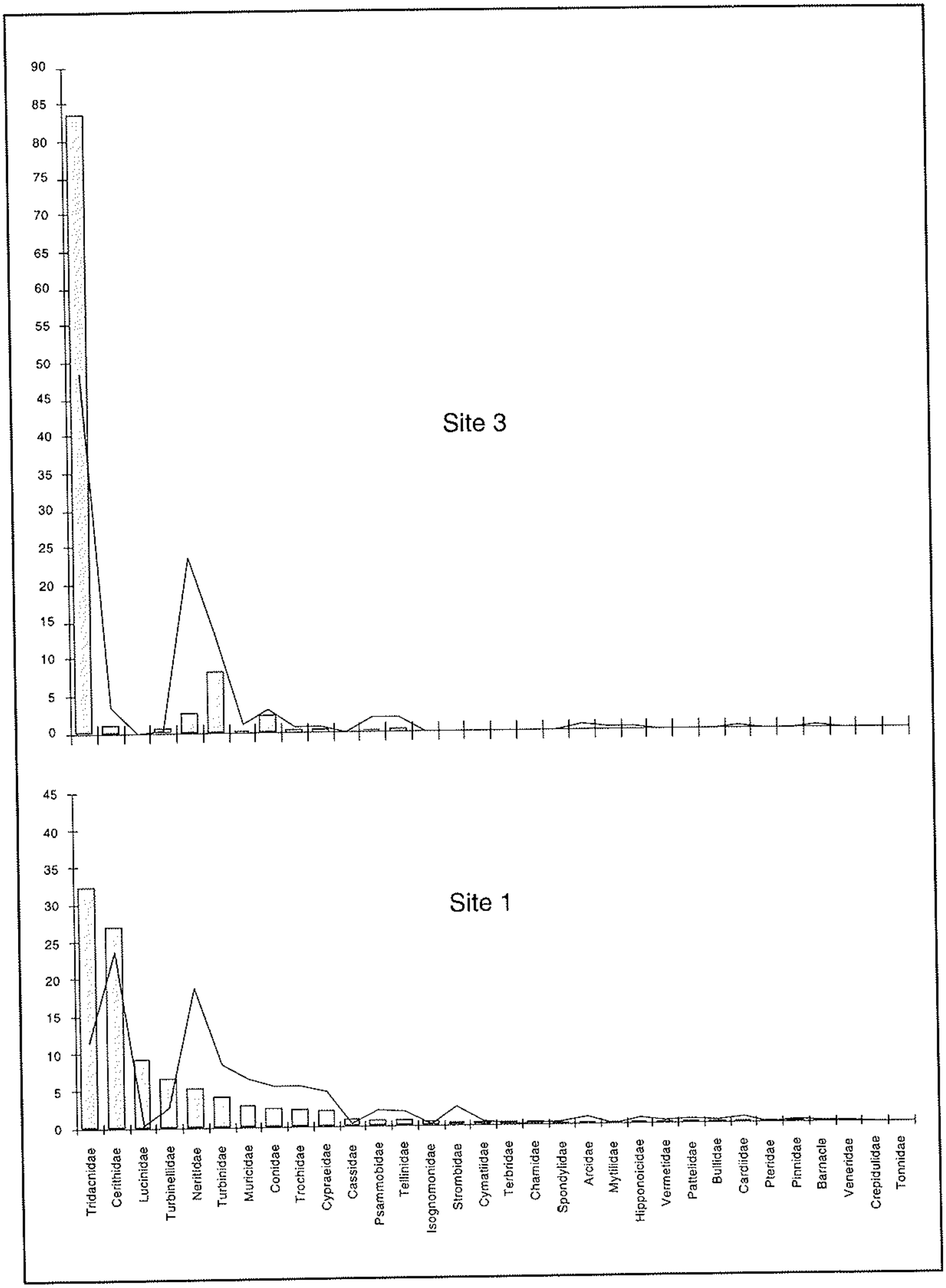

FIGURE 18. Counts (line) and weight (shaded) of shellfish from Ujae sites 1 and 3.

