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Contraction of the Southeast Polynesian Interaction Sphere and Resource Depression on Temoe Atoll

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ABSTRACT

The southeast Polynesian interaction sphere, involving most frequently islands in Mangareva and the Pitcairn group, was active for at least five centuries beginning about AD 1000. By western contact in the early seventeenth century, all islands in the Pitcairn group were abandoned, signalling a contraction of the sphere. Systematic survey and excavations were conducted on Temoe Atoll, the next closest island to the main Mangareva group, to determine the spatial and temporal boundaries of that contraction. The excavations in five late prehistoric habitation sites are described, and provide the first subsistence remains from the atoll. These consist of 21,590 bones of fish, bird, turtle, Pacific rat and human as well as 25 kg of shell midden, mostly *Turbo* gastropods. Reconstructed weights of parrotfish (Scaridae), by far the most common fish taxon, illustrate a decline in size during late prehistory, pointing to exploitation depression. The x-ray fluorescence analysis of volcanic artefacts documents ties with the main Mangareva group, suggesting that the reduced interaction sphere lasted until the early nineteenth century when Temoe was finally abandoned.

Key words: POLYNESIA, MANGAREVA, PREHISTORIC INTERACTION, RADIOCARBON DATING, X-RAY FLUORESCENCE, FAUNA, RESOURCE DECLINE, TEMOE ATOLL.

INTRODUCTION

Southeast Polynesia is an intriguing region for examining the end of the prehistoric sequence as all four islands of the Pitcairn group were abandoned some time before 1606 when Ferdinand Quiros sheltered in the lee of the raised limestone (*makatea*) island of Henderson in search of provisions. In addition to Henderson, the 4.5 km^2 volcanic Pitcairn Island also has extensive evidence of prehistoric habitation but it, too, was without people when Fletcher Christian and his mutineers arrived in the late eighteenth century to hide from the British Admiralty. After extensive archaeological field research on Henderson, Pitcairn and Mangareva (Weisler 1995, 1996 and 1998a), it seems clear that the small human populations residing in the Pitcairn group were only sustainable with periodic provisioning from the parent population on Mangareva — a high volcanic island group with a greater diversity of resources, located some 400 km to the west. Trade in adze material, volcanic oven stones and volcanic glass, transport of important cultigens such as banana, swamp taro

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(*Cyrtosperma* sp.) and candlenut (*Aleurites*), and undoubtedly marriage partners, solidified inter-island ties between Mangareva and the Pitcairn group during five hundred years beginning *ca*. AD 1000 (Weisler 1997).

Mangareva played a critical role in the southeast Polynesian interaction sphere, which at its farthest reaches included the Marquesas, Tuamotus and the Society Islands. We know that this system of interaction — involving most frequently Mangareva and the Pitcairn group — contracted sometime during the late sixteenth century, due in no small part to changing social conditions within the participating islands (Weisler 2002). The research reported here was directed at determining the spatial and temporal boundaries of that contraction. To do this the systematic survey and dating of habitation sites was initiated on Temoe Atoll, the next island west of the Pitcairn group. It was not only important to obtain dating material from habitation sites, but to collect volcanic artefacts from this low-lying coral island to document ties with Mangareva through geochemical characterisation studies.

THE ENVIRONMENTAL SETTING

Situated 40 km east of the main group and visible from the mountain peaks on Mangareva and Kamaka islands, Temoe Atoll is 6 km long and 3 km wide and encloses a rectangular-shaped lagoon (Fig. 1). One of the southernmost atolls in the Pacific, which developed on a volcanic foundation *ca*. either 4 or 15 million years ago (Pirazzoli 1987), the atoll is part of the time-progressive lineament that trends northwest from Pitcairn (Duncan and McDougall 1976). Much of the atoll rim was awash at 2000 BP, but during subsequent emergence, *motu* (islets) broadened when coral rubble and sand were thrown up from ocean swells, most prominently on the east coast where the widest landforms developed. It is no coincidence that the densest archaeological structures are situated there. A jumble of coral slabs compose the seaward half of all *motu* and were used as easily stackable construction materials for *marae* and burial cairns. The surface here is difficult to traverse and was undoubtedly why numerous stepping-stone trails transect the landscape from ocean side to lagoon shore. Other trails run perpendicular to these paths just inland from the coast. Typical of all *motu* on atolls across the Pacific, the lagoon half of most islets grades from cobbles at the centre to sand at the lagoon shore. It is here that most habitations are located.

The vegetation consists of typical strand species dominated by the shrubs *Scaevola*, *Tournefortia*, *Suriana* and *Pemphis* below a canopy of pandanus. At this latitude and with a lack of nutrient-rich soils, breadfruit may not have been able to survive on Temoe; indeed, there are none found today. Even coconut probably had a tenuous existence as it was reintroduced to Henderson island by the Pitcairners during the early part of last century which may suggest that left unattended, coconut also may not have been viable on Temoe. Indeed, early encounters by westerners in 1797, 1825, 1834, 1836 and 1842 (cited in Emory 1939: 35–38) reported an absence of coconut trees on Temoe. The dense stands seen today were planted for copra production. A few individuals of the Polynesian-introduced *none* (*Morinda citrifolia*) were seen on the east side of Ikoamonui *motu*.

Sea birds would have been an important resource for early colonists to Temoe and it is likely that bird numbers were reduced by human predation and with the introduction of rats. The greatest concentrations of nesting sea birds today are along the southern *motu* where two species of booby (*Sula dactylatra* and *S. sula*), Brown Noddy (*Anous stolidus*), Common Fairy-Tern (*Gygis alba*), Red-Tailed Tropicbird (*Phaethon rubricauda*) and the Great Crested Tern (*Sterna bergii*) were all breeding in December 2001. Adults of the Great Frigatebird (*Fregata minor*) were occasionally seen. Judging from the bird populations

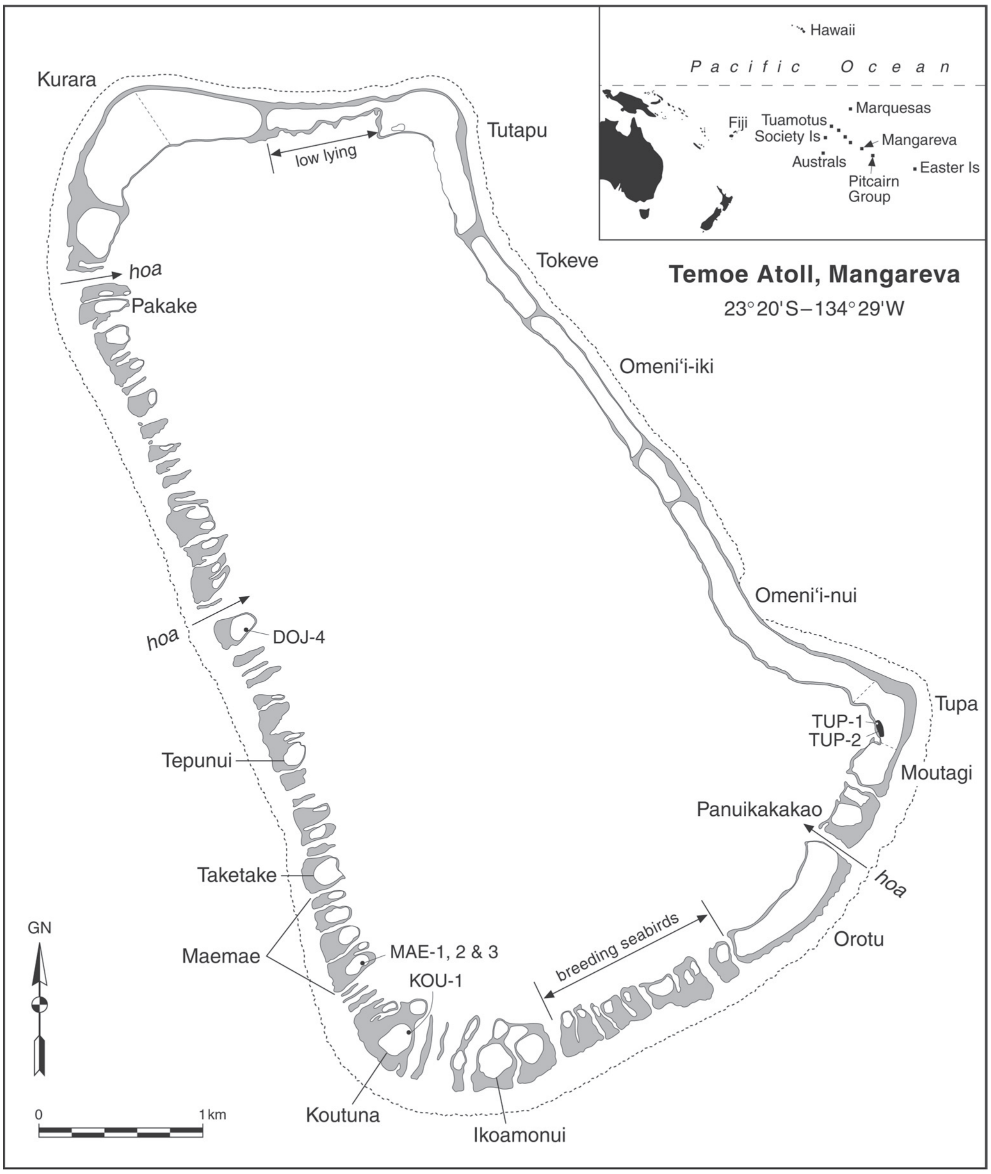

Figure 1: Map of Temoe Atoll showing the location of excavated archaeological sites. The three entrances to the lagoon used today are only passable during high tide. The map of southeast Polynesia shows the location of island groups mentioned in the text.

observed during our stay, the ease with which they can be captured, and the return for effort expended, it is likely that boobies and tropicbirds were the most common prey species.

Because Temoe is now an uninhabited island, the marine resources are substantial, but are subject to periodic harvesting during sorties originating on Mangareva. Groups of four to six people visit Temoe for several days at a time to capture lobster on the reef flats at night, collect *Turbo* gastropods along the algal crest, net fish on the ocean side, spear turtles in the lagoon and grab young Red-Tailed Tropicbirds. From observation of these sorties on several occasions, it appears that the large stocks of marine food on a pristine Temoe could not survive sustained human predation at this level, although detailed ecological studies are lacking for Temoe. It seems that a couple of months of intense predation by a founding group of 25 or so people would result in a decline in the carrying capacity of the atoll. Archaeological evidence of subsistence practices during late prehistory on Temoe suggests just this phenomenon — probably with the fish and possibly the bird fauna.

PREVIOUS ARCHAEOLOGICAL RESEARCH ON TEMOE

Kenneth Emory began the first archaeological survey on Temoe Atoll in October 1934 when he spent two days briefly noting stone structures from the northeast point at Tutapu south to Tupa (Fig. 1). A morning was spent at Kurara recording several large pavements. In total he collected some data on 80 stone structures, including 50 simple cairns (most of which may contain human burials), 2 *marae*, 21 small platforms, 1 house site (term not defined by Emory) and 6 pavements (*paepae*) — 4 with adjacent house floors.

A more systematic, intensive archaeological survey was conducted in May 1992 by Weisler and associates who visited all the *motu*, recording nearly 200 stone features such as *marae*, burial complexes consisting of cairns and platforms, stepping-stone trails, *paepae* and a midden. The settlement pattern consisted of *marae* and burial features concentrated on the ocean side of most eastern *motu*. Connecting these areas to the lagoon side were well-defined, single course, stepping-stone trails that probably bounded social units on the north and south limits. In many examples, these trails ended at or near residential complexes most prominently defined by a habitation pavement. On the southern and western-facing *motu*, habitations were more isolated, probably reflecting the fact that these *motu* are more exposed, with pronounced rocky and undulating topography; many of these *motu* get washed over by austral swells. A single midden was recorded at Ikoamonui.