most substantial islet. Although a more detailed survey and subsurface testing is required for Ebbetyu and Enylamieg islets (and excavation is needed to define the precise limits of the site on Wotya), Ujae islet was, indeed, the center of population for the atoll. This is suggested further by the presence of fish traps which were used with the changing tides. The ancient Ujae village is estimated at about 25 hectares, a larger area than all the sites on the remaining islets combined. Ujae was the focus of major terrestrial production with the largest area of aroid (presumably *Cyrtosperma chamissonis*) pit cultivation and thickest Ghyben-Herzberg fresh water lens. Prehistoric settlement may, in fact, mirror the extent of the modern village with its nearly 500 inhabitants. At least 200-300 residents seems likely, although admittedly, this is a best guess. While Enylamieg probably supported the next largest village (and probably had aroid pit cultivations), Wotya and Ebbetyu may have sustained on the order of 10-25 full-time residents, yet no evidence of pit agriculture was seen there. The smallest islets were not large enough to retain groundwater and, consequently, could not have sustained permanent habitation.

Before human colonization and settlement of Ujae Atoll, all of the forested land probably supported dense colonies of sea birds and ocean side beaches provided nesting sites for the green sea turtle. With the build-up of human populations on the largest islets of Ujae and Enylamieg, prize resources like coconut crab and sea turtles were depleted and sea bird colonies may have shifted to the smaller offshore islets (such as Bock, Bokerok, and Wotya) or, perhaps, birds on these smaller islets represent remnant populations of the atoll. Indeed, today, sea bird colonies, turtles, and coconut crabs are only found on the smaller islets. From the main islet of Ujae, it is about 12 nautical miles to the channel and the ocean side reef, making trolling sorties for pelagic species a time-consuming and labor-costly practice. During our stay, traditional-style sailing canoes would travel northwest inside the lagoon for bottom fishing, staying within about 5 km of the main village. If the channel was used to gain access to the pelagic fisheries during prehistoric times, it is likely that Bock islet would have supported temporary encampments of small groups before and after fishing in the more protected lee of the atoll. Much of the broad reef flats north of Ujae (see Fig. 2) are exposed at low tide when octopus and shellfish (especially *Cerithium nodulosum*) are collected. Stone fish traps and weirs were built on the reef flats for channelling and capturing fish and were situated to take advantage of local topographic conditions such as natural alignments of raised reef and, on the west coast of Ujae, they were constructed with their long axis parallel to the prevailing out-going current which trapped fish within the constricted end.

The marine habitats remained relatively stable over the two millennia of human occupation, yet, during this time, the effects of human predation left its signature. Bones of turtle were quite rare, suggesting depletion of previously more abundant stocks. Because the earliest few centuries of human colonization of Ujae Atoll have not been documented, it is likely that turtle bones were more common in the earliest deposits, a situation noted for other islands (Weisler 1995). The same can be said in reference to the lack of bones of extinct birds—usually the temporal domain of the first few hundred years of human occupation, especially on small atolls. Considering the marine shellfish, the earliest cultural deposits should contain a relatively high abundance of large individuals, especially of taxa such as Tridacnidae and Strombidae (*Lambis* spp.). Rather, the main ancient village at Ujae islet shares quantities of *Tridacna* similar to those of *Cerithium*—a species with a much lower meat weight per specimen and a relatively light shell. This suggests that *Cerithium* was an important food shellfish, perhaps after *Tridacna* stocks were reduced. *Lambis* spp. are quite rare in the Ujae assemblage suggesting this high meat shellfish was depleted early on.

The artifact assemblage is typical for an atoll setting with great use made of large shellfish for fashioning a range of tools and ornaments. Although it is tempting to argue for some manner of contact between the Ujae population and the volcanic island of Kosrae, or even more distant islands on the continental side of the Andesite Line, the geological locales of exotic rocks or manuports may simply signal the direction of the dominant ocean swells that cast drift trees ashore with foreign rocks entangled in their roots. One cannot, however, rule out the possibility of long distance voyaging, so well documented for other parts of the Pacific (e.g., Weisler 1997).

The Ujae archaeological study has been the first phase of a longer-term investigation of atolls situated along the rainfall gradient of the Marshall Islands. The differing rainfall regimes and the variability of atoll size, shape, and number of islets should be expressed in prehistoric settlement patterns whose diachronic study will illuminate how humans colonized, adapted, and transformed the most precarious of Pacific landscapes.

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APPENDIX 1: STRATIGRAPHIC DESCRIPTIONS

The following four profiles from site 1 record the stratigraphic variability along the 420 m excavation transect oriented 180° from the middle of the lagoon shore of Ujae islet. Unit 6, situated 14 m inland from the bottom of the vegetation line at the beach, begins the transect; unit 5 is 94 m inland; unit 2 is 218 m inland; and unit 4 is 420 m inland (see Fig. 7). The stratigraphy for units 3, 4, 7, and 8 are nearly identical in layer characteristics.

Profile Description of Site 1, Unit 6 (Fig. 12)

I Historic cultural layer and loose sand; 0-3 cm bs; average thickness is 3 cm; sharp, smooth boundary; 10YR 6/1 (gray); medium sand texture; structureless (grade), very fine (size), single grain (form) structure; loose (dry), loose (moist), and non-sticky (wet) consistence; non-plastic; no cementation; abundant roots and pores.

II Historic cultural layer and gravelly sand; 3-6 cm bs; average thickness is 3 cm; sharp, smooth boundary; 10YR 5/1 (gray); gravelly sand texture consisting of medium sand with water-rounded coral pebbles; weak, very fine, single grain structure; loose, loose, and non-sticky consistence; non-plastic; no cementation; abundant roots and pores.

III Prehistoric to protohistoric cultural layer dated to 100.6 ± 0.6% modern (Beta-79581) with dense fish bone and few food shellfish; 6-37 cm bs; average thickness is 31 cm; gradual, wavy boundary; 10YR 3/1 (very dark gray); medium sand texture; structureless, very fine, single grain structure; loose, loose, and non-sticky consistence; non-plastic; no cementation; abundant roots and pores.

IV Culturally sterile subsoil; 37-50 cm bs; average thickness is 13 cm, but bottom was not reached; boundary could not be determined; 10YR 6/3 (pale brown) with 10YR6/1 (light gray) mottles; medium sand; structureless, very fine, single grain structure; loose, loose, and non-sticky consistence; non-plastic; no cementation; abundant roots and pores.

Profile Description of Site 1, Unit 5 (Fig. 11)

I Contemporary water-rounded coral pavement; 0-5 cm bs; average 5 cm thick; very abrupt, smooth boundary; 5Y 7/1 (light gray); gravel texture; structureless (grade), very coarse (size), single grain (form); loose (dry), loose (moist), non-sticky (wet) consistence; non-plastic; no cementation; no roots and pores.

II Contemporary "floor" or base of coral pavement; 5-7 cm bs; average 2 cm thick; abrupt, smooth boundary; 2.5Y 3/3 (very dark gray); very fine to coarse sand with small gravel texture; structureless, fine, crumb; slightly hard, friable, slightly sticky; slightly plastic; no cementation; no roots or pores.

III Prehistoric cultural layer; 7-37 cm bs; average 30 cm thick; clear, wavy boundary; 2.5Y 2/0 (black); coarse sand texture; weak, fine, crumb structure; weakly coherent, friable, slightly plastic; slightly plastic; no cementation; fine, very few roots and pores.

IV Prehistoric cultural layer dated to 560 ± 70 BP (Beta-76018); 37-84 cm bs; average 47 cm thick; clear, wavy boundary; 10YR 4/1 (dark gray); coarse sand texture; structureless, fine, single grain; loose, loose, non-sticky; non-plastic; no cementation; no roots or pores.

V Sterile subsoil; 84-90+ cm bs; greater than 6 thick; boundary not visible; 5Y 7/3 (pale yellow); coarse sand texture; structureless, fine, single grain; loose, loose, non-sticky; non-plastic; no cementation; no roots or pores.