Initiating a new study, Weisler and Conte returned to Temoe in December 2001. Conte re-recorded many of the structures along the east coast adding some additional features, while Weisler conducted excavations at five habitation sites that included two middens (TUP-2 and DOJ-4) and three house pavements (TUP-1, KOU-1 and MAE-1). In total, 12.75 m^2 were excavated as part of a preliminary testing programme to determine the presence, density, complexity and age of subsurface cultural deposits in order to sketch an initial outline of the cultural-historical sequence. The excavations, stratigraphy, radiocarbon dating, artefacts, x-ray fluorescence study of volcanic artefacts and midden analysis are described below.

EXCAVATIONS

After a brief reconnaissance survey of Temoe Atoll to relocate the major habitation sites, five sites of varying sizes and internal complexity (surface architecture, mounds and midden concentrations) were selected for test excavations (Fig. 1). The sites were cleared of pandanus leaf litter and low shrubs, then the architectural features and the immediate topographic setting were mapped with plane-table and telescoping alidade. A grid of one-metre squares was superimposed over each site and units were selected for excavation. Stratigraphic excavations proceeded in 5 cm spits within layers, and sediments were screened with 2 mm mesh sieves and washed with sea water before sorting into classes: bone, charcoal, shell midden (including echinoderms and crustacea) and artefacts. At site TUP-1 (unit L6) and the test pit at DOJ-4, densely concentrated cultural material necessitated washing the sediments, then bagging the material for sorting at the University of Otago. At TUP-1, 13 units totalling 4.75 m^2 were excavated without screening the sterile soil overlying the stone pavement to expose it for mapping.

SITE 190-13-TUP-1 (GPS 23° 21′ 09″ S, 134° 27′ 21″ W)

Situated 20 m inland from the lagoon shore at Tupa *motu*, this is the largest habitation pavement on Temoe Atoll. It was originally sketch mapped in 1934 by Emory (1939: 47, 49) who noted the house floor of sand, pavement and stone "table". In 2001 the site area was in dense pandanus trees and leaf litter and soil had accumulated to a depth of 10 cm above the pavement. To enable accurate mapping (at 1:75 scale) the complete site surface was cleared of litter and selected units were excavated to reveal the extent of the subsurface pavement (Fig. 2). Soil overburden at the southeast extent of the pavement was removed in a continuous area measuring 4 x 11 m. The pavement, 12.5 m north-south by 22 m east-west (275 m^2), was partially delimited by upright slabs or curbstones (ranging from 40 to 75 cm in length), which edged the perimeter on all sides. Some portions of the pavement edge were defined by large flat beachrock slabs, mostly 50 cm in diameter but a few up to 90 cm. Test pits spaced throughout the site revealed that the paved areas were continuous. The pavement stones measured from 20 to 60 cm in diameter and were closely fitted. Near the east extent of the pavement was a circular depression (75 cm in diameter) and 5 m northeast were three upright slabs 5–10 cm above the pavement surface that delimited a possible burial (Fig. 2). The slab of Emory's table, measuring 1.75 x 0.85 m, was previously supported by beachrock legs. On the lagoon side of the pavement is a level sand area that is partially delimited on the north and south sides by several stones set on edge which define an interior width of 5.75 m, but of unknown length. This is Emory's house floor and 1 m^2 excavated there did not reveal any prehistoric artefacts.

Two 1 m^2 units were excavated to sterile subsoil: J20 was placed to cross the stone alignment that defined the pavement on one side and the possible sleeping area on the other; L6 was situated in the suspected cooking area. Two additional 1 m^2 units were excavated only down to the top of the pavement. Unit P20 had 2–5 cm of overburden and 4.0 kg of coral gravel in a sticky silty loam; unit U20 had 7–9 cm of overburden with 2.25 kg of coral gravel. An additional eleven 50 x 50 cm units were excavated to define the pavement north and south of the 19 grid line (Fig. 2). All these units exposed underlying pavement except two located outside and north of the northwest corner of the pavement.

Unit J20 produced no prehistoric artefacts and appeared to have historic disturbance throughout to the sterile subsoil. The stratigraphy is illustrated in Figure 3a and summarised below.

Layer IA. A black (10YR2/1) sandy loam with abundant coral gravel (34.75 kg), rusted metal fragments, bird and fish bone. Sediment dislodged into small 2–4 mm peds during excavation. Weak structure, weakly coherent, very friable, slightly sticky and slightly plastic.

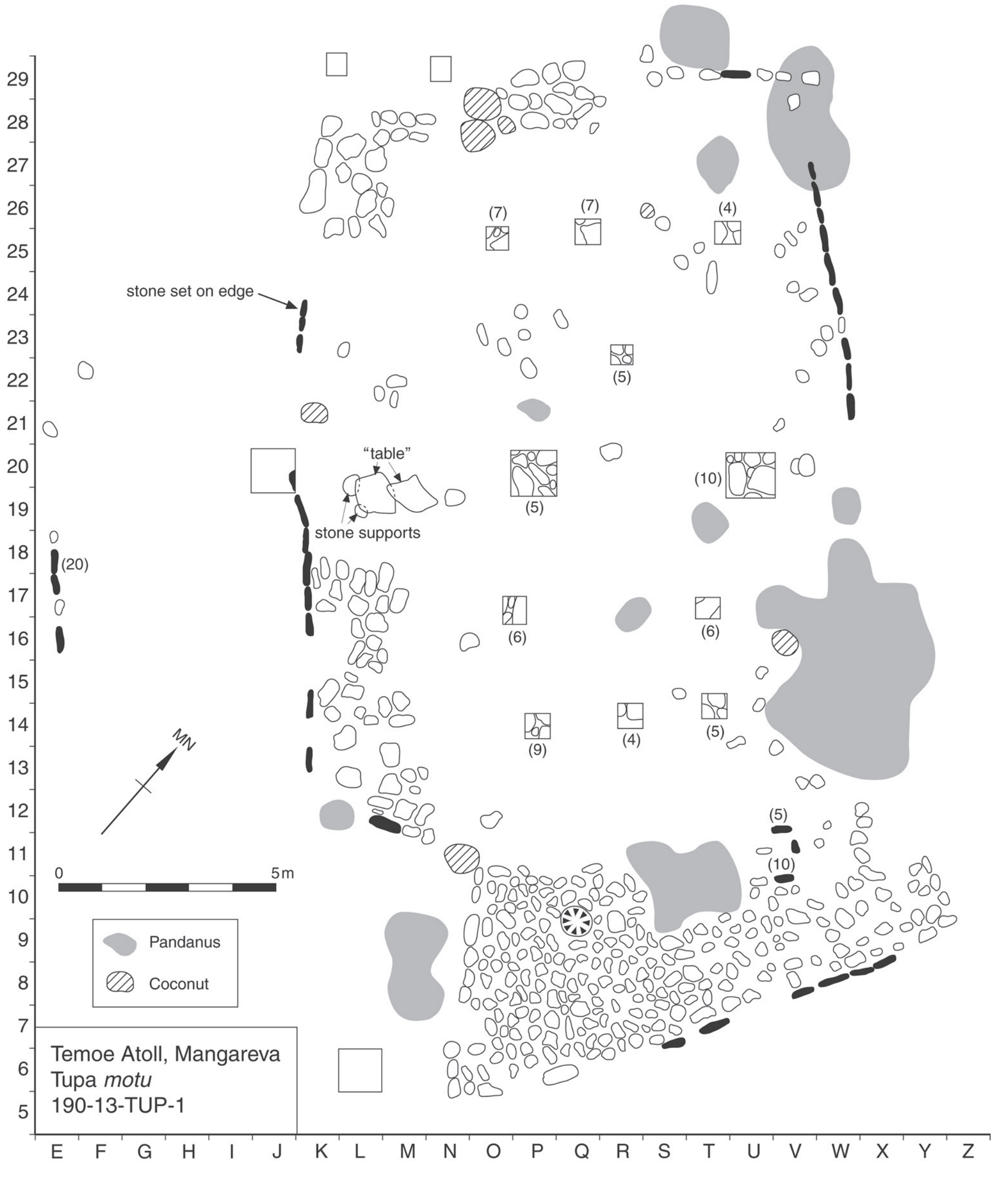

Figure 2: Plane-table and alidade map of TUP-1 showing the locations of excavation units, large pavement partially delimited by curbstones (in black) and rectangular level sandy area immediately southwest or lagoonward. Intensive cooking debris was located in the area of unit L6.

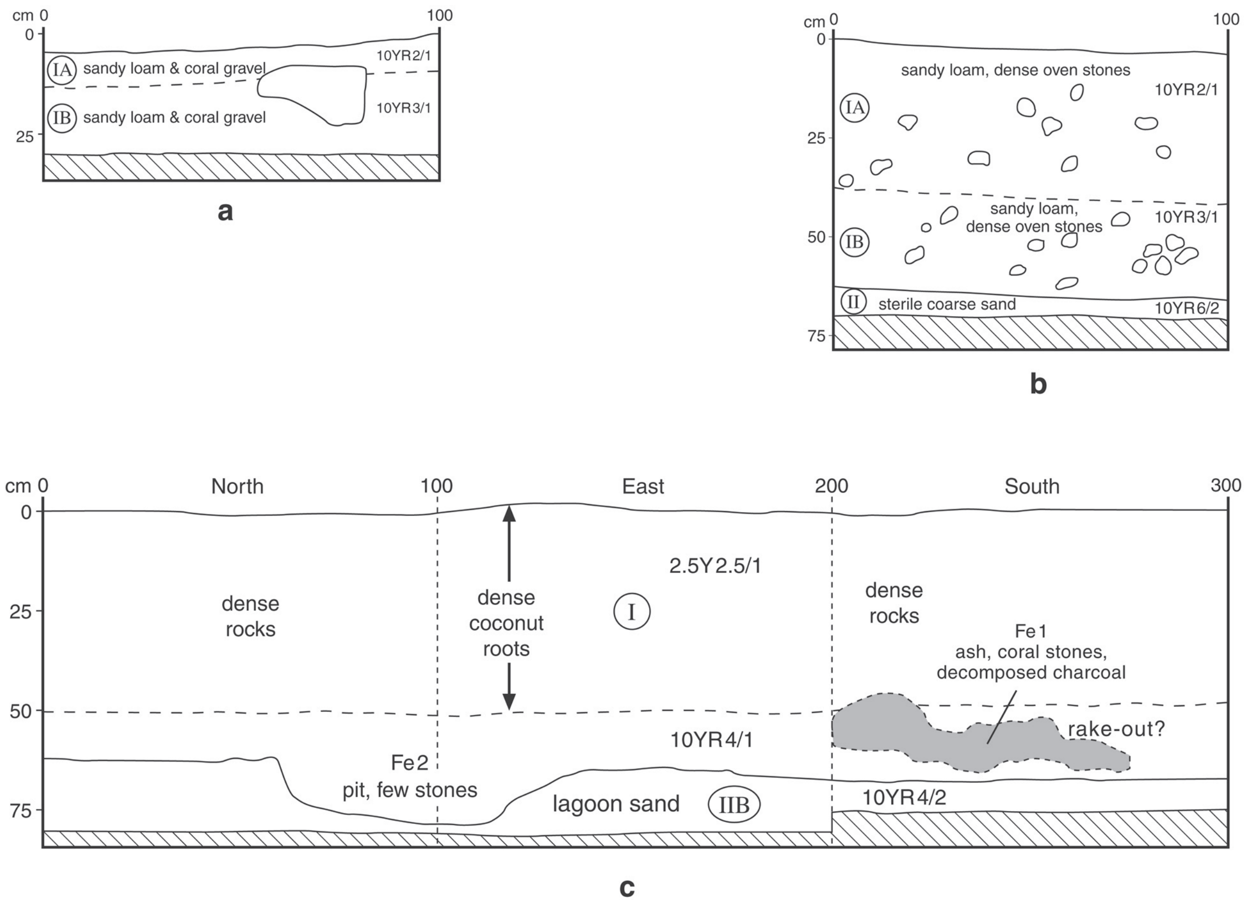

Figure 3: Excavation profiles. a. East profile unit J20 at TUP-1. b. South profile unit L6 at TUP-1. c. North, east and south profiles of TP1 at TUP-2.

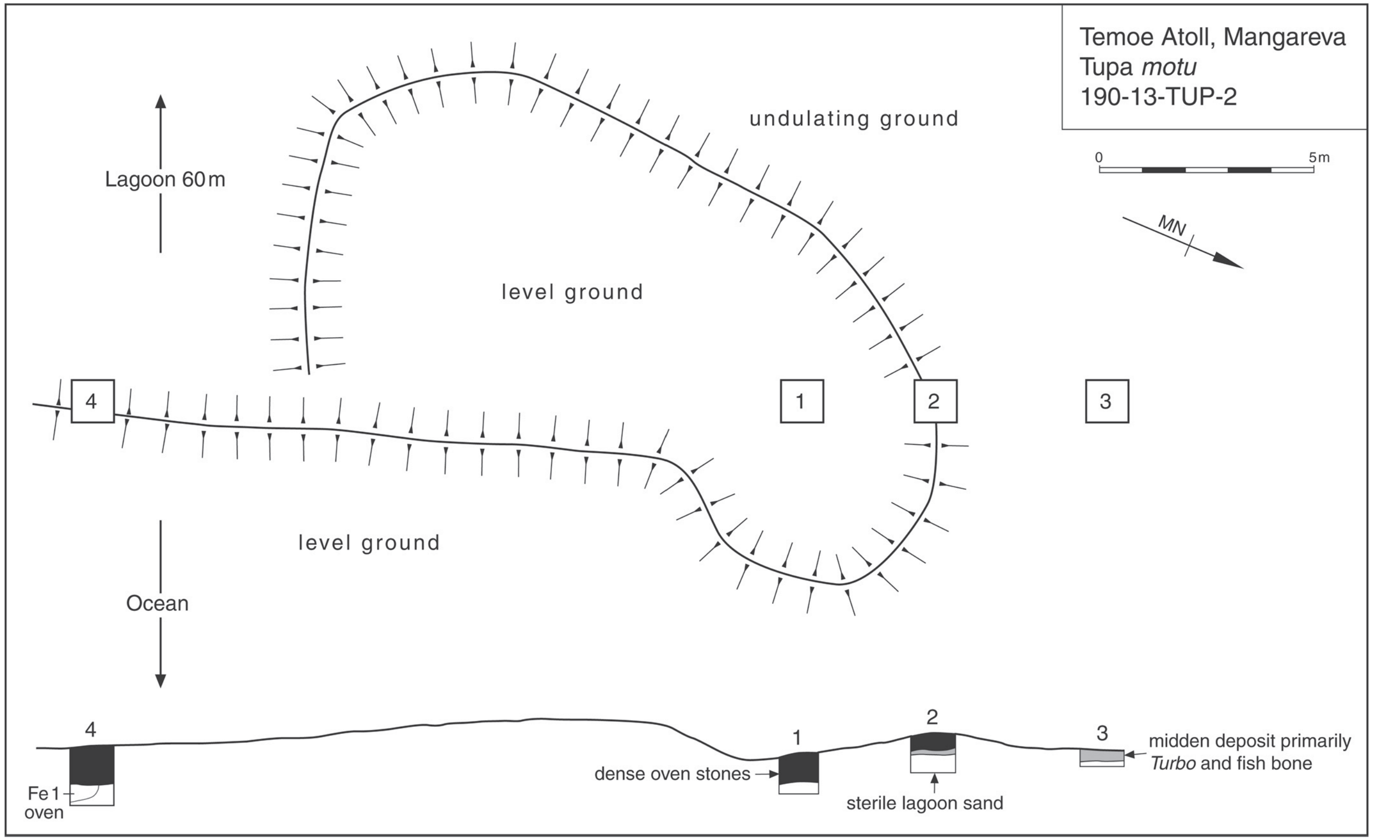

Figure 4: Plane-table and alidade map of TUP-2 showing an elongate mound of fractured coral oven stones encircling a level soil area and the stratigraphy of the excavation units.

Extremely dense coconut and pandanus roots. Boundary is clear (2.5–6.0 cm thick) and the layer is *ca*. 9 cm thick[2].

Layer IB. Very dark grey (10YR3/1) sandy loam with abundant coral gravel (14.45 kg), much of it angular, some charcoal, rusted metal fragments and bone. Weak structure, weakly coherent, very friable, slightly sticky (but less than layer IA), slightly plastic with abundant roots.

Unit L6 was excavated to determine if the immediate area was used for cooking. The unit produced abundant evidence of charcoal, fire-altered stones and food remains to 65 cm below surface. The stratigraphy is described below and illustrated in Figure 3b.

Layer IA. A black (10YR2/1) sandy loam with dense angular coral gravel (136.35 kg), charcoal, bone and one pearlshell fishhook fragment. (This shank fragment was not lent for study.) Weak structure, weakly coherent, friable, slightly sticky, slightly plastic and no cementation. Abundant roots throughout. More organic material and stickier sediments in the upper 15 cm. Boundary is clear and smooth. The layer is *ca*. 37 cm thick.

Layer IB. A dark grey (10YR4/1) version of Layer IA, but less sticky with an abrupt, smooth boundary with contact at the sterile subsoil. Some 38.0 kg of coral gravel.

Layer II. Light brownish grey (10YR6/2) coarse, sterile sand with charcoal and fragments of fire-altered coral mixed from layer IB above. A structureless, loose, non-sticky, non-plastic matrix with no cementation. Abundant roots. The layer is *ca*. 25 cm thick.

SITE 190-13-TUP-2 (GPS 23° 21′ 12″ S, 134° 27′ 18″ W)

Situated 60 m inland from the lagoon is an area 115 m long, parallel to the shore, and 25 m wide (further inland). It consists most prominently of sinuous mounds and isolated piles of angular coral oven stones under thick pandanus leaf litter (Fig. 4). Some mounds enclose level areas and at first were thought to be long-abandoned pits for growing aroids as recorded for the Tuamotus (Chazine 1990) and the Marshall Islands (Weisler 1999a). However, test excavations into one large mound revealed dense concentrations of oven stones and charcoal in a black sandy matrix. The mounds are adjacent to level soil areas and it is likely that concentrations of mounds with associated level soil areas represent discrete habitation areas (households?) within the site. Accumulation of pandanus leaves throughout the area made it difficult to locate any surface midden or artefacts. The level soil area near one elongate mound evidenced a deposit more consistent with habitation refuse. Four 1 m^2 test units were excavated in a line extending 30 m long. Two units were placed on top of mounds to determine the cultural content, while two additional units were situated on adjacent level areas. Characteristic stratigraphy of units through mounds consisted of black sediment with extremely dense concentrations of fractured coral oven stones, charcoal and tree roots, making excavation difficult. This cultural layer extended up to 1 m below surface. Lagoon sand was the sterile basal layer. One unit excavated on a flat area revealed a dark brown cultural layer *ca*. 30 cm thick with shellfish, fish bone and pumice in a loamy sand matrix. The sterile subsoil was a dark greyish brown coarse lagoon sand.

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[2]Layer and sediment characteristics are described using standardised terms in *Handbook 18, Soil Survey Manual* (United States Department of Agriculture, Washington, D.C.). Sediment colours were taken moist using the *Munsell Color Charts* (1994 edition).

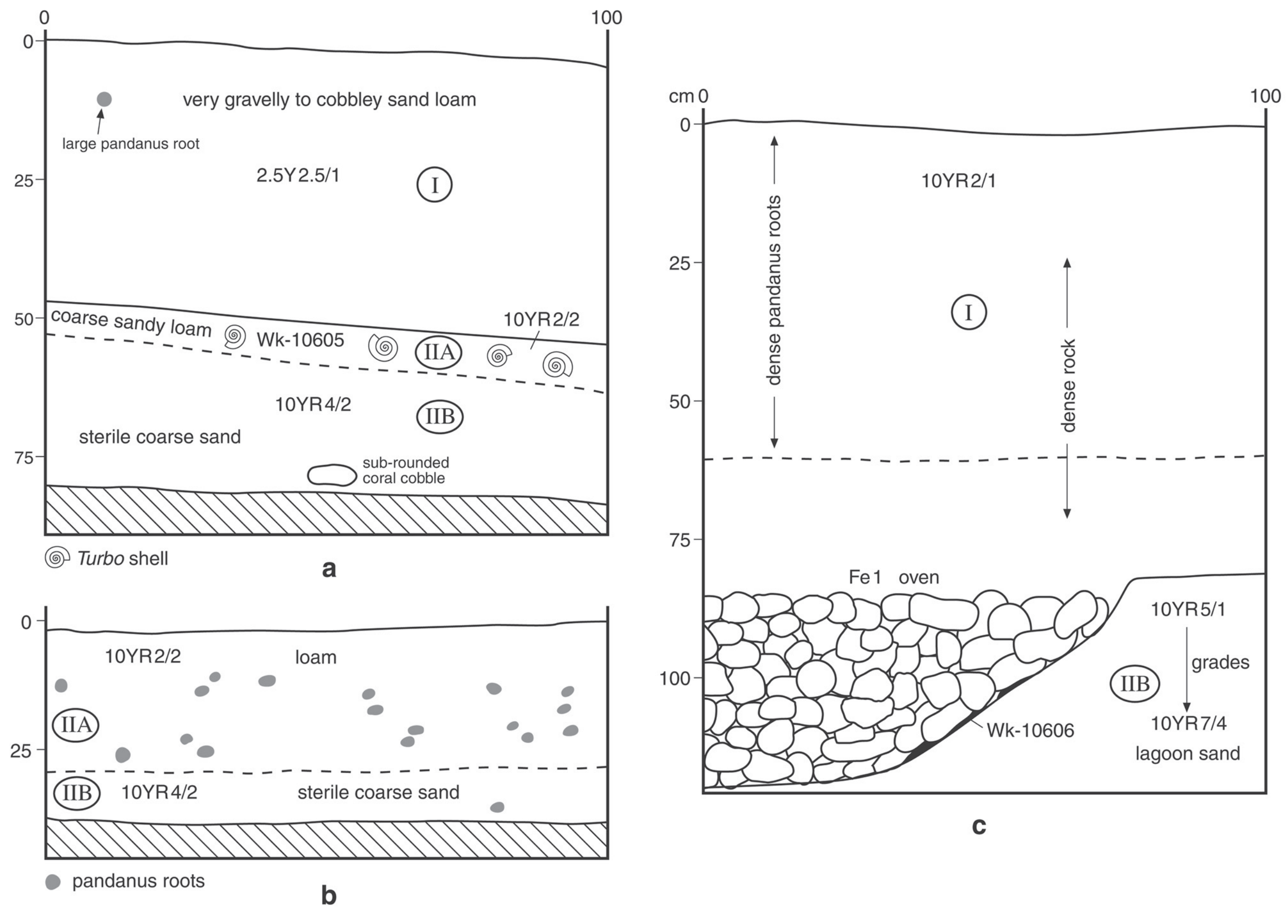

Figure 5: Excavation profiles. a. West profile of TP2 at TUP-2. b. West profile of TP3 at TUP-2. c. East profile of TP4 at TUP-2.

The four 1 m^2 excavation units suggest that the area was used for intensive oven cooking, with as yet undefined domestic activities on the adjacent level soil areas. The general stratigraphy of all units (TP1-4) is described below and illustrated in Figures 3c, 5a–c.