Profile Description of Site 1, Unit 2 (Fig. 11)

I Prehistoric cultural layer; 0-103 cm bs; average thickness is 103 cm; gradual, smooth boundary; 7.5YR 2/0 (black); gravelly sand texture; moderate (grade), medium (size), crumb (form) structure; loose (dry), very friable (moist), slightly sticky (wet) consistence; slightly plastic; no cementation, abundant, many roots and pores.

II Prehistoric cultural layer dating to 1660 ± 60 BP (Beta-74845) grading to sterile, moist, compact gravelly sand; 103-136 cm bs; average thickness is 33 cm; boundary not visible; 7.5YR 3/0 (very dark gray); gravelly sand; moderate, medium, crumb; weakly coherent, very friable, slightly sticky; slightly plastic; no cementation, abundant, many roots and pores.

Profile Description of Site 1, Unit 4 (Fig. 11)

I Sparse cultural layer with dense gravel; 0-40 cm bs; average thickness is 40 cm; smooth, clear boundary; 2.5YR 2.5/0 (black); gravelly sand texture; weak (grade), medium (size), crumb (form) structure; weakly coherent (dry), very friable (moist), slightly sticky (wet) consistence; slightly plastic; no cementation, abundant, many coconut roots and pores. Excavated with rock hammer.

II Very sparse cultural; 40-60 cm bs; average thickness is 17 cm; smooth, clear boundary; 10YR 4/1 (dark gray); gravelly sand texture; weak, medium, crumb structure; weakly coherent, very friable, slightly sticky consistence; slightly plastic; no cementation, abundant, many coconut roots and pores. Less compact than layer I, but excavated with rock hammer.

III Culturally sterile; 50-60 cm bs; average thickness is 10 cm; boundary could not be determined; 5YR 7/3 (pink); medium to coarse sand texture; structureless, fine, single grain; loose, loose, non-sticky; non-plastic; no cementation, abundant, many coconut roots and pores.

Profile Description of Site 3, Unit 1 (Fig. 13)

I Historic coral pavement, glass, and metal fragments; 0-7 cm bs; average thickness is 7 cm; abrupt, smooth boundary; 7.5YR 2/0 (black); medium to coarse sand texture with dense, water-rounded coral gravel; weak (grade), fine (size), and single grain (form) structure; loose (dry), loose (moist), and non-sticky (wet) consistence; non-plastic; no cementation; abundant roots and pores.

II Mixed historic (7-20 cm bs) and prehistoric (20-30 cm bs) cultural deposits (separated approximately by the dashed line in Fig. 13); total average thickness of 28 cm; abrupt, wavy boundary; 7.5YR 2/0 (black); medium to coarse sand with dense, water-rounded coral gravel; weak, fine, and single grain structure; loose, loose, and non-sticky consistence; slightly plastic; no cementation; abundant roots and pores.

III Main prehistoric cultural layer (35-96 cm bs) with dense ovens; radiocarbon dated to 30 ± 50 BP (Beta-79583) to 200 ± 60 BP (Beta-76019); average thickness is 61 cm; clear, wavy boundary; 2.5Y 2/0 (black) with a sterile, coarse sand pocket of 10YR 7/2 (light gray); medium to coarse sand with dense cobbles (oven stones); structureless, fine, single grain; loose, loose, non-sticky consistence; non-plastic; no cementation; abundant, many roots.

IV Sparse prehistoric cultural layer (96-118 cm bs); average thickness is 22 cm; clear, wavy boundary; 10YR 3/1 (very dark gray); medium to coarse sand with water-rounded coral gravel; structureless, fine, single grain; loose, loose, non-sticky consistence; non-plastic; no cementation; abundant, many roots.

V Culturally sterile subsoil (118-140 cm bs); average thickness is 52+ cm as bottom was not reached; boundary could not be determined; 10YR 7/2 (light gray); coarse sand and subrounded coral cobbles, 12-20 cm in maximum length; structureless, fine, single grain; loose, loose, non-sticky consistence; non-plastic; no cementation; abundant, many roots.