Layer I. A black (2.5Y2.5/1; 10YR2/1) very gravelly to cobbley sand loam with very dense fire-altered coral stones and charcoal accumulated from intensive earth oven cooking. One basin-shaped pit, one oven and a concentration of rake-out were recorded (Figs 3c and 5c). The oven, exposed in the east profile of TP4, was originally excavated from near the base of cultural layer I, *ca*. 35 cm into the sterile subsoil layer IIB. Measuring at least 72 cm wide in section and at least 1 m long in plan, the oven was densely filled with fire-altered coral stones 8 to 15 cm long. At the base of the stones and in contact with the sterile subsoil, pandanus key fragments were collected *in situ*, 101 cm below surface, for radiocarbon dating (Fig. 5c; Wk-10606), producing an age range of AD 1520–1955 calibrated at 2σ[3]. The overall layer matrix had a weak structure, loose, very friable and slightly sticky, slightly plastic and with no cementation. Abundant pandanus roots. Abrupt, smooth boundary. Excavation could only proceed by using a long, heavy metal bar to loosen the matrix because of dense concentrations of oven stones entangled in tree roots.

Layer IIA. A cultural layer consisting of a very dark brown (10YR2/2) coarse sandy loam with shellfish (mostly *Turbo*) and fish bone (scarids, serranids, cirrhitids, labrids, acanthurids and diodontids). Loose consistency, non-sticky and non-plastic, no cementation. Abundant roots. Abrupt, smooth boundary. Radiocarbon sample Wk-10605, consisting of pandanus drupe fragments dispersed from 48 to 57 cm below surface, produced an age range of AD 1650–1955 at 2σ (Fig. 5a).

Layer IIB. Culturally sterile dark greyish brown (10YR4/2; 10YR5/1 to 10YR7/4 in TP4) coarse lagoon sand subsoil. Structureless, loose, non-sticky and non-plastic, no cementation and abundant roots.

SITE 190-13-KOU-1 (GPS 23° 22′ 14″ S, 134° 28′ 58″ W)

The site is located on the north lagoon shore of Koutuna *motu* on the southwest coast of Temoe Atoll. It is situated 7 m inland from the top of the lagoon beach amongst a few pandanus and coconut trees, otherwise the area is fairly clear of vegetation. The site consists of a well-defined pavement, 3.2 m north-south by 5.0 m east-west, with a level soil area immediately to the south bounded by a single course of stones that delimits a rectangular area with interior dimensions of 2.5 x 6.0 m (Fig. 6). Fragmented *Turbo* gastropods and opercula are located in the southeast corner of this soil area. A vesicular basalt cobble (originally from a volcanic island of Mangareva; see discussion below) was found just east of this area, suggesting that a cooking locale may be present. The site, then, consists of a pavement, a stone-delimited house area and a cooking locale — a functionally similar layout to that of TUP-1. The site and environment were mapped with a plane-table and telescoping alidade at 1:50 scale and two 50 x 50 cm test units (D4 and F4) were excavated within the suspected house area. The stratigraphy is illustrated in Figures 7a and 7b and described below.

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[3]Charcoal samples were calibrated at 2σ after Stuiver and Reimer (1993) and Stuiver *et al.* (1998) for southern hemisphere samples. Because all conventional ages have standard deviations greater than 50 years, results were rounded to the nearest 10 years as suggested by Stuiver *et al.* (1998).

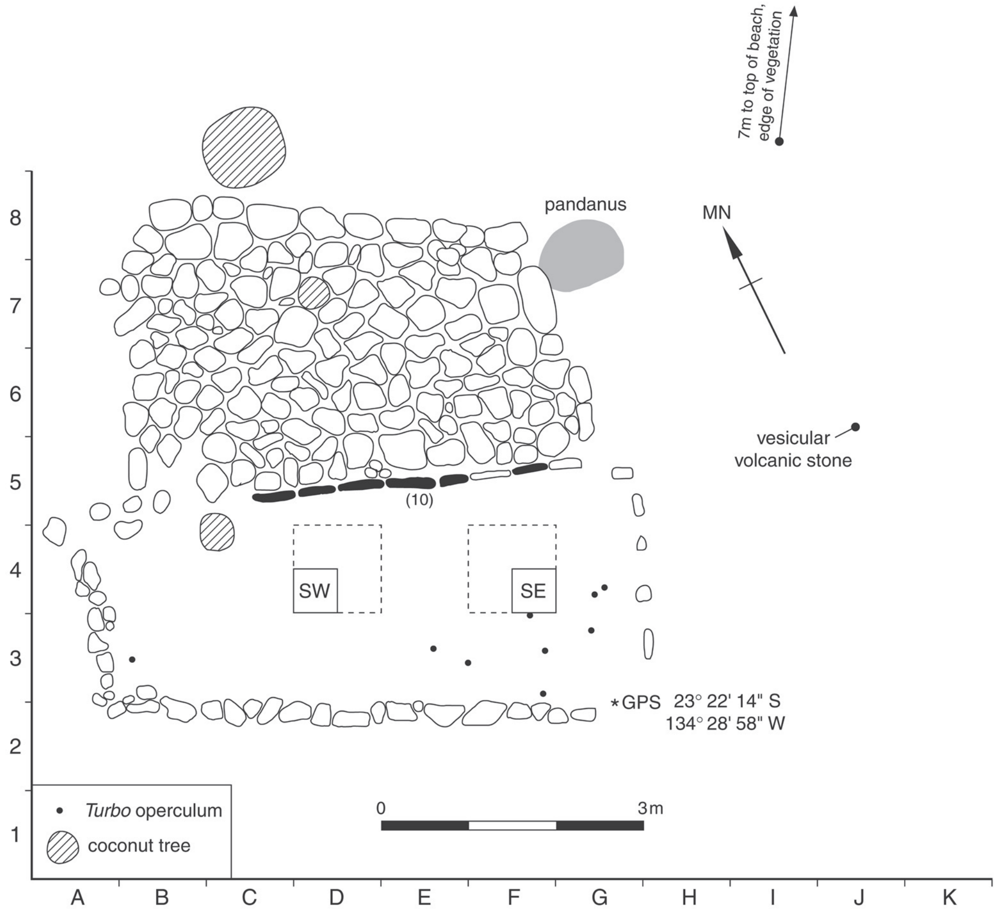

Figure 6: Plane-table and alidade map of KOU-1 habitation site showing the locations of the 50 x 50 cm excavation units and the vesicular volcanic stone originating from one of the main islands of Mangareva.

Layer IA. A black (10YR2/1) gravelly sandy loam cultural layer with dense fire-altered coral stones, dispersed charcoal, few fish bones, shellfish and in unit F4 a basin-shaped pit cut from near the base of the layer. Structureless, loose, friable, slightly sticky and slightly plastic sediment due to increased organic matter; no cementation, abundant roots. The boundary is abrupt and smooth.

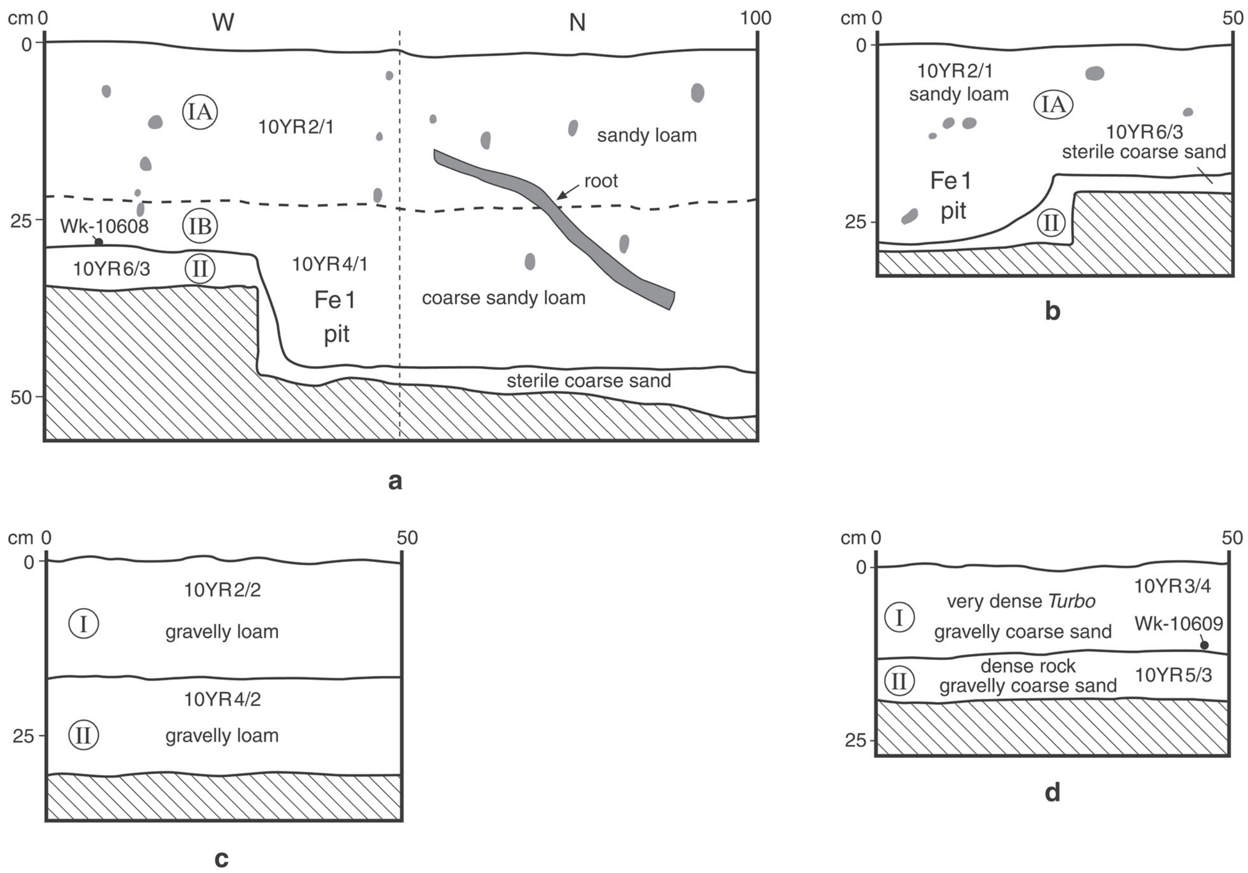

Figure 7: Excavation profiles. a. West and north profiles of unit D4 at KOU-1. b. West profile of unit F4 at KOU-1. c. North profile of unit L3 at MAE-1. d. West profile of TP1 at DOJ-4.

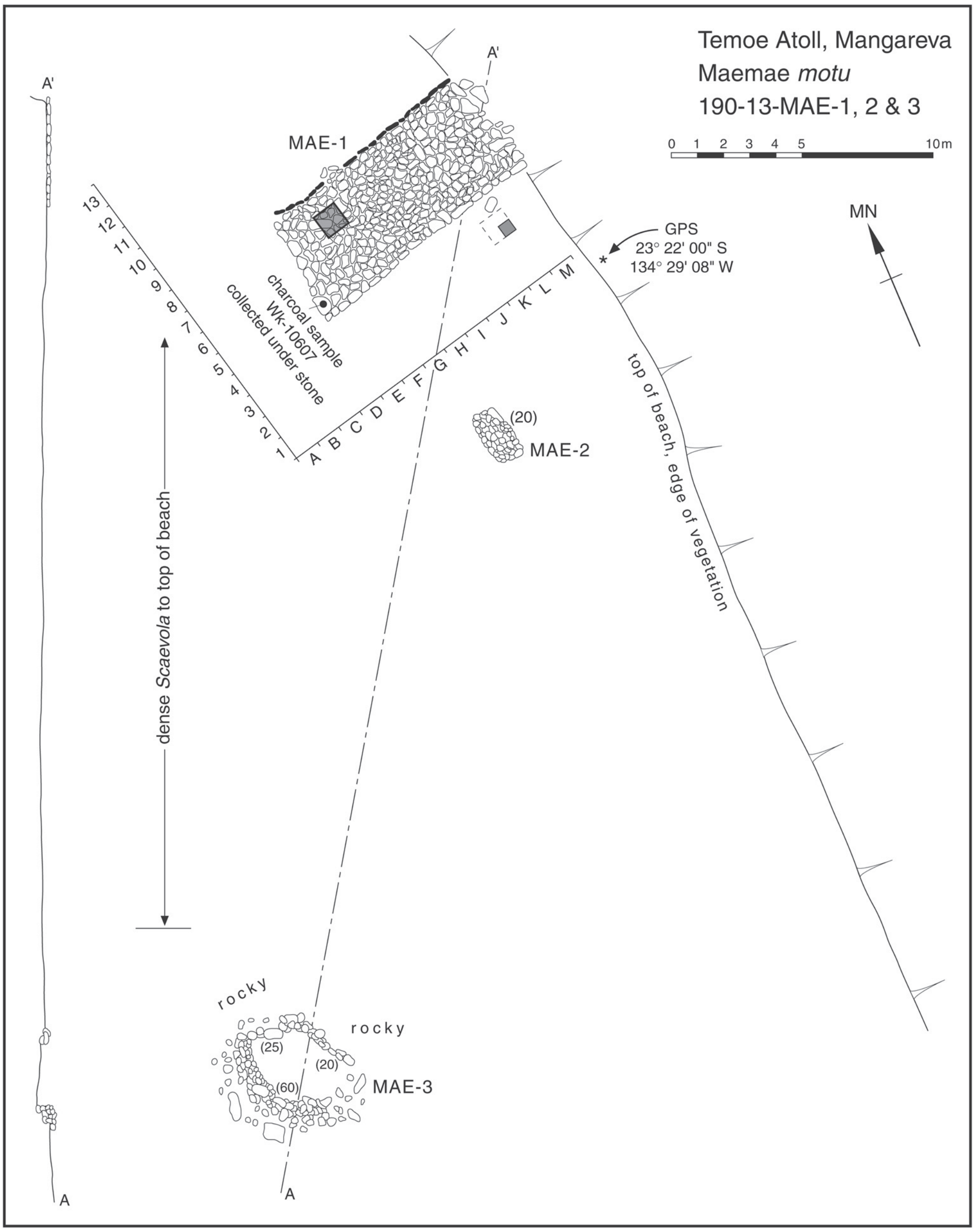

Figure 8: Plane-table and alidade map of MAE-1 showing the three architectural features and locations of excavation units.

Layer IB. Continuation of the cultural layer consisting of a dark grey (10YR4/1) coarse sandy loam with dense fire-altered coral stones, few fish bones (scarids and ostraciids) and mostly *Turbo argyrostomus* shellfish and a steep-sided pit at least 1.25 m long. Similar sediment characteristics to layer IA except IB is non-plastic and non-sticky due to less organic matter. The boundary is abrupt and smooth. A radiocarbon sample (Wk-10608; Fig.7a) of dispersed pandanus key fragments was collected from 20 to 30 cm below surface near the base of layer IB and produced a calibrated age of AD 1650–1955 at 2σ.

Layer II. The sterile subsoil consisting of a pale brown (10YR6/3) coarse lagoon sand that is structureless, loose, non-sticky and non-plastic without cementation. Abundant roots.

SITE 190-13-MAE-1 (GPS 23° 22′ 00″ S, 134° 29′ 08″ W)

The first indication of this site was a pavement eroding at the top of the lagoon shore on the north coast of Maemae *motu*, situated at the southwest corner of the atoll. The site consists of three architectural components: a pavement measuring 4 x 9 m; a small, elongate stone cairn (1.2 x 2.1 m) 20 cm high; and an eroded sub-rectangular walled structure (3.5 x 5.0 m) of uncertain function. The overall site area is 13 m (east-west) by 41 m (north-south) and it is situated on gently sloping land covered by a thick stand of *Scaevola* shrubs (Fig. 8). The north and east sides of the site are delimited by the upper beach. After clearing the site it was mapped with a plane-table and telescoping alidade at 1:100 scale. One 50 x 50 cm test unit (designated L3) was excavated immediately south of and adjacent to the pavement. A very dark brown sandy loam was encountered to a depth of 17 cm below surface and contained only sparse amounts of fish bones and shellfish with no charcoal. A 1 m^2 test unit (G7) was excavated below the pavement stones and contained much the same material as L3, but with small amounts of charcoal. At unit E4-E5, a large pavement stone was removed and coconut charcoal immediately underneath was radiocarbon dated to AD 1540–1955 (Wk-10607) at 2σ. The stratigraphy of unit L3 is illustrated in Figure 7c and described below.

Layer I. A very dark brown (10YR2/2) sandy loam with little cultural material. Structureless, loose, friable, non-sticky and non-plastic, no cementation, abundant roots. The boundary is abrupt and smooth.

Layer II. Culturally sterile dark greyish brown (10YR4/2) sandy gravel. Structureless, loose, friable, non-sticky and non-plastic, no cementation, abundant roots.

SITE 190-13-DOJ-4 (GPS 23° 20′ 51″ S, 134° 29′ 30″ W)

Situated on the west coast of the atoll, the site is located on the south lagoon shore of an unnamed *motu* (labelled J for the purposes of the site recording scheme). It is situated immediately inland from a cobble and sand beach and surrounded by low *Scaevola* shrubs on rocky terrain (Fig. 9). With site dimensions of 8 m east-west by 15 m north-south, this 120 m^2 area is covered by a thick layer of *Turbo argyrostomus*, the principal constituent of the site. A 50 x 50 cm test pit was placed near the centre of the site, 17 m inland from the low tide line. The cultural layer extended from the surface to *ca*. 15 cm below surface and contained an extremely dense concentration of *Turbo argyrostomus* and *T. setosus*, bones of small fish, and charcoal. The stratigraphy of TP1 is illustrated in Figure 7d and described below.

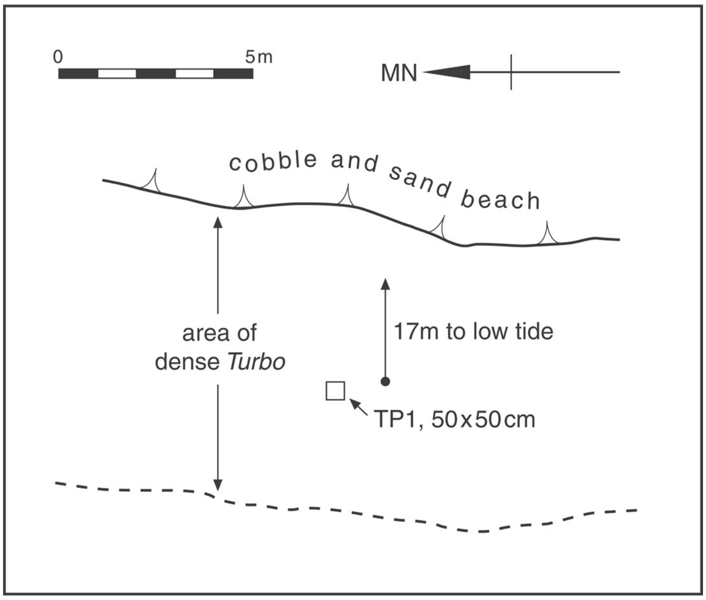

Figure 9: Compass and tape map of midden site DOJ-4 situated on the west side of Temoe Atoll.

Layer I. A cultural layer with dense *Turbo* gastropods, dispersed charcoal, bones of small fish (scarids, serranids and ostraciids) and dense unmodified coral cobbles within a dark yellowish brown (10YR3/4) coarse sand matrix. A radiocarbon sample (Wk-10609; Fig. 7d) of charcoal dispersed from 10 to 20 cm below surface was calibrated to AD 1530–1995 at 2σ. The deposit is structureless, loose and friable, non-sticky and non-plastic with no cementation. Unlike other habitation areas excavated, there were few roots. The boundary was diffuse and hard to see; it graded very gradually into layer II.

Layer II. The culturally sterile subsoil with essentially the same sediment characteristics as layer I except it was lighter in colour — brown (10YR5/3).

RADIOCARBON DATING

The objective of the radiocarbon dating programme was to obtain a date for the basal layer of all excavated sites as a first attempt at ascertaining the oldest age of habitation at each locale. The ideal situation was to collect identified, short-lived charcoal from discrete combustion features. This was only possible at TUP-2, where a large oven was originally excavated from the base of the cultural layer (*ca.* 1 m below surface) into the sterile lagoon sand subsoil and a pandanus drupe fragment was removed from between heat-altered coral oven stones. At MAE-1, a piece of coconut exocarp was obtained from under a large (40 cm long) flat pavement stone in the centre of a *paepae*. The three other samples consisted of carbonised pandanus drupe fragments dispersed throughout well-defined cultural layers. In total, five samples were dated; one each from four sites with an additional sample from the larger and stratigraphically complex TUP-2.

Sample weights were all very small and ranged from 0.094 to 1.958 g. Consequently, the accelerator mass spectrometer (AMS) dating technique was used for analysis. After drying at 30° C overnight at the University of Otago, the samples were sent to the University of Waikato Radiocarbon Dating Laboratory where they were prepared for AMS dating at the Institute of Geological and Nuclear Sciences (IGNS). Possible contaminants were removed before chemical pretreatment which consisted of washing the samples in hot 10% HCl, rinsing and treatment with 1% NaOH. The NaOH insoluble fraction was treated with hot 10% HCl, filtered, rinsed and dried.

All five of the samples returned a 'modern' age; that is, <200 years before present. However, the actual years before present were obtained for each sample for calibration purposes. Table 1 presents the details of the charcoal samples, dating results and calibration at 2σ. Considering the lack of historic materials from the dated contexts and the fact that the highest probabilities of all samples overlap during the seventeenth century, it seems likely that the dated samples represent very late prehistoric occupation about a century or so prior to atoll abandonment in the early 1800s.

TABLE 1

AMS radiocarbon age determinations for Temoe Atoll habitation sites

Lab No.	**Provenance**	**13C/12C**	**CRA**	**Material**	**Weight**
Wk-10609	DOJ-4-TP1/2	-27.3±0.2	180±57	Pandanus drupe	0.239
Wk-10608	KOU-1-D4/3	-23.8±0.2	145±57	Pandanus drupe	0.653
Wk-10607	MAE-1-E4-E5/1	-24.8±0.2	160±64	Coconut exocarp	0.094
Wk-10605	TUP-2-TP2/4	-23.7±0.2	129±61	Pandanus drupe	0.856
Wk-10606	TUP-2-TP4/5	-24.4±0.2	212±57	Pandanus drupe	1.958

Lab No.	**Context†**	**Calibrated 2σ**	**Highest Probability**
Wk-10609	10–20 cm	AD 1530–1955	64% AD 1650–1820
Wk-10608	20–30 cm	AD 1650–1955	45% AD 1670–1780; 35% AD 1800–1890
Wk-10607	below pavement	AD 1540–1955	43% AD 1650–1660; 48% AD 1890–1900
Wk-10605	48–57 cm	AD 1650–1955	43% AD 1670–1780; 40% AD 1800–1900
Wk-10606	oven, 101 cm	AD 1520–1955	26% AD 1630–1700; 38% AD 1730–1820

Calibrated after Stuiver and Reimer 1993; Stuiver *et al*. 1998 for southern hemisphere samples and calibrations rounded to nearest 10 years.
† See text for further details.

ARTEFACT COLLECTIONS

Some 24 artefacts and 8 volcanic specimens were recovered from surface contexts and the excavations at three sites and are described below.

TURTLE BONE

Shaped turtle bones were used for digging in the Tuamotus and were found associated with horticultural pits (Chazine 1982: 297–303, 332–336; Emory 1975: 36, 38). Chazine reports that turtle bone was used for “shovels” on Reao, Tuamotus as there was no *Pinctada* shell (1982: 298). With only 1.9 g of *Pinctada* recovered from the Temoe excavations (see Table 6), perhaps a similar situation existed.

Shaped pleural bone tool (artefact no. TUP-2-TP4/4-2). Reconstructed from 14 fragments that were broken during prehistory, this specimen was recovered at site TUP-2 from the southwest quadrant of TP4 at 80 cm below surface. Measuring 198.14 mm long, it is 89.95 mm wide and 7.29 mm thick at the midpoint. The poll end is 81.16 mm wide and the working edge is 19.24 mm wide. It weighs 65.9 g. This unique specimen was made from the first pleural bone amd was shaped to a rounded point and well ground along the sides (Fig. 10a); Tuamotuan shovels have straight working edges (Chazine 1982: 332–336). The used end of this artefact exhibits striations and polish on the exterior side within the distal 60 mm from the point, which are consistent with use as a digging tool (see also Chazine 1982: 301).

Shaped pleural bone tool (artefact no. TUP-2-TP2/1-1; Fig. 10b). Recovered from site TUP-2, this specimen was reconstructed from 13 fragments found in the northeast quad of TP2 at a maximum depth of 16 cm below surface. It measures 202.51 mm long (incomplete) and is 72.75 mm wide and 7.47 mm thick at the midpoint. The weight is 84.0 g. The pleural bone was smoothed along both sides of the long axis. The poll is only slightly smoothed and possibly worked to a right angle at the one corner present. The opposite or working end of the tool is missing, but it probably had a straight cutting edge as the sides are parallel and do not converge like the specimen described above.

WORKED PEARLSHELL (cf. *PINCTADA*)

Artefact no. TUP-1-J20/C1N1. This fragment is probably part of an unfinished fishhook point. It measures 20.97 mm long, 3.25 mm wide and 0.96 mm thick; it weighs 0.09 g. The pointed end appears smoothed, while towards the bend is a hinge fracture.

Artefact no. KOU-1-TPF4/1-1. Square in plan, this piece of worked pearlshell appears filed on two sides. It is 21.32 mm long, 18.52 mm wide and 1.51 mm thick; it weighs 0.7 g. It is probably the by-product of fishhook manufacture.

Artefact no. KOU-1-TPF4/1-2. This piece of worked pearlshell is also square in plan with two filed edges. It is 14.55 mm long, 12.74 mm wide and 1.39 mm thick; it weighs 0.5 g.

VOLCANIC STONES

Included here are physically unmodified volcanic stones found on the surface of sites KOU-1 and TUP-1, below the surface at TUP-2 and on the lagoon shore of Kurara and the ocean side of Tupa *motu*. One of the specimens is a vesicular basalt cobble, the kind often used in earth oven cooking, although it was not associated with a combustion feature. Three stones, found on the *paepae* of TUP-1, may have been used as oven stones, but consisted of medium basalt without many vesicles — the latter characteristic important for oven stones, but not essential. One specimen was a pebble-sized nodule of pumice and another was a chunk of obsidian embedded in a cobble of pumice. Both of these latter specimens undoubtedly came to Temoe as drift material. The other stones, however, may have been

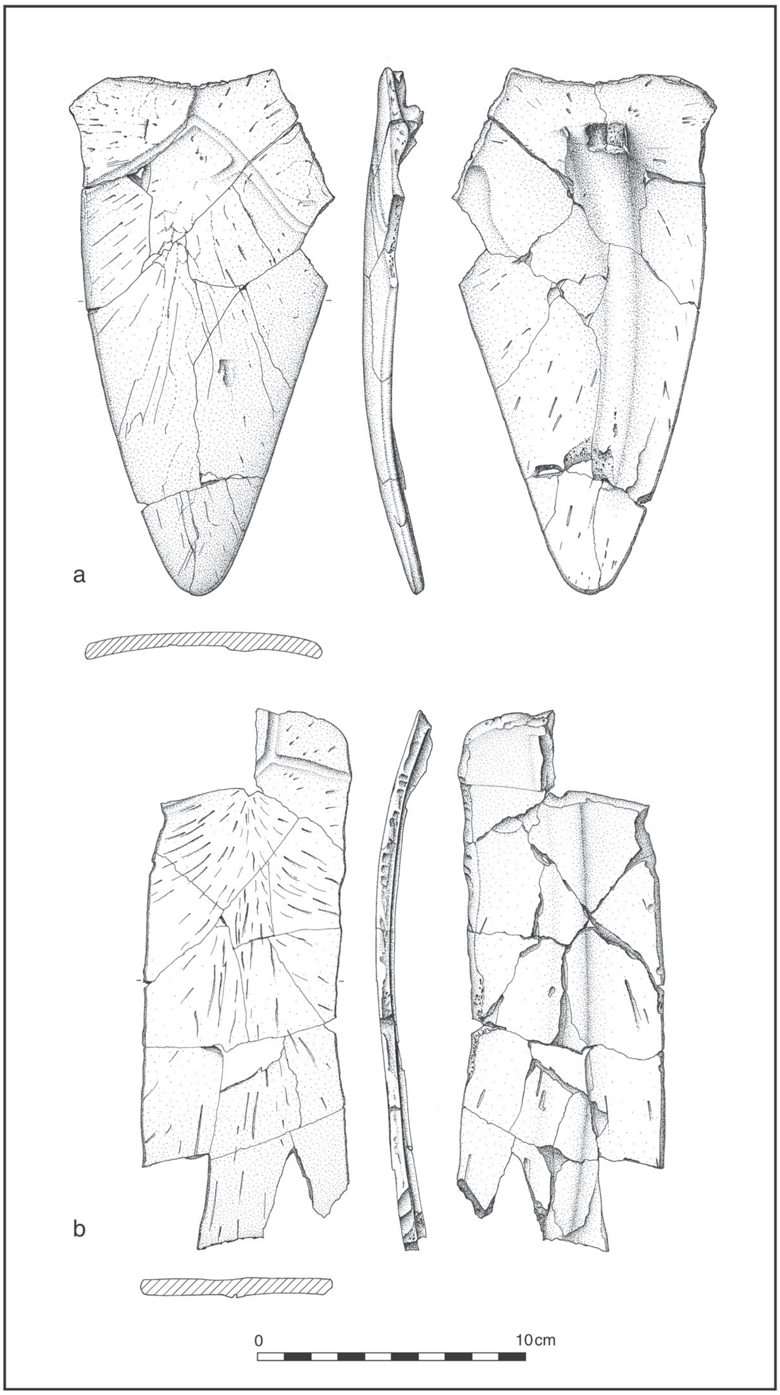

Figure 10: Reconstructed turtle bone digging tools from TUP-2.

humanly transported. The geochemical analysis of these specimens is described elsewhere in this paper for purposes of suggesting interaction with the volcanic islands of Mangareva.

Artefact no. KOU-1-SA1. A vesicular basalt fire-altered stone collected from the surface of KOU-1 (see Fig. 6). It was oblong in plan and circular in section. It measured 58 x 47 x 36 mm and weighed 99.8 g.

Artefact no. TUP-1-SA1a. From the surface of TUP-1, this basalt oven stone measured 98 x 56 x 38 mm and weighed 263.4 g.

Artefact no. TUP-1-SA1b. A dense basalt stone measuring 155 x 110 x 75 mm, it exhibits vesicles filled with 'rust'. The original stone weighed 1.1 kg and a sample of 76.8 g was taken for x-ray fluorescence analysis.

Artefact no. TUP-1-SA2. This volcanic stone measured 150 x 145 x 75 mm thick and weighed 1.65 kg before 60 g were removed for x-ray fluorescence analysis. It is a medium grained basalt with few vesicles and olivine (?) phenocrysts visible on fresh breaks.

Artefact no. TUP-2-TP3/2-1 (TUP-2-3a in Table 2). A basalt stone measuring 47 x 34 x 7 mm has a sugary appearance (medium grained texture) with plagioclase (?) phenocrysts. About 16 g were removed for x-ray fluorescence analysis.

Artefact no. Kurara. Collected from the lagoon shore of Kurara *motu*, this angular basalt stone measured 71 x 53 x 46 mm and weighed 261.6 g.

Obsidian sample. Found on the ocean side of Tupa *motu*, a nodule of obsidian was embedded in a pumice cobble. A 30.2 g sample of the glass was removed for geochemical analysis.

Pumice sample. All pumice was recovered from TUP-2, TP1 and 3. Twenty-two sub-rounded pebbles ranged in length from 14.76 to 53.06 mm. Artefact no. TUP-2-3b from TUP-2 TP3, spit 2, was 53.06 mm long and very dark grey (2.5Y3/1) on a fresh surface. It was analysed by the x-ray fluorescence technique to determine its nutritive value as a supplement to gardening soils. Atoll soils are characteristically poor in iron and trace minerals and, on some atolls, pumice was crushed and added to enrich the soils (Sachet 1955).

METAL

A total of 18 pieces (5.5 g) of rusted metal cans and wire nails were recovered from near surface contexts at TUP-1, units P20 and J20.

X-RAY FLUORESCENCE ANALYSIS OF VOLCANIC ARTEFACTS

To determine the inter-island relationships between the human populations on Temoe Atoll and those on Mangareva or elsewhere, wave-length dispersive x-ray fluorescence (XRF) analysis of volcanic artefacts was carried out. The goal is to match an artefact with its geological source. In this region of southeast Polynesia, the identification of imported artefacts from dated habitation contexts has demonstrated centuries-long ties between Mangareva and the Pitcairn group and even farther afield (Weisler 1995, 1998b, 2002). All eight volcanic specimens collected during the fieldwork were analysed (Table 2). Analytical procedures are after Johnson *et al*. (1999). Aside from the TUP-2 pumice and obsidian, all specimens are classified as tholeiitic basalts and the closest sources of these rocks is Mangareva. The source could not be on Pitcairn as there are no tholeiitic rocks there. The obsidian is an alkalic phonolite and its source, yet undetermined, may be thousands of kilometres away. Predictably, the pumice contained essential minerals that would have been an excellent soil amendment for garden soils. Although this is the first geochemical study of volcanic stones from Temoe Atoll, the results suggest that further studies will elucidate the inter-island and temporal relationships between human populations in the region.

TABLE 2

X-ray fluorescence analysis of Temoe volcanic stones

Major elements are normalised on a volatile-free basis, with total Fe expressed as FeO. † denotes values >120% of our highest standard. A=Kurara lagoon shore, B=KOU-1-SA1, C=TUP-1-SA1a, D=TUP-1-SA1a repeat (a duplicate bead made from the same rock powder), E=TUP-1-SA1b, F=TUP-1-SA2, G=TUP-2-3a, H=TUP-2-3b, I=TUPA obsidian. thb = tholetic basalt, thd = tholeitic dacite, alph = alkalic phonolite. Figures in this Table have been rounded to conform to NZ Journal of Archaeology style.

Sample	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Rock	**thb**	**thb**	**thb**	**thb**	**thb**	**thb**	**thb**	**thd**	**alph**
Unnormalised Major Elements (Weight %)									
SiO_2	50.2	48.9	49.2	49.4	49.5	49.2	49.3	68.7	55.2
Al_2O_3	14.6	16.5	14.9	14.9	14.9	16.1	16.3	14.1	20.1
TiO_2	2.4	2.5	2.4	2.4	2.6	3.2	2.7	0.52	0.52
FeO	10.9	10.5	10.3	10.4	11.5	10.9	8.8	3.0	4.1
MnO	0.17	0.12	0.16	0.16	0.17	0.14	0.12	0.14	0.14
CaO	11.7	11.6	12.4	12.4	11.4	9.4	12.4	3.0	1.6
MgO	6.9	5.9	6.6	6.6	6.2	5.5	6.2	0.85	0.67
K_2O	0.57	0.28	0.47	0.48	0.47	1.3	0.78	1.6	5.6
Na_2O	2.3	1.8	2.1	2.2	2.4	3.2	2.5	4.9	10.8
P_2O_5	0.28	0.35	0.31	0.31	0.30	0.58	0.34	0.11	0.11
Total	100.0	98.4	98.9	99.3	99.3	99.5	99.4	96.9	98.7
Unnormalised Trace Elements (ppm)									
Ni	81	127	125	125	63	87	91	6	16
Cr	146	399	191	184	66	141	268	0	9
Sc	34	37	35	36	37	28	25	13	2
V	265	231	261	270	284	243	261	26	23
Ba	117	93	123	126	117	240	191	796	9
Rb	10	2	5	5	8	20	14	27	205
Sr	354	395	386	386	368	478	470	244	117
Zr	142	147	147	148	145	261	171	154	†1900
Y	22	20	20	19	23	31	22	39	32
Nb	25	25	26	27	26	48	32	3	†230
Ga	20	20	18	21	21	24	23	18	40
Cu	90	51	86	83	53	50	58	5	8
Zn	94	80	100	100	100	105	73	62	149
Pb	0	0	0	1	1	2	0	1	37
La	23	23	19	8	19	39	22	16	124
Ce	34	52	42	40	48	69	51	35	194
Th	0	2	1	3	3	4	1	2	50

SUBSISTENCE REMAINS

Obtaining information on Temoe subsistence practices was a major objective and contributes to a growing data corpus on atoll economy (e.g., Anderson *et al*. 2002; Davidson 1971; Leach and Ward 1981; Weisler 1999b, 2001a). As on nearly all Pacific atolls, prehistoric subsistence was heavily dependent on marine resources, but there is marked variability in the contribution of terrestrial production such as aroids (especially *Colocasia* and *Cyrtosperma*) and tree crops including the ubiquitous coconut and to a lesser extent breadfruit and pandanus. Thus far no large, elongate pits — often found near the centre of the largest *motu* and used for aroid cultivation — have been identified. As mentioned above, breadfruit may not have been able to survive on Temoe and even coconut probably had a precarious existence.

The most prolific tree on atolls is pandanus as it is adapted to wet as well as dry, marginal conditions. There are at least two varieties on Temoe. The common species has small drupes without much edible flesh, while a few trees with large juicy drupes, up to 6 cm wide, were observed just east (inland) of TUP-1 and are undoubtedly a cultivated variety.

Because of the marginal nature of the terrestrial environment and the potentially long-term human occupation of the atoll (on the order of many centuries), it was likely that the effects of human predation would be archaeologically visible in the size of fish over time and with the possible extinction or extirpation of birds — a pattern that has been documented for many Pacific islands (e.g., Steadman 1995; Wragg and Weisler 1994).

TABLE 3

Bone from Temoe Atoll sites

	Site					
Taxon	**DOJ-4**	**KOU-1**	**MAE-1**	**TUP-1**	**TUP-2**	**Subtotal**
Vertebrate	-	2	-	37	4	43
Mammal						
Rattus cf. *exulans*	-	-	4	3	-	7
Rattus magn. *exulans*	2	-	2	20	1	25
Rattus sp.	-	-	-	1	-	1
Homo sapiens	-	-	-	1	-	1
Sea turtle	-	-	-	8	-	8
cf. Sea turtle	-	-	-	7	2	9
Bird	-	-	-	6	-	6
Anous stolidus	-	-	3	-	-	3
Phaethon cf. *rubricauda*	-	-	-	4	-	4
Phaethon rubricauda	-	-	-	2	-	2
Sula dactylatra	-	-	-	1	-	1
Total non-fish bone	**2**	**2**	**9**	**90**	**7**	**110**
Total Fish	**3803**	**157**	**1063**	**15940**	**407**	**21370**
Total NISP	**3807**	**161**	**1081**	**16120**	**421**	**21590**

Weisler sorted bone into fish, bird, sea turtle and rat. Fish bones were identified by Weisler to nearest taxon using a large comparative collection of tropical Pacific fish

(Weisler 2001b: Appendix 3); bird and rat bones were further identified by Trevor Worthy; sea turtle bone fragments and crustacea were identified by Weisler using comparative collections at the University of Otago. Shellfish and echinoderms were identified by Christopher Wheadon primarily using Salvat and Rives (1991) and comparative collections.

Most of the 21,590 bones inventoried from the excavations were fish and only 110 elements of other vertebrates were those of mammal (rat and human), sea turtle and bird. These are described below and listed in Table 3.

VERTEBRATES

Rat

Thirty-three bones of the Pacific rat (*Rattus* cf. *exulans*; *R*. magn *exulans*[4]) were recovered from all sites but KOU-1. Elements inventoried included in descending abundance: seven vertebra; five each maxilla and tibia; four unidentified; two each innominate, scapula, femur and tooth; and one each cranial fragment, mandible, ulna and phalange. It is uncertain whether these bones represent the remains of food.

Human

A fragment of tooth enamel (possibly a first molar shed naturally) was recovered from TUP-1, unit L6, layer 1, spit 4.

Sea Turtle

Bone fragments of sea turtle (probably *Chelonia mydas*) were found at TUP-1 and -2. All but 2 of the 17 specimens were found at unit L6, which was excavated in a cooking area. Turtles were considered a high status food in Mangareva (Buck 1938: 91, 417) and parts of the Tuamotus (Emory 1975: 40), so these remains may suggest that TUP-1 (containing the largest *paepae* on Temoe) was occupied by a household of relatively high rank.

Bird

Sixteen bird bones, representing at least three species of sea birds, were collected from near surface contexts from sites MAE-1 and TUP-1. Six elements are long bone fragments and could not be identified further. One pelvis and two phalanges were from an adult Brown Noddy — the smallest sea bird in the assemblage. The eroded condition of the pelvis suggests it was recently deposited, perhaps within the last few years. Five of the six bones of the Red-Tailed Tropicbird were from juveniles and included two proximal right radii, three proximal right ulnae and one coracoid. This species is ground-nesting today and easily captured. The red tail feathers are still collected and sold in Rikitea (Mangareva island) to ornament dance costumes. A distal right humerus of an adult Masked Booby (*Sula dactylatra*) was also collected. All these bird species are present on the atoll today. Detailed

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[4]The term 'magn' is from the Latin 'magnitudino' to indicate that the bones were the size of the named taxon without implying possible relationship. In the present case there are few other choices as to the real taxon (Trevor Worthy, pers. comm. 4 March 2003).

examination of each bone revealed that only two bones could be shown unequivocally to have been deposited through human action (see Weisler and Gargett 1993; Weisler 2001b: 104–108). The humerus of the booby exhibited a spiral fracture which is caused when the bone is broken while still fresh. The distal end of a proximal ulna of a Red-Tailed Tropicbird showed burning coloration consistent with cooking while the limb had flesh.

TABLE 4

Identified fish (NISP) from Temoe Atoll sites

Taxon	DOJ-4	KOU-1	MAE-1	TUP-1	TUP-2	Total	% taxon
Shark	-	-	-	2	-	2	<1
Elasmobranchii	-	-	-	1	-	1	<1
Marine Eel	-	1	-	-	-	1	<1
Holocentridae	2	-	-	1	-	3	<1
Fistulariidae	-	-	-	3	-	3	<1
Serranidae	10	3	12	58	9	92	2.90
Cirrhitidae	-	-	-	6	8	14	<1
Carangidae	-	1	-	1	-	2	<1
Lutjanidae	-	-	-	2	1	3	<1
Mullidae	4	-	3	2	-	9	<1
Kyphosidae	-	-	1	-	-	1	<1
Pomacentridae	-	-	1	-	-	1	<1
Labridae	-	-	4	13	2	19	<1
Scaridae	289	25	174	1746	19	2253	71.30
Polynemidae	-	-	-	1	-	1	<1
Acanthuridae	-	-	-	14	2	16	<1
Ostraciidae	67	8	39	544	4	662	20.90
Diodontidae	17	3	-	8	51	79	2.50
Total Identified	**389**	**41**	**234**	**2402**	**96**	**3162**	
Total Bones	**3803**	**157**	**1063**	**15940**	**407**	**21370**	
Percent Identified	**10.2**	**26.1**	**22.0**	**15.1**	**23.6**	**14.8**	
Weight (g)	**59.0**	**16.3**	**34.1**	**357.9**	**62.9**	**530.2**	

Fish

Altogether, 21,370 fish bones weighing 530.2 g were retained from the 2 and 6 mm sieves from all sites. Overall, 14.8% of all fish bones, quantified as number of identified specimens (NISP), were identified to at least family level — a similar identification percentage to other assemblages from atolls (e.g., Weisler 2001b). Not surprisingly scarids dominated the assemblage with 71.3% of all identified fish, with the important serranids ranked third at 2.9%. Boxfish (Ostraciidae) scales and the dermal spines of diodontids (ranked second and fourth, respectively) inflated their relative abundance in reference to most other taxa (except scarids) that were identified by the commonly used five paired mouth parts. In total, 15 families in addition to shark, Elasmobranchii (shark and rays) and marine eels were inventoried (Table 4). The common capture technique for most of these families is by netting along the lagoon or ocean side shores. However, baited hooks are used for catching hawkfish (Cirrhitidae) and serranids, while diodontids and serranids are often speared. In Mangareva, the fishing spear (*tau*) consists of six metal prongs that are lashed to a wood handle 2 m long and during our stay on Temoe, scarids, serranids and carangids (*Caranx* and *Selar*) were often taken in large numbers by this technique.

The width of the lower pharyngeal grinding plate (inferior cluster fragment) of all scarids was measured to the nearest .01 mm to estimate live fish weight (after Fleming 1986: Figures 7 and 31). Only three sites had sufficiently large samples for comparative purposes (Table 5). Using data provided in Fleming (1986) the scarids at sites DOJ-4 and MAE-1 were estimated to weigh <200 g, while at TUP-1 the reconstructed size was no more than 250 g. Although we do not have modern comparative samples from Temoe to document the size of scarids from a more or less pristine fishery objectively, we ate scarids, predominantly *Scarus frontalis*, nearly every day for about three weeks on Temoe and no individuals were as small as the archaeological specimens. In fact, one fish taken for reference, albeit a relatively large one but not exceedingly so, weighed 2.2 kg and had a pharyngeal width of 13.12 mm. Only two archaeological specimens out of 188 are near this size. I also compared the approximate length of the Temoe archaeological scarids to 20 assemblages (including the atolls of Kapingamarangi and Nukuoro) and found the mean length of the Temoe assemblage to be smaller in all cases (Fleming 1986: Table 4 and Figure 32). The diminutive size of the Temoe scarids (and perhaps the size of many fish in the entire assemblage) may represent the effects of human predation, probably exacerbated in late prehistory. This is an hypothesis that requires testing with data from larger and older assemblages.

TABLE 5

Size of lower pharyngeal elements of Scarids from Temoe archaeological sites
Measurements in mm; mean not given for sample sizes <10

Site	**N**	**Mean**	**Range**
TUP-1	140	7.83±5.47	2.69–12.17
TUP-2	2	-	6.37–13.29
KOU-1	2	-	2.88–3.52
DOJ-4	19	4.31±1.47	2.98–5.47
MAE-1	25	5.01±0.25	2.99–7.04

Two caveats must also be considered. The collection of bone from the 20 assemblages reported in Fleming (1986) occurred during a time when small-mesh sieves and water screening were not routinely used in Pacific archaeology. Consequently, many small elements may not be represented in the assemblages. However, size classes similar to the Temoe assemblage are represented (Fleming 1986: Figs 38–43). I also considered that sea birds, nesting on the ground or above many archaeological sites today, may have deposited bones of small fish. Scarids are not the preferred food of sea birds. In one Christmas Island study, the vast majority of fish taken by the Masked Booby, Red-Tailed Tropicbird and Brown Noddy were flyingfish (Exocoetidae) and 31 other fish families; there were no records of sea birds consuming scarids (Ashmole and Ashmole 1967: Appendix 3; Schreiber and Hensley 1976: 242).

TABLE 6
Midden constituents other than bone from Temoe archaeological sites (weight g)

Taxon	**DOJ-4**	**KOU-1**	**MAE-1**	**TUP-1**	**TUP-2**	**Subtotal**
GASTROPODS						
Patellidae	-	1.9	1.0	4.5	1.6	9.0
Patella flexuosa	0.4	-	4.4	-	-	4.8
Haliotidae						
Haliotis pulcherrima	4.1	-	-	0.3	-	4.4
Trochacea	-	-	-	1.0	3.1	4.1
Trochidae	-	-	-	1.2	0.5	1.7
Turbinidae	-	-	-	1.7	-	1.7
Turbo argyrostomus	9202	428	293	1295	2208	13427
Turbo setosus	2055	143	158	993	1182	4534
Turbo spp.	530	183	146	1171	458	2490
Neritidae						
Nerita plicata	4.3	4.6	3.5	26.4	3.4	42.2
Nerita plicata/undata	0.2	-	-	1.0	-	1.2
Littorinidae						
Littorina coccinea	2.8	1.5	-	1.1	-	5.4
Nodilittorina sp.	-	-	-	0.2	-	0.2
Tectarius grandinatus	0.2	27.3	2.0	15.1	8.0	52.6
Modulidae	-	-	-	0.5	-	0.5
Modulus cf. *tectum*	-	-	-	0.2	-	0.2
Cerithiidae	-	-	-	4.4	-	4.4
Cerithium rostratum	0.2	-	-	5.2	-	5.4
Cerithium sp.	-	4.0	-	0.1	-	4.1
Cerithium torulosum	-	-	-	5.8	-	5.8
Planaxidae	-	-	-	0.2	-	0.2
Strombidae						
Strombus mutabilis	-	-	0.8	-	-	0.8
Hipponicidae	-	-	-	1.1	-	1.1
Hypponyx antiquatus	-	-	-	1.6	-	1.6
Hypponyx conicus	6.7	-	-	2.3	0.6	9.6
Hypponyx pilosus	0.2	-	-	0.2	-	0.4
Cypraeidae						
Cypraea (small)	3.7	3.9	3.6	-	6.0	17.2
Cypraea sp.	-	-	-	2.7	-	2.7
Colubariidae	-	-	-	0.3	-	0.3
Muricacea	-	-	-	0.1	-	0.1
Muricidae	-	-	-	0.3	-	0.3
Drupa elegans/ricinus	-	-	-	1.6	-	1.6
Drupa rubusidaeus	4.5	-	-	-	-	4.5
Drupa sp.	1.0	2.1	-	1.7	4.0	8.8
Drupa spp.	-	-	-	1.3	-	1.3
Drupella cornus	-	-	-	-	5.9	5.9
Buccinacea	-	-	-	0.1	-	0.1
Mitracaea	-	-	-	0.2	-	0.2
Mitridae	-	-	-	1.0	-	1.0
Conidae	2.6	-	-	3.7	-	6.3
Conus sp.	-	-	-	1.2	-	1.2
Terebridae	-	-	-	8.7	1.8	10.5
Architectonicidae	17.2	-	-	5.9	0.3	23.4
Unidentified Gastropods	-	-	0.7	21.4	6.7	28.8
Total Gastropods	11835	800	614	3584	3891	20727

BIVALVES						
Arcidae						
Arca sp.	-	-	2.0	0.9	7.3	10.2
Pteriidae						
Pinctada maculata	-	-	1.7	405	2.5	409
Pinctada margaritifera	-	-	-	1.9	-	1.9
Pinctada sp.	1.5	-	-	0.9	-	2.4
Isognomonidae						
Isognomon nucleus	0.1	-	-	-	-	0.1
Isognomon sulcata	-	0.6	-	0.3	-	0.9
Spondylidae	-	-	-	0.5	-	0.5
Ostreidae						
Crassostrea cucullata	-	-	-	30.1	-	30.1
Pycnodonta hyotis	-	-	-	3.0	-	3.0
Lucinidae	-	-	-	1.0	-	1.0
Anodontia edentula	-	-	-	0.6	-	0.6
Codakia tigerina	3.4	3.4	1.4	117	35.4	160
Chamidae						
Chama imbricata	-	-	-	8.0	2.4	10.4
Chama pacifica	6.0	-	1.8	14.7	-	22.5
Chama cf. *pacifica*	-	-	-	3.5	-	3.5
Chama sp.	-	3.0	1.1	7.0	16.2	27.3
Chama spp.	-	-	-	5.4	-	5.4
Cardiidae						
Cardium orbitum	-	-	-	1.8	0.6	2.4
Fragum fragum	6.5	1.1	8.8	375	239	631
Hemicardium dionaeum	0.8	-	0.2	7.4	0.6	9.0
Hemicardium cf. *dionaeum*	-	-	0.2	-	0.5	0.7
Tridacnidae						
Tridacna maxima	286	37.0	25.8	137	51.8	537
Tridacna cf. *maxima*	-	-	-	0.1	-	0.1
Veneridae						
Gafrarium pectinatum	0.1	-	-	132	-	132
Periglypta reticulata	1.6	-	-	12.0	-	13.6
Pitar prora	-	-	-	0.5	6.6	7.1
Tellinidae	2.1	2.3	-	12.0	-	16.4
Arcopagia robusta	-	-	-	2.9	-	2.9
Scutarcopagia scobinata	-	5.0	21.4	52.9	-	79.3
Quidnipagus palatam	-	-	-	6.4	-	6.4
Unidentified Bivalves	0.6	-	-	37.6	1.0	39.2
Total Bivalves	308	52.4	64.4	1379	364	2169
Unidentified Molluscs	3.7	2.7	-	72.3	-	78.7
TOTAL MOLLUSCS	12148	855	679	5036	4256	22975
CRUSTACEANS	-	-	0.5	9.9	-	10.4
cf. *Ceonobita*	-	-	-	2.0	-	2.0
Panulirus sp.	-	-	-	1.2	-	1.2
ECHINODERMS						
Heterocentrotus sp.	23.7	0.8	15.6	2.1	1.7	43.9
TOTAL MOLLUSCS, CRUSTACEANS, AND ECHINODERMS	12171	856	694	5041	4257	23022
OTHER						
Charcoal	1.4	130	0.3	1052	741	1926
Pumice	-	-	-	-	56.0	56.0
TOTAL MIDDEN	**12173**	**986**	**695**	**6094**	**5055**	**25005**

INVERTEBRATES

Molluscs

Shellfish were removed from all samples after rescreening with 6 mm sieves. The retained molluscs were washed and dried, then identified to nearest taxon at the University of Otago. A total of 22.9 kg of shellfish are inventoried in Table 6 by weight. Gastropods dominated the assemblage with 90% of total shellfish; less than 10% were bivalves. Eighty percent of all molluscs were *Turbo* (*eriri*), either *T. argyrostomus* or *T. setosus*. More than 98% of all gastropods were *Turbo*. These molluscs are readily collected along the algal crest at low tide where Tepano Paeamara and I collected 206 *Turbo* spp. in 40 minutes on the seaward side of Tupa *motu*. The dominance of *Turbo* (as quantified by weight) on Temoe is similar to a few atolls (Leach and Ward 1981) and to *makatea* islands in general (Kirch *et al*. 1995; Weisler 1995). On many other atolls, however, *Tridacna*, *Cerithium* and *Lambis* are common food molluscs (Weisler 1999b: Table 9, 2001b: Table 7.7). This situation merits detailed study of the marine habitats on Temoe, noting species composition and biomass to see if archaeological abundance reflects natural stocks or selective prey choice.

Five taxa accounted for *ca*. 90% of all bivalves by weight. In descending order of importance they were *Fragum fragum*, *Tridacna maxima*, *Pinctada maculata*, *Codakia tigerina* and *Gafrarium pectinatum*. Unlike *Turbo* gastropods, there is relatively little food value represented by the individual size and species of these particular bivalves from the Temoe assemblage.

Echinoderms

Ninety-nine spines of the Slate Pencil Urchin (*Heterocentrotus* sp.) were identified from all sites. It is recognised that some of these spines may have entered the archaeological sites through natural *motu* formation processes. None of the spines were modified for use as abraders.

Crustacea

This faunal class was divided into three groups: hermit crab (cf. *Cenobita* sp.), which most often occupy *Turbo* shells and are ubiquitous on all *motu*; non-*Cenobita,* possibly including pincers of rock crabs such as *Grapsus* sp.; and mandibles of spiny lobster (*Panulirus* sp.). Most of the 42 fragments of crustacea were recovered from the cooking area at TUP-1. The lobster mandibles were not measured but, from comparisons with modern specimens, the approximate size of the individuals was quite small. A noticeable absence from the archaeological material was the thick-shelled Spotted Pebble Crab (*Carpilius maculatus*). Its carapace should preserve, but perhaps it was not ever very numerous, although it was observed in small numbers during our stay.

SUMMARY AND CONCLUSIONS

Exchange of hard goods, marriage partners and services was vital for sustaining small human populations on resource-poor islands. This is the case for the well-documented Henderson island and the preliminary sourcing data presented here hint of a similar situation for Temoe Atoll. That is, the community on Temoe Atoll was viable only with periodic resupply of marriage partners, imported goods and services from the main Mangareva islands. This adds another example of how small, isolated communities survived for extended periods without appreciable horticultural production. The Temoe study, although preliminary at present, does suggest that low human populations on some resource-poor islands in the subtropical zone can survive by maintaining links to better-resourced and *nearby* islands. It may be that once marine stocks (shellfish, fish, turtles and sea birds) were reduced, social mechanisms contributing to the long-term survival of the community were put in place. These may have included limiting the full-time resident population on the atoll and increasing interaction with the main Mangareva group for acquiring necessary commodities, marriage partners and services. I offer this explanation as a refinement of Anderson's recent position (2001) suggesting that the resource-poor islands of the subtropical zone could not survive in the long term without agricultural production.

The atoll has been surveyed and habitations near the lagoon shore of many *motu*, if occupied simultaneously, may suggest a resident population of about 150. Although admittedly this is a rough estimate, it is probable that a community of this size, and without substantial terrestrial production, would require at least occasional outside intervention. Alternatively, it seems likely that not all habitations were occupied at the same time. Perhaps there was a resident population that increased along with the predictable seasonal abundance of sea turtles, nesting sea birds and aggregating fish during spawning periods. The accurate timing of these natural events would support larger human populations — at least for short periods of time.

This is a first look at the culture-historical sequence for Temoe Atoll and evidence from Henderson island — where colonisation may have been as early as AD 800 to 1000 — points to at least another 600 years of occupation on Temoe that remains to be defined (Weisler 1995). What we can posit now is that the last century or so on Temoe witnessed a decline in the overall size of the most common finfish (parrotfish, Scaridae) probably caused by human predation pressure. And the limited bird bones in the habitation sites suggest in part that few sea birds survived on the atoll during late prehistory. The size of lobsters may have reduced over time as well.

Despite its relative isolation from the main Mangareva group, lack of nutrient-rich soils for growing aroids and limited potable water, Temoe Atoll had a viable settlement that subsisted primarily on finfish and shellfish that was supplemented by sea turtle and birds. The identification of volcanic stones of a probable Mangareva origin points to inter-island contacts that undoubtedly played a key role is sustaining a small human population on this ecologically marginal atoll. Radiocarbon age determinations documented occupation to the late prehistoric period (post-1600s) and the earliest part of the sequence awaits discovery and definition.

It is intriguing to suggest that the small communities on Pitcairn and Henderson islands — the farthest outposts of the southeast Polynesian interaction sphere — took up residence on Temoe after abandoning their islands, perhaps joining their Mangarevan relatives on the atoll. The voyaging time from Mangareva to Henderson was then reduced from about three and a half days to merely three hours to Temoe from the main volcanic group. With an interaction sphere stretched to its limits from social unrest during the late sixteenth century (Weisler 2002), this reduced travel time (and expense) may have made it possible for the Henderson and Pitcairn communities to survive — albeit on a new island closer to their parent population.

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